New Specification

Rewarding Learning

Centre Number

71	

Candidate Number

ADVANCED
General Certificate of Education
January 2010

Chemistry

Assessment Unit A2 1

assessing

Periodic Trends and Further Organic, Physical and Inorganic Chemistry

[AC211]

WEDNESDAY 27 JANUARY, MORNING

AC211

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**. Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 120.
Quality of written communication will be assessed in Question **11(d)(i)**.
In Section A all questions carry equal marks, i.e. **two** marks 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 (including some data) is provided.

For Examiner's use only	
Question Number	**Marks**
Section A	
1–10	
Section B	
11	
12	
13	
14	
15	
Total Marks	

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 substances, when added to water in equimolar amounts, will form the solution with the highest pH?

A ammonium chloride
B ammonium ethanoate
C potassium ethanoate
D potassium chloride

2 Which one of the following substances has a different molecular formula from its empirical formula?

A butanoic acid
B ethanal
C propanal
D propanone

3 Zinc is manufactured by the reduction of its oxide using carbon.

$$ZnO(s) \quad + \quad C(s) \quad \rightarrow \quad Zn(s) \quad + \quad CO(g)$$

$\Delta H^{\ominus} = +237\ kJ\,mol^{-1}$
$\Delta S^{\ominus} = +190\ J\,K^{-1}\,mol^{-1}$

What is the minimum temperature needed for this reaction to become feasible?

A 154 K
B 427 K
C 975 K
D 1248 K

4 How many isomers which have the molecular formula C_3H_6O can be reduced by lithal to an alcohol?

A 1
B 2
C 3
D 4

5 Which one of the following compounds contains co-ordinate (dative) bonds?

A Al_2Cl_6
B CCl_4
C $MgCl_2$
D NaCl

6 The "bromine clock" reaction proceeds according to the equation:

$$6H^+(aq) \quad + \quad 5Br^-(aq) \quad + \quad BrO_3^-(aq) \quad \rightarrow \quad 3Br_2(aq) \quad + \quad 3H_2O(l)$$

The rate equation is:

$$\text{Rate} = k[H^+]^2[Br^-][BrO_3^-]$$

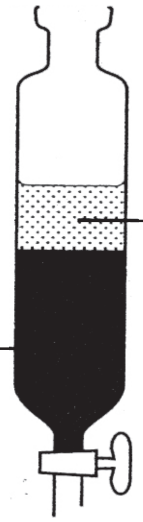
When the rate of disappearance of bromide ions is 1.2×10^{-4} mol dm^{-3} s^{-1}, which one of the following statements is correct?

A The rate of disappearance of bromate(V) ions, BrO_3^-, is 1.2×10^{-4} mol dm^{-3} s^{-1}.
B The rate of disappearance of bromate(V) ions, BrO_3^-, is 2.4×10^{-5} mol dm^{-3} s^{-1}.
C The rate of disappearance of hydrogen ions is 1.4×10^{-8} mol dm^{-3} s^{-1}.
D The rate of disappearance of hydrogen ions is 1.0×10^{-4} mol dm^{-3} s^{-1}

7 In which one of the following do all three oxides behave as indicated at room temperature?

	neutralises dilute acid	**neutralises dilute alkali**	**dissolves in water to form an acidic solution**
A	Na_2O	MgO	SiO_2
B	MgO	Al_2O_3	Cl_2O_7
C	P_4O_{10}	SiO_2	SO_3
D	Al_2O_3	SO_2	Na_2O

8 The diagram shows the distribution of a substance X between ether and water at equilibrium.



What is the value of the partition coefficient $K_d = \dfrac{[\text{X in ether}]}{[\text{X in water}]}$?

A 3.95
B 7.50
C 29.64
D 32.80

9 Which one of the following would **not** be affected by boiling with aqueous sodium hydroxide?

A ethyl ethanoate
B glycerol
C olive oil
D propanoic acid

10 What is the pH of a solution containing 6.0 g of ethanoic acid, CH_3COOH ($K_a = 1.74 \times 10^{-5}$ moldm^{-3}), and 2.0 g of sodium ethanoate, CH_3COONa, dissolved in 100 cm^3 of solution?

A 2.38
B 4.15
C 4.28
D 4.76

Section B

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

11 Formaldehyde (methanal), HCHO, is a colourless gas which is readily soluble in water. The aqueous solution is used for preserving anatomical specimens.

(a) Explain why formaldehyde is soluble in water.

____

____ [2]

(b) Formaldehyde is a reducing agent as illustrated by its reaction with Tollen's reagent.

(i) Write an equation for the oxidation of formaldehyde using [O] to represent the oxidising agent.

____ [1]

(ii) Write the half-equation for the reduction of silver ions in Tollen's reagent.

____ [1]

(iii) What is observed during this reaction?

____ [1]

(c) Formaldehyde reacts with hydrogen cyanide.

Draw a flow scheme for the mechanism of this reaction.

[3]

Examiner Only	
Marks	Remark

(d) Methanoic acid undergoes an acid catalysed reaction with bromine according to the equation:

$$Br_2(aq) + HCOOH(aq) \xrightarrow{H^+(aq)} 2Br^-(aq) + 2H^+(aq) + CO_2(g)$$

(i) Suggest an experimental method to investigate the rate of this reaction. How would you find the order of the reaction with respect to bromine?

____

____

____

____

____ [4]

Quality of written communication [2]

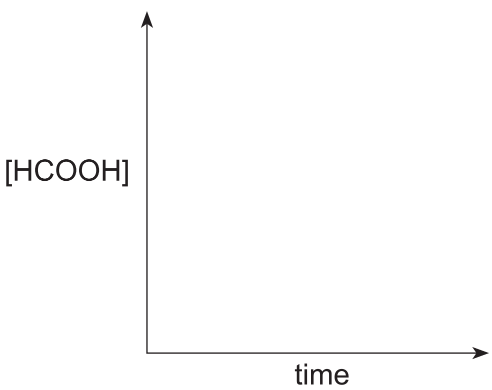
(ii) The rate law was found to be

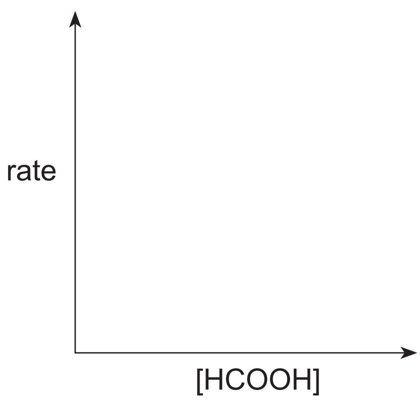
$$\text{Rate} = k[Br_2][HCOOH]$$

Deduce the units for the rate constant k.

____ [1]

(iii) On the axes below, sketch the expected shape of the graphs in this reaction.





[2]

Examiner Only

Marks	Remark

(e) Methanoic acid reacts with ethanol in the presence of concentrated sulphuric acid to form an ester.

(i) Write the equation for this esterification.

____ [2]

(ii) Name the ester formed.

____ [1]

(iii) State **two** functions of concentrated sulphuric acid in this reaction.

____

____ [2]

Examiner Only	
Marks	Remark

12 The combustion of non-renewable hydrocarbon fuels has contributed to the increase in the atmospheric concentration of carbon dioxide. This in turn is believed to be a key factor in global warming.

Examiner Only	
Marks	Remark

(a) Carbon dioxide absorbs infra-red radiation. State **two** effects this radiation has on the bonds in a carbon dioxide molecule.

____

____ [2]

(b) Photosynthesis involves conversion of carbon dioxide and water into a carbohydrate and oxygen.

(i) Write an equation for photosynthesis representing the carbohydrate as $C_6H_{12}O_6$.

____ [1]

(ii) A mature tree can produce approximately 220 kg of oxygen per year. What volume of carbon dioxide, measured at one atmosphere pressure and 20 ºC, does a tree need to produce this mass of oxygen?

____

____

____ [3]

(iii) Wood is approximately 50% cellulose. Burning wood releases carbon dioxide into the atmosphere. Write an equation for the complete combustion of cellulose. Use the formula $C_6H_{10}O_5$ to represent cellulose.

____ [2]

(c) The oceans play an important part in determining the percentage of carbon dioxide in the atmosphere. It is estimated that the oceans contain some 3.9×10^{13} tonnes of carbon in total. Calculate the mass of carbon dioxide which the oceans have absorbed to contain this mass of carbon.

____

____

____ [2]

(d) Carbon dioxide dissolves in water according to the equation:

$$CO_2(g) + aq \rightleftharpoons CO_2(aq) \quad \text{Equilibrium 1}$$

Approximately 4% of the dissolved carbon dioxide reacts with water to form hydrogencarbonate ions and hydrogen ions in a further equilibrium.

$$CO_2(aq) + H_2O(l) \rightleftharpoons HCO_3^-(aq) + H^+(aq) \quad \text{Equilibrium 2}$$

(i) Explain the effect a rise in atmospheric carbon dioxide levels would have on the position of Equilibrium 1.

____

____ [1]

(ii) Write an expression for the equilibrium constant, K_c, for Equilibrium 2.

____ [1]

(iii) A solution of carbon dioxide is weakly acidic. Explain whether the value of K_c will be large or small.

____ [1]

Examiner Only	
Marks	Remark

13 Ketones and carboxylic acids are produced by the oxidation of alcohols.

Examiner Only	
Marks	Remark

(a) The identity of an unknown ketone was determined by preparing the solid derivative from 2,4-dinitrophenylhydrazine and determining the melting point of the purified product.

(i) Write the equation for the reaction of butanone with 2,4-dinitrophenylhydrazine.

[3]

(ii) State the expected colour of the solid derivative.

____ [1]

(iii) Describe how you would purify the solid derivative.

____

____

____

____ [3]

(iv) Describe how the melting point of the purified solid would be determined experimentally.

____

____

____

____ [3]

(v) What **two** effects would impurities have on the recorded melting point?

____

____ [2]

(b) Lactic acid, $CH_3CHOHCOOH$, is a weak acid which builds up in muscles during exercise. The molecule is optically active.

Examiner Only	
Marks	Remark

(i) Explain the term **optically active**.

____

____ [2]

(ii) Draw the 3D structures of the two chiral isomers.

[2]

(c) In an experiment to determine the percentage by mass of lactic acid in an aqueous solution, 25.0 cm^3 samples of the acid solution were titrated against 1 mol dm^{-3} sodium hydroxide solution. The average titre was found to be 24.3 cm^3.

(i) Write the equation for the reaction of lactic acid with sodium hydroxide.

____ [1]

(ii) Calculate the molarity of the lactic acid solution.

____

____

____

____ [3]

(iii) Calculate the concentration of the lactic acid solution in g dm^{-3}.

____

____ [2]

(iv) Name a suitable indicator for this titration.

____ [1]

Examiner Only	
Marks	Remark

(d) A carboxylic acid was found to contain 58.7% carbon, 9.8% hydrogen and 31.5% oxygen. Deduce the empirical formula of the acid.

____

____

____

____ [3]

(e) Fats and oils are triesters of glycerol and long chain carboxylic acids. The fat contained in mutton is predominantly a triester formed from stearic acid, $CH_3(CH_2)_{16}COOH$.

(i) Draw the structure of this triester.

[2]

(ii) The saponification value of a fat provides information about the structure. Define the term **saponification value** and explain what a high value would indicate about a fat.

____

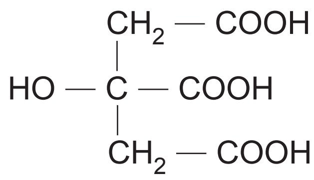
____

____

____ [4]

Examiner Only	
Marks	Remark

14 Citric acid is a weak tribasic acid found in citrus fruits. It has the following structure:



(a) **(i)** How many asymmetric (chiral) centres are present in the molecule?

____ [1]

(ii) The partially completed systematic name for citric acid is given below. Complete the name by inserting commas and hyphens in the appropriate spaces.

2 hydroxypropane 1 2 3 tricarboxylic acid [2]

(b) Citric acid reacts with sodium hydrogencarbonate in an endothermic reaction. The expression $\Delta G^{\ominus} = \Delta H^{\ominus} - T\,\Delta S^{\ominus}$ can be used to explain why endothermic processes can proceed spontaneously.

(i) Write the equation for the reaction of citric acid with **excess** sodium hydrogencarbonate.

[2]

(ii) State **one** observation which would indicate the reaction was complete.

____ [1]

(iii) Explain the meaning of the symbol $\Delta S^{\ominus}$.

____ [2]

(iv) Explain, in terms of the expression $\Delta G^{\ominus} = \Delta H^{\ominus} - T\,\Delta S^{\ominus}$, why the reaction of citric acid with sodium hydrogencarbonate proceeds spontaneously despite being endothermic.

Examiner Only	
Marks	Remark

____

____ [2]

(c) The first acid dissociation constant, K_a, for citric acid is 8.4×10^{-4} mol dm^{-3}.

(i) Write an equation for the first ionisation of citric acid in aqueous solution.

____ [1]

(ii) Write an expression for the first acid dissociation constant, K_a, for citric acid using RCOOH to represent citric acid.

____ [1]

(iii) Calculate the pH of a 0.1 mol dm^{-3} solution of citric acid assuming only the first ionisation takes place.

____

____

____

____ [3]

15 Compounds containing fluorine find diverse uses including polymer manufacture and additives for toothpaste.

Examiner Only	
Marks	Remark

(a) The polymer Teflon, polytetrafluoroethene, is made by polymerising tetrafluoroethene which itself is produced from chlorodifluoromethane according to the equation:

$$2CHClF_2(g) \rightleftharpoons C_2F_4(g) + 2HCl(g) \quad \Delta H = +128 \text{ kJ mol}^{-1}$$

(i) State and explain the effect of increasing the overall pressure on the yield of tetrafluoroethene.

____

____

____ [2]

(ii) State and explain the effect of increasing the temperature on the yield of tetrafluoroethene.

____

____

____ [2]

(iii) 0.2 mole of chlorodifluoromethane was placed in a 5 dm^3 sealed flask and heated. At equilibrium the mixture obtained contained only 0.04 mole of the gas. Calculate the value of K_c for this reaction and state its units.

____

____

____

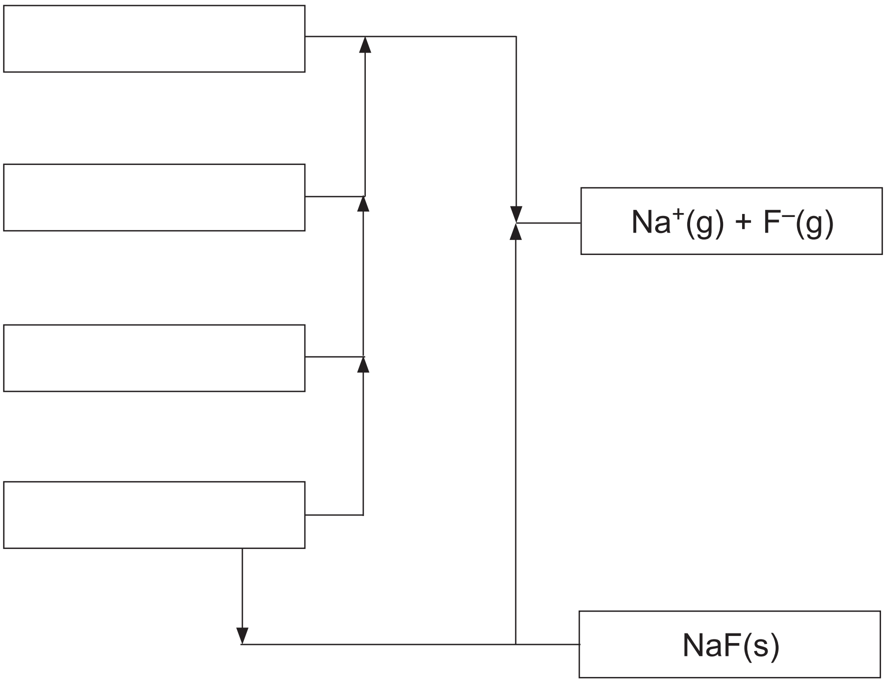
____ [4]

(iv) State **two** advantages of polymer disposal by incineration compared to landfill.

____

____ [2]

(b) Sodium fluoride is added to toothpaste to reduce tooth decay. The partially completed Born-Haber cycle for sodium fluoride is shown below.



(i) Complete the empty boxes above by inserting the appropriate chemical symbols. [4]

(ii) Using the data below, calculate the lattice enthalpy for sodium fluoride.

	kJ mol^{-1}
First ionisation energy of sodium	+496
Enthalpy of atomisation of sodium	+107
Bond enthalpy of fluorine	+158
Electron affinity of fluorine	–333
Enthalpy of formation of sodium fluoride	–574

____

____ [2]

(iii) Write the electronic configuration in s, p and d notation for a sodium ion, Na^+, and a fluoride ion, F^-.

sodium ion ______________________________________

fluoride ion ____________________________________ [2]

Examiner Only
Marks | Remark

THIS IS THE END OF THE QUESTION PAPER

Published Mark Scheme for GCE A2 Chemistry

January 2010

Issued: April 2010

NORTHERN IRELAND GENERAL CERTIFICATE OF SECONDARY EDUCATION (GCSE) AND NORTHERN IRELAND GENERAL CERTIFICATE OF EDUCATION (GCE)

MARK SCHEMES (2010)

Foreword

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 16- and 18-year-old 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 a 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.

The Council hopes that the mark schemes will be viewed and used in a constructive way as a further support to the teaching and learning processes.

CONTENTS

New Specification

Rewarding Learning

ADVANCED
General Certificate of Education
January 2010

Chemistry

Assessment Unit A2 1

assessing

Periodic Trends and Further Organic, Physical and Inorganic Chemistry

[AC211]

WEDNESDAY 27 JANUARY, MORNING

MARK SCHEME

AVAILABLE MARKS

Section A

1 C

2 A

3 D

4 B

5 A

6 B

7 B

8 C

9 B

10 B

2 marks for each correct answer [20]

Section B

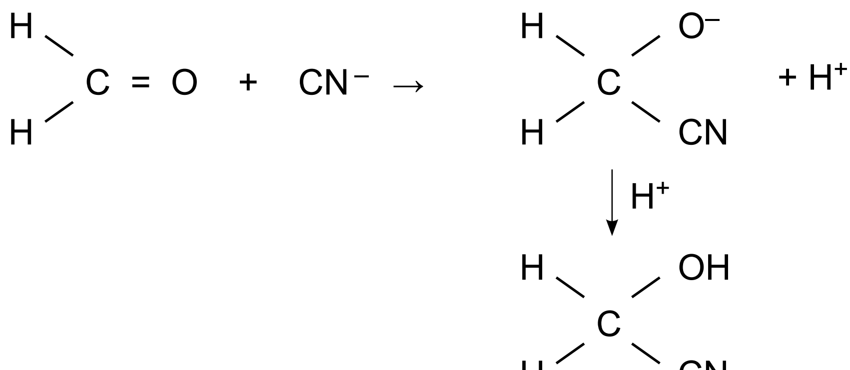
11 **(a)** hydrogen bonds [1]
between oxygen (in methanal) and hydrogen atoms (in water) [1] [2]

(b) **(i)** $HCHO + [O] \rightarrow HCOOH$ [1]

(ii) $Ag^+ + e^- \rightarrow Ag$ [1]

(iii) silver mirror [1]

(c)



Each error [-1] [3]

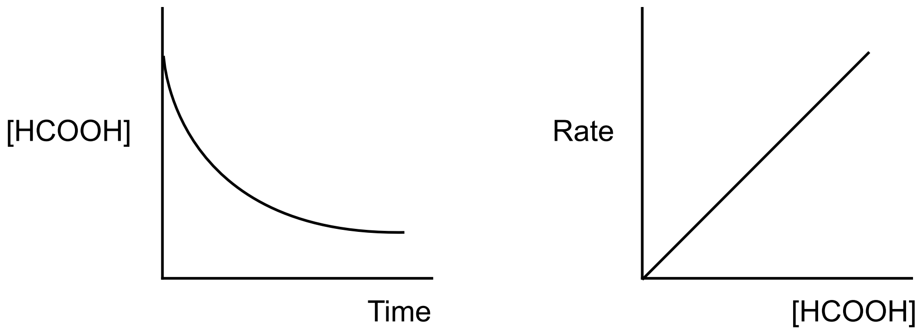
(d) **(i)** colorimetry [1]
measure absorbance / transmission [1]
with time [1]
use calibration curve [1]
} 3 from 4
plot bromine concentration against time
or rate against bromine concentration [1] [4]

measure CO_2 volume [1]
with time [1]
repeat with different bromine concentrations [1]
(plot volume against time) measure tangent at t = 0 [1]
} 3 from 4
plot rate against $[Br_2]$ [1] [4]

QWC [2]

(ii) $mol^{-1}\ dm^3\ s^{-1}$ [1]

(iii) start on y axis curve down [1]
straight line of positive slope through % [1] [2]



AVAILABLE MARKS

(e) **(i)** $HCOOH + C_2H_5OH \rightarrow HCOOC_2H_5 + H_2O$
missing water = [-1] [2]

(ii) ethyl methanoate [1]

(iii) catalyst [1]
drives equilibrium to rhs / improve yield / removes water [1] [2] 22

12 **(a)** vibrate [1]
stretch [1]
bend [1]
absorbs energy/heat [1] [2]

(b) **(i)** $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$ [1]

(ii) 220000g = 6875 moles
1 mole O_2 = 1 mole CO_2
6875 × 24
= 165 000 dm^3
Each error [-1]. Carry error through [3]

(iii) $C_6H_{10}O_5 + 6O_2 \rightarrow 6CO_2 + 5H_2O$
Unbalanced = [-1] [2]

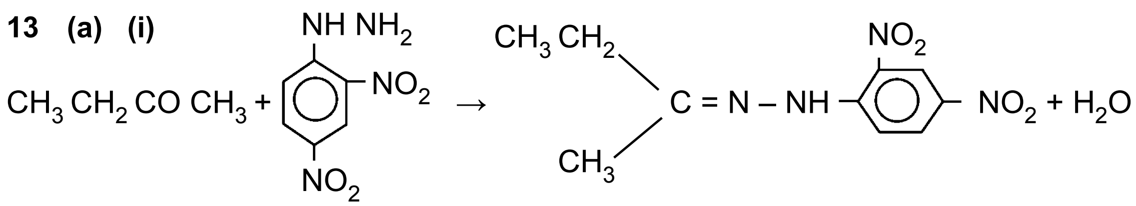
(c) $3.9 \times 10^{13} \times 44/12 = 1.43 \times 10^{14}$ tonnes
Each error [-1] [2]

(d) **(i)** moves to rhs to reduce concentration of CO_2 gas [1]

(ii) $K_c = [HCO_3^-][H^+] / [CO_2][H_2O]$ [1]

(ii) K_c small as HCO_3^- and / or H^+ concentration(s) low [1] 14

13 **(a)** **(i)**



each error [–1] [3]

(ii) yellow or orange [1]

(iii) dissolve in minimum amount [1]
of hot solvent/ethanol [1]
cool/crystallize and filter and dry [1] [1]

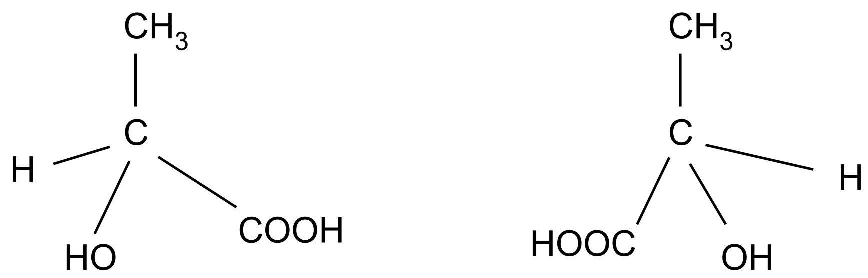
AVAILABLE MARKS

(iv) (sealed) capillary tube / m.pt apparatus [1]
heat slowly (½ – 1 degree per minute) [1]
record temperature at which melting starts
and finishes / m.pt range [1]
repeat [1]
Any [3] [3]

(v) lower [1]
broader range [1] [2]

(b) **(i)** rotate (plane) [1]
of plane polarised light [1] [2]

(ii)



[2]

(c) **(i)** $CH_3CHOHCOOH + NaOH \rightarrow CH_3CHOHCOONa + H_2O$ [1]

(ii) moles NaOH = 24.3 × 1.0 / 1000 = 0.0243 mole
moles lactic acid = 0.0243 in 25 cm^3
concentration = 0.0243 × 40 = 0.972 ($mol\,dm^{-3}$)
Each error [-1], carry error through [3]

(iii) 0.972 × 90 = 87.48($g\ dm^{-3}$)
Each error [-1], carry error through [2]

(iv) phenolphthalein [1]

(d)

C	H	O	
58.7	9.8	31.5	
4.89	9.8	1.97	divide by RAM
5	10	2	

$C_5H_{10}O_2$
Each error [-1], carry error through [3]

(e) **(i)**
$CH_3(CH_2)_{16}COOCH_2$
|
$CH_3(CH_2)_{16}COOCH$
|
$CH_3(CH_2)_{16}COOCH_2$ [2]

					AVAILABLE MARKS
		(ii)	number of mg of potassium hydroxide [1] needed to neutralise the fatty acids formed by complete hydrolysis [1] of 1g of fat [1] high value indicates fatty acid groups have low RMM/short chain [1]	[4]	30
14	(a)	(i)	0	[1]	
		(ii)	2-hydroxypropane-1,2,3-tricarboxylic acid	[2]	
	(b)	(i)	$CH_2(COOH)C(OH)(COOH)CH_2COOH + 3NaHCO_3 \rightarrow$ $CH_2(COONa)C(OH)(COONa)CH_2COONa + 3H_2O + 3CO_2$ unbalanced / not using excess = [-1]	[2]	
		(ii)	no fizzing / effervescence / temp. would stop decreasing	[1]	
		(iii)	standard [1] entropy change [1]	[2]	
		(iv)	ΔG must be negative [1] term $T\Delta S > \Delta H$ / $T\Delta S$ more positive than ΔH [1]	[2]	
	(c)	(i)	$CH_2(COOH)C(OH)(COOH)CH_2COOH \rightarrow$ $CH_2(COOH)C(OH)(COOH)CH_2COO^- + H^+$	[1]	
		(ii)	$K_a = [RCOO^-][H^+] / [RCOOH]$	[1]	
		(iii)	$K_a = [H^+]^2 / 0.1 = 8.4 \times 10^{-4}$ $[H^+]^2 = 8.4 \times 10^{-5}$ $[H^+] = 0.009165 = 2.038$ Each error [-1], carry error through	[3]	15
15	(a)	(i)	moves to lhs / decreases yield [1] to reduce pressure / volumes / number of gaseous particles [1]	[2]	
		(ii)	moves to rhs / increases yield [1] to remove thermal energy / reduce temperature / favours endothermic change [1]	[2]	

AVAILABLE MARKS

(iii) $Kc = [C_2F_4][HCl]^2 / [CHClF_2]^2$

	$CHClF_2$	C_2F_4	HCl
start	0.2	0	0
eqm	0.04	0.08	0.16
conc	0.008	0.016	0.032

$K_c = (0.016) \times (0.032)^2 / (0.008)^2$
$= 0.256$ mol dm^{-3}
units [1]
Each error [-1], carry error through [4]

(iv) produces energy [1]
less land or landfill sites needed / reduces visual impact [1] [2]

(b) (i) $Na^+(g) + F(g) + e^-$ [1]
$Na^+(g) + \frac{1}{2}F_2(g) + e^-$ [1]
$Na(g) + \frac{1}{2}F_2(g)$ [1]
$Na(s) + \frac{1}{2}F_2(g)$ [1] [4]

(ii) $-574 + \Delta H_{latt} = 107 + 496 + 158/2 - 333 = 349$
$\Delta H_{latt} = 349 + 574$
$= 923$ kJ mol^{-1}
Each error [-1], carry error through
Use of negative sign [-1] [2]

(iii) $1s^22s^22p^6$ [1]
$1s^22s^22p^6$ [1] [2] 18

Total **100**

New Specification

Rewarding Learning

Centre Number

71	

Candidate Number

ADVANCED
General Certificate of Education
2010

Chemistry

Assessment Unit A2 1

assessing

Periodic Trends and Further Organic, Physical and Inorganic Chemistry

[AC212]

FRIDAY 21 MAY, AFTERNOON

AC212

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**. Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 120.
Quality of written communication will be assessed in Question **14(c)(i)**.
In Section A all questions carry equal marks, i.e. **two** marks 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 (including some data) is provided.

