



Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2019

Centre Number

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Candidate Number

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Chemistry

Assessment Unit AS 1

assessing

Basic Concepts in Physical
and Inorganic Chemistry



[SCH12]

SCH12

MONDAY 20 MAY, MORNING

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

Answer **all sixteen** questions.

Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10. Keep in sequence when answering.

Answer **all six** questions in **Section B**. **You must answer the questions in the spaces provided.**

Do not write outside the boxed area on each page or on blank pages.

Complete in black ink only. **Do not write with a gel pen.**

INFORMATION FOR CANDIDATES

The total mark for this paper is 90.

Quality of written communication will be assessed in Question **15(c)**.

In Section A all questions carry equal marks, i.e. **one** mark for each question.

In Section B the figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

A Periodic Table of Elements, containing some data, is included with this question paper.

11852



Section A – Multiple Choice

Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

Each multiple choice question is worth 1 mark.

- 1 In which of the following does chromium **not** have an oxidation state of +6?
 - A CrO_3
 - B CrO_4^{2-}
 - C $\text{Cr}_2\text{O}_7^{2-}$
 - D Cr_2O_3

- 2 Which bonding type is described as intermolecular?
 - A Covalent
 - B Ionic
 - C Metallic
 - D van der Waals' forces

- 3 Which of the following is the formula of the nitrite ion?
 - A N^{3-}
 - B NH_4^+
 - C NO_2^-
 - D NO_3^-



4 25.0 cm³ of 0.10 M sodium hydroxide solution is exactly neutralised by

- A 12.5 cm³ of 0.05 M sulfuric acid.
- B 25.0 cm³ of 0.05 M sulfuric acid.
- C 12.5 cm³ of 0.20 M sulfuric acid.
- D 25.0 cm³ of 0.10 M sulfuric acid.

5 The electronic configuration of a Group III element is

- A 1s² 2s² 2p⁶ 3s² 3p⁶ 3d³ 4s².
- B 1s² 2s² 2p⁶ 3s² 3p⁶ 3d¹⁰ 4s² 4p¹.
- C 1s² 2s² 2p⁶ 3s² 3p⁶ 3d¹⁰ 4s² 4p².
- D 1s² 2s² 2p⁶ 3s² 3p⁶ 3d¹⁰ 4s² 4p³.

6 The bond angle in ammonia is

- A 104.5°.
- B 107°.
- C 109.5°.
- D 120°.

[Turn over



- 7 The sulfate(VI) ion can be reduced to sulfur dioxide.



Which of the following represents the correct values of x, y and z?

	x	y	z
A	2	2	4
B	2	4	2
C	4	2	2
D	4	4	2

- 8 Which type of titration can use phenolphthalein as a suitable indicator?
- A Strong acid/strong base only
- B Strong acid/strong base and weak acid/strong base
- C Strong acid/strong base and strong acid/weak base
- D Strong acid/weak base and weak acid/strong base
- 9 In which of the following molecules does the central atom obey the octet rule?
- A BF_3
- B BeCl_2
- C ClF_3
- D PH_3



10 Which species is the most powerful oxidising agent?

- A Bromide
- B Bromine
- C Chloride
- D Chlorine

[Turn over

11852



20SCH1205

Section B

Answer **all six** questions in the spaces provided.

11 Water can act as an acid or as a base. It can either lose or gain hydrogen ions.

(a) State and explain the shape of a water molecule.

[3]

(b) Water can react with hydrogen ions forming hydroxonium ions, H_3O^+ .

(i) Draw a dot and cross diagram to show the bonding in a hydroxonium ion, showing all the outer shell electrons.

[2]



(ii) Suggest why the bond angle in the hydroxonium ion is greater than the bond angle in water.

[2]

(iii) Suggest why the hydroxonium ion does not react with a hydrogen ion to form H_4O^{2+} .

[1]



- 12** Four new elements have recently been added to the Periodic Table. The four elements are given below, along with their atomic numbers and the mass numbers of their most common isotope.

element	atomic number	mass number
nihonium	113	286
moscovium	115	289
tennessine	117	294
oganesson	118	294

- (a)** What is the meaning of the following terms?

- (i)** Atomic number

_____ [1]

- (ii)** Mass number

_____ [1]

- (iii)** Isotopes

_____ [1]

- (b)** State and explain which element has the most neutrons.

_____ [2]



(c) Suggest why tennessine is placed in Group VII of the Periodic Table.

_____ [1]

(d) Erbium is a soft, silvery solid that tarnishes slowly in air. It is used in fibre optic cables. There are six known isotopes of erbium and its relative atomic mass is 167.26.

(i) Define the term **relative isotopic mass**.

_____ [2]

(ii) The table below gives the percentage abundances of six isotopes in the mass spectrum of erbium.

relative isotopic mass	161.93	163.93	165.93		167.93	169.94
% abundance	0.14	1.60	33.50	22.87	26.98	14.91

Calculate the missing relative isotopic mass.

_____ [3]

[Turn over



13 Chloroauric acid, HAuCl_4 , is an orange solid that is used widely in gold refining. During World War II, the Hungarian chemist George de Hevesy dissolved two gold Nobel Prize medals in a mixture of concentrated nitric and hydrochloric acids to prevent the Germans from confiscating them. Later the medals were reconstructed from the dissolved chloroauric acid and returned.

- (a) The reaction between gold, concentrated hydrochloric acid and concentrated nitric acid produces chloroauric acid, nitrogen(IV) oxide and water. Write the equation for this reaction.

_____ [2]

- (b) Gold is extracted from recycled electronic materials by reaction with chlorine and hydrochloric acid, forming chloroauric acid. Elemental gold is recovered by electrolysis of chloroauric acid.



- (i) Deduce the oxidation state of gold in chloroauric acid.

_____ [1]

- (ii) With reference to oxidation numbers, explain why this is a redox reaction.

_____ [3]



(c) When heated, chloroauric acid forms gold(III) chloride and hydrogen chloride gas. The bonding in gold(III) chloride is considered to be covalent.

(i) Suggest, in terms of electronegativity, why the bonding in gold(III) chloride is covalent.

[1]

(ii) Describe the chemical test for hydrogen chloride gas.

[2]

[Turn over



14 The recommended daily allowance for salt, sodium chloride, is 6.0g. Eating too much salt can lead to high blood pressure, potentially causing heart disease and strokes.

- (a) State the electronic configuration of a sodium atom and use it to explain why sodium is regarded as an s-block element.

_____ [2]

- (b) (i) Define the term **Avogadro's constant**.

_____ [1]

- (ii) Calculate the number of sodium ions in the recommended daily allowance of sodium chloride.

_____ [2]

- (c) A solid sample of salt was analysed to confirm the identity of the ions present. A flame test was first conducted on the sample using nichrome wire and concentrated hydrochloric acid to identify sodium ions. The presence of chloride ions was subsequently confirmed.

- (i) State **two** reasons why *nichrome* wire was used.

_____ [2]



(ii) State **two** reasons why concentrated hydrochloric acid was used.

[2]

(iii) State the colour observed in the flame test.

[1]

(d) Describe how the presence of chloride ions could be confirmed in the solid salt.

[4]

(e) A second salt sample was thought to be contaminated with sodium carbonate. Describe a chemical test to confirm the presence of carbonate ions.

[3]

[Turn over



(f) The salt sample, of mass 6.0 g, contaminated with sodium carbonate was dissolved in water. A solution of magnesium chloride was added, forming a precipitate of magnesium carbonate. The precipitate was filtered off and dried to give 1.4 g of magnesium carbonate.

(i) Draw a dot and cross diagram to show the bonding in magnesium chloride showing all the outer electrons.

[2]

(ii) Write the equation for the reaction between sodium carbonate and magnesium chloride.

[2]



- (iii) Use the following headings to calculate the percentage of sodium carbonate in the salt sample.

Relative formula mass of magnesium carbonate

Number of moles of magnesium carbonate

Number of moles of sodium carbonate

Relative formula mass of sodium carbonate

Mass of sodium carbonate in the sample

Percentage of sodium carbonate in the sample

[6]

[Turn over



15 The third Period in the Periodic Table from sodium to argon displays a number of periodic trends.

(a) State and explain the general trend in first ionisation energy across Period three.

[3]

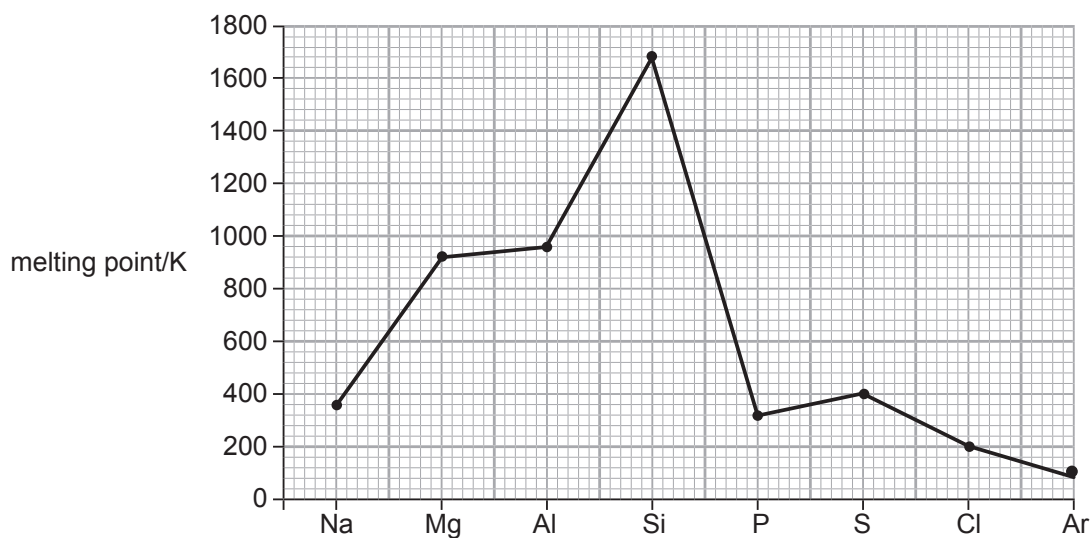
(b) (i) Write an equation, including state symbols, for the first ionisation energy of phosphorus.

[2]

(ii) Explain why the first ionisation energy of phosphorus is higher than that of sulfur.

[2]





With reference to the structure and bonding of the elements, explain the change in melting point from **silicon** to **argon**.

In this question you will be assessed on your written communication skills including the use of specialist scientific terms.

[6]

[6]

[Turn over

11852



20SCH1217

16 Lead(II) iodide is yellow and was once used as a pigment in paint until concerns over its toxicity led to its use being discontinued. It has a low solubility in water.

- (a)** Lead(II) iodide can be prepared by reaction between solutions of potassium iodide and lead(II) nitrate. Write the equation for this reaction.

_____ [2]

- (b)** 75.6 mg of lead(II) iodide dissolve in 100 cm³ of water at 20°C. Calculate the molarity of iodide ions in a saturated solution of lead(II) iodide at 20°C.

_____ [4]

- (c)** Chlorine water was added to potassium iodide solution in a test tube.

- (i)** State the colour observed.

_____ [1]

- (ii)** A solution of starch was then added to the test tube. State the colour observed.

_____ [1]



(d) (i) State **three** observations made when concentrated sulfuric acid is added to solid potassium iodide.

[3]

(ii) Explain why concentrated phosphoric acid does not give iodine when added to solid potassium iodide.

[1]

THIS IS THE END OF THE QUESTION PAPER



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20SCH1220

General Information

1 tonne = 10^6 g

1 metre = 10^9 nm

One mole of any gas at 293 K and a pressure of 1 atmosphere (10^5 Pa) occupies a volume of 24 dm^3

Avogadro Constant = $6.02 \times 10^{23} \text{ mol}^{-1}$

Planck Constant = $6.63 \times 10^{-34} \text{ Js}$

Specific Heat Capacity of water = $4.2 \text{ J g}^{-1} \text{ K}^{-1}$

Speed of Light = $3 \times 10^8 \text{ ms}^{-1}$

Characteristic absorptions in IR spectroscopy

Wavenumber/ cm^{-1}	Bond	Compound
550–850	C–X (X = Cl, Br, I)	Haloalkanes
750–1100	C–C	Alkanes, alkyl groups
1000–1300	C–O	Alcohols, esters, carboxylic acids
1450–1650	C=C	Arenes
1600–1700	C=C	Alkenes
1650–1800	C=O	Carboxylic acids, esters, aldehydes, ketones, amides, acyl chlorides
2200–2300	C≡N	Nitriles
2500–3200	O–H	Carboxylic acids
2750–2850	C–H	Aldehydes
2850–3000	C–H	Alkanes, alkyl groups, alkenes, arenes
3200–3600	O–H	Alcohols
3300–3500	N–H	Amines, amides

Proton Chemical Shifts in Nuclear Magnetic Resonance Spectroscopy (relative to TMS)

Chemical Shift	Structure	
0.5–2.0	–CH	Saturated alkanes
0.5–5.5	–OH	Alcohols
1.0–3.0	–NH	Amines
2.0–3.0	–CO–CH	Ketones
	–N–CH	Amines
	$\text{C}_6\text{H}_5\text{–CH}$	Arene (aliphatic on ring)
2.0–4.0	X–CH	X = Cl or Br (3.0–4.0) X = I (2.0–3.0)
4.5–6.0	–C=CH	Alkenes
5.5–8.5	RCONH	Amides
6.0–8.0	– C_6H_5	Arenes (on ring)
9.0–10.0	–CHO	Aldehydes
10.0–12.0	–COOH	Carboxylic acids

These chemical shifts are concentration and temperature dependent and may be outside the ranges indicated above.

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COUNCIL FOR THE CURRICULUM, EXAMINATIONS AND ASSESSMENT

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New
Specification



Data Leaflet

Including the Periodic Table of the Elements

For the use of candidates taking
Advanced Subsidiary and
Advanced Level Examinations

Copies must be free from notes or additions of any kind. No other type of data booklet or information sheet is authorised for use in the examinations

gce a/as examinations chemistry

For first teaching from September 2016
For first award of AS Level in Summer 2017
For first award of A Level in Summer 2018
Subject Code: 1110

I II THE PERIODIC TABLE OF ELEMENTS III IV V VI VII 0

Group

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen 1																	4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganes 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	98 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La [*] Lanthanum 57	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	210 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radium 88	227 Ac [†] Actinium 89	261 Rf Rutherfordium 104	262 Db Dubnium 105	266 Sg Seaborgium 106	264 Bh Bohrium 107	277 Hs Hassium 108	268 Mt Meitnerium 109	271 Ds Darmstadtium 110	272 Rg Roentgenium 111	285 Cn Copernicium 112						

* 58 – 71 Lanthanum series
† 90 – 103 Actinium series

^a
X
_b

a = relative atomic mass (approx)

x = atomic symbol

b = atomic number

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	145 Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	231 Pa Protactinium 91	238 U Uranium 92	237 Np Neptunium 93	242 Pu Plutonium 94	243 Am Americium 95	247 Cm Curium 96	245 Bk Berkelium 97	251 Cf Californium 98	254 Es Einsteinium 99	253 Fm Fermium 100	256 Md Mendelevium 101	254 No Nobelium 102	257 Lr Lawrencium 103



Rewarding Learning

**ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2019**

Chemistry

Assessment Unit AS 1

assessing

**Basic Concepts in Physical
and Inorganic Chemistry**

[SCH12]

MONDAY 20 MAY, MORNING

MARK SCHEME

General Marking Instructions

Introduction

Mark schemes are published to assist teachers and students in their preparation for examinations. Through the mark schemes teachers and students will be able to see what the examiners are looking for in response to questions and exactly where the marks have been awarded. The publishing of the mark schemes may help to show that examiners are not concerned about finding out what a student does not know but rather with rewarding students for what they do know.

The purpose of mark schemes

Examination papers are set and revised by teams of examiners and revisers appointed by the Council. The teams of examiners and revisers include experienced teachers who are familiar with the level and standards expected of students in schools and colleges.

The job of the examiners is to set the questions and the mark schemes; and the job of the revisers is to review the questions and mark schemes commenting on a large range of issues about which they must be satisfied before the question papers and mark schemes are finalised.

The questions and the mark schemes are developed in association with each other so that the issues of differentiation and positive achievement can be addressed right from the start. Mark schemes, therefore, are regarded as part of an integral process which begins with the setting of questions and ends with the marking of the examination.

The main purpose of the mark scheme is to provide a uniform basis for the marking process so that all the markers are following exactly the same instructions and making the same judgements in so far as this is possible. Before marking begins a standardising meeting is held where all the markers are briefed using the mark scheme and samples of the students' work in the form of scripts. Consideration is also given at this stage to any comments on the operational papers received from teachers and their organisations. During this meeting, and up to and including the end of the marking, there is provision for amendments to be made to the mark scheme. What is published represents the final form of the mark scheme.

It is important to recognise that in some cases there may well be other correct responses which are equally acceptable to those published: the mark scheme can only cover those responses which emerged in the examination. There may also be instances where certain judgements may have to be left to the experience of the examiner, for example where there is no absolute correct response – all teachers will be familiar with making such judgements.

Section A

- 1 D
- 2 D
- 3 C
- 4 B
- 5 B
- 6 B
- 7 C
- 8 B
- 9 D
- 10 D

[1] for each correct answer

[10]

Section A

AVAILABLE MARKS	
	10
	10

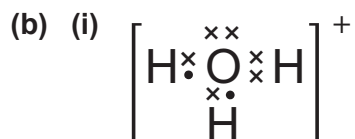
Section B

AVAILABLE
MARKS

11 (a) Bent [1]

Two lone pairs and two bonding pairs [1]

(Shape adopted) minimises repulsion [1] [3]



[2]

(ii) As there is only one lone pair [1]

No lone pair – lone pair repulsion/less lone pair – bond pair repulsion [1] [2]

(iii) Repulsion between positively charged ions [1]

8

12 (a) (i) The number of protons in (the nucleus of) an atom [1]

(ii) The (total) number (numbers) of protons and neutrons in (the nucleus of) an atom [1]

(iii) Atoms which have the same atomic number but a different mass number (contain the same number of protons but a different number of neutrons) [1]

(b) Tennessine [1]

177 neutrons [1] [2]

(c) Seven electrons in the outer energy level [1]

(d) (i) The mass of an atom of an isotope of an element relative to one-twelfth of the mass of an atom of carbon-12 [2]

(ii) $167.26 = [(161.93 \times 0.14) + (163.93 \times 1.60) + (165.93 \times 33.50) +$

$(\text{RIM} \times 22.87) + (167.93 \times 26.98) + (169.94 \times 14.91)]/100$

$\text{RIM} = 166.94$ [3]

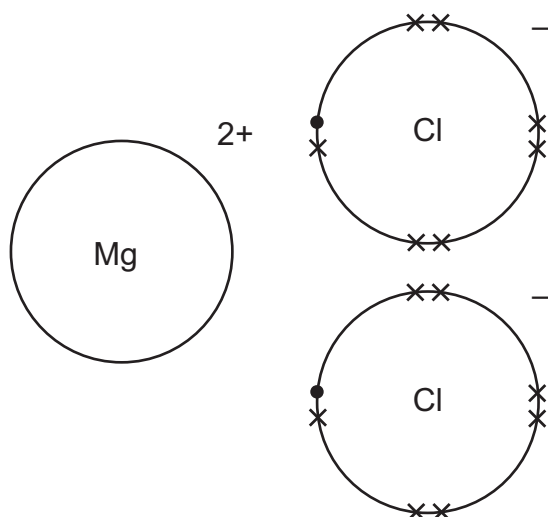
11

13 (a)	$\text{Au} + 3\text{HNO}_3 + 4\text{HCl} \rightarrow \text{HAuCl}_4 + 3\text{NO}_2 + 3\text{H}_2\text{O}$	[2]
(b) (i)	+3	[1]
(ii)	$\text{Au } 0 \rightarrow +3$ [1]	
	$\text{Cl } 0 \rightarrow -1$ [1]	
	0 to +3 oxidation and 0 to -1 reduction [1]	[3]
(c) (i)	Small difference/similar in (electronegativity) between gold and chlorine/the elements	[1]
(ii)	white fumes/smoke/solid with stopper from bottle of concentrated ammonia solution/glass rod dipped in concentrated ammonia solution	[2]
14 (a)	$1s^2 2s^2 2p^6 3s^1$ [1]	
	Outer electron in an s orbital/sub-shell [1]	[2]
(b) (i)	Number of atoms in 12.000g of carbon-12	[1]
(ii)	$6(.0)/58.5 = 0.103$	
	$0.103 \times (6.02 \times 10^{23}) = 6.2 \times 10^{22}$	[2]
(c) (i)	High melting point [1]	
	Unreactive [1]	[2]
(ii)	Cleans the wire [1]	
	Helps the solid stick to the wire [1]	
	Forms (volatile) chlorides [1]	
	to a maximum of [2]	[2]
(iii)	Yellow/orange	[1]
(d)	Dissolve the solid in water/dilute nitric acid [1]	
	Add silver nitrate solution [1]	
	White [1] precipitate [1]	[4]
(e)	Add solid to a (named) dilute acid [1]	
	(Bubble the) gas produced	
	Limewater turns milky	[3]

AVAILABLE
MARKS

9

(f) (l)



[2]



(iii) Relative formula mass of magnesium carbonate = 84

Number of moles of magnesium carbonate = $1.4/84 = 0.0167$

Number of moles of sodium carbonate = 0.0167

Relative formula mass of sodium carbonate = 106

Mass of sodium carbonate in the sample = $0.0167 \times 106 = 1.77 \text{ g}$

Percentage of sodium carbonate in the sample

$$= \frac{1.77}{6.0} \times 100 = 29.5 = 30\% \quad \text{error } [-1] \quad [6]$$

27

15 (a) Increase (across the period) [1]

Increasing nuclear charge/Atomic radius decreases [1]

Outer electron (in same shell) more strongly attracted to the nucleus [1] [3]



(ii) P has half-filled p sub-shell [1]

Half-filled (p) sub-shells have stability increased [1] [2]

(c) Indicative Content – comments related to melting points

- Silicon – giant covalent
- Many strong covalent bonds to be broken
- P, S, Cl molecular
- Argon exists as individual atoms
- Comment on van der Waals between molecules
- van der Waals depend on RMM/RAM
- Comparison of any 2 of the elements P to Ar

Response		Mark	AVAILABLE MARKS
Candidates must use appropriate specialist terms to describe fully the trend in melting point from silicon to argon (using a minimum of 6 points of indicative content including reference to all three distinct parts of the trend). They use good spelling, punctuation and grammar and the form and style are of a high standard.		[5]–[6]	13
Candidates must use appropriate specialist terms to describe the trend in melting point from silicon to argon (using a minimum of 4 points of indicative content). They use satisfactory spelling, punctuation and grammar and the form and style are of a satisfactory standard.		[3]–[4]	
Candidates briefly and partially describe the trend in melting point from silicon to argon (using a minimum of 2 points of indicative content). They use limited spelling, punctuation and grammar and they have made little use of specialist terms. The form and style are of a limited standard.		[1]–[2]	
		[6]	
16 (a)	$\text{Pb}(\text{NO}_3)_2 + 2\text{KI} \rightarrow \text{PbI}_2 + 2\text{KNO}_3$	[2]	
(b)	75.6 mg = 0.0756 g		
	Moles lead iodide in 100 cm ³ = 0.0756/461 = 1.64 × 10 ^{−4}		
	Moles of iodide ions in 100 cm ³ = 3.280 × 10 ^{−4}		
	Molarity of iodide ions = 3.280 × 10 ^{−4} /0.1 = 3.28 × 10 ^{−3} M	[4]	
(c) (i)	yellow/brown	[1]	
(ii)	blue-black	[1]	
(d) (i)	Any three from: steamy/misty fumes violet/purple vapour smell of rotten eggs yellow solid grey-black solid (on the sides of the test-tube)	[3]	
(ii)	Phosphoric acid is not an oxidising agent	[1]	12
Section B			80
Total			90



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2019

Centre Number

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Candidate Number

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Chemistry

Assessment Unit AS 2

assessing

Further Physical and Inorganic Chemistry and
an Introduction to Organic Chemistry

[SCH22]

THURSDAY 23 MAY, MORNING

Time

1 hour 30 minutes, plus your additional time allowance.

Instructions to Candidates

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

Answer **all fourteen** questions.

Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10. Keep in sequence when answering.

Answer **all four** questions in **Section B**. **You must answer the questions in the spaces provided.**

Do not write on blank pages.

Complete in black ink only.

Information for Candidates

The total mark for this paper is 90.

Quality of written communication will be assessed in

Question **13(a)(ii)**.

In Section A all questions carry equal marks, i.e. **one** mark for each question.

In Section B the figures in brackets printed at the end of each question indicate the marks awarded to each question or part question.

A Periodic Table of Elements, containing some data, is included with this question paper.

Section A – Multiple Choice

Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

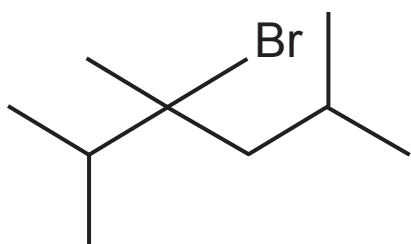
Each multiple choice question is worth 1 mark.

- 1 How many carbon to carbon bonds are there in 3,3-dichloro-2-methylbutan-2-ol?
- A 3
- B 4
- C 5
- D 6
- 2 Which sequence of elements is arranged in order of increasing bond strength?
- A F_2 O_2 N_2
- B N_2 O_2 F_2
- C O_2 F_2 N_2
- D O_2 N_2 F_2

- 3 0.005 mole of a chloride of an element Z was mixed with water and the resulting solution required 25cm^3 of 0.6M aqueous silver nitrate for complete precipitation of silver chloride. Element Z is in Group

A III.
B IV.
C V.
D VI.

- 4 The bromoalkane below reacts with ethanolic potassium hydroxide and eliminates hydrogen bromide.



What is the number of alkenes formed and how many pairs of E/Z isomers exist?

	number of alkenes	pairs of E/Z isomers
A	2	1
B	2	2
C	3	1
D	3	2

- 5 The Williamson synthesis of an ether (ROR') is summed up by the following two steps:



Using propan-2-ol and 2-chlorobutane the ether formed is

- A $\text{CH}_3\text{CH}_2\text{CH}_2\text{OCH}(\text{CH}_3)\text{CH}_2\text{CH}_3$.
- B $\text{CH}_3\text{CH}_2\text{CH}_2\text{OCH}_2\text{CH}_2\text{CH}_2\text{CH}_3$.
- C $\text{CH}_3\text{CH}(\text{CH}_3)\text{OCH}_2\text{CH}_2\text{CH}_2\text{CH}_3$.
- D $\text{CH}_3\text{CH}(\text{CH}_3)\text{OCH}(\text{CH}_3)\text{CH}_2\text{CH}_3$.
- 6 Which of the following describes a dynamic equilibrium?

	concentration of reactants and products	forward and reverse reaction rates
A	constant	equal
B	constant	not equal
C	not constant	equal
D	not constant	not equal

7 A mixture of potassium bromide and potassium carbonate contains 0.6 moles of bromide ion and 0.2 moles of carbonate ion. How many moles of potassium ions are present?

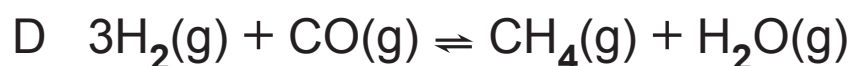
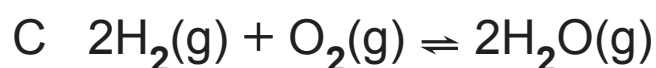
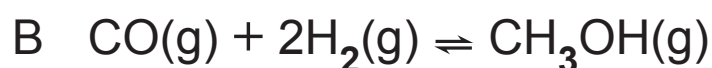
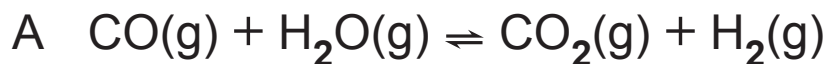
A 0.4

B 0.5

C 0.8

D 1.0

8 The total pressure is increased in each of the following reactions. For which reaction would the yield of product(s) **not** change?



9 One molecule of cuprimine contains one sulfur atom. The percentage, by mass, of sulfur in cuprimine is 21.47%. The relative molecular mass of cuprimine is

A 85.

B 101.

C 125.

D 149.

10 The general formula of an alkyl group is

A C_nH_{n+1}

B C_nH_{n-1}

C C_nH_{2n+1}

D C_nH_{2n-1}

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Section B

Answer all **four** questions in this section

11 Group II metal nitrates are formed when either the metal, the metal oxide or the metal carbonate are reacted with nitric acid. Metal nitrates are very soluble in water and all of the reactions proceed normally, apart from magnesium with nitric acid, because nitric acid is an oxidising agent and causes other reactions to take place.

(a) Write equations for the reactions of calcium, calcium oxide and calcium carbonate with dilute nitric acid.
[1 mark for each]

(i) calcium:

(ii) calcium oxide:

(iii) calcium carbonate:

(b) Magnesium does not react with most concentrations of nitric acid to give hydrogen. Instead, nitrogen(IV) oxide together with magnesium nitrate and water are produced. Write the equation for the reaction.
[1 mark]

(c) Group II metal nitrates increase in thermal stability as the Group is descended.

(i) Explain what is meant by the term **thermal stability**.
[1 mark]

(ii) Explain why thermal stability increases down the Group. [1 mark]

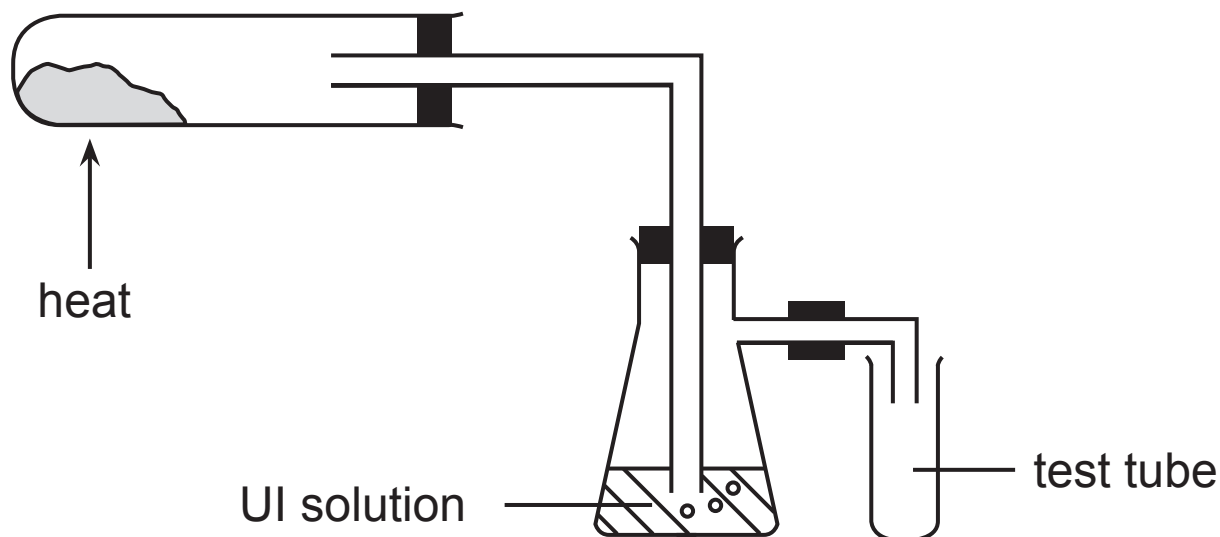
(d) When heated, the Group II nitrates, $M(\text{NO}_3)_2$, decompose according to the following equation:



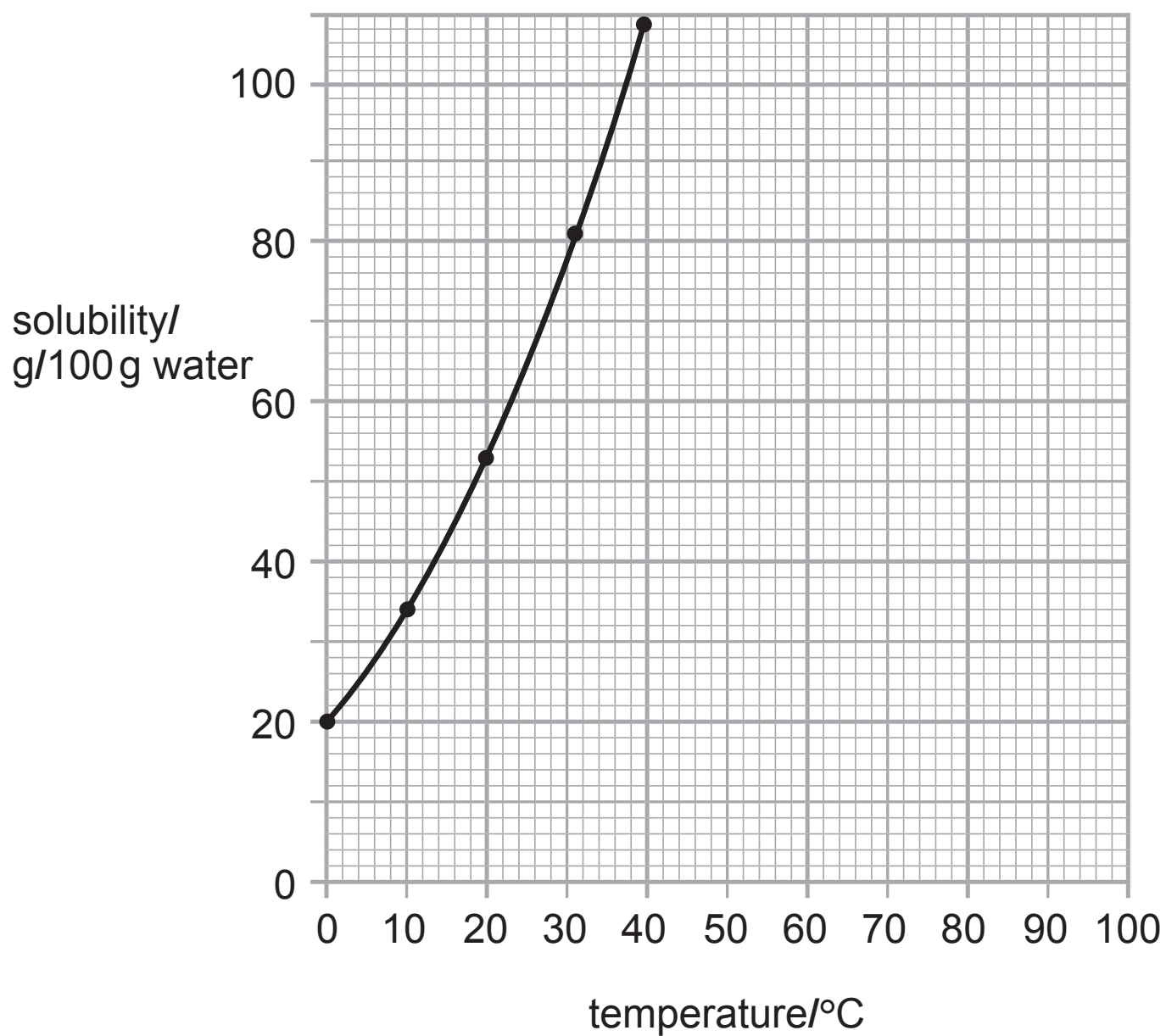
(i) Explain why the residue left after the reaction gives an alkaline solution when dissolved in water.
[1 mark]

(ii) If 3.6 g of strontium nitrate is heated and completely decomposes, what is the total volume of gases collected at 20°C and a pressure of one atmosphere?
[3 marks]

- (iii) The diagram below shows the gases from the decomposition of a nitrate passing through Universal Indicator (UI) solution and one gas being collected in a test tube. Explain why the UI solution goes red and name the gas collected in the test tube. [2 marks]



(e) Group II metal nitrates are soluble in water. The solubility curve for the Group I nitrate, rubidium nitrate, is shown below.



The following data refers to the solubility of strontium nitrate with temperature.

Solubility/g/ 100 g water	40	55	71	88	91	93	94	97	99	101
Temperature/°C	0	10	20	30	40	50	60	70	80	90

- (i) Plot the solubility curve for strontium nitrate on the axes opposite. [1 mark]
- (ii) Determine the temperature at which rubidium nitrate and strontium nitrate have the same solubility.
[1 mark]

12 Hypochlorous acid has the formula HOCl. It adds to alkenes to form chlorohydrins.



- (a) (i)** Calculate the enthalpy change for the reaction between ethene and hypochlorous acid using the following average bond enthalpies. [3 marks]

bond	enthalpy/ kJ mol^{-1}
C=C	612
C—C	347
Cl—O	272
C—Cl	346
C—O	358

- (ii)** Construct a simple labelled enthalpy level diagram for the reaction between ethene and hypochlorous acid. Insert the enthalpy value calculated in part **(i)** onto the diagram. [2 marks]



(b) Hypochlorous acid adds to alkenes because it has a polar bond, HO—Cl.

(i) Explain what is meant by the term **polar bond**.
[2 marks]

(ii) Draw the polarity of a hypochlorous acid molecule.
[1 mark]

(iii) Draw the mechanism, using curly arrows, for the reaction of hypochlorous acid with propene to form $\text{CH}_2\text{ClCHOHCH}_3$. [4 marks]

(iv) Name the compound $\text{CH}_2\text{ClCHOHCH}_3$. [2 marks]

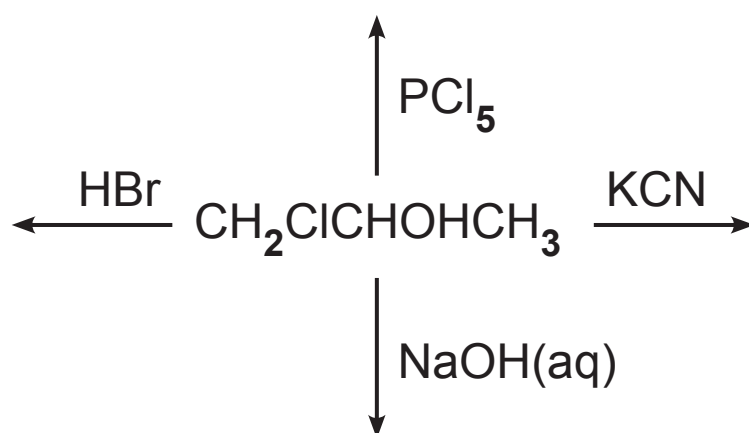
- (v) The compound $\text{CH}_2\text{ClCHOHCH}_3$ is the major product. Draw the structure of the minor product and explain why it is the minor product. [2 marks]

- (vi) If the reaction in part (iii) is carried out in the presence of sodium nitrite, NaNO_2 , some $\text{CH}_2\text{ClCHNO}_2\text{CH}_3$ is formed. Suggest how this compound is formed. [1 mark]

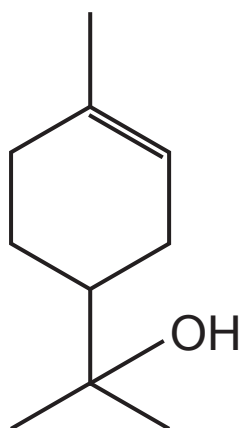
- (c) Chlorohydrins are useful in synthetic chemistry because they are bifunctional.

- (i) Suggest the meaning of the term **bifunctional**. [1 mark]

- (ii) Complete the following reaction scheme for $\text{CH}_2\text{ClCHOHCH}_3$ by drawing the organic products.
[4 marks]



13 α -Terpineol is a terpene which is the main ingredient in pine oil.



α -terpineol

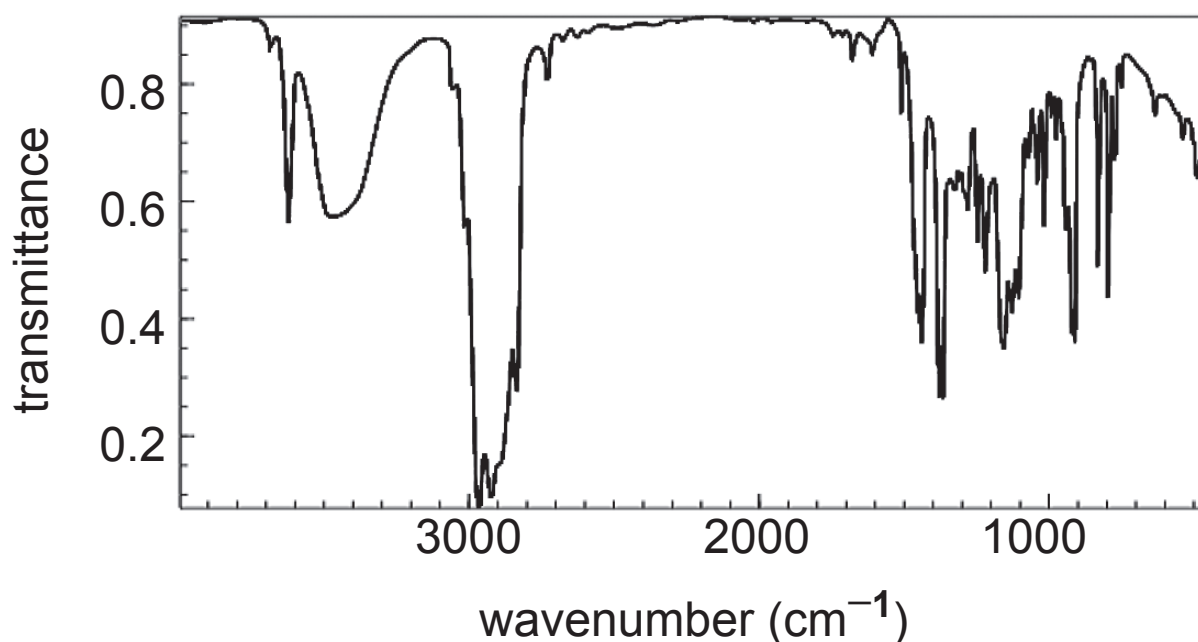
It is a colourless liquid with a smell of violets. The boiling point of α -terpineol is 214–216°C and its density is 0.93 g cm⁻³. α -Terpineol is slightly soluble in water; 2.42 g dissolves in 1 dm³ of water at room temperature.

(a) (i) Describe and explain, using calculated values, what you would observe if you added 1.1 g of α -terpineol to 200 cm³ of water in a beaker at room temperature and stirred the mixture. [4 marks]

- (ii) Explain, with full experimental detail, how you would separate α -terpineol from a mixture of 50 cm^3 of α -terpineol and 10 cm^3 of water. Your method should include separating with a funnel, distillation and drying. [6 marks]

In this question you will be assessed on your written communication skills including the use of specialist scientific terms.

(b) The purity of the α -terpineol obtained from part **(a)** may be determined by the infrared spectrum which is shown below.



(i) Explain why molecules absorb infrared radiation producing infrared spectra. [2 marks]

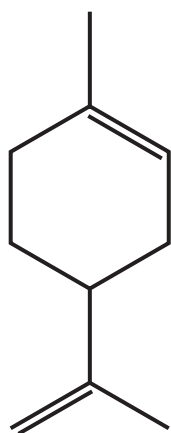
(ii) Identify the peaks, by stating the range of wavenumbers in the spectrum, which correspond to the functional groups in the molecule. [2 marks]

(iii) Explain how you could use infrared spectrometry to determine that a sample of α -terpineol is pure and free from all impurities. [1 mark]

(c) (i) Explain, using the structure of α -terpineol, whether the alcohol is primary, secondary or tertiary. [2 marks]

(ii) State what would be observed when a few drops of α -terpineol are added to acidified potassium dichromate(VI) and the mixture is heated. [1 mark]

(d) When α -terpineol is dehydrated it forms a mixture of limonene and δ -terpinene.



limonene

Suggest the structure of δ -terpinene. [1 mark]

(e) Limonene is an unsaturated hydrocarbon which reacts with bromine and hydrogen.

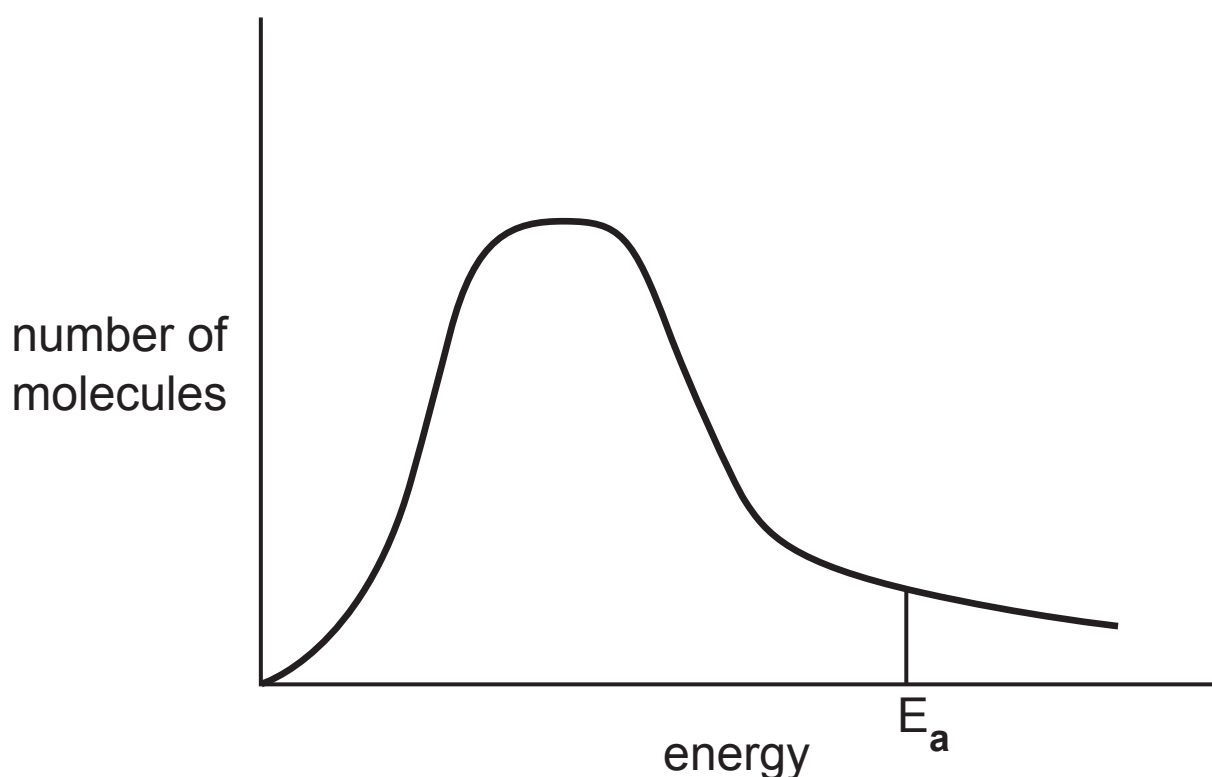
(i) Define the term **unsaturated**. [1 mark]

- (ii) Explain, giving experimental detail, how you would use bromine water to test for unsaturation.
[3 marks]

- (iii) Explain, naming the catalyst, what is meant by catalytic hydrogenation. [2 marks]

- (iv) Cadinene, $C_{15}H_{24}$, reacts with hydrogen and becomes completely saturated. 0.34 g of cadinene reacts with 80 cm^3 of hydrogen at 20°C and a pressure of one atmosphere. Calculate the number of double bonds in a molecule of cadinene.
[3 marks]

- 14** The Maxwell–Boltzmann distribution curve below shows the distribution of molecular energies in a mixture of the gases sulfur dioxide and oxygen at 25°C.



The x-axis can either be labelled as energy or speed. The distribution curve starts at the point 0,0 and at the end approaches the x-axis but does not touch it. The symbol E_a is the activation energy.

- (a)** Draw, on the axes above, the Maxwell–Boltzmann distribution curve for a mixture of sulfur dioxide and oxygen, at a **lower** temperature. [2 marks]
- (b)** Explain why the x-axis can either be labelled as energy or speed. [1 mark]

(c) Explain what it means if the distribution curve starts at the point 0,0. [1 mark]

(d) Explain what it would mean if the Maxwell–Boltzmann curve touched the x-axis at a final energy value. [1 mark]

(e) Activation energy varies from reaction to reaction.

(i) Explain the term **activation energy**. [2 marks]

(ii) Comment on the reaction speed between silver ions and chloride ions in aqueous solution and how it relates to activation energy. [2 marks]

(iii) State the effect of a catalyst on the activation energy of a reaction. [1 mark]

(f) The reaction between sulfur dioxide and oxygen is part of the process to manufacture sulfuric acid.

(i) What is the name of this industrial process?
[1 mark]

(ii) Describe and explain the conditions used in this process for the reaction between sulfur dioxide and oxygen referring to temperature, pressure and catalyst.

temperature [2 marks]

pressure [2 marks]

catalyst [1 mark]

This is the end of the question paper

Sources

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General Information

1 tonne = 10^6 g

1 metre = 10^9 nm

One mole of any gas at 293 K and a pressure of 1 atmosphere (10^5 Pa) occupies a volume of 24 dm^3

Avogadro Constant = $6.02 \times 10^{23} \text{ mol}^{-1}$

Planck Constant = $6.63 \times 10^{-34} \text{ Js}$

Specific Heat Capacity of water = $4.2 \text{ J g}^{-1} \text{ K}^{-1}$

Speed of Light = $3 \times 10^8 \text{ ms}^{-1}$

Characteristic absorptions in IR spectroscopy

Wavenumber/ cm^{-1}	Bond	Compound
550–850	C–X (X = Cl, Br, I)	Haloalkanes
750–1100	C–C	Alkanes, alkyl groups
1000–1300	C–O	Alcohols, esters, carboxylic acids
1450–1650	C=C	Arenes
1600–1700	C=C	Alkenes
1650–1800	C=O	Carboxylic acids, esters, aldehydes, ketones, amides, acyl chlorides
2200–2300	C≡N	Nitriles
2500–3200	O–H	Carboxylic acids
2750–2850	C–H	Aldehydes
2850–3000	C–H	Alkanes, alkyl groups, alkenes, arenes
3200–3600	O–H	Alcohols
3300–3500	N–H	Amines, amides

Proton Chemical Shifts in Nuclear Magnetic Resonance Spectroscopy (relative to TMS)

Chemical Shift	Structure	
0.5–2.0	–CH	Saturated alkanes
0.5–5.5	–OH	Alcohols
1.0–3.0	–NH	Amines
2.0–3.0	–CO–CH	Ketones
	–N–CH	Amines
	$\text{C}_6\text{H}_5\text{–CH}$	Arene (aliphatic on ring)
2.0–4.0	X–CH	X = Cl or Br (3.0–4.0) X = I (2.0–3.0)
4.5–6.0	–C=CH	Alkenes
5.5–8.5	RCONH	Amides
6.0–8.0	– C_6H_5	Arenes (on ring)
9.0–10.0	–CHO	Aldehydes
10.0–12.0	–COOH	Carboxylic acids

These chemical shifts are concentration and temperature dependent and may be outside the ranges indicated above.

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gce a/as examinations chemistry

For first teaching from September 2016
For first award of AS Level in Summer 2017
For first award of A Level in Summer 2018
Subject Code: 1110

I II THE PERIODIC TABLE OF ELEMENTS III IV V VI VII 0

Group

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen 1																	4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	98 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La [*] Lanthanum 57	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	210 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radium 88	227 Ac [†] Actinium 89	261 Rf Rutherfordium 104	262 Db Dubnium 105	266 Sg Seaborgium 106	264 Bh Bohrium 107	277 Hs Hassium 108	268 Mt Meitnerium 109	271 Ds Darmstadtium 110	272 Rg Roentgenium 111	285 Cn Copernicium 112						

* 58 – 71 Lanthanum series
† 90 – 103 Actinium series

^a
X
_b

a = relative atomic mass (approx)

x = atomic symbol

b = atomic number

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	145 Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	231 Pa Protactinium 91	238 U Uranium 92	237 Np Neptunium 93	242 Pu Plutonium 94	243 Am Americium 95	247 Cm Curium 96	245 Bk Berkelium 97	251 Cf Californium 98	254 Es Einsteinium 99	253 Fm Fermium 100	256 Md Mendelevium 101	254 No Nobelium 102	257 Lr Lawrencium 103



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2019**

Chemistry

Assessment Unit AS 2

assessing

Further Physical and Inorganic Chemistry
and an Introduction to Organic Chemistry

[SCH22]

THURSDAY 23 MAY, MORNING

MARK SCHEME

General Marking Instructions

Introduction

The main purpose of the mark scheme is to ensure that examinations are marked accurately, consistently and fairly. The mark scheme provides examiners with an indication of the nature and range of candidates' responses likely to be worthy of credit. It also sets out the criteria which they should apply in allocating marks to candidates' responses.

Assessment objectives

Below are the assessment objectives for **GCE Chemistry**:

Candidates should be able to:

AO1	Demonstrate knowledge and understanding of scientific ideas, processes, techniques and procedures.
AO2	Apply knowledge and understanding of scientific ideas, processes, techniques and procedures: • in a theoretical context • in a practical context • when handling quantitative and qualitative data
AO3	Analyse, interpret and evaluate scientific information, ideas and evidence (in relation to particular issues) • make judgements and reach conclusions • develop and refine practical design and procedures

Quality of candidates' responses

In marking the examination papers, examiners should be looking for a quality of response reflecting the level of maturity which may reasonably be expected of a 17- or 18-year-old which is the age at which the majority of candidates sit their GCE examinations.

Flexibility in marking

Mark schemes are not intended to be totally prescriptive. No mark scheme can cover all the responses which candidates may produce. In the event of unanticipated answers, examiners are expected to use their professional judgement to assess the validity of answers. If an answer is particularly problematic, then examiners should seek the guidance of the Supervising Examiner.

Positive marking

Examiners are encouraged to be positive in their marking, giving appropriate credit for what candidates know, understand and can do, rather than penalising candidates for errors or omissions. The exception to this for GCE Chemistry is when examiners are marking complex calculations and mechanisms when the examiners are briefed to mark by error or omission. Examiners should make use of the whole of the available mark range for any particular question and be prepared to award full marks for a response which is as good as might reasonably be expected of a 17- or 18-year-old GCE candidate.

Awarding zero marks

Marks should only be awarded for valid responses and no marks should be awarded for an answer which is completely incorrect or inappropriate.

Section A

1 B

2 A

3 A

4 C

5 D

6 A

7 D

8 A

9 D

10 C

[1] for each correct answer

AVAILABLE MARKS

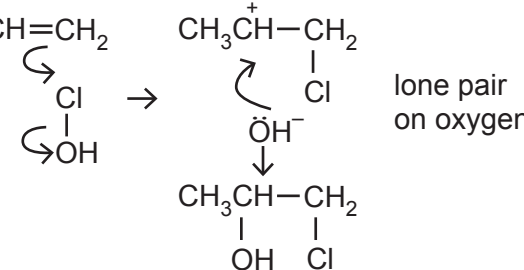
10

Section A

10

Section B

AVAILABLE MARKS

- 11 (a) (i)** $\text{Ca} + 2\text{HNO}_3 \rightarrow \text{Ca}(\text{NO}_3)_2 + \text{H}_2$ [1]
- (ii)** $\text{CaO} + 2\text{HNO}_3 \rightarrow \text{Ca}(\text{NO}_3)_2 + \text{H}_2\text{O}$ [1]
- (iii)** $\text{CaCO}_3 + 2\text{HNO}_3 \rightarrow \text{Ca}(\text{NO}_3)_2 + \text{H}_2\text{O} + \text{CO}_2$ [1]
- (b)** $\text{Mg} + 4\text{HNO}_3 \rightarrow \text{Mg}(\text{NO}_3)_2 + 2\text{NO}_2 + 2\text{H}_2\text{O}$ [1]
- (c) (i)** resistance to decomposition at high temperature [1]
- (ii)** the metal cation is larger and polarises the nitrate ion less [1]
- (d) (i)** the metal oxide (is basic) and forms a soluble hydroxide [1]
- (ii)** $\text{Sr}(\text{NO}_3)_2 = 88 + 2 \times 14 + 6 \times 16 = 88 + 28 + 96 = 212$
 $3.6 \text{ g} = 3.6/212 = 0.01698 = 0.017 \text{ mol}$
 2 mol of nitrate gives 5 mol of gas
 1 mol of nitrate gives 2.5 mol of gas
 $0.017 \text{ mol gives } 0.017 \times 2.5 = 0.0425 \text{ mol of gas} = 0.0425 \times 24 \text{ dm}^3$
 $= 1.02 \text{ dm}^3 = 1.0 \text{ dm}^3$ [3]
- (iii)** nitrogen(IV) oxide is a strongly acidic oxide [1] oxygen [1] [2]
- (e) (i)** points accurately plotted [1]
- (ii)** $35^\circ\text{C} \pm 2^\circ\text{C}$ error [1]
- 12 (a) (i)** bonds broken: $\text{C}=\text{C} + \text{O}-\text{Cl} = 612 + 272 = +884 \text{ kJ}$
 bonds formed: $\text{C}-\text{Cl} + \text{C}-\text{O} + \text{C}-\text{C} = 346 + 358 + 347 = -1051 \text{ kJ}$
 enthalpy of reaction = $+884 - 1051 = -167 \text{ kJ}$ [3]
- (ii)** exothermic reaction with reactants and products labelled
 value of -167 kJ inserted [2]
- (b) (i)** a covalent bond in which there is unequal sharing of the bonding electrons [2]
- (ii)** $\delta^- \quad \delta^+$
 $\text{HO}-\text{Cl}$ [1]
- (iii)** $\text{CH}_3\text{CH}=\text{CH}_2$ $\rightarrow$ $\text{CH}_3\overset{+}{\text{CH}}-\text{CH}_2$
 lone pair on oxygen
 $\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{Cl}$
- for mechanism [3]
 for 3 curly arrows [1] [4]
- (iv)** 1-chloropropan-2-ol or 1-chloro-2-hydroxypropane [2]
- (v)** $\text{CH}_2\text{OHCHClCH}_3$ [1] the (primary) carbocation is less stable/
 the secondary carbocation is more stable [1] [2]

14

(vi) the nitrite ion reacts with the carbocation [1]

(c) (i) two reactive groups are present [1]

(ii) $\text{CH}_2\text{ClCHClCH}_3$ [1]
 $\text{CH}_2\text{CNCHOHCH}_3$ [1]
 $\text{CH}_2\text{OHCHOHCH}_3$ [1]
 $\text{CH}_2\text{ClCHBrCH}_3$ [1] [4]

AVAILABLE
MARKS

22

13 (a) (i) 2.42g dissolves in 1000cm^3 of water; $2.42/5 = 0.484\text{g}$ dissolves in 200cm^3 of water; (0.484g is about half of 1.1g) [2]
density of terpeneol = 0.93; hence $1.1\text{g} = 1.1/0.93 = 1.18 = 1.2\text{cm}^3$
0.616 g undissolved
 0.662cm^3 floats on top [2]
the density of terpeneol is less than that of water
hence half of it disappears/dissolves and the rest floats on the surface [2]
to a maximum of [4] [4]

- (ii) Indicative content
- add to a separating funnel, allow to settle
 - run off the lower layer of water
 - add the terpeneol to a distillation flask and distil off the water
 - collect the terpeneol at $214\text{--}216^\circ\text{C}$
 - add anhydrous sodium sulfate
 - leave until clear
 - decant/filter off

Band	Response	Mark
A	Candidates must use appropriate specialist terms using a minimum of 7 points of indicative content. They must use good spelling, punctuation and grammar and the form and style are of an excellent standard.	[5]–[6]
B	Candidates must use appropriate specialist terms using a minimum of 5 points of indicative content. They must use satisfactory spelling, punctuation and grammar and the form and style are of a good standard.	[3]–[4]
C	Candidates use a minimum of 3 points of indicative content. They use limited correct spelling, punctuation and grammar and the form and style are of a basic standard.	[1]–[2]
D	Response not worthy of credit.	[0]

[6]

(b) (i) groups of atoms within a molecule absorb infrared radiation because bonds vibrate at characteristic frequency/molecular vibrations [2]

(ii) 1600 or 1700 $\text{C}=\text{C}$ (for alkene) [1]
3200–3600 $\text{O}-\text{H}$ for alcohol [1] [2]

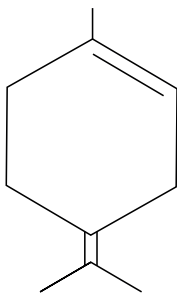
(iii) compare the IR spectrum of pure terpeneol with the impure, if they are the same the sample is pure [1]

(c) (i) it is tertiary [1] the carbon, attached to the $-\text{OH}$ is attached to three carbon atoms [1] [2]

(ii) the orange colour remains, there is no change

[1]

(d)



[1]

(e) (i) contains at least one $C=C$ or $C\equiv C$

[1]

(ii) add the unsaturated compound to bromine water [1] and shake [1]
the orange colour disappears/goes colourless [1]

[3]

(iii) adding hydrogen to a $C=C$ [1] using nickel [1]

[2]

(iv) $C_{15}H_{24} = 15 \times 12 + 24 \times 1 = 180 + 24 = 204$

$$0.34 \text{ g} = 0.34/204 = 0.00166 \text{ mol}$$

$$80 \text{ cm}^3 = 80/24000 = 0.00333 \text{ mol}$$

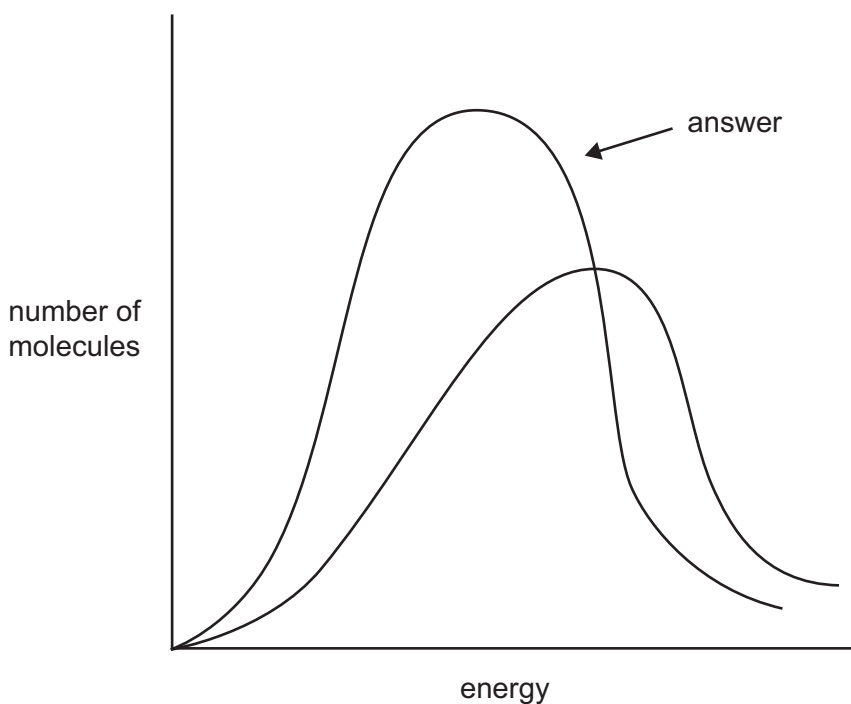
$$\text{the ratio of moles} = 0.00333/0.00166 = 2$$

hence there are 2 double bonds in one molecule of cadinene

[3]

28

- 14 (a) the curve is to the left
the peak is higher
It runs roughly parallel to the original but does not cross far to the right
It does not touch the x-axis



[-1] each error

[2]

(b)	a moving molecule has energy	[1]	AVAILABLE MARKS
(c)	at 0,0 there are zero molecules with zero energy	[1]	
(d)	no molecules have an energy higher than this value	[1]	
(e)	(i) the minimum amount of energy required for a reaction to occur	[2]	
	(ii) very fast [1] very low activation energy [1]	[2]	
	(iii) (the activation energy) is lowered	[1]	
(f)	(i) Contact process	[1]	
	(ii) 450 °C [1] reaction is exothermic but high temperature for speed [1] 1–2 atm [1] high pressure should be used but conversion % is high [1] vanadium pentoxide [1] (effective or not poisoned by arsenic)	[5]	16
Section B			80
Total			90



Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2019

Centre Number

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Candidate Number

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Chemistry

Assessment Unit AS 3

assessing

Module 3: Basic
Practical Chemistry

Practical Booklet A

[SCH31]

SCH31

WEDNESDAY 1 MAY, MORNING

TIME

1 hour 15 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

You must answer the questions in the spaces provided.

Do not write outside the boxed area on each page or on blank pages.

Complete in black ink only. **Do not write with a gel pen.**

Answer **both** questions.

INFORMATION FOR CANDIDATES

The total mark for this paper is 25.

Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

A Periodic Table of Elements (including some data) is provided.

You may not have access to notes, textbooks and other material to assist you.

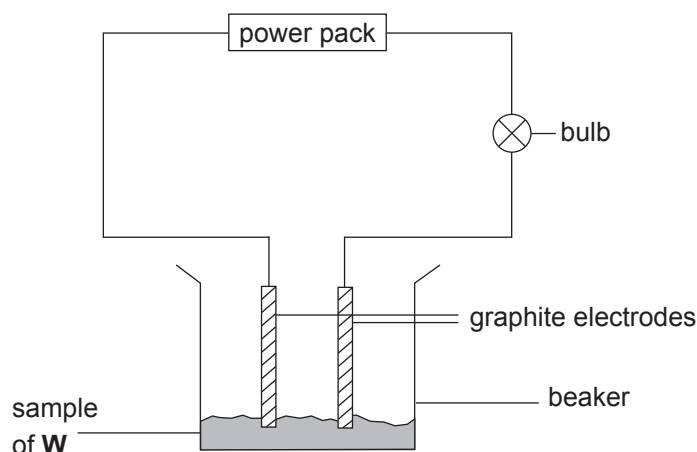
Safety glasses should be worn at all times and care should be taken during this practical examination.



1 You are provided with a white solid labelled **W**.

(a) Place 4 spatula measures of solid **W** into a 50 cm³ beaker. Carry out the following steps.

- Set up a circuit as shown below
- Use a 6 V power pack
- Dip the electrodes into solid **W**, ensuring the electrodes do not touch each other
- Switch on the power pack



(i) Record any observations.

[1]

(ii) Switch off the power pack and remove the electrodes from the beaker. Add 40 cm³ of deionised water to the beaker containing **W**. Stir to dissolve the solid. Dip the electrodes into the aqueous solution of **W** ensuring the electrodes do not touch and then switch on the power pack. Record any observations.

[3]



(iii) Explain why the observations made in (a)(i) and (a)(ii) show that **W** is an ionic salt.

[1]

(b) Solid **W** will decompose when heated. Place two spatula measures of solid **W** in a boiling tube. Place a rubber bung fitted with a delivery tube in the top of the boiling tube. Heat gently, bubbling any gases produced through limewater, contained in a second boiling tube. Remove the delivery tube from the limewater when you stop heating the boiling tube.

(i) Describe what you observe in the heated boiling tube.

[1]

(ii) Describe what you observe in the limewater.

[1]

[Turn over



(c) Dissolve 5 spatula measures of solid **W** in 20 cm³ of warm deionised water (from a kettle) in a 100 cm³ beaker. Measure out 20 cm³ of copper(II) sulfate solution and add it *slowly* to the solution of **W**.

(i) Describe what you observe happening in the beaker.

_____ [2]

(ii) Lower a lighted splint into the beaker and record any observation.

_____ [1]

(d) (i) Separate the mixture, obtained in (c), by filtration. Keep the residue and the filtrate. Transfer half a spatula measure of the wet residue to a watch glass. Add 2 cm³ of dilute hydrochloric acid to the residue on the watch glass using a dropping pipette. Gently swirl the watch glass. Describe what is observed on the watch glass.

_____ [2]

(ii) Add a few drops of silver nitrate solution to the contents on the watch glass. Describe what is observed on the watch glass.

_____ [1]



- (iii) Transfer 2 cm³ of the filtrate to a boiling tube using a dropping pipette.
Add 1 cm³ of barium chloride solution using a dropping pipette. Describe what is observed in the boiling tube.

[1]

- (iv) Carry out a flame test on the filtrate using a clean piece of nichrome wire.
What colour is produced in the Bunsen flame?

[1]

[Turn over



2 You are provided with three liquids **X**, **Y** and **Z**, in three separate containers.

- (a) Measure out 10 cm^3 of liquids **X** and **Y** and transfer them into separate boiling tubes. Add a half spatula measure of solid **W** to both boiling tubes and stir. Record the observations made in each boiling tube.

_____ [2]

- (b) Measure out 10 cm^3 of liquids **X** and **Y** and transfer them into separate boiling tubes. Using a spatula or tweezers add a calcium granule to each boiling tube.

- (i) Record **two** observations that are *the same* in both boiling tubes on addition of calcium metal to **X** and to **Y**.

_____ [2]

- (ii) Record **one** observation which is *different* in each boiling tube on addition of calcium metal to **X** and to **Y**.

_____ [1]



(c) Measure out 5 cm^3 of liquid **Y** and 5 cm^3 of liquid **Z** and transfer them to separate boiling tubes. Add 10 cm^3 of deionised water to each boiling tube. Stopper and gently shake the boiling tubes. Allow the mixtures to settle.

(i) Record the observations made in each boiling tube.

_____ [1]

(ii) Add 5 cm^3 of iodine solution to each of the boiling tubes. Replace the bungs and gently shake the boiling tubes. Allow the mixtures to settle. Describe the observations made.

_____ [2]

(iii) From the tests carried out in both (c)(i) and (c)(ii) it can be deduced that liquid **Z** is an organic liquid which is saturated. Explain how these observations support this deduction.

_____ [2]

THIS IS THE END OF THE QUESTION PAPER



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08SCH3108



Rewarding Learning

**ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2019**

Chemistry

Assessment Unit AS 3

Basic Practical Chemistry

Practical Booklet A

[SCH31]

WEDNESDAY 1 MAY, MORNING

APPARATUS AND MATERIALS LIST

Advice for centres

- All chemicals used should be at least laboratory reagent specification and labelled with appropriate safety symbols, e.g. irritant.
- For centres running multiple sessions – candidates for the later session should be supplied with clean, dry glassware. If it is not feasible, then glassware from the first session should be thoroughly washed, rinsed with deionised water and allowed to drain.
- Ensure all chemicals are in date otherwise expected observations may not be seen.
- It is the responsibility of the centre to be cognisant of all health and safety issues and to carry out a thorough risk assessment. Up to date information can be obtained at www.cleapss.org.uk
- Please note that for question 1(a) candidates are required to have a power pack within their supplied materials. CCEA stipulate that candidates must work on an individual basis in GCE chemistry practical examinations. Therefore, if centres do not have access to power packs for every individual candidate, they should manage the practical session so that half the class are completing question 1 whilst the other half are completing question 2. Then rotate.

Practical Examination

Each candidate must be supplied with safety goggles or glasses.

Question No. 1

Each candidate must be supplied with:

- access to 6V dc power pack and bulb;
- two graphite electrodes;
- electrical leads and crocodile clips;
- a small spatula, e.g. Nuffield Raised Centre Spatula (or similar);
- one beaker with 50 cm³ capacity;
- one beaker with 100 cm³ capacity;
- one glass stirring rod;
- one measuring cylinder with 50 cm³ capacity;
- a boiling tube rack;
- a boiling tube holder;
- three boiling tubes;
- one Bunsen burner;
- one heatproof mat;
- two wooden splints;
- one bung (to fit boiling tube) fitted with a delivery tube;
- one filter funnel;
- filter paper;
- one conical flask with 100 cm³ capacity;
- six dropping pipettes;
- one watch glass;
- one clean nichrome wire loop;
- a wash bottle containing deionised water;
- approximately 10 g of sodium hydrogencarbonate labelled **W** (for use in questions 1 and 2)
- access to a kettle of warm deionised water

- approximately 10 cm³ of a saturated solution of calcium hydroxide in a reagent bottle/beaker labelled **limewater**;
- approximately 40 cm³ of 0.5 mol dm⁻³ copper(II) sulfate solution (125 g dm⁻³ hydrated copper(II) sulfate) labelled **copper(II) sulfate solution** and **corrosive**.
- approximately 20 cm³ of 1.0 mol dm⁻³ hydrochloric acid labelled **dilute hydrochloric acid** and **corrosive/irritant**
- approximately 20 cm³ of barium chloride solution in a reagent bottle labelled **barium chloride solution** and **harmful**. This solution should be approximately 0.1 mol dm⁻³ (21 g dm⁻³ for BaCl₂ or 24 g dm⁻³ for BaCl₂·2H₂O).
- approximately 20 cm³ of silver nitrate solution in a reagent bottle labelled **silver nitrate solution**. This should be approximately 0.1 mol dm⁻³ (17 g dm⁻³).

Question No. 2

Each candidate must be supplied with:

- one boiling tube rack;
- six boiling tubes;
- three stoppers (to fit boiling tubes);
- a small spatula, e.g. Nuffield Raised Centre Spatula (or similar);
- three × measuring cylinders with 10 cm³ capacity;
- two glass stirring rods;
- access to plastic graduated dropping pipettes;
- tweezers
- approximately 50 cm³ of 1.0 mol dm⁻³ ethanoic acid labelled **X**.
- approximately 50 cm³ of deionised water labelled **Y**.
- approximately 10 cm³ of hexane in a sealed container labelled **Z** and **caution** and **flammable**.
- two calcium granules in a sealed container labelled **calcium** and **flammable** and **caution**.
- approximately 10 cm³ of 0.01 mol dm⁻³ iodine solution labelled **iodine solution** and **caution**.



Rewarding Learning

**ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2019**

Chemistry

Assessment Unit AS 3

Practical Assessment

Practical Booklet A

[SCH31]

WEDNESDAY 1 MAY

Confidential Instructions to the Supervisor of the Practical Examination

INSTRUCTIONS TO THE SUPERVISOR OF THE PRACTICAL EXAMINATION

General

1. The instructions contained in this document are for the use of the Supervisor **and are strictly confidential**. Under no circumstances may information concerning apparatus or materials be given before the examination to a candidate or other unauthorised person.
2. In a centre with a large number of candidates it may be necessary for two or more examination sessions to be organised. **It is the responsibility of the schools to ensure that there should be no contact between candidates taking each session.**
3. A suitable laboratory must be reserved for the examination and kept locked throughout the period of preparation. Unauthorised persons not involved in the preparation for the examination must not be allowed to enter. Candidates must not be admitted until the specified time for commencement of the examination.
4. The Supervisor must ensure that the solutions provided for the candidates are of the nature and concentrations specified in the Apparatus and Materials List.
5. **The Supervisor is to be granted access to the Teacher's Copy of Practical Booklet A on Monday 29 April 2019.** The Supervisor is asked to check, at the earliest opportunity, that the experiments and tests in the question paper may be completed satisfactorily using the apparatus, materials and solutions that have been assembled. **This question paper must then be returned to safe custody** at the earliest possible moment after the Supervisor has ensured that all is in order. **No access to the question paper should be allowed before 29 April 2019.**
6. Centres may need to carry out multiple sessions to accommodate all their candidates sitting Practical Booklet A in a laboratory. Supervision must take place from 30 minutes after the scheduled starting time of the examination, as set out in the timetable, until the time when the candidate(s) begin(s) their examination(s). This is in order to ensure that there is no contact with other candidates. The centre must appoint a member of staff from the centre to supervise the candidate(s) at all times while he/she is on the premises.
7. All apparatus should be checked before the examination, and there should be an adequate supply of spare apparatus in case of breakages. The Apparatus and Materials List should be regarded as a minimum and there is no objection to candidates being supplied with more than the minimum amount of apparatus and materials.
8. **Candidates may not use text books and laboratory notes for reference during the examination, and must be informed of this beforehand.**

9. Clear instructions must be given by the Supervisor to all candidates at the beginning of the examination concerning appropriate safety procedures and precautions. Supervisors are also advised to remind candidates that all substances in the examination must be treated with caution. **Only those tests specified in the question paper should be attempted. Candidates must not attempt any additional confirmatory tests.** Anything spilled on the skin should be washed off immediately with plenty of water. The use of appropriate eye protection is essential.
10. Supervisors are reminded that they may not assist candidates during the examination. However if, in the opinion of the Supervisor, a candidate is about to do something which may endanger him/herself or others, the Supervisor should intervene. A full written report must be sent to CCEA at once.
11. Upon request, a candidate may be given additional quantities of materials (answer paper, reagents and unknowns) without penalty. No notification need be sent to CCEA.
12. The examination room must be cleared of candidates immediately after the examination.
13. No materials will be supplied by CCEA.
14. All JCQ procedures for conducting examinations should be followed for this practical examination including displaying JCQ posters with examination information in the laboratory and removal of mobile phones. Posters should be available from your Examinations Officer.

Northern Ireland Council for the Curriculum, Examinations and
Assessment

General Certificate of Education

Advanced Subsidiary

Chemistry

Practical Booklet A

[SCH31]

Wednesday 1 May 2019

This report must be completed by the Supervisor during the examination.
The complete report should include all candidates taking this Practical
Examination. This Supervisor's Report should be copied and attached to
Each Advice Note bundle and returned to CCEA in the normal way.

Comments:

Centre Number

71

Candidate Number

Supervisor's Signature Date



Rewarding Learning

**ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2019**

Chemistry
Assessment Unit AS 3
assessing
Module 3: Practical Examination
Practical Booklet A
[SCH31]
WEDNESDAY 1 MAY, MORNING

**MARK
SCHEME**

W is sodium hydrogencarbonate.

- | | |
|---|---|
| 1 | <p>(a)</p> <p>(i) bulb does not light up [1]</p> <p>(ii) bulb lights up [1]
fizzing at both electrodes [1]
faster/more bubbling at (negative) electrode [1] [3]</p> <p>(iii) non-conductor when solid and conducts when dissolved in water [–1] for any omitted [1]</p> <p>(b)</p> <p>(i) colourless liquid formed [1]</p> <p>(ii) (gas produced) which turns limewater cloudy [1]</p> <p>(c)</p> <p>(i) green/blue/green-blue/blue-green solid/precipitate formed [1]
effervescence [1] [2]</p> <p>(ii) flame extinguished [1]</p> <p>(d)</p> <p>(i) effervescence [1]
(green) residue disappears/(green) solution formed [1] [2]</p> <p>(ii) white precipitate is formed [1]</p> <p>(iii) white precipitate formed [1]</p> <p>(iv) yellow/orange flame [1]</p> |
|---|---|

AVAILABLE
MARKS

15

X is ethanoic acid, Y is deionised water, Z is hexane.

- 2 (a)** effervescence and colourless solution formed with X [1]
 colourless solution formed with Y [1] [2]
- (b) (i)** Any **two** from:
 calcium sinks and then rises to surface
 calcium disappears
 fizzing/effervescence
 heat evolved
 (2 x [1]) [2]
- (ii)** X forms a colourless solution while Y forms a cloudy solution [1]
- (c) (i)** one layer formed with liquid Y and two layers with liquid Z/with Z
 forming upper layer [1]
- (ii)** Y (one layer that is) yellow/brown/orange [1]
 Z forms two layers: upper layer is purple/violet and lower layer is
 yellow/brown/orange [1] [2]
- (iii)** Z is immiscible with water [1]
 Z does not react with iodine [1] [2]

Total

**AVAILABLE
MARKS**

10

25



Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2019

Centre Number

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Candidate Number

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Chemistry

Assessment Unit AS 3

assessing

Module 3: Practical Examination



Practical Booklet B (Theory)

[SCH32]

SCH32

WEDNESDAY 29 MAY, AFTERNOON

TIME

1 hour 15 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

You must answer the questions in the spaces provided.

Do not write outside the boxed area on each page or on blank pages.

Complete in black ink only. **Do not write with a gel pen.**

Answer **all three** questions.

INFORMATION FOR CANDIDATES

The total mark for this paper is 55.

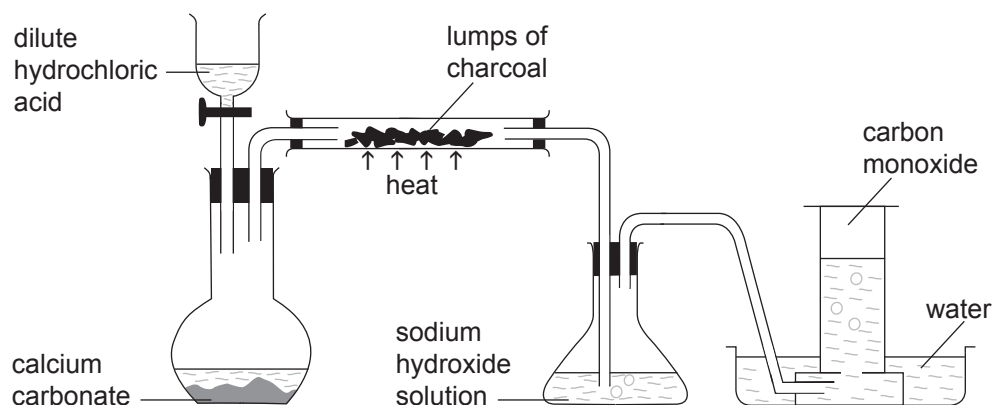
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

A Periodic Table of Elements (including some data) is provided.



- 1 Carbon monoxide is a toxic, colourless and odourless gas. Industrially, it is used to extract metals from their ores.

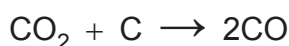
(a) In the laboratory, carbon monoxide can be made as shown in the apparatus below. Carbon dioxide is generated and passed over heated charcoal.



- (i) Describe what is observed on addition of dilute hydrochloric acid to calcium carbonate.

_____ [1]

- (ii) Explain, using oxidation numbers, why charcoal can be described as a reducing agent, in the equation below.



_____ [2]

- (iii) Using both collision theory and the concept of activation energy, explain how heating the charcoal will increase the rate of reaction.

_____ [2]



- (iv) Suggest one reason why not all of the carbon dioxide reacts when passed over heated charcoal.

_____ [1]

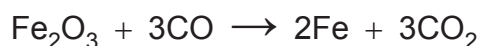
- (v) Unreacted carbon dioxide is removed by reacting it with aqueous sodium hydroxide, to form sodium carbonate and water. Write the equation for this reaction.

_____ [1]

- (vi) Describe a test to identify the presence of carbonate ions in the aqueous solution.

_____ [3]

- (b) Carbon monoxide is used to extract iron from iron(III) oxide.



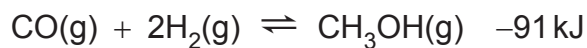
100 kg of iron(III) oxide was heated with 56 kg of carbon monoxide. Calculate the maximum mass, in kilograms, of iron produced.

_____ [3]

[Turn over



- (c) Carbon monoxide can be used to synthesise methanol as shown in the equation below.



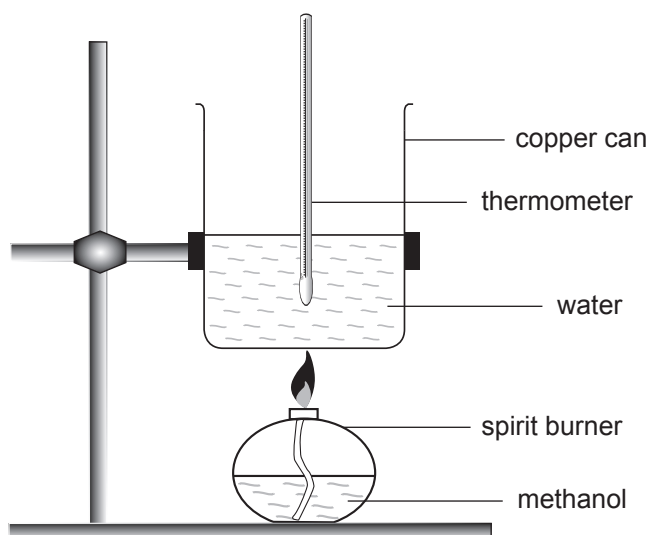
- (i) State the effect of increasing temperature on the yield of methanol.

_____ [1]

- (ii) State the effect of increasing the pressure on the yield of methanol.

_____ [1]

- (d) The apparatus below can be used to determine the enthalpy of combustion of methanol. 100 g of water was placed in the copper can.



The following results were obtained.

mass of spirit burner and methanol before burning / g	20.33
mass of spirit burner and methanol after burning / g	18.92
initial temperature of water / °C	17.5
maximum temperature reached by water / °C	88.0



(i) Why is the water stirred throughout this experiment?

_____ [1]

(ii) State **two** ways in which the apparatus could be improved to reduce heat loss.

_____ [2]

(iii) Temperature is measured using a thermometer that has graduation marks at every 1°C . The error for each temperature reading is $\pm 0.5^{\circ}\text{C}$. Calculate the percentage error associated with the temperature change in the results obtained.

_____ [2]

(iv) Using the results obtained, calculate the enthalpy of combustion of methanol.

_____ [3]

(v) At the end of the experiment a black solid is seen coating the bottom of the copper can. Name this solid and explain how it is formed.

_____ [2]

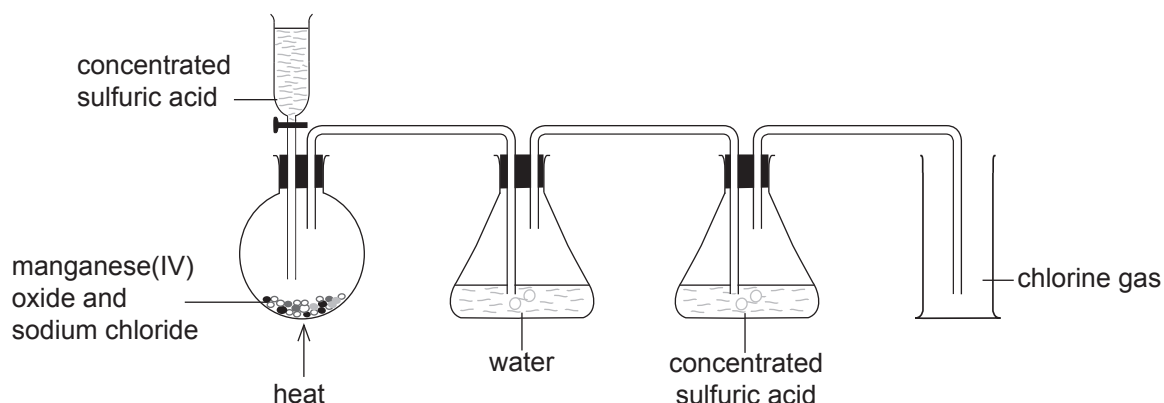
(vi) Explain, in terms of bonds, why the standard enthalpy of combustion of ethanol is greater than that of methanol.

_____ [1]

[Turn over



- 2 Dry chlorine gas can be prepared by reacting hot concentrated sulfuric acid with a mixture of sodium chloride and manganese(IV) oxide (MnO_2).



- (a) (i) In the first stage of the reaction the concentrated sulfuric acid reacts with sodium chloride to form hydrogen chloride gas. Write the equation for this reaction.

_____ [1]

- (ii) In the second stage the hydrogen chloride gas is oxidised by manganese(IV) oxide to form chlorine gas. Manganese(II) chloride and water are also formed. Write the equation for this reaction.

_____ [2]

- (iii) The chlorine gas produced in the round bottomed flask contains unreacted hydrogen chloride. How is this hydrogen chloride removed in the apparatus shown above?

_____ [1]



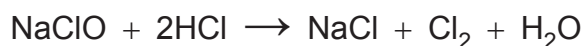
- (iv) The chlorine gas is collected by downward delivery. Suggest why chlorine is collected in this way.

_____ [1]

- (v) Describe the test that confirms the presence of chlorine gas.

_____ [2]

- (b) Chlorine can also be prepared by the reaction of sodium chlorate(I) with hydrochloric acid.



- (i) 1 cm³ of dilute hydrochloric acid is added to concentrated sodium chlorate(I) solution in a test tube. Explain why the solution turns pale green.

_____ [1]

- (ii) Outline a practical test that would confirm the presence of chloride ions in the reaction mixture.

_____ [2]

[Turn over



(c) 1 cm³ of hexane (density = 0.65 g cm⁻³) was added to 10 cm³ of a concentrated aqueous solution of chlorine in a test tube.

- (i)** What will be observed in the test tube to show that hexane and the aqueous solution are immiscible?

_____ [1]

- (ii)** The test tube is then stoppered and shaken and the contents allowed to settle. Suggest what is observed.

_____ [1]

- (iii)** The test tube is then placed under an ultraviolet light and removed after a period of time. Suggest what would be observed in the test tube.

_____ [1]

- (iv)** Name the piece of apparatus that could be used to separate the organic layer from the aqueous layer.

_____ [1]



(d) On reaction of 9.75 g of hexane with an excess of chlorine, in the presence of ultraviolet light, a mixture of products was formed including a chlorinated hydrocarbon **X**; 32.2 % of the mass of **X** is carbon and 4.5 % is hydrogen.