For Examiner's use only	
Question Number	**Marks**
Section A	
1–10	
Section B	
11	
12	
13	
14	
15	
16	
Total Marks	

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 The mechanism of the reaction

$$CH_3CH_2CHO + HCN \rightarrow CH_3CH_2CH(OH)CN$$

is described as

A electrophilic addition.
B electrophilic substitution.
C nucleophilic addition.
D nucleophilic substitution.

2 Which one of the following indicators would be suitable for a titration between molar solutions of sulphuric acid and ammonia?

		pH range
A	malachite green	0.2–1.8
B	methyl yellow	2.9–4.0
C	thymolphthalein	8.3–10.6
D	alizarin yellow	10.1–13.0

3 Methanol is manufactured by the reaction of carbon monoxide with hydrogen:

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \qquad \Delta H = -91\ kJ$$

The reaction is carried out at 250 °C and 50 atmospheres pressure. Which one of the following changes to the conditions would maximise the equilibrium yield of methanol?

	temperature	**pressure**
A	increase	increase
B	increase	decrease
C	decrease	increase
D	decrease	decrease

4 The partition coefficient, K_d, of an organic compound X between ether and water is 20.0. An aqueous solution of X containing 3.0 g in 250 cm^3 of solution was subject to solvent extraction. What mass of X was extracted on shaking with 50 cm^3 of ether?

A 0.14 g
B 0.60 g
C 2.40 g
D 2.86 g

5 What is the conjugate base of the acid HCO_3^-?

A CO_3^{2-}
B H_2CO_3
C H_3O^+
D OH^-

6 The decomposition of calcium carbonate is represented by the following equation:

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$

$\Delta H^{\ominus} = +178\ kJ\,mol^{-1}$
$\Delta S^{\ominus} = +161\ JK^{-1}\,mol^{-1}$

What is the standard free energy change, $\Delta G^{\ominus}$, for this reaction at 25 °C?

A $-48\ kJ\,mol^{-1}$
B $+130\ kJ\,mol^{-1}$
C $+174\ kJ\,mol^{-1}$
D $+339\ kJ\,mol^{-1}$

7 The compound $CH_3CH(OH)CH_2COOCH_3$ is found in marshmallows. Which one of the following statements is **incorrect**?

A Hydrolysis of the compound produces methanol as one of the products.
B The compound has only one chiral centre.
C The compound turns acidified potassium dichromate(VI) green on warming.
D The compound produces a silver mirror when heated with Tollen’s reagent.

8 Ethanedioic acid has the structure:

$$\begin{array}{c} COOH \\ | \\ COOH \end{array}$$

What volume of 0.5 M sodium hydroxide solution is required to completely neutralise 25.0 cm^3 of 0.25 M aqueous ethanedioic acid?

A 6.25 cm^3
B 12.50 cm^3
C 25.00 cm^3
D 50.00 cm^3

9 Propanone reacts with 2,4-dinitrophenylhydrazine to form a solid derivative. What is the relative molecular mass of this derivative?

A 235
B 237
C 238
D 241

10 X and Y react according to the equation

$$X + 2Y \rightarrow XY_2$$

The rate law was found by experiment to be

$$\text{Rate} = k[Y]^2$$

Which one of the following would be a possible mechanism for the reaction?

A $X + Y \rightarrow XY$ (fast); $XY + Y \rightarrow XY_2$ (slow)

B $Y + Y \rightarrow Y_2$ (slow); $Y_2 + X \rightarrow XY_2$ (fast)

C $X + Y + Y \rightarrow XY_2$ (slow)

D $X + Y \rightarrow XY$ (slow); $XY + Y \rightarrow XY_2$ (fast)

Section B

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

Examiner Only	
Marks	Remark

11 Ammonium nitrate is an important fertiliser which also finds use in explosives.

(a) Ammonium nitrate is produced by the reaction of ammonia with nitric acid.

(i) Write the equation for this reaction.

____ [1]

(ii) State and explain whether an aqueous solution of ammonium nitrate is acidic, neutral or alkaline.

____

____ [2]

(iii) The nitrate(V) ion, NO_3^-, is trigonal planar and contains a single covalent bond, a double covalent bond and a dative (co-ordinate) bond. Draw a dot and cross diagram to show the bonding in the nitrate(V) ion.

[2]

(b) Ammonium nitrate decomposes on heating to form nitrogen(I) oxide and water.

(i) Write the equation for this decomposition.

____ [1]

(ii) This reaction is exothermic and has a positive entropy change. Explain why this process is spontaneous at all temperatures.

____

____ [1]

(c) Ammonium nitrate is an artificial fertiliser.

Examiner Only	
Marks	Remark

(i) State **one** advantage of artificial fertilisers compared to natural ones.

____ [1]

(ii) Calculate the percentage of nitrogen in ammonium nitrate.

____

____

____ [2]

(d) Moderately high nitrate(V) concentrations in drinking water can result in methaemoglobinaemia in babies, the so-called "Blue-Baby" Syndrome.

(i) Explain how nitrate(V) ions enter public water supplies.

____

____ [1]

(ii) Concentrations of nitrate(V) ions in drinking water above 0.05 $mg\,cm^{-3}$ can result in "Blue-Baby" Syndrome. Calculate the molarity of this solution.

____

____

____ [3]

(iii) Nitrate(V) ions are reduced to nitrate(III) ions by bacteria. The nitrate(III) ions subsequently react with iron(II) ions in haemoglobin.

$$Fe^{2+} + NO_2^- + 2H^+ \rightarrow Fe^{3+} + NO + H_2O$$

With reference to oxidation numbers, explain why this equation is an example of a redox reaction.

____

____ [2]

12 Propanoic acid is a weak acid which finds use in buffer solutions and in the preparation of esters.

(a) Propanoic acid has a pK_a value of 4.87. Calculate the pH of a 0.05 M solution of the acid.

[4]

(b) A buffer solution may be made up by mixing propanoic acid and sodium propanoate in aqueous solution. With the aid of relevant equations, explain how this buffer resists a change in pH on addition of a small amount of acid.

[4]

(c) Methyl propanoate may be prepared in the laboratory by the reaction of propanoic acid and methanol.

(i) Write the equation for the preparation of methyl propanoate.

[1]

(ii) Concentrated sulphuric acid is added to the reaction mixture. State **one** function of this acid in the preparation.

[1]

Examiner Only	
Marks	Remark

(iii) Propanoic acid has a boiling point of 141 °C, while that of methyl propanoate is only 79 °C despite its higher relative formula mass. Explain the difference in the two boiling points.

____

____

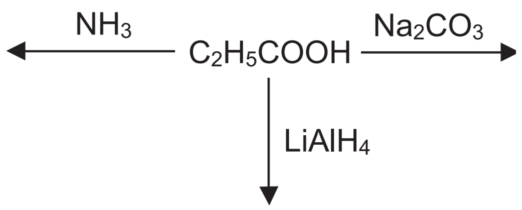
____ [2]

(iv) Propanoyl chloride may be used in place of propanoic acid for this preparation. State **two** advantages of using the acyl chloride.

____

____ [2]

(d) Complete the diagram below by inserting the organic product formed in each case.



[3]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

13 On crossing the third period of the Periodic Table, from sodium to chlorine, the change in character from metallic to non-metallic is clearly evident in the elements and their compounds.

(a) Using **only** third period elements answer the following questions.

(i) Name the element which forms an oxide in which it has an oxidation state of +6.

____ [1]

(ii) Name the oxide which has the highest melting point.

____ [1]

(iii) State the formula of the chloride which in its solid form contains both ionic and covalent bonds.

____ [1]

(iv) Classify the following oxides as acidic, amphoteric or basic.

oxide	classification
magnesium	
silicon	
phosphorus	

[3]

(b) Gallium is a Group III element which Mendeleev predicted would be similar to aluminium despite not having been discovered when he constructed his original Periodic Table.

(i) Gallium oxide is neutralised by hydrochloric acid. Write the equation for this reaction.

____ [2]

(ii) Gallium chloride dimerises in a similar way to aluminium chloride thus resulting in the formula Ga_2Cl_6. Draw a dot and cross diagram, using outer shells only, to show the bonding in Ga_2Cl_6.

[2]

14 Iodine is an essential element for healthy growth and fertility in animals.

Examiner Only	
Marks	Remark

(a) The element may be prepared in the laboratory by heating potassium iodide with concentrated sulphuric acid and manganese(IV) oxide. Iodine, potassium hydrogensulphate, manganese(II) sulphate and water are formed. Write the equation for this preparation.

____ [2]

(b) Iodine reacts with propanone in an acid catalysed reaction.

$$CH_3COCH_3 + I_2 \rightarrow CH_3COCH_2I + HI$$

The rate law was determined to be:

$$\text{Rate} = k[CH_3COCH_3][H^+]$$

(i) Name the instrument which could be used to measure the concentration of iodine in conjunction with a calibration curve.

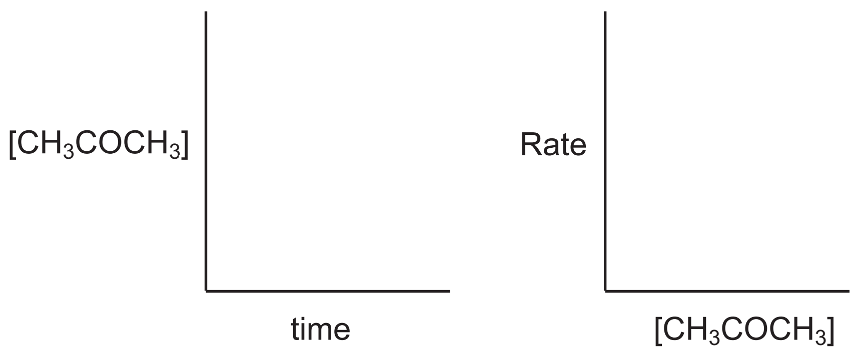
____ [1]

(ii) State what the symbol k represents and deduce its units.

k ____

units ____ [2]

(iii) On the axes below, sketch the expected shape of the graphs for this reaction.

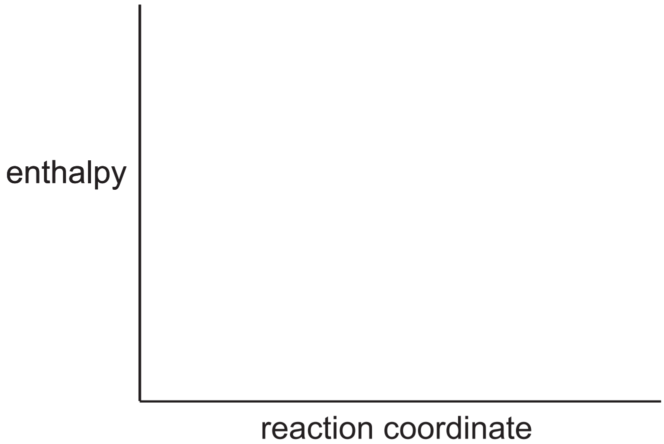


[2]

(iv) Deduce the overall effect of doubling the initial concentrations of propanone, iodine and acid on the initial rate of reaction.

____ [1]

(v) On the axes below, draw an enthalpy level diagram for the reaction labelling both the catalysed and uncatalysed pathways, assuming the reaction is exothermic.



[2]

(vi) Suggest what effect, if any, the use of a catalyst will have on the value of k for this reaction at a given temperature.

____ [1]

(c) The iodine value of a fat or oil provides information about its structure.

(i) Describe, with experimental detail, how you would determine the iodine value of a sample of linseed oil. Details on calculations should not be given.

____

____

____

____

____

____

____

____ [5]

Quality of written communication [2]

(ii) Linseed oil has a relatively low iodine value. What does this tell you about its structure?

____ [1]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

(d) Hydrogen and iodine react to form hydrogen iodide according to the equation:

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

Equimolar amounts of hydrogen and iodine were allowed to reach equilibrium at a given temperature. At equilibrium 75% of the hydrogen, by mass, had been converted to hydrogen iodide.

(i) Calculate K_c for this reaction and state its units.

____

____

____ [3]

(ii) Explain why the volume of the container was not needed to calculate K_c for this reaction.

____ [1]

(iii) Calculate the value of K_c for the reverse reaction at the same temperature.

____ [1]

(e) Lead(II) iodide is a bright yellow solid produced by mixing solutions of lead(II) nitrate and potassium iodide. 50.0 cm^3 of 0.4 M potassium iodide were mixed with excess lead(II) nitrate solution. The precipitate was filtered, washed, dried and found to weigh 3.8 g. Calculate the percentage yield.

$$Pb(NO_3)_2(aq) + 2KI(aq) \rightarrow PbI_2(s) + 2KNO_3(aq)$$

____

____

____

____ [3]

BLANK PAGE

(Questions continue overleaf)

15 Sea water contains over 3% by mass of dissolved chlorides such as sodium and magnesium.

Examiner Only	
Marks	Remark

(a) Chlorine exhibits a wide range of oxidation states in its compounds. Deduce the oxidation state of chlorine in each of the compounds below.

Cl_2O_7 ______________________________

$HClO_2$ ______________________________ [2]

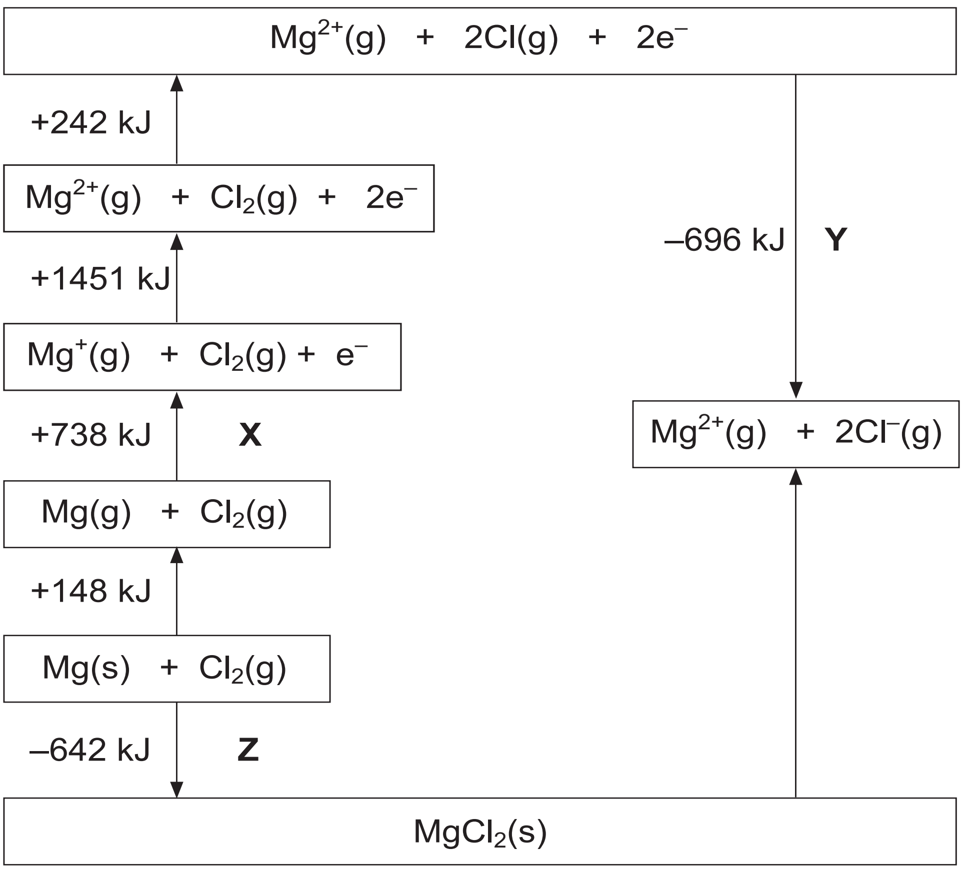
(b) Magnesium chloride is an ionic compound.

(i) State the electronic configuration of a magnesium ion and a chloride ion in the ground state using the s, p and d notation.

magnesium ion, Mg^{2+} ______________________________

chloride ion, Cl^- ______________________________ [2]

(ii) The Born-Haber cycle for the formation of magnesium chloride is shown below.



Name the energy changes X, Y and Z.

X ______________________________

Y ______________________________

Z ______________________________ [3]

(iii) Calculate the lattice enthalpy for magnesium chloride.

____

______________________________ [2]

(c) Both thionyl chloride, $SOCl_2$, and phosphorus pentachloride react with carboxylic acids to yield the same organic product.

(i) Write equations to show the reaction of both thionyl chloride and phosphorus pentachloride with butanoic acid.

____

______________________________ [2]

(ii) Explain the advantage of using thionyl chloride instead of phosphorus pentachloride in the preparation of an acyl chloride.

____

______________________________ [2]

(d) Sulphuryl chloride, SO_2Cl_2, dissociates at high temperatures according to the equation:

$$SO_2Cl_2(g) \rightleftharpoons SO_2(g) + Cl_2(g) \qquad \Delta H = +93 \text{ kJ mol}^{-1}$$

(i) State and explain the effect of increasing the temperature on the extent of dissociation.

____

______________________________ [2]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

(ii) State and explain the effect of increasing the total pressure on the extent of dissociation.

____

____ [2]

(iii) When 2.0 moles of sulphuryl chloride were allowed to dissociate at a given temperature, the equilibrium mixture was found to contain 1.5 moles of chlorine at a total pressure of 150 kPa. Calculate the value of the equilibrium constant K_p for this reaction and state its units.

____

____

____

____

____

____ [4]

(e) Sulphuryl chloride is rapidly hydrolysed by water.

$$SO_2Cl_2 + 2H_2O \rightarrow H_2SO_4 + 2HCl$$

Calculate the pH of the solution made by dissolving 135 g of sulphuryl chloride in water to make 1 dm^3 of solution.

____

____

____ [3]

Examiner Only	
Marks	Remark

16 Aldehydes are so named because they can be obtained from alcohols ("al") by dehydrogenation ("dehyd") using a finely divided copper catalyst at 300 °C.

(a) Write the equation for the dehydrogenation of ethanol to ethanal.

____ [1]

(b) Ethanal reacts with cold dilute potassium carbonate solution to yield 3-hydroxybutanal, $CH_3CH(OH)CH_2CHO$ which is optically active.

(i) Explain the term **optically active**.

____

____ [2]

(ii) Draw the three-dimensional structures for the two optical isomers of 3-hydroxybutanal.

[2]

(ii) 3-hydroxybutanal may be dehydrated to form but-2-enal. Suggest a structure for but-2-enal.

[1]

THIS IS THE END OF THE QUESTION PAPER

Published Mark Schemes for GCE A2 Chemistry

Summer 2010

Issued: October 2010

NORTHERN IRELAND GENERAL CERTIFICATE OF SECONDARY EDUCATION (GCSE) AND NORTHERN IRELAND GENERAL CERTIFICATE OF EDUCATION (GCE)

MARK SCHEMES (2010)

Foreword

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 16- and 18-year-old 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 a 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.

The Council hopes that the mark schemes will be viewed and used in a constructive way as a further support to the teaching and learning processes.

CONTENTS

New Specification

Rewarding Learning

ADVANCED
General Certificate of Education
2010

Chemistry

Assessment Unit A2 1

assessing

Periodic Trends and Further Organic, Physical and Inorganic Chemistry

[AC212]

FRIDAY 21 MAY, AFTERNOON

MARK SCHEME

		AVAILABLE MARKS

Section A

1 C

2 B

3 C

4 C

5 A

6 B

7 D

8 C

9 C

10 B

[2] for each correct answer	[20]	20
	Section A	**20**

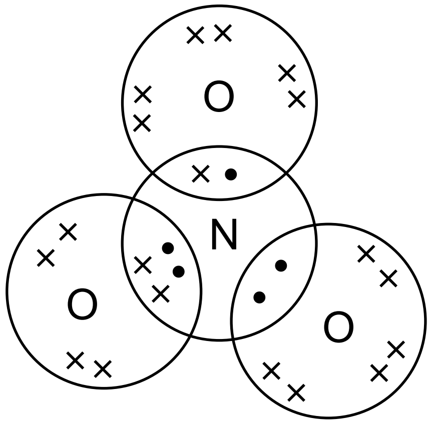
AVAILABLE MARKS

Section B

11 **(a)** **(i)** $NH_3 + HNO_3 \rightarrow NH_4NO_3$ [1]

(ii) acid [1]
salt of strong acid and weak base [1] [2]

(iii)



each error [–1] [2]

(b) **(i)** $NH_4NO_3 \rightarrow N_2O + 2H_2O$ [1]

(ii) ΔG always negative [1]

(c) **(i)** volume / smell / storage / composition [1]

(ii) mass NH_4NO_3 = 80

%N = (2 × 14 / 80) × 100

= 35%

award [2] directly for correct answer, each error [–1] [2]

(d) **(i)** leaching of fertilisers / detergents [1]

(ii) $= 0.05 \times 10^{-3}$g per cm^3

= 0.05 g per dm^3

= 0.05/62

$= 8.06 \times 10^{-4}$ M

each error [–1], carry error through [3]

(iii) iron +2 to +3 oxidation [1]
nitrogen reduction +3 to +2 [1] [2] 16

AVAILABLE MARKS

12 **(a)** $pK_a = 4.87$

$K_a = 1.35 \times 10^{-5}$ mol dm^{-3}

$K_a = [CH_3CH_2COO^-][H^+] / [CH_3CH_2COOH]$

$1.35 \times 10^{-5} = [H^+]^2 / 0.05$

$[H^+]^2 = 6.74 \times 10^{-7}$

$[H^+] = 8.2 \times 10^{-4}$

$pH = -\log(8.2 \times 10^{-4})$

pH = 3.09 **or** 3.085 **or** 3.1

each error [–1], carry error through [4]

(b) $CH_3CH_2COOH \rightleftharpoons CH_3CH_2COO^- + H^+$ eqn 1 [1]

$CH_3CH_2COONa \rightarrow CH_3CH_2COO^- + Na^+$ eqn 2 [1]

add acid

pushes equilibrium 1 to lhs / H^+ react with $CH_3CH_2COO^-$ [1]

salt acts as a source of $CH_3CH_2COO^-$ [1]

to a maximum of 4 [4]

(c) **(i)** $CH_3CH_2COOH + CH_3OH \rightleftharpoons CH_3CH_2COOCH_3 + H_2O$ [1]

(ii) catalyst / increases yield / pushes eqn to rhs / absorbs water [1] [1]

(iii) propanoic acid has hydrogen bonding (between O–H)
the ester has no hydrogen bonding [1]
comment on relative strengths of bonding [1] [2]

(iv) higher yield / not reversible [1]
faster [1]
other product gaseous [1]
any **two** [2]

(d) $NH_3 \rightarrow C_2H_5COONH_4$ [1]

$Na_2CO_3 \rightarrow CH_3CH_2COONa$ [1]

$LiAlH_4 \rightarrow CH_3CH_2CH_2OH$ [1] [3] 17

AVAILABLE MARKS

13 (a) (i) sulphur [1]

(ii) magnesium oxide [1]

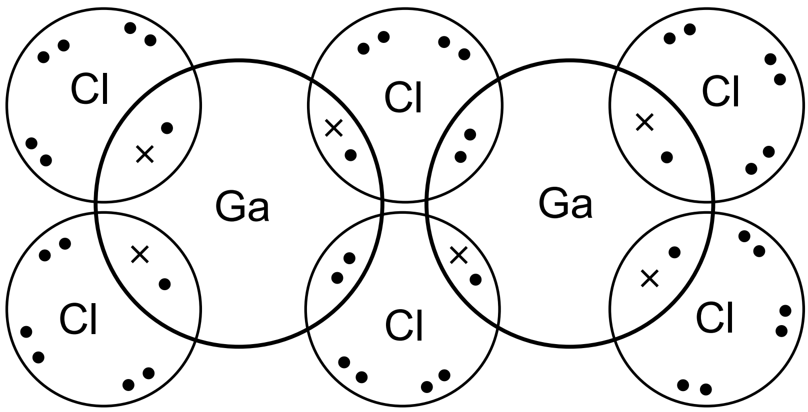
(iii) PCl_5 or $PCl_4^+PCl_6^-$ [1]

(iv) basic [1]
acidic [1]
acidic [1] [3]

(b) (i) $Ga_2O_3 + 6HCl \rightarrow 2GaCl_3 + 3H_2O$ [2]

unbalanced [–1]

(ii)



[2] 10

AVAILABLE MARKS

14 (a) $2KI + 3H_2SO_4 + MnO_2 \rightarrow I_2 + 2KHSO_4 + MnSO_4 + 2H_2O$ [2]

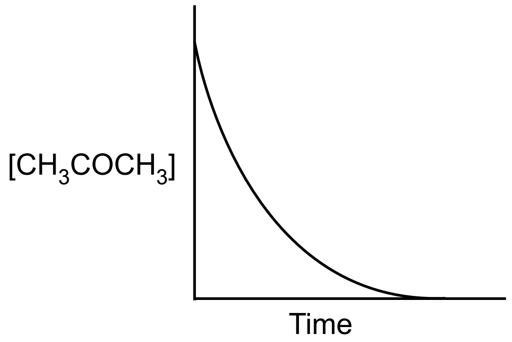
unbalanced [–1]

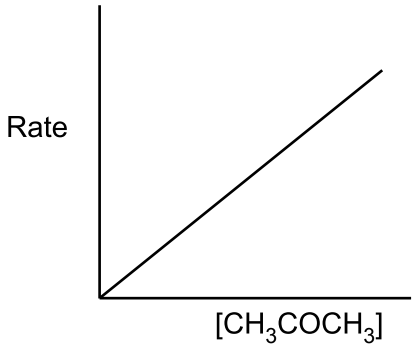
(b) (i) colorimeter [1] [1]

(ii) rate constant [1]

$dm^3mol^{-1}s^{-1}$ [1] [2]

(iii)

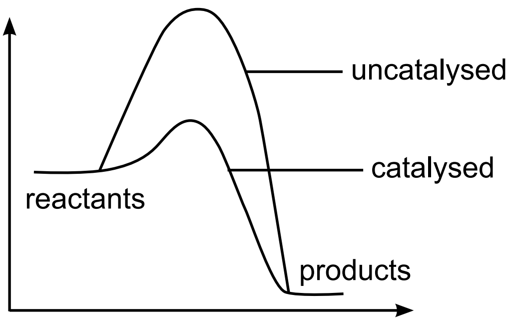




[2]

(iv) × 4 [1]

(v)



missing label [–1] [2]

(vi) increases k (as Eact is smaller) [1]

AVAILABLE MARKS

(c) **(i)** known mass of oil [1]
add Wij's solution and place in dark and add KI(aq) [1]
prepare blank [1]
titrate with standard sodium thiosulphate [1]
starch indicator [1] [5]

Quality of written communication: [2]

2 marks	The candidate expresses ideas clearly and fluently through well-linked sentences and paragraphs. Arguments are generally relevant and well-structured. There are few errors of grammar, punctuation and spelling.
1 mark	The candidate expresses ideas clearly, if not always fluently. Arguments may sometimes stray from the point. There may be some errors of grammar, punctuation and spelling, but not such as to suggest a weakness in these areas.
0 marks	The candidate expresses ideas satisfactorily, but without precision. Arguments may be of doubtful relevance or obscurely presented. Errors in grammar, punctuation and spelling are sufficiently intrusive to disrupt the understanding of the passage.

(ii) saturated / few C=C double bonds [1]

(d) **(i)** $H_2 + I_2 \rightarrow 2HI$

1 1 0

0.25 0.25 1.5

$K_c = [HI]^2 / [H_2]\,[I_2]$

$= 1.5^2 / 0.25 \times 0.25$

= 36 [2]

no units [1] [3]

(ii) volumes would cancel [1]

(iii) 0.0277 or $\frac{1}{36}$ (carry error through from part **(i)**) [1]

(e) $Pb(NO_3)_2 + 2KI \rightarrow PbI_2 + 2KNO_3$

moles KI = 50 × 0.4 / 1000 = 0.02 gives 0.01 mol PbI_2

moles PbI_2 formed = 3.8 / 461 = 0.00824

% yield = (0.00824 / 0.01) × 100

= 82.4%

award [3] for correct answer

each error [–1], carry error through [3] 27

AVAILABLE MARKS

15 **(a)** +7 [1]
+3 [1] [2]

(b) **(i)** $1s^22s^22p^6$ [1]

$1s^22s^22p^63s^23p^6$ [1] [2]

(ii) X = first ionisation energy of Mg [1]
Y = (twice) electron affinity for chlorine [1]
Z = (standard) enthalpy of formation of $MgCl_2$ [1] [3]

(iii) +148 +738 +1451 + 242 –696 = –642 + ΔH_{latt}

ΔH_{latt} = +2525 ($kJmol^{-1}$)

each error [–1] [2]

(c) **(i)** $CH_3CH_2CH_2COOH + SOCl_2 \rightarrow CH_3CH_2CH_2COCl + SO_2 + HCl$ [1]

$CH_3CH_2CH_2COOH + PCl_5 \rightarrow CH_3CH_2CH_2COCl + POCl_3 + HCl$ [1] [2]

(ii) more pure [1]
other products are gaseous [1] [2]

(d) **(i)** (increase dissociation)
increase temperature moves eqn to rhs [1]
to absorb thermal energy / endothermic direction [1] [2]

(ii) (decreased dissociation)
eqn moves to lhs [1]
to side with fewer molecules / reduce pressure [1] [2]

(iii)

SO_2Cl_2	$\rightarrow$	SO_2	+	Cl_2
2		0		0
0.5		1.5		1.5

partial pressure SO_2 = 1.5 / 3.5 × 150 = 64.285

partial pressure Cl_2 = 64.285

partial pressure SO_2Cl_2 = 0.5 / 3.5 × 150 = 21.43

$K_p = PP(SO_2) \times PP(Cl_2) / PP(SO_2Cl_2)$

$= (64.285)^2 / 21.43$

= 192.85 [3] kPa [1]

each error [–1], carry error through [4]

AVAILABLE MARKS

(e) $SO_2Cl_2 + 2H_2O \rightarrow H_2SO_4 + 2HCl$

1 mole $SO_2Cl_2 \rightarrow$ 4 moles H^+

135 g = 1 mole

$[H^+]$ = 4M

pH = –log 4

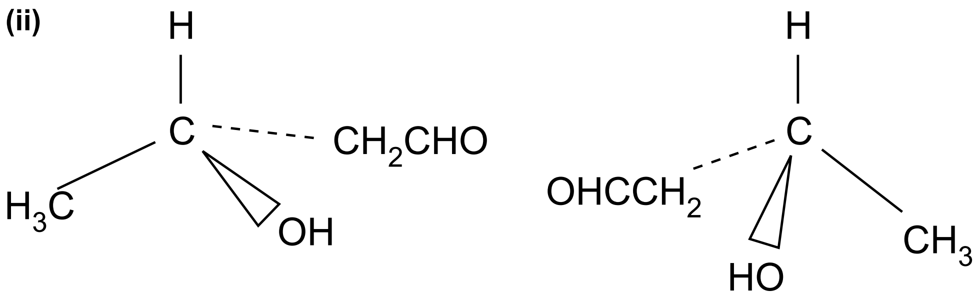
= –0.6

each error [–1], carry error through [3] 24

16 (a) $C_2H_5OH \rightarrow CH_3CHO + H_2$ [1]

(b) (i) rotate (the plane) [1]
of plane polarised light [1]
(plane must be mentioned at least once) [2]

(ii)



[2]

(iii) $CH_3—CH═CH—CHO$ [1] 6

Section B	**100**
Total	**120**

New Specification

Rewarding Learning

ADVANCED
General Certificate of Education
2010

Chemistry

Assessment Unit A2 2

assessing

Analytical, Transition Metals, Electrochemistry
and Further Organic Chemistry

[AC222]

TUESDAY 1 JUNE, AFTERNOON

MARK SCHEME

		AVAILABLE MARKS
Section A		
1 C		
2 A		
3 D		
4 C		
5 B		
6 C		
7 D		
8 D		
9 C		
10 B		
[2] for each correct answer	[20]	20
	Section A	**20**

AVAILABLE MARKS

Section B

11 (a)

Titration	Indicator	Colour change	
		from	to
Magnesium/Edta	Eriochrome black T	Red	Blue
Iodine/Thiosulphate	Starch	Blue/Black	Colourless

[1] for the correct indicator
[1] for the correct colour change [6]

(b) (i) $MnO_4^- + 8H^+ + 5Fe^{2+} \rightarrow Mn^{2+} + 4H_2O + 5Fe^{3+}$
Formulae [1], balancing [1] [2]

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

(iii) Moles of MnO_4^- = $(18.7 \times 0.01)/1000 = 1.87 \times 10^{-4}$

Moles of $FeC_4H_2O_4$ in 25 cm^3 = $(1.87 \times 10^{-4}) \times 5 = 9.35 \times 10^{-4}$

Moles of $FeC_4H_2O_4$ in 250 cm^3 = 9.35×10^{-3}

Mass of $FeC_4H_2O_4$ = $(9.35 \times 10^{-3}) \times 170 = 1.59$ g

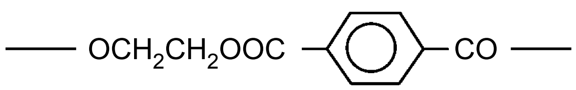
Mass of $FeC_4H_2O_4$ in 1 tablet = $1.59/5 = 0.318$ g

(4 marks, [–1] for each mistake) [4] 14

12 (a) (i) Temperature: 20–75 °C [1]
Pressure: 1–25 atmospheres [1]
Catalyst: Ziegler/titanium(IV) chloride and triethylaluminium [1] [3]

(ii) High density: (little branching/high crystallinity)/low flexibility
or
Low density: (high branching/low crystallinity)/high flexibility [2]

(b) (i)



2 marks ([–1] for each mistake) [2]

(ii) e.g. clothing/plastic bottles [1] 8

AVAILABLE MARKS

13 (a) Polydentate ligand: a ligand with more than one lone pair of electrons which forms more than one central bond (with a coordinate/dative metal) [2]

(b) (i) 4 [1]

(ii) Square planar [1]

(iii) —— : Covalent bond [1]
----- : Hydrogen bond [1]
⟶ : Dative/Co-ordinate bond [1] [3]

(c) (dimethylglyoxime) replaces 6 water molecules/
or 3 molecules → 7 molecules. [1]
This increases the overall entropy [1] [2] 9

14 (a) methyl –2, 4, 6 – trinitrobenzene [1]

(b) $2C_7H_5N_3O_6 + 10\frac{1}{2}$ or $\frac{21}{2}\,O_2 \rightarrow 14CO_2 + 3N_2 + 5H_2O$
Formulae [1], balancing [1] [2]

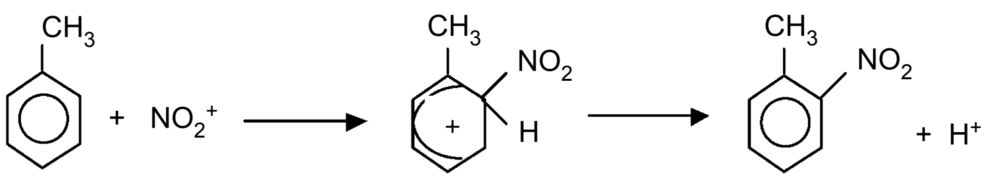
(c) (i) Concentrated nitric acid [1] and concentrated sulphuric acid [1] [2]

(ii) $HNO_3 + 2H_2SO_4 \rightarrow NO_2^+ + 2HSO_4^- + H_3O^+$
Formulae [1], balancing [1] [2]

(iii) Nitronium ion [1]

(d) (i) Electrophilic [1] substitution [1] [2]

(ii)



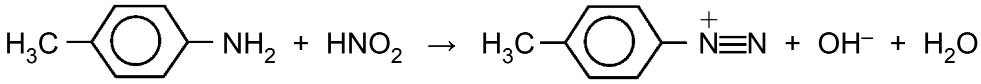
([–1] for each mistake) [2]

(e) (i) Tin [1] in (concentrated) hydrochloric acid [1] [2]

(ii) Addition of alkali to the salt [1]
([–1] for each mistake)

		AVAILABLE MARKS
(f) **(i)** $NaNO_2 + HCl \rightarrow HNO_2 + HCl$	[1]	
(ii) Below 10°C	[1]	

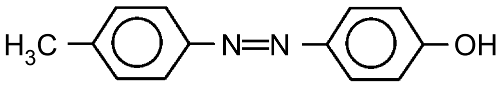
(iii)



([–1] for each mistake) [2]

(g) **(i)** Coupling [1]

(ii)



([–1] for each mistake) [2]

(iii) Conjugated (double bonds)/Delocalised/Energy levels close together [1]
Hence electron excited/move to higher energy level [1]
Removes a colour from light [1] [3] 25

15 **(a)** Transition metal atoms/ions have an incomplete d-subshell. [1]

(b) **(i)** $2SO_2 + O_2 \rightarrow 2SO_3$ [1]

(ii) It is in a different physical state from the reactants. [1]

(iii) Reactants adsorb onto the surface [1]
Bonds weakened in the reactants [1]
Bonds form in products and products are desorbed from the surface [1]
Orientation/closer together/lower activation energy [1]
Any 3 from 4 [3]

(c) **(i)**

Ion	Colour
VO_2^+ (aq)	
VO^{2+} (aq)	**Blue**
V^{3+} (aq)	**Green**
V^{2+} (aq)	

([1] each) [2]

AVAILABLE MARKS

(ii) $3VO_2^+(aq) + 6H^+(aq) + Cr(s) \rightarrow 3VO^{2+}(aq) + 3H_2O(l) + Cr^{3+}(aq)$

Formulae [1], balancing [1]

e.m.f. +1.74 V [1] [3]

(d) (i) Hydrogen peroxide [1]

(ii) Green [1] to yellow [1] [2]

(iii) Colour change from orange to yellow [1]
H^+ ions will be removed [1]
Equilibrium moves to the left [1] [3] 17

16 (a) (i) $C_{18}H_{27}O_3N$ [1]

(ii) 100 cm^3 contain 5 g
1000 cm^3 contain 50 g

$\frac{50}{305}$ = 0.164 mol dm^{-3} [3]

(b) Place sample at the corner of a chromatogram [1]
Run the chromatogram in a suitable solvent [1]
(Dry chromatogram and) run at right angles in a different solvent [1]
Development + Compare R_f values or chromatogram run with capsaicin [1]
Quality of written communication [2] [6] 10

17 (a) (i) **Primary**: sequence of amino acids [1]
Secondary: alpha helix/beta pleated sheet [1] due to the formation of a hydrogen bond between the nitrogen of one peptide bond and the oxygen of another further along the chain [1]
Tertiary: cross links between amino acids [1] due to H-bonds between amino acids/electrostatic attractions between polar groups/dipole–dipole interactions/Van der Waals forces between non-polar groups/disulphide bridges [1] [5]

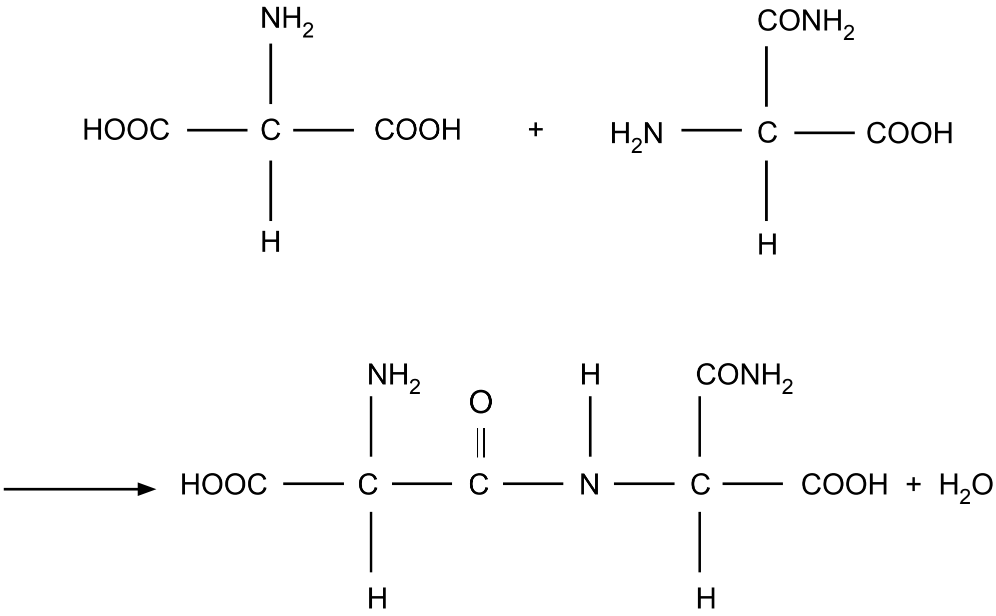
(ii) The enzyme provides an active site [1]/lock and key mechanism [1] [2]

(iii) High temperature denatures the enzyme [1]
the structure and the active site is no longer functional [1]
(disrupts the secondary and tertiary structures by breaking bonds [1])
Any **two** [2]

AVAILABLE MARKS

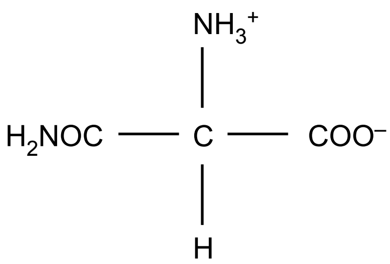
(b) (i) React with ammonia and heat the ammonium salt [1]

(ii)



([–1] for each mistake) [2]

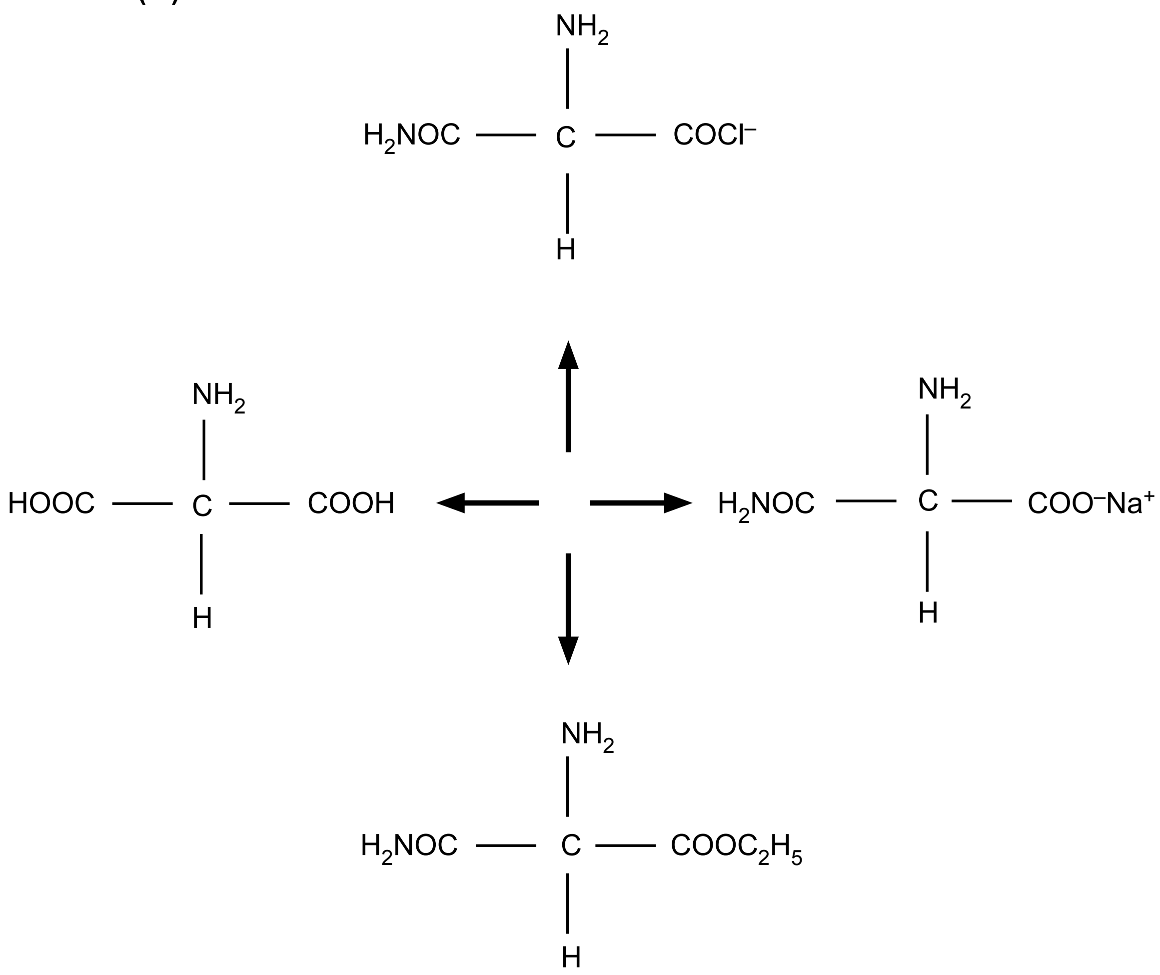
(iii)



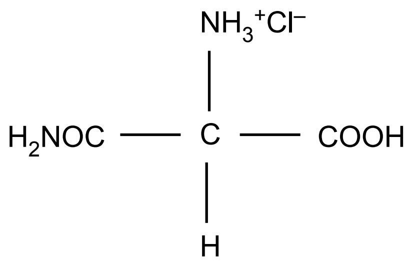
[1]

AVAILABLE MARKS

(iv)



or



([1] each) [4] 17

Section B	**100**
Total	**120**

New Specification

Rewarding Learning

ADVANCED
General Certificate of Education
2010

Chemistry

Assessment Unit A2 3

Internal Assessment
Practical Examination 1

[AC231]

THURSDAY 20 MAY

MARK SCHEME

AVAILABLE MARKS

Annotation

1. Please do all marking in red ink.
2. All scripts are checked for mathematical errors. Please adopt the 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. As candidates have access to scripts please do not write any inappropriate comments on their scripts.

1 Titration exercise

(a) **Rinse** out a pipette with the solution of potassium iodate (V) and **transfer** a known volume of the solution into a (conical) flask [1]
Add a portion of sulphuric acid and a sample of potassium iodide [1]
Rinse out the burette with the solution of sodium thiosulphate and **fill** the burette [1]
Add the solution from the burette until the solution turns a straw yellow colour [1]
Add starch indicator [1]
Continue to add the solution from the burette one drop at a time until the solution changes from blue/black to colourless [1]
Repeat for reliability [1]

To a maximum of [6]

Mark denied if:
(i) there is no mention of rinsing pipette
(ii) there is no mention of rinsing burette

(b) Table [1]
Significant figures [2]
Calculation of average titre [2]
Titration consistency [2]
Agreement with supervisor's titre [3] [10]

NOTES:

Table:

Table should include initial burette reading, final burette reading, and volume delivered. Units should be included for volume delivered (may be omitted in the other readings). Mark denied if no indication of units.

Significant figures:

All burette readings should be to at least one decimal place – each mistake is penalised by 1 mark.
(However, initial burette readings of 0 are penalised once only)
If used, the second decimal position should be 0 or 5 only – other values are penalised by 1 mark for each.

Average titre:

Values for accurate titrations only should be used.
The use of the rough value is [−1].

AVAILABLE MARKS

The average value can be two decimal places, e.g. 25.37
An incorrect calculation is 0. Units must be included.
Mark denied if:
(i) only one accurate titration done or if the titre is not calculated correctly
(ii) units not included loses one mark

Titration consistency:

This is the difference between the first and second accurate readings

Difference	Mark
±0.1	[2]
±0.2	[1]
±0.3	[0]

Titration agreement with supervisor:

This is the difference between the average titre and the supervisor's value

Difference	Marks
±0.1	[3]
±0.2	[2]
±0.3	[1]
±0.4	[0]

Please note that the supervisor's titre should be recorded at the bottom of page 3 in the candidate's script in RED INK.
The marks for table, significant figures etc should be recorded on the left-hand side of the candidate's table of results.

(c) Correct calculation of moles of sodium thiosulphate [1]
Number of moles of sodium thiosulphate divided by two [1]

(d) **(i)** $\underline{\mathbf{2}}\ IO_3^- + \underline{\mathbf{12}}\ H^+ + \mathbf{10\ e^-} \longrightarrow I_2 + \underline{\mathbf{6}}\ H_2O$

2 **12** and **6** [1]

10 e⁻ [1]

(ii) $2\ IO_3^- + 12\ H^+ + 10\ I^- \longrightarrow 6\ I_2 + 6\ H_2O$

or $IO_3^- + 6\ H^+ + 5\ I^- \longrightarrow 3\ I_2 + 3\ H_2O$ [2]

(e) Moles of iodine from **(c)** divided by 3 [1]
then multiplied by 40 (1000/25) [1]
then multiplied by RFM of KIO_3 which is 214 [1] 25

Consequential marking/carry error through (CET) to be applied in calculations e.g. incorrect ratio in (d)(ii) can be carried through into part (e).

AVAILABLE MARKS

2 Observation/deduction

There are 28 scoring points available in question 2.
However the maximum marks for this question is 25.

In Tests 3 and 5 candidates can score additional marks to those indicated – see below.

If the candidate scores more than 25 then MAX 25 should be written at beginning of question in the teacher mark column.

(a) Test 1 *Blue [1] solid*

Test 2 *Blue solution [1]*

Test 3 *White [1] precipitate [1] blue solution remains [1]*
Candidates can score all three marks

Test 4 *Blue [1] precipitate [1]*

Test 5 *Blue [1] precipitate [1]*
precipitate dissolves [1]
deep blue solution [1]
Candidates can score all four marks

Test 6 *Green [1] solution [1]*
or yellow-green

Test 2 $[Cu(H_2O)_6]^{2+}$ *[1] – square bracket essential*

Test 5 $[Cu(NH_3)_4(H_2O)_2]^{2+}$ *[1] – square bracket essential*

Test 6 $[CuCl_4]^{2-}$ *[1] – square bracket essential*

Hydrated [1]
Copper (II) sulphate [1] (Accept copper sulphate.)