(i) Deduce the empirical formula of compound **X**.

[3]

(ii) The mass of compound **X** obtained was 2.54 g. Given that the percentage yield is 10 %, calculate the relative molecular mass of **X**.

[3]

(iii) Deduce the molecular formula of compound **X**.

[1]

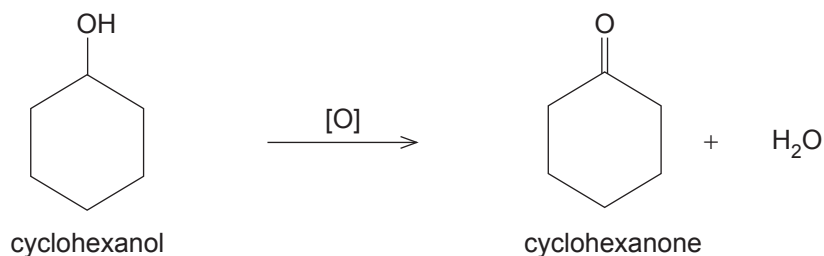
(iv) Explain why the reaction of hexane with an excess of chlorine produces a mixture of chlorinated hydrocarbons.

[1]

[Turn over]



- 3 Cyclohexanone is manufactured on a large scale for the production of nylon. In the laboratory it can be prepared by refluxing cyclohexanol with concentrated sulfuric acid and excess sodium dichromate(VI). The mixture is then fractionally distilled. The crude distillate is a mixture of cyclohexanone and water.



	boiling point / °C	density / g cm ⁻³	RMM
cyclohexanol	161	0.96	100
cyclohexanone	156	0.95	98

- (a) Define the term **reflux**.

_____ [1]

- (b) Outline a procedure which could be carried out to obtain a dry sample of cyclohexanone from the crude distillate.

_____ [2]



- (c) The oxidation of 20 cm^3 of cyclohexanol yielded 15 cm^3 of cyclohexanone. Calculate the percentage yield of cyclohexanone.

[3]

- (d) State why the oxidation of cyclohexanol did not produce a carboxylic acid.

[1]

THIS IS THE END OF THE QUESTION PAPER



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12SCH3212

General Information

1 tonne = 10^6 g

1 metre = 10^9 nm

One mole of any gas at 293 K and a pressure of 1 atmosphere (10^5 Pa) occupies a volume of 24 dm^3

Avogadro Constant = $6.02 \times 10^{23} \text{ mol}^{-1}$

Planck Constant = $6.63 \times 10^{-34} \text{ Js}$

Specific Heat Capacity of water = $4.2 \text{ J g}^{-1} \text{ K}^{-1}$

Speed of Light = $3 \times 10^8 \text{ ms}^{-1}$

Characteristic absorptions in IR spectroscopy

Wavenumber/ cm^{-1}	Bond	Compound
550–850	C–X (X = Cl, Br, I)	Haloalkanes
750–1100	C–C	Alkanes, alkyl groups
1000–1300	C–O	Alcohols, esters, carboxylic acids
1450–1650	C=C	Arenes
1600–1700	C=C	Alkenes
1650–1800	C=O	Carboxylic acids, esters, aldehydes, ketones, amides, acyl chlorides
2200–2300	C≡N	Nitriles
2500–3200	O–H	Carboxylic acids
2750–2850	C–H	Aldehydes
2850–3000	C–H	Alkanes, alkyl groups, alkenes, arenes
3200–3600	O–H	Alcohols
3300–3500	N–H	Amines, amides

Proton Chemical Shifts in Nuclear Magnetic Resonance Spectroscopy (relative to TMS)

Chemical Shift	Structure	
0.5–2.0	–CH	Saturated alkanes
0.5–5.5	–OH	Alcohols
1.0–3.0	–NH	Amines
2.0–3.0	–CO–CH	Ketones
	–N–CH	Amines
	$\text{C}_6\text{H}_5\text{–CH}$	Arene (aliphatic on ring)
2.0–4.0	X–CH	X = Cl or Br (3.0–4.0) X = I (2.0–3.0)
4.5–6.0	–C=CH	Alkenes
5.5–8.5	RCONH	Amides
6.0–8.0	– C_6H_5	Arenes (on ring)
9.0–10.0	–CHO	Aldehydes
10.0–12.0	–COOH	Carboxylic acids

These chemical shifts are concentration and temperature dependent and may be outside the ranges indicated above.

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COUNCIL FOR THE CURRICULUM, EXAMINATIONS AND ASSESSMENT

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New
Specification



Data Leaflet

Including the Periodic Table of the Elements

For the use of candidates taking
Advanced Subsidiary and
Advanced Level Examinations

Copies must be free from notes or additions of any kind. No other type of data booklet or information sheet is authorised for use in the examinations

gce a/as examinations chemistry

For first teaching from September 2016
For first award of AS Level in Summer 2017
For first award of A Level in Summer 2018
Subject Code: 1110

IIIIVVVIVII0

THE PERIODIC TABLE OF ELEMENTS

Group

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen 1																	4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganes 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	98 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La [*] Lanthanum 57	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	210 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radium 88	227 Ac [†] Actinium 89	261 Rf Rutherfordium 104	262 Db Dubnium 105	266 Sg Seaborgium 106	264 Bh Bohrium 107	277 Hs Hassium 108	268 Mt Meitnerium 109	271 Ds Darmstadtium 110	272 Rg Roentgenium 111	285 Cn Copernicium 112						

* 58 – 71 Lanthanum series
† 90 – 103 Actinium series

aXb

a = relative atomic mass (approx)
x = atomic symbol
b = atomic number

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	145 Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	231 Pa Protactinium 91	238 U Uranium 92	237 Np Neptunium 93	242 Pu Plutonium 94	243 Am Americium 95	247 Cm Curium 96	245 Bk Berkelium 97	251 Cf Californium 98	254 Es Einsteinium 99	253 Fm Fermium 100	256 Md Mendelevium 101	254 No Nobelium 102	257 Lr Lawrencium 103



Rewarding Learning

**ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2019**

Chemistry
Assessment Unit AS 3
assessing

Module 3: Practical Examination
Practical Booklet B

[SCH32]

WEDNESDAY 29 MAY, AFTERNOON

**MARK
SCHEME**

Annotation

1. Please do all marking in **red** ink.
2. All scripts should be checked for mathematical errors. Please adopt a system of one tick (✓) equals 1 mark, e.g. if you have awarded 4 marks for part of a question then 4 ticks (✓) should be on this candidate's answer.
3. The total mark for each question should be recorded in a circle placed opposite the question number in the teacher mark column.
4. As candidates have access to scripts please do not write any inappropriate comments on their scripts.

General points

- All calculations are marked according to the number of errors made.
- Errors can be carried through. If the wrong calculation is carried out then the incorrect answer can be carried through. One mistake at the start of a question does not always mean that all marks are lost.
- Listing is when more than one answer is given for a question that only requires one answer, e.g. the precipitate from a chloride with silver nitrate is a white solid; if the candidate states a white or a cream solid, one answer is correct and one answer is wrong. Hence they cancel out.
- Although names might be in the mark scheme it is generally accepted that formulae can replace them. Formulae and names are often interchangeable in chemistry.
- The marking of colours is defined in the 'CCEA GCE Chemistry Acceptable Colours' document.

MARKING GUIDELINES

Interpretation of the Mark Scheme

- **Carry error through**
This is where mistakes/wrong answers are penalised when made, but if carried into further steps of the question, then no further penalty is applied. This pertains to calculations and observational/deduction exercises. Please annotate candidates' answers by writing the letters c.e.t. on the appropriate place in the candidates' answers.
- **Oblique/forward slash**
This indicates an acceptable alternative answer(s).
- **Brackets**
Where an answer is given in the mark scheme and is followed by a word/words in brackets, this indicates that the information within the brackets is non-essential for awarding the mark(s).

- 1 (a) (i) effervescence/bubbling/fizzing [1]
- (ii) oxidation number of C in charcoal increased from 0 to +2 in carbon monoxide/oxidation number of C in CO₂ reduced from +4 to +2 [1]
reducing agent is oxidised [1] [2]
- (iii) more particles with energy greater/equal to E_{act} [1]
more frequent/successful collisions [1] [2]
- (iv) incomplete reduction of carbon dioxide/charcoal not heated enough/
carbon dioxide passed through too quickly (soon) [1]
- (v) CO₂ + 2NaOH → Na₂CO₃ + H₂O [1]
- (vi) add dilute acid [1]
bubble gas produced through limewater [1]
turns milky [1] [3]
- (b) 100 kg of Fe₂O₃ = 100,000 g
RFM of Fe₂O₃ = 160
moles of Fe₂O₃ = 625
- 56 kg of CO = 56,000 g
RMM of CO = 28
moles of CO = 2000
- Fe₂O₃ is limiting factor
- moles of Fe = 1250
mass of Fe = 1250 × 56 = 70,000 g = 70 kg
(error [-1]) [3]
- (c) (i) (high temperature) decreases yield [1]
- (ii) (high pressure) increases yield [1]
- (d) (i) to ensure the even distribution of heat [1]
- (ii) surround apparatus with screen to reduce draughts [1]
place a lid on the copper can [1] [2]
- (iii) % error = $\frac{2 \times 0.5}{70.5} \times 100 = 1.4\% = 1\%$ [2]
- (iv) mass of methanol = 20.33 – 18.92 = 1.41 g
moles of methanol = 1.41/32 = 141/3200 (0.0440625)
- q = (-)100 × 4.2 × 70.5 = (-)29610 J (29.61 kJ)
- ΔH = -29610/0.044 = -672954.5 J (mol⁻¹)
= -673 kJ (mol⁻¹) = -700 kJ (mol⁻¹)
(error [-1]) [3]
- (v) carbon [1]
incomplete combustion [1] [2]
- (vi) more (bonds) broken/formed [1]

AVAILABLE
MARKS

- 2 (a) (i) $\text{H}_2\text{SO}_4 + \text{NaCl} \rightarrow \text{NaHSO}_4 + \text{HCl}$ [1]
- (ii) $\text{MnO}_2 + 4\text{HCl} \rightarrow \text{Cl}_2 + \text{MnCl}_2 + 2\text{H}_2\text{O}$ [2]
- (iii) dissolves in the water (to form hydrochloric acid) [1]
- (iv) heavier than air [1]
- (v) bleaches damp Universal/litmus Indicator paper (error [-1]) [2]
- (b) (i) a solution of chlorine water is green [1]
- (ii) add silver nitrate solution [1]
white precipitate is formed [1] [2]
- (c) (i) two layers are formed [1]
- (ii) the bottom layer turns colourless
or
the upper layer turns (pale) green [1]
- (iii) pale green colour disappears [1]
- (iv) separating funnel [1]
- (d) (i)
- | | | | |
|---|------|------|------|
| | C: | H: | Cl |
| Mass | 32.2 | 4.5 | 63.3 |
| R.A.M | 12 | 1 | 35.5 |
| Moles | 2.68 | 4.5 | 1.78 |
| Ratio | 1.50 | 2.52 | 1.00 |
| | 3 | 5 | 2 |
| Empirical formula = $\text{C}_3\text{H}_5\text{Cl}_2$ | | | |
- (error [-1]) [3]
- (ii) mass of hexane = 9.75 g
RMM = 86
moles of hexane = $9.75/86$
= 0.1134
moles of X obtained = 0.01134
RFM of X = $2.54/0.01134 = 223.986$
= 224
(error [-1]) [3]
- (iii) $\text{C}_6\text{H}_{10}\text{Cl}_4$ [1]
- (iv) substitution can replace any H atom/multiple substitution can occur [1]

AVAILABLE
MARKS

22

3 (a) repeated boiling and condensing of a reaction mixture	[1]	AVAILABLE MARKS
(b) add anhydrous magnesium sulfate/calcium sulfate/calcium chloride to the distillate until clear/no longer cloudy filter off drying agent/decant off liquid (error [–1])	[2]	
(c) mass of cyclohexanol = $0.96 \times 20 = 19.2 \text{ g}$ moles of cyclohexanol = $19.2/100 = 0.192$ expected moles of cyclohexanone = 0.192 expected mass of cyclohexanone = $0.192 \times 98 = 18.82 \text{ g}$ actual mass of cyclohexanone = $15 \times 0.95 = 14.25 \text{ g}$ actual moles of cyclohexanone = $14.25/98 = 0.145$ % yield = $14.25/18.82 \times 100 = 75.7\% = 76\%$ or % yield = $0.145/0.192 \times 100 = 75.5\% = 76\%$ (error [–1]) or % yield = $\frac{15 \times 0.95}{0.192 \times 98} \times 100 = 75.733$	[3]	
(d) cyclohexanol is a secondary alcohol/not a primary alcohol/ cyclohexanone will not be oxidised to the carboxylic acid (with this oxidising agent)	[1]	7
Total		55



Rewarding Learning

ADVANCED
General Certificate of Education
2019

Centre Number

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Candidate Number

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Chemistry

Assessment Unit A2 1

assessing

Further Physical and
Organic Chemistry



[ACH12]

ACH12

TUESDAY 4 JUNE, AFTERNOON

TIME

2 hours.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

Answer **all twenty-one** questions.

Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10. Keep in sequence when answering.

Answer **all eleven** questions in **Section B**.

You must answer the questions in the spaces provided.

Do not write outside the boxed area on each page or on blank pages.

Complete in black ink only. **Do not write with a gel pen.**

INFORMATION FOR CANDIDATES

The total mark for this paper is 110.

Quality of written communication will be assessed in Questions **12(a)(ii)** and **20(a)(ii)**.

In Section A all questions carry equal marks, i.e. **one** mark for each question.

In Section B the figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

A Periodic Table of Elements, containing some data, is included with this question paper.

12201



28ACH1201

Section A

For each of the following questions only **one** of the lettered responses (A–D) is correct.

Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

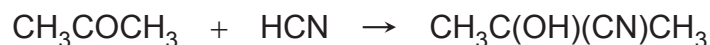
- 1 How many sigma bonds are there in benzene?
 - A 3
 - B 6
 - C 12
 - D 24

- 2 Which compound has the highest boiling point?
 - A Methanal
 - B Methanol
 - C Methanoic acid
 - D Methyl methanoate

- 3 Which reagent will distinguish between the molecules $\text{C}_6\text{H}_5\text{CHO}$ and $\text{C}_6\text{H}_5\text{COCH}_3$?
 - A Aqueous bromine
 - B Aqueous diammine silver(I) ions
 - C Lithium tetrahydridoaluminate(III)
 - D Sodium



- 4 The following reaction is an intermediate stage in the manufacture of the polymer perspex.



What type of reaction is this?

- A Electrophilic addition
 - B Nucleophilic addition
 - C Nucleophilic substitution
 - D Radical substitution
- 5 For which compound is it possible to construct a Born–Haber cycle?
- A Boron trichloride
 - B Hydrogen chloride
 - C Lead(II) chloride
 - D Phosphorus(III) chloride
- 6 What is the name of the NO_2^+ ion?
- A Nitrate cation
 - B Nitrite cation
 - C Nitronium ion
 - D Nitrosonium ion

[Turn over



- 7 What is the percentage of carbon in dimethylbenzene?
- A 88.9 %
B 89.7 %
C 90.3 %
D 90.6 %
- 8 Vegetable oils are hardened to
- A convert to unsaturated fats.
B increase the melting temperature.
C prevent oxidation.
D reduce viscosity.
- 9 What is the conjugate base of the acid HCO_3^- ?
- A CO_3^-
B CO_3^{2-}
C H_2CO_3
D OH^-
- 10 Which pair of reactants would produce the ester $\text{C}_3\text{H}_7\text{CO}_2\text{C}_2\text{H}_5$?
- A $\text{C}_2\text{H}_5\text{Cl}$ and $\text{C}_3\text{H}_7\text{CO}_2\text{H}$
B $\text{C}_3\text{H}_7\text{OH}$ and $\text{C}_2\text{H}_5\text{COCl}$
C $\text{C}_2\text{H}_5\text{OH}$ and $\text{C}_3\text{H}_7\text{COCl}$
D $\text{C}_3\text{H}_7\text{Cl}$ and $\text{C}_2\text{H}_5\text{CO}_2\text{H}$





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(Questions continue overleaf)

12201

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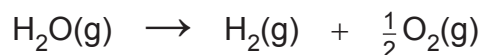


28ACH1205

Section B

Answer **all eleven** questions in this section

- 11 The splitting of water into hydrogen and oxygen becomes feasible at 5440 K.



molecule	$\text{H}_2\text{O}(\text{g})$	$\text{H}_2(\text{g})$	$\text{O}_2(\text{g})$
$S / \text{J K}^{-1} \text{mol}^{-1}$	189	131	205

- (a) Define the term **entropy**.

_____ [1]

- (b) Using the data in the table, calculate the molar entropy change for this reaction.

_____ [1]

- (c) Suggest, and explain, the effect upon the entropy change if liquid water was split instead of gaseous water.

_____ [2]



(d) Define the term **feasible**.

[1]

(e) Calculate the value for the molar enthalpy change for the splitting of gaseous water at 5440 K.

[2]

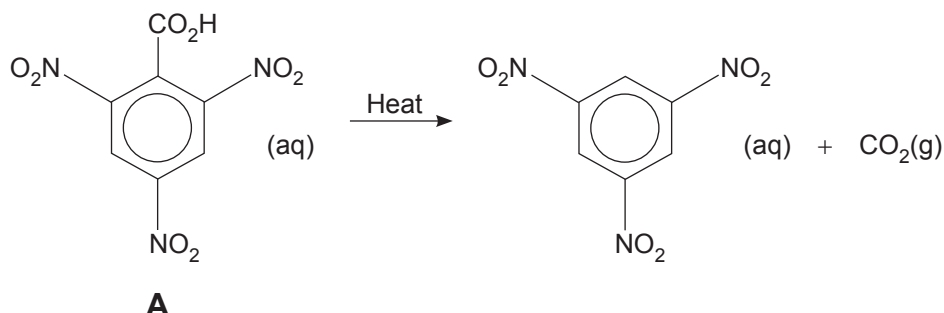
[Turn over]

12201



28ACH1207

- 12 In 1931 Moelwyn-Hughes and Hinshelwood monitored the decarboxylation of the strong acid **A**:



- (a) (i) Suggest an IUPAC name for the organic product.

[1]

- (ii) Moelwyn-Hughes and Hinshelwood followed the kinetics of the reaction by titration. Explain how they could have determined the rate of reaction. Include in your answer the names of an alkali and an indicator which could be used. Indicate what steps and graphs would be needed to determine the order of reaction with respect to **A**.

In this question you will be assessed on using your written communication skills including the use of specialist scientific terms.



_____ [6]

- (b) Moelwyn-Hughes and Hinshelwood obtained the following data from their experiments.

experiment	$[A] \times 10^{-4} / \text{mol dm}^{-3}$	initial rate $\times 10^{-6} / \text{mol dm}^{-3}\text{min}^{-1}$
1	2.50	2.40
2	1.67	1.64
3	1.04	1.02

- (i) State the order of the reaction.

_____ [1]

- (ii) Using the results from experiment 1 calculate the rate constant, stating its units.

_____ [2]

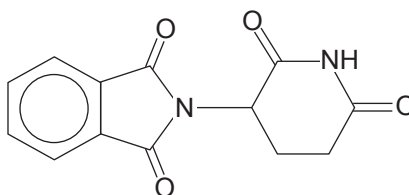
- (iii) Explain why the rate constant would increase if the experiment was repeated at a higher temperature.

_____ [1]

[Turn over



- 13 Thalidomide was first marketed in 1957 as a sedative to reduce morning sickness during pregnancy. It contains a chiral centre and exists as two optical isomers.



thalidomide

- (a) Circle the chiral centre in the structure above. [1]

- (b) Define the term **optical isomers**.

[1]

- (c) The original use of thalidomide led to babies being born with deformed limbs. It was found that one optical isomer of thalidomide caused these birth defects. Suggest how the drug action may be determined by the stereochemistry of the drug.

[1]

- (d) Thalidomide, in the sedative, was used as a racemic mixture. Define the term **racemic mixture** and explain why a racemic mixture would be optically inactive.

[2]



14 The titration curve for a strong acid with a strong alkali can be determined by measuring pH using specialised pH paper or a pH meter.

(a) Suggest an advantage and a disadvantage of using the pH meter compared to pH paper.

[2]

(b) Explain, using your knowledge of titration curves, why both methyl orange and phenolphthalein are suitable indicators for this titration.

[1]

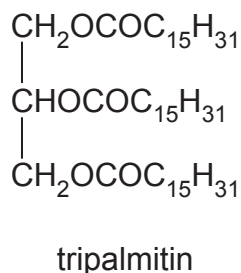
(c) Explain whether the salt solution formed from the reaction between sulfuric acid and sodium hydroxide is neutral or not.

[1]

[Turn over]



- 15 The ester tripalmitin can be used to make biodiesel using transesterification. Tripalmitin is formed when glycerol reacts with palmitic acid.



- (a) Write an equation for the formation of tripalmitin from glycerol and palmitic acid.

[2]

- (b) Use the structure of tripalmitin to explain whether tripalmitin is a saturated or unsaturated fat.

_____ [2]

- (c) Explain the term **transesterification**.

_____ [2]



(d) Write the equation for the reaction between tripalmitin and methanol forming molecules, some of which are used in biodiesel.

[1]

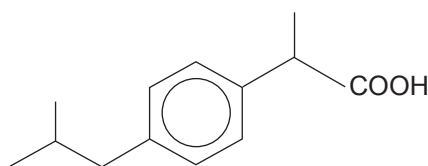
(e) From the equation written in (d), write the formula of the product that could be used as biodiesel.

[1]

[Turn over

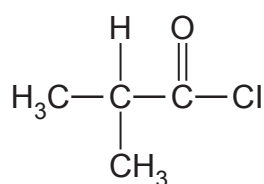


- 16** Benzene is used to synthesise the analgesic, ibuprofen. This occurs using a multi-step reaction involving both Friedel–Crafts acylation and alkylation.



ibuprofen

- (a)** The first step in this reaction is the acylation of benzene with 2-methylpropanoyl chloride. The structure of 2-methylpropanoyl chloride is shown below.



2-methylpropanoyl chloride

Show the mechanism for the catalysed reaction between 2-methylpropanoyl chloride and benzene, using aluminium chloride as a catalyst.

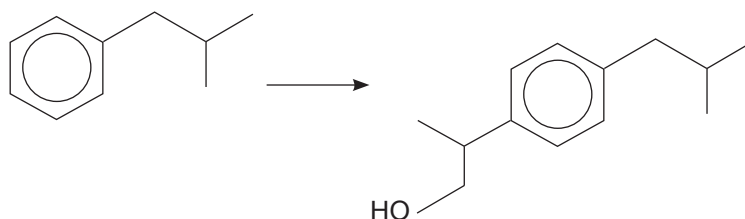
[5]



- (b) Draw a dot and cross diagram for the aluminium-containing intermediate species formed by the catalyst during this reaction.

[1]

- (c) A later step in the synthesis is shown below.



Suggest the structure of the organic reagent used for the step shown.

[1]

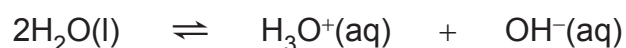
- (d) The acylation and alkylation reactions of benzene are substitution reactions. Explain why benzene undergoes substitution reactions rather than addition reactions.

[1]

[Turn over]



- 17 The dissociation of water is an endothermic process. At 60 °C the ionic product of water, K_w , has a value of $9.3 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6}$.



- (a) (i) Write the expression for K_w .

_____ [1]

- (ii) Explain why the expression for K_w does not include the concentration of water.

_____ [1]

- (b) (i) Calculate the pH of water at 60 °C. Give your answer to two decimal places.

_____ [2]

- (ii) Explain whether water at 60 °C is neutral, acidic or alkaline.

_____ [2]



- (iii) Calculate the pH of a solution containing 256.5 g of barium hydroxide dissolved in 500 cm³ of water at 60 °C. Give your answer to two decimal places.

[4]

- (c) (i) An acidic buffer is formed when 10.0 cm³ of 0.12 mol dm⁻³ aqueous sodium hydroxide is added to 25.0 cm³ of 0.18 mol dm⁻³ ethanoic acid. Calculate the pH of this buffer. The pK_a of ethanoic acid is 4.76. Give your answer to two decimal places.

[4]

- (ii) Explain, using an equation, the effect of adding small amounts of acid to the buffer.

[2]

[Turn over]



- 18** Sulfur dioxide is reacted with oxygen to form sulfur trioxide in the manufacture of sulfuric acid in the Contact Process.



- (a)** State the pressure and catalyst used in this reaction.

[2]

- (b)** Explain why the temperature chosen for this reaction, 450 °C, can be described as a compromise temperature.

[2]

- (c)** Write an expression for K_c for the above reaction.

[1]



- (d) Sulfur dioxide, oxygen and sulfur trioxide were mixed and allowed to reach equilibrium in a 20 dm^3 container. At equilibrium, 8.0 moles of sulfur dioxide and 10.0 moles of sulfur trioxide were present. Calculate the number of moles of oxygen present if the numerical value of K_c is $27.9\text{ mol}^{-1}\text{ dm}^3$.

[4]



19 The lattice enthalpy of magnesium chloride is 2493 kJ mol^{-1} and that of calcium chloride is 2237 kJ mol^{-1} .

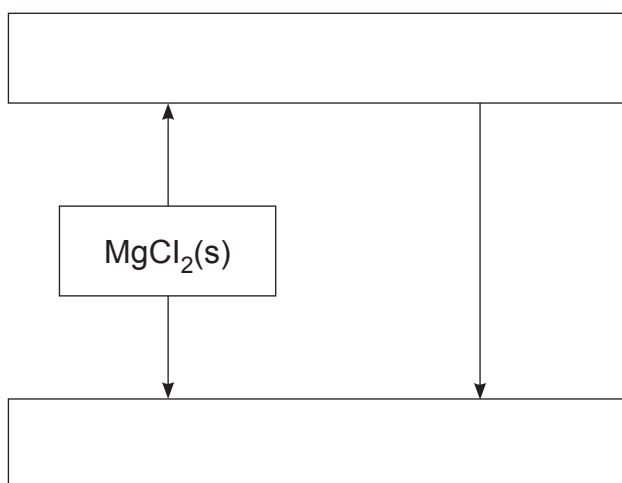
- (a) (i)** Write an equation, including state symbols, for the lattice enthalpy of calcium chloride.

_____ [2]

- (ii)** Explain why the lattice enthalpy of magnesium chloride is greater than that of calcium chloride.

_____ [1]

- (b) (i)** The enthalpy of solution of magnesium chloride is -155 kJ mol^{-1} . Complete the following enthalpy diagram for dissolving magnesium chloride.



[2]



(ii) Calculate the enthalpy of hydration of magnesium ions. The enthalpy of hydration of chloride ions is -364 kJ mol^{-1} .

[2]

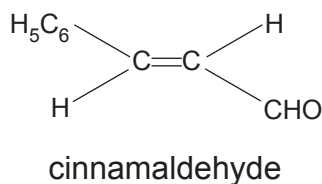
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12201



28ACH1221

- 20** Cinnamaldehyde is a pale yellow liquid that can be obtained from the bark of cinnamon trees.



- (a) (i)** Cinnamaldehyde is a geometric isomer. State and explain which geometric isomer cinnamaldehyde is.

_____ [2]

- (ii)** Explain how a pale yellow oil suspected as being cinnamaldehyde, could be identified using 2,4-dinitrophenylhydrazine. Include in your answer experimental details of the preparation of cinnamaldehyde-2,4-dinitrophenylhydrazone.

In this question you will be assessed on using your written communication skills including the use of specialist scientific terms.





[6]

- (b)** Write an equation for the reduction of cinnamaldehyde with lithium using $[H]$ to represent the reducing agent.

[1]

- (c)** Oxidation of cinnamaldehyde produces cinnamic acid which is a solid at room temperature with a melting point of $132-133^{\circ}\text{C}$. Explain why cinnamic acid has a higher melting point than cinnamaldehyde.

[3]

[Turn over



21 Ethanoyl chloride can be used in the preparation of esters. It reacts readily with moisture in the air.

(a) Write an equation for the reaction of ethanoyl chloride with water.

_____ [1]

(b) Describe a chemical test for the inorganic product of the reaction, indicating a positive result for this test.

_____ [2]

(c) (i) Write an equation for the reaction of excess ethanoyl chloride with ethane-1,2-diol to produce an ester.

_____ [2]

(ii) Calculate the percentage yield if 31 g of ethane-1,2-diol produces 49 g of the ester.

_____ [3]



- (d) State **three** advantages of using ethanoyl chloride instead of ethanoic acid in esterification reactions.

[3]

- (e) Give the formula and the IUPAC name of a reagent that could convert ethanoic acid into ethanoyl chloride.

[2]

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28ACH1226



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28ACH1227

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245088



28ACH1228

General Information

1 tonne = 10^6 g

1 metre = 10^9 nm

One mole of any gas at 293 K and a pressure of 1 atmosphere (10^5 Pa) occupies a volume of 24 dm^3

Avogadro Constant = $6.02 \times 10^{23} \text{ mol}^{-1}$

Planck Constant = $6.63 \times 10^{-34} \text{ Js}$

Specific Heat Capacity of water = $4.2 \text{ J g}^{-1} \text{ K}^{-1}$

Speed of Light = $3 \times 10^8 \text{ ms}^{-1}$

Characteristic absorptions in IR spectroscopy

Wavenumber/ cm^{-1}	Bond	Compound
550–850	C–X (X = Cl, Br, I)	Haloalkanes
750–1100	C–C	Alkanes, alkyl groups
1000–1300	C–O	Alcohols, esters, carboxylic acids
1450–1650	C=C	Arenes
1600–1700	C=C	Alkenes
1650–1800	C=O	Carboxylic acids, esters, aldehydes, ketones, amides, acyl chlorides
2200–2300	C≡N	Nitriles
2500–3200	O–H	Carboxylic acids
2750–2850	C–H	Aldehydes
2850–3000	C–H	Alkanes, alkyl groups, alkenes, arenes
3200–3600	O–H	Alcohols
3300–3500	N–H	Amines, amides

Proton Chemical Shifts in Nuclear Magnetic Resonance Spectroscopy (relative to TMS)

Chemical Shift	Structure	
0.5–2.0	–CH	Saturated alkanes
0.5–5.5	–OH	Alcohols
1.0–3.0	–NH	Amines
2.0–3.0	–CO–CH	Ketones
	–N–CH	Amines
	$\text{C}_6\text{H}_5\text{–CH}$	Arene (aliphatic on ring)
2.0–4.0	X–CH	X = Cl or Br (3.0–4.0) X = I (2.0–3.0)
4.5–6.0	–C=CH	Alkenes
5.5–8.5	RCONH	Amides
6.0–8.0	– C_6H_5	Arenes (on ring)
9.0–10.0	–CHO	Aldehydes
10.0–12.0	–COOH	Carboxylic acids

These chemical shifts are concentration and temperature dependent and may be outside the ranges indicated above.

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COUNCIL FOR THE CURRICULUM, EXAMINATIONS AND ASSESSMENT

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New
Specification



Data Leaflet

Including the Periodic Table of the Elements

For the use of candidates taking
Advanced Subsidiary and
Advanced Level Examinations

Copies must be free from notes or additions of any kind. No other type of data booklet or information sheet is authorised for use in the examinations

gce a/as examinations chemistry

For first teaching from September 2016
For first award of AS Level in Summer 2017
For first award of A Level in Summer 2018
Subject Code: 1110

I II THE PERIODIC TABLE OF ELEMENTS III IV V VI VII 0

Group

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen 1																	4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganes 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	98 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La [*] Lanthanum 57	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	210 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radium 88	227 Ac [†] Actinium 89	261 Rf Rutherfordium 104	262 Db Dubnium 105	266 Sg Seaborgium 106	264 Bh Bohrium 107	277 Hs Hassium 108	268 Mt Meitnerium 109	271 Ds Darmstadtium 110	272 Rg Roentgenium 111	285 Cn Copernicium 112						

^a

X

_b

a = relative atomic mass (approx)

x = atomic symbol

b = atomic number

* 58 – 71 Lanthanum series

† 90 – 103 Actinium series

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	145 Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	231 Pa Protactinium 91	238 U Uranium 92	237 Np Neptunium 93	242 Pu Plutonium 94	243 Am Americium 95	247 Cm Curium 96	245 Bk Berkelium 97	251 Cf Californium 98	254 Es Einsteinium 99	253 Fm Fermium 100	256 Md Mendelevium 101	254 No Nobelium 102	257 Lr Lawrencium 103



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2019

Chemistry

Assessment Unit A2 1

assessing

Further Physical and Organic Chemistry

[ACH12]

TUESDAY 4 JUNE, AFTERNOON

**MARK
SCHEME**

General Marking Instructions

Introduction

Mark schemes are published to assist teachers and students in their preparation for examinations. Through the mark schemes, teachers and students will be able to see what the examiners are looking for in response to questions and exactly where the marks have been awarded. The publishing of the mark schemes may help to show that examiners are not concerned about finding out what a student does not know but rather, with rewarding students for what they do know.

The purpose of mark schemes

Examination papers are set and revised by teams of examiners and revisers appointed by the Council. The teams of examiners and revisers include experienced teachers who are familiar with the level and standards expected of students in schools and colleges.

The job of the examiners is to set the questions and the mark schemes; and the job of the revisers is to review the questions and mark schemes commenting on a large range of issues about which they must be satisfied before the question papers and mark schemes are finalised.

The questions and the mark schemes are developed in association with each other so that the issues of differentiation and positive achievement can be addressed right from the start. Mark schemes, therefore, are regarded as part of an integral process which begins with the setting of questions and ends with the marking of the examination.

The main purpose of the mark scheme is to provide a uniform basis for the marking process so that all the markers are following exactly the same instructions and making the same judgements in so far as this is possible. Before marking begins, a standardising meeting is held where all the markers are briefed using the mark scheme and samples of the students' work in the form of scripts. Consideration is also given at this stage to any comments on the operational papers received from teachers and their organisations. During this meeting, and up to and including the end of the marking, there is provision for amendments to be made to the mark scheme. The document published represents the final form of the mark scheme.

It is important to recognise that in some cases there may well be other correct responses which are equally acceptable to those published: the mark scheme can only cover those responses which emerged in the examination. There may also be instances where certain judgements may have to be left to the experience of the examiner, for example where there is no absolute correct response – all teachers will be familiar with making such judgements.

Section A

- 1 C
- 2 C
- 3 B
- 4 B
- 5 C
- 6 C
- 7 D
- 8 B
- 9 B
- 10 C

[1] for each correct answer

[10]

Section A

AVAILABLE MARKS	
	10
	10

Section B

**AVAILABLE
MARKS**

- 11 (a)** A measure of disorder [1]
- (b)** $(131 + 102.5) - (189) = 233.5 - 189 = 44.5 \text{ J K}^{-1} (\text{mol}^{-1})$ [1]
- (c)** The entropy change would be larger [1] as liquid water has lower entropy value than gaseous water [1] (liquid water is less disordered than gaseous water) [2]
- (d)** (A reaction for which) $\Delta G < 0$ [1]
- (e)** $0 = \Delta H - \frac{T\Delta S}{1000}$

$$\Delta H = \frac{5440 (44.5)}{(1000)} = \frac{242080}{1000}$$

$$= 242.08 \text{ kJ}(\text{mol}^{-1})$$

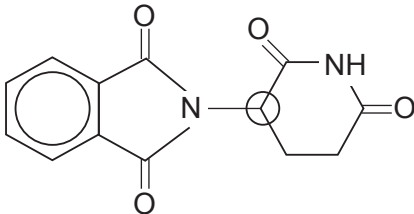
$$= 242 \text{ kJ}(\text{mol}^{-1})$$
 [2]

7

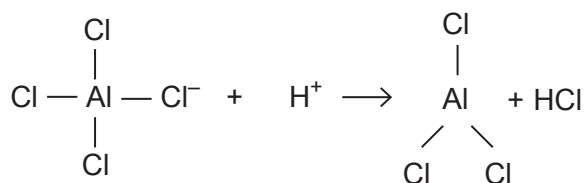
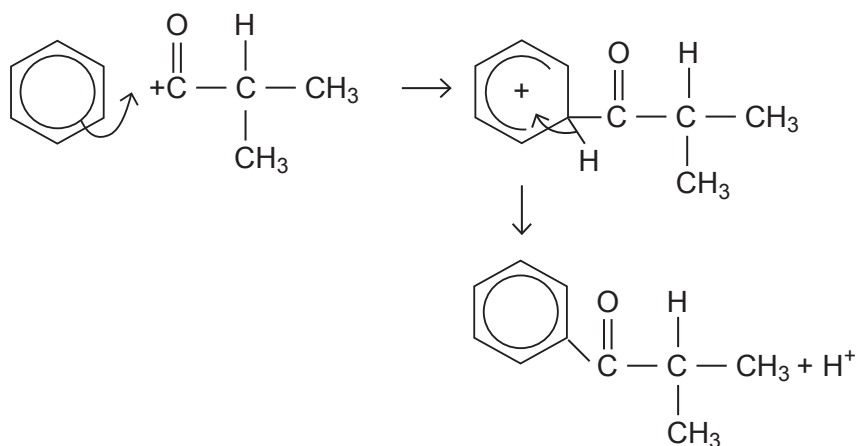
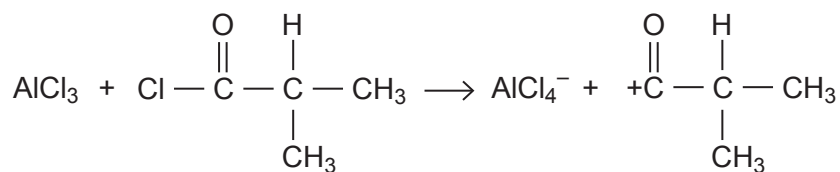
- 12 (a) (i)** 1,3,5-trinitrobenzene [1]
- (ii)**
- Take sample from the reaction mixture at different times/intervals
 - Quench reaction with ice
 - Titrate against standard sodium hydroxide solution with phenolphthalein/methyl orange indicator
 - Plot a graph of concentration against time
 - Take tangents and measure the gradient
 - Plot a graph of rate against concentration. Determine order from the shape of this graph.

Band	Response	Mark
A	Candidates must use appropriate specialist terms using a minimum of 5 points of indicative content. They must use good spelling, punctuation and grammar and the form and style are of an excellent standard.	[5]–[6]
B	Candidates must use appropriate specialist terms using a minimum of 3 points of indicative content. They must use satisfactory spelling, punctuation and grammar and the form and style are of a good standard.	[3]–[4]
C	Candidates use a minimum of 1 point of indicative content. They use limited correct spelling, punctuation and grammar and the form and style are of a basic standard.	[1]–[2]
D	Response not worthy of credit.	[0]

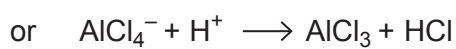
[6]

		AVAILABLE MARKS
(b) (i)	First order	[1]
(ii)	Rate constant = $2.40 \times 10^{-6} / 2.50 \times 10^{-4}$ = $2.40 / 2.50 \times 10^{-2}$ = 0.960×10^{-2} = $0.00960 \text{ min}^{-1} / 9.60 \times 10^{-3} \text{ min}^{-1}$	[2]
(iii)	Greater proportion of successful collisions as greater fraction of molecules will have $E > E_A$ (increases the constant in the rate equation)	[1]
13 (a)		[1]
(b)	Molecules which exist as non-superimposable mirror images.	[1]
(c)	The receptor sites are stereospecific	[1]
(d)	A 50:50 mixture of two optical isomers [1] The effects of each isomer (being equal and opposite) cancel each other out [1]	[2]
14 (a)	Advantage – more precise/quantitative value/easier to discern pH Disadvantage – must be stored properly/time to set up/more expensive	[1] [1]
(b)	Vertical section passes through the (pH) range in which both indicators change colour	[1]
(c)	Neutral as it is the salt of a strong acid and base	[1]
15 (a)	$\begin{array}{c} \text{CH}_2\text{OH} \\ \\ \text{CHOH} \\ \\ \text{CH}_2\text{OH} \end{array} + 3\text{C}_{15}\text{H}_{31}\text{COOH} \rightleftharpoons \begin{array}{c} \text{CH}_2\text{OCOC}_{15}\text{H}_{31} \\ \\ \text{CHOCOC}_{15}\text{H}_{31} \\ \\ \text{CH}_2\text{OCOC}_{15}\text{H}_{31} \end{array} + 3\text{H}_2\text{O}$	[2]
(b)	Saturated [1] $\text{C}_{15}\text{H}_{31}$ is $\text{C}_n\text{H}_{2n+1}$ [1] Second mark dependent on the first	[2]
(c)	A reaction where the alkyl group of an ester is exchanged with the alkyl group of an alcohol/carboxylic acid	[2]
(d)	$\begin{array}{c} \text{CH}_2\text{OCOC}_{15}\text{H}_{31} \\ \\ \text{CHOCOC}_{15}\text{H}_{31} \\ \\ \text{CH}_2\text{OCOC}_{15}\text{H}_{31} \end{array} + 3\text{CH}_3\text{OH} \rightleftharpoons \begin{array}{c} \text{CH}_2\text{OH} \\ \\ \text{CHOH} \\ \\ \text{CH}_2\text{OH} \end{array} + 3\text{C}_{15}\text{H}_{31}\text{COOCH}_3$	[1]
(e)	$\text{C}_{15}\text{H}_{31}\text{COOCH}_3$	[1]
		11
		5
		4
		8

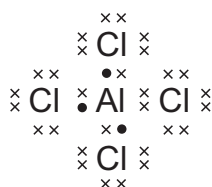
16 (a)



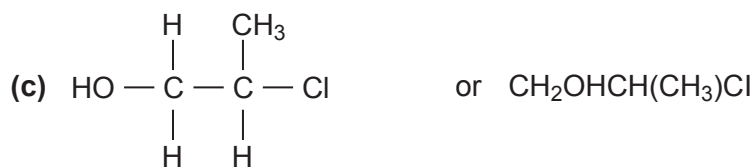
[5]



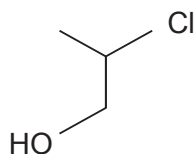
(b)



[1]



or



[1]

(d) Addition reactions would remove stability

[1]

AVAILABLE
MARKS

8

- 17 (a) (i)** $K_w = [H^+][OH^-]$
 or $K_w = [H^+(aq)][OH^-(aq)]$
 or $K_w = [H_3O^+][OH^-]$
 or $K_w = [H_3O^+(aq)][OH^-(aq)]$ [1]
- (ii)** $[H_2O]$ is effectively constant/ $[H_2O]$ is incorporated into the value of K_w i.e. $K_w = [H_3O^+(aq)][OH^-(aq)][H_2O]$ [1]
- (b) (i)** $9.3 \times 10^{-14} = [H^+(aq)]^2$
 $[H^+(aq)] = 3.05 \times 10^{-7}$
 $pH = 6.52$ [2]
- (ii)** Neutral [1] as H^+/H_3O^+ and OH^- form in equal amounts [1]
 Second mark is dependent on the first [2]
- (iii)** $Ba(OH)_2$ RFM = $137 + 2 \times (16 + 1) = 171$
 $256.5/171 = 1.497 = 1.5$ mol
 moles = 1.5
 $[OH^-] = 2 \times 1.5/0.5 = 6$
 $[H^+(aq)][OH^-(aq)] = 9.3 \times 10^{-14}$
 $[H^+(aq)] \times 6 = 9.3 \times 10^{-14}$
 $[H^+(aq)] = 9.3 \times 10^{-14}/6 = 1.55 \times 10^{-14}$
 $pH = 13.81$ [4]
- (c) (i)** $CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$
 moles of acid $\frac{25.0}{1000} \times 0.18 = 0.0045$
 moles of alkali $\frac{10.0}{1000} \times 0.12 = 0.0012$
 excess acid = 0.0033 moles
 moles of salt = 0.0012 moles
 $K_a = 10^{-4.76} = 1.74 \times 10^{-5} \text{ mol dm}^{-3}$
 $K_a = \frac{[H^+][\text{salt}]}{[\text{acid}]}$ $[H^+] = \frac{K_a[\text{acid}]}{[\text{salt}]}$
 $[H^+] = \frac{(1.74 \times 10^{-5})(0.0033)}{(0.0012)}$
 $[H^+] = 4.78 \times 10^{-5} \text{ mol dm}^{-3}$
 $pH = 4.32$ [4]
- (ii)** $CH_3COO^- + H^+ \rightleftharpoons CH_3COOH$ [1]
 H^+ removed by salt, $[H^+(aq)]$ remains constant, pH unchanged [1]
 Second mark is dependent on the first [2]

AVAILABLE
MARKS

16

18 (a) 1–2 atm pressure [1], vanadium pentoxide catalyst [1] [2]

(b) Lower temperatures give a better yield but are slower [1] (or converse)
450 °C is a compromise between yield and rate [1] [2]

(c) $K_c = \frac{[\text{SO}_3]^2}{[\text{SO}_2]^2 [\text{O}_2]}$ [1]

$$(d) K_c = \frac{\left(\frac{10}{20}\right)^2}{\left(\frac{8}{20}\right)^2 \left(\frac{x}{20}\right)} = \frac{0.25}{(0.16)(0.05x)} = 27.9$$

$$= \frac{0.25}{0.008x} = 27.9$$

$$0.25 = (27.9 \times 0.008x)$$

$$0.25 = 0.2232x$$

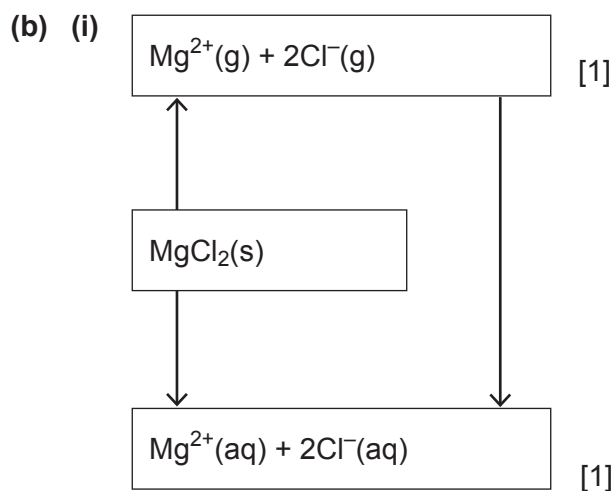
$$1.12 = x$$

$$1.1 = x$$

[4]

19 (a) (i) $\text{CaCl}_2(\text{s}) \rightarrow \text{Ca}^{2+}(\text{g}) + 2\text{Cl}^{-}(\text{g})$ [2]

(ii) Mg^{2+} has a higher charge density than Ca^{2+} /smaller ion than Ca^{2+} [1]



[2]

(ii) $-155 = 2493 + x + 2(-364)$
 $x = -1920 \text{ kJ mol}^{-1}$

[2]

AVAILABLE
MARKS

9

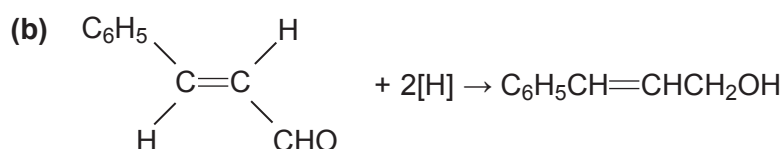
7

20 (a) (i) E isomer [1] high priority groups on opposite sides of C=C [1] [2]
Second mark dependent on the first

- (ii) • Place (5 cm³) of 2,4-dinitrophenylhydrazine solution in a test tube/suitable container. Add some drops of the test liquid/ (pale yellow) oil.
- Cool (the mixture in iced water).
 - Filter off the crystals using suction filtration.
 - Dry by sucking air over the crystals in the Buchner or in a low temperature oven/dessicator
 - Determine the melting point.
 - Compare to data book

Band	Response	Mark
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D	Response not worthy of credit.	[0]

[6]



[1]

- (c) Intermolecular forces between cinnamic acid molecules are van der Waals' and hydrogen bonds [1]

Intermolecular forces between cinnamaldehyde molecules are van der Waals' and permanent dipole–dipole [1]

More energy required to break hydrogen bonds [1]

[3]

AVAILABLE
MARKS

12

21 (a) $\text{CH}_3\text{COCl} + \text{H}_2\text{O} \rightarrow \text{CH}_3\text{COOH} + \text{HCl}$	[1]	AVAILABLE MARKS
(b) Hold over a glass rod which has been dipped in concentrated ammonia solution [1] white smoke [1]	[2]	
(c) (i) $(\text{CH}_2\text{OH})_2 + 2\text{CH}_3\text{COCl} \rightarrow (\text{CH}_2\text{OOCCH}_3)_2 + 2\text{HCl}$	[2]	
(ii) Moles ethane-1,2-diol = $31/62 = 0.5$ $(\text{CH}_2\text{OOCCH}_3)_2 = (\text{C}_3\text{H}_5\text{O}_2)_2 = \text{C}_6\text{H}_{10}\text{O}_4$ $M_r = 72 + 10 + 64 = 146$ Theoretical yield = $0.5 \times 146 = 73\text{g}$ % yield = $49/73 \times 100 = 67.1\%$ = 67%	[3]	
(d) No catalyst needed [1] Goes to completion/higher yield [1] Less purification [1]	[3]	
(e) Phosphorus(V) chloride, PCl_5 /phosphorus(III) chloride, PCl_3 /thionyl chloride, SOCl_2	[2]	13
Section B		100
Total		110



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2019

Centre Number

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Candidate Number

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Chemistry

Assessment Unit A2 2

assessing

Analytical, Transition Metals,
Electrochemistry and Further
Organic Chemistry

[ACH22]

ACH22

TUESDAY 11 JUNE, AFTERNOON

TIME

2 hours.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

Answer **all fifteen** questions.

Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10. Keep in sequence when answering.

Answer **all five** questions in **Section B**.

You must answer the questions in the spaces provided.

Do not write outside the boxed area on each page or on blank pages.

Complete in black ink only. **Do not write with a gel pen.**

INFORMATION FOR CANDIDATES

The total mark for this paper is 110.

Quality of written communication will be assessed in Questions **11(g)** and **13(d)**.

In Section A all questions carry equal marks, i.e. **one** mark for each question.

In Section B the figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

A Periodic Table of Elements, containing some data, is included with this question paper.

12188



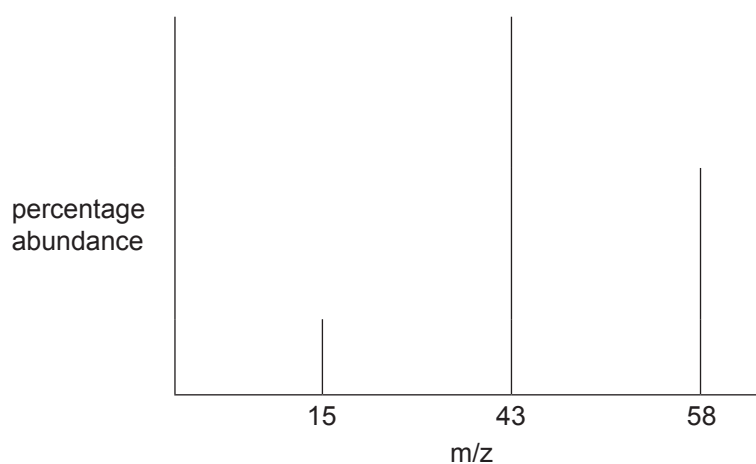
28ACH2201

Section A

For each of the following questions only **one** of the lettered responses (A–D) is correct.

Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

- 1 Part of a mass spectrum is shown below.



The compound producing the mass spectrum is

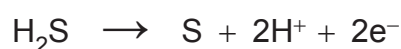
- A propane.
- B propan-1-ol.
- C propan-2-ol.
- D propanone.



2 Three acetylating agents, arranged in order of the vigour of their reaction with phenylamine, starting with the most reactive, are

- A ethanoyl chloride, ethanoic acid, ethanoic anhydride.
- B ethanoyl chloride, ethanoic anhydride, ethanoic acid.
- C ethanoic anhydride, ethanoic acid, ethanoyl chloride.
- D ethanoic anhydride, ethanoyl chloride, ethanoic acid.

3 Hydrogen sulfide is oxidised by acidified potassium manganate(VII) as shown by the following half-equation:



The volume, in cm^3 , of 0.02 M KMnO_4 required to oxidise 0.001 mol of H_2S is

- A 10.
- B 20.
- C 40.
- D 50.

4 How many aromatic isomers of dichlorobenzene exist?

- A 1
- B 2
- C 3
- D 4

[Turn over



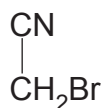
- 5 On complete combustion, 6.0 g of an organic compound gave 8.8 g of carbon dioxide and 3.6 g of water as the only products. The empirical formula of the compound is
- A CH_2 .
B CHO .
C CH_2O .
D $\text{C}_2\text{H}_4\text{O}$.
- 6 Excess ethanoyl chloride reacts with $\text{CH}_2\text{OHCH}_2\text{NH}_2$ to produce
- A $\text{CH}_2\text{OHCH}_2\text{NHCOCH}_3$.
B $\text{CH}_2\text{OHCH}_2\text{N}(\text{COCH}_3)_2$.
C $\text{CH}_3\text{COOCH}_2\text{CH}_2\text{NH}_2$.
D $\text{CH}_3\text{COOCH}_2\text{CH}_2\text{NHCOCH}_3$.
- 7 Which substance can exhibit geometrical isomerism?
- A $[\text{Co}(\text{NH}_3)_5\text{Cl}]^{2+}$ octahedral structure
B $\text{Cu}(\text{CN})_2$ linear structure
C $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$ square planar structure
D $[\text{Zn}(\text{NH}_3)_2\text{Cl}_2]$ tetrahedral structure
- 8 Salicylic acid is used in the removal of warts because it
- A alters the pH that warts grow in.
B attacks the warts and removes them.
C destroys the alkaline environment that warts flourish in.
D destroys the bacteria producing warts.



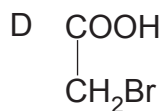
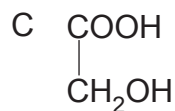
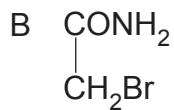
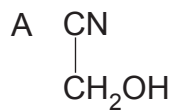
9 The systematic name for LiAlH_4 is

- A lithal.
- B lithium tetrahydridaluminate(III).
- C lithium tetrahydridealuminate(III).
- D lithium tetrahydridoaluminate(III).

10 When the following compound is completely hydrolysed



which product is formed?

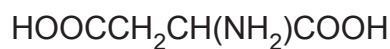


Section B

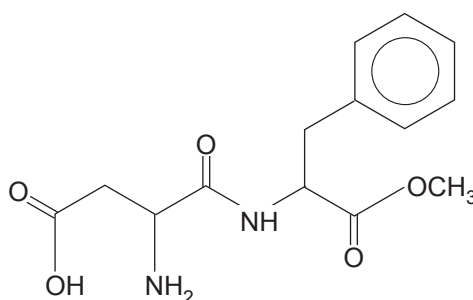
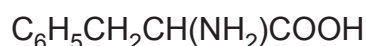
Answer **all five** questions in the spaces provided

- 11** Aspartame is an artificial sweetener which is about 200 times sweeter than sugar. It is a methyl ester of a dipeptide formed from the two α -amino acids, aspartic acid and phenylalanine.

Aspartic acid



Phenylalanine



aspartame

- (a)** On the structure of aspartame, shown above, circle and label:

(i) the ester group

[1]

(ii) the peptide link

[1]

- (b)** Both aspartic acid and phenylalanine are found in nature and are known as α -amino acids. Suggest the meaning of the term **α -amino acid**.

[2]



(c) Explain why both aspartic acid and phenylalanine are optically active.

[1]

(d) Suggest why aspartic acid is classified as an acidic amino acid and phenylalanine is classified as a neutral amino acid.

[2]

(e) Draw the structures of the **two** peptides which are produced when the following amino acids are reacted with each other.



[2]

(f) Name **one** reagent that can be used to hydrolyse peptides.

[1]

[Turn over



(g) When aspartame is hydrolysed a mixture of aspartic acid, phenylalanine and methanol is produced. The mixture of products can be analysed using TLC. Explain, giving full experimental detail, how you would use TLC to prove that phenylalanine and aspartic acid are produced and why methanol cannot be detected.

In this question you will be assessed on using your written communication skills including the use of specialist scientific terms.

[6]

[6]

(h) Aspartame is stable at pH 4.3 but breaks down at elevated temperatures or at high pH. Suggest why it is not suitable to use as a sweetener in baking but is ideal for soft drinks.

[2]

[2]



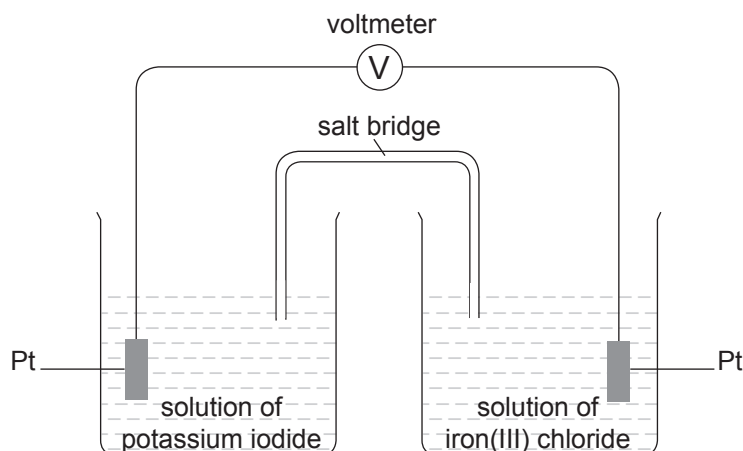
- (i) When aspartame is made, it is important to use the correct chiral isomers of phenylalanine and aspartic acid. The binding sites for the taste receptors on the tongue act in a similar way to the mechanism of the action of enzymes. Explain the action of aspartame on taste receptors.

[2]

[Turn over



- 12 The reaction between iron(III) and iodide ions may be studied in a cell as shown below.



A solution of iron(III) chloride is placed in one beaker and a solution of potassium iodide in the other beaker. A salt bridge connects the beakers.

(a) The salt bridge can be made using a glass tube or paper.

(i) Name a chemical which is usually used to make a salt bridge.

_____ [1]

(ii) Describe how you would make a salt bridge from paper in the laboratory.

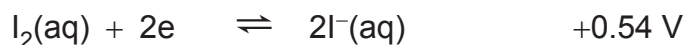
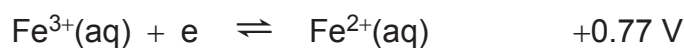
_____ [1]

(iii) State **two** reasons for using a salt bridge in an electrochemical cell.

_____ [2]



(b) The electrode potentials for the two half-cells taking place in the reaction are:



(i) Calculate the emf of the cell.

[2]

(ii) Write a conventional representation for the cell.

[2]

(iii) Write the equation for the reaction taking place.

[1]

(iv) Explain which way electrons will flow in the cell.

[2]

[Turn over



(c) Before the cell operates Fe^{3+} ions and I^- ions are present. After the cell operates Fe^{2+} ions are present together with I_2 molecules. State how you would test for each of these species and the results expected for positive tests.

(i) Fe^{3+}

_____ [2]

(ii) Fe^{2+}

_____ [2]

(iii) I^-

_____ [2]

(iv) I_2

_____ [2]





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(Questions continue overleaf)

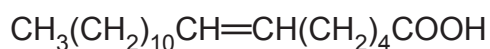
12188

[Turn over



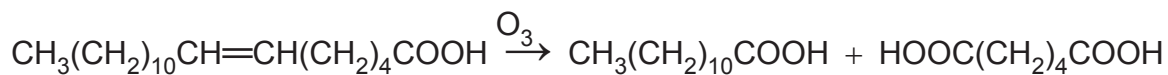
28ACH2213

13 Petroselinic acid is a long chain fatty acid which is found in coriander seeds.



petroselinic acid

It is of interest because ozonolysis gives auric acid and adipic acid, used in the manufacture of nylon.



petroselinic acid

auric acid

adipic acid

(a) Petroselinic acid is a positional isomer of oleic acid. It has the double bond in position 6; in oleic acid it is in position 9.

(i) Suggest the meaning of the term **positional isomer**.

[2]

(ii) Draw the structures of the two fatty acids which are produced when oleic acid is ozonolysed.

[2]



(b) The amount of petroselinic acid in coriander seeds can be determined by GLC. Petroselinic acid, which is a white solid, is first converted into its methyl ester which is a liquid.

(i) Suggest why petroselinic acid is a solid and methyl petroselinate is a liquid.

[2]

(ii) Suggest why petroselinic acid is converted into the methyl ester for GLC analysis.

[1]

(iii) Explain how the percentage of petroselinic acid in a sample can be determined from a GLC chromatography trace.

[2]

[Turn over



(c) Nylon is made from the reaction of adipic acid with 1,6-diaminohexane. It is a condensation polymer.

(i) Draw one repeating unit of the nylon polymer formed when adipic acid reacts with 1,6-diaminohexane.

[2]

(ii) Explain what is meant by the term **condensation** polymer.

[1]

(iii) Explain why nylon contains an amide bond and not a peptide link despite the fact that both bonds have the same structure.

[1]

(iv) Kevlar is a polymer formed by the reaction of 1,4-diaminobenzene with terephthaloyl dichloride. Write the equation for the reaction of one molecule of 1,4-diaminobenzene with one molecule of terephthaloyl dichloride.

[3]



[2]

- In this question you will be assessed on using your written communication skills including the use of specialist scientific terms.**

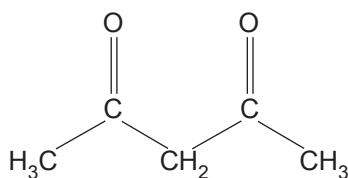
[6]

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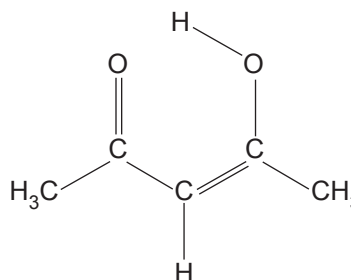


28ACH2217

- 14 Pentane-2,4-dione (acetylacetone) is an unusual compound. It exists as a mixture of isomers.

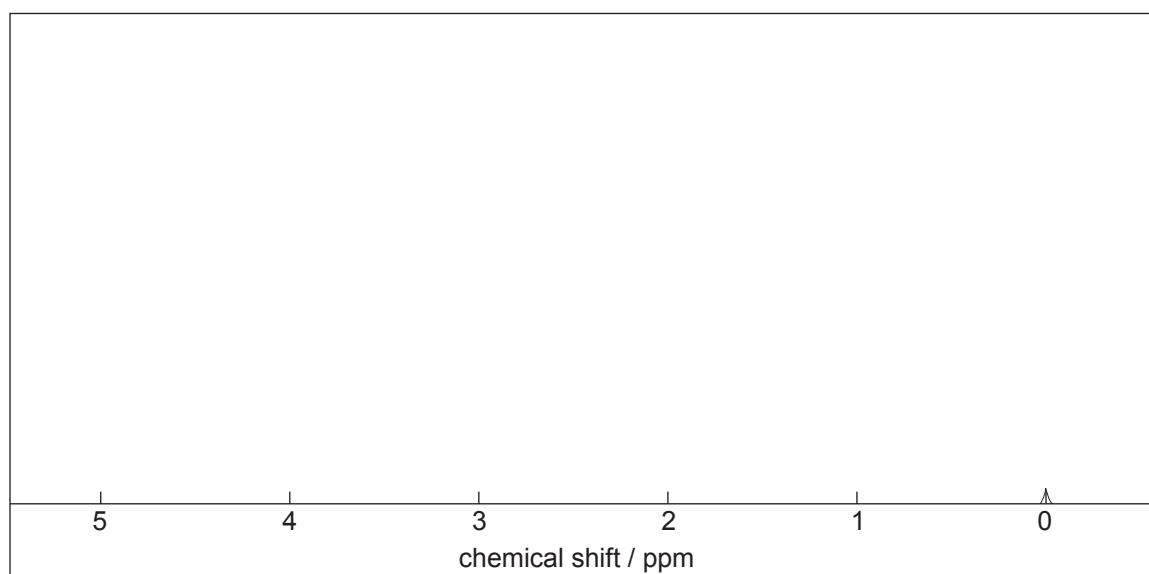


keto form



enol form

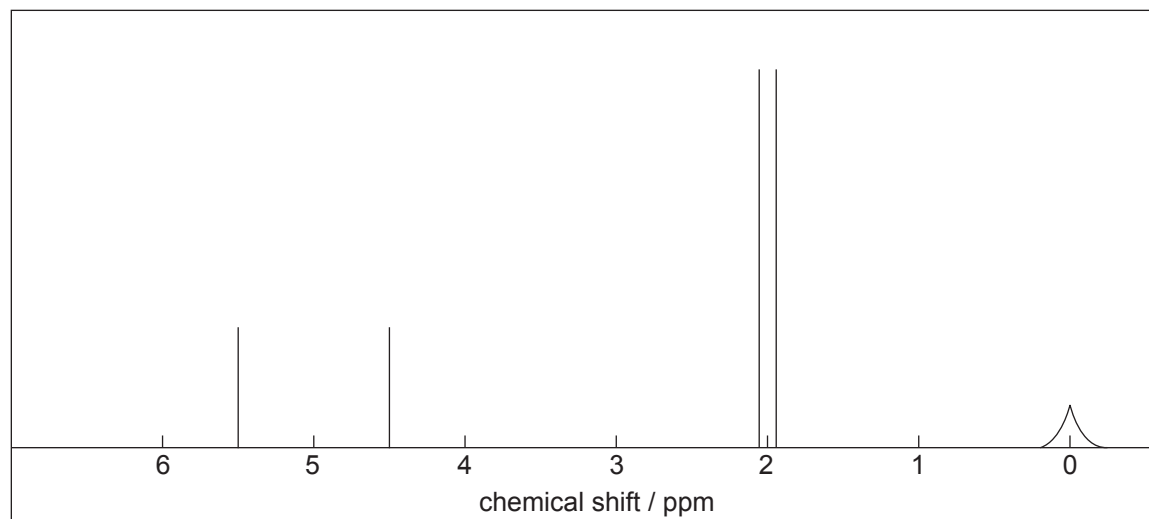
- (a) The nmr spectrum of pentane-2,4-dione at room temperature shows that it is a mixture of isomers.
- (i) On the following nmr axes draw the expected nmr spectrum, including an integration curve, of pentane-2,4-dione as the keto form. Use the data leaflet for your answer.



[2]

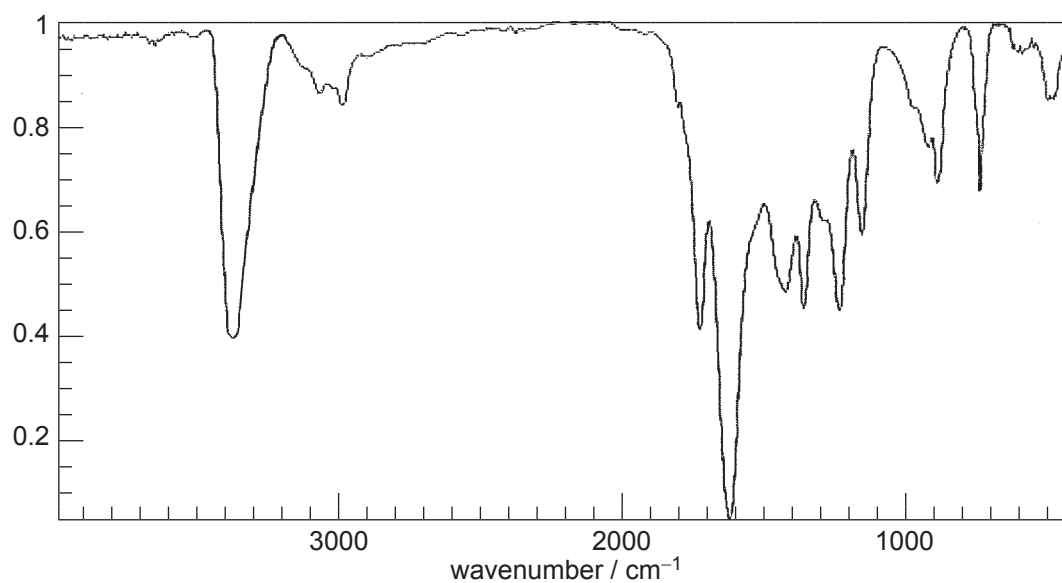


- (ii) The following is the nmr spectrum of pentane-2,4-dione as an enol at room temperature. Using the data in the data leaflet, label the peaks in the spectrum with the appropriate hydrogen atoms from the enol form.



[2]

- (b) The infrared spectrum of pentane-2,4-dione is shown below. Explain how it suggests that pentane-2,4-dione is a mixture of isomers.



[2]

[Turn over



(c) It is possible to titrate the enol isomer of pentane-2,4-dione using bromine because the $C=C$ bond reacts faster in an addition reaction than in any possible substitution reaction with bromine.

(i) How would you slow down the substitution reaction before the titration was carried out?

_____ [1]

(ii) How would you know that the end point had been reached?

_____ [1]

(iii) In a titration, 25.0 cm^3 of a 0.008 M solution of pentane-2,4-dione was reacted with a 0.002 M solution of bromine. The titration value was 4.6 cm^3 of bromine solution. Use these values to calculate the percentage of pentane-2,4-dione which exists in the enol form.

_____ [4]



(d) Pentane-2,4-dione is a ligand represented by the symbol acac. It combines with many transition metal ions to form complexes.

(i) How many coordinate bonds can pentane-2,4-dione form?

[1]

(ii) It reacts with copper(II) ions to form $[\text{Cu}(\text{acac})_3]^{2+}$ which has an octahedral structure. Draw a 3D structure of this octahedral complex using dotted lines and wedges.

[2]

(iii) Explain why $[\text{Cu}(\text{acac})_3]^{2+}$ reacts with edta.

[2]

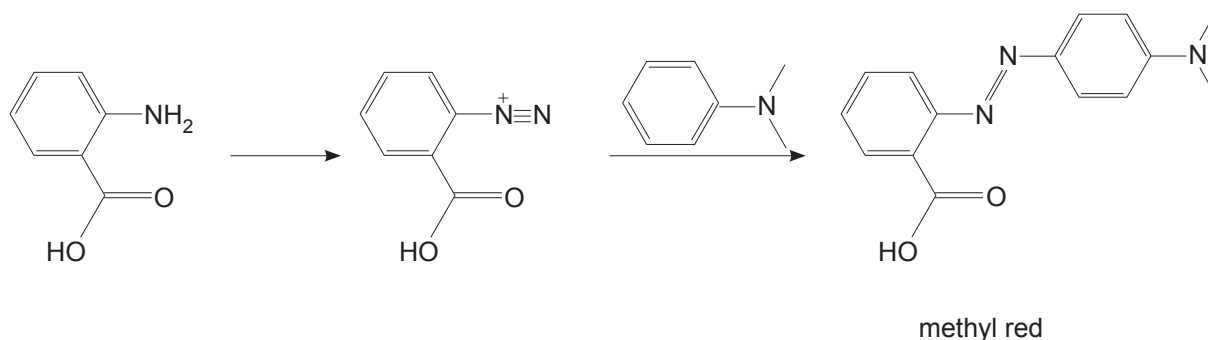
(e) Pentane-2,4-dione does not form a hydrazone with phenylhydrazine. Instead, it forms a substituted pyrazole which has a melting point of 107–108 °C. Explain how this reaction can be used to identify pentane-2,4-dione.

[1]

[Turn over]



- 15** Methyl red is a dye and can be used as an indicator. It is synthesised by the reaction of dimethylaniline with the diazonium salt of anthranilic acid.



- (a)** Name the reagents used to produce the diazonium ion and the condition under which they are used.

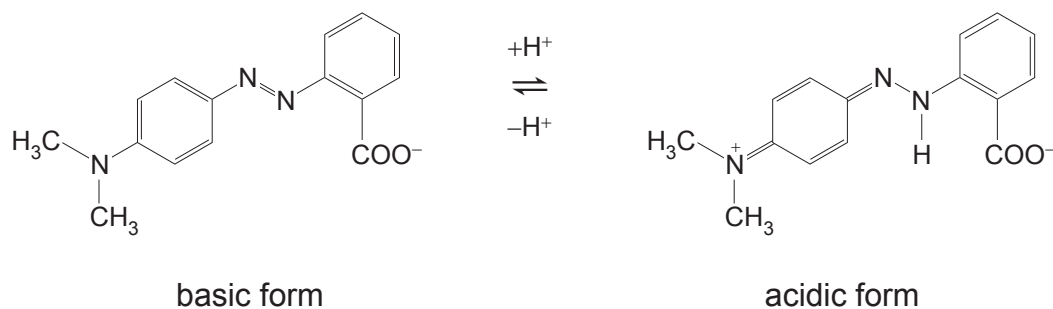
_____ [2]

- (b) (i)** Explain why methyl red is a coloured compound.

_____ [4]



(ii) Methyl red is red in its acidic form and yellow in its basic form.



Suggest why the two forms have different colours.

_____ [2]

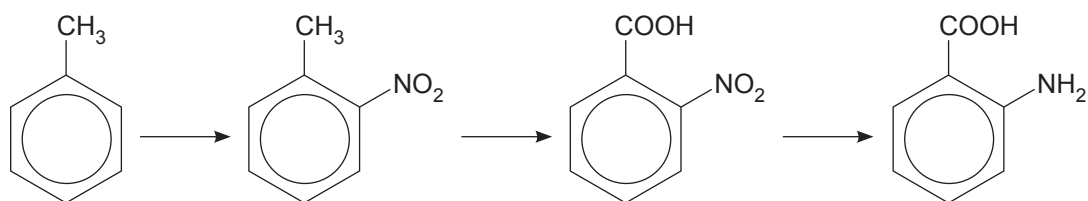
(c) Methyl red is insoluble in water. It forms a sodium salt which has a solubility of 800 mg in 1 cm³ of water. Explain why methyl red is insoluble in water but the sodium salt is soluble in water.

_____ [2]

[Turn over



(d) The synthesis of anthranilic acid may be carried out as follows.



(i) Name the reagents used to carry out the nitration of methylbenzene.

[2]

(ii) The reagent used to oxidise the 2-methylnitrobenzene is acidified potassium manganate(VII). State the colour change observed.

[2]



(e) The reduction of the nitrobenzoic acid is carried out using tin and concentrated hydrochloric acid.

(i) Write the equation for the reaction of tin with hydrochloric acid.

[2]

(ii) The anthranilic acid is obtained as the phenylammonium salt. Draw the structure of the salt and explain why the addition of sodium hydroxide solution liberates the amino group but does not produce anthranilic acid.

[3]

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28ACH2226



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28ACH2228

General Information

1 tonne = 10^6 g

1 metre = 10^9 nm

One mole of any gas at 293 K and a pressure of 1 atmosphere (10^5 Pa) occupies a volume of 24 dm^3

Avogadro Constant = $6.02 \times 10^{23} \text{ mol}^{-1}$

Planck Constant = $6.63 \times 10^{-34} \text{ Js}$

Specific Heat Capacity of water = $4.2 \text{ J g}^{-1} \text{ K}^{-1}$

Speed of Light = $3 \times 10^8 \text{ ms}^{-1}$

Characteristic absorptions in IR spectroscopy

Wavenumber/ cm^{-1}	Bond	Compound
550–850	C–X (X = Cl, Br, I)	Haloalkanes
750–1100	C–C	Alkanes, alkyl groups
1000–1300	C–O	Alcohols, esters, carboxylic acids
1450–1650	C=C	Arenes
1600–1700	C=C	Alkenes
1650–1800	C=O	Carboxylic acids, esters, aldehydes, ketones, amides, acyl chlorides
2200–2300	C≡N	Nitriles
2500–3200	O–H	Carboxylic acids
2750–2850	C–H	Aldehydes
2850–3000	C–H	Alkanes, alkyl groups, alkenes, arenes
3200–3600	O–H	Alcohols
3300–3500	N–H	Amines, amides

Proton Chemical Shifts in Nuclear Magnetic Resonance Spectroscopy (relative to TMS)

Chemical Shift	Structure	
0.5–2.0	–CH	Saturated alkanes
0.5–5.5	–OH	Alcohols
1.0–3.0	–NH	Amines
2.0–3.0	–CO–CH	Ketones
	–N–CH	Amines
	$\text{C}_6\text{H}_5\text{–CH}$	Arene (aliphatic on ring)
2.0–4.0	X–CH	X = Cl or Br (3.0–4.0) X = I (2.0–3.0)
4.5–6.0	–C=CH	Alkenes
5.5–8.5	RCONH	Amides
6.0–8.0	– C_6H_5	Arenes (on ring)
9.0–10.0	–CHO	Aldehydes
10.0–12.0	–COOH	Carboxylic acids

These chemical shifts are concentration and temperature dependent and may be outside the ranges indicated above.

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Including the Periodic Table of the Elements

For the use of candidates taking
Advanced Subsidiary and
Advanced Level Examinations

Copies must be free from notes or additions of any kind. No other type of data booklet or information sheet is authorised for use in the examinations

gce a/as examinations chemistry

For first teaching from September 2016
For first award of AS Level in Summer 2017
For first award of A Level in Summer 2018
Subject Code: 1110

IIIIVVVIVII0

THE PERIODIC TABLE OF ELEMENTS

Group

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen 1																	4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganes 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	98 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La [*] Lanthanum 57	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	210 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radium 88	227 Ac [†] Actinium 89	261 Rf Rutherfordium 104	262 Db Dubnium 105	266 Sg Seaborgium 106	264 Bh Bohrium 107	277 Hs Hassium 108	268 Mt Meitnerium 109	271 Ds Darmstadtium 110	272 Rg Roentgenium 111	285 Cn Copernicium 112						

* 58 – 71 Lanthanum series
† 90 – 103 Actinium series

aXb

a = relative atomic mass (approx)
x = atomic symbol
b = atomic number

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	145 Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	231 Pa Protactinium 91	238 U Uranium 92	237 Np Neptunium 93	242 Pu Plutonium 94	243 Am Americium 95	247 Cm Curium 96	245 Bk Berkelium 97	251 Cf Californium 98	254 Es Einsteinium 99	253 Fm Fermium 100	256 Md Mendelevium 101	254 No Nobelium 102	257 Lr Lawrencium 103



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2019

Chemistry

Assessment Unit A2 2

assessing

Analytical, Transition Metals, Electrochemistry
and Further Organic Chemistry

[ACH22]

TUESDAY 11 JUNE, AFTERNOON

MARK SCHEME

General Marking Instructions

Introduction

Mark schemes are published to assist teachers and students in their preparation for examinations. Through the mark schemes, teachers and students will be able to see what examiners are looking for in response to questions and exactly where the marks have been awarded. The publishing of the mark schemes may help to show that examiners are not concerned about finding out what a student does not know but rather, with rewarding students for what they do know.

The Purpose of Mark Schemes

Examination papers are set and revised by teams of examiners and revisers appointed by the Council. The teams of examiners and revisers include experienced teachers who are familiar with the level and standards expected of students in schools and colleges.

The job of the examiners is to set the questions and the mark schemes; and the job of the revisers is to review the questions and mark schemes commenting on a large range of issues about which they must be satisfied before the question papers and mark schemes are finalised.

The questions and the mark schemes are developed in association with each other so that the issues of differentiation and positive achievement can be addressed right from the start. Mark schemes, therefore, are regarded as part of an integral process which begins with the setting of questions and ends with the marking of the examination.

The main purpose of the mark scheme is to provide a uniform basis for the marking process so that all the markers are following exactly the same instructions and making the same judgements in so far as this is possible. Before marking begins, a standardising meeting is held where all the markers are briefed using the mark scheme and samples of the students' work in the form of scripts. Consideration is also given at this stage to any comments on the operational papers received from teachers and their organisations. During this meeting, and up to and including the end of the marking, there is provision for amendments to be made to the mark scheme. The document published represents this final form of the mark scheme.

It is important to recognise that in some cases there may well be other correct responses which are equally acceptable to those published: the mark scheme can only cover those responses which emerged in the examination. There may also be instances where certain judgements may have to be left to the experience of the examiner, for example, where there is no absolute correct response – all teachers will be familiar with making such judgements.

Section A

- 1 D
- 2 B
- 3 B
- 4 C
- 5 C
- 6 D
- 7 C
- 8 B
- 9 D
- 10 C

[1] for each correct answer

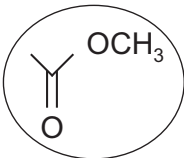
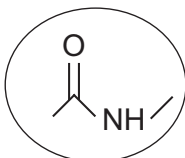
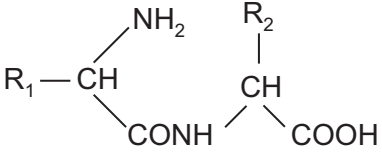
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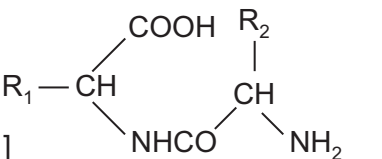
Section A

AVAILABLE MARKS	
	10
	10

Section B

AVAILABLE
MARKS

- 11 (a) (i)** circle the ester group  [1]
- (ii)** circle the peptide link  [1]
- (b)** amine group and carboxylic acid group [1]
attached to the same/first carbon atom [1] [2]
(second mark dependent on first)
- (c)** contains a carbon atom attached to 4 different groups/chiral centre [1]
- (d)** aspartic acid has two -COOH and one basic [1]
phenylalanine has one basic and one acidic [1] [2]
- (e)**
-  [1]

 [1] [2]
- (f)** a named strong acid, e.g. (dilute) sulfuric acid or (dil/conc) hydrochloric acid
a named strong base, e.g. (dilute/conc) sodium/potassium hydroxide [1]
- (g)** indicative content
- spot onto TLC sheet the mixture (of products and spot onto TLC sheet samples of phenylalanine and aspartic acid)
 - use appropriate solvent, e.g. ethanol
 - place in “sealed” beaker
 - run until near end of TLC sheet
 - place under UV/place in iodine/ninhydrin
 - methanol evaporates/ethanol and methanol are miscible
 - comparison, e.g. of spots or R_f values
- | Band | Response | Mark |
|------|---|---------|
| A | Candidates must use appropriate specialist terms using a minimum of 6 points of indicative content. They must use good spelling, punctuation and grammar and the form and style are of an excellent standard. | [5]–[6] |
| B | Candidates must use appropriate specialist terms using a minimum of 4 points of indicative content. They must use satisfactory spelling, punctuation and grammar and the form and style are of a good standard. | [3]–[4] |
| C | Candidates must use appropriate specialist terms using a minimum of 2 points of indicative content. They use limited correct spelling, punctuation and grammar and the form and style are of a basic standard. | [1]–[2] |
| D | Response not worthy of credit | [0] |
- [6]
- (h)** baking occurs at a high temperature, soft drinks are at room temperature
Or have a pH in range 2.5–4.0. Soft drinks are acidic [2]
- (i)** the aspartame molecule (specifically) fits into [1]
the binding site of the taste receptor [1] [2]

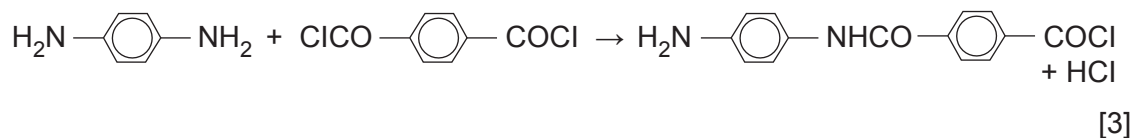
12	(a) (i)	e.g. potassium chloride	[1]	AVAILABLE MARKS
	(ii)	soak a strip of filter paper in a (saturated/concentrated) solution of potassium chloride	[1]	
	(iii)	to complete the circuit/conducts without introducing a metal [1] maintains the balance of anions and cations [1]	[2]	
(b)	(i)	(+)0.23 V	[2]	
	(ii)	$\text{Pt} \text{I}^-(\text{aq}), \text{I}_2(\text{aq}) \text{Fe}^{3+}(\text{aq}), \text{Fe}^{2+}(\text{aq}) \text{Pt}$	[2]	
	(iii)	$2\text{Fe}^{3+} + 2\text{I}^- \rightarrow 2\text{Fe}^{2+} + \text{I}_2$	[1]	
	(iv)	electrons are produced in the iodine system and flow from left to right	[2]	
(c)	(i)	react with aqueous NaOH/ammonia [1]		
		brown precipitate [1]	[2]	
	(ii)	react with aqueous NaOH/ammonia [1]		
		green precipitate [1]	[2]	
	(iii)	react with aqueous silver nitrate [1]		
		yellow precipitate [1]	[2]	
	(iv)	starch (solution) [1]		
		goes blue-black [1]	[2]	19
13	(a) (i)	have the same formula [1]		
		position of the functional group/double bond in the isomers is different [1]	[2]	
	(ii)	$\text{CH}_3(\text{CH}_2)_7\text{COOH}$ [1]		
		$\text{HOOC}(\text{CH}_2)_7\text{COOH}$ [1]	[2]	
(b)	(i)	petroselinic acid has hydrogen bonds between molecules [1] which are stronger than intermolecular forces [1]	[2]	
		removal of $-\text{COOH}/\text{H}$ bond answer/van der Waals forces lower than H-bond [1]		
	(ii)	the ester is more volatile and passes through the GLC faster	[1]	
	(iii)	add the areas under the peaks/signal [1]		
		divide the area under the petroselinic acid peak by the total $\times 100$ [1]	[2]	

(c) (i) $(\text{HOOC}(\text{CH}_2)_4\text{COOH} + \text{NH}_2(\text{CH}_2)_6\text{NH}_2 \rightarrow)$
 $-\text{OC}(\text{CH}_2)_4\text{CONH}(\text{CH}_2)_6\text{NH}-$ [2]

(ii) Polymers formed by the elimination of small molecules such as water or hydrogen chloride when monomers join together [1]

(iii) peptides formed from amino acids [1]

(iv)



(v) both contain an amide group [1]/which is hydrolysed by microorganisms [1] [2]

(d) Indicative content

- primary structure is the sequence of amino acids
- secondary structure is twisting/coiling of the chain into a helix/or β -pleated sheets using hydrogen bonds
- tertiary structure is the bending/folding of the secondary structure using disulfide bridges and one other interaction
- enzymes lose their activity at (low) or high temperature
- enzymes lose their activity at low or high pH
- enzyme structure is denatured

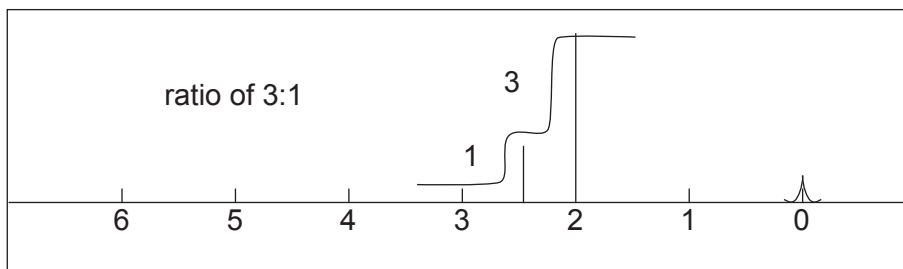
Band	Response	Mark
A	Candidates must use appropriate specialist terms using a minimum of 5 points of indicative content. They must use good spelling, punctuation and grammar and the form and style are of an excellent standard.	[5]–[6]
B	Candidates must use appropriate specialist terms using a minimum of 3 points of indicative content. They must use satisfactory spelling, punctuation and grammar and the form and style are of a good standard.	[3]–[4]
C	Candidates must use appropriate specialist terms using a minimum of 1 point of indicative content. They use limited correct spelling, punctuation and grammar and the form and style are of a basic standard.	[1]–[2]
D	Response not worthy of credit	[0]

[6]

AVAILABLE
MARKS

24

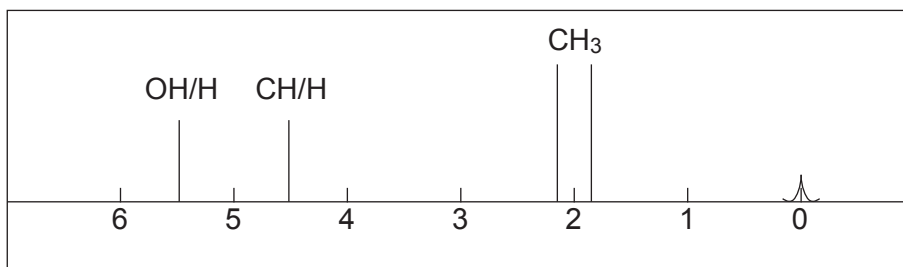
14 (a) (i)



chemical shift

[2]

(ii)



chemical shift

[2]

(b) Any **two** from:

peak in spectrum which fits with range 3200–3600 cm^{-1} for alcohols [1]

peak at 1610 in spectrum which fits with range 1600–1700 for alkenes [1]

peak at 1750 in spectrum which fits with range 1650–1800 for ketones [1]

(2 × [1])

[2]

(c) (i) wrap in paper/keep in dark

[1]

(ii) the orange/yellow/brown colour of bromine remains

[1]

(iii) 25 cm^3 of 0.008 M pentane-2,4-dione

contains $25 \times 10^{-3} \times 8 \times 10^{-3} = 2 \times 10^{-4} \text{ mol}$

4.6 cm^3 of 0.002 M bromine solution

contains $4.6 \times 10^{-3} \times 2 \times 10^{-3} = 9.2 \times 10^{-6} \text{ mol}$

% of double bonds in

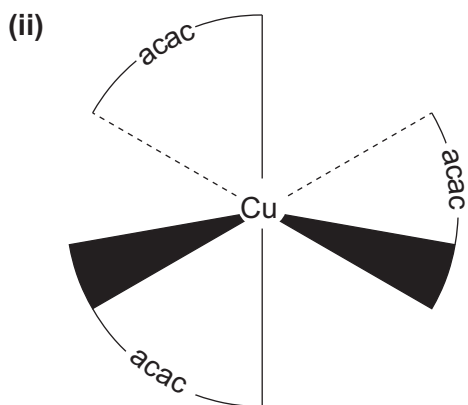
pentane-2,4-dione = $9.2 \times 10^{-6} / 2 \times 10^{-4} = 4.6 \times 10^{-2} \times 100$

= 4.6% = 5%

[4]

AVAILABLE
MARKS

(d) (i) two [1]



[2]

(iii) (one) edta reacts to produce three molecules of acac [1]
increase in entropy [1]

[2]

(e) measure the melting point of the product; if it is 107–8°C it must be pentane-2,4-dione

[1]

18

15 (a) sodium nitrite and (dil/conc) hydrochloric acid [1]
temperature 0–10°C/in ice [1]

[2]

(b) (i) highly delocalised electrons in molecule [1]
gives closer proximity of electronic energy levels [1]
electrons more easily promoted (to higher levels) [1]
a colour is removed from the light [1]

[4]

(ii) the structure of the double bonds/the delocalisation is different in the molecules [1]
different proximity of energy levels/more easily promoted in one molecule, etc. [1]

[2]

(c) sodium salt is ionic or can form bonds with water [1]
methyl red does not have groups to increase solubility except –COOH [1]

[2]

(d) (i) conc/concentrated sulfuric acid/H₂SO₄/H₂SO₄(l) [1]

conc/concentrated nitric acid/HNO₃/HNO₃(l) [1]

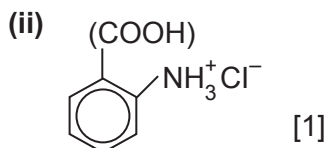
[2]

(ii) purple to colourless

[2]

(e) (i) $\text{Sn} + 2\text{HCl} \rightarrow \text{SnCl}_2 + \text{H}_2$

[2]



the NaOH reacts with –NH₃⁺Cl[–] to give –NH₂ + NaCl [1]
the NaOH reacts with –COOH to give –CO₂Na [1]

[3]

19

Section B

100

Total

110



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General Certificate of Education
2019

Centre Number

--	--	--	--	--

Candidate Number

--	--	--	--	--

Chemistry

Assessment Unit A2 3

assessing

Further Practical Chemistry

Practical Booklet A



[ACH31]

ACH31

THURSDAY 9 MAY, MORNING

TIME

1 hour 15 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

You must answer the questions in the spaces provided.