(b) *2 layers* [1]
red/red-brown [1]
solid [1]

structure of propanal [1]
structure of propanone [1]

(c) *solid disappears/dissolves* [1]
bubbles/fizzes/effervescence [1]
colourless gas/solution [1]
becomes warm [1]
Max 3

structure of propanoic acid [1]
structure of ethyl methanoate [1] 25

AVAILABLE MARKS

3 Planning exercise

(a) $Sn + 2\,I_2 \longrightarrow SnI_4$ [2]
(unbalanced [–1])

(b) Want actual yield of 6.0 g (0.00957 moles)

$\therefore$ theoretical yield is 6.67g [1] (or 0.0106 moles)

moles of iodine needed 0.0212 moles [1]

mass of iodine 5.40 [1] g [1]

Correct answer gets 4 marks. Units missing from final answer [–1] [4]

(c) **(i)** gloves since iodine is corrosive or DCM is toxic [1]
no naked flame/use electrical heater since DCM is flammable [1] [2]

(ii) repeated [1] boiling and condensing [1] of a reaction mixture
(without loss of material) [2]

(d) **(i)** colour (of iodine) [1] disappears [1] [2]

(ii) filter [1] [1]

(iii) evaporate the solvent until crystals begin to appear [1]
allow to cool and then filter [1] [2]

or

distil off the solvent [1]
using a water bath/fume cupboard / crystals in flask [1]

(iv) dissolve in minimum of the hot DCM [1]
filter while hot [1]
allow filtrate to cool [1]
filter again [1] to a maximum of [3]

		AVAILABLE MARKS
Quality of written communication:		
2 marks	The candidate expresses ideas clearly and fluently through well-linked sentences and paragraphs. Arguments are generally relevant and well-structured. There are few errors of grammar, punctuation and spelling.	
1 mark	The candidate expresses ideas clearly, if not always fluently. Arguments may sometimes stray from the point. There may be some errors of grammar, punctuation and spelling, but not such as to suggest a weakness in these areas.	
0 marks	The candidate expresses ideas satisfactorily, but without precision. Arguments may be of doubtful relevance or obscurely presented. Errors in grammar, punctuation and spelling are sufficiently intrusive to disrupt the understanding of the passage. [2]	20
	Total	**70**

New Specification

Rewarding Learning

ADVANCED
General Certificate of Education
2010

Chemistry

Assessment Unit A2 3

Internal Assessment
Practical Examination 2

[AC232]

FRIDAY 21 MAY

MARK SCHEME

AVAILABLE MARKS

Annotation

1. Please do all marking in red ink.
2. All scripts are checked for mathematical errors. Please adopt the 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. As candidates have access to scripts please do not write any inappropriate comments on their scripts.

1 Titration exercise

(a) **Rinse** out a pipette with the solution of sodium iodate (V) and **transfer** a known volume of the solution into a (conical) flask [1]
Add a portion of sulphuric acid and a sample of potassium iodide [1]
Rinse out the burette with the solution of sodium thiosulphate and **fill** the burette [1]
Add the solution from the burette until the solution turns a straw yellow colour [1]
Add starch indicator [1]
Continue to add the solution from the burette one drop at a time until the solution changes from blue/black to colourless [1]
Repeat for reliability [1]

To a maximum of [6]

Mark denied if:
(i) there is no mention of rinsing pipette
(ii) there is no mention of rinsing burette

(b) Table [1]
Significant figures [2]
Calculation of average titre [2]
Titration consistency [2]
Agreement with supervisor's titre [3] [10]

NOTES:

Table:

Table should include initial burette reading, final burette reading, and volume delivered. Units should be included for volume delivered (may be omitted in the other readings). Mark denied if no indication of units.

Significant figures:

All burette readings should be to at least one decimal place – each mistake is penalised by 1 mark.
(However, initial burette readings of 0 are penalised once only)
If used, the second decimal position should be 0 or 5 only – other values are penalised by 1 mark for each.

AVAILABLE MARKS

Average titre:

Values for accurate titrations only should be used.
The use of the rough value is [−1].
The average value can be two decimal places, e.g. 25.37
An incorrect calculation is 0. Units must be included.
Mark denied if only one accurate titration done or if the titre is not calculated correctly.
Units not included loses one mark.

Titration consistency:

This is the difference between the first and second accurate readings

Difference	Mark
±0.1	[2]
±0.2	[1]
±0.3	[0]

Titration agreement with supervisor:

This is the difference between the average titre and the supervisor's value

Difference	Marks
±0.1	[3]
±0.2	[2]
±0.3	[1]
±0.4	[0]

Please note that the supervisor's titre should be recorded at the bottom of page 3 in the candidate's script in RED INK.
The marks for table, significant figures etc should be recorded on the left-hand side of the candidate's table of results.

(c) Correct calculation of moles of sodium thiosulphate [1]
Number of moles of sodium thiosulphate divided by two [1]

(d) **(i)** $\underline{\mathbf{2}}\ IO_3^- + \underline{\mathbf{12}}\ H^+ + \mathbf{10\ e^-} \longrightarrow I_2 + \underline{\mathbf{6}}\ H_2O$

<u>2</u> **<u>12</u>** and **<u>6</u>** [1]

10 e⁻ [1]

(ii) $2\ IO_3^- + 12\ H^+ + 10\ I^- \longrightarrow 6\ I_2 + 6\ H_2O$

or $IO_3^- + 6\ H^+ + 5\ I^- \longrightarrow 3\ I_2 + 3\ H_2O$ [2]

(e) Moles of iodine from **(c)** divided by 3 [1]
then multiplied by 40 (1000/25) [1]
then multiplied by RFM of $NaIO_3$ which is 198 [1] 25

Consequential marking/carry error through (CET) to be applied in calculations e.g. incorrect ratio in (d)(ii) can be carried through into part (e).

	AVAILABLE MARKS

2 Observation/deduction

There are 28 scoring points available in question 2.
However the maximum marks for this question is 25.

In Tests 3 and 5 candidates can score additional marks to those indicated – see below.

If the candidate scores more than 25 then MAX 25 should be written at beginning of question in the teacher mark column.

(a) Test 1 *Pink [1] solid – accept red or red-brown*

Test 2 *Pink solution[1]*

Test 3 *White [1] precipitate [1] pink solution remains [1]*
Candidates can score all three marks

Test 4 *Blue [1] precipitate [1]*

Test 5 *Blue [1] precipitate [1]*
precipitate dissolves [1]
yellow-brown solution [1]
Candidates can score all four marks

Test 6 *Blue [1] solution [1]*

Test 2 $[Co(H_2O)_6]^{2+}$ *[1] – square bracket essential*

Test 5 $[Co(NH_3)_6]^{2+}$ *[1] – square bracket essential*

Test 6 $[CoCl_4]^{2-}$ *[1] – square bracket essential*

Hydrated [1]
Cobalt (II) sulphate [1] (Accept cobalt sulphate.)

(b) *2 layers* [1]
red/red-brown [1]
solid [1]

structure of propanal [1]
structure of propanone [1]

(c) *solid disappears/dissolves* [1]
bubbles/fizzes/effervescence [1]
colourless gas/solution [1]
becomes warm [1]
Max 3

structure of propanoic acid [1]
structure of ethyl methanoate [1] 25

AVAILABLE MARKS

3 Planning exercise

(a) $C_3H_7COOH + C_4H_9OH \rightleftharpoons C_3H_7COOC_4H_9 + H_2O$

(equilibrium arrows missing [–1]) [2]

(b) Want actual yield of 0.181 moles/26.1 g [1]

∴ theoretical yield is 0.259 moles/37.3 g [1]

moles of butanoic acid needed 0.259 moles [1]

mass of butanoic acid 22.8 [1] g [1]

Correct answer gets 4 marks. Units missing from final answer [–1] [4]

(c) Procedure:

Add (excess) butan-1-ol, butanoic acid and concentrated sulphuric acid to a (round-bottomed or pear-shaped) flask [1]
Reflux the mixture [1]
distil [1]
collect at 163–167°C [1]

Safety:

Either: gloves since concentrated sulphuric acid is corrosive
Or: add concentrated sulphuric acid slowly since exothermic
Or: add anti-bump granules to promote smooth boiling [1] [5]

(d) **(i)** shake with solution of sodium carbonate / hydrogencarbonate [1]
using a separating funnel [1]
separate the two layers/release pressure [1] [3]

(ii) (shake with) suitable named anhydrous solid [1]
filter/decant [1] [2]

(iii) distillation [1]
collect at 165°C (164°–166°) [1] [2]

Quality of written communication:

		AVAILABLE MARKS
2 marks	The candidate expresses ideas clearly and fluently through well-linked sentences and paragraphs. Arguments are generally relevant and well-structured. There are few errors of grammar, punctuation and spelling.	
1 mark	The candidate expresses ideas clearly, if not always fluently. Arguments may sometimes stray from the point. There may be some errors of grammar, punctuation and spelling, but not such as to suggest a weakness in these areas.	
0 marks	The candidate expresses ideas satisfactorily, but without precision. Arguments may be of doubtful relevance or obscurely presented. Errors in grammar, punctuation and spelling are sufficiently intrusive to disrupt the understanding of the passage. [2]	20
	Total	**70**

Rewarding Learning

Centre Number

71	

Candidate Number

ADVANCED
General Certificate of Education
January 2011

Chemistry

Assessment Unit A2 1

assessing

Periodic Trends and Further Organic, Physical and Inorganic Chemistry

[AC212]

WEDNESDAY 26 JANUARY, MORNING

AC212

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**. Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 120.
Quality of written communication will be assessed in Question **15(b)(iii)**.
In Section A all questions carry equal marks, i.e. **two** marks 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 (including some data) is provided.

For Examiner's use only	
Question Number	**Marks**
Section A	
1–10	
Section B	
11	
12	
13	
14	
15	
16	
Total Marks	

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 When the contents of a gas cylinder containing 19 kg of propane have been completely burned the increase in atmospheric carbon dioxide is

A 19 kg
B 38 kg
C 57 kg
D 76 kg

2 For the reaction of hydrogen with nitrogen monoxide the rate equation is:

$$\text{Rate} = k[H_2][NO]^2$$

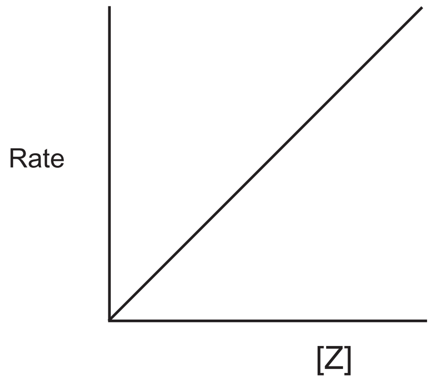
What are the units of the rate constant?

A $\text{mol}^{-1}\ \text{dm}^{3}\ \text{s}^{-1}$
B $\text{mol dm}^{-3}\ \text{s}^{-1}$
C $\text{mol}^{-2}\ \text{dm}^{-6}\ \text{s}^{-1}$
D $\text{mol}^{-2}\ \text{dm}^{6}\ \text{s}^{-1}$

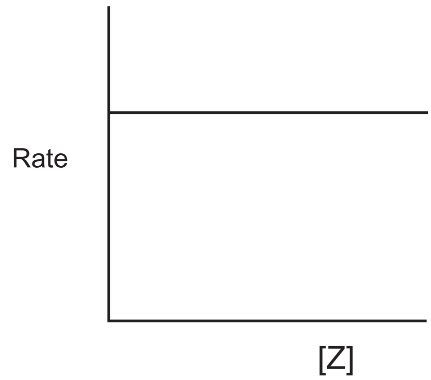
3 Which one of the following oxides has ionic bonding and reacts with water to form a strongly alkaline solution?

A Al_2O_3
B Na_2O
C P_4O_{10}
D SO_3

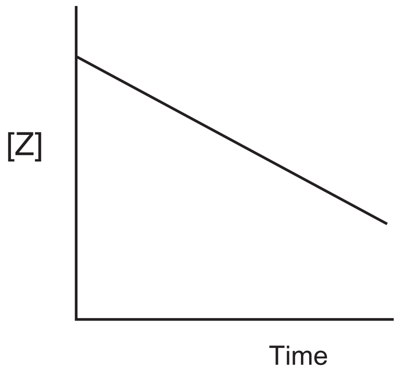
4 Which one of the following graphs shows a reaction that is first order with respect to reactant Z?



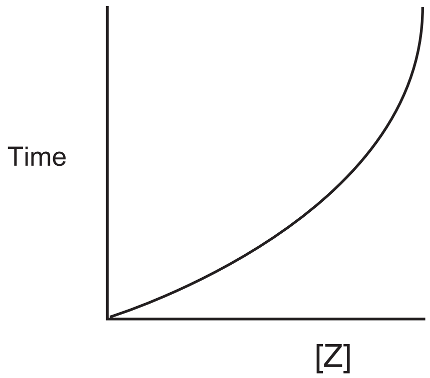
A



B



C



D

5 Which one of the following represents the units of K_c for the equilibrium shown below?

$$N_2(g) \quad + \quad 3H_2(g) \quad \rightleftharpoons \quad 2NH_3(g)$$

A mol^{-2} dm^{-6}
B mol^{-2} dm^{6}
C mol^{2} dm^{-6}
D mol^{2} dm^{6}

6 The partition coefficient of an organic acid between ether and water is 5. When 100 cm^3 of a solution containing 10 g of the acid is shaken with two successive 20.0 cm^3 portions of ether, what mass of the acid would be extracted?

A 2.5 g
B 5.0 g
C 6.0 g
D 7.5 g

7 Which one of the following organic compounds does **not** exist?

A An aldehyde with formula C_2H_4O
B An alkene with formula C_6H_{12}
C An ester with formula $C_3H_6O_2$
D A ketone with formula C_2H_4O

8 Consider the equilibrium:

$$2SO_2(g) \quad + \quad O_2(g) \quad \rightleftharpoons \quad 2SO_3(g)$$

Which one of the following is true when the total pressure of the system is increased at a constant temperature?

	Mole fraction of SO_3	**Value of K_p**
A	Increases	Decreases
B	Increases	Increases
C	Decreases	Unchanged
D	Increases	Unchanged

9 An equilibrium mixture contains 56 g of nitrogen gas, 14 g of hydrogen gas and 34 g of ammonia gas. Which one of the following is the mole fraction of hydrogen gas?

A 0.135
B 0.250
C 0.636
D 0.700

10 Which one of the following salts will dissolve to produce a solution with the highest pH?

A ammonium chloride
B ammonium ethanoate
C sodium chloride
D sodium ethanoate

Section B

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

Examiner Only	
Marks	Remark

11 Data for the reduction of iron(III) oxide by carbon, are shown in the table below.

$$2Fe_2O_3(s) \quad + \quad 3C(s) \quad \rightarrow \quad 4Fe(s) \quad + \quad 3CO_2(g)$$

Substance	$\Delta H_f^\ominus$/kJ mol^{-1}	$S^\ominus$/J K^{-1} mol^{-1}
Fe_2O_3	–824.2	87.4
C	0.0	5.7
Fe	0.0	27.3
CO_2	–393.5	213.6

(a) (i) Calculate the values of $\Delta H^\ominus$, $\Delta S^\ominus$ and $\Delta G^\ominus$ for the reaction at 298 K.

$\Delta H^\ominus$ ______________________________

____

______________________________ [2]

$\Delta S^\ominus$ ______________________________

____

______________________________ [2]

$\Delta G^\ominus$ ______________________________

____

______________________________ [1]

(ii) Using your results from part **(i)** explain why this reaction is not feasible at 298 K.

______________________________ [1]

(b) Calculate the temperature above which this reaction is feasible.

____

____

______________________________ [2]

12 The strength of the ionic bonding in compounds, such as magnesium fluoride and magnesium chloride, is related to the lattice enthalpy of the compound.

Examiner Only
Marks | Remark

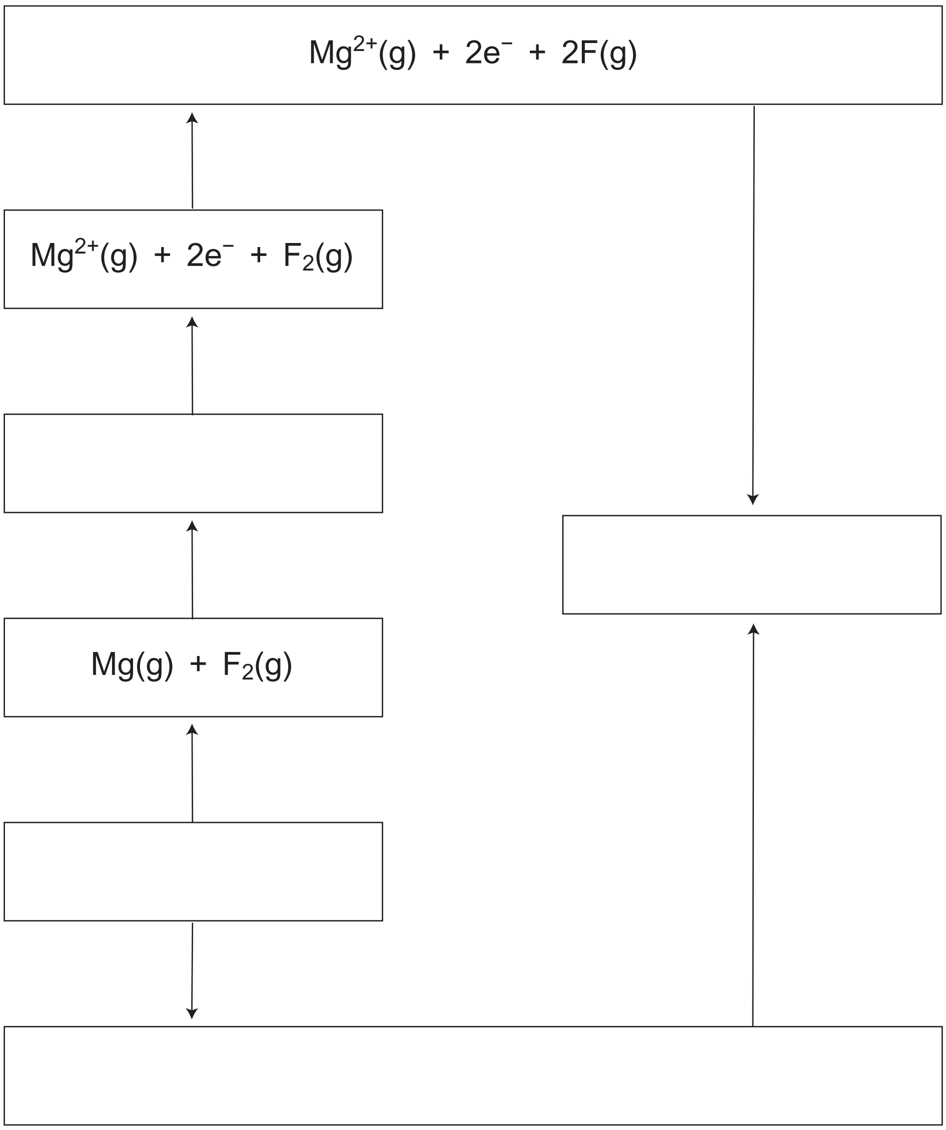
(a) Define the term **lattice enthalpy**.

____

____

____ [2]

(b) (i) Complete the Born-Haber cycle for magnesium fluoride:



[4]

(ii) Using the data given below, calculate the lattice enthalpy for magnesium fluoride.

	$kJ\,mol^{-1}$
Standard enthalpy of formation for magnesium fluoride	–1123
First electron affinity of fluorine	–348
Atomisation enthalpy of fluorine	79
First ionisation enthalpy of magnesium	736
Second ionisation enthalpy of magnesium	1450
Atomisation enthalpy of magnesium	150

____

____

____

____ [2]

(c) Magnesium fluoride and magnesium chloride are both soluble in water. Magnesium chloride has an enthalpy of solution of –155 $kJ\,mol^{-1}$.

(i) Using diagrams, show how magnesium and fluoride ions interact with water molecules in an aqueous solution of magnesium fluoride.

[2]

(ii) Given that the enthalpies of hydration of magnesium ions and chloride ions are –1920 $kJ\,mol^{-1}$ and –364 $kJ\,mol^{-1}$ respectively, calculate the lattice enthalpy of magnesium chloride.

____

____

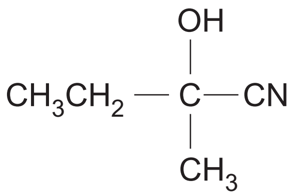
____ [2]

Examiner Only	
Marks	Remark

Examiner Only

Marks	Remark

13 Butanone reacts with hydrogen cyanide to form a product that contains an asymmetric centre.



The reaction mechanism is similar to that for the reaction between hydrogen cyanide and propanone.

(a) (i) Give the systematic name of the product.

____ [2]

(ii) What type of stereoisomerism is shown by the product?

____ [1]

(iii) Draw the 3D representations of the stereoisomers.

[2]

(iv) Name the mechanism for the reaction.

____ [1]

(v) Draw the mechanism for this reaction.

[3]

(b) Butanone can be reduced using lithal. The product is optically inactive and dehydrates to give a mixture of but-1-ene and but-2-ene.

(i) Using [H] to represent lithal, write the balanced equation for the reduction.

____ [2]

(ii) Name the product.

____ [1]

(iii) Give the meaning of the term **optically inactive**.

____

____ [1]

(iv) Suggest why the product is optically inactive.

____

____ [2]

(v) Draw and label the E and Z isomers of but-2-ene.

[2]

Examiner Only	
Marks	Remark

Examiner Only

Marks	Remark

(c) Butanal is a structural isomer of butanone. Describe, giving practical details, how you would carry out a chemical test to distinguish between samples of butanal and butanone.

____

____

____

____

____

____ [3]

(d) 2,4-dinitrophenylhydrazine reacts with both butanone and butanal to form 2,4-dinitrophenylhydrazones.

(i) Write the equation for the reaction of butanone with 2,4-dinitrophenylhydrazine.

[3]

(ii) What would be observed in the reaction?

____

____ [2]

(iii) Explain, experimentally, how the 2,4-dinitrophenylhydrazones can be used to confirm the identity of the reactants.

[4]

Examiner Only

Marks	Remark

14 At 25 °C, the acid dissociation constant, K_a, for propanoic acid is 1.35×10^{-5} mol dm^{-3}. A buffer solution can be prepared by mixing a solution of propanoic acid with a solution of sodium propanoate.

(a) **(i)** Write the expression for the acid dissociation constant of propanoic acid.

[1]

(ii) Calculate the pH of a 0.25 mol dm^{-3} solution of propanoic acid.

____

____

____

____ [3]

(iii) What is meant by the term **buffer solution**?

____

____

____ [2]

Examiner Only

Marks	Remark

(iv) Calculate the pH of the buffer solution formed when 300 cm^3 of a 0.25 mol dm^{-3} solution of propanoic acid is mixed with 200 cm^3 of a 0.15 mol dm^{-3} solution of sodium propanoate.

____

____

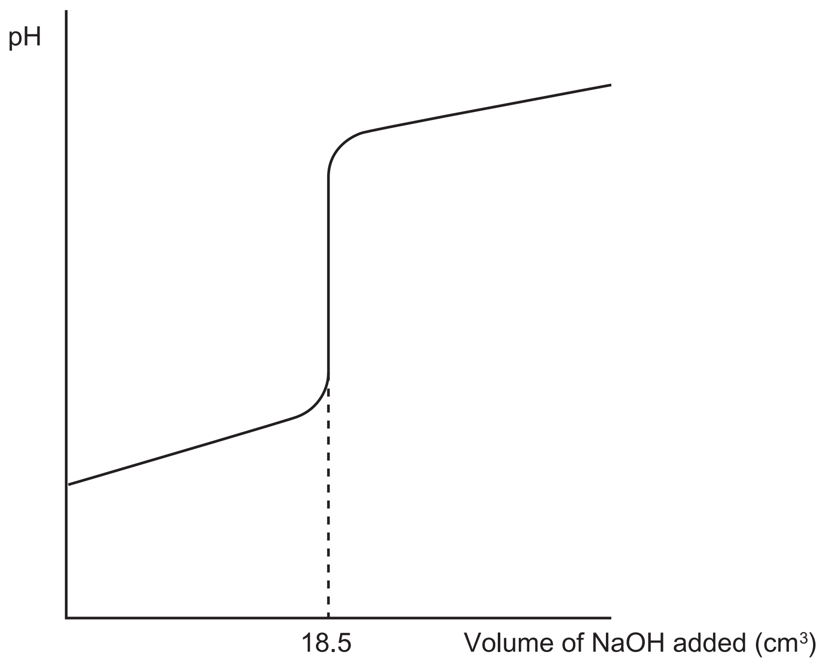
____

____

____

____ [4]

(b) The titration curve below shows the change in pH when a 0.20 mol dm^{-3} solution of sodium hydroxide is added, from a burette, to 25.0 cm^3 of a solution of propanoic acid of unknown concentration.



(i) Write the equation for the neutralisation reaction which occurs.

____ [1]

Examiner Only	
Marks	Remark

(ii) Suggest a suitable indicator for this titration. Give the colour change and explain why the indicator is suitable.

____

____

____

____ [4]

(iii) Calculate the concentration of the propanoic acid.

____

____

____

____ [3]

(iv) At 25 °C, K_w has the value 1.00×10^{-14} $mol^2 dm^{-6}$. Calculate the pH of the 0.20 $mol dm^{-3}$ solution of sodium hydroxide.

____

____

____ [2]

Examiner Only	
Marks	Remark

15 Fats and vegetable oils are triesters of long-chain carboxylic acids. Base catalysed hydrolysis of an oil produces glycerol and the sodium salt of octadeca-9,12-dienoic acid as the only products.

$$CH_3(CH_2)_4CH{=}CHCH_2CH{=}CH(CH_2)_7COOH$$

octadeca-9,12-dienoic acid

(a) **(i)** Draw the structure of glycerol.

[1]

(ii) State the systematic name for glycerol.

____ [2]

(iii) Draw the structure of the oil.

[1]

(iv) Define the term **iodine value** as applied to an oil.

____

____

____ [2]

Examiner Only	
Marks	Remark

(v) Use the definition given in part **(iv)** and the structure given in part **(iii)** to calculate the iodine value of the oil.

Examiner Only

Marks	Remark

____

____

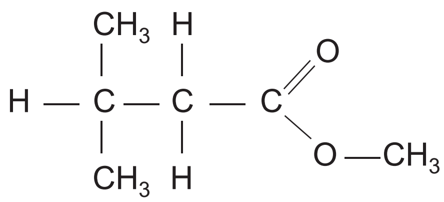
____

____

____

____ [4]

(b) Simple monoesters, such as the one shown below, can be prepared by reacting carboxylic acids with alcohols:



(i) Give the systematic names of the carboxylic acid and alcohol required to prepare this ester.

Acid ____ [1]

Alcohol ____ [1]

(ii) Write the equation for the formation of the ester.

____ [2]

(iii) Describe, giving experimental details, the preparation of a pure, dry sample of the ester.

____

____

____

____

____

____

____

____

____

____

____ [6]

Quality of written communication [2]

Examiner Only

Marks	Remark

Examiner Only	
Marks	Remark

16 The concentration of CO_2 in the atmosphere depends on natural and man-made processes.

(a) State **two** natural processes by which CO_2 concentration in the atmosphere is decreased.

____ [2]

(b) Carbon dioxide can be produced during the production of electricity.

(i) Explain why the carbon dioxide forms.

____

____

____ [2]

(ii) Industry attempts to reduce the emission of CO_2 by reacting emitted gases with alkaline slurries containing hydroxide ions. Write an equation for the reaction of aqueous carbon dioxide with OH^- ions.

____ [2]

(c) Carbon dioxide molecules in the atmosphere absorb IR radiation which leads to carbon dioxide being called a "Greenhouse" gas.

(i) Explain how CO_2 absorbs IR radiation.

____

____ [1]

(ii) Explain what a Greenhouse gas does in terms of Global Warming.