Do not write outside the boxed area on each page or on blank pages.

Complete in black ink only. **Do not write with a gel pen.**

Answer **all three** questions.

INFORMATION FOR CANDIDATES

The total mark for this paper is 30.

Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

A Periodic Table of Elements (including some data) is provided.

You may not have access to notes, textbooks and other material to assist you.

Safety glasses must be worn at all times and care should be taken during the practical examination.

12289.06R



08ACH3101

- 1 You are required to titrate standard sodium thiosulfate solution against the iodine liberated by the reaction of potassium iodate(V) with excess potassium iodide in solution.

You are provided with:

- a solution of potassium iodate(V)
- three 20 cm³ portions of dilute sulfuric acid
- three 1.0 g portions of potassium iodide
- 0.10 mol dm⁻³ sodium thiosulfate solution
- starch indicator

You should:

- Step 1. Fill the burette with the 0.10 mol dm⁻³ sodium thiosulfate solution
- Step 2. Use the pipette to transfer 25.0 cm³ of the potassium iodate(V) solution to a conical flask
- Step 3. Add a portion of dilute sulfuric acid to the conical flask
- Step 4. Add a portion of potassium iodide to the conical flask and swirl the flask
- Step 5. Carry out the titration

- (a) (i) Record your results in a table.

[3]



(ii) Use your results to calculate the mean titre.

[2]

(b) (i) Describe what you observed in the conical flask when you carried out Step 4.

[1]

(ii) Describe the **three** changes observed in the conical flask when you carried out Step 5.

[3]

(iii) Calculate the percentage uncertainty in your mean titre. Assume the burette has an uncertainty of $\pm 0.10 \text{ cm}^3$.

[2]

[Turn over]

12289.06R



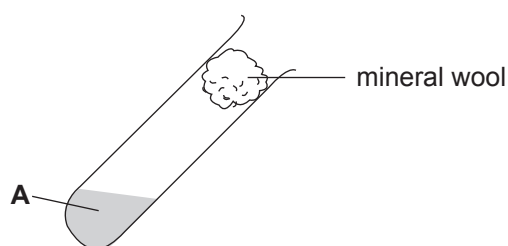
08ACH3103

2 You are provided with a compound labelled **A**.

(a) Describe the appearance of **A**.

_____ [1]

(b) Weigh out approximately 10 g of **A** and record the mass to one decimal place. Transfer **A** to a boiling tube. Push a plug of mineral wool into the top of the boiling tube. Find the mass of the boiling tube and its contents and record it to one decimal place.



Mass of **A** _____

Mass of boiling tube and its contents _____ [1]

(c) (i) Heat **A** in the boiling tube until there is no further change in its appearance, stating **two** observations.

_____ [2]

(ii) Allow the boiling tube to cool. Record the mass of the boiling tube and its contents to one decimal place and calculate the loss in mass.

_____ [1]



- (d) (i) Remove the plug of mineral wool from the boiling tube using tweezers. Add two spatula measures of its contents to 25 cm³ of 2M sulfuric acid in a beaker. Heat the beaker and its contents on a tripod and gauze without boiling and stir gently until there is no further change. State **two** observations.

Keep the beaker and its contents for use in (d) (ii).

_____ [2]

- (ii) Add two spatula measures of **A** to the contents of the beaker used in (d) (i). State **two** observations.

_____ [2]

- (e) (i) Pour approximately 4 cm³ of the solution, obtained in (d) (ii), into a test tube. Add an equal volume of 2M sodium hydroxide solution. State **one** observation.

Keep the contents of the test tube for use in (e) (ii).

_____ [1]

- (ii) Add 6 cm³ of concentrated hydrochloric acid to the test tube. Stopper and shake the test tube. State **two** observations.

_____ [2]

[Turn over



3 You are provided with cinnamic acid and propanone.

(a) Add approximately 12 cm^3 of ethanol to the sample of cinnamic acid in a boiling tube. Shake the boiling tube until the cinnamic acid dissolves. Pour half of the solution into a second boiling tube and keep it for use in (a) (iii).

(i) Add one drop of the solution from the first boiling tube onto damp Universal Indicator paper and record the pH value.

_____ [1]

(ii) Into the first boiling tube, containing the solution of cinnamic acid in ethanol, add an equal volume of deionised water followed by approximately 6 cm^3 of bromine water. Stopper and shake the boiling tube. State **two** observations.

_____ [2]

(iii) Into the second boiling tube, containing the solution of cinnamic acid in ethanol, add an equal volume of deionised water followed by a spatula measure of sodium hydrogencarbonate. State **two** observations.

_____ [2]

(b) Place a watch glass on a heatproof mat and add several drops of propanone to the watch glass. Carefully touch the liquid with a lighted splint. Using a test tube holder, place the bottom half of an empty test tube in the flame. State **two** observations.

_____ [2]





THIS IS THE END OF THE QUESTION PAPER

12289.06R



08ACH3107

DO NOT WRITE ON THIS PAGE

For Examiner's use only	
Question Number	Marks
1	
2	
3	

Total Marks	
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Examiner Number

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2019

Chemistry
Assessment Unit A2 3
assessing
Further Practical Chemistry
Practical Booklet A
[ACH31]
THURSDAY 9 MAY, MORNING

**APPARATUS
AND
MATERIALS
LIST**

Advice for centres

- All chemicals used should be at least laboratory reagent specification and labelled with appropriate safety symbols, e.g. irritant.
- For centres running multiple sessions – candidates for the later session should be supplied with clean, dry glassware. If it is not feasible, then glassware from the first session should be thoroughly washed, rinsed with deionised water and allowed to drain.
- Ensure all chemicals are in date otherwise expected observations may not be seen.
- It is the responsibility of the centre to be cognisant of all health and safety issues and to carry out a thorough risk assessment. Up to date information can be obtained at www.cleapss.org.uk

Practical Examination

Each candidate must be supplied with safety goggles or glasses.

Question No. 1

Each candidate must be supplied with:

- a 50 cm³ burette of at least B quality
- a funnel for filling the burette
- a retort stand and burette clamp
- access to beakers
- a 25 cm³ pipette of at least class B quality
- a safety pipette filler
- 3 × 250 cm³ conical flasks
- a white tile or white paper
- a wash bottle containing deionised water
- 150 cm³ of 0.10 mol dm⁻³ sodium thiosulfate solution labelled **0.10 mol dm⁻³ sodium thiosulfate solution**.
- 150 cm³ of potassium iodate(V) solution of concentration 3.36 g dm⁻³ labelled **potassium iodate(V) solution and oxidising**.
- 3 × 20 cm³ portions of sulfuric acid solution labelled **Q1 dilute sulfuric acid and irritant**.
This solution should be of approximate concentration 1 M.
(Centres may choose to leave out a reagent bottle containing approximately 100 cm³ of 1 M sulfuric acid labelled **dilute sulfuric acid and irritant** and a 25 cm³ measuring cylinder and give candidates adequate instruction in this part.)
- 3 × 1 g portions of solid potassium iodide labelled **potassium iodide**.
- a dropper bottle containing starch solution labelled **starch indicator**.

Question No. 2

- Copper(II) carbonate (12 g) labelled **A** and **irritant**
- a plastic weighing boat or filter paper
- a small spatula, e.g. Nuffield Raised Centre Spatula (or similar size)
- 2 × boiling tubes
- 1 × test tube
- test tube/boiling tube rack
- 1 × stirring rod
- stopper to fit test tube
- dry mineral wool
- access to a balance reading to at least 1 d.p.
- test tube (boiling tube) holder
- tweezers
- bunsen burner
- tripod, gauze and heatproof mat
- 10 cm³ measuring cylinder or access to plastic graduated dropping pipette
- 25 cm³ measuring cylinder
- 100 cm³ beaker
- 25–50 cm³ of 2M sulfuric acid labelled **Q2 2M sulfuric acid** and **corrosive**
- 10 cm³ of 2M sodium hydroxide labelled **Q2 2M sodium hydroxide** and **corrosive**
- 10 cm³ of concentrated hydrochloric acid labelled as **Q2 concentrated hydrochloric acid** and **corrosive**. This should be stored and used in a fume cupboard with access to a 10 cm³ measuring cylinder
- access to a lighter or matches

Question No. 3

- 0.6 g of cinnamic acid labelled **cinnamic acid** and **irritant**
- access to reagent bottle of ethanol labelled **ethanol** and **highly flammable**
- access to Universal Indicator paper (Johnston Test Papers pH 1 to pH 14)
- a small spatula, e.g. Nuffield Raised Centre Spatula (or similar size)
- 2 × boiling tubes
- test tube/boiling tube rack
- access to 0.2 M bromine water in a fume cupboard (yellow/orange in colour) labelled **bromine water**
- a 25 cm³ measuring cylinder
- 2 × watch glasses
- access to plastic graduated dropping pipettes
- a wash bottle containing deionised water
- a wooden splint
- a test tube
- a test tube holder
- stopper to fit a boiling tube
- a heatproof mat
- 1 g of sodium hydrogencarbonate labelled **sodium hydrogencarbonate**
- approximately 5 cm³ of propanone labelled **propanone** and **flammable**
- access to a lighter or matches



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2019

Chemistry

Assessment Unit A2 3

Practical Assessment

Practical Booklet A

[ACH31]

THURSDAY 9 MAY

Confidential Instructions to the Supervisor of the Practical Examination

INSTRUCTIONS TO THE SUPERVISOR OF THE PRACTICAL EXAMINATION

General

1. The instructions contained in this document are for the use of the Supervisor **and are strictly confidential**. Under no circumstances may information concerning apparatus or materials be given before the examination to a candidate or other unauthorised person.
2. In a centre with a large number of candidates it may be necessary for two or more examination sessions to be organised. **It is the responsibility of the schools to ensure that there should be no contact between candidates taking each session.**
3. A suitable laboratory must be reserved for the examination and kept locked throughout the period of preparation. Unauthorised persons not involved in the preparation for the examination must not be allowed to enter. Candidates must not be admitted until the specified time for commencement of the examination.
4. The Supervisor must ensure that the solutions provided for the candidates are of the nature and concentrations specified in the Apparatus and Materials List.
5. **The Supervisor is to be granted access to the Teacher's Copy of Practical Booklet A on Friday 3 May 2019.** The Supervisor is asked to check, at the earliest opportunity, that the experiments and tests in the question paper may be completed satisfactorily using the apparatus, materials and solutions that have been assembled. **This question paper must then be returned to safe custody** at the earliest possible moment after the Supervisor has ensured that all is in order. **No access to the question paper should be allowed before Friday 3 May 2019.**
6. Centres may need to carry out multiple sessions to accommodate all their candidates sitting Practical Booklet A in a laboratory. Supervision must take place from 30 minutes after the scheduled starting time of the examination, as set out in the timetable, until the time when the candidate(s) begin(s) their examination(s). This is in order to ensure that there is no contact with other candidates. The centre must appoint a member of staff from the centre to supervise the candidate(s) at all times while he/she is on the premises.
7. All apparatus should be checked before the examination, and there should be an adequate supply of spare apparatus in case of breakages. The Apparatus and Materials List should be regarded as a minimum and there is no objection to candidates being supplied with more than the minimum amount of apparatus and materials.
8. **Candidates may not use text books and laboratory notes for reference during the examination, and must be informed of this beforehand.**

9. Clear instructions must be given by the Supervisor to all candidates at the beginning of the examination concerning appropriate safety procedures and precautions. Supervisors are also advised to remind candidates that all substances in the examination must be treated with caution. **Only those tests specified in the question paper should be attempted. Candidates must not attempt any additional confirmatory tests.** Anything spilled on the skin should be washed off immediately with plenty of water. The use of appropriate eye protection is essential.
10. Supervisors are reminded that they may not assist candidates during the examination. However if, in the opinion of the Supervisor, a candidate is about to do something which may endanger him/herself or others, the Supervisor should intervene. A full written report must be sent to CCEA at once.
11. Upon request, a candidate may be given additional quantities of materials (answer paper, reagents and unknowns) without penalty. No notification need be sent to CCEA.
12. The examination room must be cleared of candidates immediately after the examination.
13. No materials will be supplied by CCEA.
14. All JCQ procedures for conducting examinations should be followed for this practical examination including displaying JCQ posters with examination information in the laboratory and removal of mobile phones. Posters should be available from your Examinations Officer.

Northern Ireland Council for the Curriculum, Examinations and
Assessment

General Certificate of Education

Advanced

Chemistry

Practical Booklet A

[ACH31]

Thursday 9 May 2019

Centre Number

71

Candidate Number

This report must be completed by the Supervisor during the examination.
The complete report should include all candidates taking this Practical
Examination. This Supervisor's Report should be copied and attached to
Each Advice Note bundle and returned to CCEA in the normal way.

Comments:

Supervisor's Signature Date

General Information

1 tonne = 10^6 g

1 metre = 10^9 nm

One mole of any gas at 293 K and a pressure of 1 atmosphere (10^5 Pa) occupies a volume of 24 dm^3

Avogadro Constant = $6.02 \times 10^{23} \text{ mol}^{-1}$

Planck Constant = $6.63 \times 10^{-34} \text{ Js}$

Specific Heat Capacity of water = $4.2 \text{ J g}^{-1} \text{ K}^{-1}$

Speed of Light = $3 \times 10^8 \text{ ms}^{-1}$

Characteristic absorptions in IR spectroscopy

Wavenumber/ cm^{-1}	Bond	Compound
550–850	C–X (X = Cl, Br, I)	Haloalkanes
750–1100	C–C	Alkanes, alkyl groups
1000–1300	C–O	Alcohols, esters, carboxylic acids
1450–1650	C=C	Arenes
1600–1700	C=C	Alkenes
1650–1800	C=O	Carboxylic acids, esters, aldehydes, ketones, amides, acyl chlorides
2200–2300	C≡N	Nitriles
2500–3200	O–H	Carboxylic acids
2750–2850	C–H	Aldehydes
2850–3000	C–H	Alkanes, alkyl groups, alkenes, arenes
3200–3600	O–H	Alcohols
3300–3500	N–H	Amines, amides

Proton Chemical Shifts in Nuclear Magnetic Resonance Spectroscopy (relative to TMS)

Chemical Shift	Structure	
0.5–2.0	–CH	Saturated alkanes
0.5–5.5	–OH	Alcohols
1.0–3.0	–NH	Amines
2.0–3.0	–CO–CH	Ketones
	–N–CH	Amines
	$\text{C}_6\text{H}_5\text{–CH}$	Arene (aliphatic on ring)
2.0–4.0	X–CH	X = Cl or Br (3.0–4.0) X = I (2.0–3.0)
4.5–6.0	–C=CH	Alkenes
5.5–8.5	RCONH	Amides
6.0–8.0	– C_6H_5	Arenes (on ring)
9.0–10.0	–CHO	Aldehydes
10.0–12.0	–COOH	Carboxylic acids

These chemical shifts are concentration and temperature dependent and may be outside the ranges indicated above.

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COUNCIL FOR THE CURRICULUM, EXAMINATIONS AND ASSESSMENT

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New
Specification



Data Leaflet

Including the Periodic Table of the Elements

For the use of candidates taking
Advanced Subsidiary and
Advanced Level Examinations

Copies must be free from notes or additions of any kind. No other type of data booklet or information sheet is authorised for use in the examinations

gce a/as examinations chemistry

For first teaching from September 2016
For first award of AS Level in Summer 2017
For first award of A Level in Summer 2018
Subject Code: 1110

I II THE PERIODIC TABLE OF ELEMENTS III IV V VI VII 0

Group

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen 1																	4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganes 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	98 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La [*] Lanthanum 57	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	210 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radium 88	227 Ac [†] Actinium 89	261 Rf Rutherfordium 104	262 Db Dubnium 105	266 Sg Seaborgium 106	264 Bh Bohrium 107	277 Hs Hassium 108	268 Mt Meitnerium 109	271 Ds Darmstadtium 110	272 Rg Roentgenium 111	285 Cn Copernicium 112						

^a
X
_b

a = relative atomic mass (approx)

x = atomic symbol

b = atomic number

* 58 – 71 Lanthanum series

† 90 – 103 Actinium series

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	145 Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	231 Pa Protactinium 91	238 U Uranium 92	237 Np Neptunium 93	242 Pu Plutonium 94	243 Am Americium 95	247 Cm Curium 96	245 Bk Berkelium 97	251 Cf Californium 98	254 Es Einsteinium 99	253 Fm Fermium 100	256 Md Mendelevium 101	254 No Nobelium 102	257 Lr Lawrencium 103



Rewarding Learning

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2019

Chemistry
Assessment Unit A2 3
assessing
Further Practical Chemistry
Practical Booklet A
[ACH31]
THURSDAY 9 MAY, MORNING

MARK
SCHEME

			AVAILABLE MARKS
1	(a) (i)	Initial burette reading recorded Final burette reading recorded Volume delivered recorded and calculated correctly Readings/volumes to one decimal place Units recorded Accurate titrations agree $\pm 0.2\text{cm}^3$ Each omission/error [-1]	[3]
	(ii)	Correct calculation of the mean titre to at least one decimal place Unit essential [1] Accuracy of value (the value should be within the range $20.0\text{--}25.0\text{cm}^3$) [1]	[2]
	(b) (i)	(Colourless) solution turns brown. (White solid disappears/dissolves.)	[1]
	(ii)	Add the sodium thiosulfate (solution) until the solution in the conical flask turns straw yellow, (then add starch) [1] (solution in conical flask) turns blue-black [1] Add the sodium thiosulfate solution dropwise until the solution (in the conical flask) turns colourless [1]	[3]
	(iii)	$\frac{0.20}{\text{mean titre}} \times 100$ [1] Answer to two significant figures [1]	[2]
2	(a)	Green powder	[1]
	(b)	Both masses recorded to one decimal place and the first mass $10(\pm 0.5)\text{g}$	[1]
	(c) (i)	(Green) solid turns black/solid moves/colourless liquid at the top of the boiling tube	[2]
	(ii)	Mass recorded to one decimal place, correct subtraction and mass decrease of between 10 and 35% i.e. if 10.0 g was transferred to the boiling tube then the mass decrease should be $1.0\text{--}3.5\text{g}$	[1]
	(d) (i)	Black solid disappears/dissolves [1] (Colourless) solution turns blue [1]	[2]
	(ii)	Green solid disappears/dissolves [1] Bubbles/effervescence [1]	[2]
	(e) (i)	A blue precipitate forms	[1]
	(ii)	The blue precipitate disappears [1] and solution turns green [1]	[2]
	(a) (i)	pH 2–5	[1]
	(ii)	(Yellow) colour disappears [1]/white solid formed [1]	[2]
3	(iii)	Solid disappears [1] bubbles/effervescence/fizzing [1] Colourless solution formed [1] max of 2	[2]
	(b)	Yellow/orange flame [1] test tube coated with a black solid/turns black [1]	[2]
	Total		30

11

12

7



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General Certificate of Education
2019

Centre Number

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Candidate Number

--	--	--	--	--

Chemistry

Assessment Unit A2 3

assessing

Further Practical Chemistry

Practical Booklet A



[ACH31]

ACH31

THURSDAY 9 MAY, MORNING

TIME

1 hour 15 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

You must answer the questions in the spaces provided.

Do not write outside the boxed area on each page or on blank pages.

Complete in black ink only. **Do not write with a gel pen.**

Answer **all three** questions.

INFORMATION FOR CANDIDATES

The total mark for this paper is 30.

Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

A Periodic Table of Elements (including some data) is provided.

You may not have access to notes, textbooks and other material to assist you.

Safety glasses must be worn at all times and care should be taken during the practical examination.

12289.06R



08ACH3101

- 1 You are required to titrate standard sodium thiosulfate solution against the iodine liberated by the reaction of potassium iodate(V) with excess potassium iodide in solution.

You are provided with:

- a solution of potassium iodate(V)
- three 20 cm³ portions of dilute sulfuric acid
- three 1.0 g portions of potassium iodide
- 0.10 mol dm⁻³ sodium thiosulfate solution
- starch indicator

You should:

- Step 1. Fill the burette with the 0.10 mol dm⁻³ sodium thiosulfate solution
- Step 2. Use the pipette to transfer 25.0 cm³ of the potassium iodate(V) solution to a conical flask
- Step 3. Add a portion of dilute sulfuric acid to the conical flask
- Step 4. Add a portion of potassium iodide to the conical flask and swirl the flask
- Step 5. Carry out the titration

- (a) (i) Record your results in a table.

[3]



(ii) Use your results to calculate the mean titre.

[2]

(b) (i) Describe what you observed in the conical flask when you carried out Step 4.

[1]

(ii) Describe the **three** changes observed in the conical flask when you carried out Step 5.

[3]

(iii) Calculate the percentage uncertainty in your mean titre. Assume the burette has an uncertainty of $\pm 0.10 \text{ cm}^3$.

[2]

[Turn over]

12289.06R



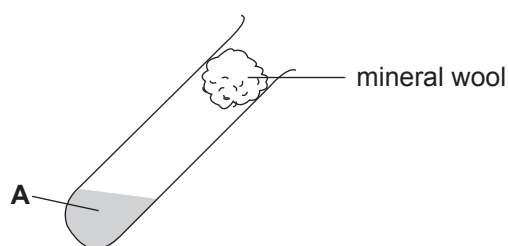
08ACH3103

2 You are provided with a compound labelled **A**.

(a) Describe the appearance of **A**.

_____ [1]

(b) Weigh out approximately 10 g of **A** and record the mass to one decimal place. Transfer **A** to a boiling tube. Push a plug of mineral wool into the top of the boiling tube. Find the mass of the boiling tube and its contents and record it to one decimal place.



Mass of **A** _____

Mass of boiling tube and its contents _____ [1]

(c) (i) Heat **A** in the boiling tube until there is no further change in its appearance, stating **two** observations.

_____ [2]

(ii) Allow the boiling tube to cool. Record the mass of the boiling tube and its contents to one decimal place and calculate the loss in mass.

_____ [1]



- (d) (i) Remove the plug of mineral wool from the boiling tube using tweezers. Add two spatula measures of its contents to 25 cm³ of 2M sulfuric acid in a beaker. Heat the beaker and its contents on a tripod and gauze without boiling and stir gently until there is no further change. State **two** observations.

Keep the beaker and its contents for use in (d) (ii).

_____ [2]

- (ii) Add two spatula measures of **A** to the contents of the beaker used in (d) (i). State **two** observations.

_____ [2]

- (e) (i) Pour approximately 4 cm³ of the solution, obtained in (d) (ii), into a test tube. Add an equal volume of 2M sodium hydroxide solution. State **one** observation.

Keep the contents of the test tube for use in (e) (ii).

_____ [1]

- (ii) Add 6 cm³ of concentrated hydrochloric acid to the test tube. Stopper and shake the test tube. State **two** observations.

_____ [2]

[Turn over



3 You are provided with cinnamic acid and propanone.

(a) Add approximately 12 cm^3 of ethanol to the sample of cinnamic acid in a boiling tube. Shake the boiling tube until the cinnamic acid dissolves. Pour half of the solution into a second boiling tube and keep it for use in (a) (iii).

(i) Add one drop of the solution from the first boiling tube onto damp Universal Indicator paper and record the pH value.

_____ [1]

(ii) Into the first boiling tube, containing the solution of cinnamic acid in ethanol, add an equal volume of deionised water followed by approximately 6 cm^3 of bromine water. Stopper and shake the boiling tube. State **two** observations.

_____ [2]

(iii) Into the second boiling tube, containing the solution of cinnamic acid in ethanol, add an equal volume of deionised water followed by a spatula measure of sodium hydrogencarbonate. State **two** observations.

_____ [2]

(b) Place a watch glass on a heatproof mat and add several drops of propanone to the watch glass. Carefully touch the liquid with a lighted splint. Using a test tube holder, place the bottom half of an empty test tube in the flame. State **two** observations.

_____ [2]





THIS IS THE END OF THE QUESTION PAPER

12289.06R



08ACH3107

DO NOT WRITE ON THIS PAGE

For Examiner's use only	
Question Number	Marks
1	
2	
3	

Total Marks	
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Examiner Number

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General Certificate of Education
2019

Chemistry
Assessment Unit A2 3
assessing
Further Practical Chemistry
Practical Booklet A
[ACH31]
THURSDAY 9 MAY, MORNING

**APPARATUS
AND
MATERIALS
LIST**

Advice for centres

- All chemicals used should be at least laboratory reagent specification and labelled with appropriate safety symbols, e.g. irritant.
- For centres running multiple sessions – candidates for the later session should be supplied with clean, dry glassware. If it is not feasible, then glassware from the first session should be thoroughly washed, rinsed with deionised water and allowed to drain.
- Ensure all chemicals are in date otherwise expected observations may not be seen.
- It is the responsibility of the centre to be cognisant of all health and safety issues and to carry out a thorough risk assessment. Up to date information can be obtained at www.cleapss.org.uk

Practical Examination

Each candidate must be supplied with safety goggles or glasses.

Question No. 1

Each candidate must be supplied with:

- a 50 cm³ burette of at least B quality
- a funnel for filling the burette
- a retort stand and burette clamp
- access to beakers
- a 25 cm³ pipette of at least class B quality
- a safety pipette filler
- 3 × 250 cm³ conical flasks
- a white tile or white paper
- a wash bottle containing deionised water
- 150 cm³ of 0.10 mol dm⁻³ sodium thiosulfate solution labelled **0.10 mol dm⁻³ sodium thiosulfate solution**.
- 150 cm³ of potassium iodate(V) solution of concentration 3.36 g dm⁻³ labelled **potassium iodate(V) solution and oxidising**.
- 3 × 20 cm³ portions of sulfuric acid solution labelled **Q1 dilute sulfuric acid and irritant**. This solution should be of approximate concentration 1 M.
(Centres may choose to leave out a reagent bottle containing approximately 100 cm³ of 1 M sulfuric acid labelled **dilute sulfuric acid and irritant** and a 25 cm³ measuring cylinder and give candidates adequate instruction in this part.)
- 3 × 1 g portions of solid potassium iodide labelled **potassium iodide**.
- a dropper bottle containing starch solution labelled **starch indicator**.

Question No. 2

- Copper(II) carbonate (12 g) labelled **A** and **irritant**
- a plastic weighing boat or filter paper
- a small spatula, e.g. Nuffield Raised Centre Spatula (or similar size)
- 2 × boiling tubes
- 1 × test tube
- test tube/boiling tube rack
- 1 × stirring rod
- stopper to fit test tube
- dry mineral wool
- access to a balance reading to at least 1 d.p.
- test tube (boiling tube) holder
- tweezers
- bunsen burner
- tripod, gauze and heatproof mat
- 10 cm³ measuring cylinder or access to plastic graduated dropping pipette
- 25 cm³ measuring cylinder
- 100 cm³ beaker
- 25–50 cm³ of 2M sulfuric acid labelled **Q2 2M sulfuric acid** and **corrosive**
- 10 cm³ of 2M sodium hydroxide labelled **Q2 2M sodium hydroxide** and **corrosive**
- 10 cm³ of concentrated hydrochloric acid labelled as **Q2 concentrated hydrochloric acid** and **corrosive**. This should be stored and used in a fume cupboard with access to a 10 cm³ measuring cylinder
- access to a lighter or matches

Question No. 3

- 0.6 g of cinnamic acid labelled **cinnamic acid** and **irritant**
- access to reagent bottle of ethanol labelled **ethanol** and **highly flammable**
- access to Universal Indicator paper (Johnston Test Papers pH 1 to pH 14)
- a small spatula, e.g. Nuffield Raised Centre Spatula (or similar size)
- 2 × boiling tubes
- test tube/boiling tube rack
- access to 0.2 M bromine water in a fume cupboard (yellow/orange in colour) labelled **bromine water**
- a 25 cm³ measuring cylinder
- 2 × watch glasses
- access to plastic graduated dropping pipettes
- a wash bottle containing deionised water
- a wooden splint
- a test tube
- a test tube holder
- stopper to fit a boiling tube
- a heatproof mat
- 1 g of sodium hydrogencarbonate labelled **sodium hydrogencarbonate**
- approximately 5 cm³ of propanone labelled **propanone** and **flammable**
- access to a lighter or matches



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2019

Chemistry

Assessment Unit A2 3

Practical Assessment

Practical Booklet A

[ACH31]

THURSDAY 9 MAY

Confidential Instructions to the Supervisor of the Practical Examination

INSTRUCTIONS TO THE SUPERVISOR OF THE PRACTICAL EXAMINATION

General

1. The instructions contained in this document are for the use of the Supervisor **and are strictly confidential**. Under no circumstances may information concerning apparatus or materials be given before the examination to a candidate or other unauthorised person.
2. In a centre with a large number of candidates it may be necessary for two or more examination sessions to be organised. **It is the responsibility of the schools to ensure that there should be no contact between candidates taking each session.**
3. A suitable laboratory must be reserved for the examination and kept locked throughout the period of preparation. Unauthorised persons not involved in the preparation for the examination must not be allowed to enter. Candidates must not be admitted until the specified time for commencement of the examination.
4. The Supervisor must ensure that the solutions provided for the candidates are of the nature and concentrations specified in the Apparatus and Materials List.
5. **The Supervisor is to be granted access to the Teacher's Copy of Practical Booklet A on Friday 3 May 2019.** The Supervisor is asked to check, at the earliest opportunity, that the experiments and tests in the question paper may be completed satisfactorily using the apparatus, materials and solutions that have been assembled. **This question paper must then be returned to safe custody** at the earliest possible moment after the Supervisor has ensured that all is in order. **No access to the question paper should be allowed before Friday 3 May 2019.**
6. Centres may need to carry out multiple sessions to accommodate all their candidates sitting Practical Booklet A in a laboratory. Supervision must take place from 30 minutes after the scheduled starting time of the examination, as set out in the timetable, until the time when the candidate(s) begin(s) their examination(s). This is in order to ensure that there is no contact with other candidates. The centre must appoint a member of staff from the centre to supervise the candidate(s) at all times while he/she is on the premises.
7. All apparatus should be checked before the examination, and there should be an adequate supply of spare apparatus in case of breakages. The Apparatus and Materials List should be regarded as a minimum and there is no objection to candidates being supplied with more than the minimum amount of apparatus and materials.
8. **Candidates may not use text books and laboratory notes for reference during the examination, and must be informed of this beforehand.**

9. Clear instructions must be given by the Supervisor to all candidates at the beginning of the examination concerning appropriate safety procedures and precautions. Supervisors are also advised to remind candidates that all substances in the examination must be treated with caution. **Only those tests specified in the question paper should be attempted. Candidates must not attempt any additional confirmatory tests.** Anything spilled on the skin should be washed off immediately with plenty of water. The use of appropriate eye protection is essential.
10. Supervisors are reminded that they may not assist candidates during the examination. However if, in the opinion of the Supervisor, a candidate is about to do something which may endanger him/herself or others, the Supervisor should intervene. A full written report must be sent to CCEA at once.
11. Upon request, a candidate may be given additional quantities of materials (answer paper, reagents and unknowns) without penalty. No notification need be sent to CCEA.
12. The examination room must be cleared of candidates immediately after the examination.
13. No materials will be supplied by CCEA.
14. All JCQ procedures for conducting examinations should be followed for this practical examination including displaying JCQ posters with examination information in the laboratory and removal of mobile phones. Posters should be available from your Examinations Officer.

Northern Ireland Council for the Curriculum, Examinations and
Assessment

General Certificate of Education

Advanced

Chemistry

Practical Booklet A

[ACH31]

Thursday 9 May 2019

Centre Number

71

Candidate Number

This report must be completed by the Supervisor during the examination.
The complete report should include all candidates taking this Practical
Examination. This Supervisor's Report should be copied and attached to
Each Advice Note bundle and returned to CCEA in the normal way.

Comments:

Supervisor's Signature Date

General Information

1 tonne = 10^6 g

1 metre = 10^9 nm

One mole of any gas at 293 K and a pressure of 1 atmosphere (10^5 Pa) occupies a volume of 24 dm^3

Avogadro Constant = $6.02 \times 10^{23} \text{ mol}^{-1}$

Planck Constant = $6.63 \times 10^{-34} \text{ Js}$

Specific Heat Capacity of water = $4.2 \text{ J g}^{-1} \text{ K}^{-1}$

Speed of Light = $3 \times 10^8 \text{ ms}^{-1}$

Characteristic absorptions in IR spectroscopy

Wavenumber/ cm^{-1}	Bond	Compound
550–850	C–X (X = Cl, Br, I)	Haloalkanes
750–1100	C–C	Alkanes, alkyl groups
1000–1300	C–O	Alcohols, esters, carboxylic acids
1450–1650	C=C	Arenes
1600–1700	C=C	Alkenes
1650–1800	C=O	Carboxylic acids, esters, aldehydes, ketones, amides, acyl chlorides
2200–2300	C≡N	Nitriles
2500–3200	O–H	Carboxylic acids
2750–2850	C–H	Aldehydes
2850–3000	C–H	Alkanes, alkyl groups, alkenes, arenes
3200–3600	O–H	Alcohols
3300–3500	N–H	Amines, amides

Proton Chemical Shifts in Nuclear Magnetic Resonance Spectroscopy (relative to TMS)

Chemical Shift	Structure	
0.5–2.0	–CH	Saturated alkanes
0.5–5.5	–OH	Alcohols
1.0–3.0	–NH	Amines
2.0–3.0	–CO–CH	Ketones
	–N–CH	Amines
	$\text{C}_6\text{H}_5\text{–CH}$	Arene (aliphatic on ring)
2.0–4.0	X–CH	X = Cl or Br (3.0–4.0) X = I (2.0–3.0)
4.5–6.0	–C=CH	Alkenes
5.5–8.5	RCONH	Amides
6.0–8.0	– C_6H_5	Arenes (on ring)
9.0–10.0	–CHO	Aldehydes
10.0–12.0	–COOH	Carboxylic acids

These chemical shifts are concentration and temperature dependent and may be outside the ranges indicated above.

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COUNCIL FOR THE CURRICULUM, EXAMINATIONS AND ASSESSMENT

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Email: info@ccea.org.uk Web: www.ccea.org.uk



New
Specification



Data Leaflet

Including the Periodic Table of the Elements

For the use of candidates taking
Advanced Subsidiary and
Advanced Level Examinations

Copies must be free from notes or additions of any kind. No other type of data booklet or information sheet is authorised for use in the examinations

gce a/as examinations chemistry

For first teaching from September 2016
For first award of AS Level in Summer 2017
For first award of A Level in Summer 2018
Subject Code: 1110

I II THE PERIODIC TABLE OF ELEMENTS III IV V VI VII 0

Group

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen 1																	4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganes 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	98 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La [*] Lanthanum 57	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	210 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radium 88	227 Ac [†] Actinium 89	261 Rf Rutherfordium 104	262 Db Dubnium 105	266 Sg Seaborgium 106	264 Bh Bohrium 107	277 Hs Hassium 108	268 Mt Meitnerium 109	271 Ds Darmstadtium 110	272 Rg Roentgenium 111	285 Cn Copernicium 112						

* 58 – 71 Lanthanum series
† 90 – 103 Actinium series

^a
X
_b

a = relative atomic mass (approx)

x = atomic symbol

b = atomic number

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	145 Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	231 Pa Protactinium 91	238 U Uranium 92	237 Np Neptunium 93	242 Pu Plutonium 94	243 Am Americium 95	247 Cm Curium 96	245 Bk Berkelium 97	251 Cf Californium 98	254 Es Einsteinium 99	253 Fm Fermium 100	256 Md Mendelevium 101	254 No Nobelium 102	257 Lr Lawrencium 103



Rewarding Learning

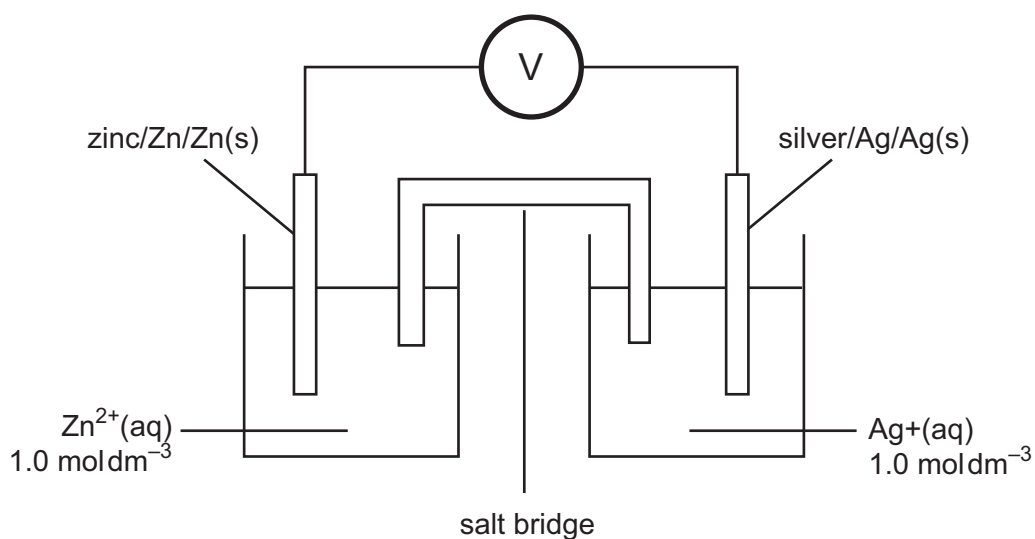
ADVANCED
General Certificate of Education
2019

Chemistry
Assessment Unit A2 3
assessing
Further Practical Chemistry
Practical Booklet B (Theory)
[ACH32]

WEDNESDAY 19 JUNE, MORNING

**MARK
SCHEME**

- 1 (a)** Run with solvent [1]
- Dry and mark the solvent front [1]
- Rotate by 90° (anti-clockwise) [1]
- Locate with, e.g. ninhydrin, iodine or UV light [1] [4]
- (b)** Solvent 1 (6 ÷ 10 =) 0.6 Solvent 2 (9 ÷ 10 =) 0.9 [1]
- (c)** Repeat the two-way chromatography using separate samples of pure leucine and serine [1]
- Second mark dependent on first
- Compare the positions of the spots/R_f values [1] [2]
- (d)** Two-way chromatography improves separation/greater separation between the spots [1]
- (e) (i)** Only one peak in the chromatogram [1]
- (ii)** The retention time matches that of the pure drug [1]
- The mass spectrum matches that of the pure drug [1] [2]
- 2 (a)** The potential difference/voltage/emf measured when a half-cell is connected to the standard hydrogen electrode under standard conditions [2]
- (b) (i)** 298K (or 25° C)

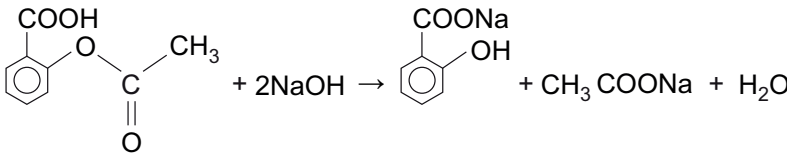


- each missing detail [-1] [4]
- (ii)** $\text{emf} = 0.80 - (-0.76) = +1.56 \text{ V}$ [1]
- (c)** $+1.61 = -0.76 - (x)$
 $x = -2.37 \text{ V}$ [1]

AVAILABLE
MARKS

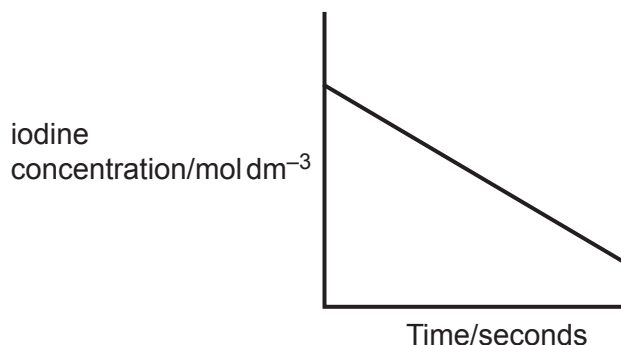
11

8

	AVAILABLE MARKS
3 (a) (i) Aldehyde [1] The formation of the orange solid suggests that A is either an aldehyde or ketone/contains a carbonyl group [1] and the formation of the silver mirror means it is not a ketone [1] [3] (ii) Propanal and $\text{CH}_3\text{CH}_2\text{CHO}^+$ [1] (b) (i) Carboxylic acid [1] The vigorous reaction with phosphorus pentachloride suggests that B contains an $-\text{OH}$ group [1], the effervescence with sodium carbonate suggests that B is a carboxylic acid/acidic [1] [3] (ii) $\text{CH}_3\text{CH}_2\text{COO}^+\text{H}$ [1] shift should be in the range 10.0–12.0 ppm [1] Second mark dependent on the first [2] (iii) CH_3 triplet – two hydrogens on the adjacent carbon [1] CH_2 quartet – three hydrogens on the adjacent carbon [1] [2]	11
4 (a) Either: RMM of aspirin = $(9 \times 12) + (8 \times 1) + (4 \times 16) = 180$ Actual yield of aspirin = $18.0/180 = 0.1$ mole Theoretical yield of aspirin = $(0.1/40) \times 100 = 0.25$ mole RMM of salicylic acid = $(7 \times 12) + (6 \times 1) + (3 \times 16) = 138$ Mass of salicylic acid = $0.25 \times 138 = 34.5\text{g}$ Error [–1] Or: Theoretical yield of aspirin = $(18.0/40) \times 100 = 45\text{g}$ RMM of aspirin = $(9 \times 12) + (8 \times 1) + (4 \times 16) = 180$ Theoretical yield of aspirin = $45/180 = 0.25$ mole RMM of salicylic acid = $(7 \times 12) + (6 \times 1) + (3 \times 16) = 138$ Mass of salicylic acid = $0.25 \times 138 = 34.5\text{g}$ Error [–1] [3] (b) Dissolve the crude product in the minimum volume of hot water/methanol/ethanol [1] Filter while hot [1] Allow filtrate to cool [1] Filter crystals under suction [1] [4] (c) place some solid in a capillary tube sealed at one end [1] place the capillary tube in melting point apparatus/oil bath [1] heat slowly [1] record temperature at which melting begins and ends [1] a sharp melting point confirms the purity of the aspirin [1] [5] (d)  [1]	13

- 5 (a) • plot a calibration curve/graph (absorption v $[I_2]$) [1]
 • using known concentrations of iodine [1]
 • place reaction tube mixture in colorimeter recording absorption v time [1]
 • convert absorbance to $[I_2]$ (using calibration graph) [1] [4]

(b) (i)



axes correctly labelled [1]
 straight line with negative gradient [1] [2]

(ii) value of the gradient = rate of reaction [1]

(c) so that concentrations of propanone and hydrogen ions remain (effectively) constant [1] 8

6 (a) (i) Acidified manganate(VII) acts as (its own) indicator/titration is self-indicating [1]

(ii) colourless [1] to pink [1] [2]

(b) Moles of manganate(VII) = $0.020 \times (18.0/1000) = 3.6 \times 10^{-4}$

1:5 ratio of $(MnO_4^-): Fe^{2+}$

Moles of iron(II) = $5 \times 3.6 \times 10^{-4} = 1.8 \times 10^{-3}$ [2]

(c) (i) $Zn + 2 Fe^{3+} \rightarrow Zn^{2+} + 2 Fe^{2+}$ [1]

reducing agent/ reduces iron(III) to iron(II) [1] [2]

(ii) Moles of manganate(VII) = $0.02 \times (30.0/1000) = 6.0 \times 10^{-4}$

Moles of iron(II) = $5 \times 6.0 \times 10^{-4} = 3.0 \times 10^{-3}$

Increase in moles of iron(II) = $3.0 \times 10^{-3} - 1.8 \times 10^{-3} = 1.2 \times 10^{-3}$

% increase = $(1.2 \times 10^{-3} / 3.0 \times 10^{-3}) \times 100 = 40\%$

or

$(30.0 - 18.0) / 30.0 \times 100 = 40\%$

Total

9

60



Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education

Centre Number

--	--	--	--	--

Candidate Number

--	--	--	--

Chemistry

Assessment Unit AS 1

assessing

Basic Concepts in Physical
and Inorganic Chemistry



[SCH12]

SCH12

Assessment

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

Answer **all fifteen** questions.

Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10. Keep in sequence when answering.

Answer **all five** questions in **Section B**. **You must answer the questions in the spaces provided.**

Do not write outside the boxed area on each page or on blank pages.

Complete in black ink only. **Do not write with a gel pen.**

INFORMATION FOR CANDIDATES

The total mark for this paper is 90.

Quality of written communication will be assessed in Question **15(d)**.

In Section A all questions carry equal marks, i.e. **one** mark for each question.

In Section B the figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

A Data Leaflet, containing a Periodic Table of the Elements, is included for your use.

12351

Assessment Level of Control:

Tick the relevant box (✓)

Controlled Conditions	
Other	



Section A

For each of the following questions only one of the lettered responses (A–D) is correct.

Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

- 1 Which one of the following elements is the strongest reducing agent?
 - A Calcium
 - B Fluorine
 - C Iodine
 - D Potassium

- 2 Electronegativity is the
 - A ability of an atom to attract electrons from another atom.
 - B attraction of an atom for a bonding pair of electrons.
 - C attraction between the nucleus and the electrons of an atom.
 - D energy required for a gaseous atom to gain an electron.

- 3 Addition of excess barium chloride solution to 1.60 g of a metal sulfate, dissolved in water, gave a precipitate of 2.33 g of barium sulfate. The metal sulfate was
 - A CaSO_4
 - B CuSO_4
 - C MgSO_4
 - D Na_2SO_4



- 4 Which gas contains the least number of electrons per mole?
- A Carbon dioxide
- B Nitrogen
- C Sulfur dioxide
- D Water vapour
- 5 8 g of a hydrocarbon contains 6 g of carbon. What is the formula of the hydrocarbon?
- A CH_4
- B C_2H_2
- C C_2H_4
- D C_6H_8
- 6 A mixture of sodium sulfate and copper(II) sulfate contains 3 moles of sulfate ions and 1 mole of copper(II) ions. The number of moles of sodium ions present is
- A 1
- B 2
- C 3
- D 4

[Turn over

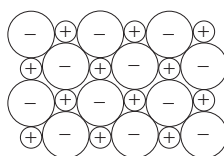


- 7 Naturally occurring hydrogen contains hydrogen, ${}^1_1\text{H}$ and deuterium, ${}^2_1\text{D}$. The following ions are produced in a mass spectrometer:



Which pair of ions has the same mass?

- A H^+ and D^+
- B H_2^+ and D_2^+
- C H_2^+ and D^+
- D H_2^+ and HD^+
- 8 The diagram below represents an ionic substance.



The substance is

- A LiI
- B MgCl_2
- C MgO
- D RbF
- 9 How many carbon atoms are present in 0.02 mg of graphite?
- A 1×10^{18}
- B 2×10^{18}
- C 1×10^{21}
- D 1×10^{22}



10 Which one of the following has the greatest mass?

A 1 mol of CH_3COCH_3

B 1 mol of CO_2

C 1 mol of MgCO_3

D 1 mol of $\text{Mg}(\text{OH})_2$

[Turn over

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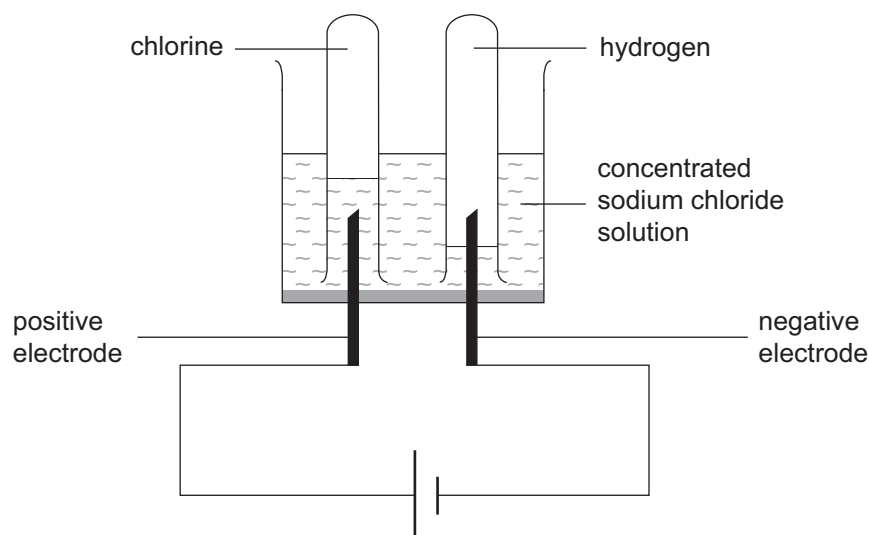


24SCH1205

Section B

Answer **all five** questions in this section

- 11** The electrolysis of a concentrated solution of sodium chloride can be carried out using the apparatus below.



- (a)** How would you alter the external circuit to show that electricity is flowing?

[1]



(b) At the positive electrode chloride ions lose electrons to form chlorine gas.

(i) Write an equation, including state symbols, for the reaction taking place.

_____ [2]

(ii) Describe the appearance of chlorine gas.

_____ [1]

(iii) Describe how you could show that chlorine is present in the test tube.

_____ [2]

(c) At the negative electrode hydrogen ions gain electrons to form hydrogen gas.

(i) Write an equation, including state symbols, for the reaction taking place.

_____ [2]

(ii) Describe the appearance of hydrogen gas.

_____ [1]

(iii) Describe how you could show that hydrogen is present in the test tube.

_____ [1]

(d) In the apparatus shown opposite, the electrodes are platinum. Suggest an alternative material that could be used in place of platinum.

_____ [1]

[Turn over



- (e) The solution around the negative electrode becomes alkaline as the electrolysis proceeds.

Explain how you would show that the solution becomes alkaline.

_____ [2]

- (f) Chlorine reacts with cold dilute sodium hydroxide solution and hot concentrated sodium hydroxide solution. Write equations for each of these reactions.

cold dilute

hot concentrated

_____ [4]





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(Questions continue overleaf)

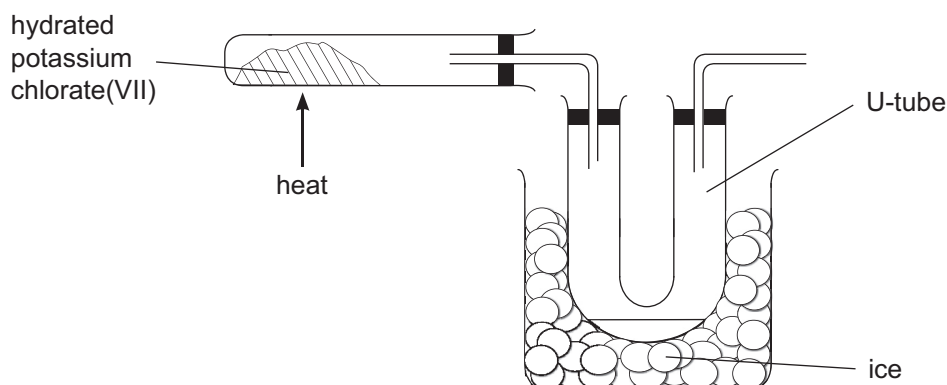
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24SCH1209

- 12 A sample of hydrated potassium chlorate(VII), $\text{KClO}_4 \cdot x\text{H}_2\text{O}$, was gently heated using the apparatus shown below. A colourless liquid was collected in the U-tube.



The white crystals of the hydrated potassium chlorate(VII) changed into a white powder. The colourless liquid collected is water.

- (a) (i) Define the term **hydrated**.

_____ [1]

- (ii) Why is ice used in the beaker?

_____ [1]

- (iii) Describe how you would determine the mass of the water collected.

_____ [2]



(iv) Draw a diagram to show a hydrogen bond between two molecules of water. Include all partial charges and lone pairs.

[3]

(b) Explain why the white crystals turn to a white powder.

[1]

(c) 3.85 g of hydrated potassium chlorate(VII) produced 0.44 g of water. Use these masses to deduce the formula of the hydrated potassium chlorate(VII).

[4]

[Turn over]



(d) When anhydrous potassium chlorate(VII) is strongly heated it produces potassium chloride and oxygen.

(i) Write the equation for the decomposition of anhydrous potassium chlorate(VII) to produce potassium chloride and oxygen.

_____ [1]

(ii) Describe how you could test for the ions present in potassium chloride.

_____ [5]

(iii) Describe the test for oxygen gas.

_____ [1]



(iv) Draw a labelled diagram to show how you would heat anhydrous potassium chlorate(VII) and collect and measure the volume of oxygen produced at room temperature and pressure.

[3]

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[Turn over



24SCH1213

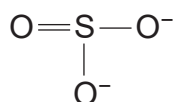
13 The sulfite, sulfate and thiosulfate ions have the following formulae.

Sulfite SO_3^{2-}

Sulfate SO_4^{2-}

Thiosulfate $\text{S}_2\text{O}_3^{2-}$

(a) The bonding in the sulfite ion can be represented by:



Draw and name the shape of this ion.

Name of shape _____ [2]

(b) Complete the table below.

ion	oxidation state of sulfur	formula of barium salt
SO_3^{2-}		
SO_4^{2-}		
$\text{S}_2\text{O}_3^{2-}$		

[3]



- (c) You are provided with a mixture of solid sodium nitrate and solid sodium sulfate. Describe how you would remove sulfate ions, using precipitation, from the mixture.

[4]

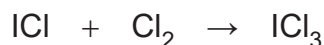
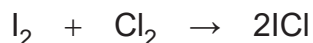
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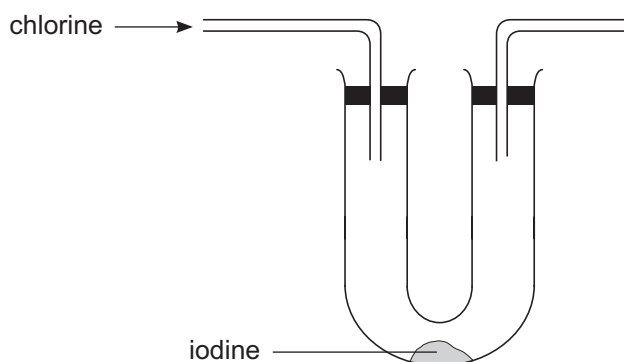


24SCH1215

- 14** Iodine reacts with chlorine at room temperature to produce iodine monochloride which then reacts further with chlorine to produce iodine trichloride.



The reaction may be carried out by passing chlorine over iodine crystals in a U-tube at room temperature.



Iodine monochloride forms black crystals that melt at 14 °C and iodine trichloride forms yellow crystals that melt at 101 °C.

- (a)** Explain why the reaction is carried out in a fume cupboard.

[1]

- (b)** Suggest why iodine trichloride is obtained as a liquid during the experiment.

[1]



(c) Iodine monochloride is a diatomic molecule.

Draw the dot and cross diagram for iodine monochloride using outer electrons only.

[1]

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[Turn over]



24SCH1217

(d) Iodine trichloride is a tetra-atomic molecule.

- (i)** Draw the dot and cross diagram for iodine trichloride using outer electrons only.

[1]

- (ii)** Draw the shape of the iodine trichloride molecule and show the polarity of the bonds.

[2]

- (iii)** Name the shape of the iodine trichloride molecule.

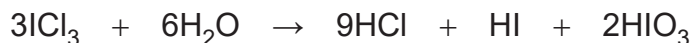
[1]

- (iv)** State and explain whether iodine trichloride is a polar or non-polar molecule.

[1]



- (e) Iodine trichloride reacts with water in a disproportionation reaction according to the following equation.



- (i) Calculate the oxidation number of iodine in ICl_3 , HI and HIO_3 .

_____ [2]

- (ii) Define a **disproportionation** reaction.

_____ [2]

- (iii) Use the oxidation numbers of iodine to explain why this is a disproportionation reaction.

_____ [2]

- (iv) Calculate the molarity of HIO_3 if 9.34 g of solid iodine trichloride reacts with excess water and the volume is made up to 250 cm^3 in a volumetric flask. Give your answer to 3 significant figures.

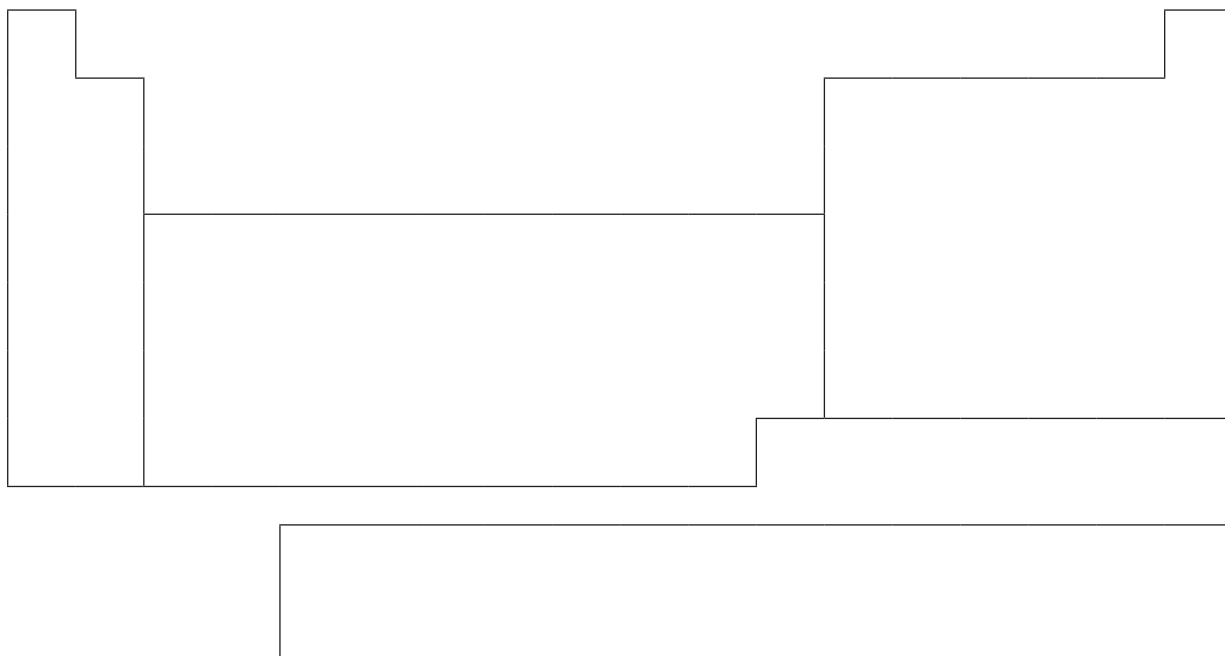
_____ [3]

[Turn over]



15 The Periodic Table on the data leaflet shows the elements with their relative atomic mass, symbol and atomic number.

(a) A representation of the Periodic Table is shown below. Four areas are outlined.



These areas contain s-block, p-block, d-block and f-block elements. Identify the four blocks by writing s, p, d and f on them. [2]

(b) Define **relative atomic mass**.

[2]



(c) The elements copper and chlorine are in different blocks of the Periodic Table.

(i) Write the electronic configurations of a copper atom and a chlorine atom.

copper _____

chlorine _____ [2]

(ii) Write an equation to represent the second ionisation of chlorine.

_____ [2]

(iii) Explain why the second ionisation energy of chlorine is larger than its first.

_____ [1]

(d) Describe the structure and bonding in lithium, carbon (diamond) and oxygen.

In this question you will be assessed on using your written communication skills including the use of specialist scientific terms.

_____ [6]



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24SCH1222





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24SCH1224



Rewarding Learning

**ADVANCED SUBSIDIARY (AS)
General Certificate of Education**

Chemistry

Assessment Unit AS 1

assessing

**Basic Concepts in Physical
and Inorganic Chemistry**

[SCH12]

Assessment

**MARK
SCHEME**

General Marking Instructions

Introduction

Mark schemes are published to assist teachers and students in their preparation for examinations. Through the mark schemes teachers and students will be able to see what the examiners are looking for in response to questions and exactly where the marks have been awarded. The publishing of the mark schemes may help to show that examiners are not concerned about finding out what a student does not know but rather with rewarding students for what they do know.

The purpose of mark schemes

Examination papers are set and revised by teams of examiners and revisers appointed by the Council. The teams of examiners and revisers include experienced teachers who are familiar with the level and standards expected of students in schools and colleges.

The job of the examiners is to set the questions and the mark schemes; and the job of the revisers is to review the questions and mark schemes commenting on a large range of issues about which they must be satisfied before the question papers and mark schemes are finalised.

The questions and the mark schemes are developed in association with each other so that the issues of differentiation and positive achievement can be addressed right from the start. Mark schemes, therefore, are regarded as part of an integral process which begins with the setting of questions and ends with the marking of the examination.

The main purpose of the mark scheme is to provide a uniform basis for the marking process so that all the markers are following exactly the same instructions and making the same judgements in so far as this is possible. Before marking begins a standardising meeting is held where all the markers are briefed using the mark scheme and samples of the students' work in the form of scripts. Consideration is also given at this stage to any comments on the operational papers received from teachers and their organisations. During this meeting, and up to and including the end of the marking, there is provision for amendments to be made to the mark scheme. What is published represents the final form of the mark scheme.

It is important to recognise that in some cases there may well be other correct responses which are equally acceptable to those published: the mark scheme can only cover those responses which emerged in the examination. There may also be instances where certain judgements may have to be left to the experience of the examiner, for example where there is no absolute correct response – all teachers will be familiar with making such judgements.

General marking guidance for GCE Chemistry

1. Alternative responses

In general, a solidus (/) used between responses indicates alternative answers or parts of an answer.

When a solidus may be confused with part of the answer (for example as a division sign or with units) “or” may be used to show alternatives.

Example: What is observed when propanone is warmed with Tollens' reagent? [1]

MS: remains colourless/no change [1]

2. Acceptable colours and observations

For the use of a solidus with the colours supplied in the **acceptable colour changes and observations** document, the solidus indicates that one of the responses should be given.

Example: What colour is the flame observed when a flame test is carried out on a sample of sodium chloride? [1]

MS: yellow/orange [1]

Response	Candidate Response	Marks awarded	Notes
1	yellow	1	Correct response
2	orange	1	Correct response
3	yellow-orange	0	Both responses with a hyphen not credited

In the acceptable colour changes and observations document, where two colours are given with a hyphen between them, this indicates that both colours are required in a response with the hyphen between them.

Example: What is observed when a few drops of sodium hydroxide solution are added to a solution containing Cr^{3+} ions? [1]

MS: green-blue ppt [1]

Response	Candidate Response	Marks awarded	Notes
1	green-blue ppt	1	Correct response
2	blue-green ppt	1	Correct response
3	blue/green ppt	0	Hyphen is required between the colours
4	blue ppt	0	Both colours required with a hyphen
5	green ppt	0	Both colours required with a hyphen

Note that in Booklet A of AS3 and A23, more flexibility is allowed on the marking of colours. A range of colours and shades of those colours will be accepted.

3. Brackets in a response

Normal parentheses used in a mark scheme response means that a term is not required for the response to be marked correct. However, an incorrect term would lose the mark.

Example: Describe how you would make a salt bridge using paper in the laboratory. [1]

MS: Soak a strip of filter paper in a (saturated/concentrated) solution of potassium chloride/potassium nitrate [1]

Response	Candidate Response	Marks awarded	Notes
1	soak filter paper in potassium chloride solution	1	Correct response
2	soak a piece of filter paper in dilute potassium nitrate solution	0	Not accepted as dilute is incorrect

4. Marking of lists

Where candidates give extra responses, additional correct responses can be ignored.

Additional neutral responses can also be ignored. A neutral response is one which does not have a bearing on the question but is not incorrect.

Additional incorrect responses **cancel out** a correct response to the marking point to which they pertain.

Example: Describe how the presence of chloride ions could be confirmed in a sample of solid sodium chloride. [4]

MS: dissolve the solid in water/nitric acid [1]

add silver nitrate solution [1]

white [1] precipitate [1]

[4]

Response	Candidate Response	Marks awarded	Notes
1	Dissolve the solid in nitric acid and add silver nitrate solution and you will get a white precipitate/solution	3	The last mark is not awarded as solution is an incorrect response cancelling out the correct response.
2	Put the solid in water and add silver nitrate and ammonia. You will get a white precipitate.	3	No mention of solution with silver nitrate and ammonia is not completely incorrect but in context of this response it cancels out the second mark as well if they had written solution
3	Add silver nitrate solution and you get a white precipitate/solution	2	First mark not awarded and precipitate mark not awarded as solution would cancel this out

5. Marking values where a range is given

Where a numerical range is given, correct responses are any value in the range, the range itself or any other range given which falls within the MS range.

Example: Name the reagents and conditions under which they are used to form the benzenediazonium ion from phenylamine. [2]

MS: sodium nitrite and (dil/conc) hydrochloric acid [1]
temperature 0 – 10 °C/in ice [1]

Focussing on the range awarded for the second mark.

Response	Candidate Response	Marks awarded	Notes
1	0	1	A single value within the accepted range
2	1	1	A single value within the accepted range
3	5	1	A single value within the accepted range
4	10	1	A single value within the accepted range
5	2.5	1	A single value within the accepted range
6	0–10	1	The accepted range
7	5–10	1	A range given within the accepted range
8	5–15	0	Range given outside the accepted range

6. Names of compounds

- Any question which asks you to “name” a chemical expects a correct chemical name and any errors in the name given by a candidate will be a –1 error.
- Where a question asks for an IUPAC name for an organic compound, the answer will require, where appropriate, correct locant numbers, dashes, commas and spaces. Each error is –1.
- The term systematic name is often used in inorganic nomenclature where oxidation states are required, e.g. sodium sulfate(IV). An incorrect oxidation state would be a –1 error.

7. Marking equations

Some general points about formulae and equations:

- Equations are usually worth 1 mark if they do not require balancing, however very familiar equations with balancing may only be worth 1 mark and in that case all formulae and balancing must be correct.
- Equations worth 2 marks are marked as [1] for all formulae being correct and [1] for correct balancing. The balancing mark is dependent on the formulae mark and is only considered if all the formulae are correct. If any formula incorrect, no marks are awarded.
- Some more complex structural equations are worth 3 marks. Details of how to mark these questions will be provided in the mark scheme.

8. QWC

Quality of written communication is marked using indicative content and a banded mark scheme.

The initial marking is for the indicative content points. The number of indicative content points places a candidate in a specific band. The overall marks awarded should be in that band based on the standard of the written communication.

A typical banded grid from a mark scheme where there would be 8 indicative content points is shown below:

Band	Response	Mark
A	Candidates must use appropriate specialist terms including a minimum of 7 points of indicative content. They use good spelling, punctuation and grammar and the form and style are of a high standard.	[5]–[6]
B	Candidates must use appropriate specialist terms including a minimum of 5 points of indicative content. They use satisfactory spelling, punctuation and grammar and the form and style are of a satisfactory standard.	[3]–[4]
C	Candidates provide a brief and partial response including a minimum of 2 points of indicative content. They use limited spelling, punctuation and grammar and they have made little use of specialist terms. The form and style are of a limited standard.	[1]–[2]
D	Response not worthy of credit.	[0]

[6]

A candidate who provides 5 indicative content points is placed in band B and can be awarded 3 or 4 overall marks (out of 6) for their response based on the spelling, punctuation and grammar.

Generally, the upper mark in a band would be awarded unless the quality of the written communication was very poor (i.e. multiple spelling, punctuation and grammar errors).

9. Marking calculations

- The total marks in a calculation are given at the end of the question part on the mark scheme and each error in the calculation is –1 mark.
- Errors in a calculation may be carried forward within part of a calculation. This should be indicated using ECF.
- Where a specific number of significant figures or decimal places is asked for in the question, this should be provided and not following this instruction would be classed as an error.
- The phrase “appropriate number of significant figures” is used where a candidate must make a decision about the number of significant figures they use for their final answer. This will be the lowest number of significant figures in the data provided which is used in the calculation.
- Calculations which use the number in the calculator and arrive at the correct answer (following any instructions regarding significant figures or decimal places) can be awarded full marks.
- A correct numerical answer to a calculation (given to the specified number of significant figures or decimal places or correct appropriate number of significant figures) can be awarded full marks provided that the question does not state that working out must be shown.
- Where appropriate, units would be required with a numerical answer.

10. Definitions

- Definitions are provided in the clarification of terms document. Each error/omission in the definition is –1. Correct extra information provided by a candidate would not be penalised.
- Minor errors should not be penalised if they do not change the meaning of the answer given.

11. Organic structures

- Structural formulae should generally show the individual groups or atoms bonded to each carbon atom in the main chain or ring structure. CH_3 , CH_2 , CH , OH , NH_2 , CN , CHO , CO , COOH , COCl , COO , CONH_2 etc do not need to be expanded to show all bonds except where specifically asked for in the question.
- Skeletal formulae must show the angled chain. Functional groups should be clearly shown with all atoms except for carbon atoms.
- Each organic structure is generally worth 1 mark. However more complex structures may be worth more marks.
- Connectivity of atoms in structural formulae should only be penalised based on what is presented in the table.
- Bonds to groups on the left (or right) of a structure should be connected to the correct atom apart from in the case of CH_3 groups.
- Bonds going vertically to groups should be bonded to the correct atom, however if the bond appears to be close to the required atom, this may be accepted.

Accepted		Not accepted		
$\begin{array}{c} \\ \text{H}_3\text{C}-\text{C}- \\ \end{array}$		N/A		
$\begin{array}{c} \\ \text{CH}_3-\text{C}- \\ \end{array}$		N/A		
$\begin{array}{c} \\ \text{CH}_3\text{CH}_2-\text{C}- \\ \end{array}$		$\begin{array}{c} \\ \text{CH}_2\text{CH}_3-\text{C}- \\ \end{array}$		
$\begin{array}{c} \\ -\text{C}- \\ \\ \text{CH}_2\text{CH}_3 \end{array}$		$\begin{array}{c} \\ -\text{C}- \\ \\ \text{CH}_3\text{CH}_2 \end{array}$		
$\begin{array}{c} \\ \text{H}_2\text{N}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{NH}_2 \end{array}$	$\begin{array}{c} \\ \text{NH}_2-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{H}_2\text{N} \end{array}$	
$\begin{array}{c} \\ \text{HO}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{OH} \end{array}$	$\begin{array}{c} \\ \text{OH}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{HO} \end{array}$	
$\begin{array}{c} \\ \text{NC}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{CN} \end{array}$	$\begin{array}{c} \\ \text{CN}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{NC} \end{array}$	
$\begin{array}{c} \\ \text{OHC}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{CHO} \end{array}$	$\begin{array}{c} \\ \text{CHO}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{OHC} \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{CHO} \end{array}$
$\begin{array}{c} \\ \text{HOOC}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{COOH} \end{array}$	$\begin{array}{c} \\ \text{COOH}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{HOOC} \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{COOH} \end{array}$

12. Mechanisms

The following features are required for electrophilic addition, electrophilic substitution, nucleophilic substitution and nucleophilic addition mechanisms:

1. Curly arrows (coming from a bond or the ring of a benzene ring or from a lone pair of electrons)
When the curly arrow is showing the formation of a bond, it may go to the atom, close to the atom or in the position where the bond would form.
2. Lone pairs of electrons shown as a double dot beside the relative atom/ion.
3. Any charges on the intermediates in the mechanism.
4. Any leaving group shown in the products for substitution mechanisms.

Note that for radical substitution mechanisms the dot may be placed before or after the radical.

13. Marking diagrams

- Diagrams of apparatus are again marked in terms of the errors. Each error is –1.
- Diagrams of apparatus are expected to be two-dimensional cross-sectional diagrams of the assembled apparatus with clear labelling and recognisable pieces of apparatus.
- There should be no blockage to the flow of liquids or gases in a diagram of apparatus such as a line across the end of a delivery tube or the exit or entry from a piece of glassware unless intentional such as the valve in a separating funnel.

14. Solution/aqueous

- When describing a practical method or test and a solution of a substance is used, the term **solution** is required in the response unless it is in brackets in the mark scheme.
- The term solution is equivalent to aqueous. For example, aqueous sodium hydroxide is the same as sodium hydroxide solution.
- Solution is not required for dilute acids.

Section A

- 1 D
- 2 B
- 3 B
- 4 D
- 5 A
- 6 D
- 7 C
- 8 A
- 9 A
- 10 C

[1] for each correct answer

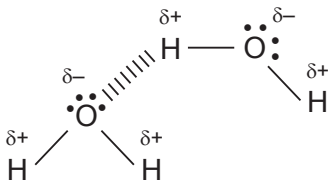
[10]

Section A

AVAILABLE MARKS	
	10
	10

Section B

AVAILABLE
MARKS

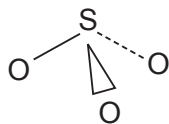
- 11 (a)** include a light bulb or an ammeter in the circuit [1]
- (b) (i)** $2\text{Cl}^-(\text{aq}) \rightarrow \text{Cl}_2(\text{g}) + 2\text{e}^-$ [2]
- (ii)** green/yellow-green/green-yellow [1]
- (iii)** damp Universal Indicator paper/litmus paper [1] is bleached [1] [2]
- (c) (i)** $2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g})$ [2]
- (ii)** colourless [1]
- (iii)** pop with burning splint [1]
- (d)** carbon/graphite [1]
- (e)** add Universal Indicator/suitable indicator [1] goes blue/correct colour [1] [2]
- (f)** $2\text{NaOH} + \text{Cl}_2 \rightarrow \text{NaCl} + \text{NaClO} + \text{H}_2\text{O}$ [2]
 $6\text{NaOH} + 3\text{Cl}_2 \rightarrow 5\text{NaCl} + \text{NaClO}_3 + 3\text{H}_2\text{O}$ [2] [4]
- 12 (a) (i)** a salt which contains water of crystallisation [1]
- (ii)** to condense (the water vapour) [1]
- (iii)** weigh U-tube without the water [1]
 weigh U-tube with the water and subtract the values [1] [2]
- (iv)**
- 

hydrogen bond drawn [1]
 2 lone pairs on each O atom [1]
 all partial charges [1] [3]
- (b)** water of crystallisation is lost/becomes anhydrous [1]
- (c)** mass of potassium chlorate(VII) = $3.85\text{g} - 0.44\text{g} = 3.41\text{g}$
 RFM of $\text{KClO}_4 = 39 + 35.5 + 4 \times 16 = 138.5$
 moles of potassium chlorate(VII) = $3.41/138.5 = 0.0246$
 moles of water = $\frac{0.44}{18} = 0.0244$
 $\text{KClO}_4 \cdot \text{H}_2\text{O}$ [4]
- (d) (i)** $\text{KClO}_4 \rightarrow \text{KCl} + 2\text{O}_2$ [1]
- (ii)** flame test [1] gives lilac flame [1]
 dissolve [1] silver nitrate solution [1] white precipitate [1] [5]
- (iii)** glowing splint relights [1]
- (iv)** • suitable container containing KClO_4
 • heat
 • connection to gas syringe/inverted measuring cylinder/inverted burette over water
 error [−1] [3]

17

22

13 (a)



[1]

pyramidal

[1]

[2]

(b)

ion	oxidation state of sulfur	formula of barium salt
SO_3^{2-}	+4	BaSO_3
SO_4^{2-}	+6	BaSO_4
$\text{S}_2\text{O}_3^{2-}$	+2	BaS_2O_3

[3]

(c)

dissolve the mixture in (water) [1]

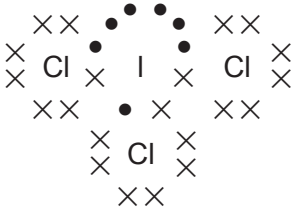
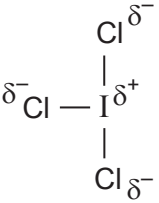
add excess [1] barium chloride solution/barium nitrate solution [1]

filter the precipitate [1]

[4]

AVAILABLE
MARKS

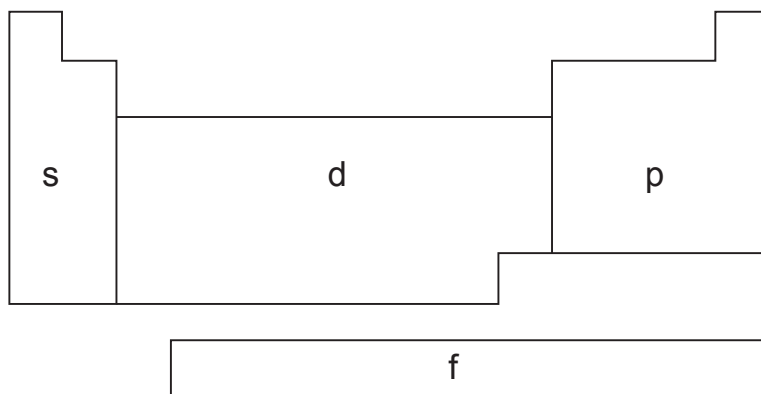
9

- 14 (a) chlorine is poisonous/toxic [1]
- (b) the reaction is exothermic [1]
- (c)  [1]
- (d) (i)  [1]
- (ii) 
correct shape drawn [1]
all bond polarities shown [1] [2]
- (iii) T-shaped [1]
- (iv) polar because the dipoles do not cancel [1]
- (e) (i) +3 -1 +5 [2]
- (ii) oxidation and reduction of the same element in the same reaction [2]
- (iii) +3 to +5 oxidation [1]
+3 to -1 reduction [1] [2]
- (iv) moles of $\text{ICl}_3 = 9.34/233.5 = 0.04$
moles of $\text{HIO}_3 = (0.04/3) \times 2 = 0.02667$
molarity = $0.02667 \times 4 = 0.107 \text{ M}$ [3]

AVAILABLE
MARKS

17

15 (a)



[2]

(b) the average (weighted mean) mass of an atom of an element relative to one-twelfth of the mass of an atom of carbon-12

[2]

(c) (i) Cu $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$
 Cl $1s^2 2s^2 2p^6 3s^2 3p^5$

[2]

(ii) $Cl^+(g) \rightarrow Cl^{2+}(g) + e^-$
 equation [1]; state symbols [1]

[2]

(iii) effective nuclear charge is greater

[1]

(d) **indicative content**

Lithium:

- (metallic) lattice
- attraction between positive ions and delocalised electrons

Carbon (diamond):

- giant covalent/macromolecular
- each carbon covalently bond to 4 others/tetrahedral

Oxygen:

- molecular covalent
- van der Waals' forces between molecules
- double covalent bond between (oxygen) atoms

Band	Response	Mark
A	Candidates must use appropriate specialist terms using a minimum of 6 points of indicative content. They must use good spelling, punctuation and grammar and the form and style are of an excellent standard.	[5]–[6]
B	Candidates must use appropriate specialist terms using a minimum of 4 points of indicative content. They must use satisfactory spelling, punctuation and grammar and the form and style are of a good standard.	[3]–[4]
C	Candidates use a minimum of 3 points of indicative content. They use limited correct spelling, punctuation and grammar and the form and style are of a basic standard.	[1]–[2]
D	Not worthy of credit.	[0]

[6]

AVAILABLE
MARKS

15

Section B

80

Total

90



Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education

Centre Number

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Candidate Number

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Chemistry

Assessment Unit AS 2

assessing

Further Physical and Inorganic
Chemistry and an Introduction to
Organic Chemistry



[SCH22]

SCH22

Assessment

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

Answer **all sixteen** questions.

Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10. Keep in sequence when answering.

Answer **all six** questions in **Section B**. **You must answer the questions in the spaces provided.**

Do not write outside the boxed area on each page or on blank pages.

Complete in black ink only. **Do not write with a gel pen.**

INFORMATION FOR CANDIDATES

The total mark for this paper is 90.

Quality of written communication will be assessed in Question **15(c)(ii)**.

In Section A all questions carry equal marks, i.e. **one** mark for each question.

In Section B the figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

A Periodic Table of Elements, containing some data, is included with this question paper.

12526

Assessment Level of Control:

Tick the relevant box (✓)

Controlled Conditions	
Other	



20SCH2201

Section A

For each of the following questions only **one** of the lettered responses (A – D) is correct. **Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.**

- 1 Damage to the ozone layer allows more
 - A infrared radiation to escape from the atmosphere.
 - B infrared radiation to reach the Earth's surface.
 - C ultraviolet radiation to escape from the atmosphere.
 - D ultraviolet radiation to reach the Earth's surface.

- 2 Which is the electronic configuration of a Group II ion?
 - A $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$
 - B $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$
 - C $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2$
 - D $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$

- 3 The intermolecular forces present in alcohols are
 - A hydrogen bonds.
 - B hydrogen bonds and dipole-dipole attractions.
 - C hydrogen bonds and van der Waals' forces.
 - D hydrogen bonds, dipole-dipole attractions and van der Waals' forces.



4 When excess calcium is added to water the

- A solution formed turns cloudy.
- B solution formed turns blue litmus paper red.
- C gas given off relights a glowing splint.
- D gas given off turns limewater milky.

5 Which molecule has the highest boiling point?

- A C_2H_4
- B C_2H_6
- C $\text{C}_2\text{H}_5\text{OH}$
- D $\text{C}_2\text{H}_5\text{Cl}$

6 Which is the empirical formula of a hydrocarbon containing 82.8%, by mass, of carbon?

- A C_2H_5
- B C_4H_5
- C C_4H_{10}
- D C_5H_4

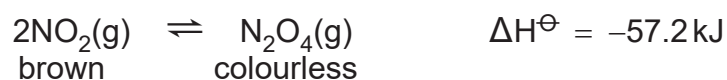
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7 Which halogenoalkane will **not** damage the ozone layer?

- A $\text{CH}_3\text{CH}_2\text{F}$
- B $\text{CH}_2\text{ClCH}_2\text{F}$
- C $\text{CHCl}_2\text{CH}_2\text{F}$
- D $\text{CHCl}_2\text{CHF}_2$

8 For the following equilibrium



which statement is correct?

- A Increasing the temperature makes the mixture lighter coloured
 - B Increasing the pressure makes the mixture darker coloured
 - C The equilibrium mixture is coloured
 - D The equilibrium mixture is colourless
- 9 Which molecule has the greatest number of lone pairs of electrons?
- A CH_3CHO
 - B $\text{CH}_3\text{CH}_2\text{Cl}$
 - C $\text{CH}_3\text{CH}_2\text{OH}$
 - D CH_2CH_2



10 Which structure can **not** be formed in the polymerisation of chloroethene, CH_2CHCl ?

- A $-\text{CHClCH}_2\text{CHClCH}_2-$
- B $-\text{CH}_2\text{CHClCHClCH}_2-$
- C $-\text{CHClCH}_2\text{CH}_2\text{CHCl}-$
- D $-\text{CH}_2\text{CCl}_2\text{CH}_2\text{CH}_2-$

[Turn over



Section B

Answer **all six** questions in this section

11 Decane is an alkane found in petrol.

(a) Decane has ten carbon atoms. Write the formula of decane.

_____ [1]

(b) State **three** pollutants which are formed when petrol is burned.

_____ [3]

(c) Decane can undergo thermal cracking to form a molecule of hexane and a molecule of an alkene. The alkene exhibits geometric isomerism.

(i) Define the term **geometric isomerism**.

_____ [1]

(ii) Write the equation for the thermal cracking of decane.

_____ [1]

(iii) Draw and identify the geometric isomers of the alkene formed.

[2]





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12526

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20SCH2207

12 (a) Calcium and barium are found in Group II of the Periodic Table.

Explain why calcium and barium are described as s-block elements.

_____ [1]

(b) The table below shows the first ionisation energies for the Group II elements.

element	first ionisation energy /kJ mol ⁻¹
beryllium	900
magnesium	740
calcium	590
strontium	550
barium	500

(i) Write the equation, including state symbols, for the first ionisation energy of calcium.

_____ [1]

(ii) Explain the trend in the first ionisation energies of the Group II elements.

_____ [2]



- (c) State and explain the change in thermal stability of the Group II carbonates as the group is descended.

[3]

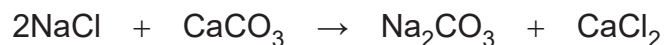
- (d) Calcium and barium both react with water. Write an equation for the reaction of barium with water.

[2]

[Turn over



- 13 Sodium carbonate, Na_2CO_3 , is manufactured from concentrated brine and limestone. The overall equation for the process is:



- (a) (i) Calculate the percentage atom economy for the production of sodium carbonate, giving your answer to one decimal place.

_____ [2]

- (ii) The process produces 1.0 tonne of sodium carbonate from 1.0 tonne of limestone with excess brine. Calculate the percentage yield.

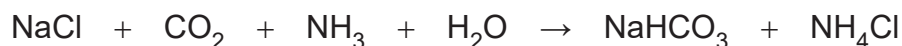
_____ [3]

- (b) The process takes place in four stages.

Stage I The limestone is calcined at $950 - 1100^\circ\text{C}$.



Stage II Carbon dioxide is passed through concentrated aqueous brine and ammonia.



Stage III The sodium hydrogencarbonate is filtered off and the ammonium chloride solution is reacted with calcium oxide.



Stage IV The sodium hydrogencarbonate is calcined at $160 - 230^\circ\text{C}$.



- (i) Suggest what is meant by the term **calcined**.

_____ [1]



(ii) Suggest why ammonia is not added continuously throughout the process.

[1]

(c) The enthalpy change for the overall process can be calculated using Hess's Law and standard enthalpy of formation, $\Delta_f H^\ominus$, values.

(i) State **Hess's Law**.

[2]

(ii) Explain what is meant by the term **standard enthalpy of formation**, $\Delta_f H^\ominus$.

[2]

(iii) Use the standard enthalpy of formation values from the table below to calculate the enthalpy change for the overall chemical equation for the process.

compound	$\Delta_f H^\ominus / \text{kJ mol}^{-1}$
NaCl	-411
CaCO ₃	-1207
Na ₂ CO ₃	-1131
CaCl ₂	-795

[2]

[Turn over]



- 14** Sulfuric acid is manufactured by the Contact process. Sulfur is burned to form sulfur dioxide. The sulfur dioxide is passed into a catalytic chamber and reacts with oxygen to form sulfur trioxide.



- (a) (i)** Name the catalyst used in the catalytic chamber.

_____ [1]

- (ii)** State the conditions of temperature and pressure used.

_____ [2]

- (iii)** State and explain the effect of increasing the temperature on the yield of sulfur trioxide and the rate of the reaction.

Yield: _____

Rate: _____

_____ [4]



- (iv) State and explain the effect of increasing the pressure on the yield of sulfur trioxide and the rate of the reaction.

Yield: _____

Rate: _____

_____ [4]

- (v) Write an expression for the equilibrium constant for this reaction and state its units.

_____ [2]

[Turn over]



(b) (i) Complete the diagram below to draw the Maxwell–Boltzmann distribution of energies for molecules in a gaseous mixture by:

- labelling the axes.
- drawing a curve, labelled A, to represent the distribution of energies.
- marking and labelling the activation energy for the uncatalysed reaction, E_a , and the catalysed reaction, $E_{a(\text{cat})}$.



[3]

(ii) Draw a second curve on the diagram above, labelled B, to show the distribution of energies when the temperature is lowered.

[2]





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20SCH2215

15 1-chloro-2-methylpropane, $(\text{CH}_3)_2\text{CHCH}_2\text{Cl}$, is one of two organic products produced by the reaction of hydrogen chloride with 2-methylpropene.

(a) (i) Name and draw the mechanism for forming 1-chloro-2-methylpropane.

Name: _____

Mechanism:

[5]

(ii) 2-chloro-2-methylpropane is also formed during the preparation. State and explain which product will be formed in the greater quantity.

[2]

(b) 1-chloro-2-methylpropane reacts with potassium cyanide.

(i) Write the equation for the reaction.

_____ [1]

(ii) Give the IUPAC name of the organic product formed in the reaction.

_____ [1]



16 (a) Butane and butan-1-ol are both used as fuels.

(i) Write the equations for the complete combustion of butane and butan-1-ol.

_____ [2]

(ii) The enthalpy of combustion of butane is $-2877 \text{ kJ mol}^{-1}$ and that of butan-1-ol is $-2674 \text{ kJ mol}^{-1}$. Explain, in terms of bonds, the difference in the enthalpies of combustion.

_____ [2]

(b) (i) Draw the structure and give the IUPAC name of the secondary alcohol which is an isomer of butan-1-ol.

_____ [2]

(ii) Draw the structure and give the IUPAC name of the tertiary alcohol which is an isomer of butan-1-ol.

_____ [2]



- (c) Oxidation can be used to distinguish between the secondary and tertiary alcohols identified in (b)(i) and (b)(ii).

Name a suitable oxidising agent and state the conditions needed. Give the observations in each case.

[4]

- (d) Infrared spectroscopy can be used to distinguish between butanone and butanoic acid.

- (i) Explain how infrared absorption arises in molecules.

[1]

- (ii) Explain how infrared spectroscopy could be used to distinguish between butanone and butanoic acid.

[2]

THIS IS THE END OF THE QUESTION PAPER



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20SCH2220



Rewarding Learning

**ADVANCED SUBSIDIARY (AS)
General Certificate of Education**

Chemistry

Assessment Unit AS 2

assessing

Further Physical and Inorganic Chemistry
and an Introduction to Organic Chemistry

[SCH22]

Assessment

MARK SCHEME

General Marking Instructions

Introduction

The main purpose of the mark scheme is to ensure that examinations are marked accurately, consistently and fairly. The mark scheme provides examiners with an indication of the nature and range of candidates' responses likely to be worthy of credit. It also sets out the criteria which they should apply in allocating marks to candidates' responses.

Assessment objectives

Below are the assessment objectives for **GCE Chemistry**:

Candidates should be able to:

AO1	Demonstrate knowledge and understanding of scientific ideas, processes, techniques and procedures.
AO2	Apply knowledge and understanding of scientific ideas, processes, techniques and procedures: • in a theoretical context • in a practical context • when handling quantitative and qualitative data
AO3	Analyse, interpret and evaluate scientific information, ideas and evidence (in relation to particular issues) • make judgements and reach conclusions • develop and refine practical design and procedures

Quality of candidates' responses

In marking the examination papers, examiners should be looking for a quality of response reflecting the level of maturity which may reasonably be expected of a 17- or 18-year-old which is the age at which the majority of candidates sit their GCE examinations.

Flexibility in marking

Mark schemes are not intended to be totally prescriptive. No mark scheme can cover all the responses which candidates may produce. In the event of unanticipated answers, examiners are expected to use their professional judgement to assess the validity of answers. If an answer is particularly problematic, then examiners should seek the guidance of the Supervising Examiner.

Positive marking

Examiners are encouraged to be positive in their marking, giving appropriate credit for what candidates know, understand and can do rather than penalising candidates for errors or omissions. The exception to this for GCE Chemistry is when Examiners are marking complex calculations and mechanisms when the Examiners are briefed to mark by error or omission. Examiners should make use of the whole of the available mark range for any particular question and be prepared to award full marks for a response which is as good as might reasonably be expected of a 17- or 18-year-old GCE candidate.

Awarding zero marks

Marks should only be awarded for valid responses and no marks should be awarded for an answer which is completely incorrect or inappropriate.

General marking guidance for GCE Chemistry

1. Alternative responses

In general, a solidus (/) used between responses indicates alternative answers or parts of an answer.

When a solidus may be confused with part of the answer (for example as a division sign or with units) “or” may be used to show alternatives.

Example: What is observed when propanone is warmed with Tollens’ reagent? [1]
MS: remains colourless/no change [1]

2. Acceptable colours and observations

For the use of a solidus with the colours supplied in the **acceptable colour changes and observations** document, the solidus indicates that one of the responses should be given.

Example: What colour is the flame observed when a flame test is carried out on a sample of sodium chloride? [1]
MS: yellow/orange [1]

Response	Candidate Response	Marks awarded	Notes
1	yellow	1	Correct response
2	orange	1	Correct response
3	yellow-orange	0	Both responses with a hyphen not credited

In the acceptable colour changes and observations document, where two colours are given with a hyphen between them, this indicates that both colours are required in a response with the hyphen between them.

Example: What is observed when a few drops of sodium hydroxide solution are added to a solution containing Cr^{3+} ions? [1]
MS: green-blue ppt [1]

Response	Candidate Response	Marks awarded	Notes
1	green-blue ppt	1	Correct response
2	blue-green ppt	1	Correct response
3	blue/green ppt	0	Hyphen is required between the colours
4	blue ppt	0	Both colours required with a hyphen
5	green ppt	0	Both colours required with a hyphen

Note that in Booklet A of AS3 and A23, more flexibility is allowed on the marking of colours. A range of colours and shades of those colours will be accepted.

3. Brackets in a response

Normal parentheses used in a mark scheme response means that a term is not required for the response to be marked correct. However, an incorrect term would lose the mark.

Example: Describe how you would make a salt bridge using paper in the laboratory. [1]
MS: Soak a strip of filter paper in a (saturated/concentrated) solution of potassium chloride/potassium nitrate [1]

Response	Candidate Response	Marks awarded	Notes
1	soak filter paper in potassium chloride solution	1	Correct response
2	soak a piece of filter paper in dilute potassium nitrate solution	0	Not accepted as dilute is incorrect

4. Marking of lists

Where candidates give extra responses, additional correct responses can be ignored.

Additional neutral responses can also be ignored. A neutral response is one which does not have a bearing on the question but is not incorrect.

Additional incorrect responses **cancel out** a correct response to the marking point to which they pertain.

Example: Describe how the presence of chloride ions could be confirmed in a sample of solid sodium chloride. [4]

MS: dissolve the solid in water/nitric acid [1]
add silver nitrate solution [1]
white [1] precipitate [1]

[4]

Response	Candidate Response	Marks awarded	Notes
1	Dissolve the solid in nitric acid and add silver nitrate solution and you will get a white precipitate/solution	3	The last mark is not awarded as solution is an incorrect response cancelling out the correct response.
2	Put the solid in water and add silver nitrate and ammonia. You will get a white precipitate.	3	No mention of solution with silver nitrate and ammonia is not completely incorrect but in context of this response it cancels out the second mark as well if they had written solution
3	Add silver nitrate solution and you get a white precipitate/solution	2	First mark not awarded and precipitate mark not awarded as solution would cancel this out

5. Marking values where a range is given

Where a numerical range is given, correct responses are any value in the range, the range itself or any other range given which falls within the MS range.

Example: Name the reagents and conditions under which they are used to form the benzenediazonium ion from phenylamine. [2]

MS: sodium nitrite and (dil/conc) hydrochloric acid [1]
temperature 0 – 10 °C/in ice [1]

Focussing on the range awarded for the second mark.

Response	Candidate Response	Marks awarded	Notes
1	0	1	A single value within the accepted range
2	1	1	A single value within the accepted range
3	5	1	A single value within the accepted range
4	10	1	A single value within the accepted range
5	2.5	1	A single value within the accepted range
6	0–10	1	The accepted range
7	5–10	1	A range given within the accepted range
8	5–15	0	Range given outside the accepted range

6. Names of compounds

- Any question which asks you to “name” a chemical expects a correct chemical name and any errors in the name given by a candidate will be a –1 error.
- Where a question asks for an IUPAC name for an organic compound, the answer will require, where appropriate, correct locant numbers, dashes, commas and spaces. Each error is –1.
- The term systematic name is often used in inorganic nomenclature where oxidation states are required, e.g. sodium sulfate(IV). An incorrect oxidation state would be a –1 error.

7. Marking equations

Some general points about formulae and equations:

- Equations are usually worth 1 mark if they do not require balancing, however very familiar equations with balancing may only be worth 1 mark and in that case all formulae and balancing must be correct.
- Equations worth 2 marks are marked as [1] for all formulae being correct and [1] for correct balancing. The balancing mark is dependent on the formulae mark and is only considered if all the formulae are correct. If any formula incorrect, no marks are awarded.
- Some more complex structural equations are worth 3 marks. Details of how to mark these questions will be provided in the mark scheme.

8. QWC

Quality of written communication is marked using indicative content and a banded mark scheme.

The initial marking is for the indicative content points. The number of indicative content points places a candidate in a specific band. The overall marks awarded should be in that band based on the standard of the written communication.

A typical banded grid from a mark scheme where there would be 8 indicative content points is shown below:

Band	Response	Mark
A	Candidates must use appropriate specialist terms including a minimum of 7 points of indicative content. They use good spelling, punctuation and grammar and the form and style are of a high standard.	[5]–[6]
B	Candidates must use appropriate specialist terms including a minimum of 5 points of indicative content. They use satisfactory spelling, punctuation and grammar and the form and style are of a satisfactory standard.	[3]–[4]
C	Candidates provide a brief and partial response including a minimum of 2 points of indicative content. They use limited spelling, punctuation and grammar and they have made little use of specialist terms. The form and style are of a limited standard.	[1]–[2]
D	Response not worthy of credit.	[0]

[6]

A candidate who provides 5 indicative content points is placed in band B and can be awarded 3 or 4 overall marks (out of 6) for their response based on the spelling, punctuation and grammar.

Generally, the upper mark in a band would be awarded unless the quality of the written communication was very poor (i.e. multiple spelling, punctuation and grammar errors).

9. Marking calculations

- The total marks in a calculation are given at the end of the question part on the mark scheme and each error in the calculation is –1 mark.
- Errors in a calculation may be carried forward within part of a calculation. This should be indicated using ECF.
- Where a specific number of significant figures or decimal places is asked for in the question, this should be provided and not following this instruction would be classed as an error.
- The phrase “appropriate number of significant figures” is used where a candidate must make a decision about the number of significant figures they use for their final answer. This will be the lowest number of significant figures in the data provided which is used in the calculation.
- Calculations which use the number in the calculator and arrive at the correct answer (following any instructions regarding significant figures or decimal places) can be awarded full marks.
- A correct numerical answer to a calculation (given to the specified number of significant figures or decimal places or correct appropriate number of significant figures) can be awarded full marks provided that the question does not state that working out must be shown.
- Where appropriate, units would be required with a numerical answer.

10. Definitions

- Definitions are provided in the clarification of terms document. Each error/omission in the definition is –1. Correct extra information provided by a candidate would not be penalised.
- Minor errors should not be penalised if they do not change the meaning of the answer given.

11. Organic structures

- Structural formulae should generally show the individual groups or atoms bonded to each carbon atom in the main chain or ring structure. CH_3 , CH_2 , CH , OH , NH_2 , CN , CHO , CO , COOH , COCl , COO , CONH_2 etc do not need to be expanded to show all bonds except where specifically asked for in the question.
- Skeletal formulae must show the angled chain. Functional groups should be clearly shown with all atoms except for carbon atoms.
- Each organic structure is generally worth 1 mark. However more complex structures may be worth more marks.
- Connectivity of atoms in structural formulae should only be penalised based on what is presented in the table.
- Bonds to groups on the left (or right) of a structure should be connected to the correct atom apart from in the case of CH_3 groups.
- Bonds going vertically to groups should be bonded to the correct atom, however if the bond appears to be close to the required atom, this may be accepted.

Accepted		Not accepted		
$\begin{array}{c} \\ \text{H}_3\text{C}-\text{C}- \\ \end{array}$		N/A		
$\begin{array}{c} \\ \text{CH}_3-\text{C}- \\ \end{array}$		N/A		
$\begin{array}{c} \\ \text{CH}_3\text{CH}_2-\text{C}- \\ \end{array}$		$\begin{array}{c} \\ \text{CH}_2\text{CH}_3-\text{C}- \\ \end{array}$		
$\begin{array}{c} \\ -\text{C}- \\ \\ \text{CH}_2\text{CH}_3 \end{array}$		$\begin{array}{c} \\ -\text{C}- \\ \\ \text{CH}_3\text{CH}_2 \end{array}$		
$\begin{array}{c} \\ \text{H}_2\text{N}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{NH}_2 \end{array}$	$\begin{array}{c} \\ \text{NH}_2-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{H}_2\text{N} \end{array}$	
$\begin{array}{c} \\ \text{HO}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{OH} \end{array}$	$\begin{array}{c} \\ \text{OH}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{HO} \end{array}$	
$\begin{array}{c} \\ \text{NC}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{CN} \end{array}$	$\begin{array}{c} \\ \text{CN}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{NC} \end{array}$	
$\begin{array}{c} \\ \text{OHC}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{CHO} \end{array}$	$\begin{array}{c} \\ \text{CHO}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{OHC} \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{CHO} \end{array}$
$\begin{array}{c} \\ \text{HOOC}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{COOH} \end{array}$	$\begin{array}{c} \\ \text{COOH}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{HOOC} \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{COOH} \end{array}$

12. Mechanisms

The following features are required for electrophilic addition, electrophilic substitution, nucleophilic substitution and nucleophilic addition mechanisms:

1. Curly arrows (coming from a bond or the ring of a benzene ring or from a lone pair of electrons)
When the curly arrow is showing the formation of a bond, it may go to the atom, close to the atom or in the position where the bond would form.
2. Lone pairs of electrons shown as a double dot beside the relative atom/ion.
3. Any charges on the intermediates in the mechanism.
4. Any leaving group shown in the products for substitution mechanisms.

Note that for radical substitution mechanisms the dot may be placed before or after the radical.

13. Marking diagrams

- Diagrams of apparatus are again marked in terms of the errors. Each error is –1.
- Diagrams of apparatus are expected to be two-dimensional cross-sectional diagrams of the assembled apparatus with clear labelling and recognisable pieces of apparatus.
- There should be no blockage to the flow of liquids or gases in a diagram of apparatus such as a line across the end of a delivery tube or the exit or entry from a piece of glassware unless intentional such as the valve in a separating funnel.

14. Solution/aqueous

- When describing a practical method or test and a solution of a substance is used, the term **solution** is required in the response unless it is in brackets in the mark scheme.
- The term solution is equivalent to aqueous. For example, aqueous sodium hydroxide is the same as sodium hydroxide solution.
- Solution is not required for dilute acids.

Section A

- 1 D
- 2 D
- 3 D
- 4 A
- 5 C
- 6 A
- 7 A
- 8 C
- 9 B
- 10 D

[1] for each correct answer

[10]

Section A

AVAILABLE MARKS	
	10
	10

Section B

AVAILABLE
MARKS

- 11 (a)** $C_{10}H_{22}$ [1]
- (b)** Carbon monoxide, carbon, nitrogen oxides, sulfur oxides
(Any **three**) [3]
- (c) (i)** Molecules with the same structural formula, but different arrangement
of atoms, due to the presence of one or more $C=C$ bonds [1]
- (ii)** $C_{10}H_{22} \rightarrow C_6H_{14} + C_4H_8$ [1]
- (iii)**
- $$\begin{array}{c}
 \text{H} \quad \quad \text{CH}_3 \\
 \diagdown \quad \diagup \\
 \text{C} = \text{C} \\
 \diagup \quad \diagdown \\
 \text{CH}_3 \quad \quad \text{H}
 \end{array}$$

E-but-2-ene

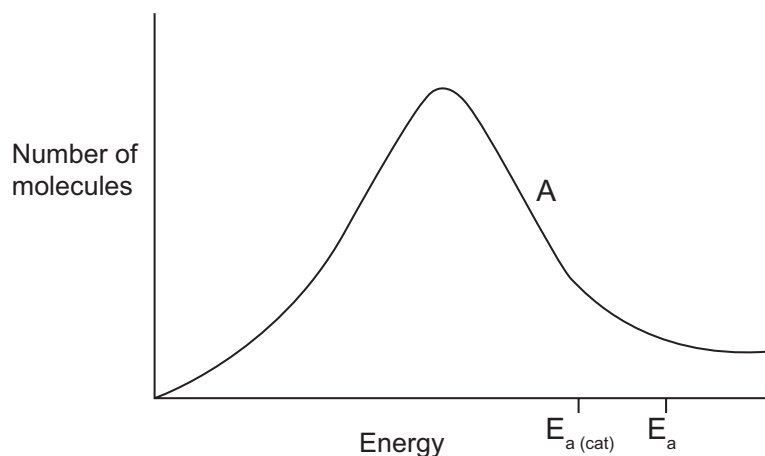
$$\begin{array}{c}
 \text{H} \quad \quad \text{H} \\
 \diagdown \quad \diagup \\
 \text{C} = \text{C} \\
 \diagup \quad \diagdown \\
 \text{CH}_3 \quad \quad \text{CH}_3
 \end{array}$$

Z-but-2-ene
- [2] 8
- 12 (a)** Outer electron(s) are in an s-subshell/orbital [1]
- (b) (i)** $\text{Ca(g)} \rightarrow \text{Ca}^+(\text{g}) + \text{e}^{(-)}$ [1]
- (ii)** As the group is descended:
outer electrons are further from the nucleus [1]
increased shielding (of the outer electrons) [1] [2]
- (c)** Thermal stability increases down the Group [1]
Cation size increases down the Group [1]
There is less polarising effect on the carbonate ion (making it
more stable) [1] [3]
- (d)** $\text{Ba} + 2\text{H}_2\text{O} \rightarrow \text{Ba(OH)}_2 + \text{H}_2$ [2] 9

	AVAILABLE MARKS
13 (a) (i) $106/(106 + 111) \times 100 = 48.8\%$ ([–1] for each error) [2] (ii) Moles of $\text{CaCO}_3 = 10\,000$ moles Moles of $\text{Na}_2\text{CO}_3 = 10\,000$ moles Mass of $\text{Na}_2\text{CO}_3 = 1\,060\,000\text{g} = 1.06$ tonnes Percentage yield = $1/1.06 \times 100 = 94.3/94\%$ ([–1] for each error) [3]	
(b) (i) Decomposed by heating (in the absence of air)/ produces carbon dioxide [1]	
(ii) Same number of moles of ammonia used (in Stage II) as produced (in Stage III)/ammonia acts like a catalyst [1]	
(c) (i) The enthalpy change for a reaction is independent of the route taken, provided the initial and final conditions are the same. ([–1] for each error) [2]	
(ii) The enthalpy change when one mole of compound is formed from its elements under standard conditions. ([–1] for each error) [2]	
(iii) $2(-411) + (-1207) + \Delta H = -1131 + (-795)$ $\Delta H = 2029 - 1926 = +103 \text{ (kJ mol}^{-1}\text{/kJ)}$ ([–1] for each error) [2]	13

- 14 (a) (i)** vanadium(V) oxide/vanadium pentoxide [1]
- (ii)** 1–2 atm [1]
450°C [1] [2]
- (iii)** Yield: decreases [1]
Reaction is exothermic so increasing the temperature moves the position of equilibrium to the left [1]
Rate: increases [1]
more particles have the activation energy so more successful collisions per second [1] [4]
- (iv)** Yield: increases [1]
fewer molecules on right so position of equilibrium moves to the right [1]
Rate: increases [1]
particles closer together so more successful collisions per second [1] [4]
- (v)** $K_c = \frac{[\text{SO}_3]^2}{[\text{SO}_2]^2[\text{O}_2]}$ [1]
Unit = $\text{mol}^{-1}\text{dm}^3$ [1] [2]

(b) (i)

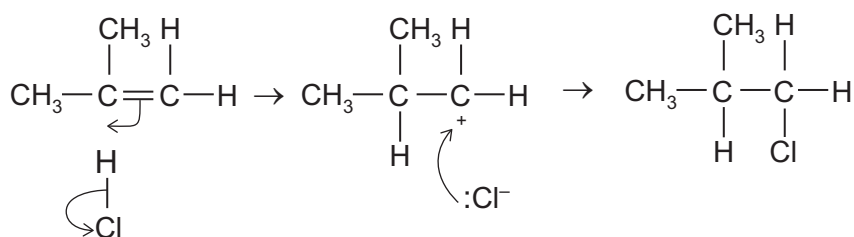


- axes labelled [1]
curve labelled A [1]
 E_a and $E_{a(\text{cat})}$ labelled [1] [3]
- (ii)** Peak moved to the left [1]
Peak higher [1]
(second curve should cross other curve only once and should be asymptotic to energy axis; each error –1) [2]

AVAILABLE
MARKS

18

15 (a) (i) Electrophilic addition [1]



(-1 for each error)

[4]

[5]

- (ii) 2-chloro-2-methylpropane [1] as the carbocation is more stable [1]
second mark dependent on the first

[2]



[1]

- (ii) 3-methylbutanenitrile

[1]

- (iii) Nucleophilic substitution

[1]

- (c) (i) (2-)methylpropan-1-ol

[1]

- (ii) **Indicative content:**

- place NaBr and alcohol
- in a round bottomed/pear shaped flask
- lower into (a beaker of) cold water/cool
- slowly add concentrated sulfuric acid with swirling
- add anti-bumping granules
- reflux
- distil off impure 1-bromo-2-methylpropane

Band	Response	Mark
A	Candidates must use appropriate specialist terms to fully describe the preparation using 6–7 points of indicative content. They must use good spelling, punctuation and grammar and the form and style are of an excellent standard.	[5]–[6]
B	Candidates must use appropriate specialist terms to fully describe the preparation using 3–5 points of indicative content. They must use satisfactory spelling, punctuation and grammar and the form and style are of a good standard.	[3]–[4]
C	Candidates must partially describe the preparation using 1–2 points of indicative content. They use limited correct spelling, punctuation and grammar and the form and style are of a basic standard.	[1]–[2]
D	Response not worthy of credit.	[0]

[6]

AVAILABLE
MARKS

17



Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education

Centre Number

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Candidate Number

--	--	--	--	--

Chemistry

Assessment Unit AS 3

assessing

Module 3: Basic
Practical Chemistry

Practical Booklet A

[SCH31]

SCH31

Assessment

TIME

1 hour 15 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

You must answer the questions in the spaces provided.

Do not write outside the boxed area on each page or on blank pages.

Complete in black ink only. **Do not write with a gel pen.**

Answer **all** questions.

INFORMATION FOR CANDIDATES

The total mark for this paper is 25.

Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

A Periodic Table of the Elements (including some data) is provided.

You may not have access to notes, textbooks and other material to assist you.

Safety glasses should be worn at all times and care should be taken during this practical examination.

Assessment Level of Control:

Tick the relevant box (✓)

Controlled Conditions	
Other	



1 You are provided with:

- ethanol
- ethane-1,2-diol

(a) (i) Follow the procedure below.

Step 1 Fill the burette with ethanol.

Step 2 Run 50.0 cm^3 of ethanol from the burette into a conical flask and record the time taken to the nearest second using a stopclock.

Step 3 Repeat steps 1 and 2 using ethane-1,2-diol instead of ethanol.

Step 4 Present your results in a suitable table below.

[3]

(ii) Calculate the flow rate of ethanol and ethane-1,2-diol in $\text{cm}^3\text{ s}^{-1}$. Give your answers to one decimal place.

[2]



- (b) For the following tests, volumes are approximate and may be measured using graduated disposable pipettes.

Record all observations.

- (i) Place 5 cm³ of ethanol in a test tube and add 5 cm³ of deionised water.

[1]

- (ii) Place 10 drops of ethanol on a watch glass and ignite using a burning splint.

[1]

- (iii) Place 2 cm³ of acidified potassium dichromate(VI) solution in a test tube and add 10 drops of ethanol. Place the mixture in a hot water bath.

[1]

- (iv) Place 2 cm³ of ethanol in a test tube and add half a spatula-measure of phosphorus pentachloride in a fume cupboard.

[3]

[Turn over



2 You are provided with a sample of **X**.

- (a) Place the sample of **X** in a boiling tube and add 5 cm^3 of 0.5 mol dm^{-3} sodium hydroxide solution. Heat gently in a Bunsen burner flame and test the gas evolved using damp universal indicator paper. Record all observations. **Keep the contents of the boiling tube for use in part (b). Allow it to cool for two minutes before carrying out part (b).**

[3]

- (b) To the contents of the boiling tube from part (a), add 5 cm^3 of nitric acid followed by 5 drops of silver nitrate solution. Record your observations.

[1]



3 You are provided with two metal salts labelled **A** and **B**.

(a) Describe the appearance of **A** and **B**.

A _____

B _____ [2]

(b) Carry out the procedures below and record your observations.

(i) Dissolve the sample of **A** in approximately 20 cm³ of deionised water in a 100 cm³ beaker. Repeat this for **B** in a separate 100 cm³ beaker.

Keep the solutions formed.

A _____

B _____ [2]

(ii) Place 2 cm³ of solution **A** in a test tube. Add 5 drops of 2.0 mol dm⁻³ sodium hydroxide solution. Repeat this in a separate test tube for solution **B**.

A _____

B _____ [2]

(iii) Place 2 cm³ of potassium thiocyanate solution in a test tube. Add 1 drop of solution **A**. Repeat this in a separate test tube for solution **B**.

A _____

B _____ [2]

(iv) Place 2 cm³ of solution **A** in a test tube. Add 10 cm³ of sodium carbonate solution. Repeat this in a separate test tube for solution **B**.

A _____

B _____ [2]



THIS IS THE END OF THE QUESTION PAPER

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08SCH3106



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08SCH3107

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08SCH3108



Rewarding Learning

**ADVANCED SUBSIDIARY (AS)
General Certificate of Education**

Chemistry
Assessment Unit AS 3
assessing
Module 3: Practical Examination
Practical Booklet A
[SCH31]

Assessment

**MARK
SCHEME**

General marking guidance for GCE Chemistry

1. Alternative responses

In general, a solidus (/) used between responses indicates alternative answers or parts of an answer.

When a solidus may be confused with part of the answer (for example as a division sign or with units) “or” may be used to show alternatives.

Example: What is observed when propanone is warmed with Tollens' reagent? [1]

MS: remains colourless/no change [1]

2. Acceptable colours and observations

For the use of a solidus with the colours supplied in the **acceptable colour changes and observations** document, the solidus indicates that one of the responses should be given.

Example: What colour is the flame observed when a flame test is carried out on a sample of sodium chloride? [1]

MS: yellow/orange [1]

Response	Candidate Response	Marks awarded	Notes
1	yellow	1	Correct response
2	orange	1	Correct response
3	yellow-orange	0	Both responses with a hyphen not credited

In the acceptable colour changes and observations document, where two colours are given with a hyphen between them, this indicates that both colours are required in a response with the hyphen between them.

Example: What is observed when a few drops of sodium hydroxide solution are added to a solution containing Cr^{3+} ions? [1]

MS: green-blue ppt [1]

Response	Candidate Response	Marks awarded	Notes
1	green-blue ppt	1	Correct response
2	blue-green ppt	1	Correct response
3	blue/green ppt	0	Hyphen is required between the colours
4	blue ppt	0	Both colours required with a hyphen
5	green ppt	0	Both colours required with a hyphen

Note that in Booklet A of AS3 and A23, more flexibility is allowed on the marking of colours. A range of colours and shades of those colours will be accepted.

3. Brackets in a response

Normal parentheses used in a mark scheme response means that a term is not required for the response to be marked correct. However, an incorrect term would lose the mark.

Example: Describe how you would make a salt bridge using paper in the laboratory. [1]
MS: Soak a strip of filter paper in a (saturated/concentrated) solution of potassium chloride/potassium nitrate [1]

Response	Candidate Response	Marks awarded	Notes
1	soak filter paper in potassium chloride solution	1	Correct response
2	soak a piece of filter paper in dilute potassium nitrate solution	0	Not accepted as dilute is incorrect

4. Marking of lists

Where candidates give extra responses, additional correct responses can be ignored.

Additional neutral responses can also be ignored. A neutral response is one which does not have a bearing on the question but is not incorrect.

Additional incorrect responses **cancel out** a correct response to the marking point to which they pertain.

Example: Describe how the presence of chloride ions could be confirmed in a sample of solid sodium chloride. [4]

MS: dissolve the solid in water/nitric acid [1]
add silver nitrate solution [1]
white [1] precipitate [1]

[4]

Response	Candidate Response	Marks awarded	Notes
1	Dissolve the solid in nitric acid and add silver nitrate solution and you will get a white precipitate/solution	3	The last mark is not awarded as solution is an incorrect response cancelling out the correct response.
2	Put the solid in water and add silver nitrate and ammonia. You will get a white precipitate.	3	No mention of solution with silver nitrate and ammonia is not completely incorrect but in context of this response it cancels out the second mark as well if they had written solution
3	Add silver nitrate solution and you get a white precipitate/solution	2	First mark not awarded and precipitate mark not awarded as solution would cancel this out

5. Marking values where a range is given

Where a numerical range is given, correct responses are any value in the range, the range itself or any other range given which falls within the MS range.

Example: Name the reagents and conditions under which they are used to form the benzenediazonium ion from phenylamine. [2]

MS: sodium nitrite and (dil/conc) hydrochloric acid [1]
temperature 0 – 10 °C/in ice [1]

Focussing on the range awarded for the second mark.

Response	Candidate Response	Marks awarded	Notes
1	0	1	A single value within the accepted range
2	1	1	A single value within the accepted range
3	5	1	A single value within the accepted range
4	10	1	A single value within the accepted range
5	2.5	1	A single value within the accepted range
6	0–10	1	The accepted range
7	5–10	1	A range given within the accepted range
8	5–15	0	Range given outside the accepted range

6. Names of compounds

- Any question which asks you to “name” a chemical expects a correct chemical name and any errors in the name given by a candidate will be a –1 error.
- Where a question asks for an IUPAC name for an organic compound, the answer will require, where appropriate, correct locant numbers, dashes, commas and spaces. Each error is –1.
- The term systematic name is often used in inorganic nomenclature where oxidation states are required, e.g. sodium sulfate(IV). An incorrect oxidation state would be a –1 error.

7. Marking equations

Some general points about formulae and equations:

- Equations are usually worth 1 mark if they do not require balancing, however very familiar equations with balancing may only be worth 1 mark and in that case all formulae and balancing must be correct.
- Equations worth 2 marks are marked as [1] for all formulae being correct and [1] for correct balancing. The balancing mark is dependent on the formulae mark and is only considered if all the formulae are correct. If any formula incorrect, no marks are awarded.
- Some more complex structural equations are worth 3 marks. Details of how to mark these questions will be provided in the mark scheme.

8. QWC

Quality of written communication is marked using indicative content and a banded mark scheme.

The initial marking is for the indicative content points. The number of indicative content points places a candidate in a specific band. The overall marks awarded should be in that band based on the standard of the written communication.

A typical banded grid from a mark scheme where there would be 8 indicative content points is shown below:

Band	Response	Mark
A	Candidates must use appropriate specialist terms including a minimum of 7 points of indicative content. They use good spelling, punctuation and grammar and the form and style are of a high standard.	[5]–[6]
B	Candidates must use appropriate specialist terms including a minimum of 5 points of indicative content. They use satisfactory spelling, punctuation and grammar and the form and style are of a satisfactory standard.	[3]–[4]
C	Candidates provide a brief and partial response including a minimum of 2 points of indicative content. They use limited spelling, punctuation and grammar and they have made little use of specialist terms. The form and style are of a limited standard.	[1]–[2]
D	Response not worthy of credit.	[0]

[6]

A candidate who provides 5 indicative content points is placed in band B and can be awarded 3 or 4 overall marks (out of 6) for their response based on the spelling, punctuation and grammar.

Generally, the upper mark in a band would be awarded unless the quality of the written communication was very poor (i.e. multiple spelling, punctuation and grammar errors).

9. Marking calculations

- The total marks in a calculation are given at the end of the question part on the mark scheme and each error in the calculation is –1 mark.
- Errors in a calculation may be carried forward within part of a calculation. This should be indicated using ECF.
- Where a specific number of significant figures or decimal places is asked for in the question, this should be provided and not following this instruction would be classed as an error.
- The phrase “appropriate number of significant figures” is used where a candidate must make a decision about the number of significant figures they use for their final answer. This will be the lowest number of significant figures in the data provided which is used in the calculation.
- Calculations which use the number in the calculator and arrive at the correct answer (following any instructions regarding significant figures or decimal places) can be awarded full marks.
- A correct numerical answer to a calculation (given to the specified number of significant figures or decimal places or correct appropriate number of significant figures) can be awarded full marks provided that the question does not state that working out must be shown.
- Where appropriate, units would be required with a numerical answer.

10. Definitions

- Definitions are provided in the clarification of terms document. Each error/omission in the definition is –1. Correct extra information provided by a candidate would not be penalised.
- Minor errors should not be penalised if they do not change the meaning of the answer given.

11. Organic structures

- Structural formulae should generally show the individual groups or atoms bonded to each carbon atom in the main chain or ring structure. CH_3 , CH_2 , CH , OH , NH_2 , CN , CHO , CO , COOH , COCl , COO , CONH_2 etc do not need to be expanded to show all bonds except where specifically asked for in the question.
- Skeletal formulae must show the angled chain. Functional groups should be clearly shown with all atoms except for carbon atoms.
- Each organic structure is generally worth 1 mark. However more complex structures may be worth more marks.
- Connectivity of atoms in structural formulae should only be penalised based on what is presented in the table.
- Bonds to groups on the left (or right) of a structure should be connected to the correct atom apart from in the case of CH_3 groups.
- Bonds going vertically to groups should be bonded to the correct atom, however if the bond appears to be close to the required atom, this may be accepted.

Accepted		Not accepted		
$\begin{array}{c} \\ \text{H}_3\text{C}-\text{C}- \\ \end{array}$		N/A		
$\begin{array}{c} \\ \text{CH}_3-\text{C}- \\ \end{array}$		N/A		
$\begin{array}{c} \\ \text{CH}_3\text{CH}_2-\text{C}- \\ \end{array}$		$\begin{array}{c} \\ \text{CH}_2\text{CH}_3-\text{C}- \\ \end{array}$		
$\begin{array}{c} \\ -\text{C}- \\ \\ \text{CH}_2\text{CH}_3 \end{array}$		$\begin{array}{c} \\ -\text{C}- \\ \\ \text{CH}_3\text{CH}_2 \end{array}$		
$\begin{array}{c} \\ \text{H}_2\text{N}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{NH}_2 \end{array}$	$\begin{array}{c} \\ \text{NH}_2-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{H}_2\text{N} \end{array}$	
$\begin{array}{c} \\ \text{HO}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{OH} \end{array}$	$\begin{array}{c} \\ \text{OH}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{HO} \end{array}$	
$\begin{array}{c} \\ \text{NC}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{CN} \end{array}$	$\begin{array}{c} \\ \text{CN}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{NC} \end{array}$	
$\begin{array}{c} \\ \text{OHC}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{CHO} \end{array}$	$\begin{array}{c} \\ \text{CHO}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{OHC} \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{CHO} \end{array}$
$\begin{array}{c} \\ \text{HOOC}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{COOH} \end{array}$	$\begin{array}{c} \\ \text{COOH}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{HOOC} \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{COOH} \end{array}$

12. Mechanisms

The following features are required for electrophilic addition, electrophilic substitution, nucleophilic substitution and nucleophilic addition mechanisms:

1. Curly arrows (coming from a bond or the ring of a benzene ring or from a lone pair of electrons)
When the curly arrow is showing the formation of a bond, it may go to the atom, close to the atom or in the position where the bond would form.
2. Lone pairs of electrons shown as a double dot beside the relative atom/ion.
3. Any charges on the intermediates in the mechanism.
4. Any leaving group shown in the products for substitution mechanisms.

Note that for radical substitution mechanisms the dot may be placed before or after the radical.

13. Marking diagrams

- Diagrams of apparatus are again marked in terms of the errors. Each error is –1.
- Diagrams of apparatus are expected to be two-dimensional cross-sectional diagrams of the assembled apparatus with clear labelling and recognisable pieces of apparatus.
- There should be no blockage to the flow of liquids or gases in a diagram of apparatus such as a line across the end of a delivery tube or the exit or entry from a piece of glassware unless intentional such as the valve in a separating funnel.

14. Solution/aqueous

- When describing a practical method or test and a solution of a substance is used, the term **solution** is required in the response unless it is in brackets in the mark scheme.
- The term solution is equivalent to aqueous. For example, aqueous sodium hydroxide is the same as sodium hydroxide solution.
- Solution is not required for dilute acids.

			AVAILABLE MARKS
1	(a) (i)	table with headings [1] units [1] results (recorded to nearest second and longer time for ethane-1,2-diol) [1]	[3]
	(ii)	correct calculation of flow rate in $\text{cm}^3 \text{s}^{-1}$ for both liquids [1] values quoted to 1 decimal place [1]	[2]
	(b) (i)	one layer/mix/colourless solution formed	[1]
	(ii)	(clean) blue flame/blue flame with orange tip	[1]
	(iii)	orange solution changes to green	[1]
2	(iv)	misty fumes/steamy fumes [1] fizzing/hissing [1] solid disappears [1]	[3]
	(a)	white solid disappears [1] colourless solution [1] damp universal indicator paper changes to blue [1]	[3]
	(b)	white precipitate	[1]
	(a)	A = green solid [1] B = off-white solid [1]	[2]
	(b) (i)	A = colourless or green solution [1] B = yellow or orange solution [1]	[2]
3	(ii)	A = green precipitate [1] B = brown precipitate [1]	[2]
	(iii)	A = no change/remains colourless [1] B = (blood) red solution [1]	[2]
	(iv)	A = green-blue precipitate [1] B = brown precipitate [1]	[2]
	Total		10
			25



Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education

Centre Number

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Candidate Number

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Chemistry

Assessment Unit AS 3

assessing

Module 3: Practical Examination

Practical Booklet B (Theory)



[SCH32]

SCH32

Assessment

TIME

1 hour 15 minutes.

Assessment Level of Control:

Tick the relevant box (✓)

Controlled Conditions	
Other	

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

You must answer the questions in the spaces provided.

Do not write outside the boxed area on each page or on blank pages.

Complete in black ink only. **Do not write with a gel pen.**

Answer **all six** questions.

INFORMATION FOR CANDIDATES

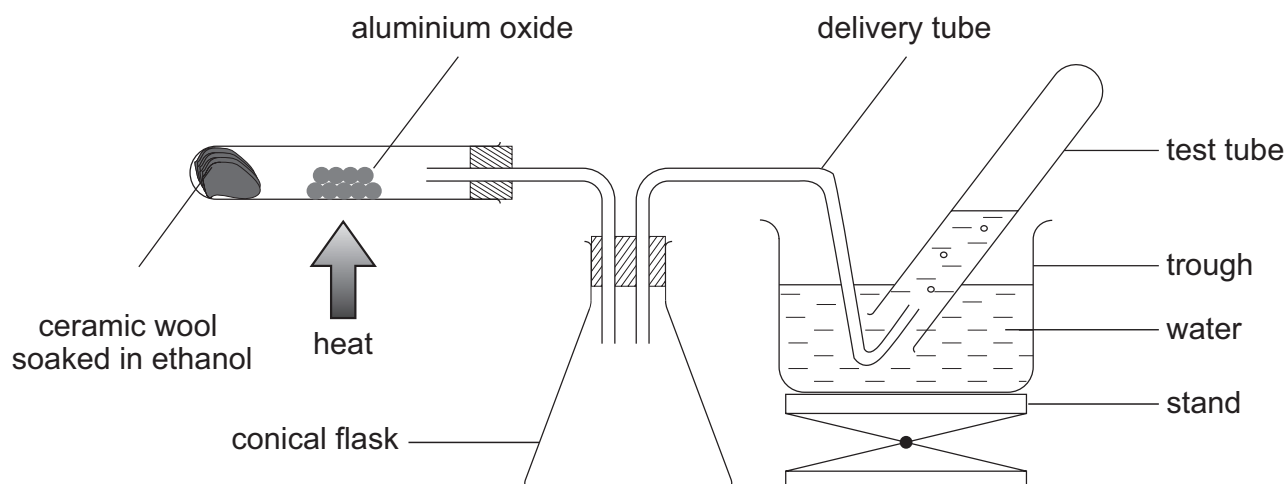
The total mark for this paper is 55.

Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

A Periodic Table of Elements (including some data) is provided.



- 1 Alkenes may be produced by the dehydration of alcohols. The apparatus used in the dehydration of ethanol to produce ethene is shown below.



- (a) Suggest the equation for the dehydration of ethanol.

_____ [1]

- (b) Suggest a reason for including the conical flask in the apparatus shown above.

_____ [1]

- (c) Explain why ethene can be collected over water.

_____ [1]

- (d) Describe a chemical test that would prove that ethene is unsaturated.

_____ [3]



(e) An alternative source of alkenes is the elimination of a hydrogen halide from a halogenoalkane by refluxing it with a solution of potassium hydroxide dissolved in ethanol.

(i) Define the term **reflux**.

_____ [1]

(ii) Write an equation for the reaction of bromoethane with potassium hydroxide to produce ethene.

_____ [1]

(f) (i) Calculate the atom economies for the preparation of ethene by the reactions in (a) and (e)(ii).

_____ [2]

(ii) Explain which preparation would be preferred based upon the atom economies calculated in (f)(i).

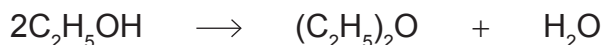
_____ [1]

[Turn over]



- 2 Ethanol can be dehydrated using concentrated sulfuric acid to form ethoxyethane ($\text{C}_2\text{H}_5)_2\text{O}$. Ethoxyethane has a boiling point of 34°C . The reaction mixture is heated and the impure ethoxyethane is separated by distillation and collected.

(a) The equation for the formation of ethoxyethane is shown below.



Calculate the volume of ethanol required to synthesise 3.0 g of ethoxyethane if the percentage yield of this reaction is 46%.

Ethanol has a density of 0.79 g cm^{-3} .

Give your answer to 1 decimal place.

[4]

- (b) Describe, giving practical details, how acidic impurities can be removed from ethoxyethane by washing. Ethoxyethane is immiscible with water and has a density of 0.71 g cm^{-3} .

[5]



(c) Describe, giving practical details, how the ethoxyethane can be dried.

[3]

[Turn over

12628



12SCH3205

- 3 The standard enthalpy of neutralisation of a strong acid can be determined using a “coffee cup calorimeter”.

(a) Define **standard enthalpy of neutralisation**.

_____ [1]

- (b) 50.0 cm^3 of 1.00 mol dm^{-3} sodium hydroxide solution were mixed with 50.0 cm^3 of 1.00 mol dm^{-3} hydrochloric acid. The initial temperature of both solutions was 23.2°C and the temperature increased to 29.7°C after mixing. Calculate the enthalpy of neutralisation, assuming the density of the reaction mixture is 1.00 g cm^{-3} and its specific heat capacity is $4.2 \text{ J g}^{-1} \text{ K}^{-1}$.

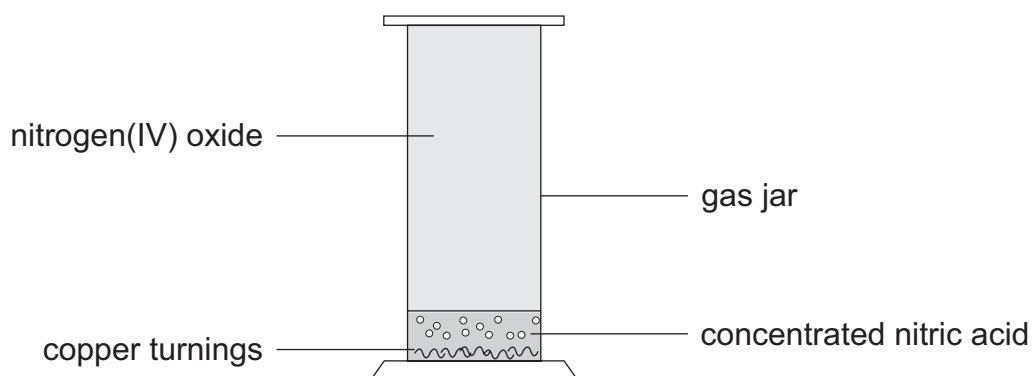
_____ [3]

- (c) State and explain whether the enthalpy of neutralisation would be more or less exothermic if the experiment was repeated using 1.00 mol dm^{-3} ethanoic acid in place of the 1.00 mol dm^{-3} hydrochloric acid.

_____ [2]



- 4 Concentrated nitric acid was added to a gas jar containing copper turnings in a fume cupboard. A redox reaction occurred producing the brown gas nitrogen(IV) oxide and copper(II) nitrate.



- (a) (i) Write the half-equation for the oxidation of copper.

_____ [1]

- (ii) Write the half-equation for the reduction of nitric acid to nitrogen(IV) oxide.

_____ [1]

- (iii) Using your answers to (a)(i) and (a)(ii), write the overall ionic equation for the reaction of copper with concentrated nitric acid.

_____ [1]

- (b) (i) Suggest why the reaction is performed in a fume cupboard.

_____ [1]

- (ii) State and explain another safety precaution that is necessary.

_____ [1]

[Turn over



- 5 A titration was performed to determine the identity of X in the metal carbonate, X_2CO_3 . A 500 cm^3 solution containing 5.20 g of X_2CO_3 was prepared and a 25.0 cm^3 portion of the solution was titrated against 0.200 mol dm^{-3} hydrochloric acid.

The equation for the reaction is:



- (a) Describe how the 500 cm^3 solution of the metal carbonate is prepared for use in this titration.

[5]



(b) The following results were obtained from the titration.

	initial burette reading / cm ³	final burette reading / cm ³	titre / cm ³
rough		19.3	19.3
1 st accurate	19.3		18.7
2 nd accurate	10.0	28.9	

(i) Complete the table above. [1]

(ii) Calculate the mean titre.

_____ [1]

(iii) Calculate the relative formula mass of the metal carbonate X_2CO_3 using the mean titre value.

_____ [3]

(iv) Identify the metal X.

_____ [1]

[Turn over]



- (c) An alternative method to determine the metal present in a carbonate is by thermal decomposition. A metal carbonate, MCO_3 , was heated until it was fully decomposed. The following results were obtained:

mass of crucible	10.20 g
mass of crucible + metal carbonate before decomposition	15.16 g
mass of crucible + product after decomposition	13.40 g

The equation for the decomposition of the metal carbonate is:



- (i) Explain how you could determine that the decomposition was complete.

[1]

- (ii) Calculate the relative atomic mass of the metal M. Use this value to identify the metal.

[3]



6 Concentrated acids are used in reactions with metal halides and in flame tests.

(a) Describe how you would carry out a flame test to confirm the presence of calcium ions in a sample of solid calcium sulfate.

[3]

(b) Compare the observations which are made when concentrated phosphoric acid and concentrated sulfuric acid are added to separate portions of solid potassium iodide.

[3]

THIS IS THE END OF THE QUESTION PAPER



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12SCH3212



**ADVANCED SUBSIDIARY (AS)
General Certificate of Education**

Chemistry
Assessment Unit AS 3
assessing
Module 3: Practical Examination
Practical Booklet B (Theory)
[SCH32]

Assessment

**MARK
SCHEME**

General Marking Instructions

Introduction

The main purpose of the mark scheme is to ensure that examinations are marked accurately, consistently and fairly. The mark scheme provides examiners with an indication of the nature and range of candidates' responses likely to be worthy of credit. It also sets out the criteria which they should apply in allocating marks to candidates' responses.

Assessment objectives

Below are the assessment objectives for **GCE Chemistry**:

Candidates should be able to:

AO1	Demonstrate knowledge and understanding of scientific ideas, processes, techniques and procedures.
AO2	Apply knowledge and understanding of scientific ideas, processes, techniques and procedures: • in a theoretical context • in a practical context • when handling quantitative and qualitative data
AO3	Analyse, interpret and evaluate scientific information, ideas and evidence (in relation to particular issues) • make judgements and reach conclusions • develop and refine practical design and procedures

Quality of candidates' responses

In marking the examination papers, examiners should be looking for a quality of response reflecting the level of maturity which may reasonably be expected of a 17 or 18-year-old which is the age at which the majority of candidates sit their GCE examinations.

Flexibility in marking

Mark schemes are not intended to be totally prescriptive. No mark scheme can cover all the responses which candidates may produce. In the event of unanticipated answers, examiners are expected to use their professional judgement to assess the validity of answers. If an answer is particularly problematic, then examiners should seek the guidance of the Supervising Examiner.

Positive marking

Examiners are encouraged to be positive in their marking, giving appropriate credit for what candidates know, understand and can do rather than penalising candidates for errors or omissions. The exception to this for GCE Chemistry is when examiners are marking complex calculations and mechanisms when the examiners are briefed to mark by error or omission. Examiners should make use of the whole of the available mark range for any particular question and be prepared to award full marks for a response which is as good as might reasonably be expected of a 17 or 18-year-old GCE candidate.

Awarding zero marks

Marks should only be awarded for valid responses and no marks should be awarded for an answer which is completely incorrect or inappropriate.

Marking Calculations

In marking answers involving calculations, examiners should apply the 'carry error through' rule so that candidates are not penalised more than once for a computational error. To avoid a candidate being penalised, marks can be awarded where correct conclusions or inferences are made from their incorrect calculations.

Types of mark schemes

Mark schemes for tasks or questions which require candidates to respond in extended written form are marked on the basis of levels of response which take account of the quality of written communication.

Other questions which require only short answers are marked on a point for point basis with marks awarded for each valid piece of information provided.

Levels of response

In deciding which level of response to award, examiners should look for the number of indicative content points in candidate responses to ensure that the answer has been written to coincide with the question. In deciding which mark within a particular level to award to any response, quality of communication will be assessed and examiners are expected to use their professional judgement.

The following guidance is provided to assist examiners.

- **Threshold performance:** Response which just merits inclusion in the level but the quality of communication is basic should be awarded a mark at the bottom of the range.
- **High performance:** Response which fully satisfies the level description for both content and quality of communication should be awarded a mark at the top of the range.

Quality of written communication

Quality of written communication is taken into account in assessing candidates' responses to all tasks and questions on theory examination papers that require them to respond in extended written form. These tasks and questions are marked on the basis of levels of response. The description for each level of response includes reference to the quality of written communication.

For conciseness, quality of written communication is distinguished within levels of response as follows:

Level C: Quality of written communication is basic.

Level B: Quality of written communication is good.

Level A: Quality of written communication is excellent.

In interpreting these level descriptions, examiners should refer to the more detailed guidance provided below:

Level C (Basic): Basic reference to scientific terminology. The candidate makes only a limited selection and use of an appropriate form and style of writing. The organisation of material may lack clarity and coherence. There is little use of specialist vocabulary. Presentation, spelling, punctuation and grammar may be such that intended meaning is not clear.

Level B (Good): Good reference to scientific terminology. The candidate makes a reasonable selection and use of an appropriate form and style of writing. Relevant material is organised with some clarity and coherence. There is some use of appropriate specialist vocabulary. Presentation, spelling, punctuation and grammar are sufficiently competent to make meaning clear.

Level A (Excellent): Excellent reference to scientific terminology. The candidate successfully selects and uses the most appropriate form and style of writing. Relevant material is organised with a high degree of clarity and coherence. There is widespread and accurate use of appropriate specialist vocabulary. Presentation, spelling, punctuation and grammar are of a sufficiently high standard to make meaning clear.

General marking guidance for GCE Chemistry

1. Alternative responses

In general, a solidus (/) used between responses indicates alternative answers or parts of an answer.

When a solidus may be confused with part of the answer (for example as a division sign or with units) “or” may be used to show alternatives.

Example: What is observed when propanone is warmed with Tollens' reagent? [1]

MS: remains colourless/no change [1]

2. Acceptable colours and observations

For the use of a solidus with the colours supplied in the **acceptable colour changes and observations** document, the solidus indicates that one of the responses should be given.

Example: What colour is the flame observed when a flame test is carried out on a sample of sodium chloride? [1]

MS: yellow/orange [1]

Response	Candidate Response	Marks awarded	Notes
1	yellow	1	Correct response
2	orange	1	Correct response
3	yellow-orange	0	Both responses with a hyphen not credited

In the acceptable colour changes and observations document, where two colours are given with a hyphen between them, this indicates that both colours are required in a response with the hyphen between them.

Example: What is observed when a few drops of sodium hydroxide solution are added to a solution containing Cr^{3+} ions? [1]

MS: green-blue ppt [1]

Response	Candidate Response	Marks awarded	Notes
1	green-blue ppt	1	Correct response
2	blue-green ppt	1	Correct response
3	blue/green ppt	0	Hyphen is required between the colours
4	blue ppt	0	Both colours required with a hyphen
5	green ppt	0	Both colours required with a hyphen

Note that in Booklet A of AS3 and A23, more flexibility is allowed on the marking of colours. A range of colours and shades of those colours will be accepted.

3. Brackets in a response

Normal parentheses used in a mark scheme response means that a term is not required for the response to be marked correct. However, an incorrect term would lose the mark.

Example: Describe how you would make a salt bridge using paper in the laboratory. [1]

MS: Soak a strip of filter paper in a (saturated/concentrated) solution of potassium chloride/potassium nitrate [1]

Response	Candidate Response	Marks awarded	Notes
1	soak filter paper in potassium chloride solution	1	Correct response
2	soak a piece of filter paper in dilute potassium nitrate solution	0	Not accepted as dilute is incorrect

4. Marking of lists

Where candidates give extra responses, additional correct responses can be ignored.

Additional neutral responses can also be ignored. A neutral response is one which does not have a bearing on the question but is not incorrect.

Additional incorrect responses **cancel out** a correct response to the marking point to which they pertain.

Example: Describe how the presence of chloride ions could be confirmed in a sample of solid sodium chloride. [4]

MS: dissolve the solid in water/nitric acid [1]
add silver nitrate solution [1]
white [1] precipitate [1]

[4]

Response	Candidate Response	Marks awarded	Notes
1	Dissolve the solid in nitric acid and add silver nitrate solution and you will get a white precipitate/solution	3	The last mark is not awarded as solution is an incorrect response cancelling out the correct response.
2	Put the solid in water and add silver nitrate and ammonia. You will get a white precipitate.	3	No mention of solution with silver nitrate and ammonia is not completely incorrect but in context of this response it cancels out the second mark as well if they had written solution
3	Add silver nitrate solution and you get a white precipitate/solution	2	First mark not awarded and precipitate mark not awarded as solution would cancel this out

5. Marking values where a range is given

Where a numerical range is given, correct responses are any value in the range, the range itself or any other range given which falls within the MS range.

Example: Name the reagents and conditions under which they are used to form the benzenediazonium ion from phenylamine. [2]

MS: sodium nitrite and (dil/conc) hydrochloric acid [1]
temperature 0 – 10 °C/in ice [1]

Focussing on the range awarded for the second mark.

Response	Candidate Response	Marks awarded	Notes
1	0	1	A single value within the accepted range
2	1	1	A single value within the accepted range
3	5	1	A single value within the accepted range
4	10	1	A single value within the accepted range
5	2.5	1	A single value within the accepted range
6	0–10	1	The accepted range
7	5–10	1	A range given within the accepted range
8	5–15	0	Range given outside the accepted range

6. Names of compounds

- Any question which asks you to “name” a chemical expects a correct chemical name and any errors in the name given by a candidate will be a –1 error.
- Where a question asks for an IUPAC name for an organic compound, the answer will require, where appropriate, correct locant numbers, dashes, commas and spaces. Each error is –1.
- The term systematic name is often used in inorganic nomenclature where oxidation states are required, e.g. sodium sulfate(IV). An incorrect oxidation state would be a –1 error.

7. Marking equations

Some general points about formulae and equations:

- Equations are usually worth 1 mark if they do not require balancing, however very familiar equations with balancing may only be worth 1 mark and in that case all formulae and balancing must be correct.
- Equations worth 2 marks are marked as [1] for all formulae being correct and [1] for correct balancing. The balancing mark is dependent on the formulae mark and is only considered if all the formulae are correct. If any formula incorrect, no marks are awarded.
- Some more complex structural equations are worth 3 marks. Details of how to mark these questions will be provided in the mark scheme.

8. QWC

Quality of written communication is marked using indicative content and a banded mark scheme.

The initial marking is for the indicative content points. The number of indicative content points places a candidate in a specific band. The overall marks awarded should be in that band based on the standard of the written communication.

A typical banded grid from a mark scheme where there would be 8 indicative content points is shown below:

Band	Response	Mark
A	Candidates must use appropriate specialist terms including a minimum of 7 points of indicative content. They use good spelling, punctuation and grammar and the form and style are of a high standard.	[5]–[6]
B	Candidates must use appropriate specialist terms including a minimum of 5 points of indicative content. They use satisfactory spelling, punctuation and grammar and the form and style are of a satisfactory standard.	[3]–[4]
C	Candidates provide a brief and partial response including a minimum of 2 points of indicative content. They use limited spelling, punctuation and grammar and they have made little use of specialist terms. The form and style are of a limited standard.	[1]–[2]
D	Response not worthy of credit.	[0]

[6]

A candidate who provides 5 indicative content points is placed in band B and can be awarded 3 or 4 overall marks (out of 6) for their response based on the spelling, punctuation and grammar.

Generally, the upper mark in a band would be awarded unless the quality of the written communication was very poor (i.e. multiple spelling, punctuation and grammar errors).

9. Marking calculations

- The total marks in a calculation are given at the end of the question part on the mark scheme and each error in the calculation is –1 mark.
- Errors in a calculation may be carried forward within part of a calculation. This should be indicated using ECF.
- Where a specific number of significant figures or decimal places is asked for in the question, this should be provided and not following this instruction would be classed as an error.
- The phrase “appropriate number of significant figures” is used where a candidate must make a decision about the number of significant figures they use for their final answer. This will be the lowest number of significant figures in the data provided which is used in the calculation.
- Calculations which use the number in the calculator and arrive at the correct answer (following any instructions regarding significant figures or decimal places) can be awarded full marks.
- A correct numerical answer to a calculation (given to the specified number of significant figures or decimal places or correct appropriate number of significant figures) can be awarded full marks provided that the question does not state that working out must be shown.
- Where appropriate, units would be required with a numerical answer.

10. Definitions

- Definitions are provided in the clarification of terms document. Each error/omission in the definition is –1. Correct extra information provided by a candidate would not be penalised.
- Minor errors should not be penalised if they do not change the meaning of the answer given.

11. Organic structures

- Structural formulae should generally show the individual groups or atoms bonded to each carbon atom in the main chain or ring structure. CH_3 , CH_2 , CH , OH , NH_2 , CN , CHO , CO , COOH , COCl , COO , CONH_2 etc do not need to be expanded to show all bonds except where specifically asked for in the question.
- Skeletal formulae must show the angled chain. Functional groups should be clearly shown with all atoms except for carbon atoms.
- Each organic structure is generally worth 1 mark. However more complex structures may be worth more marks.
- Connectivity of atoms in structural formulae should only be penalised based on what is presented in the table.
- Bonds to groups on the left (or right) of a structure should be connected to the correct atom apart from in the case of CH_3 groups.
- Bonds going vertically to groups should be bonded to the correct atom, however if the bond appears to be close to the required atom, this may be accepted.

Accepted		Not accepted		
$\begin{array}{c} \\ \text{H}_3\text{C} - \text{C} - \\ \end{array}$		N/A		
$\begin{array}{c} \\ \text{CH}_3 - \text{C} - \\ \end{array}$		N/A		
$\begin{array}{c} \\ \text{CH}_3\text{CH}_2 - \text{C} - \\ \end{array}$		$\begin{array}{c} \\ \text{CH}_2\text{CH}_3 - \text{C} - \\ \end{array}$		
$\begin{array}{c} \\ - \text{C} - \\ \\ \text{CH}_2\text{CH}_3 \end{array}$		$\begin{array}{c} \\ - \text{C} - \\ \\ \text{CH}_3\text{CH}_2 \end{array}$		
$\begin{array}{c} \\ \text{H}_2\text{N} - \text{C} - \\ \end{array}$	$\begin{array}{c} \\ - \text{C} - \\ \\ \text{NH}_2 \end{array}$	$\begin{array}{c} \\ \text{NH}_2 - \text{C} - \\ \end{array}$	$\begin{array}{c} \\ - \text{C} - \\ \\ \text{H}_2\text{N} \end{array}$	
$\begin{array}{c} \\ \text{HO} - \text{C} - \\ \end{array}$	$\begin{array}{c} \\ - \text{C} - \\ \\ \text{OH} \end{array}$	$\begin{array}{c} \\ \text{OH} - \text{C} - \\ \end{array}$	$\begin{array}{c} \\ - \text{C} - \\ \\ \text{HO} \end{array}$	
$\begin{array}{c} \\ \text{NC} - \text{C} - \\ \end{array}$	$\begin{array}{c} \\ - \text{C} - \\ \\ \text{CN} \end{array}$	$\begin{array}{c} \\ \text{CN} - \text{C} - \\ \end{array}$	$\begin{array}{c} \\ - \text{C} - \\ \\ \text{NC} \end{array}$	
$\begin{array}{c} \\ \text{OHC} - \text{C} - \\ \end{array}$	$\begin{array}{c} \\ - \text{C} - \\ \\ \text{CHO} \end{array}$	$\begin{array}{c} \\ \text{CHO} - \text{C} - \\ \end{array}$	$\begin{array}{c} \\ - \text{C} - \\ \\ \text{OHC} \end{array}$	$\begin{array}{c} \\ - \text{C} - \\ \\ \text{CHO} \end{array}$
$\begin{array}{c} \\ \text{HOOC} - \text{C} - \\ \end{array}$	$\begin{array}{c} \\ - \text{C} - \\ \\ \text{COOH} \end{array}$	$\begin{array}{c} \\ \text{COOH} - \text{C} - \\ \end{array}$	$\begin{array}{c} \\ - \text{C} - \\ \\ \text{HOOC} \end{array}$	$\begin{array}{c} \\ - \text{C} - \\ \\ \text{COOH} \end{array}$

12. Mechanisms

The following features are required for electrophilic addition, electrophilic substitution, nucleophilic substitution and nucleophilic addition mechanisms:

1. Curly arrows (coming from a bond or the ring of a benzene ring or from a lone pair of electrons)
When the curly arrow is showing the formation of a bond, it may go to the atom, close to the atom or in the position where the bond would form.
2. Lone pairs of electrons shown as a double dot beside the relative atom/ion.
3. Any charges on the intermediates in the mechanism.
4. Any leaving group shown in the products for substitution mechanisms.

Note that for radical substitution mechanisms the dot may be placed before or after the radical.

13. Marking diagrams

- Diagrams of apparatus are again marked in terms of the errors. Each error is –1.
- Diagrams of apparatus are expected to be two-dimensional cross-sectional diagrams of the assembled apparatus with clear labelling and recognisable pieces of apparatus.
- There should be no blockage to the flow of liquids or gases in a diagram of apparatus such as a line across the end of a delivery tube or the exit or entry from a piece of glassware unless intentional such as the valve in a separating funnel.

14. Solution/aqueous

- When describing a practical method or test and a solution of a substance is used, the term **solution** is required in the response unless it is in brackets in the mark scheme.
- The term solution is equivalent to aqueous. For example, aqueous sodium hydroxide is the same as sodium hydroxide solution.
- Solution is not required for dilute acids.

			AVAILABLE MARKS
1	(a) $\text{C}_2\text{H}_5\text{OH} \longrightarrow \text{C}_2\text{H}_4 + \text{H}_2\text{O}$	[1]	11
	(b) Conical flask prevents suckback (or suitable description of prevention of suckback)	[1]	
	(c) Ethene is insoluble in water	[1]	
	(d) Add bromine water to test tube [1] (stopper) and shake [1] bromine water changes from orange to colourless [1]	[3]	
	(e) (i) Repeated boiling and condensing of a (reaction) mixture	[1]	
	(ii) $\text{C}_2\text{H}_5\text{Br} + \text{KOH} \longrightarrow \text{KBr} + \text{H}_2\text{O} + \text{C}_2\text{H}_4$	[1]	
	(f) (i) Dehydration : atom economy = $\frac{28}{46} \times 100 = 61\%$ [1] Reaction with KOH atom economy = $\frac{28}{165} \times 100 = 17\%$ [1]	[2]	
	(ii) Dehydration preferred as atom economy is (much) higher	[1]	
2	(a) Moles of ethoxyethane = $\frac{3.0}{74}$ = 0.0405 Moles for 100% = $\frac{0.0405}{46} \times 100$ = 0.088 Moles of ethanol = $\frac{2}{0.088}$ = 0.176 moles Mass of ethanol = 0.176×46 = 8.096 g Volume of ethanol = $\frac{8.096}{0.79}$ = 10.2 cm ³ /10.3 cm ³	[4]	
	(b) Place in a separating funnel [1] Add (a portion of) sodium carbonate solution/sodium hydrogencarbonate solution [1] Stopper and shake and release the pressure at regular intervals by inverting and opening the tap [1] Allow to stand until the layers settle [1] Retain the upper layer [1]	[5]	
	(c) Add a spatula measure of a suitable drying agent (for example anhydrous magnesium sulfate, anhydrous sodium sulfate or anhydrous calcium chloride) to the impure liquid product in a suitable container [1] Swirl and add more drying agent until liquid is clear [1] Decant/filter [1]	[3]	12

	AVAILABLE MARKS
3 (a) The enthalpy change when one mole of water is produced in a neutralisation reaction under standard conditions [1] (b) $q = (100)(4.2)(6.5) = 2730 \text{ J} = 2.73 \text{ kJ}$ Moles $\text{H}_2\text{O} = \frac{50}{1000} \times 1.0 = 0.05$ $\Delta H = \frac{2.73}{0.05} = -54.6 \text{ kJ mol}^{-1}$ (units essential; allow $-54\,600 \text{ J mol}^{-1}$) [3] (c) Value would be less exothermic [1] ionisation of undissociated ethanoic acid requires energy [1] second mark is dependent on the first [2]	6
4 (a) (i) $\text{Cu} \longrightarrow \text{Cu}^{2+} + 2\text{e}^-$ [1] (ii) $\text{HNO}_3 + \text{H}^+ + \text{e}^- \longrightarrow \text{NO}_2 + \text{H}_2\text{O}$ [1] or $\text{NO}_3^- + 2\text{H}^+ + \text{e}^- \longrightarrow \text{NO}_2 + \text{H}_2\text{O}$ (iii) $2\text{HNO}_3 + 2\text{H}^+ + \text{Cu} \longrightarrow \text{Cu}^{2+} + 2\text{NO}_2 + 2\text{H}_2\text{O}$ [1] or $2\text{NO}_3^- + 4\text{H}^+ + \text{Cu} \longrightarrow \text{Cu}^{2+} + 2\text{NO}_2 + 2\text{H}_2\text{O}$ (b) (i) Nitrogen(IV) oxide is poisonous/toxic [1] (ii) Wear gloves when handling concentrated acid as it is corrosive [1]	5

- 5 (a) Dissolve 5.20 g of the solid in (deionised) water in a beaker [1]
 Transfer the solution to a 500 cm³ volumetric flask [1]
 Rinse the beaker and glass rod with deionised water and add washings to the volumetric flask [1]
 Make up to the mark by adding deionised water until the bottom of the meniscus is on the mark [1]
 Stopper the flask and invert to mix [1] [5]

(b) (i)

	initial burette reading (cm ³)	final burette reading (cm ³)	titre (cm ³)
rough	0.0		
1 st accurate		38.0	
2 nd accurate			18.9

[1]

(ii) 18.8 cm³

[1]

(iii) Moles of acid = $\frac{18.8 \times 0.2}{1000} = 3.76 \times 10^{-3}$

Moles of metal carbonate = 1.88×10^{-3} in 25 cm³

Moles of metal carbonate in 500 cm³ = $9.4 \times 10^{-4} \times 20 = 0.0376$

Formula mass of metal carbonate = $5.20/0.0376 = 138$

(allow 138.3 etc)

[3]

(iv) $X_2CO_3 = 138$

$X_2 = 138 - 60 = 78$

$X = 39$

X is potassium/K

[1]

- (c) (i) Heat and weigh and repeat until there is no change in mass (allow heat to constant mass)

[1]

(ii) Mass of CO₂ = 1.76 g

Moles of CO₂ = 0.04 moles

Moles of metal carbonate = 0.04

RFM = $4.96 \div 0.04 = 124$

A_r of M = $124 - 60 = 64$

M is copper/Cu

[3]

or based on metal oxide MO

RFM = $\frac{3.2}{0.04} = 80$

RAM of metal M = 64

M is copper/Cu

AVAILABLE
MARKS

15

- 6 (a)** Dip the nichrome wire into concentrated hydrochloric acid [1]
 Dip the wire into the test solid and hold the wire in a blue Bunsen (burner) flame [1]
 Brick red/red flame [1] [3]
- (b)** Both reactions produce misty fumes or steamy fumes [1]
 Sulfuric acid reaction:
 Produces a yellow solid/produces a rotten egg smell [1]
 Produces a grey-black solid/produces a purple vapour (or purple gas) [1] [3]

Total

**AVAILABLE
MARKS**

6

55



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Chemistry

Assessment Unit A2 1

assessing

Further Physical and
Organic Chemistry



[ACH12]

ACH12

Assessment

TIME

2 hours.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

Answer **all seventeen** questions.

Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10. Keep in sequence when answering.

Answer **all seven** questions in **Section B**.

You must answer the questions in the spaces provided.

Do not write outside the boxed area on each page or on blank pages.

Complete in black ink only. **Do not write with a gel pen.**

INFORMATION FOR CANDIDATES

The total mark for this paper is 110.

Quality of written communication will be assessed in Questions **14(e)** and **16(e)(ii)**.

In Section A all questions carry equal marks, i.e. **one** mark for each question.

In Section B the figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

A Periodic Table of Elements, containing some data, is included with this question paper.

12340.04R

Assessment Level of Control:

Tick the relevant box (✓)

Controlled Conditions	
Other	



28ACH1201

Section A

For each of the following questions only **one** of the lettered responses (A–D) is correct.

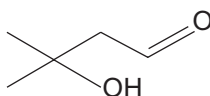
Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

1 In the equilibrium below



which two species are acting as acids?

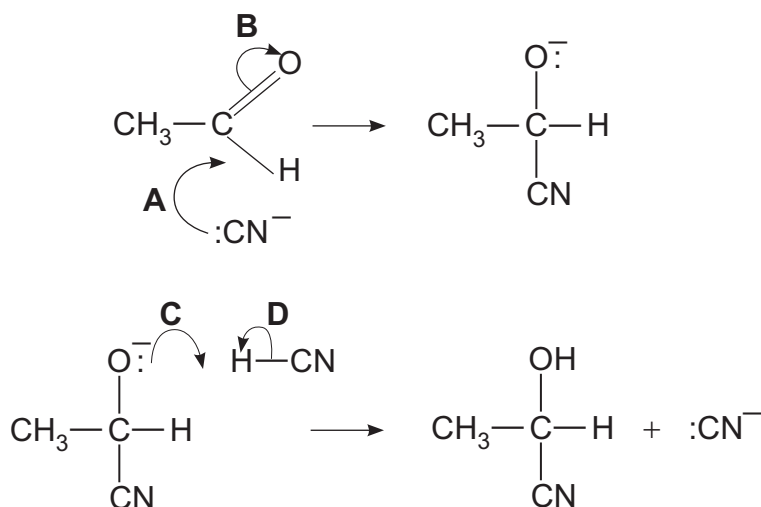
- A CCl_3COOH and CH_3COOH
 - B CCl_3COOH and CCl_3COO^-
 - C CCl_3COOH and $\text{CH}_3\text{COOH}_2^+$
 - D CCl_3COO^- and $\text{CH}_3\text{COOH}_2^+$
- 2 What is the name of the following compound?



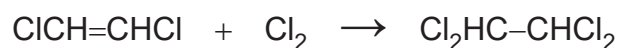
- A 1-hydroxy-1,1-dimethylpropanal
 - B 2-hydroxy-2-methylbutanal
 - C 3-hydroxy-3-methylbutanal
 - D 3-hydroxy-3,3-dimethylpropanal
- 3 Which statement concerning the nitration of methyl benzoate is **not** correct?
- A Concentrated sulfuric acid acts as an acid
 - B Concentrated nitric acid acts as an acid
 - C The nitronium ion acts as an electrophile
 - D The product is a cream solid



- 4 A mechanism for the reaction of ethanal with hydrogen cyanide is drawn below. Which curly arrow shows the incorrect direction of movement of an electron pair?



- 5 The kinetics of the following reaction were studied and the results obtained are shown below.



$[\text{ClCH=CHCl}] / \text{mol dm}^{-3}$	$[\text{Cl}_2] / \text{mol dm}^{-3}$	rate / $\text{mol dm}^{-3} \text{ s}^{-1}$
0.1	0.1	2.7×10^{-6}
0.3	0.1	8.1×10^{-6}
0.5	0.1	1.35×10^{-5}
0.25	0.2	1.35×10^{-5}

The rate equation is

- A rate = $k[\text{ClCH=CHCl}]$.
- B rate = $k[\text{ClCH=CHCl}][\text{Cl}_2]$.
- C rate = $k[\text{ClCH=CHCl}][\text{Cl}_2]^2$.
- D rate = $k[\text{ClCH=CHCl}]^2[\text{Cl}_2]$.

[Turn over



- 6 7.85 g of ethanoyl chloride are completely hydrolysed in water.



What volume of 2.00 M NaOH(aq) is needed to neutralise the resulting solution?

- A 10 cm³
- B 50 cm³
- C 100 cm³
- D 200 cm³
- 7 Which compound produces a red precipitate when heated with Fehling's solution?
- A CH₃COCH₂CH₃
- B CH₃CH₂CH₂COOH
- C CH₃CH₂CH₂CHO
- D CH₃CH₂COOCH₃
- 8 Which indicator would be suitable for a titration between 0.1 M solutions of hydrochloric acid and ammonia?

	indicator	pH range
A	cresol red	0.2–1.8
B	congo red	3.0–7.0
C	cresolphthalein	8.2–9.8
D	indigo carmine	11.6–14.0



9 A mixture of 0.200 mol ethanoic acid and 0.111 mol of ethanol was allowed to reach equilibrium. The ethanoic acid present at equilibrium required 54.4 cm³ of 2.00 M sodium hydroxide solution to react completely. What is the value of the equilibrium constant?

- A 0.259
- B 0.823
- C 3.86
- D 34.8

10 Which statement about benzene is correct?

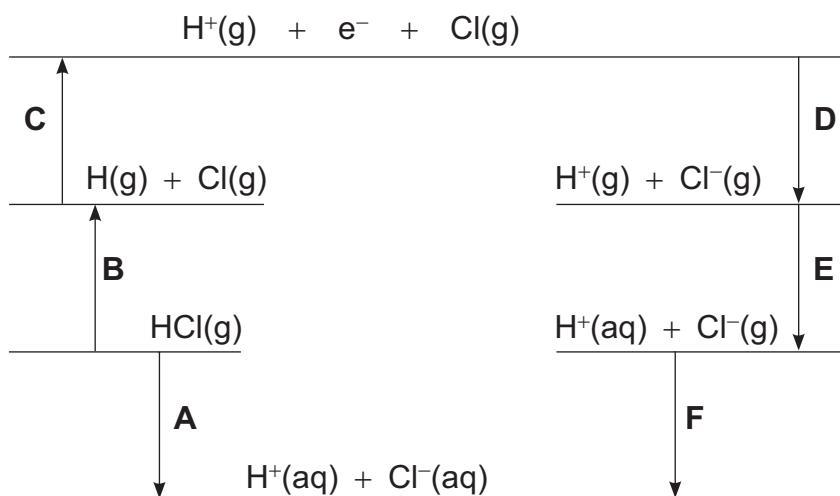
- A The bond lengths in the molecule are equal
- B There are twelve delocalised electrons in the molecule
- C The empirical formula of benzene is C₆H₆
- D The molecule is planar



Section B

Answer **all seven** questions in this section

- 11** The enthalpy cycle shown below can be used to determine the enthalpy change when hydrogen chloride is dissolved in water.



(a) Name the following enthalpy changes.

B _____

C _____

D _____ [3]



(b) Use the data in the table below to calculate **A**.

enthalpy change	$\Delta H / \text{kJ mol}^{-1}$
B	+432
C	+1312
D	−349
E	−1091
F	−378

[2]

(c) Explain, with the aid of a diagram of the chloride ion and water molecules, why enthalpy change **F** is exothermic.

[2]

[Turn over]



12 There are three carbonyl compounds that have the molecular formula C_4H_8O . Two of these are aldehydes and one is a ketone.

(a) Draw the structures of these three compounds and give their IUPAC name in the table below.

compound	structural formula	IUPAC name
A which is an aldehyde		
B which is an aldehyde		
C which is a ketone		

[3]

(b) State and explain which of these two aldehydes has the lower boiling point.

[3]



(c) (i) Write the equation for the reaction of compound **C** with 2,4-dinitrophenylhydrazine.

[2]

(ii) Explain, with full experimental detail, how the purified organic product of the reaction in (c) (i) can be used to identify compound **C**.

[4]

[Turn over

12340.04R



28ACH1209

(d) Carbonyl compounds react with hydrogen cyanide.

(i) Name the mechanism for the reaction.

_____ [1]

(ii) Hydrogen cyanide is generated *in situ* by the reaction of potassium cyanide with hydrochloric acid. Write the equation for this reaction.

_____ [1]

(iii) Hydrogen cyanide is weakly acidic.



The reaction occurs at pH 4–5. Use the above equilibrium to suggest why a lower pH is not used.

_____ [2]



(e) Another compound, which does not contain the carbonyl group, also has the molecular formula C_4H_8O . It reacts with bromine water, changing it from orange to colourless. When heated with acidified potassium dichromate(VI) it undergoes oxidation.

(i) Identify the **two** different functional groups present in the compound.

_____ [1]

(ii) Suggest a structure for the compound.

[1]

(iii) Suggest the name of the organic product when the compound in (e) (ii) is completely oxidised using acidified potassium dichromate(VI).

_____ [2]

[Turn over]

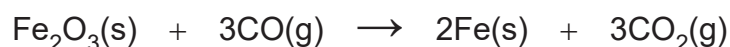
12340.04R



28ACH1211

- 13 Iron is produced from the ore haematite, which contains iron(III) oxide, in the blast furnace.

(a) Iron(III) oxide can be reduced by carbon monoxide to produce iron.



The standard enthalpy change for the reaction is $-24.8 \text{ kJ mol}^{-1}$ and the standard entropy change for the reaction is $15.2 \text{ J K}^{-1} \text{ mol}^{-1}$.

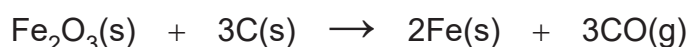
(i) Define the term **feasible**.

_____ [1]

(ii) Explain why this reaction is feasible at all temperatures.

_____ [2]

(b) At high temperatures, the reaction between iron(III) oxide and carbon becomes feasible. Data for the reaction are shown below.



substance	$\Delta_f H^\ominus / \text{kJ mol}^{-1}$	$S^\ominus / \text{J K}^{-1} \text{mol}^{-1}$
Fe_2O_3	-824	87.4
C	0	5.7
Fe	0	27.3
CO	-111	214

(i) Explain why the standard enthalpy changes of formation for carbon and iron are both zero.

_____ [1]



(ii) Calculate the standard enthalpy change for the reaction.

[2]

(iii) Calculate the standard entropy change for the reaction.

[2]

(c) Calculate the temperature at which the value of the standard free energy change, $\Delta G^\ominus$, for the reactions in (a) and (b) is the same.

[2]

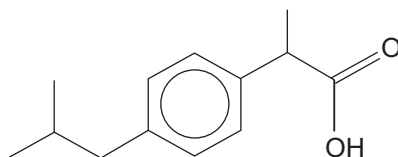
[Turn over]

12340.04R



28ACH1213

- 14 Ibuprofen is a drug used to treat fever, pain and inflammation. It was first synthesised in the 1960s and became available commercially in 1983. The structure of ibuprofen is shown below.



- (a) State the molecular formula of ibuprofen.

_____ [1]

- (b) (i) Ibuprofen contains an asymmetric centre. Define the term **asymmetric (chiral) centre**.

_____ [1]

- (ii) Label the asymmetric centre on the structure of ibuprofen above with an asterisk (*).

[1]

- (iii) Draw the three-dimensional structures for the two optical isomers of ibuprofen.

[2]



(c) Ibuprofen works by inhibiting cyclooxygenase enzymes in the body. The active site of the enzyme is stereospecific. However, the drug is usually administered as a racemic mixture.

(i) Define the term **racemic mixture**.

[1]

(ii) Suggest what is meant by the term stereospecific.

[1]

(iii) Suggest why only one of the ibuprofen optical isomers produces the desired effect in the body.

[1]

[Turn over

12340.04R



28ACH1215

(d) Ibuprofen reacts as an acid as it contains the carboxyl group. It is virtually insoluble in water; 21 mg of ibuprofen dissolves in 1 dm³ of water at 25 °C.

(i) The pK_a of ibuprofen is 4.9. Calculate the pH of a 21 mg dm⁻³ solution of ibuprofen. Give your answer to 2 decimal places.

[4]

(ii) Write an equation for the reaction between ibuprofen and sodium hydroxide.

[1]

(iii) State and explain whether the salt produced from the reaction of ibuprofen with sodium hydroxide is acidic, alkaline or neutral.

[2]



- (e) Describe a procedure, using a titration, which could be used to determine whether ibuprofen is more soluble in methanol or water. Include, in your answer, the name of the indicator and any colour change.

Explain how the results would show in which solvent the ibuprofen is more soluble.

In this question you will be assessed on your written communication skills including the use of specialist scientific terms.

[6]

[6]

[Turn over

12340.04R



28ACH1217

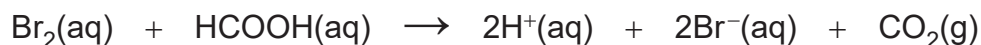
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12340.04R



28ACH1218

- 15** The rate of reaction between solutions of bromine and excess methanoic acid was investigated by monitoring the concentration of bromine over time. Samples of the reaction mixture were taken at regular intervals, quenched and analysed.



- (a)** Explain why each sample taken from the reaction mixture was quenched before analysis.

[1]

- (b)** Describe, using colorimetry, how the concentration of bromine in each sample could be determined.

[3]

[Turn over]

12340.04R



28ACH1219

(c) The results obtained were plotted on the graph shown opposite.

- (i)** Use the graph to determine the time taken for the concentration of the bromine to decrease from 0.100 M to 0.050 M and from 0.050 M to 0.025 M.

_____ [1]

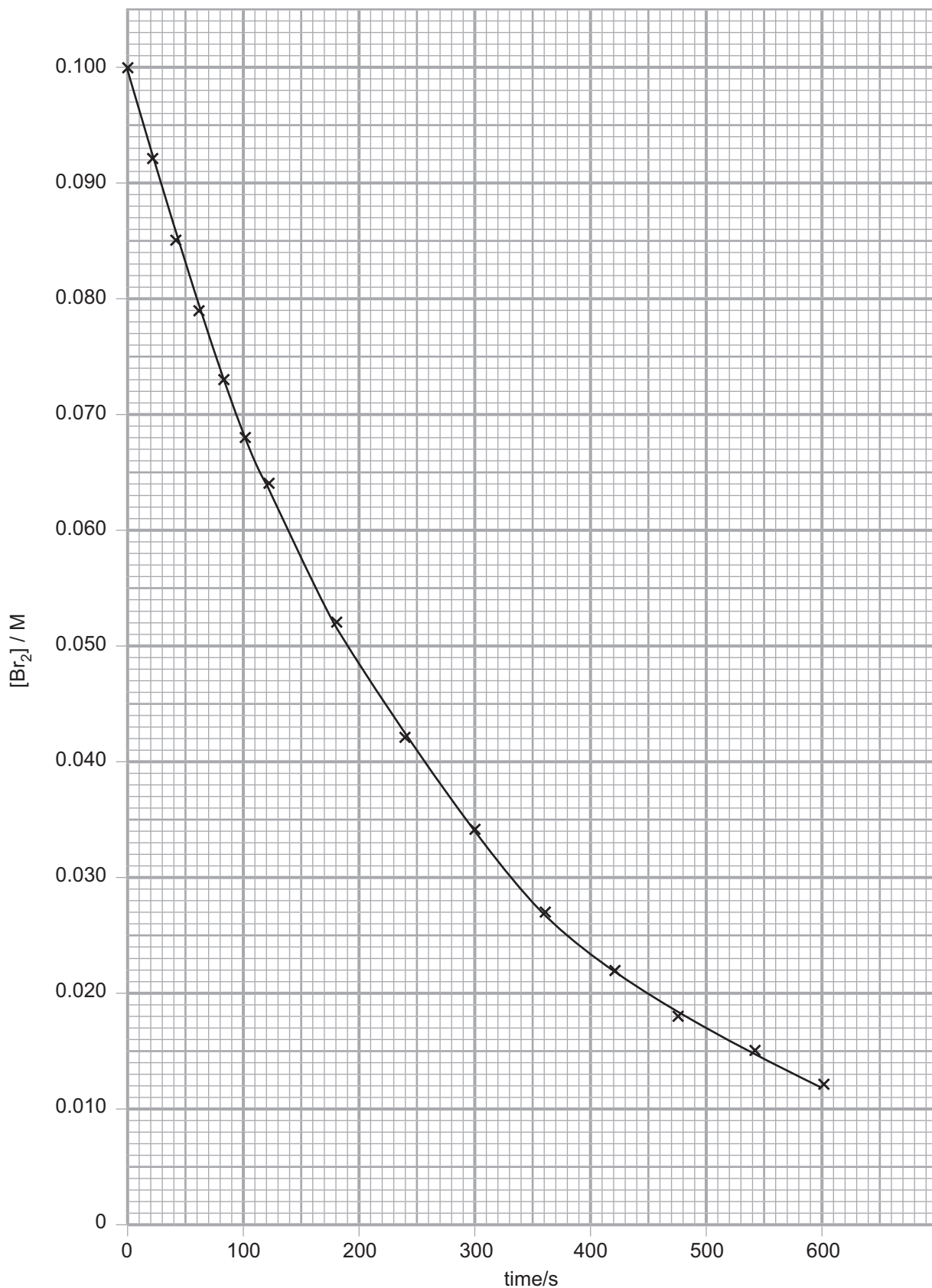
- (ii)** Suggest, using the times calculated in **(c) (i)**, the order of reaction with respect to bromine.

_____ [2]

- (iii)** Suggest why a large excess of methanoic acid was used to investigate the order of reaction with respect to bromine.