____

____

____ [2]

THIS IS THE END OF THE QUESTION PAPER

Rewarding Learning

ADVANCED
General Certificate of Education
January 2011

Chemistry

Assessment Unit A2 1

assessing

Periodic Trends and Further Organic, Physical and Inorganic Chemistry

[AC212]

WEDNESDAY 26 JANUARY, MORNING

MARK SCHEME

SECTION A

			AVAILABLE MARKS
1	C		
2	D		
3	B		
4	A		
5	B		
6	D		
7	D		
8	D		
9	C		
10	D		
[2] for each correct answer		[20]	20

SECTION B

AVAILABLE MARKS

11 **(a)** **(i)** $\Delta H^{\ominus} = \sum \Delta H_f^{\ominus}$ (products) $- \sum \Delta H_f^{\ominus}$ (reactants)
$= [3 \times -393.5] - [2 \times -824.2]$
$= 467.9$ kJ mol^{-1} [2]

$\Delta S^{\ominus} = \sum S^{\ominus}$ (products) $- \sum S^{\ominus}$ (reactants)
$= [(4 \times 27.3) + (3 \times 213.6)] - [(2 \times 87.4) + (3 \times 5.7)]$
$= 558.1$ J K^{-1} mol^{-1} [2]

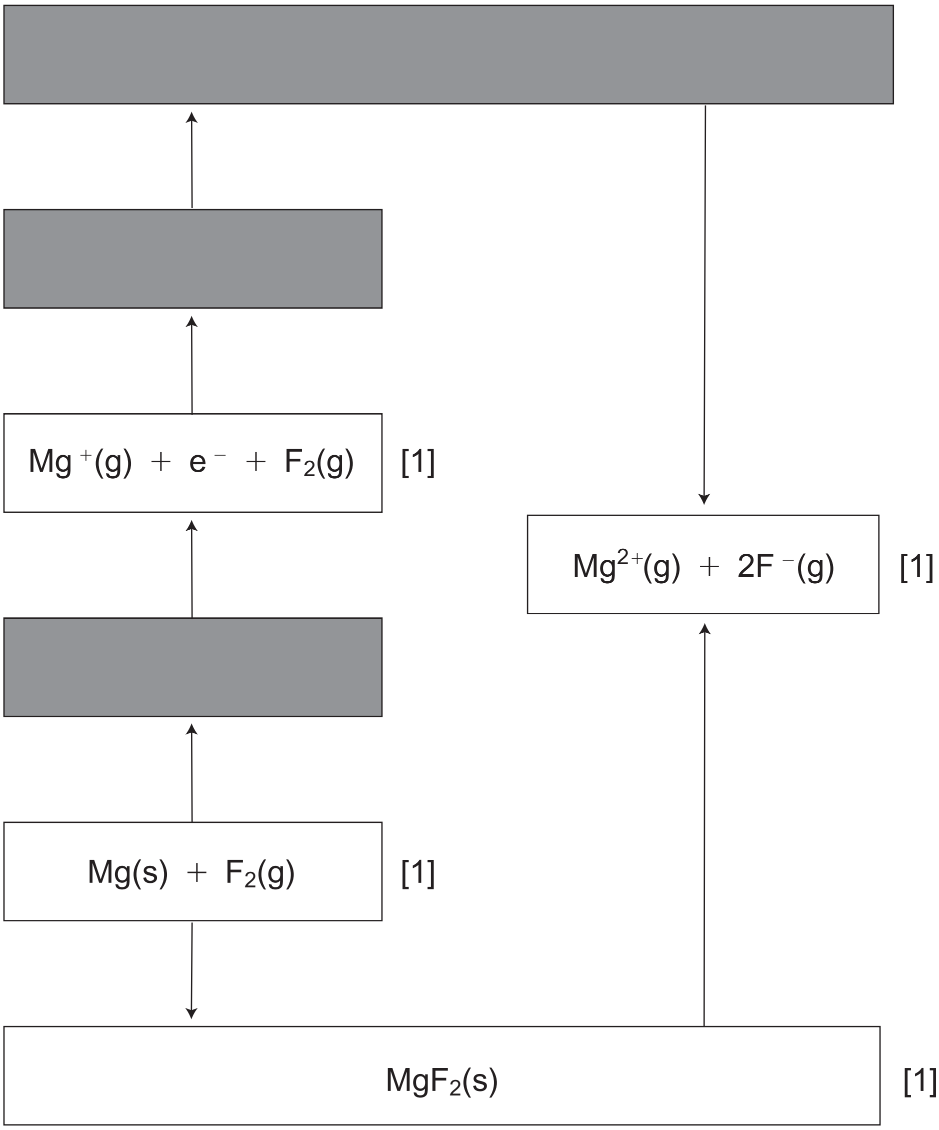
$\Delta G^{\ominus} = \Delta H^{\ominus} - T\,\Delta S^{\ominus}$
$= 467.9 - (298 \times 0.5581)$
$= 301.6$ kJ mol^{-1} [1]

(ii) $\Delta G^{\ominus}$ is positive [1]

(b) $T = (\Delta H^{\ominus} \div \Delta S^{\ominus})$
$= (467.9 \div 0.5581)$
$= 838$ K [2] 8

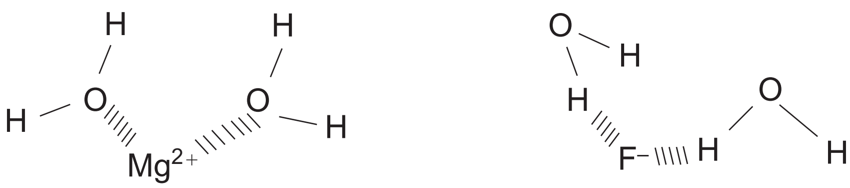
12 (a) The energy required to convert 1 mole of an ionic solid into gaseous ions [2]

(b) (i)



(ii) LE = (+1123) + (150) + (736) + (1450) + (2 × 79) + (2 × −348) = 2921 kJ mol^{-1} [2]

(c) (i)



[1] [1] [2]

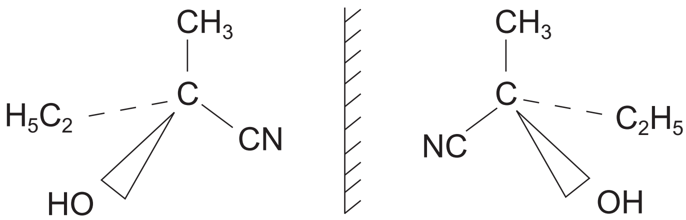
(ii) LE = (−155) − [(−1920) + (2 × −364)] = 2493 kJ mol^{-1} [2]

AVAILABLE MARKS
12

13 (a) (i) 2-hydroxy-2-methylbutanenitrile [2]

(ii) optical [1]

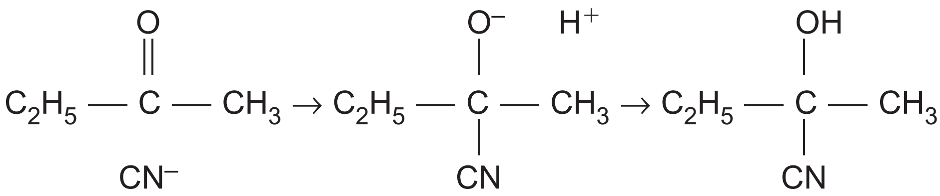
(iii)



correct 3D representation [1]
mirror image [1]

(iv) nucleophilic addition [1]

(v)



[3]

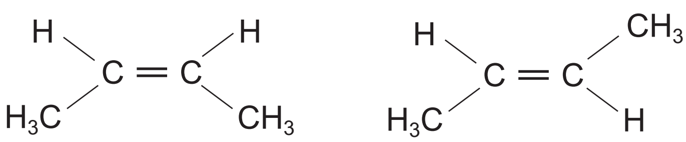
(b) (i) $CH_3COCH_2CH_3 + 2[H] \rightarrow CH_3CH(OH)CH_2CH_3$ [2]

(ii) butan-2-ol [1]

(iii) does not rotate the plane of plane polarised light [1]

(iv) the product contains equal amounts of both optical isomers [2]

(v)

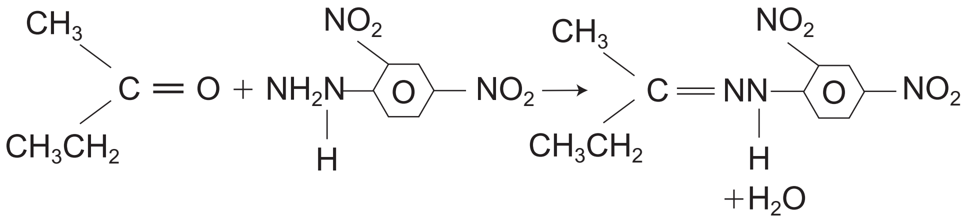


Z E

structures [1]
labels [1]

(c) Heat [1] with
either acidified potassium dichromate
Tollens' reagent or Fehling's solution [1]
Correct positive result with butanal no change with butanone [1] [3]

(d) **(i)**



[3]

(ii) yellow/orange [1] solid [1] [2]

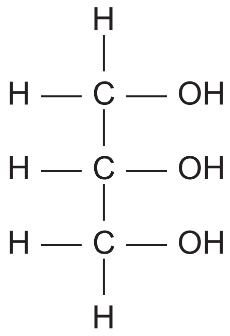
(iii) capillary tube [1]
heat slowly [1]
temp (range) when melts [1]
comparison [1] [4]

AVAILABLE MARKS

29

					AVAILABLE MARKS
14	**(a)**	**(i)**	$K_a = \dfrac{[CH_3CH_2COO^-][H^+]}{[CH_3CH_2COOH]}$	[1]	
		(ii)	$K_a = [H^+]^2 \div [CH_3CH_2COOH]$ $[H^+] = 0.00184$ pH = 2.74	[1] [1] [1]	
		(iii)	A solution which minimises changes in pH on addition of small amounts of acid or alkali	[2]	
		(iv)	Moles of acid $0.25 \times 0.3 = 0.075$ Moles of salt $0.15 \times 0.2 = 0.03$ (Concentration of acid = 0.15 moldm^{-3}) (Concentration of acid = 0.06 moldm^{-3}) $[H^+] = K_a \times$ ([acid]/[salt]) $= 3.38 \times 10^{-5}$ moldm^{-3} pH = 4.47	[4]	
	(b)	**(i)**	$CH_3CH_2COOH + NaOH \rightarrow CH_3CH_2COONa + H_2O$	[1]	
		(ii)	phenolphthalein Colourless to pink Range matches the vertical portion of the titration curve	[1] [2] [1]	
		(iii)	moles of NaOH $= 0.20 \times (18.5/1000) = 0.0037$ Moles of $CH_3CH_2COOH = 0.0037$ Concentration of $CH_3CH_2COOH = 0.148$ moldm^{-3}	[3]	
		(iv)	$[H^+] = K_w \div [OH^-] = 5 \times 10^{-14}$ moldm^{-3} pH = 13.30	[1] [1]	20

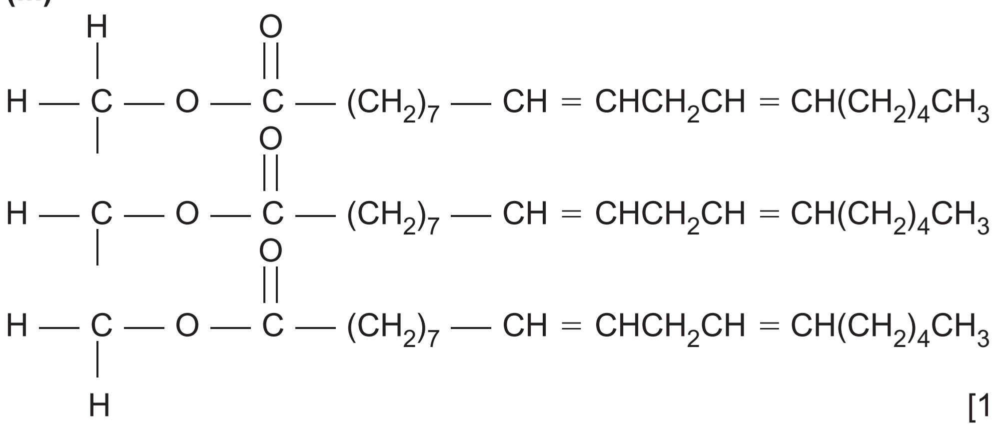
15 (a) (i)



[1]

(ii) propane-1,2,3-triol [2]

(iii)



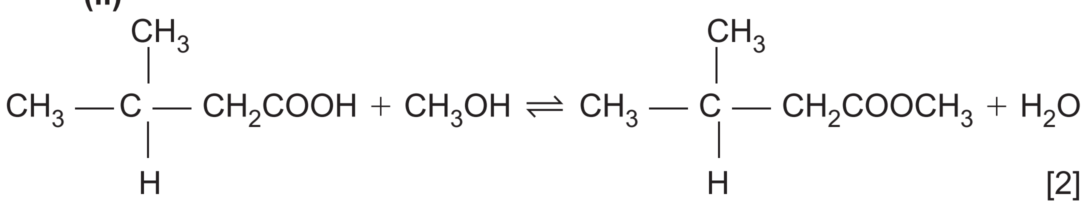
[1]

(iv) the grams of iodine [1] required to saturate 100 g of an oil [1] [2]

(v) RMM of oil = 878
Moles of oil in 100 g = 0.114
Moles of iodine required = 0.683
Mass of iodine = 174 [4]

(b) (i) 3-methylbutanoic acid [1]
Methanol [1]

(ii)



[2]

AVAILABLE MARKS

				AVAILABLE MARKS
		(iii)	Acid and alcohol into round bottomed flask and add concentrated sulphuric acid slowly [1] Add anti-bumping granules Heat under reflux [1] Distill and collect at boiling point of ester [1] Shake with aqueous sodium carbonate and release pressure [1] Separate ester layer using separating funnel [1] Add a named drying agent [1] Decant/filter [1] To a maximum of [6]	
			Quality of written communication [2]	22
16	**(a)**		Photosynthesis [1] solubility of the gas in surface waters [1]	
	(b)	**(i)**	reference to combustion [1] of (hydrocarbon) fuels [1] [2]	
		(ii)	$CO_2 + 2OH^- \rightarrow CO_3^{2-} + H_2O$ [2]	
	(c)	**(i)**	reference to $C = O$ bonds vibrating more [1]	
		(ii)	prevents IR radiation "escaping" into space [1] this causes the atmospheric temperature to increase [1]	9
			Section B	**100**
			Total	**120**

Rewarding Learning

ADVANCED
General Certificate of Education
2011

Chemistry

Assessment Unit A2 1

assessing

Periodic Trends and Further Organic, Physical and Inorganic Chemistry

[AC212]

MONDAY 23 MAY, AFTERNOON

AC212

Centre Number

71	

Candidate Number

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 number 1 to 10. Keep in sequence when answering.
Answer **all six** questions in **Section B**. Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 120.
Quality of written communication will be assessed in Question **13(a)(iv)**.
In Section A all questions carry equal marks, i.e. **two** marks 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 (including some data) is provided.

For Examiner's use only	
Question Number	**Marks**
Section A	
1–10	
Section B	
11	
12	
13	
14	
15	
16	
Total Marks	

Section A

Examiner Only	
Marks	Remark

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 oxides has a giant covalent structure?

A Al_2O_3
B Na_2O
C P_4O_{10}
D SiO_2

2 Heat is produced when magnesium reacts with sulfuric acid:

$$Mg(s) \quad + \quad H_2SO_4(aq) \quad \rightarrow \quad MgSO_4(aq) \quad + \quad H_2(g)$$

Which one of the following is true for the reaction?

A ΔS is negative
B ΔH is positive
C ΔG is positive
D the reaction is feasible at any temperature

3 Magnesium chloride has a lattice enthalpy of 2493 kJ mol^{-1} and an enthalpy of solution of -155 kJ mol^{-1}. If the enthalpy of hydration for Mg^{2+} ions is -1920 kJ mol^{-1} then the enthalpy of hydration for Cl^- ions is:

A -728 kJ mol^{-1}
B -364 kJ mol^{-1}
C $+364$ kJ mol^{-1}
D $+728$ kJ mol^{-1}

Examiner Only	
Marks	Remark

4 One mole of propanoic acid, one mole of methanol and two moles of water were mixed and allowed to reach equilibrium. At equilibrium 0.5 mole of methyl propanoate was present. The value of K_c for this reaction is

A 1.00
B 1.25
C 5.00
D 10.00

5 Propanone reacts with iodine in the presence of an acid according to the equation:

$$CH_3COCH_3(aq) \quad + \quad I_2(aq) \quad \rightarrow \quad CH_3COCH_2I(aq) \quad + \quad HI(aq)$$

The most appropriate method for investigating the rate of this reaction is

A colorimetry.
B weighing the reaction vessel.
C titrating samples with an acid.
D use a graduated syringe.

6 Which one of the following represents the units of K_c for the following equilibrium?

$$2\,SO_2(g) \quad + \quad O_2(g) \quad \rightleftharpoons \quad 2\,SO_3(g)$$

A $mol^{-1}\,dm^{-3}$
B $mol\,dm^{-3}$
C $mol^{-1}\,dm^{3}$
D $mol\,dm^{3}$

7 Which one of the following compounds reacts with both $LiAlH_4$ and PCl_5?

A CH_3CH_2OH
B CH_3CH_2CHO
C CH_3COCH_3
D CH_3CH_2COOH

8 The standard entropy change for the following reaction is $139\,J\,K^{-1}\,mol^{-1}$.

$$Fe_2O_3(s) \quad + \quad 3\,H_2(g) \quad \rightarrow \quad 2\,Fe(s) \quad + \quad 3\,H_2O(g)$$

The standard entropies of $Fe_2O_3(s)$, $H_2(g)$ and Fe(s) are 90, 131 and $27\,J\,K^{-1}\,mol^{-1}$ respectively. Which one of the following is the standard entropy of steam?

A $332\,J\,K^{-1}\,mol^{-1}$
B $189\,J\,K^{-1}\,mol^{-1}$
C $145\,J\,K^{-1}\,mol^{-1}$
D $85\,J\,K^{-1}\,mol^{-1}$

9 Butan–1–ol was reacted with an excess of propanoic acid in the presence of a small amount of concentrated sulfuric acid. 6.0 g of the alcohol produced 7.4 g of the ester. Which one of the following is the percentage yield of the ester?

A 57%
B 70%
C 75%
D 81%

10 Which one of the following chlorides has atoms joined together by coordinate bonding?

A Al_2Cl_6
B $MgCl_2$
C NaCl
D PCl_5

Examiner Only	
Marks	Remark

Section B

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

11 Ethane–1,2–diol ($HOCH_2CH_2OH$) is used in the production of polyesters.

(a) **(i)** Write an equation for the reaction of ethane–1,2–diol with excess ethanoic acid, in the presence of concentrated sulfuric acid, to form a diester.

____ [2]

(ii) Write an expression for the equilibrium constant, K_c, for the above reaction and state its units.

____ [2]

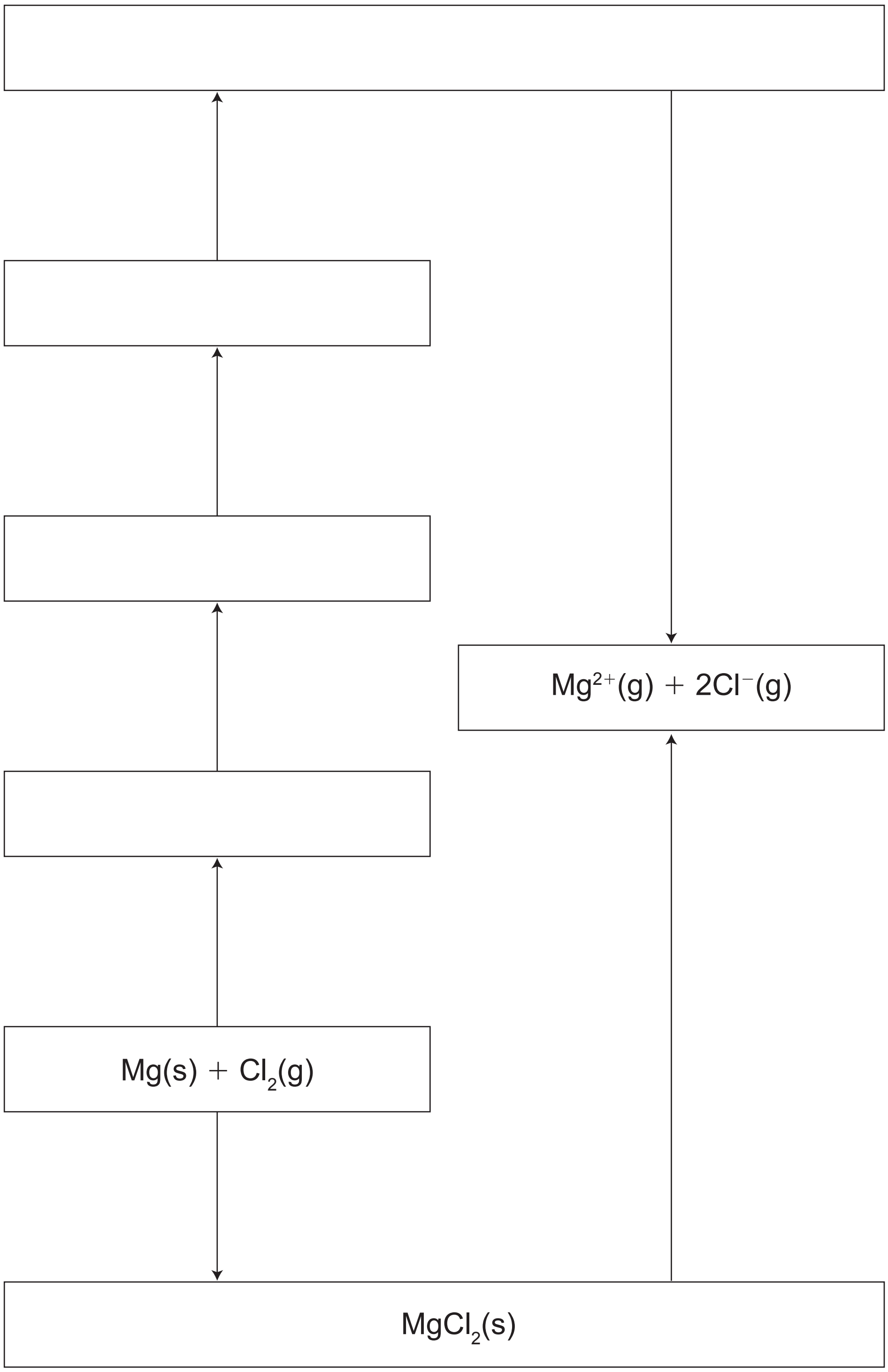
(b) Using [O] to represent an oxidising agent, write an equation for the oxidation of ethane–1,2–diol with excess oxidising agent.

____ [2]

Examiner Only	
Marks	Remark

12 Magnesium chloride is a water-soluble ionic compound formed from magnesium and chlorine.

(a) (i) Complete the Born–Haber cycle for the formation of magnesium chloride.



[4]

Examiner Only
Marks	Remark

(ii) Using the data given below, calculate the electron affinity of chlorine.

	$kJ\,mol^{-1}$
Standard enthalpy of formation for magnesium chloride	−642
Lattice enthalpy for magnesium chloride	2493
Atomisation enthalpy of chlorine	121
First ionisation enthalpy of magnesium	736
Second ionisation enthalpy of magnesium	1450
Atomisation enthalpy of magnesium	150

____

____

____

____ [2]

(b) Give the electron structure of:

magnesium ions _______________________________ [1]

chloride ions _______________________________ [1]

(c) Magnesium chloride dissolves in water and has an enthalpy of solution of $-155\,kJ\,mol^{-1}$. Define the term **enthalpy of solution**.

____

____

____ [2]

Examiner Only

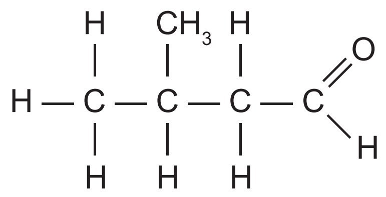
Marks	Remark

13 Simple aldehydes and ketones have the same general formula.

(a) (i) What is the general formula of an aldehyde or ketone?

____ [1]

(ii) Name the following aldehyde.



____ [1]

(iii) Draw and name **two** structural isomers of the above compound which are ketones.

Isomer 1

Name ____ [2]

Isomer 2

Name ____ [2]

Examiner Only	
Marks	Remark

(iv) Describe, with experimental details, how an aldehyde can be distinguished from a ketone.

____

____

____

____

____

____

____ [4]

Quality of written communication [2]

(v) Draw a structural isomer of the aldehyde in **(ii)** which exhibits *cis-trans* (E–Z) stereoisomerism.

[1]

(vi) Draw and label the stereoisomers of the above compound.

[3]

Examiner Only	
Marks	Remark

(b) Unknown ketones can be identified by reacting with 2,4–dinitrophenylhydrazine.

(i) Describe the appearance of the organic product formed when an unknown ketone reacts with 2,4–dinitrophenylhydrazine.

____

____ [2]

(ii) Draw the structure of the product obtained when butanone reacts with 2,4–dinitrophenylhydrazine.

[3]

(iii) How can this product be used to confirm the identity of butanone?

____

____

____

____ [2]

(iv) Using [H] to represent the reducing agent, write an equation for the reduction of butanone and name the product.

____ [3]

Examiner Only	
Marks	Remark

14 Sulfuric acid is described as a strong Brønsted–Lowry acid and sodium hydroxide as a strong Brønsted–Lowry base. Carboxylic acids contain the $-COOH$ functional group and are described as weak Brønsted–Lowry acids. The most familiar carboxylic acid is ethanoic acid, which is present in vinegar.

Examiner Only	
Marks	Remark

(a) (i) What is meant by the term **strong acid**?

____

____ [1]

(ii) What is meant by the term **Brønsted–Lowry acid**?

____

____ [1]

(iii) Write an equation to define pH.

____ [1]

(iv) Calculate the pH of a 0.20 mol dm^{-3} solution of completely ionised sulfuric acid.

____

____

____ [2]

(v) Write an equation to define K_w.

____ [1]

(vi) Calculate the pH of a 0.20 mol dm^{-3} solution of sodium hydroxide ($K_w = 1.00 \times 10^{-14}$ mol^2 dm^{-6}).

____

____

____ [2]

(vii) Write an equation for the neutralisation of sulfuric acid using sodium hydroxide.

____ [2]

(b) The acid dissociation constant, K_a, for ethanoic acid is 1.74×10^{-5} mol dm^{-3}.