_____ [1]





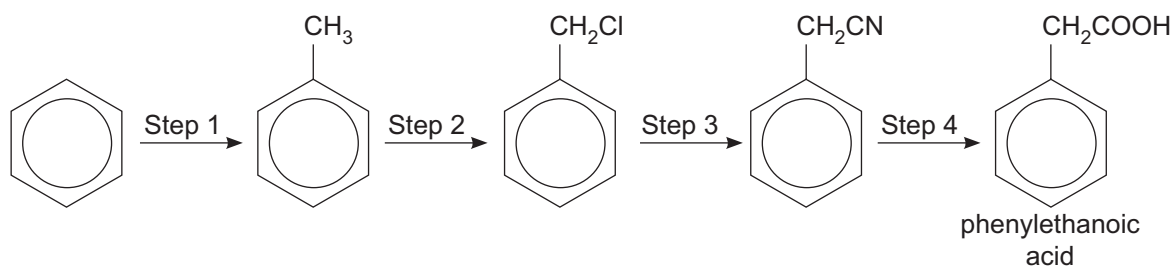
12340.04R

[Turn over



28ACH1221

- 16** Phenylethanoic acid is a white solid used in perfumes on account of its honey-like odour. It can be synthesised from benzene as shown below.



- (a)** State the reagent and catalyst needed for Step 1.

_____ [1]

- (b)** Draw the mechanism for Step 1 using curly arrows. Include equations for the formation of the electrophile and regeneration of the catalyst.

[5]



- (c) (i) Chlorine is used in Step 2. Name the reaction mechanism and state the essential condition for the reaction.

_____ [2]

- (ii) Methylbenzene is formed in Step 1. It can undergo an electrophilic substitution reaction with chlorine to form three monochlorinated products. Draw the structures of these three products.

[2]

- (d) The compound produced in Step 3 is hydrolysed in Step 4, in the presence of dilute hydrochloric acid, to produce phenylethanoic acid. Write an equation for this reaction.

_____ [2]

[Turn over

12340.04R



28ACH1223

- (e) The ethyl ester of phenylethanoic acid is used as a flavouring on account of its honey-like flavour.
- (i) Write the equation for the formation of the ethyl ester from phenylethanoic acid.

[2]

- (ii) Describe, giving experimental details, the preparation of a pure, dry sample of the liquid ethyl ester.

In this question you will be assessed on your written communication skills including the use of specialist scientific terms.

[6]



(iii) Draw the structure of a reagent that could be used in place of phenylethanoic acid to produce the ester in (e)(i).

[2]

12340.04R

[Turn over



28ACH1225

- 17 Cocoa butter is a mixture of triesters derived from three main fatty acids: stearic acid, palmitic acid and oleic acid.

fatty acid	formula
stearic acid	$\text{CH}_3(\text{CH}_2)_{16}\text{COOH}$
palmitic acid	$\text{CH}_3(\text{CH}_2)_{14}\text{COOH}$
oleic acid	$\text{CH}_3(\text{CH}_2)_7\text{CHCH}(\text{CH}_2)_7\text{COOH}$

- (a) The three main triesters which make up cocoa butter are often abbreviated as POS, SOS and POP. The abbreviation POS means that the triester contains palmitic, oleic and stearic acids.

- (i) Suggest the structure of the triester POS.

[2]

- (ii) State and explain, giving **one** reason, which of the three triesters has the lowest melting point.

[3]



- (b) Bromine reacts with cocoa butter. Describe how a solution of bromine water could be used to confirm the removal of unsaturation from a sample of cocoa butter.

[3]

- (c) The number of C=C double bonds in a triester can be determined by catalytic hydrogenation.

- (i) Name the catalyst used in the reaction.

[1]

- (ii) 0.732 g of a triester, $C_{57}H_{98}O_6$, required 120 cm^3 of hydrogen for complete hydrogenation measured at room temperature and pressure. Calculate the average number of C=C double bonds per fatty acid chain.

[3]

THIS IS THE END OF THE QUESTION PAPER



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28ACH1228



Rewarding Learning

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Chemistry
Assessment Unit A2 1
assessing

Further Physical and Organic Chemistry

[ACH12]

Assessment

**MARK
SCHEME**

General Marking Instructions

Introduction

Mark schemes are published to assist teachers and students in their preparation for examinations. Through the mark schemes teachers and students will be able to see what the examiners are looking for in response to questions and exactly where the marks have been awarded. The publishing of the mark schemes may help to show that examiners are not concerned about finding out what a student does not know but rather with rewarding students for what they do know.

The purpose of mark schemes

Examination papers are set and revised by teams of examiners and revisers appointed by the Council. The teams of examiners and revisers include experienced teachers who are familiar with the level and standards expected of students in schools and colleges.

The job of the examiners is to set the questions and the mark schemes; and the job of the revisers is to review the questions and mark schemes commenting on a large range of issues about which they must be satisfied before the question papers and mark schemes are finalised.

The questions and the mark schemes are developed in association with each other so that the issues of differentiation and positive achievement can be addressed right from the start. Mark schemes, therefore, are regarded as part of an integral process which begins with the setting of questions and ends with the marking of the examination.

The main purpose of the mark scheme is to provide a uniform basis for the marking process so that all the markers are following exactly the same instructions and making the same judgements in so far as this is possible. Before marking begins a standardising meeting is held where all the markers are briefed using the mark scheme and samples of the students' work in the form of scripts. Consideration is also given at this stage to any comments on the operational papers received from teachers and their organisations. During this meeting, and up to and including the end of the marking, there is provision for amendments to be made to the mark scheme. What is published represents the final form of the mark scheme.

It is important to recognise that in some cases there may well be other correct responses which are equally acceptable to those published: the mark scheme can only cover those responses which emerged in the examination. There may also be instances where certain judgements may have to be left to the experience of the examiner, for example where there is no absolute correct response – all teachers will be familiar with making such judgements.

General marking guidance for GCE Chemistry

1. Alternative responses

In general, a solidus (/) used between responses indicates alternative answers or parts of an answer.

When a solidus may be confused with part of the answer (for example as a division sign or with units) “or” may be used to show alternatives.

Example: What is observed when propanone is warmed with Tollens' reagent? [1]

MS: remains colourless/no change [1]

2. Acceptable colours and observations

For the use of a solidus with the colours supplied in the **acceptable colour changes and observations** document, the solidus indicates that one of the responses should be given.

Example: What colour is the flame observed when a flame test is carried out on a sample of sodium chloride? [1]

MS: yellow/orange [1]

Response	Candidate Response	Marks awarded	Notes
1	yellow	1	Correct response
2	orange	1	Correct response
3	yellow-orange	0	Both responses with a hyphen not credited

In the acceptable colour changes and observations document, where two colours are given with a hyphen between them, this indicates that both colours are required in a response with the hyphen between them.

Example: What is observed when a few drops of sodium hydroxide solution are added to a solution containing Cr^{3+} ions? [1]

MS: green-blue ppt [1]

Response	Candidate Response	Marks awarded	Notes
1	green-blue ppt	1	Correct response
2	blue-green ppt	1	Correct response
3	blue/green ppt	0	Hyphen is required between the colours
4	blue ppt	0	Both colours required with a hyphen
5	green ppt	0	Both colours required with a hyphen

Note that in Booklet A of AS3 and A23, more flexibility is allowed on the marking of colours. A range of colours and shades of those colours will be accepted.

3. Brackets in a response

Normal parentheses used in a mark scheme response means that a term is **not required** for the response to be marked correct. However, an incorrect term would lose the mark.

Example: Describe how you would make a salt bridge using paper in the laboratory. [1]
MS: Soak a strip of filter paper in a (saturated/concentrated) solution of potassium chloride/potassium nitrate [1]

Response	Candidate Response	Marks awarded	Notes
1	soak filter paper in potassium chloride solution	1	Correct response
2	soak a piece of filter paper in dilute potassium nitrate solution	0	Not accepted as dilute is incorrect

4. Marking of lists

Where candidates give extra responses, additional correct responses can be ignored.

Additional neutral responses can also be ignored. A neutral response is one which does not have a bearing on the question but is not incorrect.

Additional incorrect responses **cancel out** a correct response to the marking point to which they pertain.

Example: Describe how the presence of chloride ions could be confirmed in a sample of solid sodium chloride. [4]

MS: dissolve the solid in water/nitric acid [1]
add silver nitrate solution [1]
white [1] precipitate [1]

[4]

Response	Candidate Response	Marks awarded	Notes
1	Dissolve the solid in nitric acid and add silver nitrate solution and you will get a white precipitate/solution	3	The last mark is not awarded as solution is an incorrect response cancelling out the correct response.
2	Put the solid in water and add silver nitrate and ammonia. You will get a white precipitate.	3	No mention of solution with silver nitrate and ammonia is not completely incorrect but in context of this response it cancels out the second mark as well if they had written solution
3	Add silver nitrate solution and you get a white precipitate/solution	2	First mark not awarded and precipitate mark not awarded as solution would cancel this out

5. Marking values where a range is given

Where a numerical range is given, correct responses are any value in the range, the range itself or any other range given which falls within the MS range.

Example: Name the reagents and conditions under which they are used to form the benzenediazonium ion from phenylamine. [2]

MS: sodium nitrite and (dil/conc) hydrochloric acid [1]
temperature 0 – 10 °C/in ice [1]

Focussing on the range awarded for the second mark.

Response	Candidate Response	Marks awarded	Notes
1	0	1	A single value within the accepted range
2	1	1	A single value within the accepted range
3	5	1	A single value within the accepted range
4	10	1	A single value within the accepted range
5	2.5	1	A single value within the accepted range
6	0–10	1	The accepted range
7	5–10	1	A range given within the accepted range
8	5–15	0	Range given outside the accepted range

6. Names of compounds

- Any question which asks you to “name” a chemical expects a correct chemical name and any errors in the name given by a candidate will be a –1 error.
- Where a question asks for an IUPAC name for an organic compound, the answer will require, where appropriate, correct locant numbers, dashes, commas and spaces. Each error is –1.
- The term systematic name is often used in inorganic nomenclature where oxidation states are required, e.g. sodium sulfate(IV). An incorrect oxidation state would be a –1 error.

7. Marking equations

Some general points about formulae and equations:

- Equations are usually worth 1 mark if they do not require balancing, however very familiar equations with balancing may only be worth 1 mark and in that case all formulae and balancing must be correct.
- Equations worth 2 marks are marked as [1] for all formulae being correct and [1] for correct balancing. The balancing mark is dependent on the formulae mark and is only considered if all the formulae are correct. If any formula incorrect, no marks are awarded.
- Some more complex structural equations are worth 3 marks. Details of how to mark these questions will be provided in the mark scheme.

8. QWC

Quality of written communication is marked using indicative content and a banded mark scheme.

The initial marking is for the indicative content points. The number of indicative content points places a candidate in a specific band. The overall marks awarded should be in that band based on the standard of the written communication.

A typical banded grid from a mark scheme where there would be 8 indicative content points is shown below:

Band	Response	Mark
A	Candidates must use appropriate specialist terms including a minimum of 7 points of indicative content. They use good spelling, punctuation and grammar and the form and style are of a high standard.	[5]–[6]
B	Candidates must use appropriate specialist terms including a minimum of 5 points of indicative content. They use satisfactory spelling, punctuation and grammar and the form and style are of a satisfactory standard.	[3]–[4]
C	Candidates provide a brief and partial response including a minimum of 2 points of indicative content. They use limited spelling, punctuation and grammar and they have made little use of specialist terms. The form and style are of a limited standard.	[1]–[2]
D	Response not worthy of credit.	[0]

[6]

A candidate who provides 5 indicative content points is placed in band B and can be awarded 3 or 4 overall marks (out of 6) for their response based on the spelling, punctuation and grammar.

Generally, the upper mark in a band would be awarded unless the quality of the written communication was very poor (i.e. multiple spelling, punctuation and grammar errors).

9. Marking calculations

- The total marks in a calculation are given at the end of the question part on the mark scheme and each error in the calculation is –1 mark.
- Errors in a calculation may be carried forward within part of a calculation. This should be indicated using ECF.
- Where a specific number of significant figures or decimal places is asked for in the question, this should be provided and not following this instruction would be classed as an error.
- The phrase “appropriate number of significant figures” is used where a candidate must make a decision about the number of significant figures they use for their final answer. This will be the lowest number of significant figures in the data provided which is used in the calculation.
- Calculations which use the number in the calculator and arrive at the correct answer (following any instructions regarding significant figures or decimal places) can be awarded full marks.
- A correct numerical answer to a calculation (given to the specified number of significant figures or decimal places or correct appropriate number of significant figures) can be awarded full marks provided that the question does not state that working out must be shown.
- Where appropriate, units would be required with a numerical answer.

10. Definitions

- Definitions are provided in the clarification of terms document. Each error/omission in the definition is -1. Correct extra information provided by a candidate would not be penalised.
- Minor errors should not be penalised if they do not change the meaning of the answer given.

11. Organic structures

- Structural formulae should generally show the individual groups or atoms bonded to each carbon atom in the main chain or ring structure. CH_3 , CH_2 , CH , OH , NH_2 , CN , CHO , CO , COOH , COCl , COO , CONH_2 etc do not need to be expanded to show all bonds except where specifically asked for in the question.
- Skeletal formulae must show the angled chain. Functional groups should be clearly shown with all atoms except for carbon atoms.
- Each organic structure is generally worth 1 mark. However more complex structures may be worth more marks.
- Connectivity of atoms in structural formulae should only be penalised based on what is presented in the table.
- Bonds to groups on the left (or right) of a structure should be connected to the correct atom apart from in the case of CH_3 groups.
- Bonds going vertically to groups should be bonded to the correct atom, however if the bond appears to be close to the required atom, this may be accepted.

Accepted		Not accepted		
$\begin{array}{c} \\ \text{H}_3\text{C}-\text{C}- \\ \end{array}$		N/A		
$\begin{array}{c} \\ \text{CH}_3-\text{C}- \\ \end{array}$		N/A		
$\begin{array}{c} \\ \text{CH}_3\text{CH}_2-\text{C}- \\ \end{array}$		$\begin{array}{c} \\ \text{CH}_2\text{CH}_3-\text{C}- \\ \end{array}$		
$\begin{array}{c} \\ -\text{C}- \\ \\ \text{CH}_2\text{CH}_3 \end{array}$		$\begin{array}{c} \\ -\text{C}- \\ \\ \text{CH}_3\text{CH}_2 \end{array}$		
$\begin{array}{c} \\ \text{H}_2\text{N}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{NH}_2 \end{array}$	$\begin{array}{c} \\ \text{NH}_2-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{H}_2\text{N} \end{array}$	
$\begin{array}{c} \\ \text{HO}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{OH} \end{array}$	$\begin{array}{c} \\ \text{OH}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{HO} \end{array}$	
$\begin{array}{c} \\ \text{NC}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{CN} \end{array}$	$\begin{array}{c} \\ \text{CN}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{NC} \end{array}$	
$\begin{array}{c} \\ \text{OHC}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{CHO} \end{array}$	$\begin{array}{c} \\ \text{CHO}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{OHC} \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{CHO} \end{array}$
$\begin{array}{c} \\ \text{HOOC}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{COOH} \end{array}$	$\begin{array}{c} \\ \text{COOH}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{HOOC} \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{COOH} \end{array}$

12. Mechanisms

The following features are required for electrophilic addition, electrophilic substitution, nucleophilic substitution and nucleophilic addition mechanisms:

1. Curly arrows (coming from a bond or the ring of a benzene ring or from a lone pair of electrons)
When the curly arrow is showing the formation of a bond, it may go to the atom, close to the atom or in the position where the bond would form.
2. Lone pairs of electrons shown as a double dot beside the relative atom/ion.
3. Any charges on the intermediates in the mechanism.
4. Any leaving group shown in the products for substitution mechanisms.

Note that for radical substitution mechanisms the dot may be placed before or after the radical.

13. Marking diagrams

- Diagrams of apparatus are again marked in terms of the errors. Each error is -1.
- Diagrams of apparatus are expected to be two-dimensional cross-sectional diagrams of the assembled apparatus with clear labelling and recognisable pieces of apparatus.
- There should be no blockage to the flow of liquids or gases in a diagram of apparatus such as a line across the end of a delivery tube or the exit or entry from a piece of glassware unless intentional such as the valve in a separating funnel.

14. Solution/aqueous

- When describing a practical method or test and a solution of a substance is used, the term **solution** is required in the response unless it is in brackets in the mark scheme.
- The term solution is equivalent to aqueous. For example, aqueous sodium hydroxide is the same as sodium hydroxide solution.
- Solution is not required for dilute acids.

Section A

- 1 C
- 2 C
- 3 B
- 4 D
- 5 B
- 6 C
- 7 C
- 8 B
- 9 C
- 10 D

[1] for each correct answer

[10]

Section A

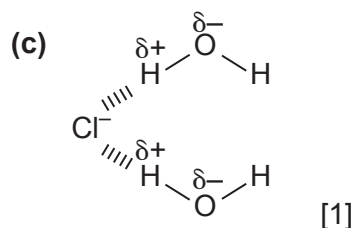
AVAILABLE MARKS	
	10
	10

Section B

AVAILABLE
MARKS

- 11 (a)** B: Bond dissociation enthalpy (of hydrogen chloride) [1]
 C: (First) ionisation energy of hydrogen [1]
 D: First electron affinity of chlorine [1] [3]

(b) $\Delta H = (+432) + (+1312) + (-349) + (-1091) + (-378) = -74 \text{ kJ mol}^{-1}$ [2]



bonds/attractions form which releases energy [1] [2]

7

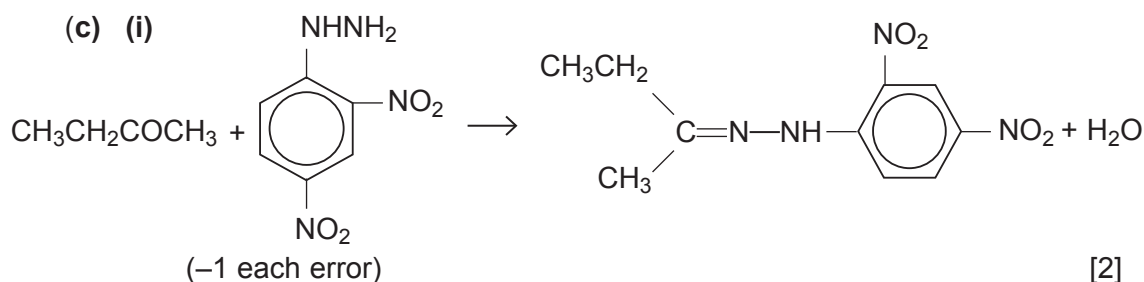
12 (a)

compound	structural formula	name
A	$ \begin{array}{ccccccc} & \text{H} & & \text{H} & & \text{H} & \\ & & & & & & \\ \text{H} & - \text{C} & - & \text{C} & - & \text{C} & - \text{C} \\ & & & & & & \backslash \\ & \text{H} & & \text{H} & & \text{H} & \text{O} \\ & & & & & & // \\ & & & & & & \text{H} \end{array} $	butanal
B	$ \begin{array}{ccc} & \text{CH}_3 & \\ & & \\ \text{H}_3\text{C} & - \text{C} & - \text{C} \\ & & \backslash \\ & \text{H} & \text{O} \\ & & // \\ & & \text{H} \end{array} $	(2-)methylpropanal
C	$ \begin{array}{ccccccc} & \text{H} & & \text{O} & & \text{H} & & \text{H} \\ & & & & & & & \\ \text{H} & - \text{C} & - & \text{C} & - & \text{C} & - & \text{C} - \text{H} \\ & & & & & & & \\ & \text{H} & & & & \text{H} & & \text{H} \end{array} $	butanone

Error [-1] [3]

Note that A and B are interchangeable

- (b)** B is branched (A is not) [1]
 Fewer points of contact/molecules cannot get as close [1]
 Weaker van der Waals' forces [1] [3]



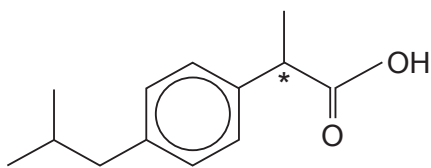
- (ii)** put some solid in a capillary tube/melting point tube sealed at one end [1]
 heat slowly [1]
 record the temperature at which the solid starts and finishes melting [1]
 compare the temperature with values in a data book [1] [4]

(d) (i) nucleophilic addition	[1]	AVAILABLE MARKS
(ii) $\text{KCN} + \text{HCl} \longrightarrow \text{HCN} + \text{KCl}$	[1]	
(iii) Lower pH moves position of equilibrium to the left-hand side [1] This reduces the amount of CN^- (which acts as the nucleophile) [1]	[2]	
(e) (i) $\text{C}=\text{C}$ $-\text{OH}$ [1]	[1]	
(ii) One of the following:		
$\text{CH}_2=\text{CH}-\text{CH}_2-\text{CH}_2\text{OH}$		
$\text{CH}_2=\text{CH}-\underset{\text{OH}}{\text{CH}}-\text{CH}_3$		
$\text{CH}_3-\text{CH}=\text{CH}-\text{CH}_2\text{OH}$	[1]	
(iii) but-3-enoic acid/but-3-enone/but-2-enoic acid (-1 for each error)	[2]	
13 (a) (i) A reaction for which $\Delta G < 0$	[1]	20
(ii) ΔH is negative [1] ΔS is positive/ $-\text{T}\Delta S$ is negative [1]	[2]	
(b) (i) They are both elements	[1]	
(ii) $3(-111) - (-824) = +491 \text{ kJ mol}^{-1}$	[2]	
(iii) $[2(27.3) + 3(214)] - [87.4 + 3(5.7)]$ $696.6 - 104.5 = +592.1 \text{ J K}^{-1} \text{ mol}^{-1}$	[2]	
(c) $-24.8 - \text{T}(15.2/1000) = 491 - \text{T}(592.1/1000)$ $-24.8 - 0.0152\text{T} = 491 - 0.5921\text{T}$ $0.5921\text{T} - 0.0152\text{T} = 491 + 24.8$ $0.5769\text{T} = 515.8$ $\text{T} = 894.1\text{K}$	[2]	

14 (a) $C_{13}H_{18}O_2$ [1]

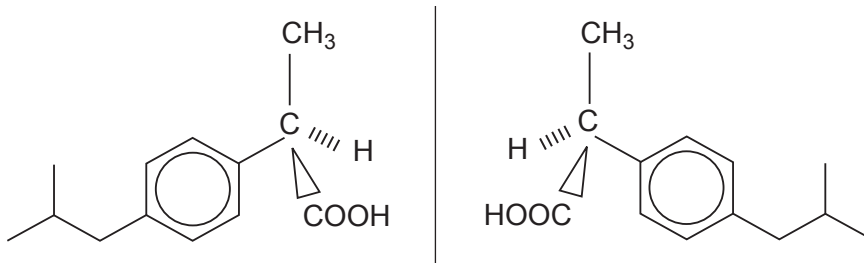
(b) (i) An atom which has four different atoms or groups attached [1]

(ii)



[1]

(iii)



[2]

(c) (i) A 50:50 mixture of two optical isomers [1]

(ii) The active site will only bond with molecules which have a particular orientation/shape [1]

(iii) Only one optical isomer fits in the active site [1]

(d) (i) $pK_a = 4.9$, $K_a = 1.26 \times 10^{-5}$
 $21 \text{ mg dm}^{-3} = 0.021 \text{ g dm}^{-3} = 1.02 \times 10^{-4} \text{ mol dm}^{-3}$

$$1.26 \times 10^{-5} = [H^+]^2 / 1.02 \times 10^{-4}$$

$$[H^+]^2 = 1.29 \times 10^{-9}$$

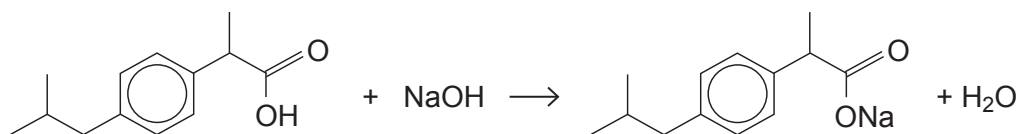
$$[H^+] = 3.59 \times 10^{-5}$$

$$pH = 4.44$$

[4]

(ii) $C_{12}H_{17}COOH + NaOH \rightarrow C_{12}H_{17}COONa + H_2O$ [1]

or



(iii) Alkaline [1]

Salt of a weak acid and strong base [1]

[2]

AVAILABLE
MARKS

(e) Indicative content

- Add ibuprofen to methanol until no more dissolves
- Add ibuprofen to water until no more dissolves
- Filter the mixtures
- Titrate equal volumes of each ibuprofen solution with a standard solution of sodium hydroxide
- Phenolphthalein indicator
- Colourless to pink
- Ibuprofen is more soluble in the solvent which requires the greater volume of sodium hydroxide solution.

Response	Mark
Candidates must use appropriate specialist terms to describe the procedure (using a minimum of 6 points of indicative content). They use good spelling, punctuation and grammar and the form and style are of a high standard.	[5]–[6]
Candidates must use appropriate specialist terms to describe the procedure (using a minimum of 4 points of indicative content). They use satisfactory spelling, punctuation and grammar and the form and style are of a satisfactory standard.	[3]–[4]
Candidates briefly and partially describe the procedure (using a minimum of 2 points of indicative content). They use limited spelling, punctuation and grammar and they have made little use of specialist terms. The form and style are of a limited standard.	[1]–[2]

[6]

21

15 (a) To prevent the mixture reacting further [1]

(b) Measure absorbance of known concentrations of Br₂(aq) and plot a calibration curve [1]
 measure absorbance of each sample [1]
 use calibration curve to determine bromine concentration [1] [3]

(c) (i) 0.100 M → 0.050 M 0 s → 190 s t = 190 s
 0.050 M → 0.025 M 190 s → 380 s t = 190 s [1]

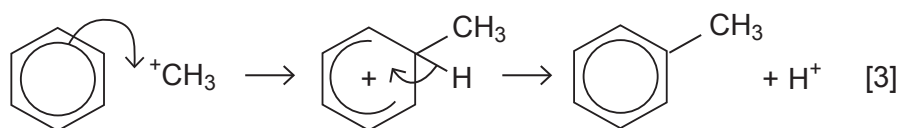
(ii) First order [1]
 Time taken for concentration decrease by half is the same [1] [2]

(iii) The concentration of methanoic acid remains approximately constant [1]

8

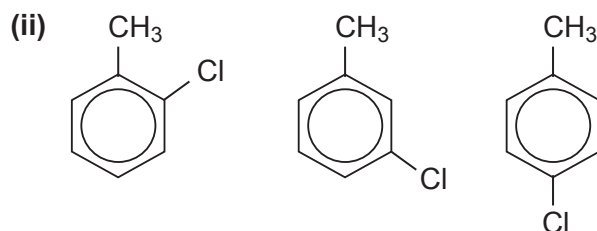
16 (a) Chloromethane/CH₃Cl
Aluminium chloride/AlCl₃ [1] [1]

(b) CH₃Cl + AlCl₃ → ⁺CH₃ + AlCl₄⁻ [1]



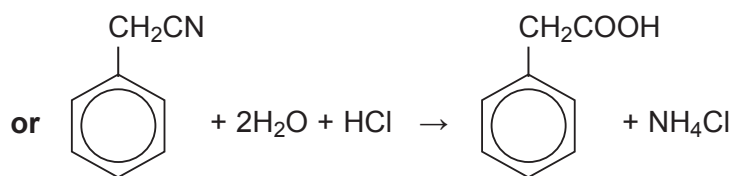
H⁺ + AlCl₄⁻ → HCl + AlCl₃ [1] [5]

(c) (i) Radical substitution [1]
UV light [1] [2]

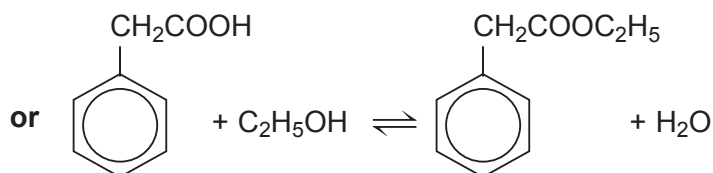


3 correct [2]; 2 correct [1] [2]

(d) C₆H₅CH₂CN + 2H₂O + HCl → C₆H₅CH₂COOH + NH₄Cl [2]



(e) (i) C₆H₅CH₂COOH + C₂H₅OH ⇌ C₆H₅CH₂COOC₂H₅ + H₂O [2]



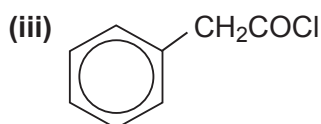
(ii) **Indicative content**

- Add the acid, alcohol and anti-bumping granules into a round bottomed/pear shaped flask
- Add concentrated sulfuric acid slowly
- Heat under reflux
- Distil crude product
- Shake with aqueous sodium carbonate and release pressure
- Separate ester layer using separating funnel
- Add a named drying agent and decant/filter
- Distil pure product and collect at boiling point of ester

AVAILABLE
MARKS

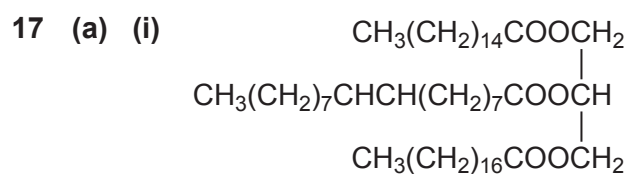
Response	Mark
Candidates must use appropriate specialist terms to describe the procedure (using a minimum of 7 points of indicative content). They use good spelling, punctuation and grammar and the form and style are of a high standard.	[5]–[6]
Candidates must use appropriate specialist terms to describe the procedure (using a minimum of 5 points of indicative content). They use satisfactory spelling, punctuation and grammar and the form and style are of a satisfactory standard.	[3]–[4]
Candidates briefly and partially describe the procedure (using a minimum of 3 points of indicative content). They use limited spelling, punctuation and grammar and they have made little use of specialist terms. The form and style are of a limited standard.	[1]–[2]

[6]



[2]

22



[2]

(ii) POP [1]

Lowest RFM of the three triesters [1]

Weakest van der Waals' forces between the molecules [1]

[3]

(b) add bromine water and shake/mix [1]
 changes from orange to colourless [1]
 repeat until orange colour remains [1]

[3]

(c) (i) Nickel

[1]

(ii) $0.732/878 = 8.34 \times 10^{-4}$ moles of triester

$120 \text{ cm}^3 = 0.005$ moles H_2

$0.005/8.34 \times 10^{-4} = 6$

Average number of double bonds per fatty acid chain = 2

[3]

12

Section B

100

Total

110



Rewarding Learning

ADVANCED
General Certificate of Education

Centre Number

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Candidate Number

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Chemistry

Assessment Unit A2 2

assessing

Analytical, Transition Metals,
Electrochemistry and Further
Organic Chemistry

[ACH22]

ACH22

Assessment

TIME

2 hours.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

Answer **all sixteen** questions.

Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10. Keep in sequence when answering.

Answer **all six** questions in **Section B**.

You must answer the questions in the spaces provided.

Do not write outside the boxed area on each page or on blank pages.

Complete in black ink only. **Do not write with a gel pen.**

INFORMATION FOR CANDIDATES

The total mark for this paper is 110.

Quality of written communication will be assessed in Questions **14(c)** and **16(a)**.

In Section A all questions carry equal marks, i.e. **one** mark for each question.

In Section B the figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

A Periodic Table of the Elements, containing some data, is included with this question paper.

12684



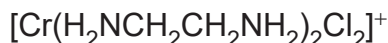
28ACH2201

Section A

For each of the following questions only **one** of the lettered responses (A–D) is correct.

Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

- 1 What is the co-ordination number and the oxidation state of chromium in the following complex?



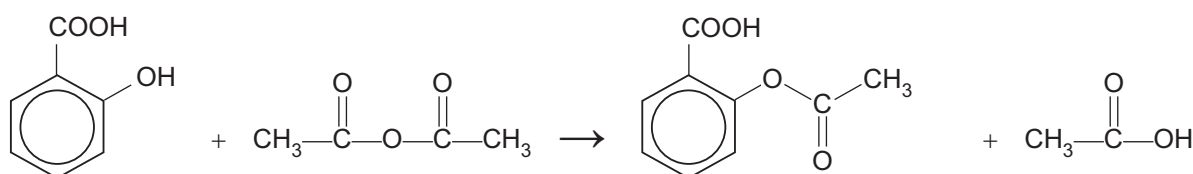
- A 4 and +1
- B 4 and +3
- C 6 and +1
- D 6 and +3
- 2 Which of the following is **not** a reason why TMS is used as a standard in nuclear magnetic resonance spectroscopy?
- A It contains twelve chemically equivalent hydrogen atoms
- B It is unreactive
- C It only produces one peak in the spectrum
- D The hydrogen atoms in TMS are not well shielded
- 3 How many molecular ions peaks would be present in the mass spectrum of CHCl_3 ?
- A 2
- B 3
- C 4
- D 5



4 The acid-catalysed hydrolysis of propanamide produces

- A a propanoate and ammonia.
- B a propanoate and an ammonium salt.
- C propanoic acid and ammonia.
- D propanoic acid and an ammonium salt.

5 The reaction of salicylic acid with ethanoic anhydride is as follows:



Assuming a 25% yield, what mass of salicylic acid (RMM 138) is required to produce 4.50 g of aspirin (RMM 180)?

- A 1.13 g
- B 3.45 g
- C 13.8 g
- D 18.0 g

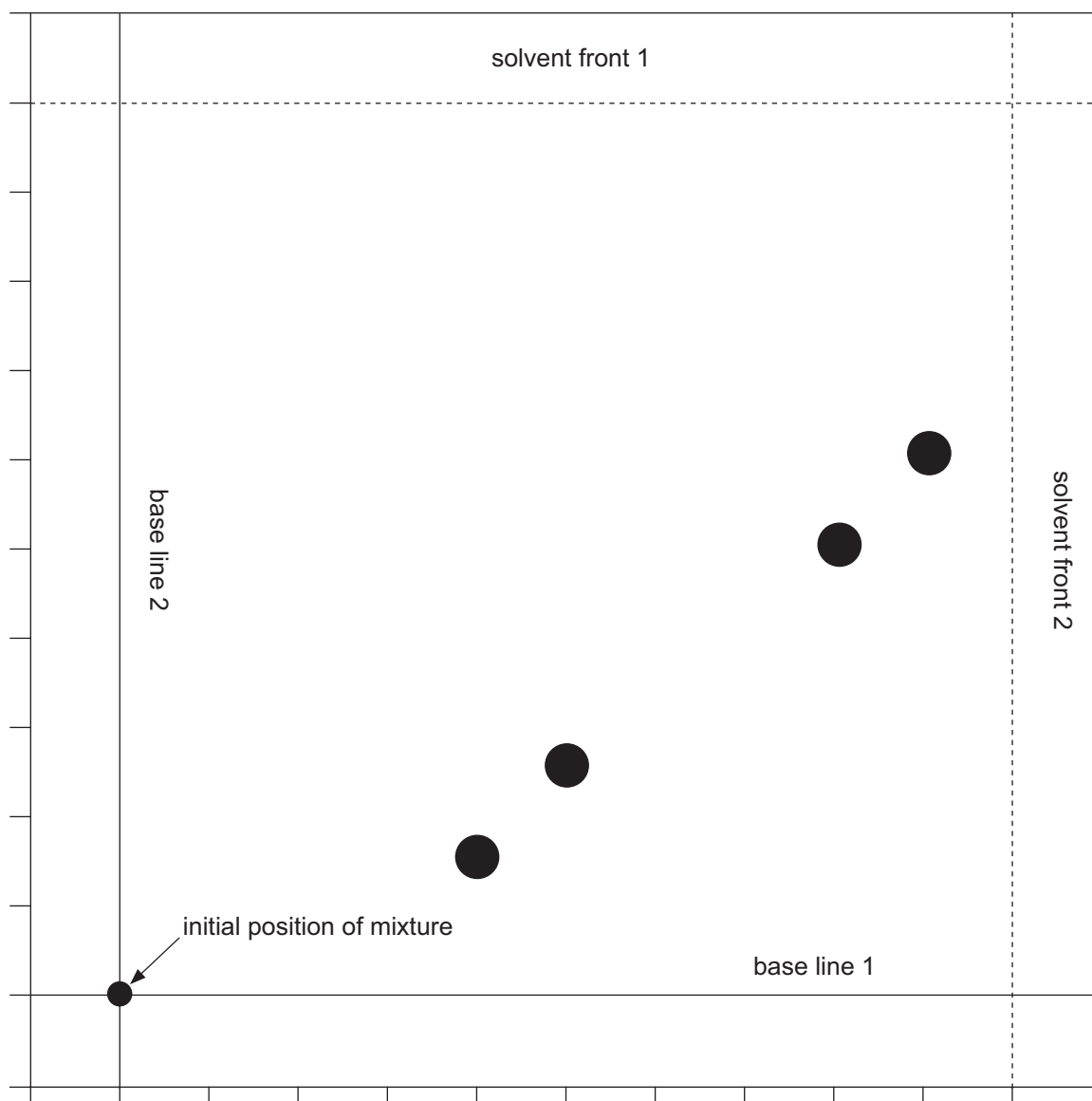
6 An aqueous solution containing the VO²⁺ ion is

- A blue
- B green
- C violet
- D yellow

[Turn over



7 A two-way chromatogram for a mixture containing four amino acids is shown below:



Which of the following gives the correct R_f values for one of the amino acids?

	Solvent 1	Solvent 2
A	0.40	0.15
B	0.50	0.25
C	0.50	0.80
D	0.90	0.60



- 8 When dissolved in a solution of sodium hydroxide, glycine exists as
- A a cation.
 - B a dipolar ion.
 - C a neutral molecule.
 - D an anion.
- 9 Which colour change is produced when an acidified solution of iodate(V) ions is reduced by iodide ions?
- A Blue-black to colourless
 - B Brown to colourless
 - C Brown to straw/yellow
 - D Colourless to brown
- 10 When aqueous sodium hydroxide is added to an aqueous solution of a transition metal compound, a green-blue precipitate is formed which is soluble in excess aqueous sodium hydroxide. The transition metal ion present in the original solution is
- A Cr^{3+} .
 - B Fe^{2+} .
 - C Fe^{3+} .
 - D Ni^{2+} .

[Turn over

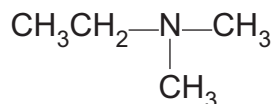


Section B

Answer **all six** questions in the spaces provided

- 11** Butylamine, $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2$, is a primary amine which exists as a colourless liquid at room temperature and pressure (20°C and 1 atm). It has a boiling point of 78°C and has a “fishy” smell.

- (a)** Dimethylethylamine (a tertiary amine) is a structural isomer of butylamine with a boiling point of 37°C .



dimethylethylamine

- (i)** Name a secondary amine that is a structural isomer of butylamine.

_____ [1]

- (ii)** Explain the relative basic strength of primary and secondary amines.

_____ [2]



(iii) Explain why butylamine has a higher boiling point than dimethylethylamine.

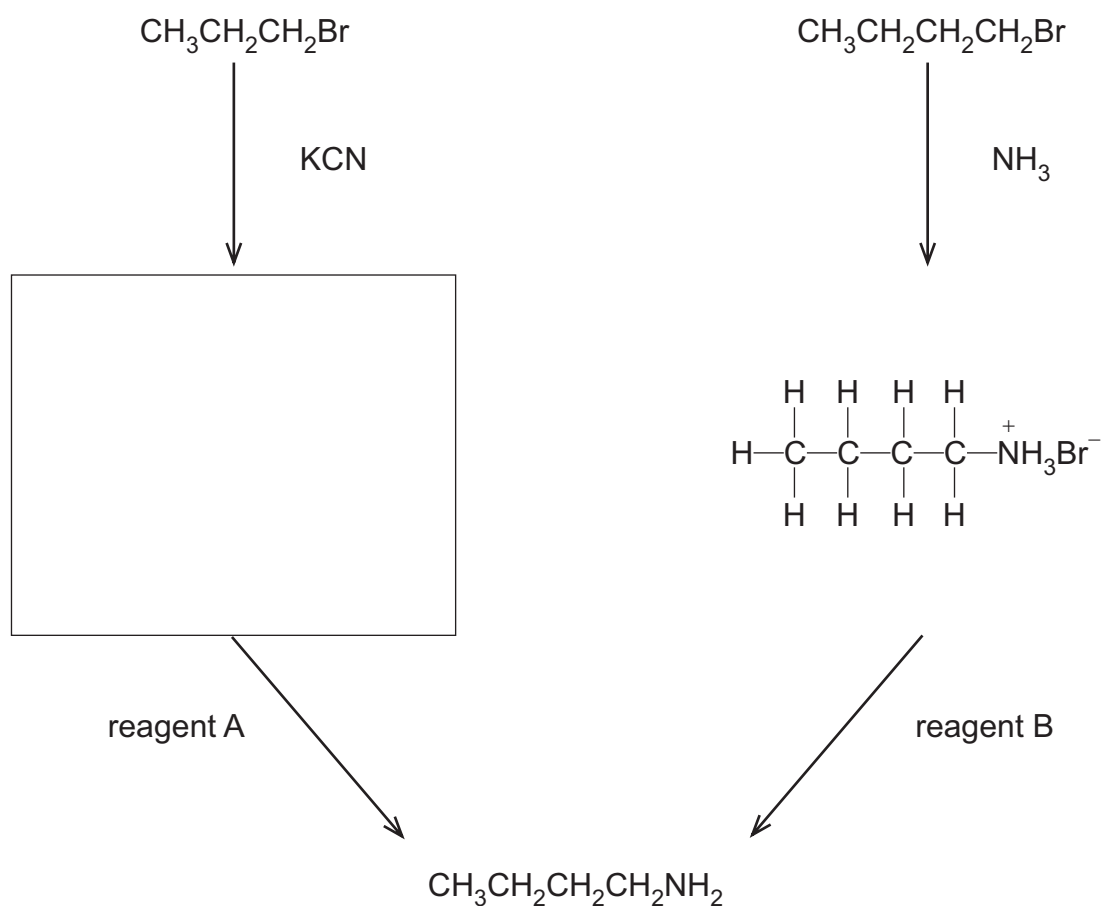
[3]

(iv) Write an equation for the reaction which occurs when an excess of dimethylethylamine reacts with sulfuric acid.

[2]



(b) Butylamine can be formed from 1-bromopropane or 1-bromobutane.



(i) Complete the diagram by including the missing structure in the box provided.

[1]

(ii) Name reagents A and B.

Reagent A _____ [1]

Reagent B _____ [1]



(iii) Name the organic product formed when 1-bromopropane reacts with potassium cyanide.

_____ [1]

(iv) Give an equation for the second step in the formation of butylamine from 1-bromobutane.

_____ [1]

(c) Unknown amines can be identified by reacting with ethanoyl chloride or benzoyl chloride, $\text{C}_6\text{H}_5\text{COCl}$.

(i) Write an equation for the reaction of butylamine with benzoyl chloride.

_____ [1]

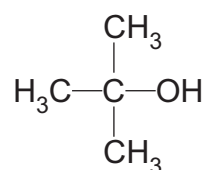
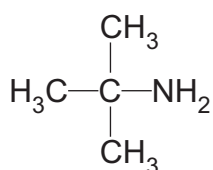
(ii) How can the purified product of the reaction in part (c)(i) be used to identify the amine as butylamine?

_____ [2]

[Turn over]



- (d) The structural isomer of butylamine shown below has a very similar structure to the tertiary alcohol 2-methylpropan-2-ol.



2-methylpropan-2-ol

- (i) Explain why the alcohol is classified as tertiary.

[1]

- (ii) Classify the amine as primary, secondary or tertiary and explain your answer.

[2]





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12684

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28ACH2211

12 Hydrated copper(II) sulfate, hydrated nickel(II) sulfate and hydrated zinc sulfate dissolve in water to form solutions containing the $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$, $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ and $[\text{Zn}(\text{H}_2\text{O})_6]^{2+}$ complexes.

(a) (i) Deduce the electronic configurations of the following atom and ion:

Cu _____

Cu^{2+} _____ [2]

(ii) Name the $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ complex and draw its shape using dotted lines and wedges.

_____ [2]

(iii) State the colours, if any, of the solutions containing the following complexes.

$[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ _____

$[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ _____

$[\text{Zn}(\text{H}_2\text{O})_6]^{2+}$ _____ [2]



(iv) In terms of electronic configuration, what is a transition metal?

[2]

(v) In terms of electronic configuration, why is zinc not a transition metal?

[1]

(b) When a few drops of sodium hydroxide solution are added to a solution containing the $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ complex, a precipitate forms, which can be represented as $[\text{Cu}(\text{OH})_2(\text{H}_2\text{O})_4]$. On addition of an excess of aqueous ammonia, the precipitate disappears and a deep blue solution forms.

(i) Using the formula $[\text{Cu}(\text{OH})_2(\text{H}_2\text{O})_4]$, write an ionic equation for the formation of the precipitate.

[1]

(ii) Using the formula $[\text{Cu}(\text{OH})_2(\text{H}_2\text{O})_4]$, write an ionic equation for the reaction which occurs on addition of an excess of aqueous ammonia.

[2]

[Turn over



(c) A solution was prepared by dissolving hydrated nickel(II) sulfate in water. On addition of an excess of aqueous ammonia, the $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ complex is converted to $[\text{Ni}(\text{NH}_3)_6]^{2+}$. When an excess of 1,2-diaminoethane (en) is then added, all the ammonia ligands are replaced and a purple solution is formed. When an excess of the polydentate ligand, edta, is added the purple solution turns blue.

(i) What is the colour of the $[\text{Ni}(\text{NH}_3)_6]^{2+}$ complex?

_____ [1]

(ii) Write an equation for the replacement of the ammonia ligands by 1,2-diaminoethane (en).

_____ [2]

(iii) Suggest a reason why the enthalpy change for the reaction in part (c)(ii) is approximately zero.

_____ [2]

(iv) Suggest a reason why the reversal of the replacement of the ammonia ligands is not feasible.

_____ [2]



(v) What is a **polydentate ligand**?

[2]

(vi) Write an equation for the reaction which results in the conversion of the purple solution to a blue solution.

[2]

[Turn over]

12684



28ACH2215

13 Polyethylene terephthalate and nylon are classified as condensation polymers and they are biodegradable.

(a) (i) What type of condensation polymer is polyethylene terephthalate?

_____ [1]

(ii) Draw the repeating structural unit in polyethylene terephthalate.

[1]

(b) (i) What type of condensation polymer is nylon?

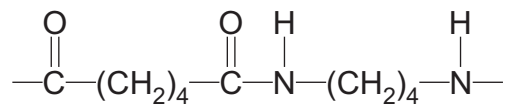
_____ [1]

(ii) Why is nylon biodegradable?

_____ [2]



(c) The repeating structural unit in a condensation polymer, **X**, is shown below:



(i) Draw the skeletal formulae for the two monomers required to produce polymer **X**.

[2]

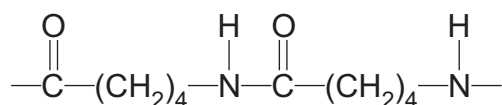
(ii) Name the monomers required to produce polymer **X**.

[2]

[Turn over]



- (d) A section of the polymer chain in a different condensation polymer, **Y**, is shown below. This section is isomeric with the repeating structural unit of polymer **X**.



- (i) Name the monomer required to produce polymer **Y**.

_____ [1]

- (ii) Suggest why the attractions between the polymer chains in **X** and **Y** are stronger than the attractions between polyester molecules of comparable length.

_____ [2]

- (iii) Why can the repeating structural units in **X** and **Y** be described as isomeric?

_____ [2]





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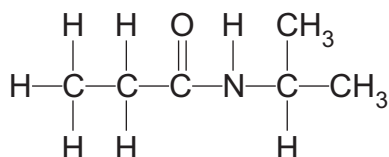
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28ACH2219

- 14 The N-substituted amide shown below can be prepared by reacting an acyl chloride with a primary amine.



- (a) Name the acyl chloride and the primary amine which would be used.

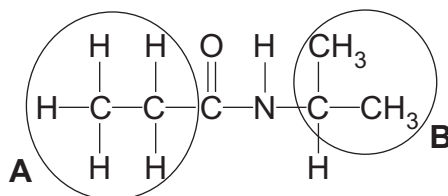
_____ [2]

- (b) Identify the ion which produces a peak at an m/z value of 57 in the mass spectrum of this N-substituted amide.

_____ [1]

- (c) Describe the high resolution ^1H nmr spectrum of this N-substituted amide. Your answer should make reference to the information that would be provided by an integration curve. References to spin-spin splitting patterns should be limited to the hydrogen atoms in the groups which have been circled and labelled as **A** and **B**. References to chemical shift should be limited to the hydrogen atom which is directly bonded to the nitrogen atom.

In this question you will be assessed on using your written communication skills including the use of specialist scientific terms.







[6]

[Turn over

12684



28ACH2221

15 Cells are used in everyday life as a source of electrical energy.

- (a) A conventional representation of a cell which has an emf of +0.50 V is given below:



The standard electrode potential for the half-cell with the more positive value is +2.01 V.

- (i) Define the term **standard electrode potential**.

[2]

- (ii) Calculate the standard electrode potential of the other half-cell.

[1]

- (iii) Which species in this cell is the strongest oxidising agent?

[1]

- (iv) Which species in this cell is the strongest reducing agent?

[1]

- (v) Write the half-equation for the reaction which occurs at the positive electrode when the cell is discharging, and explain whether the process is oxidation or reduction.

[2]



- (vi) Write the half-equation for the reaction which occurs at the negative electrode when the cell is discharging, and explain whether the process is oxidation or reduction.

_____ [2]

- (vii) Write an overall equation for the cell reaction when the cell is discharging.

_____ [1]

- (b) Rechargeable lithium cells are used to power mobile phones and laptops. The cell reactions and standard electrode potentials for a lithium cell are given below:



- (i) Calculate the emf of this lithium cell.

_____ [1]

- (ii) Write an equation for the overall reaction that occurs when this lithium cell is being **recharged**.

_____ [2]

[Turn over



(c) Rechargeable cells and hydrogen fuel cells have the potential to power vehicles.

(i) Give an environmental advantage associated with the use of a hydrogen fuel cell.

[1]

(ii) Give a disadvantage associated with the use of a hydrogen fuel cell.

[1]

(iii) State **two** disadvantages that lithium-ion rechargeable cells have compared with fuel cells when used to power vehicles.

[2]





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28ACH2225

16 Hydrochloric acid in the stomach creates the optimum pH for enzymes to work. Indigestion remedies are used to treat excess acid in the stomach. A back titration can be used to determine the percentage of calcium carbonate in an indigestion tablet.

- (a) Describe how you would carry out a back titration in order to determine the percentage of calcium carbonate in an indigestion tablet. Details of any calculations are not required.

In this question you will be assessed on using your written communication skills including the use of specialist scientific terms.

[6]

- (b)** Write **two** equations to represent the reactions which occur in the method described in part **(a)**.

[2]



- (c) It is stated that the indigestion remedy known as “Milk of Magnesia” contains 415 mg of magnesium hydroxide in every 5.00 cm³ of the remedy. Calculate the number of moles of hydrochloric acid which can be neutralised using 205 cm³ of the remedy.

[3]

- (d) Amino acids are the building blocks for enzymes.

- (i) Give the structure and IUPAC name of an amino acid which contains an asymmetric centre.

[2]

- (ii) Explain why amino acids have relatively high melting points.

[2]

- (e) Suggest why an increase in pH, in the stomach, would result in the enzymes in the stomach becoming less effective.

[3]



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28ACH2228



Rewarding Learning

ADVANCED
General Certificate of Education

Chemistry

Assessment Unit A2 2

assessing

Analytical, Transition Metals, Electrochemistry
and Further Organic Chemistry

[ACH22]

Assessment

**MARK
SCHEME**

General Marking Instructions

Introduction

Mark schemes are published to assist teachers and students in their preparation for examinations. Through the mark schemes, teachers and students will be able to see what examiners are looking for in response to questions and exactly where the marks have been awarded. The publishing of the mark schemes may help to show that examiners are not concerned about finding out what a student does not know but rather, with rewarding students for what they do know.

The Purpose of Mark Schemes

Examination papers are set and revised by teams of examiners and revisers appointed by the Council. The teams of examiners and revisers include experienced teachers who are familiar with the level and standards expected of students in schools and colleges.

The job of the examiners is to set the questions and the mark schemes; and the job of the revisers is to review the questions and mark schemes commenting on a large range of issues about which they must be satisfied before the question papers and mark schemes are finalised.

The questions and the mark schemes are developed in association with each other so that the issues of differentiation and positive achievement can be addressed right from the start. Mark schemes, therefore, are regarded as part of an integral process which begins with the setting of questions and ends with the marking of the examination.

The main purpose of the mark scheme is to provide a uniform basis for the marking process so that all the markers are following exactly the same instructions and making the same judgements in so far as this is possible. Before marking begins, a standardising meeting is held where all the markers are briefed using the mark scheme and samples of the students' work in the form of scripts. Consideration is also given at this stage to any comments on the operational papers received from teachers and their organisations. During this meeting, and up to and including the end of the marking, there is provision for amendments to be made to the mark scheme. The document published represents this final form of the mark scheme.

It is important to recognise that in some cases there may well be other correct responses which are equally acceptable to those published: the mark scheme can only cover those responses which emerged in the examination. There may also be instances where certain judgements may have to be left to the experience of the examiner, for example, where there is no absolute correct response – all teachers will be familiar with making such judgements.

General marking guidance for GCE Chemistry

1. Alternative responses

In general, a solidus (/) used between responses indicates alternative answers or parts of an answer.

When a solidus may be confused with part of the answer (for example as a division sign or with units) “or” may be used to show alternatives.

Example: What is observed when propanone is warmed with Tollens' reagent? [1]

MS: remains colourless/no change [1]

2. Acceptable colours and observations

For the use of a solidus with the colours supplied in the **acceptable colour changes and observations** document, the solidus indicates that one of the responses should be given.

Example: What colour is the flame observed when a flame test is carried out on a sample of sodium chloride? [1]

MS: yellow/orange [1]

Response	Candidate Response	Marks awarded	Notes
1	yellow	1	Correct response
2	orange	1	Correct response
3	yellow-orange	0	Both responses with a hyphen not credited

In the acceptable colour changes and observations document, where two colours are given with a hyphen between them, this indicates that both colours are required in a response with the hyphen between them.

Example: What is observed when a few drops of sodium hydroxide solution are added to a solution containing Cr^{3+} ions? [1]

MS: green-blue ppt [1]

Response	Candidate Response	Marks awarded	Notes
1	green-blue ppt	1	Correct response
2	blue-green ppt	1	Correct response
3	blue/green ppt	0	Hyphen is required between the colours
4	blue ppt	0	Both colours required with a hyphen
5	green ppt	0	Both colours required with a hyphen

Note that in Booklet A of AS3 and A23, more flexibility is allowed on the marking of colours. A range of colours and shades of those colours will be accepted.

3. Brackets in a response

Normal parentheses used in a mark scheme response means that a term is **not required** for the response to be marked correct. However, an incorrect term would lose the mark.

Example: Describe how you would make a salt bridge using paper in the laboratory. [1]

MS: Soak a strip of filter paper in a (saturated/concentrated) solution of potassium chloride/potassium nitrate [1]

Response	Candidate Response	Marks awarded	Notes
1	soak filter paper in potassium chloride solution	1	Correct response
2	soak a piece of filter paper in dilute potassium nitrate solution	0	Not accepted as dilute is incorrect

4. Marking of lists

Where candidates give extra responses, additional correct responses can be ignored.

Additional neutral responses can also be ignored. A neutral response is one which does not have a bearing on the question but is not incorrect.

Additional incorrect responses **cancel out** a correct response to the marking point to which they pertain.

Example: Describe how the presence of chloride ions could be confirmed in a sample of solid sodium chloride. [4]

MS: dissolve the solid in water/nitric acid [1]

add silver nitrate solution [1]

white [1] precipitate [1]

[4]

Response	Candidate Response	Marks awarded	Notes
1	Dissolve the solid in nitric acid and add silver nitrate solution and you will get a white precipitate/solution	3	The last mark is not awarded as solution is an incorrect response cancelling out the correct response.
2	Put the solid in water and add silver nitrate and ammonia. You will get a white precipitate.	3	No mention of solution with silver nitrate and ammonia is not completely incorrect but in context of this response it cancels out the second mark as well if they had written solution
3	Add silver nitrate solution and you get a white precipitate/solution	2	First mark not awarded and precipitate mark not awarded as solution would cancel this out

5. Marking values where a range is given

Where a numerical range is given, correct responses are any value in the range, the range itself or any other range given which falls within the MS range.

Example: Name the reagents and conditions under which they are used to form the benzenediazonium ion from phenylamine. [2]

MS: sodium nitrite and (dil/conc) hydrochloric acid [1]
temperature 0 – 10 °C/in ice [1]

Focussing on the range awarded for the second mark.

Response	Candidate Response	Marks awarded	Notes
1	0	1	A single value within the accepted range
2	1	1	A single value within the accepted range
3	5	1	A single value within the accepted range
4	10	1	A single value within the accepted range
5	2.5	1	A single value within the accepted range
6	0–10	1	The accepted range
7	5–10	1	A range given within the accepted range
8	5–15	0	Range given outside the accepted range

6. Names of compounds

- Any question which asks you to “name” a chemical expects a correct chemical name and any errors in the name given by a candidate will be a –1 error.
- Where a question asks for an IUPAC name for an organic compound, the answer will require, where appropriate, correct locant numbers, dashes, commas and spaces. Each error is –1.
- The term systematic name is often used in inorganic nomenclature where oxidation states are required, e.g. sodium sulfate(IV). An incorrect oxidation state would be a –1 error.

7. Marking equations

Some general points about formulae and equations:

- Equations are usually worth 1 mark if they do not require balancing, however very familiar equations with balancing may only be worth 1 mark and in that case all formulae and balancing must be correct.
- Equations worth 2 marks are marked as [1] for all formulae being correct and [1] for correct balancing. The balancing mark is dependent on the formulae mark and is only considered if all the formulae are correct. If any formula incorrect, no marks are awarded.
- Some more complex structural equations are worth 3 marks. Details of how to mark these questions will be provided in the mark scheme.

8. QWC

Quality of written communication is marked using indicative content and a banded mark scheme.

The initial marking is for the indicative content points. The number of indicative content points places a candidate in a specific band. The overall marks awarded should be in that band based on the standard of the written communication.

A typical banded grid from a mark scheme where there would be 8 indicative content points is shown below:

Band	Response	Mark
A	Candidates must use appropriate specialist terms including a minimum of 7 points of indicative content. They use good spelling, punctuation and grammar and the form and style are of a high standard.	[5]–[6]
B	Candidates must use appropriate specialist terms including a minimum of 5 points of indicative content. They use satisfactory spelling, punctuation and grammar and the form and style are of a satisfactory standard.	[3]–[4]
C	Candidates provide a brief and partial response including a minimum of 2 points of indicative content. They use limited spelling, punctuation and grammar and they have made little use of specialist terms. The form and style are of a limited standard.	[1]–[2]
D	Response not worthy of credit.	[0]

[6]

A candidate who provides 5 indicative content points is placed in band B and can be awarded 3 or 4 overall marks (out of 6) for their response based on the spelling, punctuation and grammar.

Generally, the upper mark in a band would be awarded unless the quality of the written communication was very poor (i.e. multiple spelling, punctuation and grammar errors).

9. Marking calculations

- The total marks in a calculation are given at the end of the question part on the mark scheme and each error in the calculation is –1 mark.
- Errors in a calculation may be carried forward within part of a calculation. This should be indicated using ECF.
- Where a specific number of significant figures or decimal places is asked for in the question, this should be provided and not following this instruction would be classed as an error.
- The phrase “appropriate number of significant figures” is used where a candidate must make a decision about the number of significant figures they use for their final answer. This will be the lowest number of significant figures in the data provided which is used in the calculation.
- Calculations which use the number in the calculator and arrive at the correct answer (following any instructions regarding significant figures or decimal places) can be awarded full marks.
- A correct numerical answer to a calculation (given to the specified number of significant figures or decimal places or correct appropriate number of significant figures) can be awarded full marks provided that the question does not state that working out must be shown.
- Where appropriate, units would be required with a numerical answer.

10. Definitions

- Definitions are provided in the clarification of terms document. Each error/omission in the definition is -1. Correct extra information provided by a candidate would not be penalised.
- Minor errors should not be penalised if they do not change the meaning of the answer given.

11. Organic structures

- Structural formulae should generally show the individual groups or atoms bonded to each carbon atom in the main chain or ring structure. CH_3 , CH_2 , CH , OH , NH_2 , CN , CHO , CO , COOH , COCl , COO , CONH_2 etc do not need to be expanded to show all bonds except where specifically asked for in the question.
- Skeletal formulae must show the angled chain. Functional groups should be clearly shown with all atoms except for carbon atoms.
- Each organic structure is generally worth 1 mark. However more complex structures may be worth more marks.
- Connectivity of atoms in structural formulae should only be penalised based on what is presented in the table.
- Bonds to groups on the left (or right) of a structure should be connected to the correct atom apart from in the case of CH_3 groups.
- Bonds going vertically to groups should be bonded to the correct atom, however if the bond appears to be close to the required atom, this may be accepted.

Accepted		Not accepted		
$\begin{array}{c} \\ \text{H}_3\text{C}-\text{C}- \\ \end{array}$		N/A		
$\begin{array}{c} \\ \text{CH}_3-\text{C}- \\ \end{array}$		N/A		
$\begin{array}{c} \\ \text{CH}_3\text{CH}_2-\text{C}- \\ \end{array}$		$\begin{array}{c} \\ \text{CH}_2\text{CH}_3-\text{C}- \\ \end{array}$		
$\begin{array}{c} \\ -\text{C}- \\ \\ \text{CH}_2\text{CH}_3 \end{array}$		$\begin{array}{c} \\ -\text{C}- \\ \\ \text{CH}_3\text{CH}_2 \end{array}$		
$\begin{array}{c} \\ \text{H}_2\text{N}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{NH}_2 \end{array}$	$\begin{array}{c} \\ \text{NH}_2-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{H}_2\text{N} \end{array}$	
$\begin{array}{c} \\ \text{HO}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{OH} \end{array}$	$\begin{array}{c} \\ \text{OH}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{HO} \end{array}$	
$\begin{array}{c} \\ \text{NC}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{CN} \end{array}$	$\begin{array}{c} \\ \text{CN}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{NC} \end{array}$	
$\begin{array}{c} \\ \text{OHC}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{CHO} \end{array}$	$\begin{array}{c} \\ \text{CHO}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{OHC} \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{CHO} \end{array}$
$\begin{array}{c} \\ \text{HOOC}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{COOH} \end{array}$	$\begin{array}{c} \\ \text{COOH}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{HOOC} \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{COOH} \end{array}$

12. Mechanisms

The following features are required for electrophilic addition, electrophilic substitution, nucleophilic substitution and nucleophilic addition mechanisms:

1. Curly arrows (coming from a bond or the ring of a benzene ring or from a lone pair of electrons)
When the curly arrow is showing the formation of a bond, it may go to the atom, close to the atom or in the position where the bond would form.
2. Lone pairs of electrons shown as a double dot beside the relative atom/ion.
3. Any charges on the intermediates in the mechanism.
4. Any leaving group shown in the products for substitution mechanisms.

Note that for radical substitution mechanisms the dot may be placed before or after the radical.

13. Marking diagrams

- Diagrams of apparatus are again marked in terms of the errors. Each error is -1.
- Diagrams of apparatus are expected to be two-dimensional cross-sectional diagrams of the assembled apparatus with clear labelling and recognisable pieces of apparatus.
- There should be no blockage to the flow of liquids or gases in a diagram of apparatus such as a line across the end of a delivery tube or the exit or entry from a piece of glassware unless intentional such as the valve in a separating funnel.

14. Solution/aqueous

- When describing a practical method or test and a solution of a substance is used, the term **solution** is required in the response unless it is in brackets in the mark scheme.
- The term solution is equivalent to aqueous. For example, aqueous sodium hydroxide is the same as sodium hydroxide solution.
- Solution is not required for dilute acids.

Section A

- 1 D
- 2 D
- 3 C
- 4 D
- 5 C
- 6 A
- 7 C
- 8 D
- 9 D
- 10 A

[1] for each correct answer

[10]

Section A

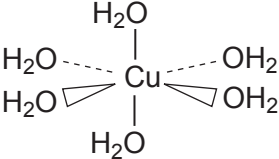
AVAILABLE MARKS	
	10
	10

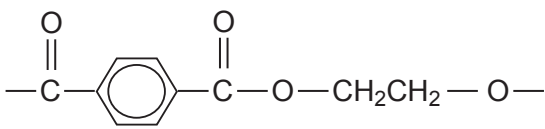
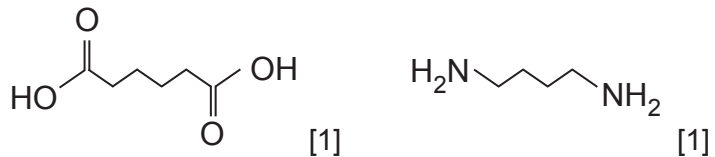
Section B

AVAILABLE
MARKS

- 11 (a) (i)** diethylamine/methylpropylamine [1]
- (ii)** primary amine has one alkyl group bonded to nitrogen atom and secondary amine has two [1]
two alkyl groups make the lone pair more available [1] [2]
- (iii)** hydrogen bonding between butylamine molecules [1]
no hydrogen bonding between dimethylethylamine molecules [1]
greater area of contact between (linear) butylamine molecules than between (branched) dimethylethylamine so greater van der Waals' forces between the molecules [1] [3]
- (iv)** $2\text{CH}_3\text{CH}_2\text{N}(\text{CH}_3)_2 + \text{H}_2\text{SO}_4 \rightarrow (\text{CH}_3\text{CH}_2\text{NH}(\text{CH}_3)_2)_2\text{SO}_4$ [2]
- (b) (i)** $\text{CH}_3\text{CH}_2\text{CH}_2\text{CN}$ [1]
- (ii)** Reagent A lithium tetrahydridoaluminate(III)/lithium aluminium hydride/lithal [1]
Reagent B sodium hydroxide [1] [2]
- (iii)** butanenitrile [1]
- (iv)**
 $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_3^+ \text{Br}^- + \text{NaOH} \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2 + \text{NaBr} + \text{H}_2\text{O}$ [1]
- (c) (i)**
 $\text{C}_6\text{H}_5\text{COCl} + \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2 \rightarrow \text{C}_6\text{H}_5\text{CONHCH}_2\text{CH}_2\text{CH}_2\text{CH}_3 + \text{HCl}$ [1]
- (ii)** determine its melting point [1]
compare with known values in data book [1] [2]
- (d) (i)** three carbons directly attached to the same carbon as the –OH group [1]
- (ii)** primary [1]
one carbon directly attached to the nitrogen atom/presence of NH_2 group [1] [2]

19

- 12 (a) (i)** Cu $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}/1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$ [1]
 Cu²⁺ $1s^2 2s^2 2p^6 3s^2 3p^6 3d^9$ [1]
- (ii)**
- 
- [1]
- hexaaquacopper(II) [1] [2]
- (iii)** blue
 green
 colourless [2]
- (iv)** an element which forms at least one stable ion with a partially filled d-subshell [2]
- (v)** Zn²⁺/the only stable ion does not have a partially filled d subshell [1]
- (b) (i)** $[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 2\text{OH}^- \rightarrow [\text{Cu}(\text{OH})_2(\text{H}_2\text{O})_4] + 2\text{H}_2\text{O}$ [1]
- (ii)** $[\text{Cu}(\text{OH})_2(\text{H}_2\text{O})_4] + 4\text{NH}_3 \rightarrow [\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+} + 2\text{H}_2\text{O} + 2\text{OH}^-$ [2]
- (c) (i)** blue [1]
- (ii)** $[\text{Ni}(\text{NH}_3)_6]^{2+} + 3\text{en} \rightarrow [\text{Ni}(\text{en})_3]^{2+} + 6\text{NH}_3$
 or
 $[\text{Ni}(\text{NH}_3)_6]^{2+} + 3\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2 \rightarrow [\text{Ni}(\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2)_3]^{2+} + 6\text{NH}_3$ [2]
- (iii)** breaking 6 Ni–N bonds forming 6 Ni–N bonds/same number and type of bonds broken and formed [1]
 energy involved in breaking and forming bonds is approximately equal [1] [2]
- (iv)** 7 moles to 4 moles [1]
 $\Delta S < 0$ /decrease in entropy [1]
 $\Delta G > 0$ [1] max [2]
- (v)** a ligand which uses many lone pairs of electrons to form more than two co-ordinate bonds with a central metal atom or ion in a complex. [2]
- (vi)** $[\text{Ni}(\text{en})_3]^{2+} + \text{edta}^{4-} \rightarrow [\text{Ni}(\text{edta})]^{2-} + 3\text{en}$
 or
 $[\text{Ni}(\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2)_3]^{2+} + \text{edta}^{4-} \rightarrow [\text{Ni}(\text{edta})]^{2-} + 3\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2$ [2]

- 13 (a) (i) polyester [1]
- (ii)  [1]
- (b) (i) polyamide [1]
- (ii) the amide link [1]
can be hydrolysed by the action of microorganisms [1] [2]
- (c) (i)  [1] [1] [2]
- (ii) hexanedioic acid [1] butanediamine/1,4-diaminobutane/butane-1,4-diamine [1] [2]
- (d) (i) 5-aminopentanoic acid [1]
- (ii) X and Y can form hydrogen bonds (between the molecules) [1]
as they contain N-H and C=O groups [1] [2]
- (iii) same (molecular) formula [1] different structure [1] [2]

AVAILABLE
MARKS

14

14 (a) propanoyl chloride [1] 2-aminopropane [1] [2]

(b) $\text{CH}_3\text{CH}_2\text{CO}^+$ [1]

(c) **Indicative content**

Integration:

- chemically equivalent hydrogens are in a 3:2:1:1:6 ratio

Spin-spin splitting:

For A

- CH_3 appears as a triplet
- CH_2 appears as a quartet

For B

- 2 CH_3 appears as a doublet

Chemical shift:

- N–H highest chemical shift
- at 5.5–8.5 ppm

Band	Response	Mark
A	Candidates must use appropriate specialist terms using a minimum of 5 points of indicative content. They must use good spelling, punctuation and grammar and the form and style are of an excellent standard.	[5]–[6]
B	Candidates must use appropriate specialist terms using a minimum of 3 points of indicative content. They must use satisfactory spelling, punctuation and grammar and the form and style are of a good standard.	[3]–[4]
C	Candidates must use a minimum of 2 points of indicative content. They use limited correct spelling, punctuation and grammar and the form and style are of a basic standard.	[1]–[2]
D	Response not worthy of credit	[0]

[6]

AVAILABLE
MARKS

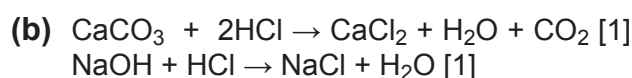
9

15 (a) (i) the potential difference measured when a half-cell is connected to the standard hydrogen electrode under standard conditions. [2]	AVAILABLE MARKS
(ii) +1.51 V [1]	
(iii) $\text{S}_2\text{O}_8^{2-}$ [1]	
(iv) Mn^{2+} [1]	
(v) $\text{S}_2\text{O}_8^{2-} + 2\text{e}^- \rightarrow 2\text{SO}_4^{2-}$ [1] Reduction – gain of electrons [1] [2]	
(vi) $\text{Mn}^{2+} + 4\text{H}_2\text{O} \rightarrow \text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^-$ [1] Oxidation – loss of electrons [1] [2]	
(vii) $2\text{Mn}^{2+} + 8\text{H}_2\text{O} + 5\text{S}_2\text{O}_8^{2-} \rightarrow 2\text{MnO}_4^- + 16\text{H}^+ + 10\text{SO}_4^{2-}$ [1]	
(b) (i) +2.90 V [1]	
(ii) $\text{LiMnO}_2 \rightarrow \text{Li} + \text{MnO}_2$ [2]	
(c) (i) (the water produced is) non-polluting [1]	
(ii) hydrogen production may use fossil fuels which leads to global warming/uses resources/uses toxic chemicals in manufacture/flammability of hydrogen/storage of hydrogen or other suitable answer [1]	
(iii) limit to travel distance/recharging is time consuming [1] any reference to environmental issues [1] [2]	17

- 16 (a)
- weigh the tablet
 - add excess hydrochloric acid
 - titrate the excess hydrochloric acid
 - with a standard solution of sodium hydroxide/alkali
 - using phenolphthalein as an indicator
 - until the indicator changes from colourless to pink

Band	Response	Mark
A	Candidates must use appropriate specialist terms using a minimum of 5 points of indicative content. They must use good spelling, punctuation and grammar and the form and style are of an excellent standard.	[5]–[6]
B	Candidates must use appropriate specialist terms using a minimum of 3 points of indicative content. They must use satisfactory spelling, punctuation and grammar and the form and style are of a good standard.	[3]–[4]
C	Candidates must use a minimum of 2 points of indicative content. They use limited correct spelling, punctuation and grammar and the form and style are of a basic standard.	[1]–[2]
D	Response not worthy of credit	[0]

[6]

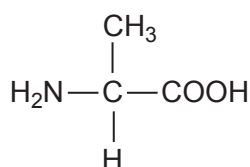


[2]

- (c) mass in $205\text{ cm}^3 = 17015\text{ mg}$ ($\times 41$)
mass in $205\text{ cm}^3 = 17.015\text{ g}$ ($\div 1000$)
moles in $205\text{ cm}^3 = 0.2934$ ($\div 58$)
moles of $\text{HCl} = 0.587$ ($\times 2$)

[3]

- (d) (i) 2-aminopropanoic acid



[2]

or any amino acid apart from glycine

- (ii) exist as dipolar ions/zwitterions [1]
held together by strong electrostatic attractions/ionic bonding [1]

[2]

- (e) changes the tertiary structure/disrupts ionic interactions [1]
alters the shape of the active site [1]
substrate cannot (induce a) fit [1]

[3]

AVAILABLE
MARKS

18

Section B

100

Total

110



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Chemistry
Assessment Unit A2 3
assessing
Further Practical Chemistry
Practical Booklet A
[ACH31]
Assessment

**APPARATUS
AND
MATERIALS
LIST**

Advice for centres

- All chemicals used should be at least laboratory reagent specification and labelled with appropriate safety symbols, e.g. irritant.
- For centres running multiple sessions – candidates for the later session should be supplied with clean, dry glassware. If it is not feasible then glassware from the first session should be thoroughly washed, rinsed with deionised water and allowed to drain.
- Ensure all chemicals are in date, otherwise expected observations may not be seen.
- It is the responsibility of the centre to be cognisant of all health and safety issues and to carry out a thorough risk assessment. Up-to-date information can be obtained at www.cleaps.org.uk

Practical Examination

Each candidate must be supplied with safety goggles or glasses.

Question No. 1

Each candidate must be supplied with:

- a spatula
- a Bunsen burner
- a heatproof mat
- three boiling tubes
- two test tubes
- a test tube rack
- a boiling tube rack
- a boiling tube holder
- one glass rod
- six measuring cylinders with 10 cm³ capacity
- a beaker of 250 cm³ capacity (for a hot water bath)
- a conical flask of 250 cm³ capacity
- a kettle to supply hot water
- two wooden splints
- matches
- several disposable pipettes
- a wash bottle containing deionised water
- weighing boat
- 250 cm³ measuring cylinder or 250 cm³ beaker with calibrations
- white tile (also required for Question 2)
- stopclock/stopwatch (also required for Question 2)
- access to an accurate balance (reading to 2 decimal places)
- approximately 20 g of sucrose labelled **S**
- approximately 50 cm³ of a 1% sucrose solution labelled **S (aq)**
- approximately 10 cm³ of 0.02 mol dm⁻³ acidified potassium manganate(VII) solution labelled **potassium manganate(VII) solution** (solution should be freshly made)
- approximately 10 cm³ of 1.0 mol dm⁻³ hydrochloric acid labelled **dilute hydrochloric acid** and **corrosive/irritant**
- approximately 20 cm³ of 1.0 mol dm⁻³ sodium carbonate solution labelled **sodium carbonate solution**
- approximately 30 cm³ of 1.0 mol dm⁻³ sodium hydroxide solution labelled **dilute sodium hydroxide solution** and **corrosive/irritant**
- approximately 20 cm³ of Fehling's solution (a mix of equal volumes of Fehling's No.1 and Fehling's No.2) labelled **Fehling's solution** and **corrosive** (solution should be freshly made)
- approximately 10 cm³ of 2,4-dinitrophenylhydrazine solution labelled **2,4-dinitrophenylhydrazine solution**.

Question No. 2

Each candidate must be supplied with:

- one 50 cm³ burette of at least B quality
- a funnel (for filling the burette)
- 100 cm³ beaker (waste beaker for burette)
- a white tile
- a retort stand and burette clamp
- a measuring cylinder with 25 cm³ capacity
- two measuring cylinders with 10 cm³ capacity
- four conical flasks of 250 cm³ capacity
- several disposable pipettes
- a wash bottle containing deionised water
- a stopclock/stopwatch
- approximately 100 cm³ of 0.04 mol dm⁻³ potassium iodide solution labelled **potassium iodide solution**
- approximately 50 cm³ of a 0.04 mol dm⁻³ iron(III) chloride solution labelled **iron(III) chloride solution**
- approximately 50 cm³ of 0.005 mol dm⁻³ sodium thiosulfate solution labelled **sodium thiosulfate solution**
- a dropper bottle containing 2% starch solution labelled **starch solution**



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Chemistry
Assessment Unit A2 3
assessing
Further Practical Chemistry
Practical Booklet A
[ACH31]

Assessment

**MARK
SCHEME**

General marking guidance for GCE Chemistry

1. Alternative responses

In general, a solidus (/) used between responses indicates alternative answers or parts of an answer.

When a solidus may be confused with part of the answer (for example as a division sign or with units) “or” may be used to show alternatives.

Example: What is observed when propanone is warmed with Tollens' reagent? [1]
MS: remains colourless/no change [1]

2. Acceptable colours and observations

For the use of a solidus with the colours supplied in the **acceptable colour changes and observations** document, the solidus indicates that one of the responses should be given.

Example: What colour is the flame observed when a flame test is carried out on a sample of sodium chloride? [1]
MS: yellow/orange [1]

Response	Candidate Response	Marks awarded	Notes
1	yellow	1	Correct response
2	orange	1	Correct response
3	yellow-orange	0	Both responses with a hyphen not credited

In the acceptable colour changes and observations document, where two colours are given with a hyphen between them, this indicates that both colours are required in a response with the hyphen between them.

Example: What is observed when a few drops of sodium hydroxide solution are added to a solution containing Cr^{3+} ions? [1]
MS: green-blue ppt [1]

Response	Candidate Response	Marks awarded	Notes
1	green-blue ppt	1	Correct response
2	blue-green ppt	1	Correct response
3	blue/green ppt	0	Hyphen is required between the colours
4	blue ppt	0	Both colours required with a hyphen
5	green ppt	0	Both colours required with a hyphen

Note that in Booklet A of AS3 and A23, more flexibility is allowed on the marking of colours. A range of colours and shades of those colours will be accepted.

3. Brackets in a response

Normal parentheses used in a mark scheme response means that a term is **not required** for the response to be marked correct. However, an incorrect term would lose the mark.

Example: Describe how you would make a salt bridge using paper in the laboratory. [1]

MS: Soak a strip of filter paper in a (saturated/concentrated) solution of potassium chloride/potassium nitrate [1]

Response	Candidate Response	Marks awarded	Notes
1	soak filter paper in potassium chloride solution	1	Correct response
2	soak a piece of filter paper in dilute potassium nitrate solution	0	Not accepted as dilute is incorrect

4. Marking of lists

Where candidates give extra responses, additional correct responses can be ignored.

Additional neutral responses can also be ignored. A neutral response is one which does not have a bearing on the question but is not incorrect.

Additional incorrect responses **cancel out** a correct response to the marking point to which they pertain.

Example: Describe how the presence of chloride ions could be confirmed in a sample of solid sodium chloride. [4]

MS: dissolve the solid in water/nitric acid [1]

add silver nitrate solution [1]

white [1] precipitate [1]

[4]

Response	Candidate Response	Marks awarded	Notes
1	Dissolve the solid in nitric acid and add silver nitrate solution and you will get a white precipitate/solution	3	The last mark is not awarded as solution is an incorrect response cancelling out the correct response.
2	Put the solid in water and add silver nitrate and ammonia. You will get a white precipitate.	3	No mention of solution with silver nitrate and ammonia is not completely incorrect but in context of this response it cancels out the second mark as well if they had written solution
3	Add silver nitrate solution and you get a white precipitate/solution	2	First mark not awarded and precipitate mark not awarded as solution would cancel this out

5. Marking values where a range is given

Where a numerical range is given, correct responses are any value in the range, the range itself or any other range given which falls within the MS range.

Example: Name the reagents and conditions under which they are used to form the benzenediazonium ion from phenylamine. [2]

MS: sodium nitrite and (dil/conc) hydrochloric acid [1]
temperature 0 – 10 °C/in ice [1]

Focussing on the range awarded for the second mark.

Response	Candidate Response	Marks awarded	Notes
1	0	1	A single value within the accepted range
2	1	1	A single value within the accepted range
3	5	1	A single value within the accepted range
4	10	1	A single value within the accepted range
5	2.5	1	A single value within the accepted range
6	0–10	1	The accepted range
7	5–10	1	A range given within the accepted range
8	5–15	0	Range given outside the accepted range

6. Names of compounds

- Any question which asks you to “name” a chemical expects a correct chemical name and any errors in the name given by a candidate will be a –1 error.
- Where a question asks for an IUPAC name for an organic compound, the answer will require, where appropriate, correct locant numbers, dashes, commas and spaces. Each error is –1.
- The term systematic name is often used in inorganic nomenclature where oxidation states are required, e.g. sodium sulfate(IV). An incorrect oxidation state would be a –1 error.

7. Marking equations

Some general points about formulae and equations:

- Equations are usually worth 1 mark if they do not require balancing, however very familiar equations with balancing may only be worth 1 mark and in that case all formulae and balancing must be correct.
- Equations worth 2 marks are marked as [1] for all formulae being correct and [1] for correct balancing. The balancing mark is dependent on the formulae mark and is only considered if all the formulae are correct. If any formula incorrect, no marks are awarded.
- Some more complex structural equations are worth 3 marks. Details of how to mark these questions will be provided in the mark scheme.

8. QWC

Quality of written communication is marked using indicative content and a banded mark scheme.

The initial marking is for the indicative content points. The number of indicative content points places a candidate in a specific band. The overall marks awarded should be in that band based on the standard of the written communication.

A typical banded grid from a mark scheme where there would be 8 indicative content points is shown below:

Band	Response	Mark
A	Candidates must use appropriate specialist terms including a minimum of 7 points of indicative content. They use good spelling, punctuation and grammar and the form and style are of a high standard.	[5]–[6]
B	Candidates must use appropriate specialist terms including a minimum of 5 points of indicative content. They use satisfactory spelling, punctuation and grammar and the form and style are of a satisfactory standard.	[3]–[4]
C	Candidates provide a brief and partial response including a minimum of 2 points of indicative content. They use limited spelling, punctuation and grammar and they have made little use of specialist terms. The form and style are of a limited standard.	[1]–[2]
D	Response not worthy of credit.	[0]

[6]

A candidate who provides 5 indicative content points is placed in band B and can be awarded 3 or 4 overall marks (out of 6) for their response based on the spelling, punctuation and grammar.

Generally, the upper mark in a band would be awarded unless the quality of the written communication was very poor (i.e. multiple spelling, punctuation and grammar errors).

9. Marking calculations

- The total marks in a calculation are given at the end of the question part on the mark scheme and each error in the calculation is –1 mark.
- Errors in a calculation may be carried forward within part of a calculation. This should be indicated using ECF.
- Where a specific number of significant figures or decimal places is asked for in the question, this should be provided and not following this instruction would be classed as an error.
- The phrase “appropriate number of significant figures” is used where a candidate must make a decision about the number of significant figures they use for their final answer. This will be the lowest number of significant figures in the data provided which is used in the calculation.
- Calculations which use the number in the calculator and arrive at the correct answer (following any instructions regarding significant figures or decimal places) can be awarded full marks.
- A correct numerical answer to a calculation (given to the specified number of significant figures or decimal places or correct appropriate number of significant figures) can be awarded full marks provided that the question does not state that working out must be shown.
- Where appropriate, units would be required with a numerical answer.

10. Definitions

- Definitions are provided in the clarification of terms document. Each error/omission in the definition is -1. Correct extra information provided by a candidate would not be penalised.
- Minor errors should not be penalised if they do not change the meaning of the answer given.

11. Organic structures

- Structural formulae should generally show the individual groups or atoms bonded to each carbon atom in the main chain or ring structure. CH_3 , CH_2 , CH , OH , NH_2 , CN , CHO , CO , COOH , COCl , COO , CONH_2 etc do not need to be expanded to show all bonds except where specifically asked for in the question.
- Skeletal formulae must show the angled chain. Functional groups should be clearly shown with all atoms except for carbon atoms.
- Each organic structure is generally worth 1 mark. However more complex structures may be worth more marks.
- Connectivity of atoms in structural formulae should only be penalised based on what is presented in the table.
- Bonds to groups on the left (or right) of a structure should be connected to the correct atom apart from in the case of CH_3 groups.
- Bonds going vertically to groups should be bonded to the correct atom, however if the bond appears to be close to the required atom, this may be accepted.

Accepted		Not accepted		
$\begin{array}{c} \\ \text{H}_3\text{C}-\text{C}- \\ \end{array}$		N/A		
$\begin{array}{c} \\ \text{CH}_3-\text{C}- \\ \end{array}$		N/A		
$\begin{array}{c} \\ \text{CH}_3\text{CH}_2-\text{C}- \\ \end{array}$		$\begin{array}{c} \\ \text{CH}_2\text{CH}_3-\text{C}- \\ \end{array}$		
$\begin{array}{c} \\ -\text{C}- \\ \\ \text{CH}_2\text{CH}_3 \end{array}$		$\begin{array}{c} \\ -\text{C}- \\ \\ \text{CH}_3\text{CH}_2 \end{array}$		
$\begin{array}{c} \\ \text{H}_2\text{N}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{NH}_2 \end{array}$	$\begin{array}{c} \\ \text{NH}_2-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{H}_2\text{N} \end{array}$	
$\begin{array}{c} \\ \text{HO}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{OH} \end{array}$	$\begin{array}{c} \\ \text{OH}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{HO} \end{array}$	
$\begin{array}{c} \\ \text{NC}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{CN} \end{array}$	$\begin{array}{c} \\ \text{CN}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{NC} \end{array}$	
$\begin{array}{c} \\ \text{OHC}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{CHO} \end{array}$	$\begin{array}{c} \\ \text{CHO}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{OHC} \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{CHO} \end{array}$
$\begin{array}{c} \\ \text{HOOC}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{COOH} \end{array}$	$\begin{array}{c} \\ \text{COOH}-\text{C}- \\ \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{HOOC} \end{array}$	$\begin{array}{c} \\ -\text{C}- \\ \\ \text{COOH} \end{array}$

12. Mechanisms

The following features are required for electrophilic addition, electrophilic substitution, nucleophilic substitution and nucleophilic addition mechanisms:

1. Curly arrows (coming from a bond or the ring of a benzene ring or from a lone pair of electrons)
When the curly arrow is showing the formation of a bond, it may go to the atom, close to the atom or in the position where the bond would form.
2. Lone pairs of electrons shown as a double dot beside the relative atom/ion.
3. Any charges on the intermediates in the mechanism.
4. Any leaving group shown in the products for substitution mechanisms.

Note that for radical substitution mechanisms the dot may be placed before or after the radical.

13. Marking diagrams

- Diagrams of apparatus are again marked in terms of the errors. Each error is -1.
- Diagrams of apparatus are expected to be two-dimensional cross-sectional diagrams of the assembled apparatus with clear labelling and recognisable pieces of apparatus.
- There should be no blockage to the flow of liquids or gases in a diagram of apparatus such as a line across the end of a delivery tube or the exit or entry from a piece of glassware unless intentional such as the valve in a separating funnel.

14. Solution/aqueous

- When describing a practical method or test and a solution of a substance is used, the term **solution** is required in the response unless it is in brackets in the mark scheme.
- The term solution is equivalent to aqueous. For example, aqueous sodium hydroxide is the same as sodium hydroxide solution.
- Solution is not required for dilute acids.

			AVAILABLE MARKS
1	S = Sucrose		
	(a) solid melts/forms a (viscous) orange/brown liquid [1] black solid formed [1] sweet smell/caramel smell/burnt smell [1] droplets of colourless liquid inside top of boiling tube [1]	[4]	
	(b) (i) purple [1] grey/blue [1] green [1] yellow [1] orange [1]	max [4]	
	(ii) different colours indicate different oxidation states	[1]	
	(c) blue colour remains/no change	[1]	
	(d) (i) red [1] precipitate [1]	[2]	
	(ii) yellow/orange [1] precipitate [1]	[2]	
	(iii) sample S did not react with Fehling's (part (c)) [1] but product from reaction in part (d)(i) showed reaction with Fehling's reagent [1]	[2]	
	(iv) reduces Fehling's solution/reacts with Fehling's solution	[1]	17
2	(a) experiment 4 = fastest time experiment 2 = slowest time all recorded to nearest second.	[2]	
	(b) rates calculated to 1 decimal place (error [−1])	[2]	
	(c) axes labelled correctly with units [1] suitable scaling/at least $\frac{3}{4}$ of graph paper used [1] points plotted correctly [1] best fit line [1] graph starts at (0,0) [1]	[5]	
	(d) (i) reaction between iodine and starch	[1]	
	(ii) any indication of a fair test	[1]	
	(iii) time delay in starting/stopping stop clock for experiments 1 and 4 /inaccuracy of using measuring cylinders	[1]	
	(iv) repeat the experiment	[1]	13
Total			30



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Centre Number

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Candidate Number

--	--	--	--	--

Chemistry

Assessment Unit A2 3

assessing

Further Practical Chemistry

Practical Booklet B (Theory)



ACH32

[ACH32]

Assessment

TIME

1 hour 15 minutes.

Assessment Level of Control:

Tick the relevant box (✓)

Controlled Conditions	
Other	

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

You must answer the questions in the spaces provided.

Do not write outside the boxed area on each page or on blank pages.

Complete in black ink only. **Do not write with a gel pen.**

Answer **all three** questions.

INFORMATION FOR CANDIDATES

The total mark for this paper is 60.

Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

A Periodic Table of Elements (including some data) is provided.



- 1 Calcium carbonate is present in some indigestion tablets. A back titration is used to calculate the percentage by mass of calcium carbonate in an indigestion tablet.

(a) Explain why a back titration must be carried out to determine the mass of calcium carbonate in an indigestion tablet.

_____ [1]

(b) The following procedure was carried out.

Step 1: Four indigestion tablets, total mass 1.76 g, were added to 25.0 cm³ of 2.00 mol dm⁻³ hydrochloric acid in a 250 cm³ conical flask.

Step 2: On completion of the reaction in **Step 1**, the contents of the conical flask were made up to 250 cm³ in a volumetric flask. The flask was labelled 'solution A'.

Step 3: 25.0 cm³ of solution A was transferred to a conical flask using a pipette. A few drops of phenolphthalein indicator solution were added to the flask with swirling.

Step 4: This solution was titrated against 0.100 mol dm⁻³ sodium hydroxide solution. **Steps 3 and 4** were repeated to obtain concordant results. A mean titre value of 24.5 cm³ was calculated.

(i) Explain how you could determine when the reaction in **Step 1** is complete.

_____ [1]

(ii) The product mixture formed in **Step 1** contains both calcium ions and chloride ions. Describe how you would carry out qualitative tests to confirm the presence of each of these ions.

test for calcium ions: _____

_____ [2]

test for chloride ions: _____

_____ [2]



(c) Describe, giving practical details, how solution **A** was prepared in **Step 2**.

[4]

(d) State the colour change in the conical flask at the end point in **Step 4**.

[1]

(e) (i) Calculate the number of moles of hydrochloric acid that reacted with the sodium hydroxide solution in **Step 4**.

[1]

(ii) Calculate the number of moles of excess hydrochloric acid in 250 cm^3 of solution **A**.

[1]

(iii) Calculate the number of moles of hydrochloric acid which reacted with calcium carbonate.

[1]

[Turn over]



(iv) Calculate the mass of calcium carbonate in the indigestion tablets.

[2]

(v) Calculate the percentage, by mass, of calcium carbonate in an indigestion tablet.

[2]



2 The table below gives the standard electrode potentials for five redox systems.

redox system	equation	$E^{\ominus}/V$
1	$\text{MnO}_4^{-}(\text{aq}) + 8\text{H}^{+}(\text{aq}) + 5\text{e}^{-} \rightleftharpoons \text{Mn}^{2+}(\text{aq}) + 4\text{H}_2\text{O}(\text{l})$	+1.51
2	$\text{Cr}_2\text{O}_7^{2-}(\text{aq}) + 14\text{H}^{+}(\text{aq}) + 6\text{e}^{-} \rightleftharpoons 2\text{Cr}^{3+}(\text{aq}) + 7\text{H}_2\text{O}(\text{l})$	+1.33
3	$\text{Ag}^{+}(\text{aq}) + \text{e}^{-} \rightleftharpoons \text{Ag}(\text{s})$	+0.80
4	$\text{Fe}^{3+}(\text{aq}) + \text{e}^{-} \rightleftharpoons \text{Fe}^{2+}(\text{aq})$	+0.77
5	$\text{Al}^{3+}(\text{aq}) + 3\text{e}^{-} \rightleftharpoons \text{Al}(\text{s})$	-1.66

(a) State the conditions that are used to measure standard electrode potentials.

_____ [2]

(b) (i) An aqueous solution of Fe^{2+} reacted with an acidic solution containing MnO_4^{-} ions.

Use the half-equations in the table to write an equation for this redox reaction.

_____ [2]

(ii) Describe a chemical test to confirm the presence of Fe^{3+} ions in an aqueous solution.

_____ [2]

[Turn over



(c) An electrochemical cell can be made, based on redox systems **2** and **3**. The cell emf is measured as + 0.53 V.

(i) The electrode potential of a silver half-cell is more positive when the concentration of silver ions is increased. Explain this in terms of equilibrium.

_____ [1]

(ii) Suggest how the change in (c)(i) will affect the emf of the electrochemical cell based on redox systems **2** and **3**.

_____ [1]

(d) Give the observation in the reduction half-cell when a current flows in the electrochemical cell set up using redox systems **1** and **3**.

_____ [1]

(e) Aluminium can be used to clean a silver spoon that has a layer of black silver sulfide. The spoon is dipped into sodium hydrogencarbonate solution. It is connected by a wire to a strip of aluminium foil, also dipping into the solution. An electrochemical reaction occurs.

(i) Draw and label a diagram of the apparatus you could set up in the laboratory to carry out this electrochemical reaction.

[2]



(ii) Write the half-equations for the oxidation and reduction reactions in the cell.

_____ [2]

(iii) Combine the two half-equations to give a redox equation for the overall reaction.

_____ [1]

(iv) Calculate the emf for this cell.

_____ [1]

(v) The aqueous sodium hydrogencarbonate also removes any aluminium hydroxide from the surface of the metal. Suggest why the removal of aluminium hydroxide is needed.

_____ [1]

(vi) During the reaction, aluminium displaces silver from the silver sulfide to form silver metal and aluminium sulfide. Write an equation for this reaction.

_____ [1]

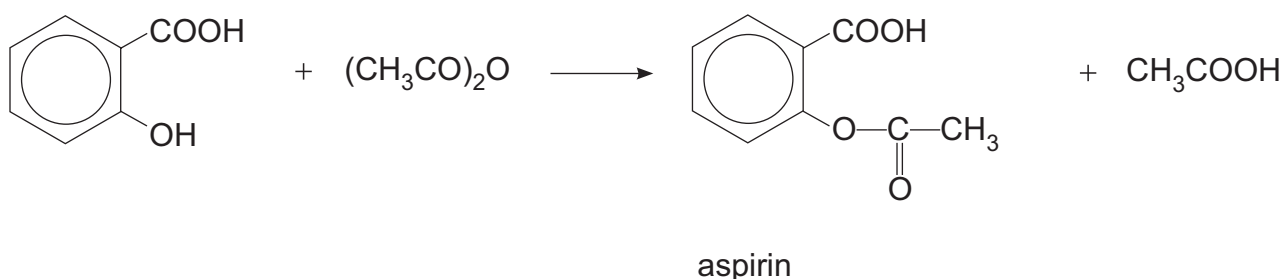
(vii) The aluminium sulfide produced reacts with the water present to form a gas with a rotten egg smell. Name this gas.

_____ [1]

[Turn over



- 3 Aspirin is a drug used in the treatment of inflammatory conditions and is an important blood decoagulant. It can be synthesised in the laboratory from the reaction of salicylic acid with ethanoic anhydride.



- (a) (i) Calculate the atom economy for this reaction.

[2]

- (ii) There are a number of alternative reagents to ethanoic anhydride for the laboratory preparation of aspirin. Name **one** of these reagents and state why it is not normally used.

[2]



(b) The laboratory synthesis of aspirin was carried out as outlined below.

Step 1: 6.0 g of salicylic acid were weighed out and transferred to a clean 250 cm³ conical flask.

Step 2: 10 cm³ of ethanoic anhydride (excess) and 1.0 cm³ of concentrated phosphoric acid were added to the conical flask.

Step 3: The flask was heated, with stirring, in a water bath for 30 minutes.

Step 4: 6 cm³ of deionised water were added to the flask.

Step 5: The crude mixture was poured onto 400 g of crushed ice.

Step 6: The crude product was collected by suction filtration.

(i) What is the role of the concentrated phosphoric acid in **Step 2**?

_____ [1]

(ii) In **Step 4** of this reaction the excess ethanoic anhydride is removed by reaction with water.

Write an equation for this reaction.

_____ [1]

(iii) Describe the appearance of the crude product collected in **Step 6** of the procedure.

_____ [1]

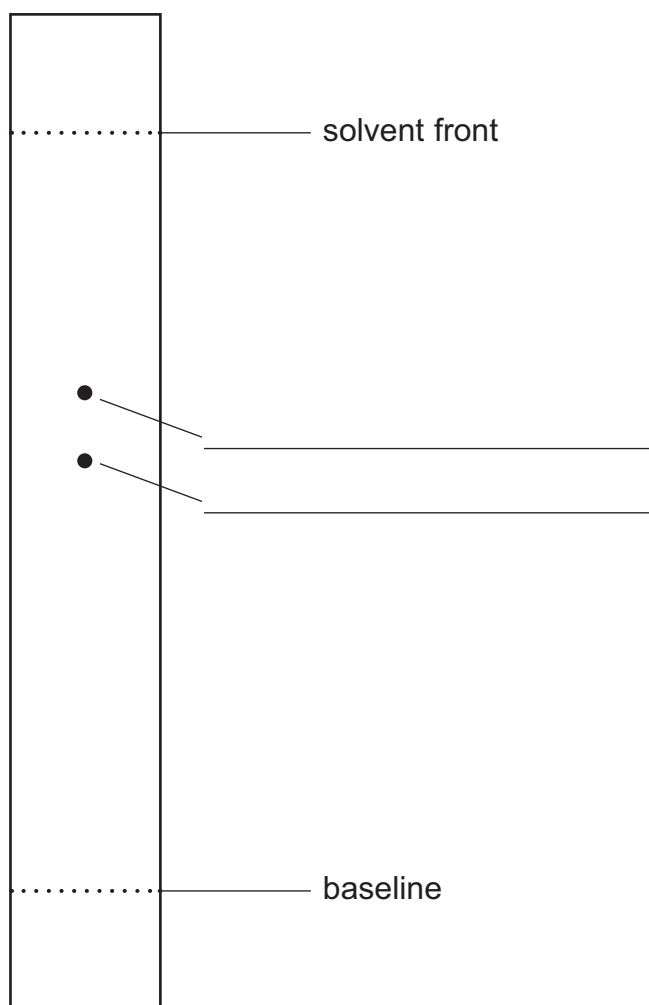
(iv) Describe the procedure carried out to recrystallise the crude product collected in **Step 6**.

_____ [3]

[Turn over]



- (c) The purity of laboratory made aspirin can be tested using thin-layer chromatography. Aspirin and salicylic acid have different R_f values. Salicylic acid is more soluble than aspirin in the mobile phase.



- (i) On the chromatogram above label each spot as either aspirin or salicylic acid. [1]
- (ii) Use the chromatogram provided, to calculate the R_f value of each spot. Take measurements from the middle of each spot. Give your answers to two significant figures.

R_f of aspirin _____

R_f of salicylic acid _____

[1]



- (d) In this synthesis 7.0 g of aspirin were produced. Calculate the percentage yield of this reaction.

[3]

- (e) (i) In the laboratory synthesis of aspirin, state **one** theoretical reason for a reduced yield of the crude product.

[1]

- (ii) In the laboratory synthesis of aspirin, state **one** practical reason for a reduced yield of crude product.

[1]

- (f) Over time, aspirin hydrolyses to reform salicylic acid. Name the functional group in aspirin that reacts with water.

[1]

[Turn over



- (g) Salicylic acid forms a coloured complex with Fe^{3+} ions. Describe how colorimetry could be used to determine the concentration of salicylic acid in an aspirin tablet.

[4]

- (h) (i) The sodium salt of aspirin is the active ingredient in soluble aspirin tablets. Give the equation for its formation from aspirin.

[1]

- (ii) State and explain an advantage of using the sodium salt of aspirin in tablets.

[1]

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ADVANCED
General Certificate of Education

Chemistry
Assessment Unit A2 3
assessing
Further Practical Chemistry
Practical Booklet B (Theory)
[ACH32]

Assessment

**MARK
SCHEME**

General Marking Instructions

Introduction

The main purpose of the mark scheme is to ensure that examinations are marked accurately, consistently and fairly. The mark scheme provides examiners with an indication of the nature and range of candidates' responses likely to be worthy of credit. It also sets out the criteria which they should apply in allocating marks to candidates' responses.

Assessment objectives

Below are the assessment objectives for **GCE Chemistry**:

Candidates should be able to:

AO1	Demonstrate knowledge and understanding of scientific ideas, processes, techniques and procedures.
AO2	Apply knowledge and understanding of scientific ideas, processes, techniques and procedures: • in a theoretical context • in a practical context • when handling quantitative and qualitative data
AO3	Analyse, interpret and evaluate scientific information, ideas and evidence (in relation to particular issues) • make judgements and reach conclusions • develop and refine practical design and procedures

Quality of candidates' responses

In marking the examination papers, examiners should be looking for a quality of response reflecting the level of maturity which may reasonably be expected of a 17- or 18-year-old which is the age at which the majority of candidates sit their GCE examinations.

Flexibility in marking

Mark schemes are not intended to be totally prescriptive. No mark scheme can cover all the responses which candidates may produce. In the event of unanticipated answers, examiners are expected to use their professional judgement to assess the validity of answers. If an answer is particularly problematic, then examiners should seek the guidance of the Supervising Examiner.

Positive marking

Examiners are encouraged to be positive in their marking, giving appropriate credit for what candidates know, understand and can do rather than penalising candidates for errors or omissions. The exception to this, for GCE Chemistry, is when examiners are marking complex calculations and mechanisms when the examiners are briefed to mark by error or omission. Examiners should make use of the whole of the available mark range for any particular question and be prepared to award full marks for a response which is as good as might reasonably be expected of a 17- or 18-year-old GCE candidate.

Awarding zero marks

Marks should only be awarded for valid responses and no marks should be awarded for an answer which is completely incorrect or inappropriate.

Marking Calculations

In marking answers involving calculations, examiners should apply the 'carry error through' rule so that candidates are not penalised more than once for a computational error. To avoid a candidate being penalised, marks can be awarded where correct conclusions or inferences are made from their incorrect calculations.

Types of mark schemes

Mark schemes for tasks or questions which require candidates to respond in extended written form are marked on the basis of levels of response which take account of the quality of written communication.

Other questions which require only short answers are marked on a point for point basis with marks awarded for each valid piece of information provided.

Levels of response

In deciding which level of response to award, examiners should look for the number of indicative content points in candidate responses to ensure that the answer has been written to coincide with the question. In deciding which mark within a particular level to award to any response, quality of communication will be assessed and examiners are expected to use their professional judgement.

The following guidance is provided to assist examiners.

- **Threshold performance:** Response which just merits inclusion in the level but the quality of communication is basic should be awarded a mark at the bottom of the range.
- **High performance:** Response which fully satisfies the level description for both content and quality of communication should be awarded a mark at the top of the range.

Quality of written communication

Quality of written communication is taken into account in assessing candidates' responses to all tasks and questions on theory examination papers that require them to respond in extended written form. These tasks and questions are marked on the basis of levels of response. The description for each level of response includes reference to the quality of written communication.

For conciseness, quality of written communication is distinguished within levels of response as follows:

Level C: Quality of written communication is basic.

Level B: Quality of written communication is good.

Level A: Quality of written communication is excellent.

In interpreting these level descriptions, examiners should refer to the more detailed guidance provided below:

Level C (Basic): Basic reference to scientific terminology. The candidate makes only a limited selection and use of an appropriate form and style of writing. The organisation of material may lack clarity and coherence. There is little use of specialist vocabulary. Presentation, spelling, punctuation and grammar may be such that intended meaning is not clear.

Level B (Good): Good reference to scientific terminology. The candidate makes a reasonable selection and use of an appropriate form and style of writing. Relevant material is organised with some clarity and coherence. There is some use of appropriate specialist vocabulary. Presentation, spelling, punctuation and grammar are sufficiently competent to make meaning clear.

Level A (Excellent): Excellent reference to scientific terminology. The candidate successfully selects and uses the most appropriate form and style of writing. Relevant material is organised with a high degree of clarity and coherence. There is widespread and accurate use of appropriate specialist vocabulary. Presentation, spelling, punctuation and grammar are of a sufficiently high standard to make meaning clear.

General marking guidance for GCE Chemistry

1. Alternative responses

In general, a solidus (/) used between responses indicates alternative answers or parts of an answer.

When a solidus may be confused with part of the answer (for example as a division sign or with units) “or” may be used to show alternatives.

Example: What is observed when propanone is warmed with Tollens' reagent? [1]

MS: remains colourless/no change [1]

2. Acceptable colours and observations

For the use of a solidus with the colours supplied in the **acceptable colour changes and observations** document, the solidus indicates that one of the responses should be given.

Example: What colour is the flame observed when a flame test is carried out on a sample of sodium chloride? [1]

MS: yellow/orange [1]

Response	Candidate Response	Marks awarded	Notes
1	yellow	1	Correct response
2	orange	1	Correct response
3	yellow-orange	0	Both responses with a hyphen not credited

In the acceptable colour changes and observations document, where two colours are given with a hyphen between them, this indicates that both colours are required in a response with the hyphen between them.

Example: What is observed when a few drops of sodium hydroxide solution are added to a solution containing Cr^{3+} ions? [1]

MS: green-blue ppt [1]

Response	Candidate Response	Marks awarded	Notes
1	green-blue ppt	1	Correct response
2	blue-green ppt	1	Correct response
3	blue/green ppt	0	Hyphen is required between the colours
4	blue ppt	0	Both colours required with a hyphen
5	green ppt	0	Both colours required with a hyphen

Note that in Booklet A of AS3 and A23, more flexibility is allowed on the marking of colours. A range of colours and shades of those colours will be accepted.

3. Brackets in a response

Normal parentheses used in a mark scheme response means that a term is **not required** for the response to be marked correct. However, an incorrect term would lose the mark.

Example: Describe how you would make a salt bridge using paper in the laboratory. [1]

MS: Soak a strip of filter paper in a (saturated/concentrated) solution of potassium chloride/potassium nitrate [1]

Response	Candidate Response	Marks awarded	Notes
1	soak filter paper in potassium chloride solution	1	Correct response
2	soak a piece of filter paper in dilute potassium nitrate solution	0	Not accepted as dilute is incorrect

4. Marking of lists

Where candidates give extra responses, additional correct responses can be ignored.

Additional neutral responses can also be ignored. A neutral response is one which does not have a bearing on the question but is not incorrect.

Additional incorrect responses **cancel out** a correct response to the marking point to which they pertain.

Example: Describe how the presence of chloride ions could be confirmed in a sample of solid sodium chloride. [4]

MS: dissolve the solid in water/nitric acid [1]
add silver nitrate solution [1]
white [1] precipitate [1]

[4]

Response	Candidate Response	Marks awarded	Notes
1	Dissolve the solid in nitric acid and add silver nitrate solution and you will get a white precipitate/solution	3	The last mark is not awarded as solution is an incorrect response cancelling out the correct response.
2	Put the solid in water and add silver nitrate and ammonia. You will get a white precipitate.	3	No mention of solution with silver nitrate and ammonia is not completely incorrect but in context of this response it cancels out the second mark as well if they had written solution
3	Add silver nitrate solution and you get a white precipitate/solution	2	First mark not awarded and precipitate mark not awarded as solution would cancel this out

5. Marking values where a range is given

Where a numerical range is given, correct responses are any value in the range, the range itself or any other range given which falls within the MS range.

Example: Name the reagents and conditions under which they are used to form the benzenediazonium ion from phenylamine. [2]

MS: sodium nitrite and (dil/conc) hydrochloric acid [1]
temperature 0 – 10 °C/in ice [1]

Focussing on the range awarded for the second mark.

Response	Candidate Response	Marks awarded	Notes
1	0	1	A single value within the accepted range
2	1	1	A single value within the accepted range
3	5	1	A single value within the accepted range
4	10	1	A single value within the accepted range
5	2.5	1	A single value within the accepted range
6	0–10	1	The accepted range
7	5–10	1	A range given within the accepted range
8	5–15	0	Range given outside the accepted range

6. Names of compounds

- Any question which asks you to “name” a chemical expects a correct chemical name and any errors in the name given by a candidate will be a –1 error.
- Where a question asks for an IUPAC name for an organic compound, the answer will require, where appropriate, correct locant numbers, dashes, commas and spaces. Each error is –1.
- The term systematic name is often used in inorganic nomenclature where oxidation states are required, e.g. sodium sulfate(IV). An incorrect oxidation state would be a –1 error.

7. Marking equations

Some general points about formulae and equations:

- Equations are usually worth 1 mark if they do not require balancing, however very familiar equations with balancing may only be worth 1 mark and in that case all formulae and balancing must be correct.
- Equations worth 2 marks are marked as [1] for all formulae being correct and [1] for correct balancing. The balancing mark is dependent on the formulae mark and is only considered if all the formulae are correct. If any formula incorrect, no marks are awarded.
- Some more complex structural equations are worth 3 marks. Details of how to mark these questions will be provided in the mark scheme.

8. QWC

Quality of written communication is marked using indicative content and a banded mark scheme.

The initial marking is for the indicative content points. The number of indicative content points places a candidate in a specific band. The overall marks awarded should be in that band based on the standard of the written communication.

A typical banded grid from a mark scheme where there would be 8 indicative content points is shown below:

Band	Response	Mark
A	Candidates must use appropriate specialist terms including a minimum of 7 points of indicative content. They use good spelling, punctuation and grammar and the form and style are of a high standard.	[5]–[6]
B	Candidates must use appropriate specialist terms including a minimum of 5 points of indicative content. They use satisfactory spelling, punctuation and grammar and the form and style are of a satisfactory standard.	[3]–[4]
C	Candidates provide a brief and partial response including a minimum of 2 points of indicative content. They use limited spelling, punctuation and grammar and they have made little use of specialist terms. The form and style are of a limited standard.	[1]–[2]
D	Response not worthy of credit.	[0]

[6]

A candidate who provides 5 indicative content points is placed in band B and can be awarded 3 or 4 overall marks (out of 6) for their response based on the spelling, punctuation and grammar.

Generally, the upper mark in a band would be awarded unless the quality of the written communication was very poor (i.e. multiple spelling, punctuation and grammar errors).

9. Marking calculations

- The total marks in a calculation are given at the end of the question part on the mark scheme and each error in the calculation is –1 mark.
- Errors in a calculation may be carried forward within part of a calculation. This should be indicated using ECF.
- Where a specific number of significant figures or decimal places is asked for in the question, this should be provided and not following this instruction would be classed as an error.
- The phrase “appropriate number of significant figures” is used where a candidate must make a decision about the number of significant figures they use for their final answer. This will be the lowest number of significant figures in the data provided which is used in the calculation.
- Calculations which use the number in the calculator and arrive at the correct answer (following any instructions regarding significant figures or decimal places) can be awarded full marks.
- A correct numerical answer to a calculation (given to the specified number of significant figures or decimal places or correct appropriate number of significant figures) can be awarded full marks provided that the question does not state that working out must be shown.
- Where appropriate, units would be required with a numerical answer.

10. Definitions

- Definitions are provided in the clarification of terms document. Each error/omission in the definition is -1. Correct extra information provided by a candidate would not be penalised.
- Minor errors should not be penalised if they do not change the meaning of the answer given.

11. Organic structures

- Structural formulae should generally show the individual groups or atoms bonded to each carbon atom in the main chain or ring structure. CH_3 , CH_2 , CH , OH , NH_2 , CN , CHO , CO , COOH , COCl , COO , CONH_2 etc do not need to be expanded to show all bonds except where specifically asked for in the question.
- Skeletal formulae must show the angled chain. Functional groups should be clearly shown with all atoms except for carbon atoms.
- Each organic structure is generally worth 1 mark. However more complex structures may be worth more marks.
- Connectivity of atoms in structural formulae should only be penalised based on what is presented in the table.
- Bonds to groups on the left (or right) of a structure should be connected to the correct atom apart from in the case of CH_3 groups.
- Bonds going vertically to groups should be bonded to the correct atom, however if the bond appears to be close to the required atom, this may be accepted.

Accepted		Not accepted		
$\begin{array}{c} \\ \text{H}_3\text{C} - \text{C} - \\ \end{array}$		N/A		
$\begin{array}{c} \\ \text{CH}_3 - \text{C} - \\ \end{array}$		N/A		
$\begin{array}{c} \\ \text{CH}_3\text{CH}_2 - \text{C} - \\ \end{array}$		$\begin{array}{c} \\ \text{CH}_2\text{CH}_3 - \text{C} - \\ \end{array}$		
$\begin{array}{c} \\ - \text{C} - \\ \\ \text{CH}_2\text{CH}_3 \end{array}$		$\begin{array}{c} \\ - \text{C} - \\ \\ \text{CH}_3\text{CH}_2 \end{array}$		
$\begin{array}{c} \\ \text{H}_2\text{N} - \text{C} - \\ \end{array}$	$\begin{array}{c} \\ - \text{C} - \\ \\ \text{NH}_2 \end{array}$	$\begin{array}{c} \\ \text{NH}_2 - \text{C} - \\ \end{array}$	$\begin{array}{c} \\ - \text{C} - \\ \\ \text{H}_2\text{N} \end{array}$	
$\begin{array}{c} \\ \text{HO} - \text{C} - \\ \end{array}$	$\begin{array}{c} \\ - \text{C} - \\ \\ \text{OH} \end{array}$	$\begin{array}{c} \\ \text{OH} - \text{C} - \\ \end{array}$	$\begin{array}{c} \\ - \text{C} - \\ \\ \text{HO} \end{array}$	
$\begin{array}{c} \\ \text{NC} - \text{C} - \\ \end{array}$	$\begin{array}{c} \\ - \text{C} - \\ \\ \text{CN} \end{array}$	$\begin{array}{c} \\ \text{CN} - \text{C} - \\ \end{array}$	$\begin{array}{c} \\ - \text{C} - \\ \\ \text{NC} \end{array}$	
$\begin{array}{c} \\ \text{OHC} - \text{C} - \\ \end{array}$	$\begin{array}{c} \\ - \text{C} - \\ \\ \text{CHO} \end{array}$	$\begin{array}{c} \\ \text{CHO} - \text{C} - \\ \end{array}$	$\begin{array}{c} \\ - \text{C} - \\ \\ \text{OHC} \end{array}$	$\begin{array}{c} \\ - \text{C} - \\ \\ \text{CHO} \end{array}$
$\begin{array}{c} \\ \text{HOOC} - \text{C} - \\ \end{array}$	$\begin{array}{c} \\ - \text{C} - \\ \\ \text{COOH} \end{array}$	$\begin{array}{c} \\ \text{COOH} - \text{C} - \\ \end{array}$	$\begin{array}{c} \\ - \text{C} - \\ \\ \text{HOOC} \end{array}$	$\begin{array}{c} \\ - \text{C} - \\ \\ \text{COOH} \end{array}$

12. Mechanisms

The following features are required for electrophilic addition, electrophilic substitution, nucleophilic substitution and nucleophilic addition mechanisms:

1. Curly arrows (coming from a bond or the ring of a benzene ring or from a lone pair of electrons)
When the curly arrow is showing the formation of a bond, it may go to the atom, close to the atom or in the position where the bond would form.
2. Lone pairs of electrons shown as a double dot beside the relative atom/ion.
3. Any charges on the intermediates in the mechanism.
4. Any leaving group shown in the products for substitution mechanisms.

Note that for radical substitution mechanisms the dot may be placed before or after the radical.

13. Marking diagrams

- Diagrams of apparatus are again marked in terms of the errors. Each error is -1.
- Diagrams of apparatus are expected to be two-dimensional cross-sectional diagrams of the assembled apparatus with clear labelling and recognisable pieces of apparatus.
- There should be no blockage to the flow of liquids or gases in a diagram of apparatus such as a line across the end of a delivery tube or the exit or entry from a piece of glassware unless intentional such as the valve in a separating funnel.

14. Solution/aqueous

- When describing a practical method or test and a solution of a substance is used, the term **solution** is required in the response unless it is in brackets in the mark scheme.
- The term solution is equivalent to aqueous. For example, aqueous sodium hydroxide is the same as sodium hydroxide solution.
- Solution is not required for dilute acids.

1 (a) calcium carbonate is insoluble in water	[1]	AVAILABLE MARKS
(b) (i) bubbles (of gas) stop forming	[1]	
(ii) test for calcium ions: dip a nichrome wire into sample solution and place in blue Bunsen (burner) flame/carry out a flame test [1] brick red/red flame [1]	[2]	
test for chloride ions: add silver nitrate solution [1] white ppt [1]	[2]	
(c) transfer the solution to the 250 cm ³ volumetric flask [1] rinse the conical flask with deionised water and add washings to the volumetric flask [1] make up to the mark by adding deionised water until the bottom of the meniscus is on the mark (or line) [1] stopper the flask and invert to mix [1]	[4]	
(d) colourless to pink	[1]	
(e) (i) moles of hydrochloric acid = 2.45×10^{-3}	[1]	
(ii) 2.45×10^{-2}	[1]	
(iii) original moles = $\frac{2.00 \times 25.0}{1000} = 0.05$ reacting moles = $0.05 - 2.45 \times 10^{-2} = 0.0255$	[1]	
(iv) Mass of calcium carbonate = $\frac{0.0255}{2} \times 100 = 1.275/1.28 \text{ g}$	[2]	
(v) $1.275 \div 1.76 \times 100 = 72/72.4\%$	[2]	18

2	(a) 100 kPa 25 °C/298 K 1 mol dm⁻³ (error [-1])	[2]
(b)	(i) $\text{MnO}_4^- + 5\text{Fe}^{2+} + 8\text{H}^+ \rightarrow \text{Mn}^{2+} + 5\text{Fe}^{3+} + 4\text{H}_2\text{O}$	[2]
	(ii) add a few drops of aqueous sodium hydroxide/ammonia solution [1] brown ppt [1]	[2]
(c)	(i) the position of equilibrium will move to the right	[1]
	(ii) emf becomes smaller/less positive	[1]
(d)	the purple colour fades/purple to colourless	[1]
(e)	(i) silver spoon and aluminium, both in contact with sodium hydrogencarbonate solution [1] connecting wire [1]	[2]
	(ii) $\text{Ag}^+ + \text{e}^- \rightarrow \text{Ag}$ [1] $\text{Al} \rightarrow \text{Al}^{3+} + 3\text{e}^-$ [1]	[2]
	(iii) $3\text{Ag}^+ + \text{Al} \rightarrow \text{Al}^{3+} + 3\text{Ag}$	[1]
	(iv) $0.80 + 1.66 = + 2.46 \text{ V}$	[1]
	(v) the aluminium would stop reacting	[1]
	(vi) $3\text{Ag}_2\text{S} + 2\text{Al} \rightarrow 6\text{Ag} + \text{Al}_2\text{S}_3$	[1]
	(vii) hydrogen sulfide	[1]

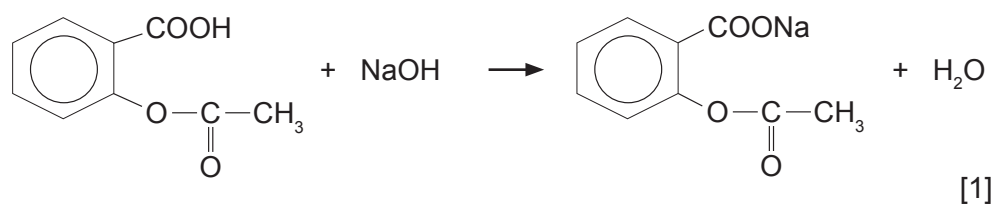
AVAILABLE
MARKS

18

- 3 (a) (i) atom economy = $\frac{180}{240} \times 100 = 75\%$ [2]
- (ii) ethanoic acid [1]
 reaction does not go to completion/reaction is too slow [1]
 or
 ethanoyl chloride [1]
 produces HCl gas/vigorous reaction/safety [1] [2]
- (b) (i) a catalyst [1]
- (ii) $(\text{CH}_3\text{CO})_2\text{O} + \text{H}_2\text{O} \rightarrow 2\text{CH}_3\text{COOH}$ [1]
- (iii) white solid/crystals [1]
- (iv) dissolve in a minimum volume of hot solvent [1]
 filter when hot using gravity filtration [1]
 allow to cool and crystallise [1]
 filter (off the crystals) using suction filtration [1]
 any 3 from 4 [3]
- (c) (i) lower spot aspirin/upper spot salicylic acid [1]
- (ii) R_f of aspirin about 0.57
 R_f of salicylic acid about 0.66 [1]
- (d) theoretical yield of aspirin = $\frac{6}{138} \times 180 = 7.83 \text{ g}$
- % yield = $\frac{7}{7.83} \times 100 = 89.4\%$ [3]
- (e) (i) incomplete reaction/side reaction [1]
- (ii) loss in transfer/loss in separation/loss in recrystallisation [1]
- (f) ester (group) [1]
- (g) prepare solutions of salicylic acid/ Fe^{3+} complex at different concentrations [1]
 plot a calibration curve of absorbance against concentration [1]
 dissolve an aspirin tablet in a suitable solvent and
 add excess aqueous Fe^{3+} ions [1]
 place in colorimeter, record absorbance and use graph to determine concentration [1] [4]

AVAILABLE
MARKS

(h) (i)



(ii) less acidic so less irritation of digestive system [1]

or

more soluble so more quickly absorbed (into bloodstream) [1]

[1]

Total

AVAILABLE
MARKS

24

60

*Rewarding Learning*

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2022

Centre Number

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Candidate Number

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Chemistry

Assessment Unit AS 1

assessing

Basic concepts in Physical
and Inorganic Chemistry



[SCH14]

SCH14

TUESDAY 17 MAY, MORNING

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

Answer **all sixteen** questions in **Sections A and B**.

You must answer the questions in the spaces provided.

Do not write outside the boxed area on each page or on blank pages.

Complete in black ink only. **Do not write with a gel pen or a pencil.**

INFORMATION FOR CANDIDATES

The total mark for this paper is 90.

Quality of written communication will be assessed in Question **13(a)(ii)**.

The figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

A Periodic Table of Elements, containing some data, is included with this question paper.



Section A

For each of the following questions, only **one** of the lettered responses (A – D) is correct.

Select the correct response for each question and write the appropriate letter in the space provided.

1 Which one of the following does **not** obey the octet rule?

- A NH_3
- B BF_3
- C OH^-
- D N_2

Answer _____ [1]

2 The first six successive ionisation energies (in kJ mol^{-1}) of an element M are:

740 1500 7700 10500 13600 18000

The formula of the oxide of M is:

- A MO
- B MO_2
- C M_2O
- D M_2O_3

Answer _____ [1]



3 Which one of the following contains a co-ordinate bond?



Answer _____ [1]

4 Bromine has two isotopes, ^{79}Br and ^{81}Br . A mass spectrum of bromine (Br_2) will only contain peaks at m/z values:

A 79 and 81

B 79, 81, 158 and 162

C 79, 81, 158, 160 and 162

D 158, 160 and 162

Answer _____ [1]

5 Which one of the following gives the correct numbers and shapes of orbitals occupied by electrons in an atom of neon?

A One spherical and one dumbbell

B One spherical and three dumbbell

C Two spherical and one dumbbell

D Two spherical and three dumbbell

Answer _____ [1]

[Turn over



6 Isotopes are atoms with:

- A different atomic numbers and different mass numbers
- B different atomic numbers and same mass number
- C same atomic number and different mass numbers
- D same atomic number and same mass number

Answer _____ [1]

7 The shape of the AlH_4^- ion is:

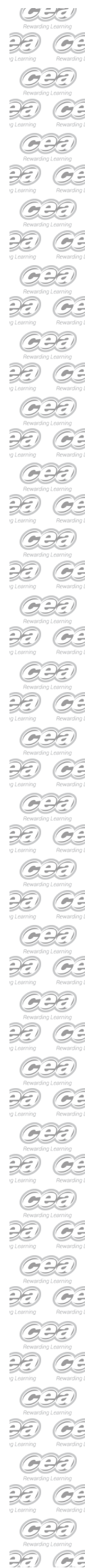
- A bent
- B pyramidal
- C tetrahedral
- D T-shaped

Answer _____ [1]

8 A white solid gives a crimson flame test and fizzes with dilute hydrochloric acid. The white solid is:

- A calcium carbonate
- B calcium nitrate
- C lithium carbonate
- D lithium nitrate

Answer _____ [1]



9 The melting points of the elements going across the third period rise to a peak and then:

- A fall
- B fall and rise again
- C fall, rise and fall again
- D fall, rise, fall and rise again

Answer _____ [1]

10 Which of the following does **not** have a giant structure?

- A calcium
- B diamond
- C sodium chloride
- D sulfur

Answer _____ [1]



Section B

Answer **all six** questions in this section

- 11** Copper(I) oxide is a red solid. It reacts with sulfuric acid in a disproportionation reaction forming copper, copper(II) sulfate and water.

(a) (i) State what is meant by a **disproportionation reaction**.

[2]

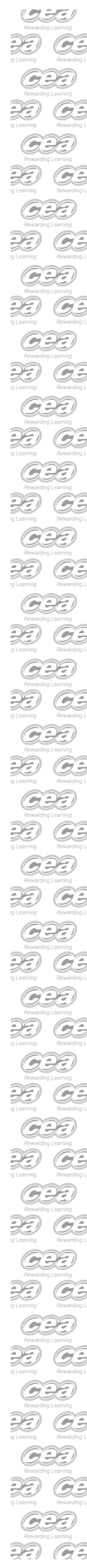
(ii) Write the equation for the disproportionation reaction.

[1]

(b) Explain how you could test for the presence of copper(II) ions in the solution formed.

Experimental details are not required.

[2]





12 The halogens are Group VII in the Periodic Table.

(a) Compare the colour and relative solubility of iodine in water and hexane.

[3]

(b) The boiling points of the hydrogen halides are shown in the table below.

Hydrogen halide	HF	HCl	HBr	HI
Boiling point /°C	20	−85	−67	−35

Explain the change in boiling points of the hydrogen halides.

[4]



(c) Bromine is an important reagent in producing chemicals such as NaBrO and NaBrO₃.

(i) Give the systematic names of NaBrO and NaBrO₃.

NaBrO _____

NaBrO₃ _____ [2]

(ii) NaBrO and NaBrO₃ can be prepared by the reaction of bromine with sodium hydroxide solution. State the conditions and write the equations for the formation of NaBrO and NaBrO₃.

NaBrO

Conditions: _____

Equation: _____

NaBrO₃

Conditions: _____

Equation: _____ [6]

(iii) Describe the test to show the presence of bromide ions in solution.

_____ [2]



(d) Both chlorine and ozone can be used in the treatment of drinking water.

- (i) Give one advantage and one disadvantage of chlorine and ozone in treating drinking water.

chlorine

Advantage: _____

Disadvantage: _____

ozone

Advantage: _____

Disadvantage: _____

_____ [4]

- (ii) Describe the test to identify chlorine gas.

_____ [2]

[Turn over



(b) (i) State what is meant by **electronegativity**.

[2]

(ii) Explain the change in electronegativity across the second period.

[2]



(c) Fluorine forms an ionic compound with lithium, lithium fluoride (LiF), and a covalent compound with oxygen, oxygen difluoride (OF₂).

(i) Using electronegativity, explain why lithium fluoride is ionic.

[1]

(ii) Draw a dot and cross diagram for a molecule of oxygen difluoride using outer electrons only.

[2]

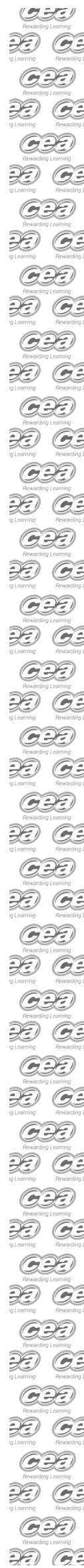
(iii) Show the polarity of an oxygen–fluorine bond, using partial charges.



[1]

(iv) State the shape of the oxygen difluoride molecule.

[1]





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(Questions continue overleaf)



14 Saline solution contains 0.90 g sodium chloride in 100 cm³ of solution.

(a) The relative formula mass of sodium chloride is 58.5.

(i) State what is meant by **relative formula mass**.

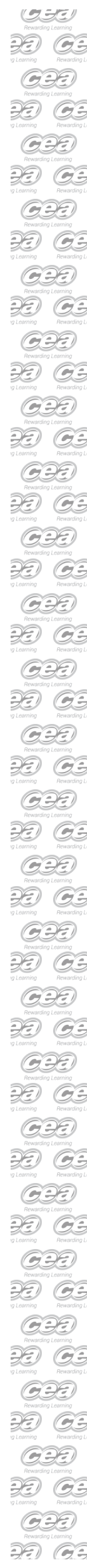
[2]

(ii) Calculate the molarity of saline solution. Give your answer to 2 significant figures.

[2]

(b) Draw a dot and cross diagram, using outer electrons only, to show the formation of sodium chloride from a sodium atom and a chlorine atom.

[2]



(c) Concentrated sulfuric acid reacts with sodium chloride to form hydrogen chloride.

(i) Write the equation for the reaction of concentrated sulfuric acid with sodium chloride.

_____ [2]

(ii) Describe the chemical test for hydrogen chloride.

_____ [2]

[Turn over



15 (a) Thallium is a metallic element that exhibits typical metallic properties. It has a relatively high melting point and is a good electrical conductor.

(i) Explain why thallium has a relatively high melting point.

[2]

(ii) Explain why thallium conducts electricity.

[2]

(b) The electron configuration of thallium can be represented as $[\text{Xe}]4f^{14}5d^{10}6s^26p^1$.

(i) Explain why thallium is described as a p-block element.

[1]

(ii) State the period and group of the Periodic Table in which thallium is found.

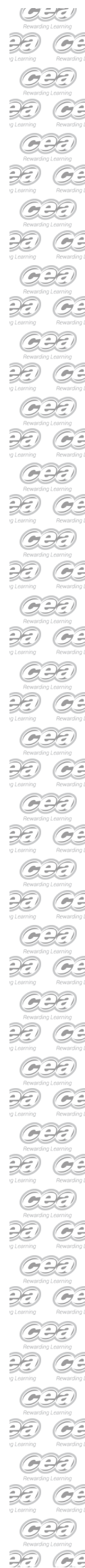
period: _____

group: _____ [2]

(iii) Thallium forms the ions Tl^+ and Tl^{3+} . Using the representation above, write the electron configuration of these ions.

Tl^+ : $[\text{Xe}]$ _____

Tl^{3+} : $[\text{Xe}]$ _____ [2]

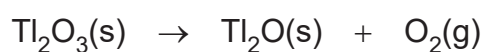


- (c) Thallium(I) sulfate was used in rat poison. It was prepared by the reaction of thallium with sulfuric acid.

Write the equation for the reaction of thallium with sulfuric acid.

_____ [2]

- (d) Thallium(III) oxide is a black solid which decomposes into thallium(I) oxide and oxygen at 800 °C according to the equation:



Calculate the loss in mass when 1.72 g of thallium(III) oxide are heated to constant mass. Give your answer to 3 significant figures.

_____ [3]

[Turn over



16 Oxalic acid is a weak acid which can form a hydrated salt, $(\text{COOH})_2 \cdot x\text{H}_2\text{O}$.

(a) Explain what is meant by the term **hydrated**.

[1]

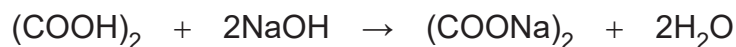
(b) Explain what is meant by a **weak acid**.

[1]

(c) The value of x in $(\text{COOH})_2 \cdot x\text{H}_2\text{O}$ may be found by titration with a standard solution of sodium hydroxide.

1.60 g of the hydrated oxalic acid were dissolved in 250 cm^3 of distilled water.
 25.0 cm^3 of the solution were transferred to a conical flask.
A suitable indicator was added.
 25.4 cm^3 of 0.100 mol dm^{-3} sodium hydroxide solution were needed for neutralisation.

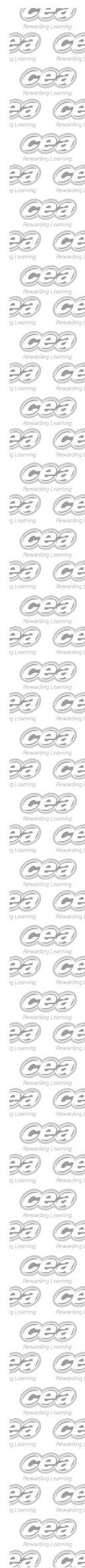
The equation for the reaction is:



(i) Suggest a suitable indicator and state the colour change at the endpoint.

Indicator: _____

From: _____ to _____ [3]





(ii) Calculate the mass of oxalic acid $(\text{COOH})_2$ in the 250 cm^3 of solution.
Give your answer to two decimal places.

[3]

(iii) Calculate the value of x in the formula $(\text{COOH})_2 \cdot x\text{H}_2\text{O}$.

[3]

THIS IS THE END OF THE QUESTION PAPER



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For Examiner's use only	
Question Number	Marks
Section A	
1–10	
Section B	
11	
12	
13	
14	
15	
16	
Total Marks	

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SCH14/6
260544



General Information

1 tonne = 10^6 g

1 metre = 10^9 nm

One mole of any gas at 293 K and a pressure of 1 atmosphere (10^5 Pa) occupies a volume of 24 dm³

Avogadro Constant = 6.02×10^{23} mol⁻¹

Planck Constant = 6.63×10^{-34} Js

Specific Heat Capacity of water = $4.2 \text{ J g}^{-1} \text{ K}^{-1}$

Speed of Light = $3 \times 10^8 \text{ ms}^{-1}$



Characteristic absorptions in IR spectroscopy

Wavenumber/cm ⁻¹	Bond	Compound
550–850	C–X (X = Cl, Br, I)	Haloalkanes
750–1100	C–C	Alkanes, alkyl groups
1000–1300	C–O	Alcohols, esters, carboxylic acids
1450–1650	C=C	Arenes
1600–1700	C=C	Alkenes
1650–1800	C=O	Carboxylic acids, esters, aldehydes, ketones, amides, acyl chlorides
2200–2300	C≡N	Nitriles
2500–3200	O–H	Carboxylic acids
2750–2850	C–H	Aldehydes
2850–3000	C–H	Alkanes, alkyl groups, alkenes, arenes
3200–3600	O–H	Alcohols
3300–3500	N–H	Amines, amides

Proton Chemical Shifts in Nuclear Magnetic Resonance Spectroscopy (relative to TMS)

Chemical Shift	Structure	
0.5–2.0	–CH	Saturated alkanes
0.5–5.5	–OH	Alcohols
1.0–3.0	–NH	Amines
2.0–3.0	–CO–CH	Ketones
	–N–CH	Amines
	C ₆ H ₅ –CH	Arene (aliphatic on ring)
2.0–4.0	X–CH	X = Cl or Br (3.0–4.0) X = I (2.0–3.0)
4.5–6.0	–C=CH	Alkenes
5.5–8.5	RCONH	Amides
6.0–8.0	–C ₆ H ₅	Arenes (on ring)
9.0–10.0	–CHO	Aldehydes
10.0–12.0	–COOH	Carboxylic acids

These chemical shifts are concentration and temperature dependent and may be outside the ranges indicated above.

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COUNCIL FOR THE CURRICULUM, EXAMINATIONS AND ASSESSMENT

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Data Leaflet

Including the Periodic Table of the Elements

For the use of candidates taking
Advanced Subsidiary and
Advanced Level Examinations

Copies must be free from notes or additions of any kind. No other type of data booklet or information sheet is authorised for use in the examinations

gce a/as examinations chemistry

I II THE PERIODIC TABLE OF ELEMENTS III IV V VI VII 0

Group

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen 1																	4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	98 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La [*] Lanthanum 57	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	210 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radium 88	227 Ac [†] Actinium 89	261 Rf Rutherfordium 104	262 Db Dubnium 105	266 Sg Seaborgium 106	264 Bh Bohrium 107	277 Hs Hassium 108	268 Mt Meitnerium 109	271 Ds Darmstadtium 110	272 Rg Roentgenium 111	285 Cn Copernicium 112						

* 58 – 71 Lanthanum series
† 90 – 103 Actinium series

a

X

b

a = relative atomic mass (approx)
x = atomic symbol
b = atomic number

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	145 Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	231 Pa Protactinium 91	238 U Uranium 92	237 Np Neptunium 93	242 Pu Plutonium 94	243 Am Americium 95	247 Cm Curium 96	245 Bk Berkelium 97	251 Cf Californium 98	254 Es Einsteinium 99	253 Fm Fermium 100	256 Md Mendelevium 101	254 No Nobelium 102	257 Lr Lawrencium 103



Rewarding Learning

**ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2022**

Chemistry

Assessment Unit AS 1

assessing

**Basic Concepts in Physical
and Inorganic Chemistry**

[SCH14]

TUESDAY 17 MAY, MORNING

**MARK
SCHEME**

General Marking Instructions

Introduction

Mark schemes are published to assist teachers and students in their preparation for examinations. Through the mark schemes teachers and students will be able to see what the examiners are looking for in response to questions and exactly where the marks have been awarded. The publishing of the mark schemes may help to show that examiners are not concerned about finding out what a student does not know but rather with rewarding students for what they do know.

The purpose of mark schemes

Examination papers are set and revised by teams of examiners and revisers appointed by the Council. The teams of examiners and revisers include experienced teachers who are familiar with the level and standards expected of students in schools and colleges.

The job of the examiners is to set the questions and the mark schemes; and the job of the revisers is to review the questions and mark schemes commenting on a large range of issues about which they must be satisfied before the question papers and mark schemes are finalised.

The questions and the mark schemes are developed in association with each other so that the issues of differentiation and positive achievement can be addressed right from the start. Mark schemes, therefore, are regarded as part of an integral process which begins with the setting of questions and ends with the marking of the examination.

The main purpose of the mark scheme is to provide a uniform basis for the marking process so that all the markers are following exactly the same instructions and making the same judgements in so far as this is possible. Before marking begins a standardising meeting is held where all the markers are briefed using the mark scheme and samples of the students' work in the form of scripts. Consideration is also given at this stage to any comments on the operational papers received from teachers and their organisations. During this meeting, and up to and including the end of the marking, there is provision for amendments to be made to the mark scheme. What is published represents the final form of the mark scheme.

It is important to recognise that in some cases there may well be other correct responses which are equally acceptable to those published: the mark scheme can only cover those responses which emerged in the examination. There may also be instances where certain judgements may have to be left to the experience of the examiner, for example where there is no absolute correct response – all teachers will be familiar with making such judgements.

COVID-19 Context

Given the unprecedented circumstances presented by the COVID-19 public health crisis, senior examiners, under the instruction of CCEA awarding organisation, are required to train assistant examiners to apply the mark scheme in case of disrupted learning and lost teaching time. The interpretation and intended application of the mark scheme for this examination series will be communicated through the standardising meeting by the Chief or Principal Examiner and will be monitored through the supervision period. This paragraph will apply to examination series in 2021-2022 only.

Section A

- 1 B
- 2 A
- 3 C
- 4 C
- 5 D
- 6 C
- 7 C
- 8 C
- 9 C
- 10 D

[1] for each correct answer

[10]

Section A

**AVAILABLE
MARKS**

10

10

Section B

- 11 (a) (i)** oxidation and reduction of the same element in the same reaction [2]
- (ii)** $\text{Cu}_2\text{O} + \text{H}_2\text{SO}_4 \rightarrow \text{Cu} + \text{CuSO}_4 + \text{H}_2\text{O}$ [1]
- (b)** flame test [1]
green-blue/blue-green (flame) [1] [2]
- 12 (a)** iodine in water: yellow/brown [1]
iodine in hexane: purple/violet [1]
solubility: more soluble in hexane [1] [3]
- (b)** van der Waals' forces increase down the group [1]
due to increasing numbers of electrons [1]
hydrogen fluoride can form hydrogen bonds between molecules [1]
hydrogen bonds are stronger than van der Waals' forces [1] [4]
- (c) (i)** sodium bromate(I) [1] and sodium bromate(V) [1] [2]
- (ii)** cold dilute sodium hydroxide solution [1]
 $\text{Br}_2 + 2\text{NaOH} \rightarrow \text{NaBr} + \text{NaBrO} + \text{H}_2\text{O}$ [2]

hot concentrated sodium hydroxide solution [1]
 $3\text{Br}_2 + 6\text{NaOH} \rightarrow 5\text{NaBr} + \text{NaBrO}_3 + 3\text{H}_2\text{O}$ [2] [6]
- (iii)** add silver nitrate solution [1]
cream precipitate [1] [2]
- (d) (i) chlorine:**
advantage: cheaper/provides residual protection/more soluble in water than ozone [1]
disadvantage: cannot kill some microorganisms/leaves chemicals in the water/unpleasant taste/toxic so low quantities used [1]

ozone:
advantage: kills more different types of microorganisms/breakdown product is oxygen/no residual chemicals in water/removes metal and organic particles/no unpleasant taste [1]
disadvantage: more expensive/does not provide residual protection/less soluble in water than chlorine [1] [4]
- (ii)** damp universal indicator paper/damp litmus paper [1] bleaches [1] [2]

AVAILABLE
MARKS

5

23

13 (a) (i) $\text{Li(g)} \rightarrow \text{Li}^{\text{+}}(\text{g}) + \text{e}^{-}$ [2]

(ii) Indicative points:

- General increase across the period
- Shielding generally remains the same
- Nuclear charge increases
- Atomic radius decreases
- Be higher than B due to stability of filled (2)s subshell
- N higher than O due to stability of half-filled (2)p subshell

Band	Response	Mark
A	Candidates must use appropriate specialist terms to fully explain the trend using a minimum of 5 points of indicative content. They must use good spelling, punctuation and grammar and the form and style are of an excellent standard.	[5]–[6]
B	Candidates must use appropriate specialist terms to explain the trend using a minimum of 3 points of indicative content. They must use satisfactory spelling, punctuation and grammar and the form and style are of a good standard.	[3]–[4]
C	Candidates explain partially the trend using a minimum of 2 points of indicative content. They use limited correct spelling, punctuation and grammar and the form and style are of a basic standard.	[1]–[2]
D	Response not worthy of credit	[0]

[6]

(b) (i) the extent to which an atom attracts the bonding electrons in a covalent bond [2]

(ii) greater nuclear charge/atomic radius decreases [1]
greater pull on (covalently) bonded electrons [1] [2]

(c) (i) large difference in electronegativity [1]

(ii)  [2]

(iii) $\overset{\delta+}{\text{O}}-\overset{\delta-}{\text{F}}$ [1]

(iv) bent [1]

AVAILABLE
MARKS

17

	AVAILABLE MARKS
14 (a) (i) the average (weighted mean) mass of a formula unit relative to one-twelfth of the mass of an atom of carbon-12 [2] (ii) $9/58.5 = 0.1538\text{ M}$ $= 0.15\text{ M}$ [2]	
(b) $\text{Na} \xrightarrow{x} \cdot\ddot{\text{Cl}}\cdot$ $[\text{Na}]^+ \quad \left[\cdot\ddot{\text{Cl}}\cdot \right]^-$ [2]	
(c) (i) $\text{NaCl} + \text{H}_2\text{SO}_4 \rightarrow \text{NaHSO}_4 + \text{HCl}$ (if balanced equation forming Na_2SO_4 is given then [-1]) [2] (ii) stopper from a bottle of concentrated ammonia solution/glass rod dipped in concentrated ammonia solution [1] white fumes/solid/smoke [1] [2]	10
15 (a) (i) metallic bonding [1] substantial energy required to break bonds/bonds are strong [1] [2] (ii) delocalised electrons [1] move and carry charge [1] [2] (b) (i) outer electron is in the p-subshell [1] (ii) period: 6 [1] group: 3 [1] [2] (iii) $[\text{Xe}] 4f^{14}5d^{10}6s^2$ [1] $[\text{Xe}] 4f^{14}5d^{10}$ [1] [2] (c) $2\text{Ti} + \text{H}_2\text{SO}_4 \rightarrow \text{Ti}_2\text{SO}_4 + \text{H}_2$ [2] (d) moles $\text{Ti}_2\text{O}_3 = \frac{1.72}{456} = 3.772 \times 10^{-3}$ moles of $\text{O}_2 = 3.772 \times 10^{-3}$ mass of $\text{O}_2 = 3.772 \times 10^{-3} \times 32 = 0.121\text{ g}$ [3]	14

16 (a) a salt which contains water of crystallisation	[1]	AVAILABLE MARKS
(b) an acid which partially dissociates in water	[1]	
(c) (i) phenolphthalein [1] colourless [1] to pink [1]	[3]	
(ii) moles of NaOH = $(25.4 \times 0.1)/1000 = 2.54 \times 10^{-3}$ moles of $(\text{COOH})_2$ in $25\text{ cm}^3 = (2.54 \times 10^{-3})/2 = 1.27 \times 10^{-3}$ moles of $(\text{COOH})_2$ in $250\text{ cm}^3 = 1.27 \times 10^{-2}$ mass of $(\text{COOH})_2$ in $250\text{ cm}^3 = (1.27 \times 10^{-2}) \times 90 = 1.14\text{ g}$	[3]	
(iii) mass of water in $1.60\text{ g} = 1.60 - 1.14 = 0.46\text{ g}$ moles $(\text{COOH})_2 : \text{H}_2\text{O} = 1.14/90 : 0.46/18$ $= 0.0127 : 0.0256$ $= 1 : 2$ x = 2	[3]	
Section B		80
Total		90



Rewarding Learning

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General Certificate of Education
2022

Centre Number

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Candidate Number

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Chemistry

Assessment Unit AS 2

assessing

Further Physical and Inorganic
Chemistry and an Introduction to
Organic Chemistry



[SCH24]

SCH24

FRIDAY 27 MAY, AFTERNOON

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

Answer **all eighteen** questions in **Sections A and B**.

You must answer the questions in the spaces provided.

Do not write outside the boxed area on each page or on blank pages.

Complete in black ink only. **Do not write with a gel pen or a pencil.**

INFORMATION FOR CANDIDATES

The total mark for this paper is 90.

Quality of written communication will be assessed in Question **17(c)**.

The figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

A Periodic Table of Elements, containing some data, is included with this question paper.



Section A

For each of the following questions, only **one** of the lettered responses (A–D) is correct.

Select the correct response for each question and write the appropriate letter in the space provided.

- 1 6.00 g of propan-1-ol ($\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$) were used to prepare 1-bromopropane ($\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$). 4.92 g of 1-bromopropane were produced. The percentage yield is:

- A 40.0%
- B 48.8%
- C 60.0%
- D 82.0%

Answer _____ [1]

- 2 How many structural isomers are there with the molecular formula C_5H_{12} ?

- A 2
- B 3
- C 4
- D 5

Answer _____ [1]

- 3 Which one of the following isomers has the lowest boiling point?

- A 2,3-dimethylbutane
- B hexane
- C 2-methylpentane
- D 3-methylpentane

Answer _____ [1]



- 4 Which one of the following sets of numbers represents the numbers required to balance the equation for the complete combustion of butane?

	butane	oxygen	carbon dioxide	water
A	1	6	4	5
B	2	12	4	5
C	2	12	8	10
D	2	13	8	10

Answer _____ [1]

- 5 What volume of hydrogen gas, measured at 293 K and 1 atmosphere, is required to completely saturate 4.10 g of the following compound?

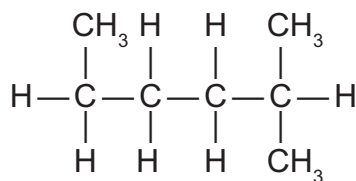


- A 600 cm³
B 1200 cm³
C 2400 cm³
D 24 dm³

Answer _____ [1]



6 What is the IUPAC name of the following molecule?



- A 1,1,4-trimethylbutane
- B 1,4,4-trimethylbutane
- C 2-methylhexane
- D 5-methylhexane

Answer _____ [1]

7 Which one of the following is a correct description of the 1-bromo-2-methylpropane obtained when methylpropene reacts with hydrogen bromide?

- | | | |
|---|---------------|---------------------------------|
| A | Major product | Formed via primary carbocation |
| B | Major product | Formed via tertiary carbocation |
| C | Minor product | Formed via primary carbocation |
| D | Minor product | Formed via tertiary carbocation |

Answer _____ [1]

8 Which one of the following gives the most thermally stable Group II carbonate and the most soluble Group II sulfate?

- | | | |
|---|-------------------|-------------------|
| A | BaCO ₃ | BaSO ₄ |
| B | BaCO ₃ | MgSO ₄ |
| C | MgCO ₃ | BaSO ₄ |
| D | MgCO ₃ | MgSO ₄ |

Answer _____ [1]



9 1,3-dibromobutane can be described as:

- A primary only
- B primary and secondary
- C primary and tertiary
- D secondary and tertiary

Answer _____ [1]

10 8.55 g of barium hydroxide were dissolved in water and the solution made up to 500 cm^3 in a volumetric flask. What is the concentration of hydroxide ions in the solution?

- A 0.025 mol dm^{-3}
- B 0.050 mol dm^{-3}
- C 0.100 mol dm^{-3}
- D 0.200 mol dm^{-3}

Answer _____ [1]



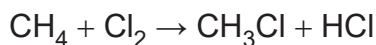
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Section B

Answer all **eight** questions in this section

- 11** An excess of methane reacts with chlorine, in the presence of UV light, to form chloromethane as one of the main products.



- (a)** Name the type of mechanism for this reaction.

_____ [2]

- (b)** Write an equation for the initiation step.

_____ [1]

- (c)** Write two equations for the propagation steps.

_____ [2]

- (d)** Write an equation for the termination step which results in the formation of ethane.

_____ [1]

- (e)** Give the IUPAC name of one other carbon-containing product which may be formed.

_____ [1]

[Turn over]



- 12 Analysis of an organic compound shows that it contains **carbon, hydrogen** and **oxygen** and it has a relative molecular mass of 88. The empirical formula of the compound can be determined using percentage composition by mass. The molecular formula can then be established using the relative molecular mass.

(a) Define the term **molecular formula**.

[1]

(b) (i) The compound contains 54.5% carbon and 9.1% hydrogen by mass. Determine the empirical formula of the compound.

[3]

(ii) Determine the molecular formula of the compound.

[1]



(iii) Using your answer to (b)(ii), suggest a possible structure for the compound which contains only one functional group and another structure which contains two different functional groups.

[2]

[Turn over



- 13 Bromoethane and 2-bromo-2-methylpropane both react with a hot dilute aqueous solution of sodium hydroxide to form the corresponding alcohol. Both mechanisms are classified as nucleophilic substitution but the mechanisms are not identical. Aqueous hydroxide ions behave as nucleophiles and the products are formed via a transition state or an intermediate.

(a) Give the IUPAC names of the alcohols formed.

_____ [1]

(b) (i) Define the term **nucleophile**.

_____ [2]

(ii) Show the polarity of the C—Br bond and explain why aqueous hydroxide ions attack bromoethane.



_____ [2]

(iii) Draw the structure of the transition state when bromoethane reacts with aqueous sodium hydroxide and suggest why 2-bromo-2-methylpropane does not form a transition state.

_____ [2]



(c) Draw the mechanism, using curly arrows, for the reaction of 2-bromo-2-methylpropane with aqueous sodium hydroxide.

[4]

[Turn over



14 The standard enthalpy of combustion of ethane can be estimated using average bond enthalpies.

(a) Define the following terms:

(i) **standard enthalpy of combustion**

[2]

(ii) **average bond enthalpy**

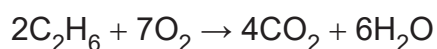
[2]

(b) Suggest why the bond enthalpy value for $\text{O}=\text{O}$ is not an **average** value.

[1]



(c) The complete combustion of ethane can be represented by the equation:



Use the bond enthalpies in the table below to calculate the **standard enthalpy of combustion** for ethane.

Bond	Bond enthalpy /kJ mol ⁻¹
C—H	413
C—C	348
O=O	497
C=O	803
O—H	464

[4]

(d) Suggest why a mixture of ethane and oxygen is stable at room temperature and does not react to form carbon dioxide and water.

[1]

[Turn over



- 15 At very high temperatures, in a closed system, nitrogen can be oxidised to form nitrogen(II) oxide in a reversible reaction:



A position of dynamic equilibrium is established and the equilibrium is described as homogeneous.

- (a) Define the term **homogeneous**.

[1]

- (b) (i) Deduce an expression and corresponding units for the equilibrium constant, K_c , for this reaction.

[2]

- (ii) What is the significance of a small value of K_c ?

[1]



(c) Explain the effect of increasing the pressure on the equilibrium yield of nitrogen(II) oxide.

[2]

(d) Explain the effect of increasing the temperature on the equilibrium yield of nitrogen(II) oxide.

[3]

[Turn over



16 Strontium and magnesium are both s-block elements. The chemistry of the two elements is very similar but strontium is significantly more reactive. Strontium oxide and magnesium oxide are both basic and will neutralise dilute nitric acid to form nitrates.

(a) (i) Deduce the electronic configuration of a strontium atom and a strontium cation:

atom _____

cation _____ [2]

(ii) Suggest why strontium is more reactive than magnesium.

_____ [2]

(b) Write an equation for the reaction of strontium with water.

_____ [1]

(c) Write an equation for the reaction of strontium oxide with dilute nitric acid.

_____ [2]



(d) It is possible to distinguish between solutions of magnesium nitrate and strontium nitrate by adding a solution which contains hydroxide ions.

(i) What would be observed when a few drops of sodium hydroxide solution were added separately to a solution of magnesium nitrate and a solution of strontium nitrate?

[2]

(ii) Write an ionic equation, with state symbols, for a reaction which occurs in **(d)(i)**.

[2]

(iii) Suggest an alternative solution which could be used, instead of a solution which contains hydroxide ions, to distinguish between solutions of magnesium nitrate and strontium nitrate.

[1]

[Turn over]

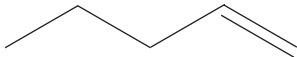
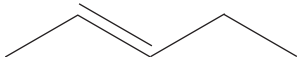
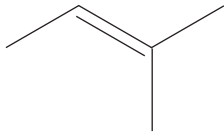


17 There are five aliphatic structural isomers with molecular formula C_5H_{10} .

(a) Define the term **structural isomers**.

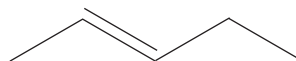
[1]

(b) Two of the aliphatic structural isomers are described as having unbranched structures and three are described as branched. Complete the table below for the five aliphatic structural isomers of C_5H_{10} .

IUPAC name of isomer	Skeletal formula
	
2-methylbut-1-ene	
	
	

[5]





Explain why the molecule on the left does not exist as E–Z isomers whereas the molecule on the right does.

In this question you will be assessed on using your written communication skills including the use of specialist scientific terms.

Z isomer:

[6]

[6]

[Turn over



18 Propan-2-ol is a secondary alcohol which has a relatively high boiling point. It is soluble in water and can be oxidised to form a ketone.

- (a) (i)** Why does propan-2-ol have a much higher boiling point than a hydrocarbon of similar relative molecular mass?

[2]

- (ii)** Draw a diagram to show the strongest type of attraction which forms between a propan-2-ol molecule and a water molecule. Show lone pairs of electrons and partial charges.

[2]



- (b) (i)** Name a reagent which can be used to oxidise propan-2-ol. Give the condition(s) required and the observations which are made.

Reagent

Condition(s)

Observations

[4]

- (ii)** Draw the structure of the ketone formed on oxidation of propan-2-ol and give its IUPAC name.

[2]

- (iii)** State two differences between the infrared spectrum of propan-2-ol and the ketone formed.

[2]



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SCH24/7
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24SCH2424

General Information

1 tonne = 10^6 g

1 metre = 10^9 nm

One mole of any gas at 293 K and a pressure of 1 atmosphere (10^5 Pa) occupies a volume of 24 dm³

Avogadro Constant = 6.02×10^{23} mol⁻¹

Planck Constant = 6.63×10^{-34} Js

Specific Heat Capacity of water = $4.2 \text{ J g}^{-1} \text{ K}^{-1}$

Speed of Light = $3 \times 10^8 \text{ ms}^{-1}$



Characteristic absorptions in IR spectroscopy

Wavenumber/cm ⁻¹	Bond	Compound
550–850	C–X (X = Cl, Br, I)	Haloalkanes
750–1100	C–C	Alkanes, alkyl groups
1000–1300	C–O	Alcohols, esters, carboxylic acids
1450–1650	C=C	Arenes
1600–1700	C=C	Alkenes
1650–1800	C=O	Carboxylic acids, esters, aldehydes, ketones, amides, acyl chlorides
2200–2300	C≡N	Nitriles
2500–3200	O–H	Carboxylic acids
2750–2850	C–H	Aldehydes
2850–3000	C–H	Alkanes, alkyl groups, alkenes, arenes
3200–3600	O–H	Alcohols
3300–3500	N–H	Amines, amides

Proton Chemical Shifts in Nuclear Magnetic Resonance Spectroscopy (relative to TMS)

Chemical Shift	Structure	
0.5–2.0	–CH	Saturated alkanes
0.5–5.5	–OH	Alcohols
1.0–3.0	–NH	Amines
2.0–3.0	–CO–CH	Ketones
	–N–CH	Amines
	C ₆ H ₅ –CH	Arene (aliphatic on ring)
2.0–4.0	X–CH	X = Cl or Br (3.0–4.0) X = I (2.0–3.0)
4.5–6.0	–C=CH	Alkenes
5.5–8.5	RCONH	Amides
6.0–8.0	–C ₆ H ₅	Arenes (on ring)
9.0–10.0	–CHO	Aldehydes
10.0–12.0	–COOH	Carboxylic acids

These chemical shifts are concentration and temperature dependent and may be outside the ranges indicated above.

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Data Leaflet

Including the Periodic Table of the Elements

For the use of candidates taking
Advanced Subsidiary and
Advanced Level Examinations

Copies must be free from notes or additions of any kind. No other type of data booklet or information sheet is authorised for use in the examinations

gce a/as examinations chemistry

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THE PERIODIC TABLE OF ELEMENTS

Group

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen 1																	4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	98 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La [*] Lanthanum 57	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	210 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radium 88	227 Ac [†] Actinium 89	261 Rf Rutherfordium 104	262 Db Dubnium 105	266 Sg Seaborgium 106	264 Bh Bohrium 107	277 Hs Hassium 108	268 Mt Meitnerium 109	271 Ds Darmstadtium 110	272 Rg Roentgenium 111	285 Cn Copernicium 112						

* 58 – 71 Lanthanum series
† 90 – 103 Actinium series

aXb

a = relative atomic mass (approx)
x = atomic symbol
b = atomic number

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	145 Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	231 Pa Protactinium 91	238 U Uranium 92	237 Np Neptunium 93	242 Pu Plutonium 94	243 Am Americium 95	247 Cm Curium 96	245 Bk Berkelium 97	251 Cf Californium 98	254 Es Einsteinium 99	253 Fm Fermium 100	256 Md Mendelevium 101	254 No Nobelium 102	257 Lr Lawrencium 103



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General Certificate of Education
2022**

Chemistry

Assessment Unit AS 2

assessing

Further Physical and Inorganic Chemistry
and an Introduction to Organic Chemistry

[SCH24]

FRIDAY 27 MAY, AFTERNOON

MARK SCHEME

General Marking Instructions

Introduction

The main purpose of the mark scheme is to ensure that examinations are marked accurately, consistently and fairly. The mark scheme provides examiners with an indication of the nature and range of candidates' responses likely to be worthy of credit. It also sets out the criteria which they should apply in allocating marks to candidates' responses.

Assessment objectives

Below are the assessment objectives for **GCE Chemistry**:

Candidates should be able to:

AO1	Demonstrate knowledge and understanding of scientific ideas, processes, techniques and procedures.
AO2	Apply knowledge and understanding of scientific ideas, processes, techniques and procedures: • in a theoretical context • in a practical context • when handling quantitative and qualitative data
AO3	Analyse, interpret and evaluate scientific information, ideas and evidence (in relation to particular issues) • make judgements and reach conclusions • develop and refine practical design and procedures

Quality of candidates' responses

In marking the examination papers, examiners should be looking for a quality of response reflecting the level of maturity which may reasonably be expected of a 17- or 18-year-old which is the age at which the majority of candidates sit their GCE examinations.

Flexibility in marking

Mark schemes are not intended to be totally prescriptive. No mark scheme can cover all the responses which candidates may produce. In the event of unanticipated answers, examiners are expected to use their professional judgement to assess the validity of answers. If an answer is particularly problematic, then examiners should seek the guidance of the Supervising Examiner.

Positive marking

Examiners are encouraged to be positive in their marking, giving appropriate credit for what candidates know, understand and can do, rather than penalising candidates for errors or omissions. The exception to this for GCE Chemistry is when examiners are marking complex calculations and mechanisms when the examiners are briefed to mark by error or omission. Examiners should make use of the whole of the available mark range for any particular question and be prepared to award full marks for a response which is as good as might reasonably be expected of a 17- or 18-year-old GCE candidate.

Awarding zero marks

Marks should only be awarded for valid responses and no marks should be awarded for an answer which is completely incorrect or inappropriate.

COVID-19 Context

Given the unprecedented circumstances presented by the COVID-19 public health crisis, senior examiners, under the instruction of CCEA awarding organisation, are required to train assistant examiners to apply the mark scheme in case of disrupted learning and lost teaching time. The interpretation and intended application of the mark scheme for this examination series will be communicated through the standardising meeting by the Chief or Principal Examiner and will be monitored through the supervision period. This paragraph will apply to examination series in 2021–2022 only.

Section A

1 A

2 B

3 A

4 D

5 C

6 C

7 C

8 B

9 B

10 D

[1] for each correct answer

AVAILABLE MARKS

10

Section A

10

Section B

AVAILABLE
MARKS

- 11 (a)** radical [1]
substitution [1] [2]
- (b)** $\text{Cl}_2 \rightarrow 2\text{Cl}\cdot$ [1]
- (c)** $\text{CH}_4 + \text{Cl}\cdot \rightarrow \cdot\text{CH}_3 + \text{HCl}$ [1]
 $\text{Cl}_2 + \cdot\text{CH}_3 \rightarrow \text{CH}_3\text{Cl} + \text{Cl}\cdot$ [1] [2]
- (d)** $\cdot\text{CH}_3 + \cdot\text{CH}_3 \rightarrow \text{C}_2\text{H}_6$ [1]
- (e)** dichloromethane/trichloromethane/tetrachloromethane [1]

7

- 12 (a)** a formula which shows the actual number of atoms of each element in a molecule [1]

(b) (i)

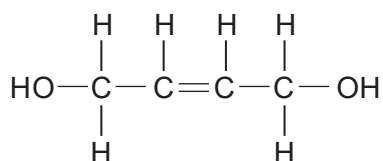
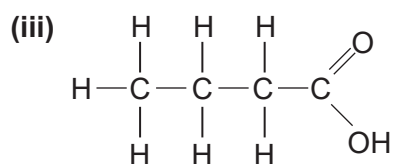
C	H	O
54.5	9.1	36.4
4.54	9.1	2.275
2	4	1

$\text{C}_2\text{H}_4\text{O}$ [3]

- (ii)** $(12 \times 2) + (1 \times 4) + (16 \times 1) = 44$

$$88 \div 44 = 2$$

molecular formula $\text{C}_4\text{H}_8\text{O}_2$ [1]



(or other alternatives) [2] [2]

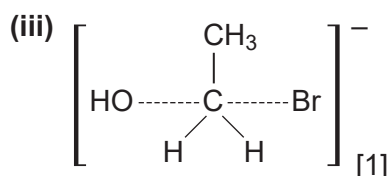
7

13 (a) ethanol and (2-)methylpropan-2-ol [1]

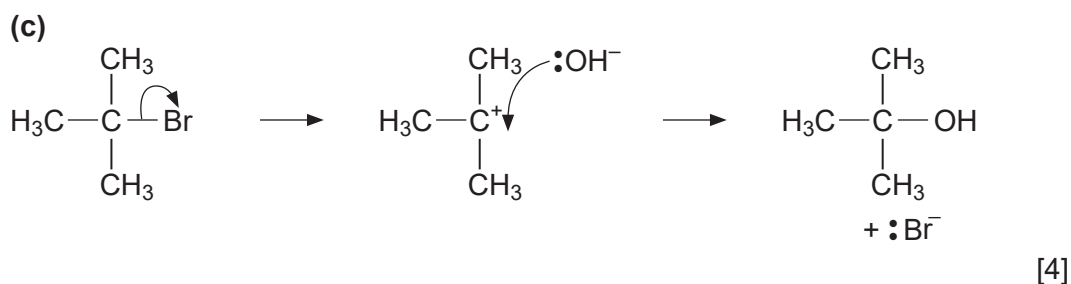
(b) (i) an ion or molecule, with a lone pair of electrons, that attacks regions of low electron density [2]

(ii) $\delta^+ \quad \delta^-$
C—Br [1]

hydroxide ion is negative/has a lone pair and will attack the δ^+ carbon [1] [2]



forms a stable tertiary carbocation/approach of the hydroxide ion is hindered by the four bulky groups [1] [2]



14 (a) (i) the enthalpy change when one mole of a substance is completely burnt in oxygen under standard conditions [2]

(ii) the energy required to break one mole of a given bond averaged over many compounds [2]

(b) O=O bond only present in the O₂ molecule [1]

(c) Bonds broken Bonds formed

12 (C—H)	8 (C=O)
2 (C—C)	12 (O—H)
7 (O=O)	
Total = 9131	Total = 11992

$$9131 - 11992 = -2861$$

$$-1430.5 \text{ kJ mol}^{-1} \quad [4]$$

(d) the reaction has a high activation energy/
no molecules have sufficient energy to react [1] [1] 10

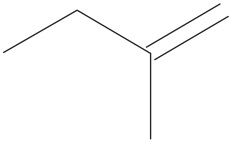
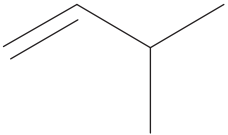
			AVAILABLE MARKS
15	(a) a reaction in which all the reactants and products are in the same physical state	[1]	9
(b)	(i) $K_c = \frac{[\text{NO}]^2}{[\text{N}_2][\text{O}_2]}$ [1] no units [1]	[2]	
	(ii) position of equilibrium lies to the left hand side/small amount of product formed	[1]	
(c)	no effect [1] same number of molecules/moles of gas on the LHS and RHS [1]	[2]	
(d)	yield increases [1] position of equilibrium moves to the right [1] the (forward) reaction is endothermic/absorbs the heat [1]	[3]	
16	(a) (i) atom: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 5s^2$ [1] cation: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$ [1]	[2]	12
	(ii) outer electrons in strontium are further from the nucleus/ more shielded than those in magnesium [1] outer electrons are lost more readily [1]	[2]	
(b)	$\text{Sr} + 2\text{H}_2\text{O} \rightarrow \text{Sr}(\text{OH})_2 + \text{H}_2$	[1]	
(c)	$\text{SrO} + 2\text{HNO}_3 \rightarrow \text{Sr}(\text{NO}_3)_2 + \text{H}_2\text{O}$	[2]	
(d)	(i) no precipitate with strontium nitrate/colourless solution/no change [1] white precipitate with magnesium nitrate [1]	[2]	
	(ii) $\text{Mg}^{2+}(\text{aq}) + 2\text{OH}^{-}(\text{aq}) \rightarrow \text{Mg}(\text{OH})_2(\text{s})$	[2]	
	(iii) any soluble sulfate, e.g. sodium sulfate	[1]	

- 17 (a) molecules which have the same molecular formula but a different structural formula

[1]

AVAILABLE
MARKS

(b)

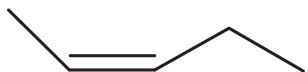
IUPAC name of isomer	Skeletal formula
pent-1-ene	
	
pent-2-ene	
2-methylbut-2-ene	
3-methylbut-1-ene	

[1] per row [5]

(c) Indicative content

AVAILABLE
MARKS

- Correct structure:



or structural
formula

- C of CH₃ higher priority than hydrogen
- C of C₂H₅ higher priority than hydrogen
- highest priority groups on the same side
- restricted rotation about the C=C
- molecule on left has two identical (methyl) groups attached to one of the carbon atoms in the C=C
- molecule on right has two different atoms/groups attached to each of the carbon atoms in the C=C

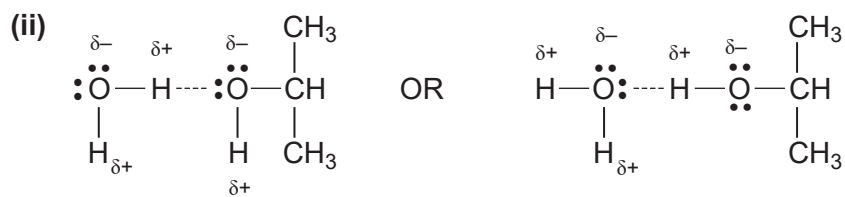
Band	Response	Mark
A	Candidates must use appropriate specialist terms using a minimum of 5 points of indicative content. They must use good spelling, punctuation and grammar and the form and style are of an excellent standard.	[5]–[6]
B	Candidates must use appropriate specialist terms using a minimum of 3 points of indicative content. They must use satisfactory spelling, punctuation and grammar and the form and style are of a good standard.	[3]–[4]
C	Candidates use a minimum of 2 points of indicative content. They use limited correct spelling, punctuation and grammar and the form and style are of a basic standard.	[1]–[2]
D	Response not worthy of credit.	[0]

[6]

12

- 18 (a) (i) hydrogen bonds between propan-2-ol molecules [1]
are stronger than van der Waals' forces between hydrocarbon molecules [1]

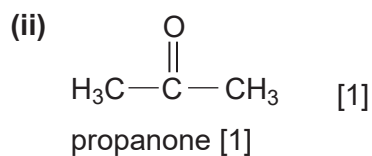
[2]



[2]

- (b) (i) reagent: potassium dichromate(VI) [1]
conditions: acidified [1] heat [1]
observations: orange to green [1]

[4]



[2]

- (iii) C—O/O—H peak in propan-2-ol [1] spectrum
C=O peak in ketone [1] spectrum

[2]

AVAILABLE
MARKS

12

Section B

80

Total

90



Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2022

Centre Number

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Candidate Number

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Chemistry

Assessment Unit AS 3

assessing

Module 3: Basic

Practical Chemistry

Practical Booklet A

[SCH31]

SCH31

MONDAY 9 MAY, MORNING

TIME

1 hour 15 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

You must answer the questions in the spaces provided.

Do not write outside the boxed area on each page or on blank pages.

Complete in black ink only. **Do not write with a gel pen.**

Answer **all** questions.

INFORMATION FOR CANDIDATES

The total mark for this paper is 25.

Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

A Periodic Table of the Elements (including some data) is provided.

You may not have access to notes, textbooks and other material to assist you.

Safety glasses should be worn at all times and care should be taken during this practical examination.



1 You are provided with a sample of solid labelled **X**.

- (a) Place a spatula measure of **X** on a watch glass. Dip nichrome wire into some deionised water and into **X**. Place in a blue Bunsen burner flame and observe the colour produced through cobalt glass. Record your observation below.

_____ [1]

- (b) Add a half spatula measure of **X** to a test tube. In a fume cupboard, place the test tube in a test tube rack and add 5 drops of concentrated sulfuric acid. Record your observations below.
Leave this test tube in the fume cupboard.

_____ [2]

- (c) Weigh out approximately 10 g of **X** in a 100 cm³ beaker and dissolve completely in approximately 50 cm³ of deionised water.

Carry out the following tests using the solution of **X**.

All volumes in the following tests are approximate and may be measured using a measuring cylinder or a graduated disposable pipette.

Record all observations.

- (i) Place 5 cm³ of the solution of **X** in a test tube. Add 2 cm³ of silver nitrate solution. Then add 5 cm³ of ammonia solution.

_____ [2]



- (ii) In a fume cupboard, place 5 cm³ of the solution of **X** in a test tube. Add 5 cm³ of chlorine water.

_____ [1]

- (iii) Place 5 cm³ of the solution of **X** in a test tube. Add 1 cm³ of lead(II) nitrate solution dropwise. Shake gently.

_____ [1]

Retain the remaining solution of X for use in part (d).

- (d) Using a 6 V power pack and graphite electrodes, pass a direct current through the remaining solution of **X** in the beaker for 3 minutes. Do not allow the electrodes to touch.

Record what you observe.

_____ [2]

Retain the resulting solution for use in part (e).

[Turn over



(e) Use the solution which was formed in (d) for the following tests.

All volumes are approximate and may be measured using a measuring cylinder or a graduated disposable pipette.

Record all observations.

- (i) Place 5 cm³ of the solution formed in (d) in a test tube. Add 2 drops of starch solution. Stopper and shake gently.

_____ [1]

- (ii) Place 5 cm³ of the solution formed in (d) in a second test tube. Add 2 cm³ of heptane. Stopper and shake gently for 1 minute.

_____ [2]



- 2 (a) • Weigh out approximately 20.0g, 15.0g, 10.0g and 5.0g of solid **X** into separate weighing boats. Record the masses to 1 decimal place in the table below.
- Using a measuring cylinder, add 50 cm³ of deionised water to a polystyrene cup which is placed in a 250 cm³ beaker.

Record all temperatures to the nearest whole number.

- Place a thermometer in the polystyrene cup and record the initial temperature of the water.
- Add the first mass of solid **X** to the deionised water in the polystyrene cup and stir using the thermometer.
- Record the final temperature when there is no further temperature change.
- Calculate the temperature change using the equation below and record this in the table.

temperature change = initial temperature – final temperature

- Repeat the experiment for the other three masses of solid **X**. The polystyrene cup may be rinsed with deionised water between each test.