(i) Write the expression for the acid dissociation constant of ethanoic acid.

[1]

(ii) Calculate the pH of a 0.20 mol dm^{-3} solution of ethanoic acid.

____

____

____

____

____ [3]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

(c) When a solution of ethanoic acid is partially neutralised using sodium hydroxide a buffer solution is formed.

(i) Write an equation for the reaction which occurs when sodium hydroxide is added to ethanoic acid.

____ [1]

(ii) Calculate the pH of the buffer solution formed when 15.0 cm^3 of a 0.20 mol dm^{-3} solution of sodium hydroxide is added to 25.0 cm^3 of a 0.20 mol dm^{-3} solution of ethanoic acid.

____

____

____

____

____

____

____ [4]

(iii) Explain how aqueous sodium ethanoate responds to the addition of a small amount of acid.

____

____

____

____ [2]

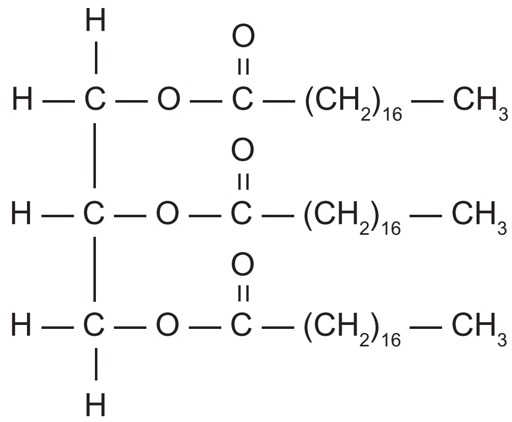
(iv) Would a solution of sodium ethanoate be acidic, alkaline or neutral? Explain your answer.

____

____

____ [2]

15 Fats are triesters of fatty acids. The saponification value of a fat provides a measure of how long the carbon chains are in the fatty acid molecules. The following fat, stearin, is present in lard:



stearin

(a) When refluxed with potassium hydroxide stearin produces the potassium salt of stearic acid (potassium stearate) and only one other product.

(i) Using R$-$ to represent $CH_3(CH_2)_{16}-$, write an equation for the reaction of stearin with excess potassium hydroxide.

[2]

(ii) State the systematic name of the other product.

____ [1]

(iii) Define the term **saponification value** as applied to a fat.

____

____

____ [3]

(iv) Use the definition and the structure of stearin to calculate its saponification value.

____

____

____

____

____

____

____ [4]

(b) The methyl ester of stearic acid is present in biodiesel.

(i) Give the molecular formula of the ester.

____ [1]

(ii) Give the equation for the complete combustion of this ester.

____ [2]

(iii) State **two** natural processes which influence the concentration of carbon dioxide in the atmosphere.

____

____ [2]

Examiner Only	
Marks	Remark

16 The ionic equation for the alkaline hydrolysis of C_4H_9Br is shown below.

$$C_4H_9Br \quad + \quad OH^- \quad \rightarrow \quad C_4H_9OH \quad + \quad Br^-$$

(a) Data for this reaction is given in the table below.

Experiment	**Initial $[C_4H_9Br]$ (mol dm^{-3})**	**Initial $[OH^-]$ (mol dm^{-3})**	**Initial Rate (mol dm^{-3}s^{-1})**
1	0.02	0.02	40.0
2	0.01	0.02	20.0
3	0.03	0.04	60.0

(i) What is the order of the reaction with respect to C_4H_9Br? Explain your reasoning.

____

____

____ [2]

(ii) What is the order with respect to OH^-? Explain your reasoning.

____

____

____ [2]

(iii) Write the rate equation for the reaction.

____ [1]

(iv) Calculate a value for the rate constant and give its units.

____

____

____ [2]

Examiner Only

Marks	Remark

(v) Draw a reaction mechanism for the hydrolysis of C_4H_9Br which is consistent with your rate equation. Show the structure of C_4H_9Br clearly in your mechanism and identify the rate determining step.

[4]

(b) There are a number of structural isomers with molecular formula C_4H_9OH. Only one of these structural isomers contains an asymmetric centre and can exist as optical isomers.

(i) What is meant by the term **asymmetric centre**?

____

____

____ [1]

(ii) Explain, in terms of structure, the meaning of the expression **optical isomers**.

____

____

____ [2]

Examiner Only	
Marks	Remark

(iii) Give the structural formula and name of the structural isomer, of C_4H_9OH, which contains an asymmetric centre.

____ [2]

(iv) Draw the 3D representations of the **two** optical isomers of the molecule identified in part **(iii)**.

[2]

(v) How can one optical isomer be distinguished from the other?

____

____

____ [2]

THIS IS THE END OF THE QUESTION PAPER

Examiner Only	
Marks	Remark

111317

Rewarding Learning

ADVANCED
General Certificate of Education
2011

Chemistry

Assessment Unit A2 1

assessing

Periodic Trends and Further Organic, Physical and Inorganic Chemistry

[AC212]

MONDAY 23 MAY, AFTERNOON

MARK SCHEME

Section A

			AVAILABLE MARKS
1	D		
2	D		
3	B		
4	C		
5	A		
6	C		
7	D		
8	B		
9	B		
10	A		
[2] for each correct answer		[20]	20
		Section A	**20**

Section B

AVAILABLE MARKS

11 (a) (i)

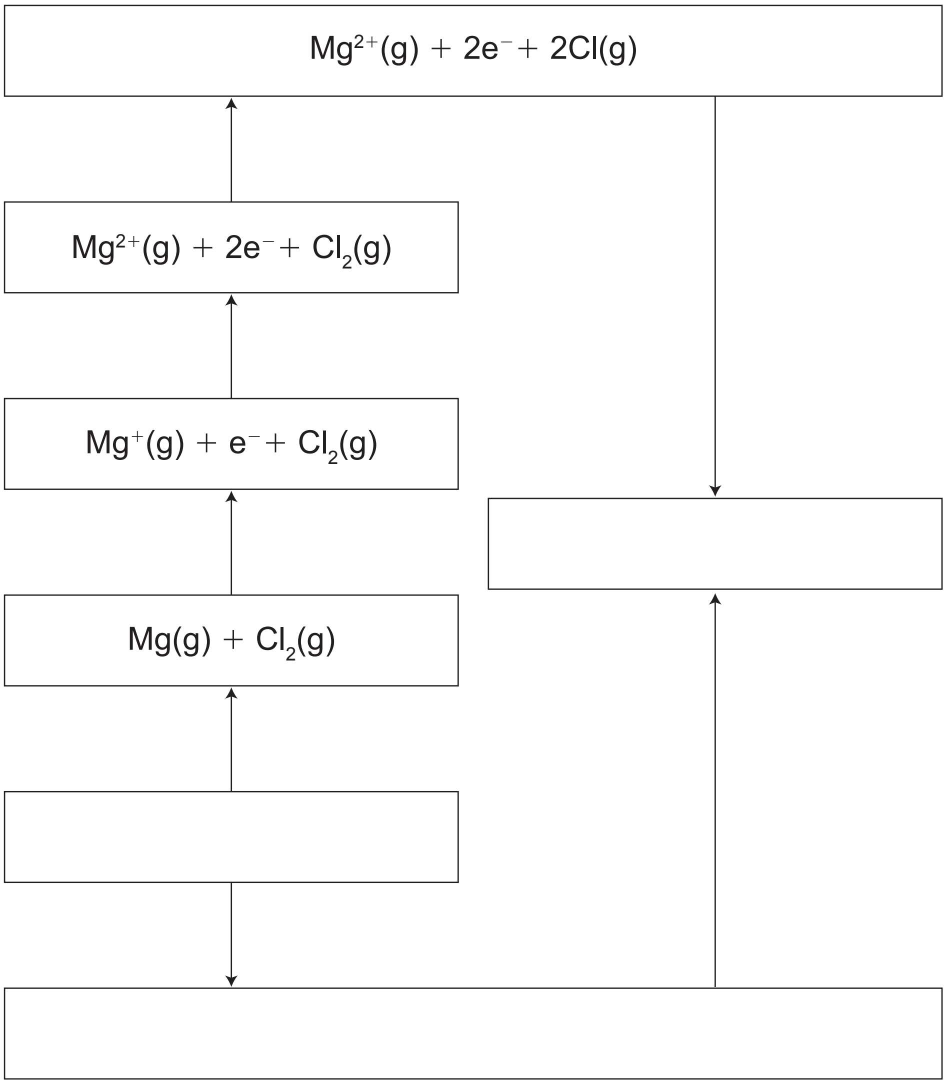
$$2CH_3COOH + HOCH_2CH_2OH \rightleftharpoons CH_3COOCH_2CH_2OOCCH_3 + 2H_2O \quad [2]$$

(ii) $$K_c = \frac{[CH_3COOCH_2CH_2OOCCH_3][H_2O]^2}{[CH_3COOH]^2[HOCH_2CH_2OH]}$$

expression [1] No units [1] [2]

(b) $HOCH_2CH_2OH + 4[O] \rightarrow HOOCCOOH + 2H_2O$ [2] 6

12 (a) (i)



[1] per box (order can vary) [4]

(ii) 2(E.A.)=(−121×2)+(−1450)+(−736)+(−150)+(−642)+(2493) [1]

E.A. = −727 ÷ 2 = −363.5 kJmol^{-1} [1]

AVAILABLE MARKS

(b) $1s^2\ 2s^2\ 2p^6$ [1]
$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$ [1]

(c) The enthalpy change which occurs when one mole of an (ionic) compound dissolves in water [2] 10

13 (a) (i) $C_nH_{2n}O$ [1]

(ii) 3–methylbutanal [1]

(iii) $CH_3CH_2CH_2COCH_3$ or $CH_3CH_2COCH_2CH_3$ or $(CH_3)_2CHCOCH_3$ [2]

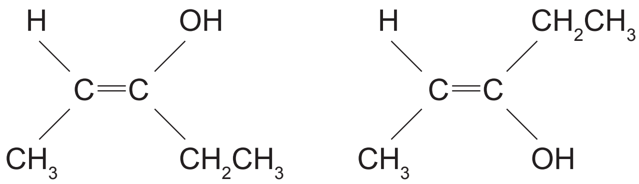
correct name for each structure
pentan–2–one, pentan–3–one or (3–)methylbutan(–2–)one [2]

(iv) suitable reagent
heat
observation for ketone
observation for aldehyde [4]

Quality of written communication [2]

(v) e.g. $CH_3CH = C(OH)CH_2CH_3$ and many others [1]

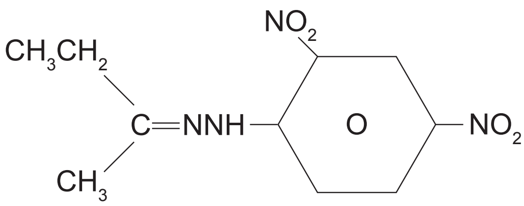
(vi)



e.g. and labels [3]

(b) (i) yellow/orange [1] solid [1] [2]

(ii)



[3]

(iii) melting point determination [1]
match (with melting point of butanone–2,4–dinitrophenylhydrazone) using tables of data [1] [2]

(iv) $CH_3COCH_2CH_3 + 2[H] \rightarrow CH_3CH(OH)CH_2CH_3$ [2]
Butan–2–ol [1] 26

14 (a) (i) fully dissociates [1]

(ii) H^+ donor [1]

(iii) $pH = -\log_{10}[H^+]$ [1]

(iv) $[H^+] = 0.4 \text{ mol dm}^{-3}$
$pH = 0.40$ [2]

(v) $K_w = [OH^-][H^+]$ [1]

(vi) $[OH^-] = 0.2 \text{ mol dm}^{-3}$ $[H^+] = 5.0 \times 10^{-14}$ [1]
$pH = 13.30$ [1] [2]

(vii) $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$ [2]

(b) (i) $K_a = \dfrac{[CH_3COO^-][H^+]}{[CH_3COOH]}$ [1]

(ii) $[H^+]^2 = 3.48 \times 10^{-6}$
$[H^+] = 1.87 \times 10^{-3}$
$pH = 2.73$ [3]

(c) (i) $CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$ [1]

(ii) initial moles of ethanoic acid $= 5.0 \times 10^{-3}$
moles of sodium hydroxide added $= 3.0 \times 10^{-3}$
moles of sodium ethanoate formed $= 3.0 \times 10^{-3}$
moles of ethanoic acid left $= 2.0 \times 10^{-3}$

$$[H^+] = 1.74 \times 10^{-5} \times \frac{2.0 \times 10^{-3}}{3.0 \times 10^{-3}} = 1.16 \times 10^{-5} \text{ mol dm}^{-3}$$

$pH = 4.94$ [4]

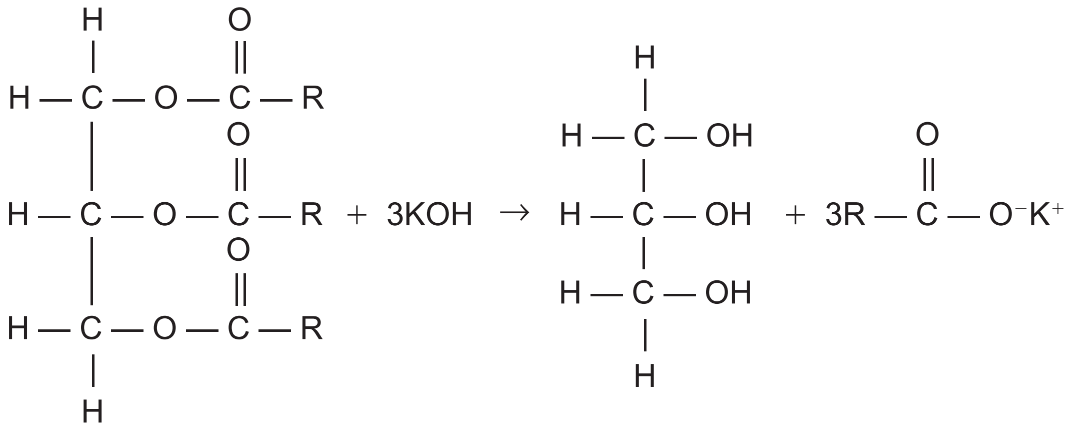
(iii) sodium ethanoate gives ethanoate ions
ethanoate ions combine with H^+ ions or equation * essential
$[H^+]$/pH remains approximately constant [2]

(iv) alkaline [1] – the salt of a weak acid and strong base [1] [2]

AVAILABLE MARKS: 23

AVAILABLE MARKS

15 (a) (i)



[2]

(ii) propane–1,2,3–triol [1]

(iii) The mass of KOH [1] in mg [1] required to completely hydrolyse/saponify 1.0 g of a fat. [1] [3]

(iv)

RMM of fat	= 890
moles of fat	= 0.00112
moles of KOH	= 0.00337
mass of KOH (in g)	= 0.189
mass of KOH (in mg)/S.V.	= 189

[4]

(b) (i) $C_{19}H_{38}O_2$ [1]

(ii) $2\ C_{19}H_{38}O_2 + 55O_2 \rightarrow 38CO_2 + 38H_2O$ [2]

(iii) photosynthesis/respiration/solubility in surface waters/decay [2] 15

AVAILABLE MARKS

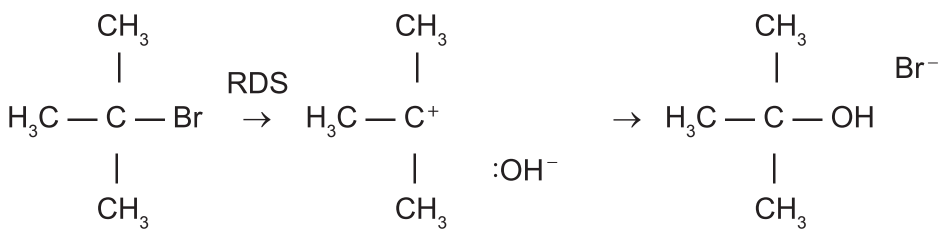
16 **(a)** **(i)** First [1] valid explanation [1] [2]

(ii) Zero [1] valid explanation [1] [2]

(iii) Rate = k $[C_4H_9Br]$ [1]

(iv) 2000 [1] s^{-1} [1] [2]

(v) tertiary structure [1]
correct RDS [1]
first step producing correct carbocation and bromide ion [1]
second step involving hydroxide attacking carbocation [1] [4]

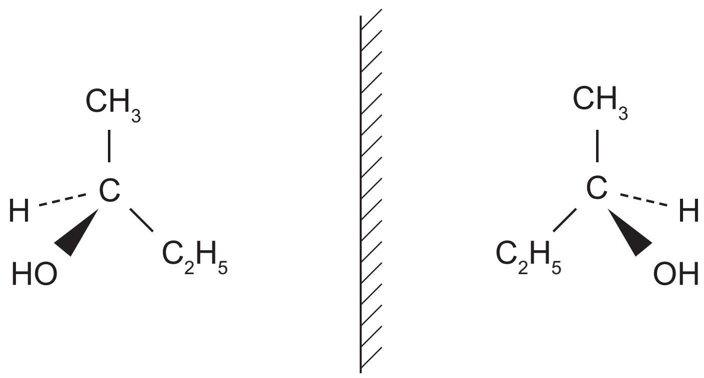


(b) **(i)** carbon with 4 different atoms/groups attached [1]

(ii) non-superimposable [1] mirror images [1] [2]

(iii) structure [1] butan–2–ol [1] [2]

(iv)



[2]

(v) plane-polarised light [1] rotated in opposite directions [1] [2] 20

Section B	**100**
Total	**120**

Rewarding Learning

Centre Number

71	

Candidate Number

ADVANCED
General Certificate of Education
January 2012

Chemistry

Assessment Unit A2 1

assessing

Periodic Trends and Further Organic, Physical and Inorganic Chemistry

[AC212]

AC212

THURSDAY 26 JANUARY, 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 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**. Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 120.
Quality of written communication will be assessed in Question **15(e)**.
In Section A all questions carry equal marks, i.e. **two** marks 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 (including some data) is provided.

For Examiner's use only	
Question Number	**Marks**
Section A	
1–10	
Section B	
11	
12	
13	
14	
15	
16	
Total Marks	

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 compounds is optically active and incapable of reducing Fehling's solution?

A $CH_3CH(CH_3)CH_2CHO$
B $CH_3CH(C_2H_5)COCH_3$
C $CH_3CHClCH_2CHO$
D $CH_3CH(CH_3)COCH_3$

2 The energy produced when an electron is added to an isolated atom would be the highest for elements in

A Group I.
B Group III.
C Group VII.
D Group VIII.

3 Which one of the following statements about the forward and reverse reactions for the reaction

$$Q + R \rightleftharpoons S + T$$

is correct when the system is at equilibrium?

A The ratio of the rates of the reverse reaction to that of the forward reaction equals the equilibrium constant.
B The rates of the reverse and forward reactions are equal to zero.
C The rates of the reverse and forward reactions are equal.
D The rate constant for the reverse reaction is the same as that of the forward reaction.

4 Which one of the following oxides has a molecular covalent structure?

A Al_2O_3
B Cl_2O_7
C MgO
D Na_2O

5 An organic compound gives an orange crystalline product with 2,4-dinitrophenylhydrazine but does not give a silver mirror with Tollen's reagent. Which one of the following molecules is the organic compound?

A ethyl propanoate
B methanal
C propanone
D propanoic acid

6 Ethane reacts with chlorine to form a variety of substituted chloro-compounds ranging from C_2H_5Cl to C_2Cl_6. Which one of the following is the number of optically active compounds formed?

A 0
B 1
C 2
D 4

7 In the equilibrium between nitrogen and hydrogen to form ammonia,

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

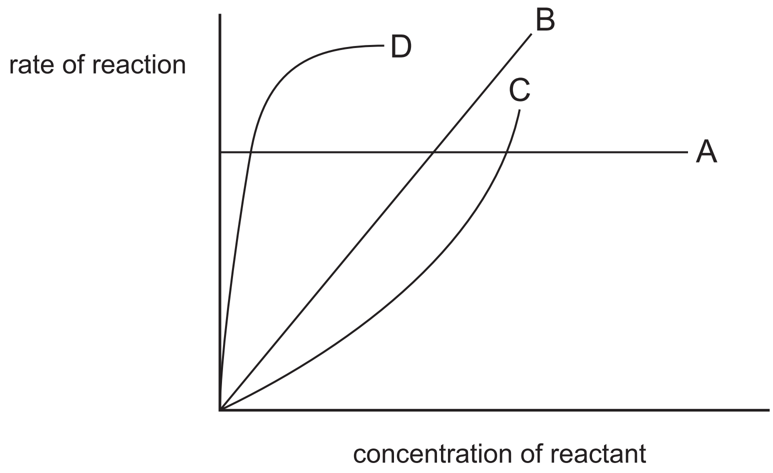
the following partial pressures were obtained.

	nitrogen	**hydrogen**	**ammonia**
Relative partial pressure	1	9	1

Which one of the following is the numerical value of the equilibrium constant, K_p?

A 1/729
B 1/9
C 9
D 729

8 Which one of the graphs shown below is that of a first order reaction?



9 Which one of the following always has units?

A K_c
B K_d
C K_p
D K_w

10 The rate equation for the reaction of propanone with iodine in acidic solution is:

$$\text{rate} = k[CH_3COCH_3][H^+]$$

Which one of the following represents the units of k?

A $mol\,dm^{-3}\,s^{-1}$
B $mol^{-1}\,dm^{3}\,s^{-1}$
C $mol^{2}\,dm^{-6}\,s^{-1}$
D $mol^{-2}\,dm^{6}\,s^{-1}$

BLANK PAGE

(Questions continue overleaf)

Section B

Answer all **six** questions in this section.

11 The formation of ammonium carbonate is being investigated as a possible method to remove carbon dioxide from combustion processes.

$$CO_2(g) + 2NH_3(g) + H_2O(l) \rightarrow (NH_4)_2CO_3(aq)$$

(a) (i) The thermodynamic quantities associated with this reaction are:

$\Delta G = -25\,kJ\,mol^{-1}$; $\Delta H = -170\,kJ\,mol^{-1}$

$S(CO_2) = +214\,J\,mol^{-1}K^{-1}$
$S(H_2O) = +70\,J\,mol^{-1}K^{-1}$
$S((NH_4)_2CO_3) = +220\,J\,mol^{-1}K^{-1}$
$S(NH_3) = +192\,J\,mol^{-1}K^{-1}$

Use the data provided to calculate the temperature at which the carbon dioxide is being removed.

____

____

____ [3]

(ii) The equilibrium constant for the reaction at 20 °C is 2.5×10^4. At 80 °C it is 0.12. Explain the reason for the drop in the value of K and state how this would affect the CO_2 removal process.

____

____ [2]

(b) Ammonium carbonate when added to ethanoic acid undergoes a spontaneous reaction producing great volumes of gas and a dramatic drop in temperature.

(i) Write the equation for the reaction.

____ [1]

(ii) Explain the meaning of the term **spontaneous** reaction.

____

____ [1]

Examiner Only	
Marks	Remark

(iii) Why should this reaction proceed when it is endothermic?

______________________________ [1]

(c) Ammonium ethanoate mixed with ethanoic acid can be used as a buffer solution.

(i) Use an equation to show how the buffer removes added hydrogen ions.

______________________________ [1]

(ii) Use an equation to show how the buffer removes added hydroxide ions.

______________________________ [1]

(d) Ammonium ethanoate solid, when heated, dissociates to form the original reactants.

(i) Including state symbols, write an equilibrium equation for the dissociation.

______________________________ [2]

(ii) Explain why heating ammonium ethanoate in the presence of ethanoic acid prevents the dissociation.

____

______________________________ [2]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

12 Pyruvic acid is a colourless liquid boiling at 165 °C (with slight decomposition) and has a smell similar to that of ethanoic acid.

$$CH_3COCOOH$$

pyruvic acid

There are several methods used to prepare pyruvic acid.

(a) Tartaric acid when heated with potassium hydrogensulfate forms pyruvic acid. The reaction is believed to take place via the formation of hydroxymaleic acid (structure I) which rearranges to oxalacetic acid (structure II).

$$\begin{array}{lclclcl} \text{CH(OH)COOH} & & \text{CHCOOH} & & \text{CH}_2\text{COOH} & & \\ | & \rightarrow & \| & \rightarrow & | & \rightarrow & \text{CH}_3\text{COCOOH} + \text{CO}_2 \\ \text{CH(OH)COOH} & & \text{C(OH)COOH} & & \text{COCOOH} & & \end{array}$$

tartaric acid I II pyruvic acid

(i) How many asymmetric centres are present in tartaric acid?

____ [1]

(ii) Structure I exists in E and Z structures. Draw the structures and label them as E and Z.

[3]

(iii) The last step in the synthesis involves **decarboxylation**. Suggest a meaning for this term.

____ [1]

Examiner Only	
Marks	Remark

(b) Another method of preparation is the oxidation of lactic acid, $CH_3CHOHCOOH$, using silver oxide suspended in water.

(i) What is the formula of silver oxide?

____ [1]

(ii) Write the equation for the formation of pyruvic acid from lactic acid using [O] to symbolise the oxidising agent.

____ [1]

(c) Another method of synthesis is the flow scheme shown below.

$$CH_3COCl \xrightarrow{A} CH_3COCN \xrightarrow{B} CH_3COCOOH$$

Suggest the names of the reagents A and B.

A ____ [1]

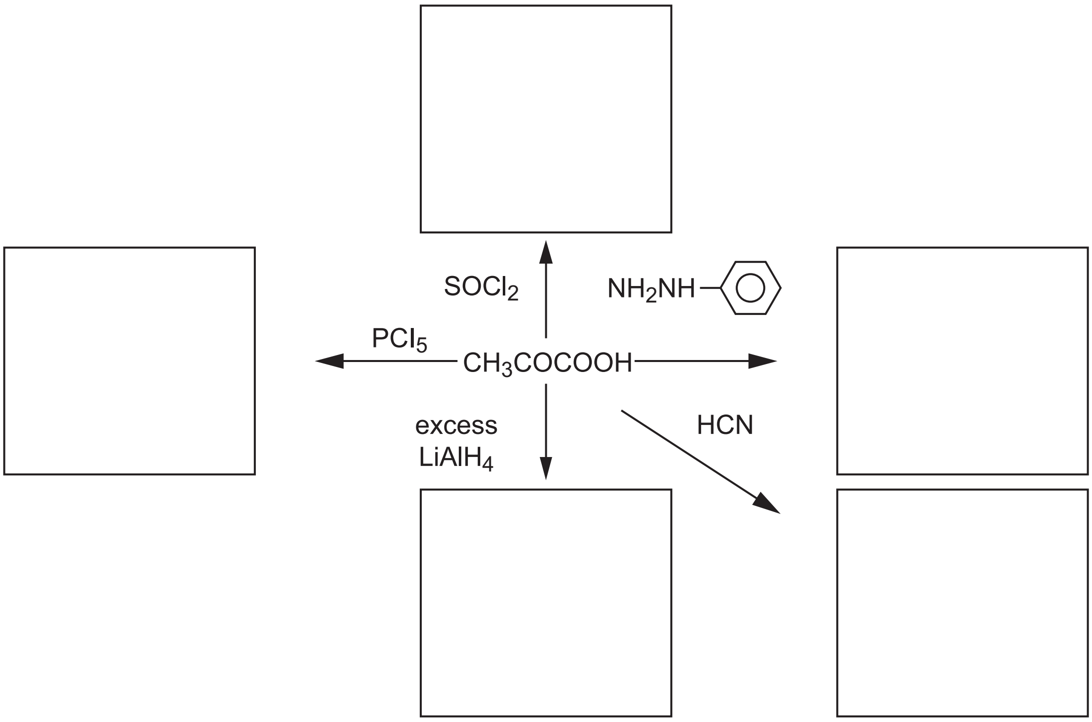
B ____ [1]

(d) A further method of preparation is to hydrolyse 2,2-dibromopropanoic acid with water. Write a flow scheme for the reaction showing the intermediate dihydroxy compound.