Mass of X /g	Initial temperature /°C	Final temperature /°C	Temperature change /°C

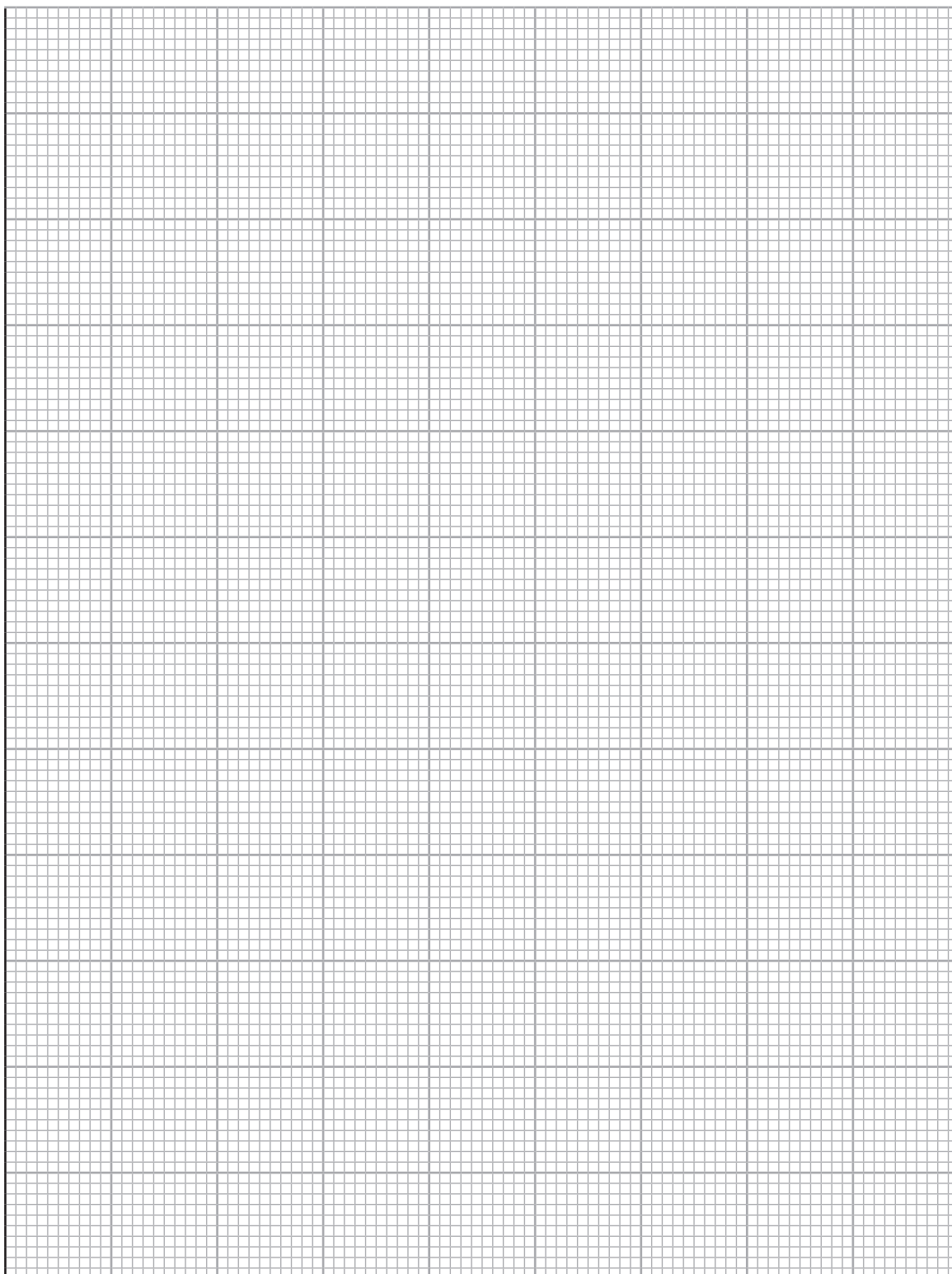
[5]

[Turn over



- (b) Plot a graph of temperature change against mass of **X** on the axes below. Label the axes. Draw a **straight best fit line starting at the origin**.

[4]



13003



08SCH3106

(c) The gradient of this straight best fit line is calculated using:

$$\text{gradient} = \frac{\text{change in temperature change}}{\text{change in mass}}$$

From your graph calculate the gradient of the straight best fit line you have drawn. Show your working out.

[3]

(d) Using the gradient calculated in (c) and the expression below, calculate the enthalpy change when 1 mole of X dissolves in water.

$$\text{enthalpy change (kJ mol}^{-1}\text{)} = \frac{\text{gradient} \times 50.0 \times 4.2 \times 166}{1000}$$

[1]

THIS IS THE END OF THE QUESTION PAPER



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Question Number	Marks
1	
2	

Total Marks	
-------------	--

Examiner Number

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SCH31/6
260991





Rewarding Learning

**ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2022**

Chemistry

Assessment Unit AS 3

Basic Practical Chemistry

Practical Booklet A

[SCH31]

MONDAY 9 MAY, MORNING

APPARATUS AND MATERIALS LIST

Advice for centres

- All chemicals used should be at least laboratory reagent specification and labelled with appropriate safety symbols, e.g. irritant.
- For centres running multiple sessions – candidates for the later session should be supplied with clean, dry glassware. If it is not feasible, then glassware from the first session should be thoroughly washed, rinsed with deionised water and allowed to drain.
- Ensure all chemicals are in date otherwise expected observations may not be seen.
- It is the responsibility of the centre to be cognisant of all health and safety issues and to carry out a thorough risk assessment. Up to date information can be obtained at www.cleapss.org.uk

Apparatus and Materials List

Each candidate must be supplied with safety goggles or glasses.

Question 1

- at least 10 disposable pipettes
- 1 × 100 cm³ beaker
- 1 × 100 cm³ measuring cylinder
- 1 × 10 cm³ measuring cylinder (rinsed out between uses)
- 1 × spatula
- 6 × test tubes
- 1 × test tube rack
- 1 × piece of nichrome wire
- 1 × cobalt glass
- 1 × Bunsen burner
- 1 × heatproof mat
- 1 × watch glass
- 2 × graphite electrodes
- 2 × crocodile clips
- 2 × electrical leads
- 1 × power pack (capable of being set to 6 V supply)
- several stoppers for test tubes
- 1 × wash bottle of deionised water
- 1 × glass rod
- 1 × stopclock
- about 70 g of solid potassium iodide labelled **X** (for use in question 1 and 2) in a sealed container
- about 10 cm³ of silver nitrate solution (0.1 mol dm⁻³/bench solution) labelled **silver nitrate solution** and **handle with caution**
- about 10 cm³ of ammonia solution labelled (0.5 mol dm⁻³) **ammonia solution**
- about 10 cm³ of lead(II) nitrate solution (0.01 mol dm⁻³) labelled **lead(II) nitrate solution** and **handle with caution**
- access to concentrated sulfuric acid and labelled **concentrated sulfuric acid** and **corrosive** (keep in fume cupboard)
- access to **starch solution**
- access to **chlorine water** in a sealed container
- access to heptane labelled **heptane** and **flammable** and **handle with caution** and **dangerous to the environment** and **health hazard** (keep in fume cupboard)
- access to an electronic balance (accurate to at least 1 decimal point)

Question 2

- solid potassium iodide labelled **X** (which should be carried over from question 1)
- 1 × thermometer (capable of reading between 0 and 50 °C clearly to nearest whole number)
- 1 × 50 cm³ measuring cylinder
- 1 × polystyrene cup
- 1 × spatula
- 1 × 250 cm³ beaker
- 4 × weighing boats
- 1 × wash bottle of deionised water
- 1 × marker for labelling weighing boats
- access to an electronic balance (accurate to at least 1 decimal place)



Rewarding Learning

**ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2022**

Chemistry

Assessment Unit AS 3

Practical Assessment

Practical Booklet A

[SCH31]

MONDAY 9 MAY, MORNING

Confidential Instructions to the Supervisor of the Practical Examination

INSTRUCTIONS TO THE SUPERVISOR OF THE PRACTICAL EXAMINATION

General

1. The instructions contained in this document are for the use of the Supervisor **and are strictly confidential**. Under no circumstances may information concerning apparatus or materials be given before the examination to a candidate or other unauthorised person.
2. In a centre with a large number of candidates it may be necessary for two or more examination sessions to be organised. **It is the responsibility of the schools to ensure that there should be no contact between candidates taking each session.**
3. A suitable laboratory must be reserved for the examination and kept locked throughout the period of preparation. Unauthorised persons not involved in the preparation for the examination must not be allowed to enter. Candidates must not be admitted until the specified time for commencement of the examination.
4. The Supervisor must ensure that the solutions provided for the candidates are of the nature and concentrations specified in the Apparatus and Materials List.
5. **The Supervisor is to be granted access to the Teacher's Copy of Practical Booklet A on Wednesday 4 May 2022.** The Supervisor is asked to check, at the earliest opportunity, that the experiments and tests in the question paper may be completed satisfactorily using the apparatus, materials and solutions that have been assembled. **This question paper must then be returned to safe custody** at the earliest possible moment after the Supervisor has ensured that all is in order. **No access to the question paper should be allowed before 4 May 2022.**
6. Centres may need to carry out multiple sessions to accommodate all their candidates sitting Practical Booklet A in a laboratory. Supervision must take place from 30 minutes after the scheduled starting time of the examination, as set out in the timetable, until the time when the candidate(s) begin(s) their examination(s). This is in order to ensure that there is no contact with other candidates. The centre must appoint a member of staff from the centre to supervise the candidate(s) at all times while they are on the premises.
7. All apparatus should be checked before the examination, and there should be an adequate supply of spare apparatus in case of breakages. The Apparatus and Materials List should be regarded as a minimum and there is no objection to candidates being supplied with more than the minimum amount of apparatus and materials.
8. **Candidates may not use text books and laboratory notes for reference during the examination, and must be informed of this beforehand.**

9. Clear instructions must be given by the Supervisor to all candidates at the beginning of the examination concerning appropriate safety procedures and precautions. Supervisors are also advised to remind candidates that all substances in the examination must be treated with caution. **Only those tests specified in the question paper should be attempted. Candidates must not attempt any additional confirmatory tests.** Anything spilled on the skin should be washed off immediately with plenty of water. The use of appropriate eye protection is essential.
10. Supervisors are reminded that they may not assist candidates during the examination. However if, in the opinion of the Supervisor, a candidate is about to do something which may endanger themselves or others, the Supervisor should intervene. A full written report must be sent to CCEA at once.
11. Upon request, a candidate may be given additional quantities of materials (answer paper, reagents and unknowns) without penalty. No notification needs to be sent to CCEA.
12. The examination room must be cleared of candidates immediately after the examination.
13. No materials will be supplied by CCEA.
14. All JCQ procedures for conducting examinations should be followed for this practical examination including displaying JCQ posters with examination information in the laboratory and removal of mobile phones. Posters should be available from your Examinations Officer.

Northern Ireland Council for the Curriculum, Examinations and
Assessment

General Certificate of Education

Advanced Subsidiary

Chemistry

Practical Booklet A

[SCH31]

Monday 9 May 2022

Centre Number

71

Candidate Number

This report must be completed by the Supervisor during the examination.
The complete report should include all candidates taking this Practical
Examination. This Supervisor's Report should be copied and attached to
Each Advice Note bundle and returned to CCEA in the normal way.

Comments:

Supervisor's Signature Date



Rewarding Learning

**ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2022**

Chemistry
Assessment Unit AS 3
assessing
Module 3: Practical Examination
Practical Booklet A
[SCH31]
MONDAY 9 MAY, MORNING

**MARK
SCHEME**

General Marking Instructions

Introduction

Mark schemes are published to assist teachers and students in their preparation for examinations. Through the mark schemes teachers and students will be able to see what examiners are looking for in response to questions and exactly where the marks have been awarded. The publishing of the mark schemes may help to show that examiners are not concerned about finding out what a student does not know but rather with rewarding students for what they do know.

The Purpose of Mark Schemes

Examination papers are set and revised by teams of examiners and revisers appointed by the Council. The teams of examiners and revisers include experienced teachers who are familiar with the level and standards expected of students in schools and colleges.

The job of the examiners is to set the questions and the mark schemes; and the job of the revisers is to review the questions and mark schemes commenting on a large range of issues about which they must be satisfied before the question papers and mark schemes are finalised.

The questions and the mark schemes are developed in association with each other so that the issues of differentiation and positive achievement can be addressed right from the start. Mark schemes, therefore, are regarded as part of an integral process which begins with the setting of questions and ends with the marking of the examination.

The main purpose of the mark scheme is to provide a uniform basis for the marking process so that all the markers are following exactly the same instructions and making the same judgements in so far as this is possible. Before marking begins a standardising meeting is held where all the markers are briefed using the mark scheme and samples of the students' work in the form of scripts. Consideration is also given at this stage to any comments on the operational papers received from teachers and their organisations. During this meeting, and up to and including the end of the marking, there is provision for amendments to be made to the mark scheme. What is published represents this final form of the mark scheme.

It is important to recognise that in some cases there may well be other correct responses which are equally acceptable to those published: the mark scheme can only cover those responses which emerged in the examination. There may also be instances where certain judgements may have to be left to the experience of the examiner, for example, where there is no absolute correct response – all teachers will be familiar with making such judgements.

COVID-19 Context

Given the unprecedented circumstances presented by the COVID-19 public health crisis, senior examiners, under the instruction of CCEA awarding organisation, are required to train assistant examiners to apply the mark scheme in case of disrupted learning and lost teaching time. The interpretation and intended application of the mark scheme for this examination series will be communicated through the standardising meeting by the Chief or Principal Examiner and will be monitored through the supervision period. This paragraph will apply to examination series in 2021–2022 only.

X = Potassium iodide

1	(a) pink flame	[1]	
	(b) any two from: misty fumes/steamy fumes hissing/fizzing black solid purple gas pungent smell yellow solid	[2]	
	(c) (i) yellow precipitate [1] precipitate remains [1]	[2]	
	(ii) colourless solution changes to yellow/brown/orange	[1]	
	(iii) yellow precipitate	[1]	
	(d) brown solution forming [1] bubbles/gas produced [1]	[2]	
	(e) (i) blue-black/black	[1]	
	(ii) two layers form [1] upper layer becomes coloured/purple/colour fades in lower layer [1]	[2]	12
2	(a) all masses recorded at approximately 5.0, 10.0, 15.0 and 20.0 [1] all masses recorded to 1 decimal place [1] [1] for each column correctly completed with temperatures to nearest whole number	[5]	
	(b) x-axis: mass of X/g and y-axis: temperature change/°C [1] points correctly plotted [2] best fit line through origin [1]	[4]	
	(c) change in temperature change change in mass gradient	[3]	
	(d) calculated value	[1]	13

Total

25



Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2022

Centre Number

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Candidate Number

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Chemistry

Assessment Unit AS 3

assessing

Module 3: Practical Examination

Practical Booklet B (Theory)



[SCH32]

SCH32

WEDNESDAY 1 JUNE, MORNING

TIME

1 hour 15 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

You must answer the questions in the spaces provided.

Do not write outside the boxed area on each page or on blank pages.

Complete in black ink only. **Do not write with a gel pen.**

Answer **all four** questions.

INFORMATION FOR CANDIDATES

The total mark for this paper is 55.

Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

A Periodic Table of Elements (including some data) is provided.



- 1 (a) Barium hydroxide is a Group II hydroxide. A sample of a saturated solution of barium hydroxide formed at 40 °C is heated to constant mass in an evaporating basin using a Bunsen burner.

The following mass measurements were taken:

Mass of evaporating basin = 45.27 g

Mass of evaporating basin and saturated solution = 61.50 g

Mass of evaporating basin and contents after heating to constant mass = 46.28 g

Calculate the solubility of barium hydroxide at 40 °C in g/100 g water based on the results of this experiment. Give your answer to 2 decimal places.

[3]

- (b) State the trends in the solubility of the Group II hydroxides and sulfates as the group is descended.

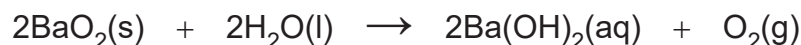
Group II hydroxides: _____

Group II sulfates: _____

[1]



- (c) Barium hydroxide may be prepared by boiling a mixture of barium peroxide, BaO₂, and water. The equation for the reaction is:



2.00 g of an impure sample of barium peroxide were boiled with an excess of water and 117 cm³ of oxygen gas (measured at room temperature and pressure) were collected in a gas syringe.

- (i) State the oxidation number of oxygen in each of the following:

BaO₂ _____

H₂O _____

Ba(OH)₂ _____

O₂ _____

[2]

- (ii) Using the volume of oxygen gas collected, calculate the percentage of barium peroxide in the sample. Give your answer to 1 decimal place.

[3]

- (iii) State the test for oxygen gas.

[1]

- (iv) Describe, without experimental detail, how you would test the solution formed for barium ions.

[2]

[Turn over



- 2 Four samples of a **mixture** of dilute ethanoic acid and ethanol were tested as shown in the table below.

(a) Complete the observations column in the table.

Sample	Test	Observations
1	Add a half-spatula measure of solid sodium carbonate to 2 cm ³ of the mixture in a test tube.	effervescence test tube feels cool solid disappears solution remains colourless
2	Add a half-spatula measure of solid phosphorus pentachloride to 2 cm ³ of the mixture in a test tube.	
3	Add 2 cm ³ of acidified potassium dichromate(VI) solution to 2 cm ³ of the mixture in a test tube. Warm in a water bath.	
4	Add a 1 cm strip of magnesium ribbon to 5 cm ³ of the mixture in a test tube.	

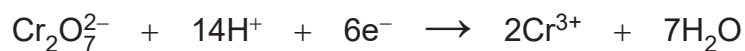
[5]



- (b) State the IUPAC name of the organic product of the reaction between phosphorus pentachloride and ethanol.

_____ [1]

- (c) Acidified potassium dichromate(VI) is an oxidising agent. The half equations for the oxidation of ethanol and reduction of dichromate(VI) ions are:



Write the ionic equation for the oxidation of ethanol using acidified dichromate(VI) ions.

_____ [2]



(ii) State and explain which indicator is used in this titration.

[1]

(iii) Calculate the relative formula mass of the acid.

[4]

(c) H_2A is a dicarboxylic acid as it contains two $-\text{COOH}$ groups. Deduce a structural formula for the acid.

[1]

[Turn over

13004



12SCH3207

4 Halogenoalkanes may be hydrolysed.

(a) The hydrolysis of halogenoalkanes using silver nitrate solution involves heating a mixture of the liquid halogenoalkane with aqueous silver nitrate and ethanol in a water bath at 50 °C. The halogenoalkanes are hydrolysed by the water in aqueous silver nitrate. The mechanism is nucleophilic substitution.

(i) Suggest why ethanol is added to the mixture.

_____ [1]

(ii) Write an equation for the hydrolysis of 1-bromobutane with water.

_____ [1]

(iii) Explain why water can act as a nucleophile.

_____ [1]

(b) The table below shows the time taken for a precipitate to form in the hydrolysis of the liquid halogenoalkanes using silver nitrate solution.

Halogenoalkane	Time for a precipitate to form / s
1-chlorobutane	565
1-bromobutane	86
1-iodobutane	46
2-bromobutane	32
2-bromo-2-methylpropane	4

(i) What is meant by the term **hydrolysis**?

_____ [1]



- (ii) State the colour of the precipitate formed when 2-bromo-2-methylpropane is hydrolysed using silver nitrate solution.

_____ [1]

- (iii) Identify the precipitate formed when 1-chlorobutane is hydrolysed using silver nitrate solution.

_____ [1]

- (iv) State and explain the trend in the relative rates of hydrolysis of the primary halogenoalkanes.

_____ [2]

- (v) Compare the relative rates of hydrolysis of primary, secondary and tertiary halogenoalkanes.

_____ [1]

[Turn over



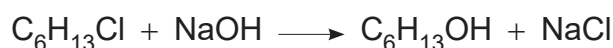
- (c) The following method may be used to hydrolyse 1-chlorohexane using sodium hydroxide solution.

10 cm³ of 1-chlorohexane were placed in a pear-shaped flask. 5 cm³ of 6.0 mol dm⁻³ sodium hydroxide solution (an excess) were added slowly whilst the flask was immersed in ice cold water. The mixture was heated under reflux for 20 minutes. The impure product, hexan-1-ol, was collected by fractional distillation between 150°C and 162°C. 4.4 cm³ of liquid were collected between these temperatures.

The table below gives the densities and boiling points of the organic reactant and product.

Substance	Density /g cm ⁻³	Boiling point /°C
1-chlorohexane	0.88	134
hexan-1-ol	0.82	157

The equation for the hydrolysis reaction is



- (i) Explain why the flask was immersed in ice cold water when the sodium hydroxide solution was being added.

_____ [1]

- (ii) Suggest why an excess of sodium hydroxide was used.

_____ [1]



(iii) Explain what is meant by heated under **reflux**.

[1]

(iv) What should be added to the reaction mixture to promote smooth boiling?

[1]

(v) Describe four changes which you would make to the apparatus used to heat under reflux, in order to carry out fractional distillation.

[4]

(vi) Assuming all of the liquid collected between 150 °C and 162 °C was hexan-1-ol, calculate the percentage yield. Give your answer to 1 decimal place.

[4]

THIS IS THE END OF THE QUESTION PAPER



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Question Number	Marks
1	
2	
3	
4	

Total Marks	
-------------	--

Examiner Number

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SCH32/5
260990



General Information

1 tonne = 10^6 g

1 metre = 10^9 nm

One mole of any gas at 293 K and a pressure of 1 atmosphere (10^5 Pa) occupies a volume of 24 dm³

Avogadro Constant = 6.02×10^{23} mol⁻¹

Planck Constant = 6.63×10^{-34} Js

Specific Heat Capacity of water = $4.2 \text{ J g}^{-1} \text{ K}^{-1}$

Speed of Light = $3 \times 10^8 \text{ m s}^{-1}$



Characteristic absorptions in IR spectroscopy

Wavenumber/cm ⁻¹	Bond	Compound
550–850	C–X (X = Cl, Br, I)	Haloalkanes
750–1100	C–C	Alkanes, alkyl groups
1000–1300	C–O	Alcohols, esters, carboxylic acids
1450–1650	C=C	Arenes
1600–1700	C=C	Alkenes
1650–1800	C=O	Carboxylic acids, esters, aldehydes, ketones, amides, acyl chlorides
2200–2300	C≡N	Nitriles
2500–3200	O–H	Carboxylic acids
2750–2850	C–H	Aldehydes
2850–3000	C–H	Alkanes, alkyl groups, alkenes, arenes
3200–3600	O–H	Alcohols
3300–3500	N–H	Amines, amides

Proton Chemical Shifts in Nuclear Magnetic Resonance Spectroscopy (relative to TMS)

Chemical Shift	Structure	
0.5–2.0	–CH	Saturated alkanes
0.5–5.5	–OH	Alcohols
1.0–3.0	–NH	Amines
2.0–3.0	–CO–CH	Ketones
	–N–CH	Amines
	C ₆ H ₅ –CH	Arene (aliphatic on ring)
2.0–4.0	X–CH	X = Cl or Br (3.0–4.0) X = I (2.0–3.0)
4.5–6.0	–C=CH	Alkenes
5.5–8.5	RCONH	Amides
6.0–8.0	–C ₆ H ₅	Arenes (on ring)
9.0–10.0	–CHO	Aldehydes
10.0–12.0	–COOH	Carboxylic acids

These chemical shifts are concentration and temperature dependent and may be outside the ranges indicated above.

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COUNCIL FOR THE CURRICULUM, EXAMINATIONS AND ASSESSMENT

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Email: info@ccea.org.uk Web: www.ccea.org.uk



Data Leaflet

Including the Periodic Table of the Elements

For the use of candidates taking
Advanced Subsidiary and
Advanced Level Examinations

Copies must be free from notes or additions of any kind. No other type of data booklet or information sheet is authorised for use in the examinations

gce a/as examinations chemistry

I II THE PERIODIC TABLE OF ELEMENTS III IV V VI VII 0

Group

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen 1																	4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	98 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La [*] Lanthanum 57	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	210 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radium 88	227 Ac [†] Actinium 89	261 Rf Rutherfordium 104	262 Db Dubnium 105	266 Sg Seaborgium 106	264 Bh Bohrium 107	277 Hs Hassium 108	268 Mt Meitnerium 109	271 Ds Darmstadtium 110	272 Rg Roentgenium 111	285 Cn Copernicium 112						

* 58 – 71 Lanthanum series
† 90 – 103 Actinium series

a

X

b

a = relative atomic mass (approx)
x = atomic symbol
b = atomic number

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	145 Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	231 Pa Protactinium 91	238 U Uranium 92	237 Np Neptunium 93	242 Pu Plutonium 94	243 Am Americium 95	247 Cm Curium 96	245 Bk Berkelium 97	251 Cf Californium 98	254 Es Einsteinium 99	253 Fm Fermium 100	256 Md Mendelevium 101	254 No Nobelium 102	257 Lr Lawrencium 103



Rewarding Learning

**ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2022**

Chemistry
Assessment Unit AS 3
assessing
Module 3: Practical Examination
Practical Booklet B (Theory)
[SCH32]

WEDNESDAY 1 JUNE, MORNING

**MARK
SCHEME**

General Marking Instructions

Introduction

The main purpose of the mark scheme is to ensure that examinations are marked accurately, consistently and fairly. The mark scheme provides examiners with an indication of the nature and range of candidates' responses likely to be worthy of credit. It also sets out the criteria which they should apply in allocating marks to candidates' responses.

Assessment objectives

Below are the assessment objectives for **GCE Chemistry**:

Candidates should be able to:

AO1	Demonstrate knowledge and understanding of scientific ideas, processes, techniques and procedures.
AO2	Apply knowledge and understanding of scientific ideas, processes, techniques and procedures: in a theoretical context in a practical context when handling quantitative and qualitative data
AO3	Analyse, interpret and evaluate scientific information, ideas and evidence (in relation to particular issues) make judgements and reach conclusions develop and refine practical design and procedures

Quality of candidates' responses

In marking the examination papers, examiners should be looking for a quality of response reflecting the level of maturity which may reasonably be expected of a 17 or 18-year-old which is the age at which the majority of candidates sit their GCE examinations.

Flexibility in marking

Mark schemes are not intended to be totally prescriptive. No mark scheme can cover all the responses which candidates may produce. In the event of unanticipated answers, examiners are expected to use their professional judgement to assess the validity of answers. If an answer is particularly problematic, then examiners should seek the guidance of the Supervising Examiner.

Positive marking

Examiners are encouraged to be positive in their marking, giving appropriate credit for what candidates know, understand and can do rather than penalising candidates for errors or omissions. The exception to this for GCE Chemistry is when examiners are marking complex calculations and mechanisms when the examiners are briefed to mark by error or omission. Examiners should make use of the whole of the available mark range for any particular question and be prepared to award full marks for a response which is as good as might reasonably be expected of a 17 or 18-year-old GCE candidate.

Awarding zero marks

Marks should only be awarded for valid responses and no marks should be awarded for an answer which is completely incorrect or inappropriate.

Marking Calculations

In marking answers involving calculations, examiners should apply the 'carry error through' rule so that candidates are not penalised more than once for a computational error. To avoid a candidate being penalised, marks can be awarded where correct conclusions or inferences are made from their incorrect calculations.

Types of mark schemes

Mark schemes for tasks or questions which require candidates to respond in extended written form are marked on the basis of levels of response which take account of the quality of written communication.

Other questions which require only short answers are marked on a point for point basis with marks awarded for each valid piece of information provided.

Levels of response

In deciding which level of response to award, examiners should look for the number of indicative content points in candidate responses to ensure that the answer has been written to coincide with the question. In deciding which mark within a particular level to award to any response, quality of communication will be assessed and examiners are expected to use their professional judgement.

The following guidance is provided to assist examiners.

- **Threshold performance:** Response which just merits inclusion in the level but the quality of communication is basic should be awarded a mark at the bottom of the range.
- **High performance:** Response which fully satisfies the level description for both content and quality of communication should be awarded a mark at the top of the range.

Quality of written communication

Quality of written communication is taken into account in assessing candidates' responses to all tasks and questions on theory examination papers that require them to respond in extended written form. These tasks and questions are marked on the basis of levels of response. The description for each level of response includes reference to the quality of written communication.

For conciseness, quality of written communication is distinguished within levels of response as follows:

Level C: Quality of written communication is basic.
Level B: Quality of written communication is good.
Level A: Quality of written communication is excellent.

In interpreting these level descriptions, examiners should refer to the more detailed guidance provided below:

Level C (Basic): Basic reference to scientific terminology. The candidate makes only a limited selection and use of an appropriate form and style of writing. The organisation of material may lack clarity and coherence. There is little use of specialist vocabulary. Presentation, spelling, punctuation and grammar may be such that intended meaning is not clear.

Level B (Good): Good reference to scientific terminology. The candidate makes a reasonable selection and use of an appropriate form and style of writing. Relevant material is organised with some clarity and coherence. There is some use of appropriate specialist vocabulary. Presentation, spelling, punctuation and grammar are sufficiently competent to make meaning clear.

Level A (Excellent): Excellent reference to scientific terminology. The candidate successfully selects and uses the most appropriate form and style of writing. Relevant material is organised with a high degree of clarity and coherence. There is widespread and accurate use of appropriate specialist vocabulary. Presentation, spelling, punctuation and grammar are of a sufficiently high standard to make meaning clear.

COVID-19 Context

Given the unprecedented circumstances presented by the COVID-19 public health crisis, senior examiners, under the instruction of CCEA awarding organisation, are required to train assistant examiners to apply the mark scheme in case of disrupted learning and lost teaching time. The interpretation and intended application of the mark scheme for this examination series will be communicated through the standardising meeting by the Chief or Principal Examiner and will be monitored through the supervision period. This paragraph will apply to examination series in 2021-2022 only.

- 1 (a) mass of water = 15.22 g
mass of solid = 1.01 g
solubility = 6.64 (g/100 g water) [3]
- (b) solubility of hydroxides increases (down the group)
solubility of sulfates decreases (down the group) [1]
- (c) (i) BaO₂ -1
H₂O -2
Ba(OH)₂ -2
O₂ 0 [2]
- (ii) moles of O₂ = $\frac{117}{24000} = 4.875 \times 10^{-3}$
mass of BaO₂ = $4.875 \times 10^{-3} \times 2 \times 169 = 1.648$ g
 $\% = \frac{1.648}{2.0} = 82.4\%$ [3]
- (iii) relights a glowing splint [1]
- (iv) flame test [1]
green/apple green flame [1] [2]
or
add a sulfate ion solution [1] white precipitate [1]

2 (a)

Sample	Test	Observations
1	Add 1 half-spatula measure of solid sodium carbonate to 2 cm ³ of the mixture in a test tube.	effervescence test tube feels cool solid disappears solution remains colourless
2	Add 1 half-spatula measure of solid phosphorus pentachloride to 2 cm ³ of the mixture in a test tube.	misty fumes/steamy fumes hissing sound solid disappears test tube warms up any two [2]
3	Add 2 cm ³ of acidified potassium dichromate(VI) solution to 2 cm ³ of the mixture in a test tube. Warm in a water bath.	solution changes from orange to green both colours required [1]
4	Add a 1 cm strip of magnesium ribbon to 5 cm ³ of the mixture in a test tube.	fizzing magnesium disappears test tube warms up solution remains colourless any two [2]

- (b) chloroethane [1]
- (c) $3\text{CH}_3\text{CH}_2\text{OH} + 16\text{H}^+ + 2\text{Cr}_2\text{O}_7^{2-} \rightarrow 3\text{CH}_3\text{COOH} + 11\text{H}_2\text{O} + 4\text{Cr}^{3+}$ [2]

AVAILABLE
MARKS

12

8

- 3 (a) weigh out accurately 1.75 g of solid H_2A [1]
 dissolve in approximately 100 cm^3 of deionised water in a beaker [1]
 transfer to a 250 cm^3 volumetric flask [1]
 ensuring all rinsings go into the flask [1]
 add deionised water until the bottom of the meniscus is on the line [1]
 stopper and invert to mix [1] [6]
- (b) (i) any **two** from:
 swirling the conical flask [1]
 adding dropwise near the end point [1]
 reading from the bottom of the meniscus [1] [2]
- (ii) phenolphthalein as it is a weak acid strong base titration [1]
- (iii) moles of $\text{NaOH} = \frac{20.4 \times 0.145}{1000} = 2.958 \times 10^{-3}$
 moles of $\text{H}_2\text{A} = \frac{2.958 \times 10^{-3}}{2} = 1.479 \times 10^{-3}$
 moles of H_2A in 250.0 $\text{cm}^3 = 0.01479$
 relative formula mass of $\text{H}_2\text{A} = \frac{1.75}{0.01479} = 118$ [4]
- (c) either:
- $$\begin{array}{ccccccc} & \text{O} & & \text{H} & & \text{H} & & \text{O} \\ & \parallel & & | & & | & & \parallel \\ \text{HO} & - \text{C} & - & \text{C} & - & \text{C} & - & \text{C} & - \text{OH} \\ & & & | & & | & & \\ & & & \text{H} & & \text{H} & & \end{array}$$

or

$$\begin{array}{ccccc} & \text{O} & & \text{O} & & \text{O} \\ & \parallel & & \parallel & & \parallel \\ \text{HO} & - \text{C} & - & \text{C} & - & \text{C} & - \text{OH} \\ & & & & & & \end{array}$$
- or correct suitable with M_r of 118 [1]

AVAILABLE
MARKS

14

4 (a) (i) dissolves both reactants/acts as solvent/mutual solvent	[1]	AVAILABLE MARKS
(ii) $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br} + \text{H}_2\text{O} \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} + \text{HBr}$	[1]	
(iii) has lone pair(s) of electrons	[1]	
(b) (i) breaking up molecules by reaction with water	[1]	
(ii) cream	[1]	
(iii) silver chloride/AgCl	[1]	
(iv) 1-iodobutane faster than 1-bromobutane faster than 1-chlorobutane	[1]	
C—I bond weaker than C—Br which is weaker than C—Cl	[1]	
(v) tertiary faster than secondary faster than primary	[1]	
(c) (i) to dissipate the heat	[1]	
(ii) maximise yield	[1]	
(iii) repeated boiling and condensing of a (reaction) mixture	[1]	
(iv) antibumping granules	[1]	
(v) Any four from:		
attach fractionating column to pear shaped flask	[1]	
attach still head/sidearm	[1]	
insert thermometer	[1]	
sidearm/still head connected to condenser angled downwards	[1]	
collection vessel	[1]	
(vi) mass of 1-chlorohexane = $10 \times 0.88 = 8.8\text{g}$		
mole of 1-chlorohexane = $\frac{8.8}{120.5} = 0.07303$		
theoretical yield of hexan-1-ol = $0.07303 \times 102 = 7.449\text{g}$		
actual yield of hexan-1-ol = $4.4 \times 0.82 = 3.608\text{g}$		
percentage yield = $\frac{3.608}{7.449} \times 100 = 48.4\%$	[4]	21
Total		55



Rewarding Learning

ADVANCED
General Certificate of Education
2022

Centre Number

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Candidate Number

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Chemistry

Assessment Unit A2 1

assessing

Further Physical and
Organic Chemistry



[ACH14]

ACH14

MONDAY 30 MAY, MORNING

TIME

2 hours.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

Answer **all fifteen** questions in **Sections A and B**.

You must answer the questions in the spaces provided.

Do not write outside the boxed area on each page or on blank pages.

Complete in black ink only. **Do not write with a gel pen or a pencil.**

INFORMATION FOR CANDIDATES

The total mark for this paper is 110.

Quality of written communication will be assessed in Questions **11(b)** and **14(b)(ii)**.

The figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

A Periodic Table of Elements, containing some data, is included with this question paper.

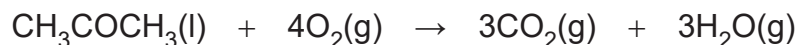


Section A

For each of the following questions, only **one** of the lettered responses (A–D) is correct.

Select the correct response for each question and write the appropriate letter in the space provided.

- 1 Which one of the following is true for the combustion of propanone as shown below?



- A ΔS is negative and ΔH is negative
- B ΔS is negative and ΔH is positive
- C ΔS is positive and ΔH is negative
- D ΔS is positive and ΔH is positive

Answer _____ [1]

- 2 Which one of the following 0.1 mol dm^{-3} solutions has a pH greater than 7?

- A ammonium chloride
- B ammonium nitrate
- C sodium citrate
- D sodium sulfate

Answer _____ [1]



3 What volume of water must be added to 10 cm^3 of a 0.2 mol dm^{-3} solution of hydrogen peroxide to make a 0.05 mol dm^{-3} solution of hydrogen peroxide?

- A 20 cm^3
- B 30 cm^3
- C 40 cm^3
- D 50 cm^3

Answer _____ [1]

4 Which one of the following compounds has the greatest lattice enthalpy?

- A calcium chloride
- B calcium oxide
- C magnesium chloride
- D magnesium oxide

Answer _____ [1]

5 Complete combustion of 40 cm^3 of a gaseous hydrocarbon requires 240 cm^3 of oxygen. 160 cm^3 of carbon dioxide are formed at room temperature and pressure. The formula of the hydrocarbon is:

- A C_4H_8
- B C_4H_{10}
- C C_6H_{12}
- D C_6H_{14}

Answer _____ [1]

[Turn over]



6 Which one of the following gives the correct mechanisms for the reactions shown?

	Reaction of cyanide ions with halogenoalkanes	Reaction of hydrogen cyanide with carbonyl compounds
A	electrophilic substitution	electrophilic addition
B	electrophilic substitution	nucleophilic addition
C	nucleophilic substitution	electrophilic addition
D	nucleophilic substitution	nucleophilic addition

Answer _____ [1]

7 0.15 mol of a fat which is a triester, required 10.8 dm^3 of hydrogen gas at room temperature and pressure for complete hydrogenation. The average number of $\text{C}=\text{C}$ double bonds in each fatty acid chain of the fat is:

- A 1
- B 2
- C 3
- D 4

Answer _____ [1]

8 What is the percentage by mass of oxygen in methyl 3-nitrobenzoate?

- A 17.6 %
- B 26.5 %
- C 35.4 %
- D 44.2 %

Answer _____ [1]

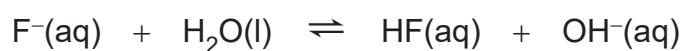


9 Which one of the following alcohols can form the ester $\text{HCOOCH}(\text{CH}_3)_2$?

- A methanol
- B 2-methylpropan-2-ol
- C propan-1-ol
- D propan-2-ol

Answer _____ [1]

10 Fluoride ions react with water in the following equilibrium:



Which one of the following shows the Brønsted–Lowry bases in this equilibrium?

- A F^- and HF
- B F^- and OH^-
- C H_2O and HF
- D H_2O and OH^-

Answer _____ [1]

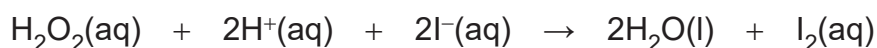
[Turn over]



Section B

Answer **all five** questions in this section

- 11** Hydrogen peroxide reacts with iodide ions according to the equation:



- (a)** The table shows data obtained from experiments investigating the initial rate of this reaction.

Experiment number	$[\text{H}_2\text{O}_2]$ $/\text{mol dm}^{-3}$	$[\text{H}^+]$ $/\text{mol dm}^{-3}$	$[\text{I}^-]$ $/\text{mol dm}^{-3}$	Initial rate of reaction $/\text{mol dm}^{-3} \text{ s}^{-1}$
1	0.050	0.050	0.050	1.24×10^{-6}
2	0.100	0.100	0.100	
3	0.100	0.200		3.72×10^{-6}
4	0.500	0.100		1.55×10^{-6}

The rate equation for the reaction is:

$$\text{rate} = k[\text{H}_2\text{O}_2][\text{I}^-]$$

- (i)** Calculate a value for the rate constant using the results of experiment 1. State the units. Give your answer to 3 significant figures.

[2]

- (ii)** Complete the table by inserting the missing values.

[3]



In this question you will be assessed on using your written communication skills including the use of specialist terms.

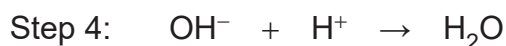
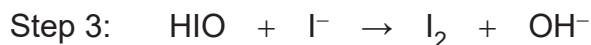
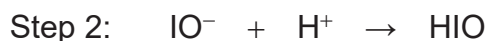
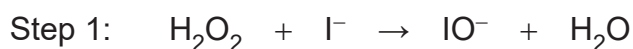
[6]

13108



28ACH1407

(c) A mechanism for the reaction is shown below in 4 steps:



(i) Explain, using the rate equation, why Step 1 is the rate determining step in this mechanism.

[1]

(ii) Suggest why Step 2 and Step 4 are faster than Steps 1 and 3.

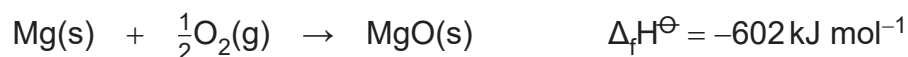
[1]

(iii) What is the systematic name for the IO^- ion?

[1]



12 Magnesium oxide is formed from its elements as follows:



(a) (i) Use the values in the table to calculate the entropy change for the reaction.

Substance	MgO(s)	O ₂ (g)	Mg(s)
Entropy /J K ⁻¹ mol ⁻¹	26.9	205	32.7

_____ [2]

(ii) Write the equation for **free energy change**.

_____ [1]

(iii) Calculate the free energy change for the formation of magnesium oxide at 298 K. State the units. Give your answer to 3 significant figures.

_____ [3]

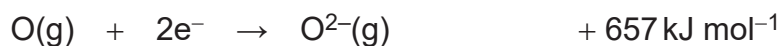
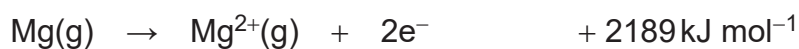
(iv) Explain why this reaction is feasible at 298 K.

_____ [1]

[Turn over



(b) The following enthalpy changes can be used to calculate the lattice enthalpy of magnesium oxide.



(i) Define **lattice enthalpy**.

[2]

(ii) Calculate the lattice enthalpy of magnesium oxide.

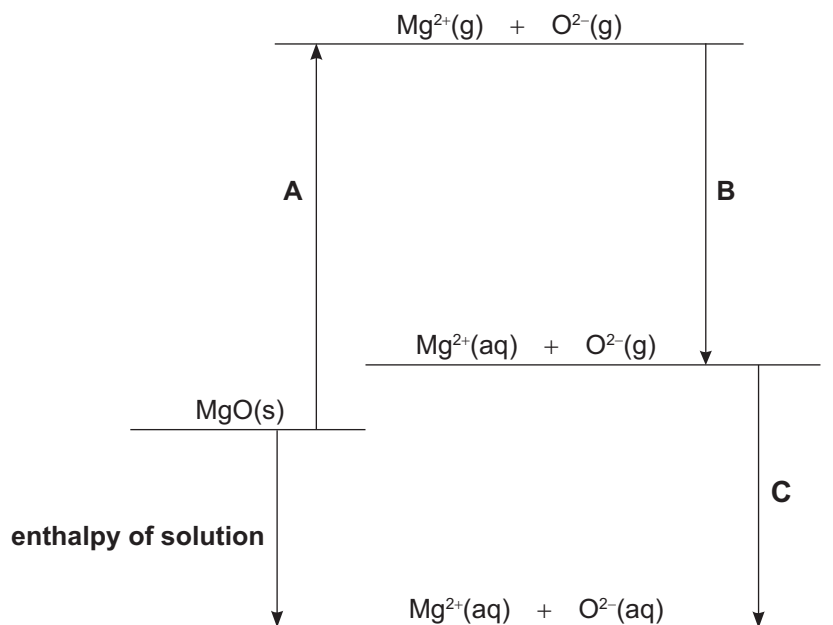
[2]

(iii) Write an equation for the second electron affinity of oxygen. Explain whether this process is exothermic or endothermic.

[2]



- (c) A theoretical value for the enthalpy of solution of magnesium oxide may be calculated using a Hess's Law diagram.



- (i) Name the enthalpy changes labelled **A** and **B**.

A _____

B _____ [2]

- (ii) Suggest why an actual value for the enthalpy of solution of magnesium oxide is not found in any data books.

_____ [1]

[Turn over



13 Benzene was first isolated by Faraday in 1825.

(a) Both benzene and propene will react with bromine but in different ways.

(i) Write equations for the reactions of bromine with benzene and bromine with propene.

benzene: _____

propene: _____ [2]

(ii) Complete the table below.

	Reaction of bromine with benzene	Reaction of bromine with propene
Name of mechanism		
IUPAC name of product		

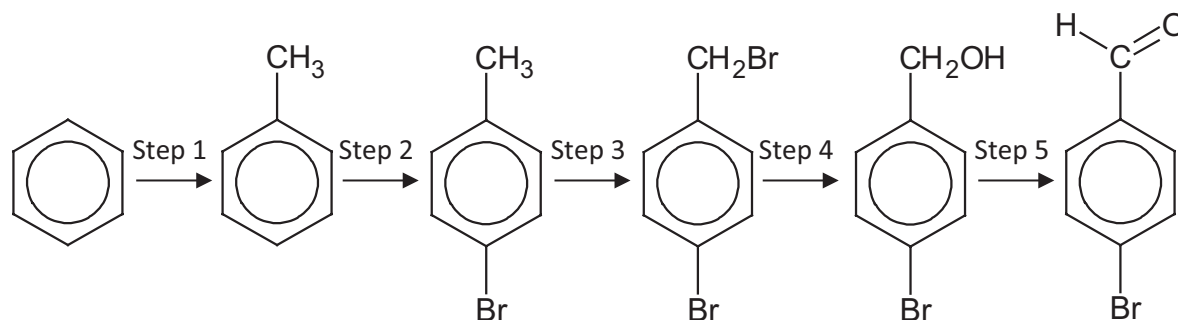
[4]

(iii) Explain why the mechanisms for the reactions in **(a)(ii)** are different.

_____ [2]



(b) (4-bromophenyl)methanal can be formed by the sequence of reactions shown below.



(i) Name the reagent and catalyst used in the formation of methylbenzene in Step 1.

reagent: _____

catalyst: _____ [2]

(ii) Methylbenzene reacts with bromine in Step 2 in the same way that benzene reacts with bromine. Including any appropriate equations, outline the mechanism for the catalysed reaction of methylbenzene and bromine in Step 2, using curly arrows.

[5]

[Turn over]



- (iii) Suggest the name for the reaction mechanism which occurs during Step 3 of the reaction sequence.

_____ [1]

- (iv) Name the reagent and the reaction conditions needed to carry out Step 5.

reagent: _____

conditions: _____ [2]

- (v) The sample of (4-bromophenyl)methanal obtained contains an organic impurity. The relative molecular mass of the impurity was determined to be 201.

Draw the structure of this organic impurity and state its IUPAC name.

IUPAC name _____ [2]



(c) (i) (4-bromophenyl)methanal reacts with 2,4-dinitrophenylhydrazine. Write an equation for this reaction.

[2]

(ii) State how the purified organic product formed from the reaction in **c(i)** could be used to confirm the identity of (4-bromophenyl)methanal.

[2]

[Turn over



14 3-methylbutan-1-ol is one of eight alcohols with the molecular formula $C_5H_{12}O$.

(a) (i) Complete the table below for some of the isomers of $C_5H_{12}O$.

Structural formula	Classification	IUPAC name
$ \begin{array}{ccccccc} & H & & H & & CH_3 & & H \\ & & & & & & & \\ HO & -C & - & C & - & C & - & C & -H \\ & & & & & & & \\ & H & & H & & H & & H \end{array} $	primary	3-methylbutan-1-ol
$ \begin{array}{ccccccc} & H & & H & & CH_3 & & H \\ & & & & & & & \\ H & -C & - & C & - & C & - & C & -OH \\ & & & & & & & \\ & H & & H & & H & & H \end{array} $	primary	
$ \begin{array}{ccccccc} & H & & H & & H & & OH & & H \\ & & & & & & & & & \\ H & -C & - & C & - & C & - & C & - & C & -H \\ & & & & & & & & & \\ & H & & H & & H & & H & & H \end{array} $		pentan-2-ol
	tertiary	
$ \begin{array}{ccccccc} & H & & H & & OH & & H \\ & & & & & & & \\ H & -C & - & C & - & C & - & C & -H \\ & & & & & & & \\ & H & & CH_3 & & H & & H \end{array} $	secondary	

[5]



(ii) Some of the alcohol isomers are optically active. Define the term **optically active**.

_____ [2]

(iii) Name the alcohols shown in the table in (a)(i) which exhibit optical activity.

_____ [2]

(iv) Name the alcohol shown in the table in (a)(i) which can be oxidised to produce an optically active compound. Draw the structural formula of the optically active compound.

Name: _____ [2]

[Turn over



(b) 3-methylbutan-1-ol undergoes an esterification reaction with ethanoic acid to form 'banana oil' which is used as a food flavouring.

(i) Write an equation for this esterification reaction.

[2]

(ii) An impure sample of 'banana oil' was obtained in a round-bottomed flask by reacting 3-methylbutan-1-ol with ethanoic acid in the presence of a concentrated sulfuric acid catalyst. The impure sample of the 'banana oil' was collected by distillation. Describe how the sample could be further purified by removing acidic impurities and water.

In this question you will be assessed on using your written communication skills including the use of specialist scientific terms.

[6]



(c) Coconut oil contains a large proportion of the triglyceride, glyceryl trilaurate. The fatty acid in this triglyceride is lauric acid, $\text{CH}_3(\text{CH}_2)_{10}\text{COOH}$.

(i) Draw the structure of glyceryl trilaurate.

[1]

(ii) Explain why glyceryl trilaurate is a solid at room temperature.

[2]

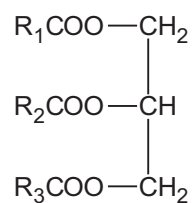
(iii) Biodiesel can be produced from oils such as coconut oil by a transesterification reaction. Define the term **transesterification**.

[2]

[Turn over]



(iv) An oil, with the general formula shown below, can be used in the formation of biodiesel.

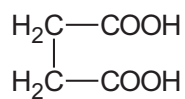


Write the equation for the formation of biodiesel by heating the oil with an excess of ethanol in the presence of a catalyst.

[2]



- 15** Succinic acid is a dicarboxylic acid. It is a white solid at room temperature and melts at 184 °C. It has a solubility in water of 0.0580 kg dm⁻³ at 20 °C.



succinic acid

- (a) (i)** Explain why succinic acid has a relatively high melting point.

[2]

- (ii)** Calculate the molarity of a saturated solution of succinic acid at 20 °C. Give your answer to 3 significant figures.

[2]

[Turn over



(b) Succinic acid undergoes two successive acid ionisation reactions with $pK_{a1} = 4.30$ and $pK_{a2} = 5.60$.

(i) Write an expression for the first acid dissociation constant for succinic acid.

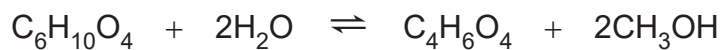
_____ [1]

(ii) Using the pK_{a1} value, calculate the pH of a $0.100 \text{ mol dm}^{-3}$ solution of succinic acid. Give your answer to 2 decimal places.

_____ [3]



- (c) Dimethyl succinate ($\text{C}_6\text{H}_{10}\text{O}_4$) is a fruit-flavoured additive for ice-cream and chewing gum. It can be hydrolysed to form succinic acid and methanol.



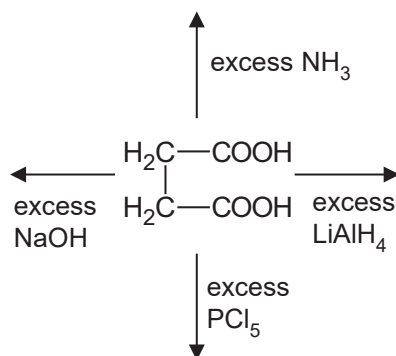
A mixture of 2.0 moles of dimethyl succinate in 5.0 moles of water is left to reach equilibrium in the presence of an acid catalyst at 50°C . At equilibrium 1.4 moles of dimethyl succinate are present. Calculate the value for K_c in this equilibrium at 50°C . Give your answer to 2 significant figures.

[4]

[Turn over



- (e) Give the structures of the organic products for the reaction of succinic acid with an excess of each reagent.



[4]

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General Information

1 tonne = 10^6 g

1 metre = 10^9 nm

One mole of any gas at 293 K and a pressure of 1 atmosphere (10^5 Pa) occupies a volume of 24 dm³

Avogadro Constant = 6.02×10^{23} mol⁻¹

Planck Constant = 6.63×10^{-34} Js

Specific Heat Capacity of water = $4.2 \text{ J g}^{-1} \text{ K}^{-1}$

Speed of Light = $3 \times 10^8 \text{ ms}^{-1}$



Characteristic absorptions in IR spectroscopy

Wavenumber/cm ⁻¹	Bond	Compound
550–850	C–X (X = Cl, Br, I)	Haloalkanes
750–1100	C–C	Alkanes, alkyl groups
1000–1300	C–O	Alcohols, esters, carboxylic acids
1450–1650	C=C	Arenes
1600–1700	C=C	Alkenes
1650–1800	C=O	Carboxylic acids, esters, aldehydes, ketones, amides, acyl chlorides
2200–2300	C≡N	Nitriles
2500–3200	O–H	Carboxylic acids
2750–2850	C–H	Aldehydes
2850–3000	C–H	Alkanes, alkyl groups, alkenes, arenes
3200–3600	O–H	Alcohols
3300–3500	N–H	Amines, amides

Proton Chemical Shifts in Nuclear Magnetic Resonance Spectroscopy (relative to TMS)

Chemical Shift	Structure	
0.5–2.0	–CH	Saturated alkanes
0.5–5.5	–OH	Alcohols
1.0–3.0	–NH	Amines
2.0–3.0	–CO–CH	Ketones
	–N–CH	Amines
	C ₆ H ₅ –CH	Arene (aliphatic on ring)
2.0–4.0	X–CH	X = Cl or Br (3.0–4.0) X = I (2.0–3.0)
4.5–6.0	–C=CH	Alkenes
5.5–8.5	RCONH	Amides
6.0–8.0	–C ₆ H ₅	Arenes (on ring)
9.0–10.0	–CHO	Aldehydes
10.0–12.0	–COOH	Carboxylic acids

These chemical shifts are concentration and temperature dependent and may be outside the ranges indicated above.

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COUNCIL FOR THE CURRICULUM, EXAMINATIONS AND ASSESSMENT

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Data Leaflet

Including the Periodic Table of the Elements

For the use of candidates taking
Advanced Subsidiary and
Advanced Level Examinations

Copies must be free from notes or additions of any kind. No other type of data booklet or information sheet is authorised for use in the examinations

gce a/as examinations chemistry

I II THE PERIODIC TABLE OF ELEMENTS III IV V VI VII 0

Group

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen 1																	4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	98 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La [*] Lanthanum 57	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	210 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radium 88	227 Ac [†] Actinium 89	261 Rf Rutherfordium 104	262 Db Dubnium 105	266 Sg Seaborgium 106	264 Bh Bohrium 107	277 Hs Hassium 108	268 Mt Meitnerium 109	271 Ds Darmstadtium 110	272 Rg Roentgenium 111	285 Cn Copernicium 112						

* 58 – 71 Lanthanum series
† 90 – 103 Actinium series

a

X

b

a = relative atomic mass (approx)
x = atomic symbol
b = atomic number

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	145 Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	231 Pa Protactinium 91	238 U Uranium 92	237 Np Neptunium 93	242 Pu Plutonium 94	243 Am Americium 95	247 Cm Curium 96	245 Bk Berkelium 97	251 Cf Californium 98	254 Es Einsteinium 99	253 Fm Fermium 100	256 Md Mendelevium 101	254 No Nobelium 102	257 Lr Lawrencium 103



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General Certificate of Education
2022

Chemistry

Assessment Unit A2 1

assessing

Further Physical and Organic Chemistry

[ACH14]

MONDAY 30 MAY, MORNING

**MARK
SCHEME**

General Marking Instructions

Introduction

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Section A

- 1 C
- 2 C
- 3 B
- 4 D
- 5 A
- 6 D
- 7 A
- 8 C
- 9 D
- 10 B

[1] for each correct answer

[10]

Section A

AVAILABLE MARKS	
	10
	10

Section B

AVAILABLE
MARKS

11 (a) (i) $k = 4.96 \times 10^{-4} \text{ [1] mol}^{-1} \text{ dm}^3 \text{ s}^{-1} \text{ [1]}$ [2]

(ii)

Experiment	$[\text{H}_2\text{O}_2]$ $/\text{mol dm}^{-3}$	$[\text{H}^+]$ $/\text{mol dm}^{-3}$	$[\text{I}^-]$ $/\text{mol dm}^{-3}$	Initial rate of reaction $/\text{mol dm}^{-3} \text{ s}^{-1}$
1				
2				$4.96 \times 10^{-6} \text{ [1]}$
3			0.075 [1]	
4			0.00625 [1]	

[3]

(b) Indicative Content

- prepare a range of samples of different concentrations of iodine
- calibrate the colorimeter (using an appropriate filter and a blank solution)
- record the absorbance of each solution of known concentration
- draw a calibration curve of absorbance against concentration
- place reaction mixture in colorimeter and record the absorbance at different times
- use the calibration curve to convert absorbance to concentration
- plot concentration of iodine against time
- rate = gradient of tangent at $t = 0\text{s}$

Band	Response	Mark
A	Candidates must use appropriate specialist terms using at least 7 points of indicative content. They must use good spelling, punctuation and grammar and the form and style are of an excellent standard.	[5]–[6]
B	Candidates must use appropriate specialist terms using at least 5 points of indicative content. They must use satisfactory spelling, punctuation and grammar and the form and style are of a good standard.	[3]–[4]
C	Candidates must use at least 3 points of indicative content. They use limited correct spelling, punctuation and grammar and the form and style are of a basic standard.	[1]–[2]
D	Response not worthy of credit.	[0]

[6]

(c) (i) both H_2O_2 and I^- are in rate equation/ H^+ not in rate equation [1]

(ii) ions attracted to each other/oppositely charged ions are present [1]

(iii) iodate(I) [1]

14

			AVAILABLE MARKS
12	(a) (i)	$\Delta S = 26.9 - (32.7 + 102.5)$ $\Delta S = 26.9 - 135.2$ $\Delta S = -108.3 \text{ (J K}^{-1}\text{ mol}^{-1}\text{)}$	[2]
	(ii)	$\Delta G = \Delta H - T\Delta S$	[1]
	(iii)	$\Delta G = -602 - (298 \times -0.1083)$ $\Delta G = -602 + 32.2734$ $\Delta G = -569.727 = -570 \text{ kJ mol}^{-1}$	[3]
	(iv)	ΔG is negative/less than 0	[1]
	(b) (i)	the enthalpy change when one mole of an ionic compound is converted to gaseous ions	[2]
	(ii)	$-602 + \Delta_{\text{latt}}H = 657 + 249 + 2189 + 148$ $-602 + \Delta_{\text{latt}}H = 3243$ $\Delta_{\text{latt}}H = +3845 \text{ kJ mol}^{-1}$	[2]
	(iii)	$\text{O}^-(\text{g}) + \text{e}^- \rightarrow \text{O}^{2-}(\text{g})$ [1] endothermic as there is repulsion between negative ion and electron [1]	[2]
	(c) (i)	A = lattice enthalpy (of magnesium oxide) [1] B = hydration enthalpy of magnesium ions [1]	[2]
	(ii)	magnesium oxide (virtually) insoluble in water/the oxide ion reacts with water to form hydroxide ions/no hydration enthalpy for the oxide ion	[1]
			16

- 13 (a) (i) $\text{C}_6\text{H}_6 + \text{Br}_2 \rightarrow \text{C}_6\text{H}_5\text{Br} + \text{HBr}$ [1]
 $\text{CH}_2\text{CHCH}_3 + \text{Br}_2 \rightarrow \text{CH}_2\text{BrCHBrCH}_3$ [1] [2]

(ii)

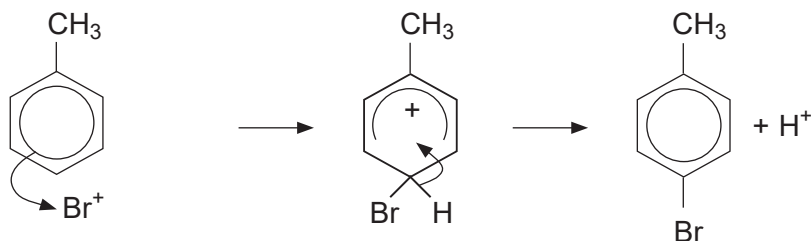
	Reaction of bromine with benzene	Reaction of bromine with propene
Name of mechanism	electrophilic substitution [1]	electrophilic addition [1]
IUPAC name of product	bromobenzene [1]	1,2-dibromopropane [1]

[4]

- (iii) pi delocalised electron ring/system in benzene [1]
 gives enhanced stability [1] [2]

- (b) (i) reagent: chloromethane [1]
 catalyst: aluminium chloride [1] [2]

- (ii) $\text{FeBr}_3 + \text{Br}_2 \rightarrow \text{FeBr}_4^- + \text{Br}^+$



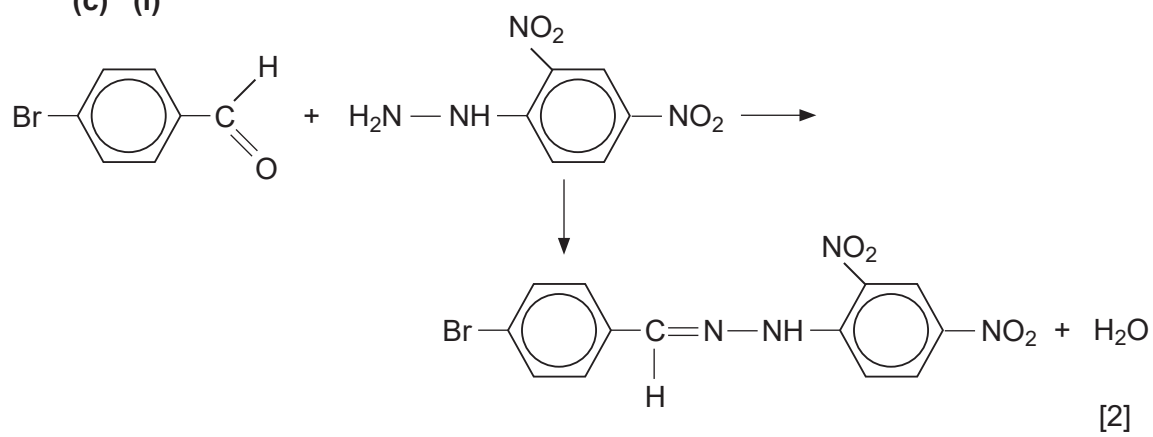
- (iii) radical substitution [1]

- (iv) acidified potassium dichromate(VI) [1]
 heat [1] [2]

- (v) [1] 4-bromobenzoic acid [1] [2]

AVAILABLE
MARKS

(c) (i)



(ii) determine melting point [1]
compare to data book [1]

[2]

24

AVAILABLE
MARKS

14 (a) (i)

AVAILABLE
MARKS

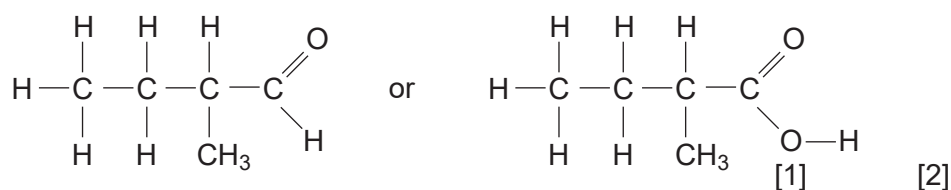
Structural formula	Classification	IUPAC name
		2-methylbutan-1-ol [1]
	secondary [1]	
$ \begin{array}{cccc} \text{H} & \text{OH} & \text{H} & \text{H} \\ & & & \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{C}-\text{H} \\ & & & \\ \text{H} & \text{CH}_3 & \text{H} & \text{H} \end{array} $ [1]		2-methylbutan-2-ol [1]
		3-methylbutan-2-ol [1]

[5]

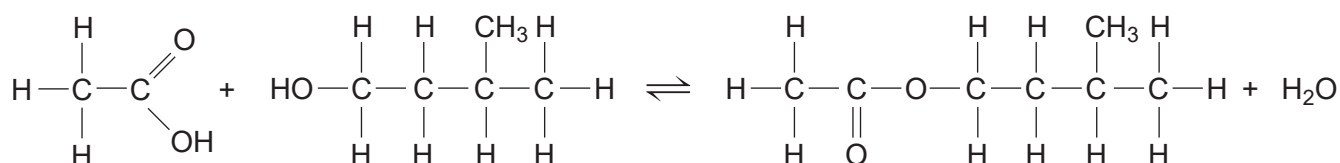
(ii) a sample which rotates the plane of plane polarised light [2]

(iii) 2-methylbutan-1-ol pentan-2-ol 3-methylbutan-2-ol [2]

(iv) 2-methylbutan-1-ol [1]



(b) (i)



[2]

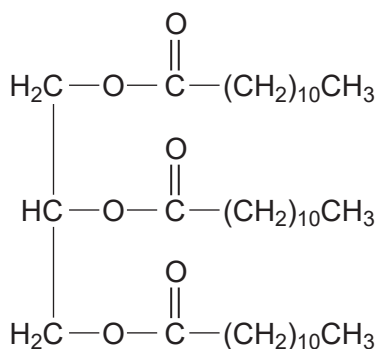
(ii) **indicative content:**

- place the impure distillate in a separating funnel
- add sodium carbonate/sodium hydrogencarbonate solution
- stopper and shake
- release pressure
- separate the layers
- add anhydrous magnesium sulfate/sodium sulfate/calcium chloride
- until the liquid is clear/no longer cloudy
- decant the liquid/filter off solid

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D	Response not worthy of credit.	[0]

[6]

(c) (i)



[1]

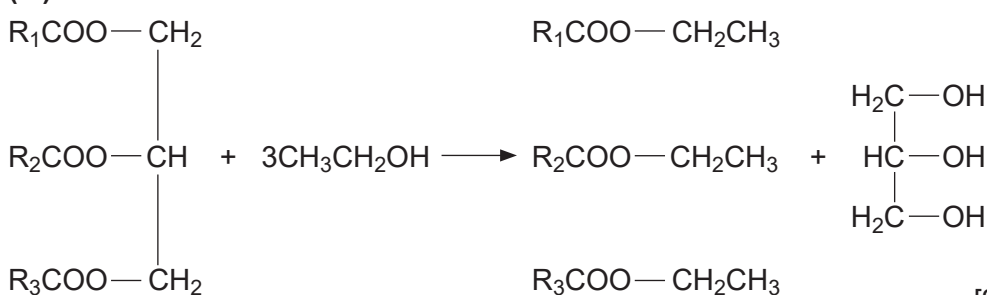
- (ii) glyceryl trilaurate has a high RFM/RMM [1]
strong van der Waals' forces between molecules [1]

[2]

- (iii) a reaction where the alkyl group of an ester is exchanged with the alkyl group of an alcohol [2]

[2]

(iv)



[2]

AVAILABLE
MARKS

26

- 15 (a) (i) hydrogen bonds [1]
between the -COOH groups in adjacent molecules require substantial energy to break [1]
(2nd mark dependent on the first) [2]

(ii) moles of succinic acid = $58.0/118 = 0.492 \text{ M}$ [2]

(b) (i) $K_a = \frac{[\text{H}^+][\text{HOOCCH}_2\text{CH}_2\text{COO}^-]}{[\text{HOOCCH}_2\text{CH}_2\text{COOH}]}$ [1]

(ii) $K_a = 10^{(-4.3)} = 5.012 \times 10^{-5}$
 $\frac{[\text{H}^+]^2}{0.100} = 5.012 \times 10^{-5}$
 $[\text{H}^+]^2 = 5.012 \times 10^{-6}$
 $[\text{H}^+] = 2.239 \times 10^{-3}$
 $\text{pH} = -\log_{10}(2.239 \times 10^{-3}) = 2.65$ [3]

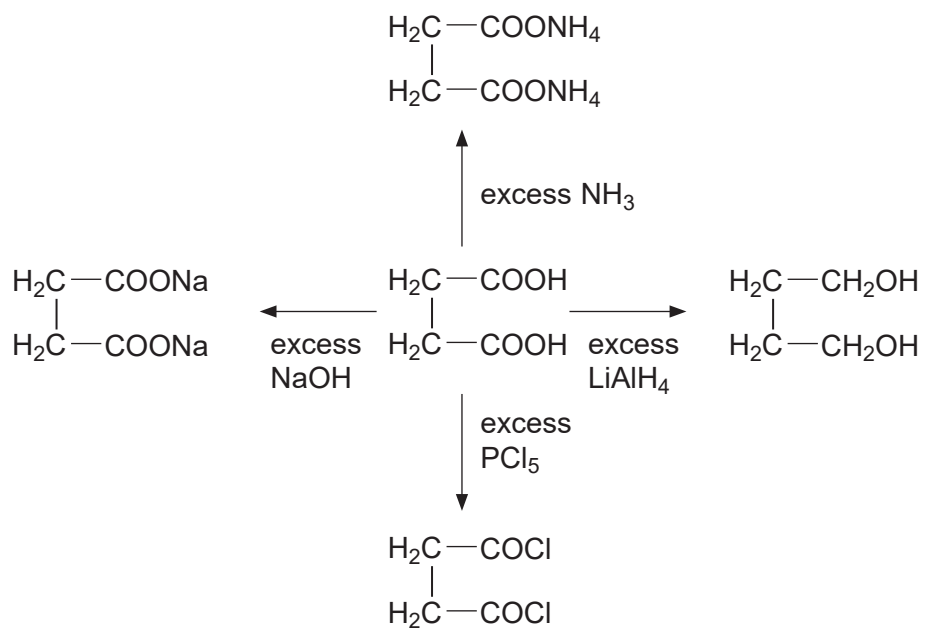
(c)

	$\text{C}_6\text{H}_{10}\text{O}_4$	$2\text{H}_2\text{O}$	$\rightleftharpoons$	$\text{C}_4\text{H}_6\text{O}_4$	$2\text{CH}_3\text{OH}$
initial	2.0	5.0		0	0
	-0.6	-1.2		+0.6	+1.2
equilibrium	1.4	3.8		0.6	1.2

$K_c = \frac{[\text{C}_4\text{H}_6\text{O}_4][\text{CH}_3\text{OH}]^2}{[\text{C}_6\text{H}_{10}\text{O}_4][\text{H}_2\text{O}]^2} = \frac{(0.6)(1.2)^2}{(1.4)(3.8)^2} = 0.042738 = 0.043$ [4]

(d) $[\text{H}^+] = 10^{(-4.80)} = 1.585 \times 10^{-5} \text{ mol dm}^{-3}$
 $[\text{CH}_3\text{COO}^-] = \frac{K_a \times [\text{CH}_3\text{COOH}]}{[\text{H}^+]} = \frac{1.74 \times 10^{-5} \times 0.100}{1.585 \times 10^{-5}} = 0.1098 \text{ mol dm}^{-3}$
 moles in $250 \text{ cm}^3 = 0.1098/4 = 0.02745$
 mass of sodium ethanoate = $0.02745 \times 82 = 2.25 \text{ g}$ [4]

(e)



[4]

Section B

Total

AVAILABLE
MARKS

20

100

110



Rewarding Learning

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General Certificate of Education
2022 Reserve Series

Chemistry

Assessment Unit A2 2

assessing

Analytical, Transition Metals, Electrochemistry
and Further Organic Chemistry

[ACH24]

THURSDAY 30 JUNE, MORNING

MARK SCHEME

General Marking Instructions

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Section A

- 1 B
- 2 B
- 3 C
- 4 B
- 5 D
- 6 B
- 7 A
- 8 D
- 9 B
- 10 C

[1] for each correct answer

[10]

Section A

AVAILABLE MARKS	
	10
	10

Section B

AVAILABLE
MARKS

- 11 (a) three carbon atoms directly bonded to the nitrogen atom,
i.e.



[1]

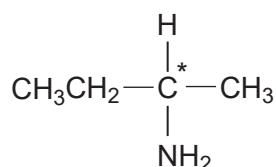
- (b) (i)

Amine	Name	Structural formula	Boiling point /°C
primary	butylamine	$\begin{array}{ccccccc} & \text{H} & \text{H} & \text{H} & \text{H} & & \\ & & & & & & \\ \text{H} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{NH}_2 & \\ & & & & & & \\ & \text{H} & \text{H} & \text{H} & \text{H} & & \end{array}$	78
primary	2-methylpropylamine	$\begin{array}{ccccccc} & \text{H} & \text{CH}_3 & \text{H} & & & \\ & & & & & & \\ \text{H} & -\text{C} & -\text{C} & -\text{C} & -\text{NH}_2 & & \\ & & & & & & \\ & \text{H} & \text{H} & \text{H} & & & \end{array}$	68
secondary	diethylamine [1]	$\begin{array}{ccccccc} & \text{H} & \text{H} & & \text{H} & \text{H} & \\ & & & & & & \\ \text{H} & -\text{C} & -\text{C} & -\text{N} & -\text{C} & -\text{C} & -\text{H} \\ & & & & & & \\ & \text{H} & \text{H} & & \text{H} & \text{H} & \end{array}$	56
tertiary	dimethylethylamine	$\begin{array}{ccccccc} & \text{H} & \text{H} & \text{CH}_3 & \text{H} & & \\ & & & & & & \\ \text{H} & -\text{C} & -\text{C} & -\text{N} & -\text{C} & -\text{H} & \\ & & & & & & \\ & \text{H} & \text{H} & & \text{H} & & \end{array}$	37

[3]

- (ii) more branched amine has lower boiling point/linear or unbranched molecule has higher boiling point [1]
weaker van der Waals' forces between branched chains [1] [2]
- (iii) tertiary amine has no H atom bonded to N atom [1]
tertiary amine cannot form hydrogen bonds between molecules [1] [2]

- (c)



[1] [1] asterisk

[2]

			AVAILABLE MARKS
(d)	(i)	A = 2-bromopropane [1] B = 1-bromo-2-methylpropane [1]	[2]
	(ii)	substitution	[1]
	(iii)	2-methylpropanenitrile	[1]
	(iv)	$\text{CH}_3\text{CH}(\text{CH}_3)\text{CN} + 4[\text{H}] \rightarrow \text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{NH}_2$	[2]
	(e) (i)	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2 + \text{HCl} \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_3\text{Cl}$	[1]
	(ii)	butylammonium chloride	[1]
	(iii)	add alkali/NaOH	[1]
	(f)	add ethanoyl chloride to form a solid [1] determine melting point [1] compare to data book for identification [1]	[3]
			22
12	(a) (i)	Cr atom: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$ [1] Cr ³⁺ ion: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3$ [1]	[2]
	(ii)	it forms at least one stable ion with a partially filled d-subshell	[1]
	(iii)	shape: octahedral	[1]
	(b)	blue precipitate [1] soluble in excess aqueous ammonia [1] forming a deep blue/dark blue solution [1] $\text{Cu}^{2+}(\text{aq}) + 2\text{OH}^{-}(\text{aq}) \rightarrow \text{Cu}(\text{OH})_2(\text{s})$ [1] $\text{Cu}(\text{OH})_2(\text{s}) + 4\text{NH}_3(\text{aq}) + 2\text{H}_2\text{O}(\text{l}) \rightarrow [\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}(\text{aq}) + 2\text{OH}^{-}(\text{aq})$ [2] [6]	[6]
	(c) (i)	blue to yellow	[1]
	(ii)	5 species on the left and 7 species on the right so increase in entropy [1]	[1]
	(iii)	$\left[\begin{array}{c} \text{Cl} \\ \\ \text{Cu} \\ / \quad \backslash \\ \text{Cl} \quad \text{Cl} \\ \\ \text{Cl} \end{array} \right]^{2-}$	[1]
	(d) (i)	green - blue	[1]
	(ii)	$[\text{Cr}(\text{OH})_6]^{3-} + 3\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2 \rightarrow [\text{Cr}(\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2)_3]^{3+} + 6\text{OH}^{-}$ or $[\text{Cr}(\text{OH})_6]^{3-} + 3\text{en} \rightarrow [\text{Cr}(\text{en})_3]^{3+} + 6\text{OH}^{-}$	[2]
	(iii)	An ion or molecule which uses two lone pairs of electrons to form two co-ordinate bonds with a central metal atom or ion in a complex	[2]
	(iv)	$[\text{Cr}(\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2)_3]^{3+} + \text{edta}^{4-} \rightarrow [\text{Cr}(\text{edta})]^{-} + 3\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2$ or $[\text{Cr}(\text{en})_3]^{3+} + \text{edta}^{4-} \rightarrow [\text{Cr}(\text{edta})]^{-} + 3\text{en}$	[2]
			20

13 (a)

Polymer	Monomer(s)	Repeating unit	Type of polymerisation
W		$-\text{OC}-\text{C}_6\text{H}_4-\text{COO}-\text{CH}_2-\text{CH}_2-\text{O}-$	
X	$\begin{array}{c} \text{H} \quad \text{CH}_3 \\ \quad \\ \text{C} = \text{C} \\ \quad \\ \text{CH}_3 \quad \text{H} \end{array}$		addition
Y		$\begin{array}{c} \text{O} \quad \quad \text{O} \quad \text{H} \quad \quad \text{H} \\ \quad \quad \quad \quad \quad \\ -\text{C}-\text{C}_6\text{H}_4-\text{C}-\text{N}-\text{C}_6\text{H}_4-\text{N}- \end{array}$	condensation
Z		$\begin{array}{c} \text{Cl} \\ \\ -\text{O}-\text{C}-\text{C}- \\ \quad \\ \text{CH}_3 \quad \text{O} \end{array}$	condensation

[1] for each correct structure

[1] for type column all correct

[5]

- (b) benzene-1,4-dicarboxylic acid [1]
ethane-1,2-diol [1]

[2]

- (c) polyester

[1]

- (d) amide groups [1] can be hydrolysed by action of microorganisms [1]

[2]

- (e) polymer Y [1]

can form hydrogen bonds between the chains/largest RMM repeating unit so strongest van der Waals' forces between chains [1]

[2]

- (f) 2-chloro-2-hydroxypropanoic acid

[1]

- (g) (i) $\text{C}_5\text{H}_{11}\text{NO}_2$

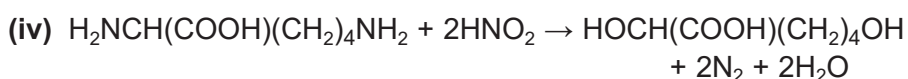
[1]

- (ii) glycine/aminoethanoic acid

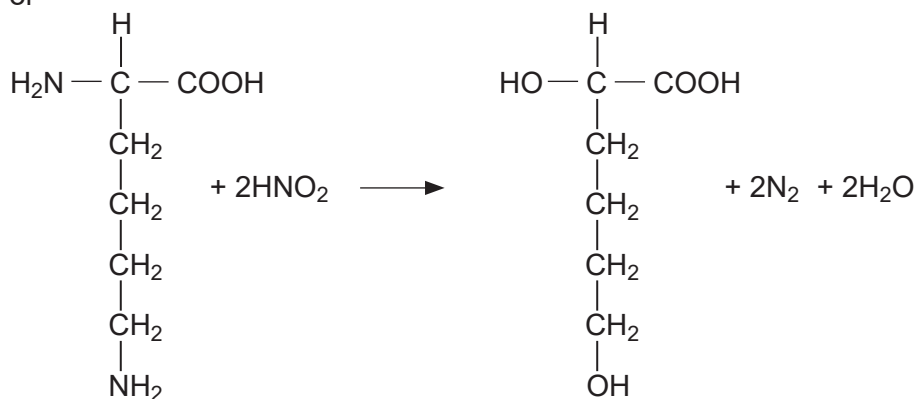
[1]

- (iii) 2,6-diaminohexanoic acid

[1]



or

accept with both NH_2 protonated and $2\text{H}_3\text{O}^+$ on right

[2]

AVAILABLE
MARKS

18

- 14 (a) (i) butanamide/N-ethylethanamide/N-propylmethanamide [1]
- (ii) 44 [1]
 CONH_2^+ [1] [2]
- (iii) peak caused by a molecular ion with an increased mass due to the presence of one carbon-13 atom [1]

(b)

Chemical shift/ppm	Spin-spin splitting pattern	Number of hydrogen atoms bonded to adjacent carbon atoms	Integration
1.3	doublet	1	6
2.3	septet (7 peaks)	6	1
7.2	singlet	0	2

[1] per row

[3]

(c) indicative content

- 4 environments/peaks
- singlet for CH_3
- singlet for NH
- quartet for CH_2 adjacent to CH_3
- triplet for CH_3 adjacent to CH_2
- integration 3:2:3:1
- triplet lowest chemical shift then quartet then singlet (CH_3) and singlet (NH)

Band	Response	Mark
A	Candidates must use appropriate specialist terms including a minimum of 6 points of indicative content. They use good spelling, punctuation and grammar and the form and style are of a high standard.	[5]–[6]
B	Candidates must use appropriate specialist terms including a minimum of 4 points of indicative content. They use satisfactory spelling, punctuation and grammar and the form and style are of a satisfactory standard.	[3]–[4]
C	Candidates brief and partial response includes a minimum of 2 points of indicative content. They use limited spelling, punctuation and grammar and they have made little use of specialist terms. The form and style are of a limited standard.	[1]–[2]
D	Response not worthy of credit	[0]

[6]

AVAILABLE
MARKS

13

- 15 (a) (i)** A = platinum [1]
- (ii)** B = Ti^{2+} and Ti^{3+} both 1 mol dm^{-3} [1]
 C = Co^{2+} 1 mol dm^{-3} [1] [2]
- (iii)** titanium electrode as oxidation occurs/loses electrons [1]
- (iv)** $\text{Pt(s)}|\text{Ti}^{2+}(\text{aq}), \text{Ti}^{3+}(\text{aq})||\text{Co}^{2+}(\text{aq})|\text{Co(s)}$ [2]
- (v)** 0.09 V [1]
- (vi)** filter paper soaked in/u tube containing gel with [1]
 (saturated) potassium nitrate solution/potassium chloride solution [1] [2]
- (b) (i)** $2\text{Ti}^{2+} + \text{Co}^{2+} \rightarrow 2\text{Ti}^{3+} + \text{Co}$ [1]
- (ii)** reactant ions used up [1]
- (c) (i)** $2\text{CH}_3\text{OH} + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 4\text{H}_2\text{O}$ [2]
- (ii)** methanol is the electron donor/
 donates electron to oxygen [1] [1]
- (iii)** constant supply of fuel required [1]

AVAILABLE
MARKS

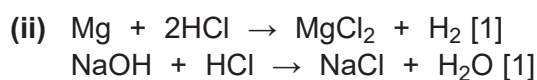
15

16 (a) (i) indicative content

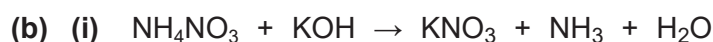
- weigh a sample of Mg ribbon
- react with known excess of HCl
- add the solution to a 250 cm³ volumetric flask and make up with deionised water until the bottom of the meniscus is on the mark
- pipette 25.0 cm³ into a conical flask
- add (3 drops of) phenolphthalein/methyl orange
- titrate with standard sodium hydroxide solution
- repeat until results are concordant

Band	Response	Mark
A	Candidates must use appropriate specialist terms including a minimum of 5 points of indicative content. They use good spelling, punctuation and grammar and the form and style are of a high standard.	[5]-[6]
B	Candidates must use appropriate specialist terms including a minimum of 3 points of indicative content. They use satisfactory spelling, punctuation and grammar and the form and style are of a satisfactory standard.	[3]-[4]
C	Candidates brief and partial response includes a minimum of 1 point of indicative content. They use limited spelling, punctuation and grammar and they have made little use of specialist terms. The form and style are of a limited standard.	[1]-[2]
D	Response not worthy of credit	[0]

[6]



[2]



[1]

- (ii) mass of $\text{NH}_4\text{NO}_3 = 0.88 \times 2.5 = 2.2 \text{ g}$
 moles of $\text{NH}_4\text{NO}_3 = \text{moles of KOH used} = 2.2/80 = 0.0275$
 moles of KOH added initially $= (50 \times 1.5)/1000 = 0.075$
 moles of KOH left over $= 0.075 - 0.0275 = 0.0475$
 moles of KOH in 25 cm³ = moles of HCl = 0.00475
 volume of HCl $= (0.00475 \times 1000)/0.225 = 21.1 \text{ cm}^3$

[3]

12

Section B

100

Total

110

AVAILABLE
MARKS



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Chemistry

Assessment Unit A2 2

assessing

Analytical, Transition Metals, Electrochemistry
and Further Organic Chemistry

[ACH24]

THURSDAY 30 JUNE, MORNING

MARK SCHEME

General Marking Instructions

Introduction

Mark schemes are published to assist teachers and students in their preparation for examinations. Through the mark schemes, teachers and students will be able to see what examiners are looking for in response to questions and exactly where the marks have been awarded. The publishing of the mark schemes may help to show that examiners are not concerned about finding out what a student does not know but rather, with rewarding students for what they do know.

The Purpose of Mark Schemes

Examination papers are set and revised by teams of examiners and revisers appointed by the Council. The teams of examiners and revisers include experienced teachers who are familiar with the level and standards expected of students in schools and colleges.

The job of the examiners is to set the questions and the mark schemes; and the job of the revisers is to review the questions and mark schemes commenting on a large range of issues about which they must be satisfied before the question papers and mark schemes are finalised.

The questions and the mark schemes are developed in association with each other so that the issues of differentiation and positive achievement can be addressed right from the start. Mark schemes, therefore, are regarded as part of an integral process which begins with the setting of questions and ends with the marking of the examination.

The main purpose of the mark scheme is to provide a uniform basis for the marking process so that all the markers are following exactly the same instructions and making the same judgements in so far as this is possible. Before marking begins, a standardising meeting is held where all the markers are briefed using the mark scheme and samples of the students' work in the form of scripts. Consideration is also given at this stage to any comments on the operational papers received from teachers and their organisations. During this meeting, and up to and including the end of the marking, there is provision for amendments to be made to the mark scheme. The document published represents this final form of the mark scheme.

It is important to recognise that in some cases there may well be other correct responses which are equally acceptable to those published: the mark scheme can only cover those responses which emerged in the examination. There may also be instances where certain judgements may have to be left to the experience of the examiner, for example, where there is no absolute correct response – all teachers will be familiar with making such judgements.

COVID-19 Context

Given the unprecedented circumstances presented by the COVID-19 public health crisis, senior examiners, under the instruction of CCEA awarding organisation, are required to train assistant examiners to apply the mark scheme in case of disrupted learning and lost teaching time. The interpretation and intended application of the mark scheme for this examination series will be communicated through the standardising meeting by the Chief or Principal Examiner and will be monitored through the supervision period. This paragraph will apply to examination series in 2021–2022 only.

Section A

- 1 B
- 2 B
- 3 C
- 4 B
- 5 D
- 6 B
- 7 A
- 8 D
- 9 B
- 10 C

[1] for each correct answer

[10]

Section A

AVAILABLE MARKS	
	10
	10

Section B

AVAILABLE
MARKS

- 11 (a) three carbon atoms directly bonded to the nitrogen atom,
i.e.



[1]

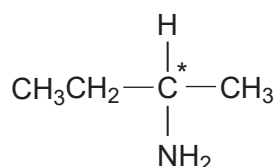
- (b) (i)

Amine	Name	Structural formula	Boiling point /°C
primary	butylamine	$\begin{array}{ccccccc} & \text{H} & \text{H} & \text{H} & \text{H} & & \\ & & & & & & \\ \text{H} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{NH}_2 & \\ & & & & & & \\ & \text{H} & \text{H} & \text{H} & \text{H} & & \end{array}$	78
primary	2-methylpropylamine	$\begin{array}{ccccccc} & \text{H} & \text{CH}_3 & \text{H} & & & \\ & & & & & & \\ \text{H} & -\text{C} & -\text{C} & -\text{C} & -\text{NH}_2 & & \\ & & & & & & \\ & \text{H} & \text{H} & \text{H} & & & \end{array}$	68
secondary	diethylamine [1]	$\begin{array}{ccccccc} & \text{H} & \text{H} & & \text{H} & \text{H} & \\ & & & & & & \\ \text{H} & -\text{C} & -\text{C} & -\text{N} & -\text{C} & -\text{C} & -\text{H} \\ & & & & & & \\ & \text{H} & \text{H} & & \text{H} & \text{H} & \end{array}$	56
tertiary	dimethylethylamine	$\begin{array}{ccccccc} & \text{H} & \text{H} & \text{CH}_3 & \text{H} & & \\ & & & & & & \\ \text{H} & -\text{C} & -\text{C} & -\text{N} & -\text{C} & -\text{H} & \\ & & & & & & \\ & \text{H} & \text{H} & & \text{H} & & \end{array}$	37

[3]

- (ii) more branched amine has lower boiling point/linear or unbranched molecule has higher boiling point [1]
weaker van der Waals' forces between branched chains [1] [2]
- (iii) tertiary amine has no H atom bonded to N atom [1]
tertiary amine cannot form hydrogen bonds between molecules [1] [2]

- (c)



[1] [1] asterisk

[2]

			AVAILABLE MARKS
(d)	(i)	A = 2-bromopropane [1] B = 1-bromo-2-methylpropane [1]	[2]
	(ii)	substitution	[1]
	(iii)	2-methylpropanenitrile	[1]
	(iv)	$\text{CH}_3\text{CH}(\text{CH}_3)\text{CN} + 4[\text{H}] \rightarrow \text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{NH}_2$	[2]
	(e) (i)	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2 + \text{HCl} \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_3\text{Cl}$	[1]
	(ii)	butylammonium chloride	[1]
	(iii)	add alkali/NaOH	[1]
	(f)	add ethanoyl chloride to form a solid [1] determine melting point [1] compare to data book for identification [1]	[3]
			22
12	(a) (i)	Cr atom: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$ [1] Cr ³⁺ ion: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3$ [1]	[2]
	(ii)	it forms at least one stable ion with a partially filled d-subshell	[1]
	(iii)	shape: octahedral	[1]
	(b)	blue precipitate [1] soluble in excess aqueous ammonia [1] forming a deep blue/dark blue solution [1] $\text{Cu}^{2+}(\text{aq}) + 2\text{OH}^{-}(\text{aq}) \rightarrow \text{Cu}(\text{OH})_2(\text{s})$ [1] $\text{Cu}(\text{OH})_2(\text{s}) + 4\text{NH}_3(\text{aq}) + 2\text{H}_2\text{O}(\text{l}) \rightarrow [\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}(\text{aq}) + 2\text{OH}^{-}(\text{aq})$ [2] [6]	[6]
	(c) (i)	blue to yellow	[1]
	(ii)	5 species on the left and 7 species on the right so increase in entropy [1]	[1]
	(iii)	$\left[\begin{array}{c} \text{Cl} \\ \\ \text{Cu} \\ / \quad \backslash \\ \text{Cl} \quad \text{Cl} \\ \\ \text{Cl} \end{array} \right]^{2-}$	[1]
	(d) (i)	green - blue	[1]
	(ii)	$[\text{Cr}(\text{OH})_6]^{3-} + 3\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2 \rightarrow [\text{Cr}(\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2)_3]^{3+} + 6\text{OH}^{-}$ or $[\text{Cr}(\text{OH})_6]^{3-} + 3\text{en} \rightarrow [\text{Cr}(\text{en})_3]^{3+} + 6\text{OH}^{-}$	[2]
	(iii)	An ion or molecule which uses two lone pairs of electrons to form two co-ordinate bonds with a central metal atom or ion in a complex	[2]
	(iv)	$[\text{Cr}(\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2)_3]^{3+} + \text{edta}^{4-} \rightarrow [\text{Cr}(\text{edta})]^{-} + 3\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2$ or $[\text{Cr}(\text{en})_3]^{3+} + \text{edta}^{4-} \rightarrow [\text{Cr}(\text{edta})]^{-} + 3\text{en}$	[2]
			20

13 (a)

Polymer	Monomer(s)	Repeating unit	Type of polymerisation
W		$-\text{OC}-\text{C}_6\text{H}_4-\text{COO}-\text{CH}_2-\text{CH}_2-\text{O}-$	
X	$\begin{array}{c} \text{H} \quad \text{CH}_3 \\ \quad \\ \text{C} = \text{C} \\ \quad \\ \text{CH}_3 \quad \text{H} \end{array}$		addition
Y		$\begin{array}{c} \text{O} \quad \quad \text{O} \quad \text{H} \quad \quad \text{H} \\ \quad \quad \quad \quad \quad \\ -\text{C}-\text{C}_6\text{H}_4-\text{C}-\text{N}-\text{C}_6\text{H}_4-\text{N}- \end{array}$	condensation
Z		$\begin{array}{c} \text{Cl} \\ \\ -\text{O}-\text{C}-\text{C}- \\ \quad \\ \text{CH}_3 \quad \text{O} \end{array}$	condensation

[1] for each correct structure

[1] for type column all correct

[5]

- (b) benzene-1,4-dicarboxylic acid [1]
ethane-1,2-diol [1]

[2]

- (c) polyester

[1]

- (d) amide groups [1] can be hydrolysed by action of microorganisms [1]

[2]

- (e) polymer Y [1]

can form hydrogen bonds between the chains/largest RMM repeating unit so strongest van der Waals' forces between chains [1]

[2]

- (f) 2-chloro-2-hydroxypropanoic acid

[1]

- (g) (i) $\text{C}_5\text{H}_{11}\text{NO}_2$

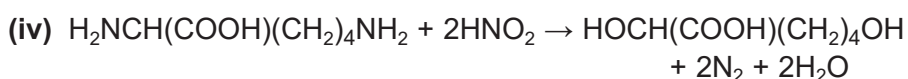
[1]

- (ii) glycine/aminoethanoic acid

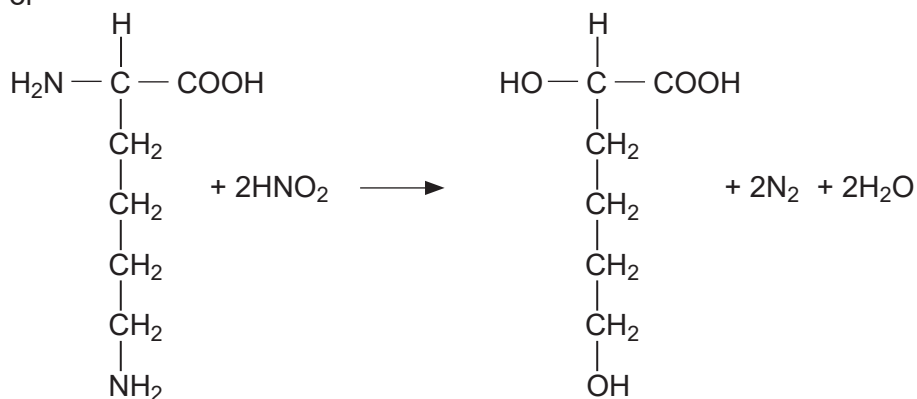
[1]

- (iii) 2,6-diaminohexanoic acid

[1]



or

accept with both NH_2 protonated and $2\text{H}_3\text{O}^+$ on right

[2]

AVAILABLE
MARKS

18

- 14 (a) (i) butanamide/N-ethylethanamide/N-propylmethanamide [1]
- (ii) 44 [1]
 CONH_2^+ [1] [2]
- (iii) peak caused by a molecular ion with an increased mass due to the presence of one carbon-13 atom [1]

(b)

Chemical shift/ppm	Spin-spin splitting pattern	Number of hydrogen atoms bonded to adjacent carbon atoms	Integration
1.3	doublet	1	6
2.3	septet (7 peaks)	6	1
7.2	singlet	0	2

[1] per row

[3]

(c) indicative content

- 4 environments/peaks
- singlet for CH_3
- singlet for NH
- quartet for CH_2 adjacent to CH_3
- triplet for CH_3 adjacent to CH_2
- integration 3:2:3:1
- triplet lowest chemical shift then quartet then singlet (CH_3) and singlet (NH)

Band	Response	Mark
A	Candidates must use appropriate specialist terms including a minimum of 6 points of indicative content. They use good spelling, punctuation and grammar and the form and style are of a high standard.	[5]–[6]
B	Candidates must use appropriate specialist terms including a minimum of 4 points of indicative content. They use satisfactory spelling, punctuation and grammar and the form and style are of a satisfactory standard.	[3]–[4]
C	Candidates brief and partial response includes a minimum of 2 points of indicative content. They use limited spelling, punctuation and grammar and they have made little use of specialist terms. The form and style are of a limited standard.	[1]–[2]
D	Response not worthy of credit	[0]

[6]

AVAILABLE
MARKS

13

- 15 (a) (i)** A = platinum [1]
- (ii)** B = Ti^{2+} and Ti^{3+} both 1 mol dm^{-3} [1]
 C = Co^{2+} 1 mol dm^{-3} [1] [2]
- (iii)** titanium electrode as oxidation occurs/loses electrons [1]
- (iv)** $\text{Pt(s)}|\text{Ti}^{2+}(\text{aq}), \text{Ti}^{3+}(\text{aq})||\text{Co}^{2+}(\text{aq})|\text{Co(s)}$ [2]
- (v)** 0.09 V [1]
- (vi)** filter paper soaked in/u tube containing gel with [1]
 (saturated) potassium nitrate solution/potassium chloride solution [1] [2]
- (b) (i)** $2\text{Ti}^{2+} + \text{Co}^{2+} \rightarrow 2\text{Ti}^{3+} + \text{Co}$ [1]
- (ii)** reactant ions used up [1]
- (c) (i)** $2\text{CH}_3\text{OH} + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 4\text{H}_2\text{O}$ [2]
- (ii)** methanol is the electron donor/
 donates electron to oxygen [1] [1]
- (iii)** constant supply of fuel required [1]

AVAILABLE
MARKS

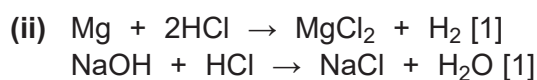
15

16 (a) (i) indicative content

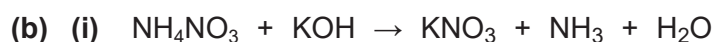
- weigh a sample of Mg ribbon
- react with known excess of HCl
- add the solution to a 250 cm³ volumetric flask and make up with deionised water until the bottom of the meniscus is on the mark
- pipette 25.0 cm³ into a conical flask
- add (3 drops of) phenolphthalein/methyl orange
- titrate with standard sodium hydroxide solution
- repeat until results are concordant

Band	Response	Mark
A	Candidates must use appropriate specialist terms including a minimum of 5 points of indicative content. They use good spelling, punctuation and grammar and the form and style are of a high standard.	[5]-[6]
B	Candidates must use appropriate specialist terms including a minimum of 3 points of indicative content. They use satisfactory spelling, punctuation and grammar and the form and style are of a satisfactory standard.	[3]-[4]
C	Candidates brief and partial response includes a minimum of 1 point of indicative content. They use limited spelling, punctuation and grammar and they have made little use of specialist terms. The form and style are of a limited standard.	[1]-[2]
D	Response not worthy of credit	[0]

[6]



[2]



[1]

- (ii) mass of $\text{NH}_4\text{NO}_3 = 0.88 \times 2.5 = 2.2 \text{ g}$
 moles of $\text{NH}_4\text{NO}_3 = \text{moles of KOH used} = 2.2/80 = 0.0275$
 moles of KOH added initially $= (50 \times 1.5)/1000 = 0.075$
 moles of KOH left over $= 0.075 - 0.0275 = 0.0475$
 moles of KOH in 25 cm³ = moles of HCl = 0.00475
 volume of HCl $= (0.00475 \times 1000)/0.225 = 21.1 \text{ cm}^3$

[3]

12

Section B

100

Total

110

AVAILABLE
MARKS



Rewarding Learning

ADVANCED
General Certificate of Education
2022 Reserve Series

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Candidate Number

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Chemistry

Assessment Unit A2 2

assessing

Analytical, Transition Metals,
Electrochemistry and Further
Organic Chemistry

[ACH24]

ACH24



THURSDAY 30 JUNE, MORNING

TIME

2 hours.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

Answer **all sixteen** questions in **Sections A and B**.

You must answer the questions in the spaces provided.

Do not write outside the boxed area on each page or on blank pages.

Complete in black ink only. **Do not write with a gel pen or a pencil.**

INFORMATION FOR CANDIDATES

The total mark for this paper is 110.

Quality of written communication will be assessed in Questions **14(c)** and **16(a)(i)**.

The figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

A Periodic Table of Elements, containing some data, is included with this question paper.



Section A

For each of the following questions, only **one** of the lettered responses (A–D) is correct.

Select the correct response for each question and write the appropriate letter in the space provided.

- 1 Which one of the following does **not** show the d-block element in the +2 oxidation state?

- A $\text{K}_4[\text{Fe}(\text{CN})_6]$
- B $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^+$
- C $\text{Na}_2[\text{HgCl}_4]$
- D $[\text{Ni}(\text{edta})]^{2-}$

Answer _____ [1]

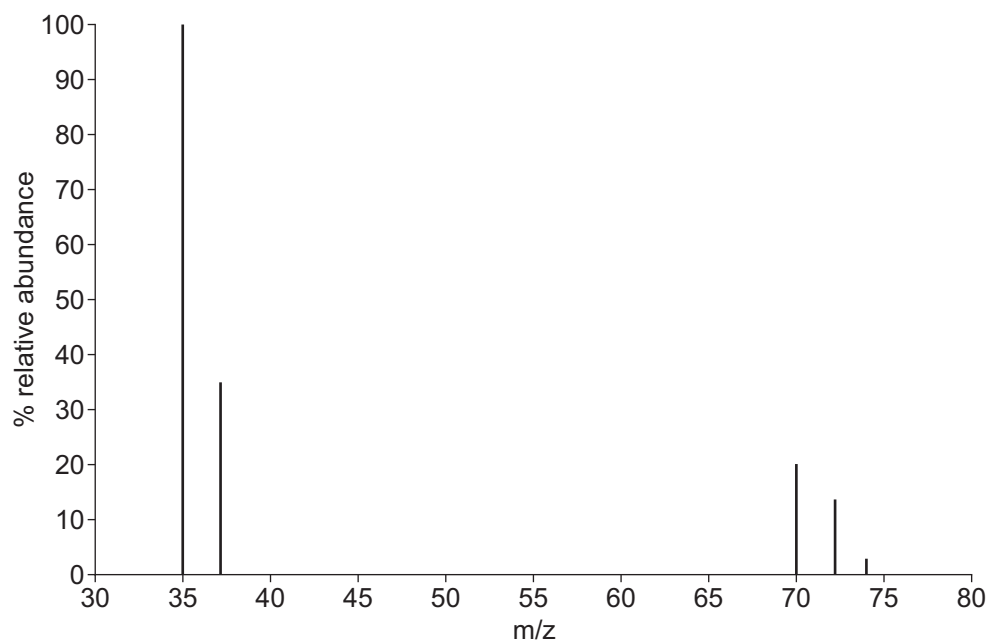
- 2 Which one of the following is most suitable for use as a solvent in nmr spectroscopy?

- A ethanol
- B tetrachloromethane
- C trichloromethane
- D water

Answer _____ [1]



3 The mass spectrum of chlorine is shown below.



Which one of the following is the ion responsible for the peak at m/z 70?

- A $^{35}\text{Cl}^+$
- B $^{37}\text{Cl}^+$
- C $^{35}\text{Cl}_2^+$
- D $^{37}\text{Cl}_2^+$

Answer _____ [1]

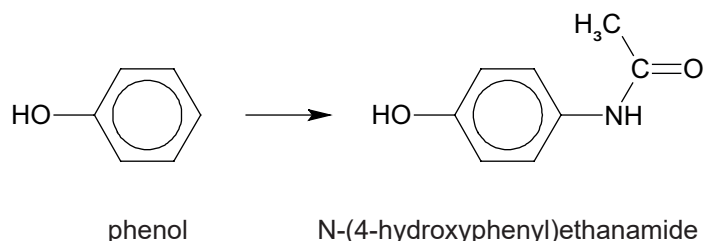


- 4 Which one of the following does **not** show the correct oxidation state of vanadium?

	Compound	Oxidation state of vanadium
A	V_2O_5	+5
B	$VOSO_4$	+2
C	$V_2(SO_4)_3$	+3
D	$(NH_4)_3VO_4$	+5

Answer _____ [1]

- 5 Paracetamol, N-(4-hydroxyphenyl)ethanamide, may be produced from phenol.



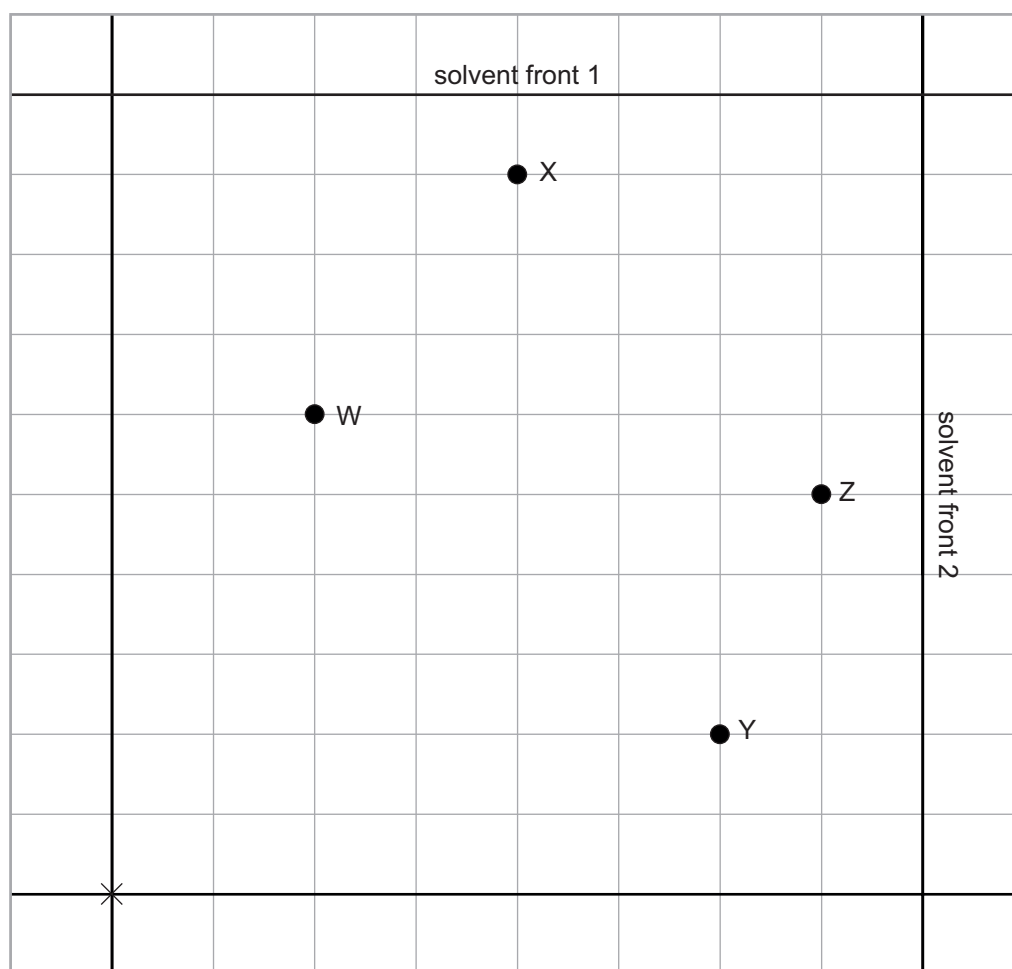
Calculate the mass of phenol (RMM 94) required to synthesise 20.0 g of N-(4-hydroxyphenyl)ethanamide (RMM 151) assuming a 35% yield.

- A 4.36 g
B 12.5 g
C 32.1 g
D 35.6 g

Answer _____ [1]



6 A two-way paper chromatogram is shown below.



Which one of the following is correct?

- A The R_f value for spot W in solvent 2 is 0.333
- B The R_f value for spot X in solvent 1 is 0.900
- C The R_f value for spot Y in solvent 2 is 0.667
- D The R_f value for spot Z in solvent 1 is 0.600

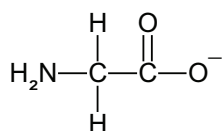
Answer _____ [1]

[Turn over]

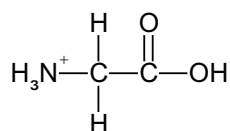


7 Which one of the following is the structure of glycine in solution at pH 11?

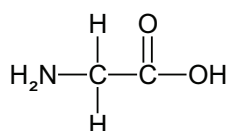
A



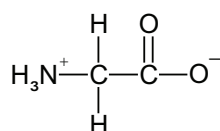
B



C



D



Answer _____ [1]

8 Which one of the following shows the correct order of the substances added to a solution of hydrogen peroxide in a titration?

	Substance 1	Substance 2	Substance 3	Substance 4
A	$\text{H}_2\text{SO}_4(\text{aq})$	$\text{KI}(\text{s})$	$\text{starch}(\text{aq})$	$\text{Na}_2\text{S}_2\text{O}_3(\text{aq})$
B	$\text{H}_2\text{SO}_4(\text{aq})$	$\text{Na}_2\text{S}_2\text{O}_3(\text{aq})$	$\text{KI}(\text{s})$	$\text{starch}(\text{aq})$
C	$\text{KI}(\text{s})$	$\text{H}_2\text{SO}_4(\text{aq})$	$\text{starch}(\text{aq})$	$\text{Na}_2\text{S}_2\text{O}_3(\text{aq})$
D	$\text{H}_2\text{SO}_4(\text{aq})$	$\text{KI}(\text{s})$	$\text{Na}_2\text{S}_2\text{O}_3(\text{aq})$	$\text{starch}(\text{aq})$

Answer _____ [1]



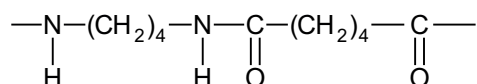
- 9 A few drops of solution **E** are added to solution **F** and a blue precipitate forms. When an excess of solution **E** is added the precipitate disappears and a yellow solution forms.

Which one of the following shows the possible identities of **E** and **F**?

	E	F
A	NH_3	CuSO_4
B	NH_3	CoSO_4
C	NaOH	CuSO_4
D	NaOH	CoSO_4

Answer _____ [1]

- 10 A section of a polymer is shown below.



Which one of the following shows the names of the monomers?

- A butanedioic acid and butane-1,4-diamine
B butanedioic acid and hexane-1,6-diamine
C hexanedioic acid and butane-1,4-diamine
D hexanedioic acid and hexane-1,6-diamine

Answer _____ [1]

[Turn over



Section B

Answer **all six** questions in this section.

- 11** There are eight amines which have the molecular formula $C_4H_{11}N$. Four of these amines, including butylamine, are primary amines, three are secondary and only one is tertiary.

(a) Define the term **tertiary amine**.

_____ [1]

- (b) (i)** Complete the table below with details of some of the amines with molecular formula $C_4H_{11}N$.

Classification of amine	Name	Structural formula	Boiling point /°C
primary	butylamine		78
primary	2-methylpropylamine	$ \begin{array}{ccccc} & H & & CH_3 & H \\ & & & & \\ H & - C & - & C & - C - NH_2 \\ & & & & \\ & H & & H & H \end{array} $	68
secondary		$ \begin{array}{ccccccc} & H & & H & & H & H \\ & & & & & & \\ H & - C & - & C & - N & - C & - C - H \\ & & & & & & \\ & H & & H & & H & H \end{array} $	56
tertiary	dimethylethylamine		37

[3]



(ii) Explain the difference in the boiling points of the two primary amines.

[2]

(iii) Explain why the boiling point of the tertiary amine is lower than that of the secondary amine.

[2]

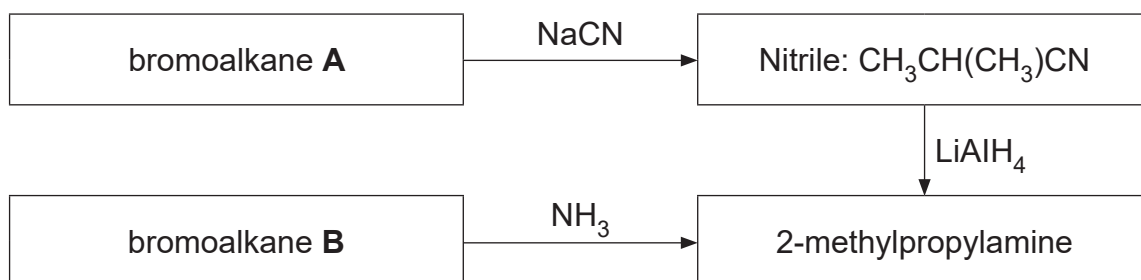
(c) One of the isomers of $C_4H_{11}N$ which is **not shown in the table** is optically active. Draw the structure of the isomer which is optically active. Label the asymmetric centre using an asterisk (*).

[2]

[Turn over



- (d) 2-methylpropylamine may be formed from two different bromoalkanes as shown below. One synthetic route is via a nitrile.



- (i) State the IUPAC names for bromoalkanes **A** and **B**.

A _____

B _____ [2]

- (ii) State the type of reaction which occurs in the reaction between bromoalkane **A** and NaCN.

_____ [1]

- (iii) State the IUPAC name of the nitrile formed when bromoalkane **A** reacts with NaCN.

_____ [1]

- (iv) Write an equation for the conversion of the nitrile into 2-methylpropylamine.

_____ [2]



(e) Butylamine reacts with hydrochloric acid to form a salt.

(i) Write an equation for the reaction of butylamine with hydrochloric acid.

_____ [1]

(ii) State the name of the salt formed.

_____ [1]

(iii) State how butylamine could be liberated from a solution of the salt.

_____ [1]

(f) Describe how ethanoyl chloride may be used to distinguish between samples of amines.

_____ [3]

[Turn over



12 Many chromium(III) compounds and copper(II) compounds dissolve in water forming the $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$ and $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ complexes respectively.

- (a) (i)** Write the electronic configuration of the chromium atom and chromium(III) ion.

chromium atom _____

chromium(III) ion _____ [2]

- (ii)** Explain why chromium is described as a transition metal.

_____ [1]

- (iii)** State the shape of the $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$ complex.

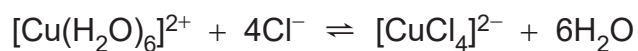
_____ [1]

- (b)** Describe what is observed when aqueous ammonia is added until it is in excess to a solution containing the $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ complex. Write equations for any reactions which occur including state symbols.

_____ [6]



- (c) The following equilibrium is established when concentrated hydrochloric acid is added to a solution containing the $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ complex.



- (i) State the colour change observed when the water ligands are replaced.

_____ [1]

- (ii) Explain why the entropy change for this reaction is positive.

_____ [1]

- (iii) Draw the 3D shape of the $[\text{CuCl}_4]^{2-}$ complex.

[1]

[Turn over]



- (d) Sodium hydroxide solution was added to a solution of chromium(III) sulfate. A precipitate formed which was soluble in excess sodium hydroxide solution forming a green solution containing $[\text{Cr}(\text{OH})_6]^{3-}$.

Excess 1,2-diaminoethane was added and the solution changed colour from green to yellow. 1,2-diaminoethane is a bidentate ligand.

Edta was added to the solution and all the 1,2-diaminoethane ligands were replaced with the edta^{4-} ligand. The solution changed colour from yellow to violet.

- (i) State the colour of the precipitate formed when sodium hydroxide solution was added.

_____ [1]

- (ii) Write an equation for the replacement of all of the hydroxide ions in the $[\text{Cr}(\text{OH})_6]^{3-}$ complex with 1,2-diaminoethane (en).

_____ [2]

- (iii) Define **bidentate ligand**.

_____ [2]

- (iv) Write an equation for the reaction which results in the conversion of the yellow solution to a violet solution.

_____ [2]





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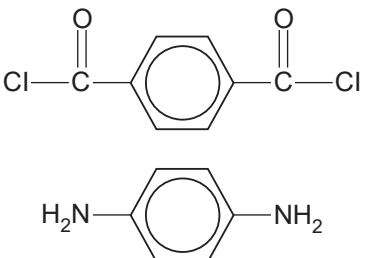
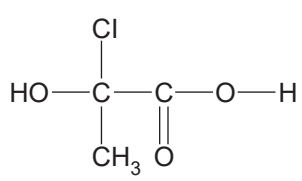
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32ACH2415

13 The table below shows some common polymers, some of which are biodegradable.

(a) Complete the table below.

Polymer	Monomer(s)	Repeating unit	Type of polymerisation
W	$\text{HOOC}\text{C}_6\text{H}_4\text{COOH}$ $\text{HOCH}_2\text{CH}_2\text{OH}$		condensation
X		$\begin{array}{cc} \text{H} & \text{CH}_3 \\ & \\ -\text{C} & - & \text{C}- \\ & \\ \text{CH}_3 & \text{H} \end{array}$	
Y			
Z			

[5]



(b) State the IUPAC name of the monomers used to form polymer **W**.

[2]

(c) What type of condensation polymer is polymer **W**?

[1]

(d) Explain why polymer **Y** is biodegradable.

[2]

(e) Explain which of the polymers you would expect to have the highest boiling point.

[2]

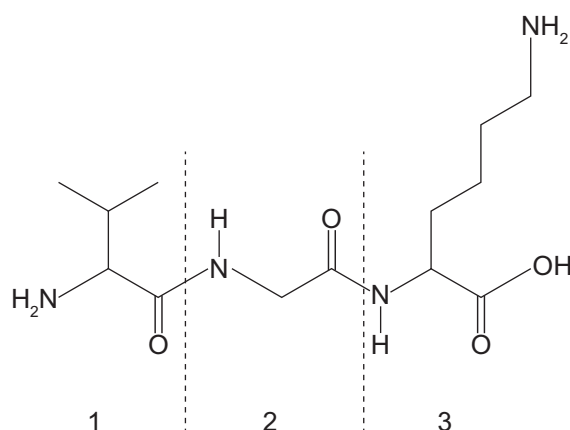
(f) Suggest the IUPAC name of the monomer used to form polymer **Z**.

[1]

[Turn over



- (g) The skeletal formula of a tripeptide is shown below. The amino acids which are used to form the peptide are labelled 1, 2 and 3.



- (i) Write the molecular formula for amino acid 1.

_____ [1]

- (ii) Identify amino acid 2.

_____ [1]

- (iii) State the IUPAC name for amino acid 3.

_____ [1]

- (iv) Write an equation for the reaction of amino acid 3 with excess nitrous acid.

_____ [2]





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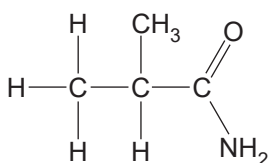
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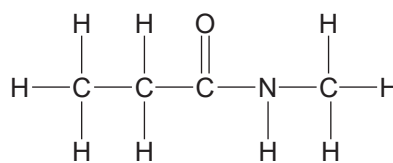


32ACH2419

- 14 Several amides, including 2-methylpropanamide and N-methylpropanamide, share the molecular formula C_4H_9NO .

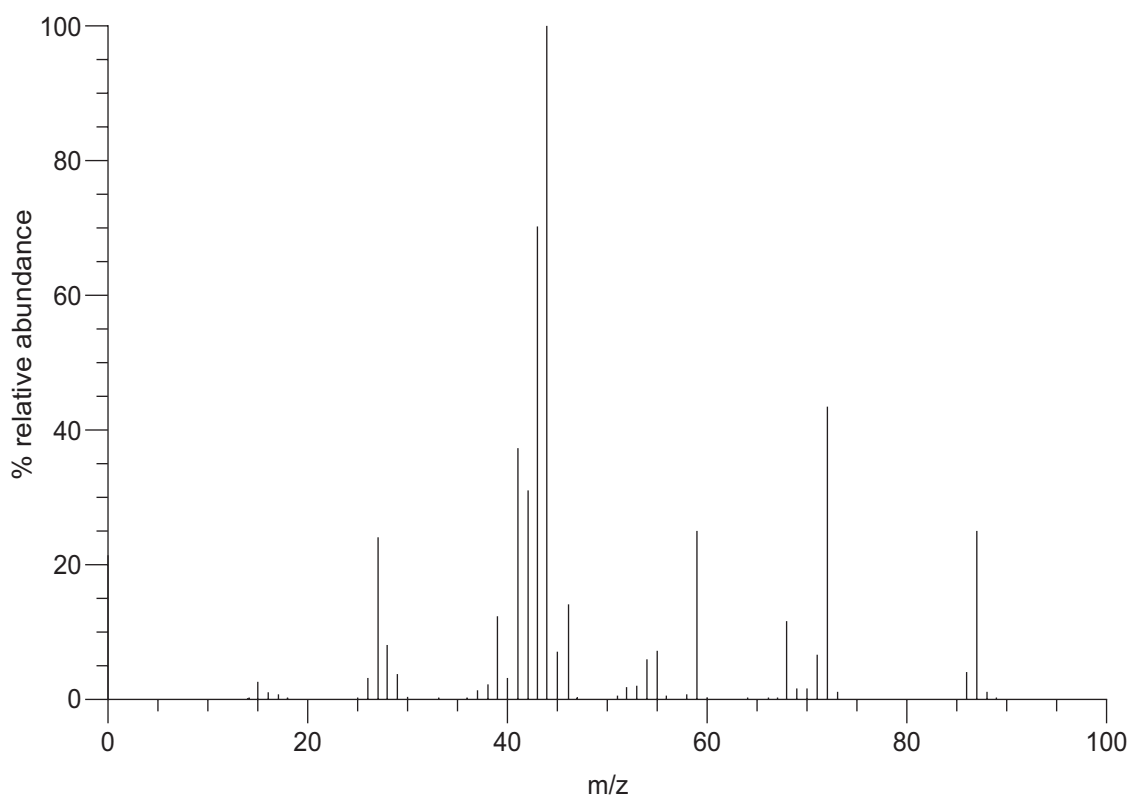


2-methylpropanamide



N-methylpropanamide

- (a) The mass spectrum of 2-methylpropanamide is shown below.



- (i) Name another amide which has the molecular formula C_4H_9NO .

_____ [1]



- (ii) Identify the m/z value of the base peak in the spectrum and write the formula of the ion which produces this peak.

_____ [2]

- (iii) Explain why there is a peak at m/z value of 88.

_____ [1]

- (b) Complete the table below which shows details of the peaks in the high resolution nmr spectrum of 2-methylpropanamide.

Chemical shift /ppm	Spin-spin splitting pattern	Number of hydrogen atoms bonded to adjacent carbon atoms	Integration
1.3			6
2.3	septet (7 peaks)		
7.2		0	

[3]

[Turn over





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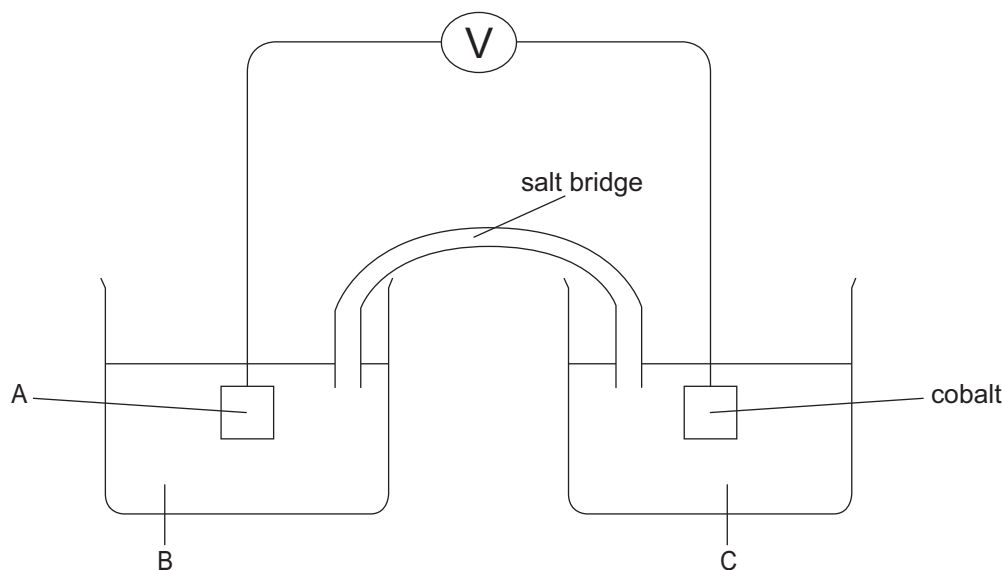
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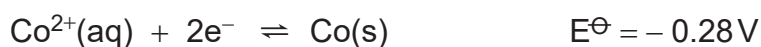
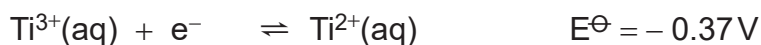


32ACH2423

- 15 Electrochemical cells are composed of a positive electrode and a negative electrode. A diagram of a cell is shown below with parts of the cell labelled.



- (a) The cell was set up using a Co^{2+}/Co electrode and a $\text{Ti}^{3+}/\text{Ti}^{2+}$ electrode. The standard electrode potentials are given below.



- (i) What material should be used for A?

_____ [1]

- (ii) Identify the positive ions in solution B and solution C and state their concentrations.

_____ [2]



(iii) State and explain in terms of electrons which electrode is the negative electrode.

[1]

(iv) Write the conventional cell representation of the cell.

[2]

(v) Calculate the emf of the cell.

[1]

(vi) Describe how you would make a salt bridge.

[2]

(b) The voltmeter in the cell in **(a)** was replaced with an ammeter which allowed the current to flow.

(i) Write an ionic equation for the overall reaction which occurs.

[1]

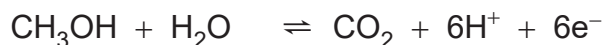
(ii) Explain why the reading on the ammeter eventually becomes zero.

[1]

[Turn over]



- (c) Alcohol based fuel cells are increasingly being used to generate electricity. The half equations for the reactions which occur at the electrodes in the methanol fuel cell are:



- (i) Write an overall equation for the reaction which occurs in the methanol fuel cell.

_____ [2]

- (ii) Explain, in terms of electrons, why methanol is described as the reducing agent in this cell.

_____ [1]

- (iii) State one disadvantage of fuel cells compared to rechargeable cells such as lithium cells.

_____ [1]





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32ACH2427

16 Companies which sell chemicals to schools and universities must provide percentage purity information for the chemicals they sell.

(a) A sample of magnesium ribbon was described as 95% pure.

(i) Describe how a back titration using a standard solution of hydrochloric acid and a named indicator could be carried out to verify the percentage purity of the sample of magnesium ribbon. Details of any calculations are not required.

In this question you will be assessed on your written communication skills including the use of specialist scientific terms.

[6]

[6]

(ii) Write two equations for the reactions which occur in the method you described in (a)(i).

[2]

[2]



(b) A sample of ammonium nitrate was analysed as follows.

A sample of 2.5 g of ammonium nitrate was mixed with 50 cm³ of 1.5 M potassium hydroxide solution and the mixture was heated for several minutes to liberate ammonia gas. The resulting solution was cooled and diluted to 250.0 cm³ in a volumetric flask. Several 25.0 cm³ portions of the resulting solution were titrated with 0.225 M hydrochloric acid.

(i) Write an equation for the reaction of ammonium nitrate with potassium hydroxide forming potassium nitrate, ammonia and water.

[1]

(ii) Calculate the titre which you would expect to obtain if the sample is 88% pure. Give your answer to 1 decimal place.

[3]

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32ACH2430



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32ACH2431

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32ACH2432



General Information

1 tonne = 10^6 g

1 metre = 10^9 nm

One mole of any gas at 293 K and a pressure of 1 atmosphere (10^5 Pa) occupies a volume of 24 dm³

Avogadro Constant = 6.02×10^{23} mol⁻¹

Planck Constant = 6.63×10^{-34} Js

Specific Heat Capacity of water = $4.2 \text{ J g}^{-1} \text{ K}^{-1}$

Speed of Light = $3 \times 10^8 \text{ m s}^{-1}$



Characteristic absorptions in IR spectroscopy

Wavenumber/cm ⁻¹	Bond	Compound
550–850	C–X (X = Cl, Br, I)	Haloalkanes
750–1100	C–C	Alkanes, alkyl groups
1000–1300	C–O	Alcohols, esters, carboxylic acids
1450–1650	C=C	Arenes
1600–1700	C=C	Alkenes
1650–1800	C=O	Carboxylic acids, esters, aldehydes, ketones, amides, acyl chlorides
2200–2300	C≡N	Nitriles
2500–3200	O–H	Carboxylic acids
2750–2850	C–H	Aldehydes
2850–3000	C–H	Alkanes, alkyl groups, alkenes, arenes
3200–3600	O–H	Alcohols
3300–3500	N–H	Amines, amides

Proton Chemical Shifts in Nuclear Magnetic Resonance Spectroscopy (relative to TMS)

Chemical Shift	Structure	
0.5–2.0	–CH	Saturated alkanes
0.5–5.5	–OH	Alcohols
1.0–3.0	–NH	Amines
2.0–3.0	–CO–CH	Ketones
	–N–CH	Amines
	C ₆ H ₅ –CH	Arene (aliphatic on ring)
2.0–4.0	X–CH	X = Cl or Br (3.0–4.0) X = I (2.0–3.0)
4.5–6.0	–C=CH	Alkenes
5.5–8.5	RCONH	Amides
6.0–8.0	–C ₆ H ₅	Arenes (on ring)
9.0–10.0	–CHO	Aldehydes
10.0–12.0	–COOH	Carboxylic acids

These chemical shifts are concentration and temperature dependent and may be outside the ranges indicated above.

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COUNCIL FOR THE CURRICULUM, EXAMINATIONS AND ASSESSMENT

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Data Leaflet

Including the Periodic Table of the Elements

For the use of candidates taking
Advanced Subsidiary and
Advanced Level Examinations

Copies must be free from notes or additions of any kind. No other type of data booklet or information sheet is authorised for use in the examinations

gce a/as examinations chemistry

I II THE PERIODIC TABLE OF ELEMENTS III IV V VI VII 0

Group

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen 1																	4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganes 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	98 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La [*] Lanthanum 57	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	210 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radium 88	227 Ac [†] Actinium 89	261 Rf Rutherfordium 104	262 Db Dubnium 105	266 Sg Seaborgium 106	264 Bh Bohrium 107	277 Hs Hassium 108	268 Mt Meitnerium 109	271 Ds Darmstadtium 110	272 Rg Roentgenium 111	285 Cn Copernicium 112						

* 58 – 71 Lanthanum series
† 90 – 103 Actinium series

a

X

b

a = relative atomic mass (approx)
x = atomic symbol
b = atomic number

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	145 Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	231 Pa Protactinium 91	238 U Uranium 92	237 Np Neptunium 93	242 Pu Plutonium 94	243 Am Americium 95	247 Cm Curium 96	245 Bk Berkelium 97	251 Cf Californium 98	254 Es Einsteinium 99	253 Fm Fermium 100	256 Md Mendelevium 101	254 No Nobelium 102	257 Lr Lawrencium 103



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General Certificate of Education
2022

Centre Number

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Candidate Number

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Chemistry

Assessment Unit A2 3

assessing

Further Practical Chemistry

Practical Booklet A



[ACH31]

ACH31

THURSDAY 12 MAY, MORNING

TIME

1 hour 15 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

You must answer the questions in the spaces provided.

Do not write outside the boxed area on each page or on blank pages.

Complete in black ink only. **Do not write with a gel pen.**

Answer **all three** questions.

INFORMATION FOR CANDIDATES

The total mark for this paper is 30.

Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

A Periodic Table of the Elements (including some data) is provided.

You may not have access to notes, textbooks and other material to assist you.

Safety glasses must be worn at all times and care should be taken during the practical examination.

12885



08ACH3101

- 1 You are provided with a sample of an iron(II) salt and an iron(III) salt and are required to investigate their chemistry.

All volumes of 3 cm³ or less in this question may be measured approximately using the graduations on a disposable pipette.

- (a) Dissolve all of the sample of each iron salt in separate 50 cm³ portions of deionised water in the labelled 100 cm³ beakers. Describe the appearance of both solutions.

iron(II) salt: _____

iron(III) salt: _____ [2]

- (b) Test each of the salt solutions formed in (a) with universal indicator paper and complete the table below.

Salt solution	Colour with universal indicator paper	Approximate pH
iron(II) salt		
iron(III) salt		

[4]

- (c) Add 2 cm³ of each iron salt solution from (a) to separate test tubes. Add 1 cm³ of sodium hydroxide solution to each test tube. Note any observations in each test tube.

iron(II) salt: _____

iron(III) salt: _____ [2]



- (d) Light a Bunsen burner. Add 2 cm^3 of the iron(III) salt solution from (a) to a test tube. Add a spatula measure of sodium carbonate to the test tube, shake gently and immediately place a lit splint in the mouth of the test tube. Note any observations.

[3]

- (e) Add 2 cm^3 of each iron salt solution from (a) to separate test tubes. Add 1 cm^3 of potassium iodide solution, followed by 2 cm^3 of cyclohexane, to each test tube. Insert a bung into each test tube and shake each test tube gently. Note the appearance of the upper layer in each test tube.

iron(II) salt: _____

iron(III) salt: _____ [2]

- (f) Add 2 cm^3 of each iron salt solution from (a) to separate test tubes. Add 1 cm^3 of ammonium thiocyanate solution to each test tube and note any observations.

iron(II) salt: _____

iron(III) salt: _____ [2]

[Turn over



- (g) (i) Add 2 cm^3 of each iron salt solution from (a) to separate test tubes. Add 1 cm of magnesium ribbon to each test tube and shake gently. State **one** observation that is the same in each test tube.

[1]

- (ii) Explain how the observations from both test tubes in (g)(i) support the deduction that magnesium is more reactive with iron(III) salt solutions than iron(II) salt solutions.

[1]

- (h) The iron(III) salt solution can be used to follow the conversion of salicylic acid to aspirin as the solution turns purple in the presence of salicylic acid but does not turn purple in the presence of aspirin.

Add a spatula measure of solid **A** and solid **B** to separate test tubes. Add five drops of the iron(III) solution from (a) to each test tube and use your observations to identify and explain whether solid **A** or **B** contains more salicylic acid.

[1]



2 You are required to carry out a back titration using an indigestion tablet.

- (a) Weigh an indigestion tablet and record the mass to 1 decimal place. Crush the tablet in a mortar using a pestle and then transfer all of the crushed tablet into a 250 cm³ beaker.

Mass of tablet: _____ [1]

- (b) Measure 50 cm³ of 1.0 mol dm⁻³ hydrochloric acid using a measuring cylinder and add to the 250 cm³ beaker with stirring. Note any observations.

_____ [1]

- (c) Filter the mixture through filter paper into a 250 cm³ volumetric flask, ensuring the beaker and glass rod are rinsed with deionised water and the washings are transferred into the flask. Describe the appearance of the residue and the filtrate.

residue: _____

filtrate: _____ [1]

- (d) Make up the solution to the mark with deionised water, then stopper and invert the flask. Titrate three 25.0 cm³ portions from the volumetric flask with 0.20 mol dm⁻³ sodium hydroxide solution using phenolphthalein indicator. Complete the following table and calculate the mean titre.

Rough titration			
First accurate titration			
Second accurate titration			

mean titre = _____ [5]

[Turn over]



- 3 You are provided with a solid, labelled **M**, which contains a transition metal ion.

All volumes of 3 cm³ or less in this question may be measured approximately using the graduations on a disposable pipette.

- (a) Dissolve all of the sample of **M** in 30 cm³ of 2.0 mol dm⁻³ sulfuric acid in a 100 cm³ beaker. State the colour of the solution.

_____ [1]

- (b) Add 2 cm³ of the solution of **M** to a test tube. Add 2 cm³ of ammonium iron(II) sulfate solution and shake the test tube gently. State the colour of the solution.

_____ [1]

- (c) (i) Add 2 cm³ of the solution of **M** to a test tube. Add 2 cm³ of potassium iodide solution and shake gently. State the colour of the solution.

_____ [1]

- (ii) Add 2 cm³ of sodium thiosulfate solution to the solution formed in (c)(i) and shake the test tube gently. State **one** observation.

_____ [1]

THIS IS THE END OF THE QUESTION PAPER





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08ACH3107

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For Examiner's use only	
Question Number	Marks
1	
2	
3	

Total Marks	
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Examiner Number

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ACH31/7
260687





Rewarding Learning

ADVANCED
General Certificate of Education
2022

Chemistry
Assessment Unit A2 3
assessing
Further Practical Chemistry
Practical Booklet A
[ACH31]
THURSDAY 12 MAY, MORNING

**APPARATUS
AND
MATERIALS
LIST**

Advice for centres

- All chemicals used should be at least laboratory reagent specification and labelled with appropriate safety symbols, e.g. irritant.
- For centres running multiple sessions – candidates for the later session should be supplied with clean, dry glassware. If it is not feasible then glassware from the first session should be thoroughly washed, rinsed with deionised water and allowed to drain.
- Ensure all chemicals are in date, otherwise expected observations may not be seen.

It is the responsibility of the centre to be cognisant of all health and safety issues and to carry out a thorough risk assessment. Up to date information can be obtained at www.cleapss.org.uk

Practical Examination

Each candidate must be supplied with safety goggles or glasses.

Question No. 1

Each candidate must be supplied with:

- 1 × deionised water bottle
- 2 × 100 cm³ beakers, one labelled iron(II) solution and one labelled iron(III) solution.
- 1 × 50 cm³ measuring cylinder
- universal indicator paper, pH range 1–14 and access to corresponding colour chart.
- 12 × test tubes
- 2 × glass stirring rods
- 2 × test tube racks
- minimum of six disposable pipettes (graduated 3 cm³)
- 1 × Bunsen burner
- 1 × heat-proof mat
- 1 × wooden splint
- 2 × bungs to fit test tubes
- 3 × spatulas
- about 1 g of iron(II) sulfate-7-water in a stoppered tube labelled **iron(II) salt** and **corrosive**
- about 1 g of iron(III) chloride-6-water in a stoppered tube labelled **iron(III) salt** and **corrosive**
- about 1 g of anhydrous sodium carbonate in a stoppered tube labelled **sodium carbonate** and **handle with caution**
- about 10 cm³ of 0.5 mol dm⁻³ sodium hydroxide solution labelled **sodium hydroxide solution for use in question 1** and **handle with caution**
- about 10 cm³ of potassium iodide solution in a stoppered reagent bottle labelled **potassium iodide solution**. This solution should be approximately 0.05 mol dm⁻³
- about 10 cm³ of cyclohexane in a stoppered reagent bottle labelled **cyclohexane** and **toxic**
- about 10 cm³ of ammonium thiocyanate solution in a stoppered reagent bottle labelled **ammonium thiocyanate solution** and **handle with caution**. This solution should be approximately 0.5 mol dm⁻³.
- 2 × 1 cm lengths of magnesium ribbon (untarnished).
- about 1 g of salicylic acid in a stoppered tube labelled **A** and **corrosive**.
- about 0.5 g of crushed aspirin tablets in a stoppered tube labelled **B** and **handle with caution**.

Question No. 2

Each candidate must be supplied with:

- 1 × weighing boat
- 1 × pestle and mortar
- 1 × spatula
- 1 × 100 cm³ beaker
- 1 × 250 cm³ beaker
- 1 × 50 cm³ measuring cylinder
- 1 × glass rod
- 1 × 250 cm³ volumetric flask
- 1 × piece of filter paper and filter funnel
- 1 × 25 cm³ pipette (at least class B quality) and pipette filler
- 3 × 250 cm³ conical flasks
- 1 × white tile
- 1 × 50.0 cm³ burette of at least class B quality
- 1 × funnel for filling burette
- 1 × retort stand and clamp
- 1 × indigestion tablet containing 500 mg calcium carbonate (e.g. supermarket homebrand)
- 1 × deionised water bottle
- phenolphthalein indicator with dropper
- about 100 cm³ of hydrochloric acid in a reagent bottle labelled **hydrochloric acid** and **handle with caution**. This solution should be 1 mol dm⁻³
- about 150 cm³ of sodium hydroxide solution in a beaker labelled **sodium hydroxide solution for use in question 2** and **handle with caution**. This solution should be 0.2 mol dm⁻³
- access to an electronic balance (minimum of 1 decimal point)

Question No. 3

Each candidate must be supplied with:

- 1 × 100 cm³ beaker
- 1 × glass rod
- 2 × test tubes
- 1 × test tube rack
- 1 × 50 cm³ measuring cylinder
- minimum of four disposable pipettes (graduated 3 cm³)
- about 0.25 g of ammonium vanadate(V) (ammonium metavanadate) in a stoppered tube labelled **M** and **toxic**
- about 10 cm³ of ammonium iron(II) sulfate solution in a reagent bottle/beaker labelled **ammonium iron(II) sulfate solution** and **handle with caution**. This solution should be approximately 0.1 mol dm⁻³
- about 10 cm³ of potassium iodide solution in a reagent bottle labelled **potassium iodide solution**. This solution should be approximately 0.05 mol dm⁻³. (This is the same solution as used in question 1 and it may be provided in one bottle or separately)
- about 10 cm³ of sodium thiosulfate solution in a reagent bottle labelled **sodium thiosulfate solution**. This solution should be approximately 0.1 mol dm⁻³
- about 50 cm³ of 2.0 mol dm⁻³ sulfuric acid labelled **2.0 mol dm⁻³ sulfuric acid** and **handle with caution** and **corrosive**



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ADVANCED
General Certificate of Education
2022

Chemistry

Assessment Unit A2 3

Practical Assessment

Practical Booklet A

[ACH31]

THURSDAY 12 MAY, MORNING

Confidential Instructions to the Supervisor of the Practical Examination

INSTRUCTIONS TO THE SUPERVISOR OF THE PRACTICAL EXAMINATION

General

1. The instructions contained in this document are for the use of the Supervisor **and are strictly confidential**. Under no circumstances may information concerning apparatus or materials be given before the examination to a candidate or other unauthorised person.
2. In a centre with a large number of candidates it may be necessary for two or more examination sessions to be organised. **It is the responsibility of the schools to ensure that there should be no contact between candidates taking each session.**
3. A suitable laboratory must be reserved for the examination and kept locked throughout the period of preparation. Unauthorised persons not involved in the preparation for the examination must not be allowed to enter. Candidates must not be admitted until the specified time for commencement of the examination.
4. The Supervisor must ensure that the solutions provided for the candidates are of the nature and concentrations specified in the Apparatus and Materials List.
5. **The Supervisor is to be granted access to the Teacher's Copy of Practical Booklet A on Monday 9 May 2022.** The Supervisor is asked to check, at the earliest opportunity, that the experiments and tests in the question paper may be completed satisfactorily using the apparatus, materials and solutions that have been assembled. **This question paper must then be returned to safe custody** at the earliest possible moment after the Supervisor has ensured that all is in order. **No access to the question paper should be allowed before Monday 9 May 2022.**
6. Centres may need to carry out multiple sessions to accommodate all their candidates sitting Practical Booklet A in a laboratory. Supervision must take place from 30 minutes after the scheduled starting time of the examination, as set out in the timetable, until the time when the candidate(s) begin(s) their examination(s). This is in order to ensure that there is no contact with other candidates. The centre must appoint a member of staff from the centre to supervise the candidate(s) at all times while they are on the premises.
7. All apparatus should be checked before the examination, and there should be an adequate supply of spare apparatus in case of breakages. The Apparatus and Materials List should be regarded as a minimum and there is no objection to candidates being supplied with more than the minimum amount of apparatus and materials.
8. **Candidates may not use text books and laboratory notes for reference during the examination, and must be informed of this beforehand.**

9. Clear instructions must be given by the Supervisor to all candidates at the beginning of the examination concerning appropriate safety procedures and precautions. Supervisors are also advised to remind candidates that all substances in the examination must be treated with caution. **Only those tests specified in the question paper should be attempted. Candidates must not attempt any additional confirmatory tests.** Anything spilled on the skin should be washed off immediately with plenty of water. The use of appropriate eye protection is essential.
10. Supervisors are reminded that they may not assist candidates during the examination. However if, in the opinion of the Supervisor, a candidate is about to do something which may endanger themselves or others, the Supervisor should intervene. A full written report must be sent to CCEA at once.
11. Upon request, a candidate may be given additional quantities of materials (answer paper, reagents and unknowns) without penalty. No notification needs to be sent to CCEA.
12. The examination room must be cleared of candidates immediately after the examination.
13. No materials will be supplied by CCEA.
14. All JCQ procedures for conducting examinations should be followed for this practical examination including displaying JCQ posters with examination information in the laboratory and removal of mobile phones. Posters should be available from your Examinations Officer.

Northern Ireland Council for the Curriculum, Examinations and
Assessment

General Certificate of Education

Advanced

Chemistry

Practical Booklet A

[ACH31]

Thursday 12 May 2022

Centre Number

71

Candidate Number

This report must be completed by the Supervisor during the examination.
The complete report should include all candidates taking this Practical
Examination. This Supervisor's Report should be copied and attached to
Each Advice Note bundle and returned to CCEA in the normal way.

Comments:

Supervisor's Signature Date



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General Certificate of Education
2022

Chemistry
Assessment Unit A2 3
assessing
Further Practical Chemistry
Practical Booklet A
[ACH31]
THURSDAY 12 MAY, MORNING

MARK
SCHEME

General Marking Instructions

Introduction

Mark schemes are published to assist teachers and students in their preparation for examinations. Through the mark schemes teachers and students will be able to see what examiners are looking for in response to questions and exactly where the marks have been awarded. The publishing of the mark schemes may help to show that examiners are not concerned about finding out what a student does not know but rather with rewarding students for what they do know.

The Purpose of Mark Schemes

Examination papers are set and revised by teams of examiners and revisers appointed by the Council. The teams of examiners and revisers include experienced teachers who are familiar with the level and standards expected of students in schools and colleges.

The job of the examiners is to set the questions and the mark schemes; and the job of the revisers is to review the questions and mark schemes commenting on a large range of issues about which they must be satisfied before the question papers and mark schemes are finalised.

The questions and the mark schemes are developed in association with each other so that the issues of differentiation and positive achievement can be addressed right from the start. Mark schemes, therefore, are regarded as part of an integral process which begins with the setting of questions and ends with the marking of the examination.

The main purpose of the mark scheme is to provide a uniform basis for the marking process so that all the markers are following exactly the same instructions and making the same judgements in so far as this is possible. Before marking begins a standardising meeting is held where all the markers are briefed using the mark scheme and samples of the students' work in the form of scripts. Consideration is also given at this stage to any comments on the operational papers received from teachers and their organisations. During this meeting, and up to and including the end of the marking, there is provision for amendments to be made to the mark scheme. What is published represents this final form of the mark scheme.

It is important to recognise that in some cases there may well be other correct responses which are equally acceptable to those published: the mark scheme can only cover those responses which emerged in the examination. There may also be instances where certain judgements may have to be left to the experience of the examiner, for example, where there is no absolute correct response – all teachers will be familiar with making such judgements.

COVID-19 Context

Given the unprecedented circumstances presented by the COVID-19 public health crisis, senior examiners, under the instruction of CCEA awarding organisation, are required to train assistant examiners to apply the mark scheme in case of disrupted learning and lost teaching time. The interpretation and intended application of the mark scheme for this examination series will be communicated through the standardising meeting by the Chief or Principal Examiner and will be monitored through the supervision period. This paragraph will apply to examination series in 2021–2022 only.

1 The iron compounds are hydrated iron(II) sulfate and hydrated iron(III) chloride.

- (a) iron(II): green/colourless (solution) [1]
iron(III): yellow/orange (solution) [1] [2]

(b)

Salt solution	Colour with universal indicator paper	Approximate pH
Iron(II) salt	orange [1]	4 [1]
Iron(III) salt	red [1]	1/2 [1]

- (c) green precipitate [1]
brown precipitate [1] [4]
[2]

- (d) brown precipitate [1]
bubbles [1]
splint goes out [1] [3]

- (e) iron(II): (upper layer remains) colourless [1]
iron(III): (upper layer turns) purple [1] [2]

- (f) iron(II): (pale) pink solution forms [1]
iron(III): (deep) red solution forms [1] [2]

- (g) (i) bubbles/metal darkens [1]
(ii) more bubbles produced/metal darkens more quickly in the test tube
containing the iron(III) salt solution [1]

- (h) solid A
iron(III) salt solution changes to purple in the test tube containing A [1]

18

2 (a) mass of tablet recorded to 1 decimal place with units [1]

(b) bubbles/(some) solid dissolves/solid remains [1]

(c) residue – white solid
filtrate – colourless (solution) [1]

(d) headings and units included/cm³ in three column headings [1]
all readings to 1 decimal place [1]
correct calculation of titres [1]
rough titre greater than accurate values [1]
correct calculation of mean titre with unit [1] [5]

8

3 M is ammonium metavanadate.

(a) yellow (solution) [1]

(b) green/blue [1]

(c) (i) brown/yellow solution [1]

(ii) blue/green solution/precipitate forms [1]

4

Total

30



Rewarding Learning

ADVANCED
General Certificate of Education
2022

Centre Number

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Candidate Number

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Chemistry

Assessment Unit A2 3

assessing

Further Practical Chemistry

Practical Booklet B (Theory)



ACH32

[ACH32]

TUESDAY 21 JUNE, MORNING

TIME

1 hour 15 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

You must answer the questions in the spaces provided.

Do not write outside the boxed area on each page or on blank pages.

Complete in black ink only. **Do not write with a gel pen.**

Answer **all four** questions.

INFORMATION FOR CANDIDATES

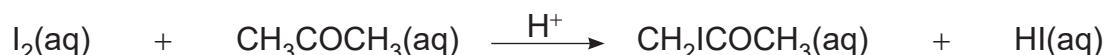
The total mark for this paper is 60.

Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

A Periodic Table of Elements (including some data) is provided.



- 1 The kinetics of the reaction between iodine and propanone were investigated. The reaction is catalysed by hydrogen ions.



The influence of the iodine concentration on the reaction rate can be studied if large excesses of propanone and sulfuric acid are used. An experiment is carried out as follows:

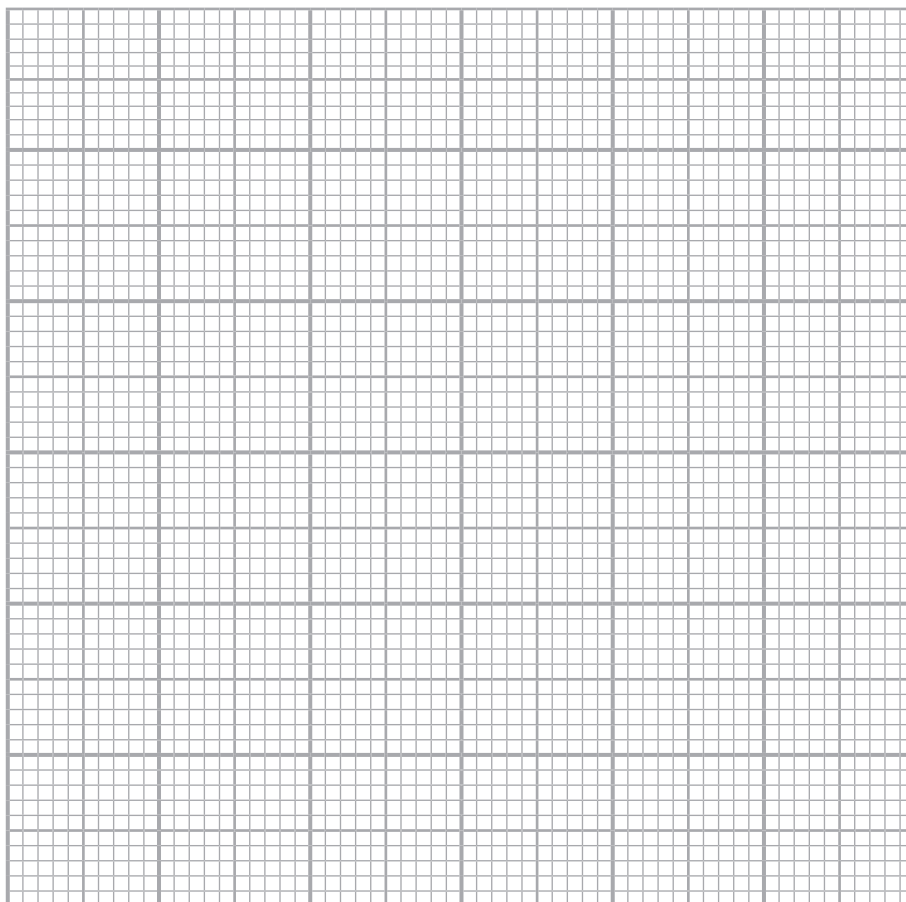
- 1 Mix 25.0 cm³ of 1.0 mol dm⁻³ propanone solution with 25.0 cm³ of 1.0 mol dm⁻³ sulfuric acid in a beaker.
- 2 Add 50.0 cm³ of 0.02 mol dm⁻³ iodine solution, stir the mixture and start a stopwatch.
- 3 Using a pipette, withdraw a 10.0 cm³ sample of the mixture and transfer it to a conical flask.
- 4 Add sodium hydrogencarbonate, with stirring, until the fizzing ceases. The time at which the sodium hydrogencarbonate is added is recorded.
- 5 Titrate the solution with 0.01 mol dm⁻³ sodium thiosulfate solution, using starch indicator.
- 6 Repeat steps 3–5 at five minute intervals.

The following results were obtained from the experiment:

Time /min	Volume of sodium thiosulfate solution /cm ³
1	11.5
6	10.2
11	9.9
16	7.8
21	6.9



- (a) Plot a graph of volume of sodium thiosulfate solution against time and draw a line of best fit.



[4]

- (b) Identify the anomalous result from the graph.

[1]

- (c) Suggest why using large excesses of propanone and sulfuric acid allows the order of reaction with respect to iodine to be deduced.

[1]

[Turn over]



(d) Explain why sodium hydrogencarbonate is added to each sample.

[1]

(e) The graph can be used to deduce the order of reaction with respect to iodine.

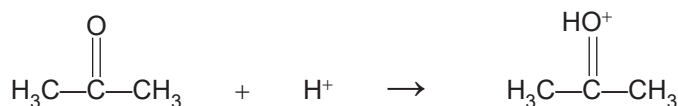
(i) Explain why a graph of volume of sodium thiosulfate solution against time can be used to deduce the order of reaction with respect to iodine.

[1]

(ii) State and explain the order of reaction with respect to iodine.

[2]

(iii) The following rate-determining step is proposed for the reaction:



Explain whether it is consistent with your answer to (e)(ii).

[1]



(f) Starch is added towards the end of each titration.

(i) State the colour changes when starch is added to each flask and at the end point of each titration.

Colour change when starch is added to flask: _____

Colour change at end point: _____

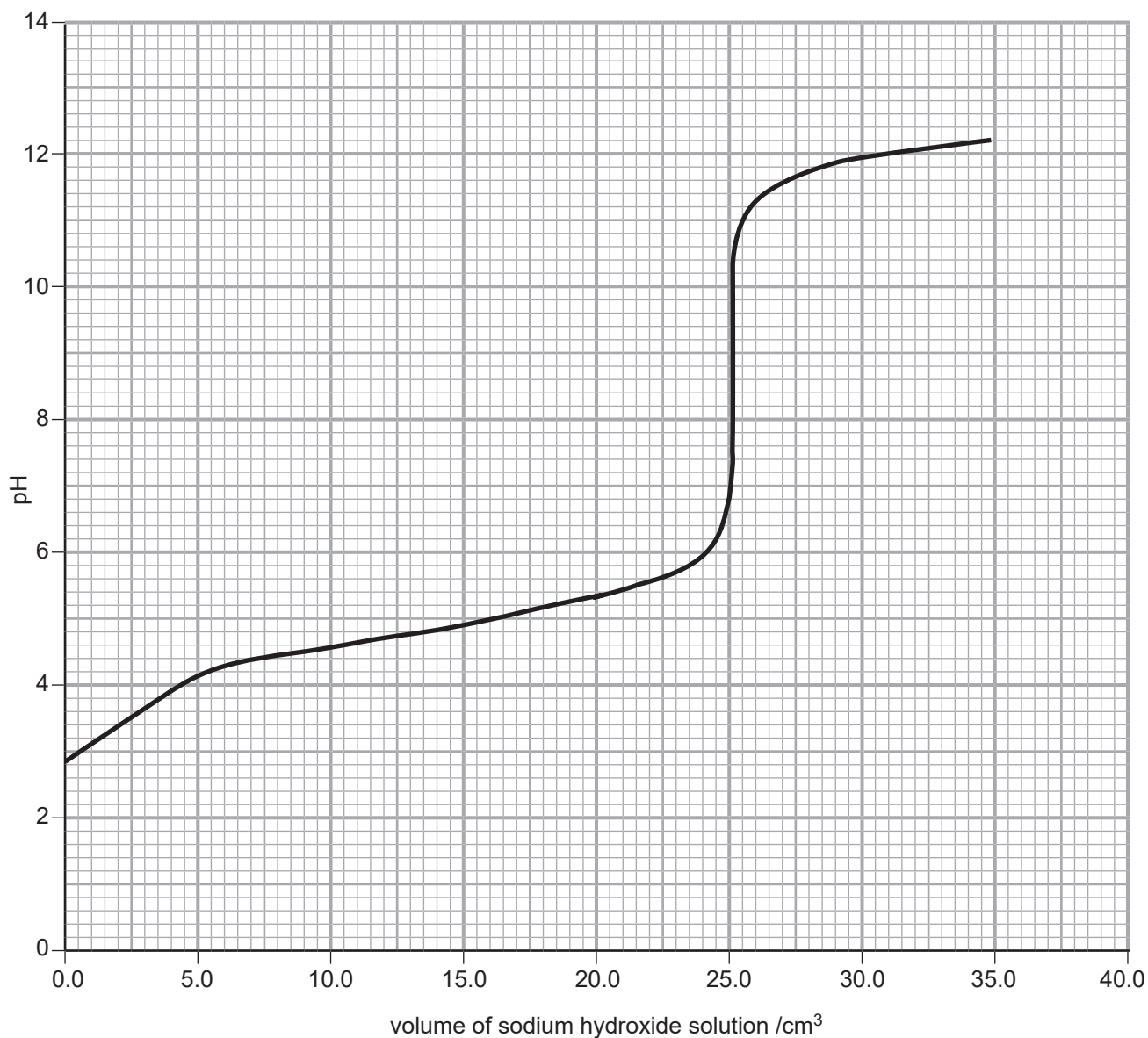
_____ [2]

(ii) Suggest why starch is not added at the start of each titration.

_____ [1]



- 2 The pH curve shown below was obtained when 25.0 cm^3 of 0.1 mol dm^{-3} ethanoic acid were titrated against 0.1 mol dm^{-3} sodium hydroxide solution.



12886.02R



16ACH3206

- (a) (i) What volume of sodium hydroxide solution is required to neutralise half of the ethanoic acid in the titration?

_____ [1]

- (ii) Use the pH curve to determine the pH of the mixture when the volume of sodium hydroxide solution in (a)(i) is added.

_____ [1]

- (iii) At the pH in (a)(ii), $[\text{CH}_3\text{COOH}] = [\text{CH}_3\text{COO}^-]$

Use your answer to (a)(ii) to determine the value of K_a for ethanoic acid. Give your answer to 3 significant figures.

_____ [1]

- (b) On the axes, sketch the pH curve that would be obtained if 0.2 mol dm^{-3} sodium hydroxide solution was used in the titration. [2]

[Turn over]

12886.02R



16ACH3207

(c) When half of the ethanoic acid is neutralised by the sodium hydroxide solution, the resulting mixture can act as a buffer solution.

(i) Define the term **buffer solution**.

_____ [1]

(ii) Explain, using an ionic equation, how this solution acts as a buffer when alkali is added.

_____ [2]

(d) Explain why a solution of sodium ethanoate has a pH above 7.

_____ [1]

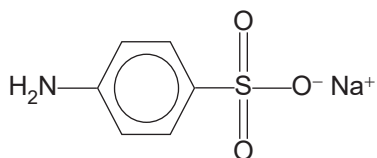
(e) The indicators bromophenol blue and thymol blue both exhibit the same colour change when used in acid-base titrations. Bromophenol blue changes colour in the pH range 3.0–4.5 and thymol blue changes colour in the pH range 8.0–9.6.

State and explain which indicator is suitable when 0.1 mol dm^{-3} ethanoic acid is titrated against 0.1 mol dm^{-3} sodium hydroxide solution.

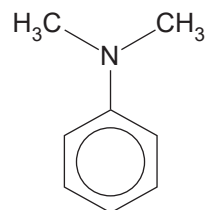
_____ [2]



- 3 Methyl orange is an azo dye. It can be synthesised from sodium sulfanilate and N,N-dimethylaniline, which react in equimolar amounts in a coupling reaction.



sodium sulfanilate



N,N-dimethylaniline

The procedure below was used to synthesise methyl orange.

2.70 g of sodium sulfanilate were dissolved in deionised water and sodium nitrite was added. The solution was poured over crushed ice and concentrated hydrochloric acid was added. N,N-dimethylaniline (1.71 g, density = 0.956 g cm⁻³), in ethanoic acid was added to this diazonium ion and the solid crude product formed. The solid was removed from the solution by suction filtration. It was recrystallised using water as a solvent and 2.32 g of methyl orange were obtained. The melting point of the recrystallised methyl orange was determined. Pure methyl orange melts at 300°C.

- (a) Sodium sulfanilate is produced by the reaction between sulfanilic acid and sodium hydroxide. Suggest why sodium sulfanilate is used in the preparation of methyl orange rather than sulfanilic acid.

[1]

[Turn over



(b) Nitrous acid is formed **in situ** by the reaction of sodium nitrite and hydrochloric acid.

(i) Suggest an explanation of the term **in situ**.

_____ [1]

(ii) Write an equation for the reaction between sodium nitrite and hydrochloric acid.

_____ [1]

(iii) Suggest why the solution was poured over crushed ice.

_____ [1]

(c) (i) Calculate the volume of N,N-dimethylaniline added to ethanoic acid.

_____ [1]

(ii) Suggest an equation for the reaction between N,N-dimethylaniline and ethanoic acid.

_____ [2]



(d) State a practical use for methyl orange.

[1]

(e) (i) Draw a labelled diagram to show how suction filtration is carried out.

[3]

(ii) State **two** advantages of suction filtration.

[2]

[Turn over]

12886.02R



16ACH3211

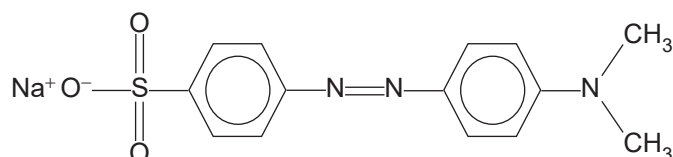
- (f) (i) Describe how the melting point of the recrystallised methyl orange was determined.

[3]

- (ii) Describe how the melting point value obtained in (f)(i) would differ from 300 °C if the sample was impure.

[2]

- (g) A structure of methyl orange is given below.



- (i) Determine which reactant, sodium sulfanilate (2.70 g) or N,N-dimethylaniline (1.71 g), is the limiting reactant in this synthesis of methyl orange.

[3]

- (ii) Use your answer to (g)(i) to calculate the percentage yield of methyl orange. Give your answer to 1 decimal place.

[3]





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(Questions continue overleaf)

12886.02R

[Turn over



16ACH3213

4 The structure of a compound with the molecular formula C_4H_7ClO can be determined using modern spectroscopic techniques. The compound is **not** an acyl chloride.

(a) The mass spectrum of the compound contains peaks at $m/z = 106$ and $m/z = 108$. The base peak occurs at $m/z = 43$.

(i) Explain the presence of the peaks at $m/z = 106$ and $m/z = 108$ and suggest why the peak at 106 has a higher relative abundance than the peak at 108.

_____ [2]

(ii) Suggest the formula of the fragment ion which gives rise to the base peak at $m/z = 43$.

_____ [1]

(b) The high resolution nmr spectrum of the compound was obtained.

(i) State the formula of a suitable solvent used in obtaining the nmr spectrum of the compound.

_____ [1]

(ii) Name the compound used as a standard in nmr spectroscopy and give **one** reason why it is used.

_____ [2]



- (iii) The high resolution nmr spectrum of the compound shows three peaks. Complete the table below.

	Integration value	Splitting pattern	Number of hydrogen atoms bonded to adjacent carbon atoms
Peak 1	3	doublet	1
Peak 2	3	singlet	
Peak 3	1		3

[2]

- (c) Based on your answers to (a)(ii) and (b)(iii), suggest the structure of the compound.

[1]

- (d) Describe a chemical test which could be used to show that the compound contains a carbonyl group.

[2]

12886.02R



16ACH3215

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Question Number	Examiner Mark	Remark
1		
2		
3		
4		
Total Marks		

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ACH32/7
260686



General Information

1 tonne = 10^6 g

1 metre = 10^9 nm

One mole of any gas at 293 K and a pressure of 1 atmosphere (10^5 Pa) occupies a volume of 24 dm³

Avogadro Constant = 6.02×10^{23} mol⁻¹

Planck Constant = 6.63×10^{-34} Js

Specific Heat Capacity of water = $4.2 \text{ J g}^{-1} \text{ K}^{-1}$

Speed of Light = $3 \times 10^8 \text{ m s}^{-1}$



Characteristic absorptions in IR spectroscopy

Wavenumber/cm ⁻¹	Bond	Compound
550–850	C–X (X = Cl, Br, I)	Haloalkanes
750–1100	C–C	Alkanes, alkyl groups
1000–1300	C–O	Alcohols, esters, carboxylic acids
1450–1650	C=C	Arenes
1600–1700	C=C	Alkenes
1650–1800	C=O	Carboxylic acids, esters, aldehydes, ketones, amides, acyl chlorides
2200–2300	C≡N	Nitriles
2500–3200	O–H	Carboxylic acids
2750–2850	C–H	Aldehydes
2850–3000	C–H	Alkanes, alkyl groups, alkenes, arenes
3200–3600	O–H	Alcohols
3300–3500	N–H	Amines, amides

Proton Chemical Shifts in Nuclear Magnetic Resonance Spectroscopy (relative to TMS)

Chemical Shift	Structure	
0.5–2.0	–CH	Saturated alkanes
0.5–5.5	–OH	Alcohols
1.0–3.0	–NH	Amines
2.0–3.0	–CO–CH	Ketones
	–N–CH	Amines
	C ₆ H ₅ –CH	Arene (aliphatic on ring)
2.0–4.0	X–CH	X = Cl or Br (3.0–4.0) X = I (2.0–3.0)
4.5–6.0	–C=CH	Alkenes
5.5–8.5	RCONH	Amides
6.0–8.0	–C ₆ H ₅	Arenes (on ring)
9.0–10.0	–CHO	Aldehydes
10.0–12.0	–COOH	Carboxylic acids

These chemical shifts are concentration and temperature dependent and may be outside the ranges indicated above.

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Data Leaflet

Including the Periodic Table of the Elements

For the use of candidates taking
Advanced Subsidiary and
Advanced Level Examinations

Copies must be free from notes or additions of any kind. No other type of data booklet or information sheet is authorised for use in the examinations

gce a/as examinations chemistry

I II THE PERIODIC TABLE OF ELEMENTS III IV V VI VII 0

Group

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen 1																	4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	98 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La [*] Lanthanum 57	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	210 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radium 88	227 Ac [†] Actinium 89	261 Rf Rutherfordium 104	262 Db Dubnium 105	266 Sg Seaborgium 106	264 Bh Bohrium 107	277 Hs Hassium 108	268 Mt Meitnerium 109	271 Ds Darmstadtium 110	272 Rg Roentgenium 111	285 Cn Copernicium 112						

* 58 – 71 Lanthanum series
† 90 – 103 Actinium series

a

X

b

a = relative atomic mass (approx)
x = atomic symbol
b = atomic number

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	145 Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	231 Pa Protactinium 91	238 U Uranium 92	237 Np Neptunium 93	242 Pu Plutonium 94	243 Am Americium 95	247 Cm Curium 96	245 Bk Berkelium 97	251 Cf Californium 98	254 Es Einsteinium 99	253 Fm Fermium 100	256 Md Mendelevium 101	254 No Nobelium 102	257 Lr Lawrencium 103



Rewarding Learning

ADVANCED
General Certificate of Education
2022

Chemistry
Assessment Unit A2 3
assessing
Further Practical Chemistry
Practical Booklet B (Theory)
[ACH32]
TUESDAY 21 JUNE, MORNING

**MARK
SCHEME**

General Marking Instructions

Introduction

Mark schemes are published to assist teachers and students in their preparation for examinations. Through the mark schemes teachers and students will be able to see what examiners are looking for in response to questions and exactly where the marks have been awarded. The publishing of the mark schemes may help to show that examiners are not concerned about finding out what a student does not know but rather with rewarding students for what they do know.

The Purpose of Mark Schemes

Examination papers are set and revised by teams of examiners and revisers appointed by the Council. The teams of examiners and revisers include experienced teachers who are familiar with the level and standards expected of students in schools and colleges.

The job of the examiners is to set the questions and the mark schemes; and the job of the revisers is to review the questions and mark schemes commenting on a large range of issues about which they must be satisfied before the question papers and mark schemes are finalised.

The questions and the mark schemes are developed in association with each other so that the issues of differentiation and positive achievement can be addressed right from the start. Mark schemes, therefore, are regarded as part of an integral process which begins with the setting of questions and ends with the marking of the examination.

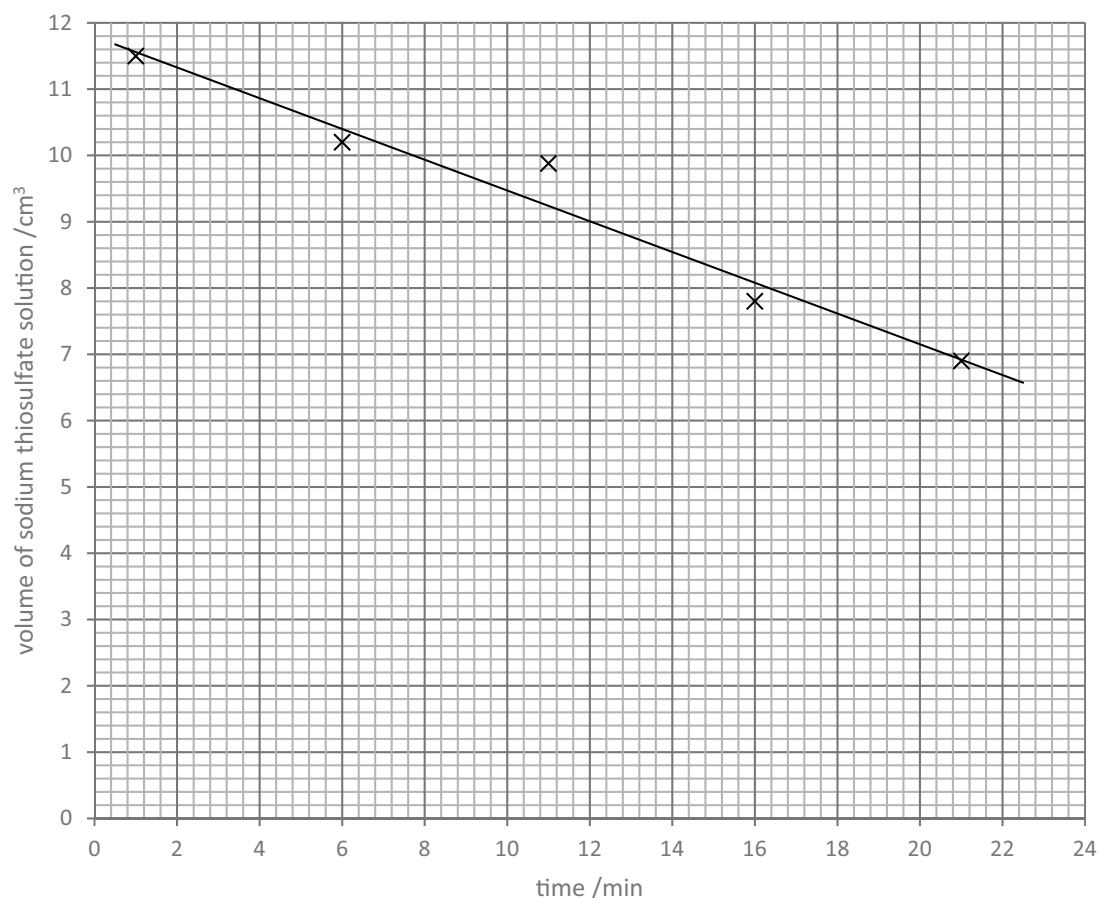
The main purpose of the mark scheme is to provide a uniform basis for the marking process so that all the markers are following exactly the same instructions and making the same judgements in so far as this is possible. Before marking begins a standardising meeting is held where all the markers are briefed using the mark scheme and samples of the students' work in the form of scripts. Consideration is also given at this stage to any comments on the operational papers received from teachers and their organisations. During this meeting, and up to and including the end of the marking, there is provision for amendments to be made to the mark scheme. What is published represents this final form of the mark scheme.

It is important to recognise that in some cases there may well be other correct responses which are equally acceptable to those published: the mark scheme can only cover those responses which emerged in the examination. There may also be instances where certain judgements may have to be left to the experience of the examiner, for example, where there is no absolute correct response – all teachers will be familiar with making such judgements.

COVID-19 Context

Given the unprecedented circumstances presented by the COVID-19 public health crisis, senior examiners, under the instruction of CCEA awarding organisation, are required to train assistant examiners to apply the mark scheme in case of disrupted learning and lost teaching time. The interpretation and intended application of the mark scheme for this examination series will be communicated through the standardising meeting by the Chief or Principal Examiner and will be monitored through the supervision period. This paragraph will apply to examination series in 2021–2022 only.

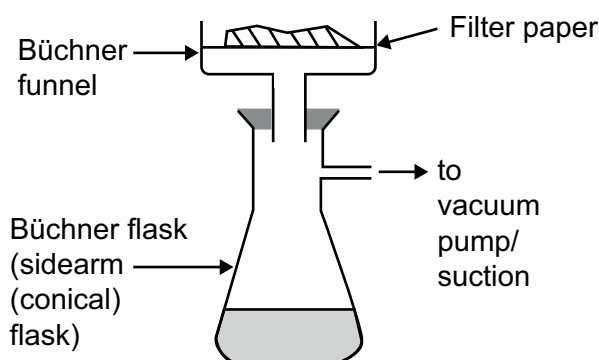
- 1 (a) y-axis labelled [1]
x-axis labelled [1]
points correctly plotted [1]
line of best fit [1] [4]



- (b) $9.9 \text{ cm}^3/11 \text{ min}$ [1]
- (c) concentrations of propanone and sulfuric acid remain effectively constant [1]
- (d) to quench the reaction/react with acid [1]
- (e) (i) concentration of iodine is related to the volume of sodium thiosulfate solution/concentration of iodine is directly proportional to the volume of thiosulfate [1]
- (ii) zero order [1]
graph is a straight line/gradient constant [1] [2]
second mark is dependent on the first
- (iii) consistent as iodine does not appear in the proposed rate-determining step [1]
- (f) (i) straw/yellow to blue-black [1]
blue-black to colourless [1] [2]
- (ii) iodine forms irreversible/insoluble complex with starch/adsorbs on surface of the starch [1]

2 (a) (i) 12.5 cm ³	[1]	AVAILABLE MARKS
(ii) 4.7–4.8	[1]	
(iii) pH = pK _a = 4.7 to 4.8 K _a = 1.58 × 10 ^{−5} to 2.00 × 10 ^{−5}	[1]	
(b) curve starts at same pH as original curve [1] similar shape of curve, vertical section drawn at volume of sodium hydroxide added = 12.5 cm ³ [1]	[2]	
(c) (i) solution which resists changes in pH on addition of small amounts of acid or alkali	[1]	
(ii) CH ₃ COOH + OH [−] → CH ₃ COO [−] + H ₂ O	[2]	
(d) ethanoic acid is a weak acid and sodium hydroxide is a strong base/ salt of a weak acid and strong base	[1]	
(e) thymol blue [1] changes colour in the vertical section of the pH curve [1]	[2]	11

- 3 (a) sodium sulfanilate is more soluble than sulfanilic acid [1]
- (b) (i) made in the reaction vessel [1]
- (ii) $\text{NaNO}_2 + \text{HCl} \rightarrow \text{HNO}_2 + \text{NaCl}$ [1]
- (iii) diazonium ions unstable at temperatures above 10°C [1]
- (c) (i) volume = $1.71/0.956 = 1.79 \text{ cm}^3$ [1]
- (ii) $\text{C}_6\text{H}_5\text{N}(\text{CH}_3)_2 + \text{CH}_3\text{COOH} \rightarrow \text{CH}_3\text{COO}^-\text{C}_6\text{H}_5\text{N}^+\text{H}(\text{CH}_3)_2$ [2]
- (d) indicator in acid base titration [1]
- (e) (i)



[3]

- (ii) faster (than gravity filtration) [1] drier product obtained [1] [2]

- (f) (i) place some solid in a capillary tube sealed at one end/
melting point tube [1]
heat slowly (using melting point apparatus) [1]
record the temperature at which the solid starts and
finishes melting [1] [3]

- (ii) melts at a lower temperature [1]
melts over a larger range [1] [2]

- (g) (i) $2.70/195 = 0.0138$ moles sodium sulfanilate
 $1.71/121 = 0.0141$ moles dimethylamine
ratio 1:1; sodium sulfanilate limiting [3]

- (ii) moles sodium sulfanilate = moles methyl orange = 0.0138
mass methyl orange = $0.0138 \times 327 = 4.51 \text{ (g)}$
percentage yield = $2.32/4.51 \times 100 = 51.4\%$ [3]

AVAILABLE
MARKS

24

- 4 (a) (i) Presence of two chlorine isotopes ^{35}Cl and ^{37}Cl [1]
 Relevant abundance of $m/z = 106$ and $m/z = 108$ is 3 : 1/ ^{35}Cl has higher abundance [1] [2]
- (ii) CH_3CO^+ [1]
- (b) (i) $\text{CCl}_4/\text{CDCl}_3$ [1]
- (ii) tetramethylsilane [1]
 one signal as all hydrogen atoms equivalent/chemically inert/
 non-toxic/easily removed from sample/H atoms more shielded [1] [2]
- (iii)
- | | Integration value | Splitting pattern | Number of bonded to adjacent carbon atoms hydrogen atoms |
|--------|-------------------|-------------------|--|
| peak 1 | 3 | doublet | 1 |
| peak 2 | 3 | singlet | 0 [1] |
| peak 3 | 1 | quartet [1] | 3 |
- [2]
- (c) $\text{CH}_3-\text{C}(\text{O})-\text{CH}(\text{Cl})-\text{CH}_3$ [1]
- (d) add compound to 2,4-dinitrophenylhydrazine solution [1]
 yellow/orange precipitate [1] [2]

Total

AVAILABLE MARKS

11

60