[2]

Examiner Only	
Marks	Remark

(e) Pyruvic acid shows both the reactions of a ketone and a carboxylic acid. Complete the following flow sequences below showing the organic product in each case.



[6]

(f) Pyruvic acid is quite a strong acid with an acid dissociation constant of 0.56. It is also miscible in water.

(i) Write the expression for the acid dissociation constant of pyruvic acid.

____ [1]

(ii) Calculate the pH of a 0.25 M solution of pyruvic acid.

____

____

____ [3]

(iii) Suggest the meaning of the term **miscible**.

____ [1]

(iv) Suggest why pyruvic acid is miscible in water.

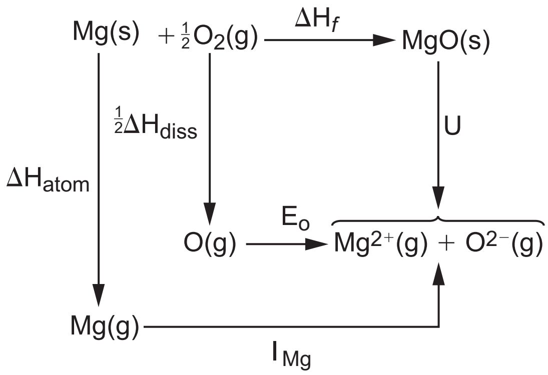
____

____ [2]

BLANK PAGE

(Questions continue overleaf)

13 The Born-Haber cycle can be written in many different ways. One of those ways is shown below.



The values of the terms shown in the scheme are:

ΔH_f = $-602\,kJ\,mol^{-1}$
ΔH_{diss} = $+498\,kJ\,mol^{-1}$
ΔH_{atom} = $+148\,kJ\,mol^{-1}$
I_{Mg} = $+2189\,kJ\,mol^{-1}$
E_o = $+657\,kJ\,mol^{-1}$

(a) Explain the meanings of the following terms.

(i) ΔH_{diss}

____ [1]

(ii) ΔH_{atom}

____ [1]

(iii) I_{Mg}

____ [1]

Examiner Only	
Marks	Remark

(b) (i) Calculate the value of U for magnesium oxide.

____

____ [2]

(ii) Using the Born-Haber cycle explain why magnesium oxide is very stable.

____

____ [2]

(c) Explain why a Born-Haber cycle cannot be constructed for phosphorus(V) oxide.

____ [1]

Examiner Only	
Marks	Remark

14 Sulfur dioxide and a small amount of sulfur trioxide are formed when sulfur burns in air. The presence of sulfur trioxide accounts for the foggy appearance of the sulfur dioxide.

(a) Write equations for the reaction of sulfur with oxygen to form sulfur dioxide and sulfur trioxide.

(i) sulfur dioxide

____ [1]

(ii) sulfur trioxide

____ [1]

(b) Sulfur dioxide and sulfur trioxide dissolve in water to form sulfurous acid and sulfuric acid. Write equations for the reactions.

(i) sulfur dioxide

____ [1]

(ii) sulfur trioxide

____ [1]

(c) Both of these acids react with sodium hydroxide to form sodium salts. These salts dissolve in water to produce solutions of different pH.

Write the equations for the reactions of sulfurous acid and sulfuric acid with excess sodium hydroxide to produce the sodium salts.

(i) sulfurous acid

____ [1]

(ii) sulfuric acid

____ [1]

(d) Explain why a saturated solution of sodium sulfite has a pH of 9 and sodium sulfate has a pH of 7.

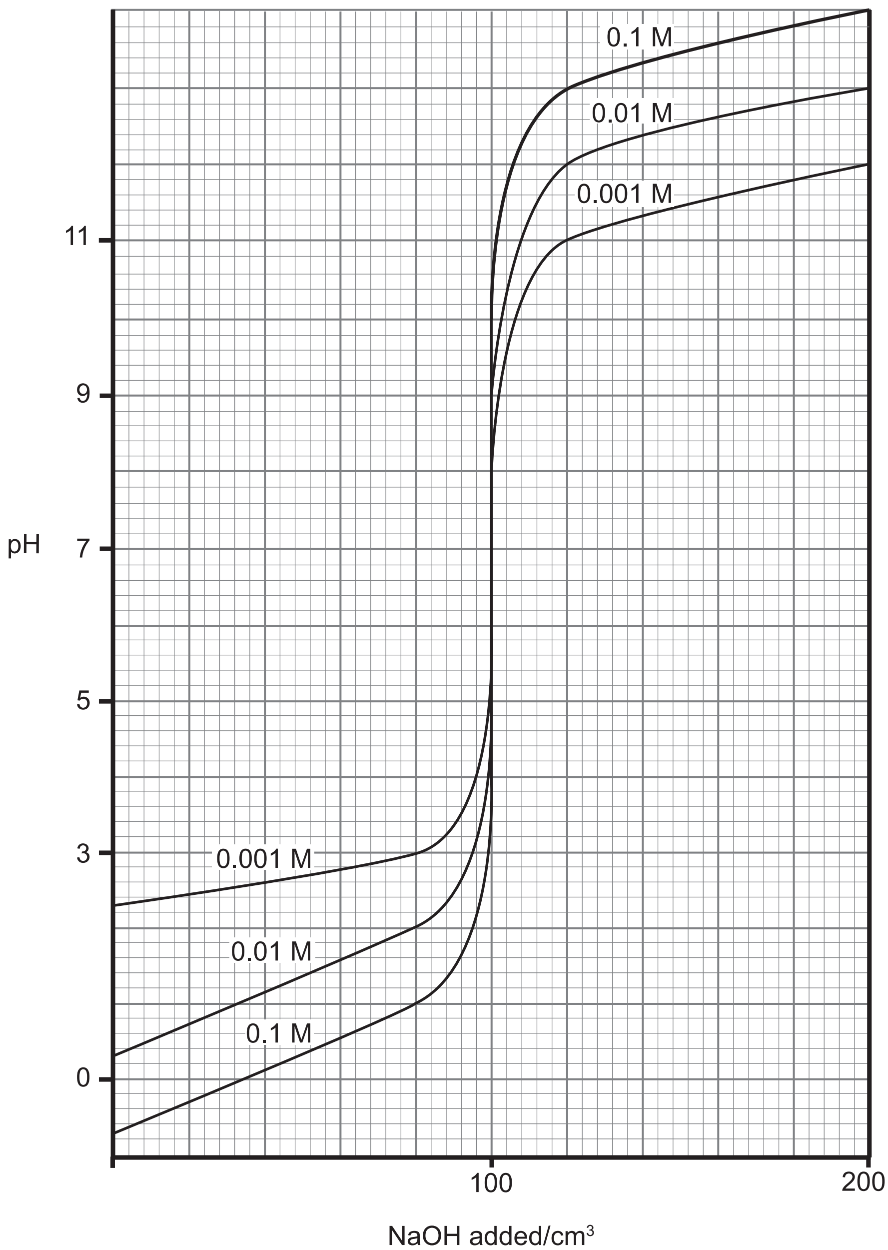
____

____

____ [3]

Examiner Only	
Marks	Remark

(e) Titration curves for the reaction of sulfuric acid with excess sodium hydroxide are shown below.



(i) Explain why the length of the vertical sections of the curves decreases with decreasing concentrations of the acid.

____ [1]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

(ii) Explain how you would choose a suitable indicator for the titration of 0.001 M sulfuric acid with 0.1 M NaOH.

____

____ [2]

(f) At the end point the addition of 0.1 cm^3 of 2 M sodium hydroxide to a solution of 1 M sulfuric acid causes a dramatic change in pH. The table below shows the changes in pH.

volume of sulfuric acid/cm^3	volume of sodium hydroxide solution added/cm^3	pH of solution
100	99.9	
100	100.0	7.0

Calculate the missing pH of the solution shown in the table.

____

____

____

____ [3]

BLANK PAGE

(Questions continue overleaf)

15 Some common unsaturated fatty acids found in oils and fats are shown below. The vast majority of unsaturated linkages are *cis*.

Examiner Only	
Marks	Remark

$CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$
oleic acid

$CH_3(CH_2)_4CH{=}CHCH_2CH{=}CH(CH_2)_7COOH$
linoleic acid

$CH_3CH_2CH{=}CHCH_2CH{=}CHCH_2CH{=}CH(CH_2)_7COOH$
linolenic acid

$CH_3(CH_2)_4CH{=}CHCH_2CH{=}CHCH_2CH{=}CHCH_2CH{=}CH(CH_2)_3COOH$
arachidonic acid

(a) Explain which of these acids are monounsaturated and which are polyunsaturated.

____

____ [2]

(b) All the double bonds in arachidonic acid are *cis*. Draw the structure of the acid.

[2]

(c) Write the equation for the reaction of oleic acid with molecular iodine.

____ [2]

(d) **(i)** It is possible to determine the iodine value of a fatty acid. Define the term **iodine value**.

____

____

____ [2]

(ii) Calculate the iodine value of linolenic acid.

[4]

(iii) State and explain which one of the acids has the highest iodine value.

[2]

(e) Explain the contribution of polyunsaturated oils or fats to the diet.

[4]

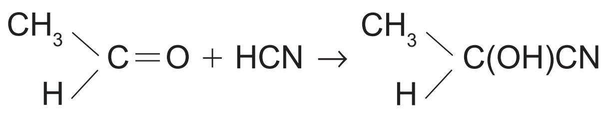
Quality of written communication [2]

(f) All of these acids can be catalytically hydrogenated in the same way as oils and fats. Name the catalyst and state the conditions used.

[3]

Examiner Only	
Marks	Remark

16 Ethanal reacts with hydrogen cyanide to form a cyanohydrin



(a) The first step is the reaction of the cyanide ion with the carbonyl group to form an intermediate. This is the rate determining step.

(i) Draw the structure of the intermediate.

[1]

(ii) Explain the meaning of the term **rate determining step**.

____

____ [1]

(iii) Write the rate equation and state the meaning of the symbol k.

____

____ [2]

(iv) What is the order of the reaction.

____ [1]

Examiner Only	
Marks	Remark

(b) The second step is the protonation of the intermediate.

(i) Write the equation for this step involving the reaction of hydrogen cyanide with the intermediate.

[2]

(ii) Explain whether you would expect this to be a slow or fast step.

____

____ [2]

(c) Suggest why this equation shows that the cyanide ion could be regarded as a catalyst in cyanohydrin formation.

____

____ [1]

(d) The structure of the intermediate in the mechanism leads to the production of an optically inactive product.

(i) Explain the meaning of the term **optically inactive**.

____

____ [2]

(ii) Draw the 3D structures of the two cyanohydrin isomers.

[2]

(iii) Explain why the cyanohydrin product is optically inactive.

____

____ [2]

Examiner Only	
Marks	Remark

THIS IS THE END OF THE QUESTION PAPER

Rewarding Learning

ADVANCED
General Certificate of Education
January 2012

Chemistry

Assessment Unit A2 1

assessing

Periodic Trends and Further Organic, Physical and Inorganic Chemistry

[AC212]

THURSDAY 26 JANUARY, MORNING

MARK SCHEME

Section A

			AVAILABLE MARKS
1	B		
2	C		
3	C		
4	B		
5	C		
6	A		
7	A		
8	B		
9	D		
10	B		
[2] for each correct answer		[20]	20
		Section A	**20**

Section B

AVAILABLE MARKS

11 **(a)** **(i)** $\Delta G = \Delta H - T\Delta S$

$\Delta S = 220 - 214 - 2 \times 192 - 70$
$= 220 - 214 - 384 - 70$
$= 220 - 668$
$= -448$

$-25 = -170 - T\Delta S$
$+145 = -T\Delta S = -T(-0.448)$
$T = \dfrac{145}{0.448}$
T = 324 K **or** 51 °C [3]

(ii) the forward reaction is exothermic [1]
less CO_2 removed [1] [2]

(b) **(i)** $(NH_4)_2CO_3 + 2CH_3COOH \rightarrow 2CH_3COONH_4 + H_2O + CO_2$ [1]

(ii) $\Delta G \leqslant 0$ [1]

(iii) $T\Delta S$ greater than ΔH [1]

(c) **(i)** $H^+ + CH_3COO^- \rightarrow CH_3COOH$ [1]

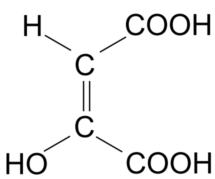
(ii) $CH_3COOH + OH^- \rightarrow CH_3COO^- + H_2O$
or $NH_4^+ + OH^- \rightarrow NH_3 + H_2O$ [1]

(d) **(i)** $CH_3COONH_4(s) \rightleftharpoons CH_3COOH(l) + NH_3(g)$ [2]

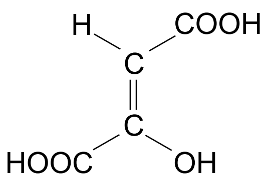
(ii) ethanoic acid is present on the RHS [1]
excess ethanoic acid will drive the equilibrium to the LHS [1] [2] 14

12 **(a)** **(i)** two [1]

(ii)



E



Z

structures [2]
correct labelling [1] [3]

(iii) removal of carbon dioxide/carboxylic acid group [1]

(b) **(i)** Ag_2O [1]

(ii) $CH_3CHOHCOOH + [O] \rightarrow CH_3COCOOH + H_2O$ [1]

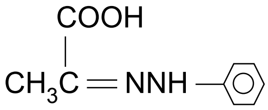
(c) sodium/potassium cyanide [1]
hydrochloric acid/sulfuric acid [1]

(d) $CH_3CBr_2COOH \rightarrow CH_3C(OH)_2COOH \rightarrow CH_3COCOOH$ [2]

AVAILABLE MARKS

(e) $SOCl_2$: $CH_3COCOCl$ [1]

$C_6H_5NHNH_2$:



[1]

HCN: $CH_3C(OH)CNCOOH$ [1]

$LiAlH_4$: $CH_3CH(OH)CH_2OH$ [2]

PCl_5: $CH_3COCOCl$ [1] [6]

(f) **(i)** $K = \dfrac{[CH_3COCOO^-]\,[H^+]}{[CH_3COCOOH]}$ [1]

(ii) $K = 0.56 = [H^+]^2/0.25$
$[H^+]^2 = 0.56 \times 0.25 = 0.14$
$[H^+] = 0.37$
pH = 0.43 [3]

(iii) very soluble/soluble in all proportions [1]

(iv) hydrogen bonding [1]
of carboxylic acid group (and carbonyl group) with water [1] [2] 24

13 **(a)** **(i)** ΔH_{diss}: heat/enthalpy of dissociation/bond energy of oxygen [1]

(ii) ΔH_{atom}: heat/enthalpy of atomisation [1]

(iii) I_{Mg}: heat/enthalpy of first and second ionisation of magnesium [1]

(b) **(i)** $-602 + U = +148 + 2189 + 249 + 657$
$-602 + U = +3243$
$U = +3845$ [2]

(ii) the value of U is very high [1]
lots of energy needed to separate the ions in MgO [1] [2]

(c) phosphorus(V) oxide is not ionic/is covalent [1] 8

14 **(a)** **(i)** $S + O_2 \rightarrow SO_2$ [1]

(ii) $2S + 3O_2 \rightarrow 2SO_3$ [1]

(b) **(i)** $SO_2 + H_2O \rightarrow H_2SO_3$ [1]

(ii) $SO_3 + H_2O \rightarrow H_2SO_4$ [1]

(c) **(i)** $2NaOH + H_2SO_3 \rightarrow Na_2SO_3 + 2H_2O$ [1]

(ii) $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$ [1]

(d) sodium hydroxide is a strong base [1]
sulfurous acid is a weak acid [1]
sulfuric acid is a strong acid [1] [3]

(e) **(i)** pH of dilute solutions is more than concentrated solutions [1]

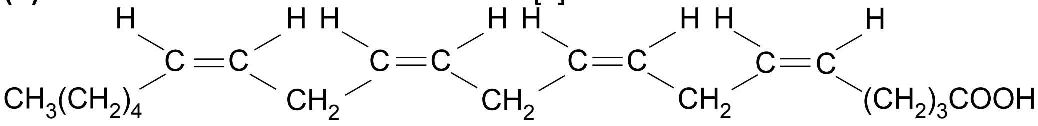
(ii) range of indicator [1]
matches vertical portion of titration curve [1] [2]

AVAILABLE MARKS

(f) moles of H^+ = 0.2000
moles of OH^- = 0.1998
excess moles of H^+= 0.0002
$[H^+]$ = 0.001
pH = 3.00 [3] 15

15 (a) monounsaturated: one double bond; oleic acid
polyunsaturated: more than one double bond; linoleic, linolenic, arachidonic acids [2]

(b) all the double bonds must be *cis* for [2]



[2]

(c) $CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH + I_2 \rightarrow CH_3(CH_2)_7CHICHI(CH_2)_7COOH$ [2]

(d) (i) the number of grams of iodine that will react with 100 g of oil/fatty acid [2]

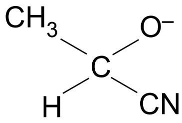
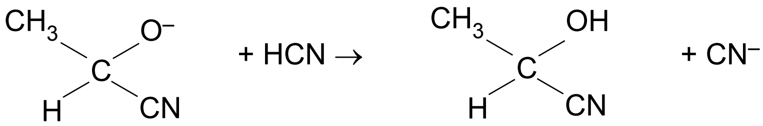
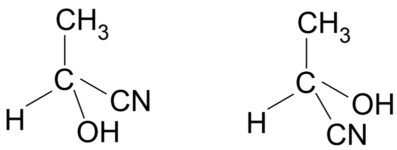
(ii) linolenic acid has the formula $C_{18}H_{30}O_2$ = 216 + 30 + 32 = 278
it has three double bonds hence requires $3I_2$ = 6 × 127 g = 762 g
278 g of linolenic reacts with 762 g iodine
100 g reacts with 762/278 × 100 = 274.1 g = 274 g of iodine [4]

(iii) arachidonic acid [1]
has four double bonds/the most double bonds [1] [2]

(e) naturally occurring polyunsaturates (mostly cis) lower risk of heart disease [1]
they lower cholesterol/lower LDLs/increase HDLs [1]
many synthetic polyunsaturates/trans fats [1]
increase the risk of heart disease [1]
linolenic acid (Omega-3) and linoleic acid (Omega-6) are essential in the diet (essential fatty acids) [1]
provide energy/insulation/organ protection [1]
synthetic role/cell membranes/hormones/prostaglandins [1]
To a maximum of [4] [4]

Quality of written communication [2]

(f) nickel [1]
finely divided [1]
100–200 °C [1] [3] 23

					AVAILABLE MARKS
16	**(a)**	**(i)**		[1]	
		(ii)	the slowest step in the reaction process/mechanism	[1]	
		(iii)	rate = k[CH_3CHO][$C\bar{N}$] [1] rate constant k [1]	[2]	
		(iv)	second order	[1]	
	(b)	**(i)**		[2]	
		(ii)	fast step [1] not involved in the rate determining step/ionic reaction [1]	[2]	
	(c)		the cyanide ion is regenerated	[1]	
	(d)	**(i)**	does not rotate the plane [1] of plane polarised light [1]	[2]	
		(ii)		[2]	
		(iii)	both products equally formed [1] no overall rotation [1]	[2]	16
				Section B	**100**
				Total	**120**

Rewarding Learning

Centre Number

71	

Candidate Number

ADVANCED
General Certificate of Education
2012

Chemistry

Assessment Unit A2 1

assessing

Periodic Trends and Further Organic, Physical and Inorganic Chemistry

[AC212]

TUESDAY 15 MAY, AFTERNOON

AC212

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**. Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 120.
Quality of written communication will be assessed in Question **14(c)**.
In Section A all questions carry equal marks, i.e. **two** marks 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 (including some data) is provided.

For Examiner's use only	
Question Number	Marks
Section A	
1–10	
Section B	
11	
12	
13	
14	
15	
16	
17	
Total Marks	

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 compounds has coordinate bonds in its structure?

A Aluminium chloride, Al_2Cl_6
B Magnesium chloride, $MgCl_2$
C Phosphorus pentachloride, PCl_5
D Sodium chloride, NaCl

2 Which one of the following equations represents the lattice enthalpy of sodium chloride?

A $NaCl(aq) \rightarrow Na(g) + Cl(g)$
B $NaCl(aq) \rightarrow Na^+(g) + Cl^-(g)$
C $NaCl(s) \rightarrow Na^+(aq) + Cl^-(aq)$
D $NaCl(s) \rightarrow Na^+(g) + Cl^-(g)$

3 Which one of the following reactions would give an increase in entropy?

A $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$
B $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$
C $H_2(g) + I_2(g) \rightarrow 2HI(g)$
D $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$

4 Which one of the following statements about the formation of an ester from ethanoyl chloride and propan-1-ol is correct?

A Concentrated sulfuric acid is required.
B Heat is required.
C The ester produced is called ethyl propanoate.
D The reaction goes to completion.

5 Which one of the following is the conjugate base of butanoic acid?

A $C_3H_7COO^-$
B $C_3H_7COOH_2^+$
C $C_4H_9COO^-$
D $C_4H_9COOH_2^+$

6 The partition coefficient of an organic compound, X, between ether and water is 6.0. Which one of the following is the mass of X extracted when an aqueous solution of X containing 2.50 g in 150 cm^3 of solution is shaken with 50 cm^3 of ether?

A 0.10 g
B 0.83 g
C 1.67 g
D 2.37 g

7 Which one of the following is the general formula of a simple carboxylic acid?

A $C_nH_nO_2$

B $C_nH_{2n}O$

C $C_nH_{2n}O_2$

D $C_nH_{2n+2}O$

8 Which one of the following statements about K_w is **not** correct?

A K_w has a value of 1×10^{-14} at 25 °C
B $pK_w = -\log K_w$
C The units of K_w are $mol\,dm^{-3}$
D The value of K_w changes with temperature

9 Which one of the following is the correct classification of silicon dioxide?

A Acidic
B Amphoteric
C Basic
D Neutral

10 A 1.1 g sample of an oil was treated with Wij's solution and excess potassium iodide solution. The liberated iodine reacted with 7.3 cm^3 of 0.1 mol dm^{-3} sodium thiosulfate solution. The blank titration required 43.5 cm^3 of sodium thiosulfate. Which one of the following is the iodine value of the oil?

A 41.76
B 45.94
C 50.53
D 58.60

BLANK PAGE

(Questions continue overleaf)

Section B

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

Examiner Only	
Marks	Remark

11 A chloroalkane is reacted with an aqueous solution of sodium hydroxide according to the following equation.

$$RCl + NaOH \rightarrow ROH + NaCl$$

(a) (i) The rate of reaction can be investigated by monitoring the concentration of sodium hydroxide. Describe a titration method for carrying this out.

____

____

____

____

____ [3]

(ii) How would you use the results to determine the rate of reaction?

____

____ [2]

(b) The following results were obtained for the reaction.

Experiment	[RCl] (mol dm^{-3})	[NaOH] (mol dm^{-3})	Rate (mol dm^{-3} s^{-1})
1	1.3×10^{-3}	9.0×10^{-4}	0.2
2	2.6×10^{-3}	9.0×10^{-4}	0.4
3	1.3×10^{-3}	1.8×10^{-3}	0.4

(i) Use these results to deduce:

the order of the reaction with respect to RCl ________________ [1]

the order of the reaction with respect to NaOH ________________ [1]

the rate equation ______________________________ [1]

(ii) Calculate the value of the rate constant stating its units.

____ [2]

(iii) Name the mechanism of this reaction.

____ [1]

(iv) Classify RCl as a primary or tertiary chloroalkane giving a reason for your answer.

____ [1]

Examiner Only	
Marks	Remark

12 Lauric acid, $C_{11}H_{23}COOH$, the main acid found in coconut oil, is also found in macadamia nuts. It is a white solid at room temperature with a melting point of 45 °C, and is insoluble in water.

Examiner Only	
Marks	Remark

(a) Write the empirical formula for lauric acid.

____ [1]

(b) Explain why ethanoic acid is soluble in water whereas lauric acid is insoluble.

____

____

____ [3]

(c) Describe a chemical test to prove that lauric acid is an acid.

____

____

____ [2]

(d) Write an equation for the reaction of lauric acid with thionyl chloride.

____ [2]

(e) Lauric acid can be reduced to the corresponding alcohol.

(i) Write an equation for the reduction using [H] to represent the reducing agent.

____ [2]

(ii) Name a suitable reducing agent.

____ [1]

(f) The main constituent of coconut oil is the triester formed from lauric acid and glycerol. It is called lauric acid triglyceride and has a saponification value of 260.

(i) What is meant by the term **saponification**?

____

____ [2]

(ii) Write an equation for the saponification of lauric acid triglyceride.

[2]

(iii) Calculate the volume of 0.1 mol dm^{-3} hydrochloric acid required to neutralise the unreacted potassium hydroxide when 100 cm^3 of 0.1 mol dm^{-3} potassium hydroxide hydrolyses 1.72 g of lauric acid triglyceride.

____

____

____

____

____

____

____

____ [4]

Examiner Only	
Marks	Remark

13 Dichlorine heptoxide is formed when perchloric acid ($HClO_4$) is treated with the dehydrating agent phosphorus pentoxide.

Examiner Only	
Marks	Remark

(a) **(i)** Write an equation for the removal of water from perchloric acid.

____ [1]

(ii) Write the equation for the reaction of phosphorus pentoxide with water.

____ [2]

(b) Deduce the oxidation numbers of the following elements:

phosphorus in phosphorus pentoxide _______________

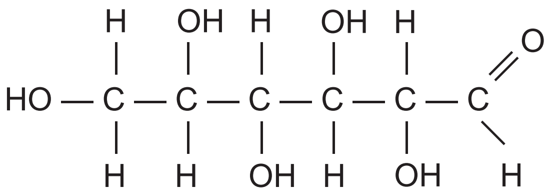
chlorine in perchloric acid _________________________ [2]

(c) Calculate the percentage of chlorine in dichlorine heptoxide to one decimal place.

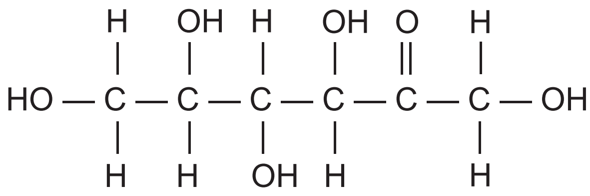
____

____ [2]

14 The structures of glucose and fructose are shown below.



glucose



fructose

(a) Glucose and fructose are **structural isomers**. What is meant by this term?

____

____ [2]

(b) Name **two** functional groups that are present in **both** glucose and fructose.

____ [2]

(c) Despite the difference in structures between glucose and fructose, suggest why they are **both** reducing agents and state what would be observed with Fehling's and Tollen's solutions.

____

____

____

____

____

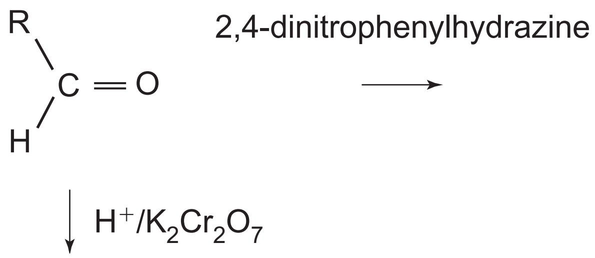
____ [4]

Quality of written communication [2]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

(d) **(i)** In the scheme below glucose is represented by RCHO. Write the structure of the organic products formed when glucose reacts with the stated reagents.



[2]

(ii) Describe the appearance of the product formed from glucose and 2,4-dinitrophenylhydrazine.

____ [2]

(iii) Giving practical details, describe how this product can be used to provide information to identify glucose.

____

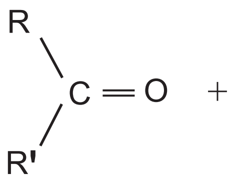
____

____

____

____ [4]

(e) Complete the flow scheme below to show the mechanism for the reaction between fructose (RCOR') and hydrogen cyanide.



[3]

15 Ozone (O_3) is found as a gas in the Earth's atmosphere. It is beneficial in the upper atmosphere as it shields the Earth from ultraviolet radiation. However, in the lower atmosphere it can act as a greenhouse gas.

Examiner Only	
Marks	Remark

(a) (i) Describe how a gas contributes to the greenhouse effect.

____

____ [2]

(ii) State one long-term result of an increase in greenhouse gases.

____ [1]

(b) Ozone is 30% dissociated at equilibrium according to the following equation:

$$2O_3(g) \rightleftharpoons 3O_2(g)$$

(i) Calculate the value of K_p for this dissociation reaction, stating its units, if the total pressure is 10 atmospheres.

____

____

____

____

____ [4]

(ii) Explain the effect of increasing the pressure on the above equilibrium.

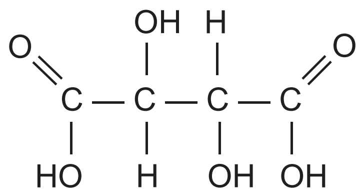
____

____ [2]

(iii) What effect would this increase in pressure have on the value of K_p?

____ [1]

16 Tartaric acid is one of several organic acids that have an important role in winemaking. These acids affect the colour and taste, assist in the fermentation process, and act as preservatives.



(a) Tartaric acid is a dicarboxylic acid. Suggest the meaning of **dicarboxylic**.

____ [1]

(b) Tartaric acid exhibits optical activity.

(i) What do you understand by the term **optical activity**?

____

____ [2]

(ii) On the structure above mark the asymmetric centre(s) in tartaric acid. [1]

(iii) Explain why some samples of tartaric acid extracted from wine do not display optical activity.

____

____ [1]

(c) The first pK_a value for the ionisation of tartaric acid is 2.9. Calculate the pH of a 0.1 mol dm^{-3} solution of tartaric acid. Assume only one H^+ dissociation.

____

____

____

____ [3]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

(d) A titration is carried out to determine the amount of tartaric acid in wine. A 25.0 cm^3 portion of white wine from a 750 cm^3 bottle is titrated against 0.2 mol dm^{-3} NaOH. 9.8 cm^3 of NaOH are required to *completely* neutralise the acid.

(i) Suggest a suitable indicator for the titration and explain your choice.

____

____ [2]

(ii) Calculate the mass of tartaric acid in the bottle of wine.

____

____

____

____ [4]

(e) Two molecules of tartaric acid can combine to form an ester. Draw the structure of an ester produced.

[2]

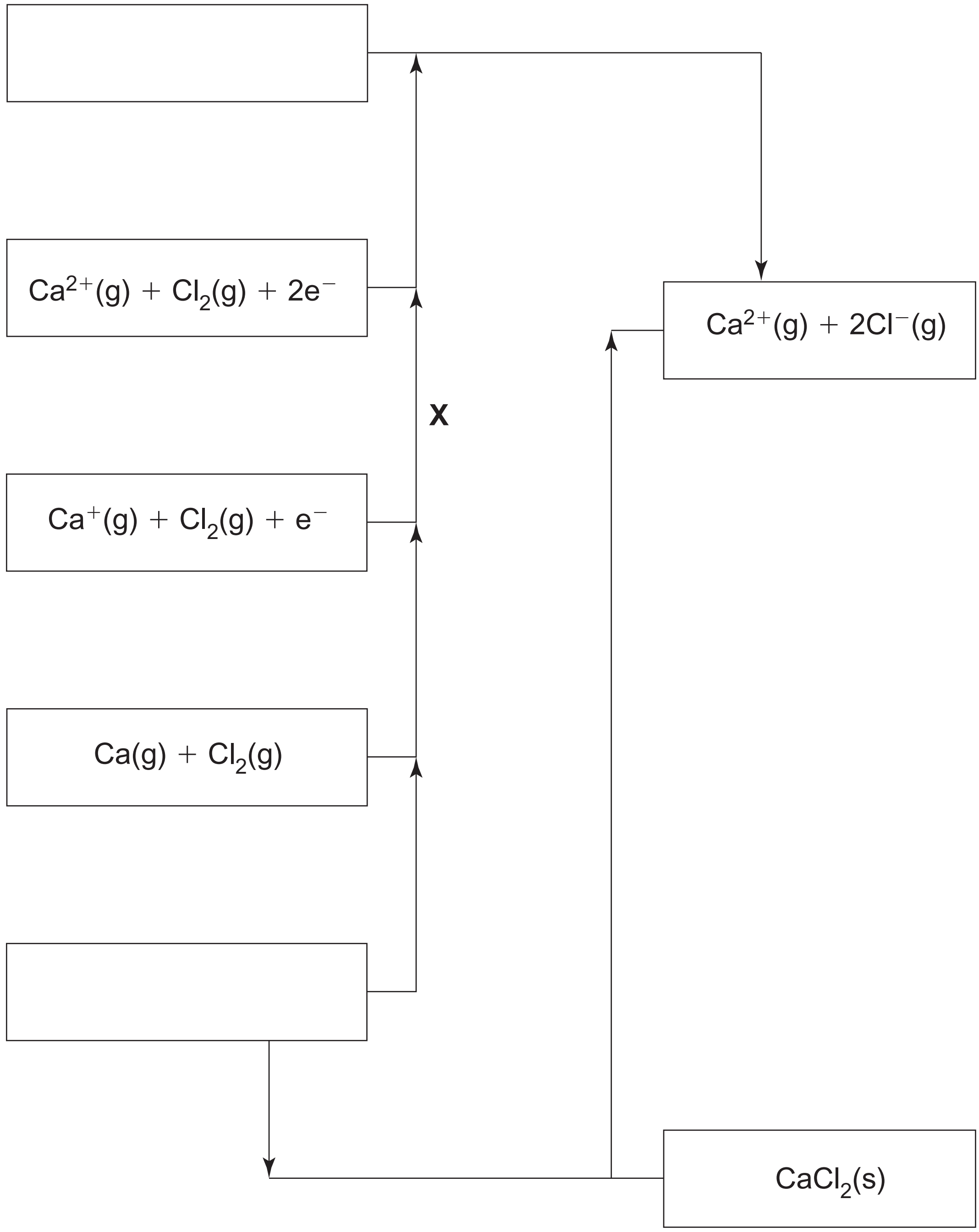
(f) A mixture of tartaric acid and tartrate ions acts as a buffer solution. Using $C_4H_6O_6$ to represent tartaric acid and $C_4H_5O_6^-$ to represent a tartrate ion, write equations to show how this buffer solution responds to the addition of acid and base.

____

____ [2]

17 The incomplete Born-Haber cycle for calcium chloride is shown below.

Examiner Only	
Marks	Remark



(a) Complete the **two** empty boxes in the cycle. [2]

(b) Name the enthalpy change that is labelled **X**.

____ [2]

(c) Using the values below calculate the lattice enthalpy of calcium chloride.

	$kJ\,mol^{-1}$
First ionisation energy of calcium	+590
Second ionisation energy of calcium	+1146
Enthalpy of atomisation of calcium	+190
Bond enthalpy of chlorine	+242
Electron affinity of chlorine	−348
Enthalpy of formation of calcium chloride	−795

____

____

____ [2]

(d) Use the lattice enthalpy which you calculated in part **(c)** and the enthalpies of hydration given below to determine the enthalpy of solution of calcium chloride.

$\Delta H_{hyd}\,(Ca^{2+}) = -1651\,kJ\,mol^{-1}$
$\Delta H_{hyd}\,(Cl^{-}) = -364\,kJ\,mol^{-1}$

____

____

____ [2]

(e) Suggest a value for the pH of the solution formed when calcium chloride is dissolved in water and explain your answer.

____

____ [2]

(f) The entropy change, ΔS, for the formation of calcium chloride is $-152\,J\,mol^{-1}K^{-1}$. Using a suitable calculation, state and explain whether or not the formation of calcium chloride is a spontaneous process at 298 K.

____

____

____

____ [3]

Examiner Only	
Marks	Remark

THIS IS THE END OF THE QUESTION PAPER

Rewarding Learning

ADVANCED
General Certificate of Education
2012

Chemistry

Assessment Unit A2 1

assessing

Periodic Trends and Further Organic, Physical and Inorganic Chemistry

[AC212]

TUESDAY 15 MAY, AFTERNOON

MARK SCHEME

Section A

			AVAILABLE MARKS
1	A		
2	D		
3	D		
4	D		
5	A		
6	C		
7	C		
8	C		
9	A		
10	A		
[2] for each correct answer		[20]	20
		Section A	**20**

Section B

					AVAILABLE MARKS
11	**(a)**	**(i)**	take samples (at regular intervals) [1] (titrate) against standard named acid [1] using named indicator [1]	[3]	
		(ii)	plot graph of concentration (of NaOH) against time [1] calculate gradient [1]	[2]	
	(b)	**(i)**	1st order [1] 1st order [1] Rate = k[RCl][NaOH] [1]	[3]	
		(ii)	170940 [1] $mol^{-1}dm^3s^{-1}$ [1]	[2]	
		(iii)	nucleophilic substitution	[1]	
		(iv)	primary – reaction is second order overall	[1]	12

12 **(a)** $C_6H_{12}O$ [1]

(b) –COOH/ethanoic acid forms H-bonds [1] formed between H of H_2O (or H of COOH) and O of COOH (or O of H_2O) [1]
lauric acid has hydrophobic/long chain [1] [3]

(c) add CO_3^{2-} / HCO_3^- to liquid lauric acid [1] fizzing/test for CO_2 [1] [2]

(d) $C_{11}H_{23}COOH + SOCl_2 \rightarrow C_{11}H_{23}COCl + HCl + SO_2$ [2]

(e) **(i)** $C_{11}H_{23}COOH + 4[H] \rightarrow C_{11}H_{23}CH_2OH + H_2O$ [2]

(ii) lithium aluminium hydride [1]

(f) **(i)** alkaline [1] hydrolysis [1] [2]

(ii) $C_3H_5(OCOC_{11}H_{23})_3 + 3NaOH \rightarrow C_3H_5(OH)_3 + 3C_{11}H_{23}COONa$

or

$$\begin{array}{l} CH_2OCOC_{11}H_{23} \\ | \\ CHOCOC_{11}H_{23} \\ | \\ CH_2OCOC_{11}H_{23} \end{array} + 3NaOH \rightarrow \begin{array}{l} CH_2OH \\ | \\ CHOH \\ | \\ CH_2OH \end{array} + 3\ C_{11}H_{23}COONa$$

[2]

(iii) saponification value = 260 mg = 0.26 g, moles KOH = 0.26/56 = 4.64×10^{-3}

(×1.72) = 7.99×10^{-3}

moles KOH unreacted = (100 × 0.1)/1000 – 7.99×10^{-3} = 2.01×10^{-3}

moles HCl = 2.01×10^{-3} volume HCl = $20.1 cm^3$
each error [–1]

AVAILABLE MARKS

or

$n_{oil} = 1.72/638 = 2.696 \times 10^{-3}$

$(1:3)\ n_{KOH}$ required $= 8.09 \times 10^{-3}$

n_{KOH} unreacted $= \left(100 \times \dfrac{0.1}{1000}\right) - 8.09 \times 10^{-3} = 1.91 \times 10^{-3}$

n_{HCl} required $= 1.91 \times 10^{-3}$

Volume HCl required $= 1.91 \times 10^{-3} \times \dfrac{1000}{0.1} = 19.1\,\text{cm}^3$ [4] 19

13 **(a)** **(i)** $2HClO_4 \rightarrow Cl_2O_7 + H_2O$ [1]

(ii) $P_4O_{10} + 6H_2O \rightarrow 4H_3PO_4$ [2]

(b) P +5 [1]
Cl +7 [1] [2]

(c) 2(35.5)/[2(35.5) + 7(16)] × 100 = 38.8% (1 d.p.) [2] 7

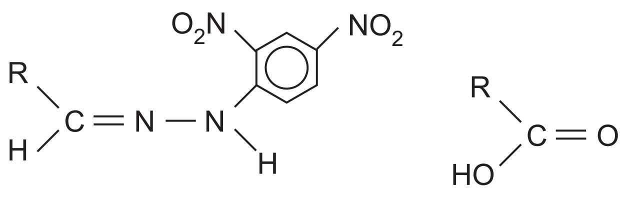
14 **(a)** same molecular formula [1] different structural formula [1] [2]

(b) hydroxyl [1] carbonyl [1] [2]

(c) glucose contains primary/secondary alcohol/aldehyde [1]
fructose contains primary/secondary alcohol [1]
silver mirror [1]
red precipitate [1] [4]
Any mention of no observations for fructose [–1]

Quality of written communication [2]

(d) **(i)**

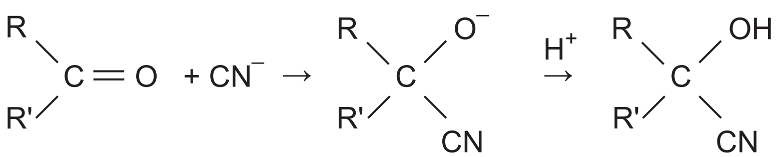


[2]

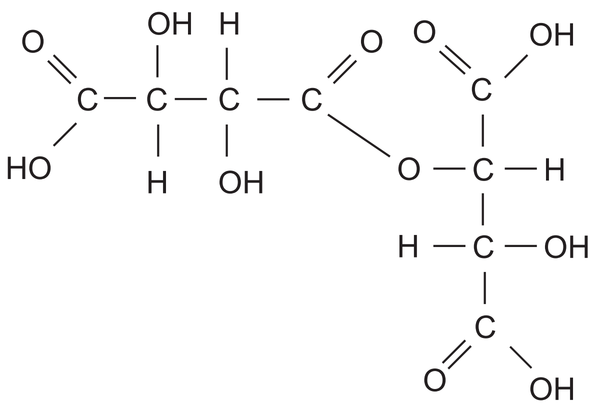
(ii) yellow/orange ppt/solid [2]

(iii) place some sample in (sealed) capillary tube [1]
heat slowly [1]
measure temperature when melting starts and finishes [1]
compare with data book values (for glucose) [1] [4]

(e)



[3] 21

					AVAILABLE MARKS
15	(a)	(i)	gases absorb/prevent escape of [1] infrared radiation [1]	[2]	
		(ii)	global warming	[1]	
	(b)	(i)	moles O_3 at start = 10; at equilibrium = 7 moles O_2 at start = 0; at equilibrium = 4.5 $ppO_3 = (10 \times 7/11.5) = 6.09$ $ppO_2 = (10 \times 4.5/11.5) = 3.91$ $K_p = (3.913)^3/(6.087)^2 = 1.62$ units → atmospheres	[4]	
		(ii)	shifts equilibrium to LHS [1] as there are fewer molecules, to reduce pressure [1]	[2]	
		(iii)	no effect	[1]	10
16	(a)		two carboxyl groups	[1]	
	(b)	(i)	ability to rotate the plane [1] of plane polarised light [1]	[2]	
		(ii)	middle two carbons	[1]	
		(iii)	equal proportions	[1]	
	(c)		$10^{-2.9} = [H^+]^2/0.1$ $[H^+] = 0.01122$ pH = 1.95	[3]	
	(d)	(i)	phenolphthalein [1] colour changes in the pH range corresponding to the vertical portion of the titration curve [1]	[2]	
		(ii)	moles NaOH = $9.8 \times 0.2/1000 = 1.96 \times 10^{-3}$ (1:2) moles tartaric acid = 9.8×10^{-4} mass tartaric acid = $(9.8 \times 10^{-4}) \times 150$ 0.147 g $0.147/25 \times 750 = 4.41$ g	[4]	
	(e)			[2]	
	(f)		$C_4H_5O_6^- + H^+ \rightarrow C_4H_6O_6$ [1] $C_4H_6O_6 + OH^- \rightarrow C_4H_5O_6^- + H_2O$ [1]	[2]	18

17	**(a)** $Ca^{2+}(g) + 2Cl(g) + 2e^-$ [1]		**AVAILABLE MARKS**
	$Ca(s) + Cl_2(g)$ [1]	[2]	
	(b) second [1] ionisation energy of calcium [1]	[2]	
	(c) $\Delta H_{latt} = -(-795) + 190 + 590 + 1146 + 242 + 2(-348) = +2267\ kJ\,mol^{-1}$	[2]	
	(d) $\Delta H_{sol} = \Delta H_{latt} + \Delta H_{hyd}(Ca^{2+}) + 2\ \Delta H_{hyd}(Cl^-)$		
	$= (+2267) + (-1651) + 2(-364) = -112\ kJ\,mol^{-1}$ [2]	[2]	
	(e) pH is 7 [1] formed from a strong acid and a strong base [1]	[2]	
	(f) $\Delta G = \Delta H - T\Delta S$		
	$= (-795) - 298\,(-\frac{152}{1000})$		
	$= -749.7\ (kJmol^{-1})$	[2]	
	Reaction is spontaneous as ΔG is negative	[1]	13
		Section B	**100**
		Total	**120**

Rewarding Learning

ADVANCED
General Certificate of Education
January 2013

Chemistry

Assessment Unit A2 1

assessing

Periodic Trends and Further Organic, Physical and Inorganic Chemistry

[AC212]

AC212

MONDAY 14 JANUARY, AFTERNOON

Centre Number

71	

Candidate Number

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**. Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 120.
Quality of written communication will be assessed in Question **15(a)(iii)**.
In Section A all questions carry equal marks, i.e. **two** marks 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 (including some data) is provided.

For Examiner's use only	
Question Number	**Marks**
Section A	
1–10	
Section B	
11	
12	
13	
14	
15	
Total Marks	

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 can affect the value of the equilibrium constant for homogeneous reactions?

A Addition of a catalyst

B Concentration of reactants

C Pressure

D Temperature

2 The following equilibrium exists in a mixture of concentrated sulfuric and nitric acids.

$$HNO_3 + 2H_2SO_4 \rightleftharpoons NO_2^+ + 2HSO_4^- + H_3O^+$$

Which one of the following statements is correct about this equilibrium?

A The concentration of NO_2^+ is lowered if water is added

B The nitric acid acts as an oxidising agent

C The species HNO_3 and NO_2^+ are a conjugate acid-base pair

D The sulfuric acid acts as a reducing agent

3 How many compounds with asymmetric carbon centres is it possible to prepare by subjecting ethane to repeated chlorination?

A 0

B 1

C 2

D 3

4 Which one of the following statements about the forward and reverse reactions for the following

$$P + Q \rightleftharpoons R + S$$

is correct when the system is at equilibrium?

A The ratio of the rates of the forward reaction to that of the reverse reaction equals the equilibrium constant

B The rates of both the forward and reverse reactions are equal to zero

C The rates of the forward and reverse reactions are equal

D The rate constant for the forward reaction equals the rate constant for the reverse reaction

5 The following is a proposed reaction mechanism for the formation of bromine from bromate ions.

$$BrO_3^- + 2H^+ \rightarrow H_2BrO_3^+$$

$$Br^- + H_2BrO_3^+ \rightarrow Br_2O_2 + H_2O$$

$$Br_2O_2 + 4H^+ + 4Br^- \rightarrow 3Br_2 + 2H_2O$$

Which one of the following is the overall equation for the reaction?

A $BrO_3^- + Br^- + 6H^+ \rightarrow Br_2 + 3H_2O$

B $BrO_3^- + 5Br^- + 6H^+ \rightarrow 3Br_2 + 3H_2O$

C $2BrO_3^- + 12H^+ \rightarrow Br_2 + 6H_2O$

D $2H_2BrO_3^+ + 8H^+ \rightarrow Br_2 + 6H_2O$

6 The rate of reaction between X and Y is third order. Which one of the following rate equations is **not** correct?

A Rate $= k\,[X]^1[Y]^3$

B Rate $= k\,[X]^1[Y]^2$

C Rate $= k\,[X]^2[Y]^1$

D Rate $= k\,[X]^2[Y]^1[Z]^0$

7 Which one of the following is the order of decreasing nucleophilic reactivity of the three species?

A $OH^- > H_2O > H_3O^+$

B $OH^- > H_3O^+ > H_2O$

C $H_2O > H_3O^+ > OH^-$

D $H_2O > OH^- > H_3O^+$

8 Which one of the following reactions has the greatest increase in entropy?

A $X_2(s) + Y_2(g) \rightarrow 2XY(g)$

B $P_2(g) + Q_2(g) \rightarrow 2PQ(g)$

C $M(s) + Z(s) \rightarrow MZ(s)$

D $2A_2(g) + B_2(g) \rightarrow 2A_2B(g)$

9 Which one of the following compounds is formed when the acid below is reduced with excess lithium aluminium hydride?

$$CH_3COCH(CHO)COOH$$

A $CH_3COCH(CH_2OH)_2$

B $CH_3COCH(CHO)CH_2OH$

C $CH_3CHOHCH(CHO)CH_2OH$

D $CH_3CHOHCH(CH_2OH)_2$

10 Which one of the following oxides dissolves in water to form an acid where the central element has an oxidation number of $+6$?

A Cl_2O_7

B P_4O_{10}

C SiO_2

D SO_3

BLANK PAGE

(Questions continue overleaf)

Examiner Only	
Marks	Remark

Section B

Answer **all five** questions in this section in the spaces provided.

11 The concepts of entropy and equilibrium can be used to explain many scientific phenomena.

(a) Explain the meaning of the term **entropy**.

____

____ [1]

(b) Explain why the endothermic reaction between ammonium carbonate and ethanoic acid is spontaneous.

____

____ [2]

(c) Explain whether reactions which have a negative entropy change and a positive enthalpy change are feasible or not.

____

____ [2]

(d) Ammonia is formed by the reaction of nitrogen with hydrogen in an equilibrium reaction.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

If 1.0 mol of nitrogen was mixed with 3.0 mol of hydrogen at 450 °C and a pressure of 3×10^7 Pa, 1.5 mol of ammonia was produced when equilibrium was reached.

(i) Calculate the mole fraction of each constituent in the equilibrium mixture.

____

____

____

____ [2]

(ii) Calculate the partial pressures of each constituent.

[2]

(iii) Calculate the value of K_p and state its units.

[2]

Examiner Only

Marks	Remark

Examiner Only	
Marks	Remark

12 The chlorides of Period 3 exhibit a variety of formulae, types of bonding and structures.

(a) Complete the table below.

name	formula	approximate pH of solution	type of bonding in the structure
sodium chloride			
magnesium chloride			
aluminium chloride			
phosphorus pentachloride			

[5]

(b) Calculate the oxidation number of each of the elements, sodium, magnesium, aluminium, phosphorus and chlorine, in the chlorides above.

____

____ [2]

(c) Write the equation for the reaction of phosphorus pentachloride with water.

____ [2]

(d) Aluminium chloride is a white solid which has a dimeric structure.

(i) Suggest the meaning of the term **dimeric**.

____

____ [1]

(ii) Draw a dot and cross diagram for aluminium chloride, using outer electrons only, labelling the coordinate and covalent bonds present.

[3]

(e) Magnesium chloride is slightly hydrolysed by water but sodium chloride is not. Why is magnesium chloride hydrolysed but sodium chloride is not?

____

____

____ [2]

Examiner Only	
Marks	Remark

(f) All of the chlorides form solutions when added to water. Sodium chloride dissolves in water by an overall endothermic process. It is explained by the following:

The NaCl(s) separates into its gaseous ions.

$NaCl(s) \rightarrow Na^{+}(g) + Cl^{-}(g) \qquad \Delta H_1 = +776\,kJ$

The gaseous ions dissolve to form aqueous ions.

$Na^{+}(g) + Cl^{-}(g) + aq \rightarrow Na^{+}(aq) + Cl^{-}(aq) \qquad \Delta H_2 = -771\,kJ$

(i) What is the name for the enthalpy value ΔH_1?

______________________________ [1]

(ii) What is the name for the enthalpy value ΔH_2?

______________________________ [1]

(iii) ΔH_3 is the enthalpy of solution. Draw a labelled diagram to show the relationship between ΔH_1, ΔH_2 and ΔH_3.

[3]

(iv) Calculate the value of ΔH_3.

______________________________ [1]

Examiner Only	
Marks	Remark

BLANK PAGE

(Questions continue overleaf)

Examiner Only	
Marks	Remark

13 Citric acid is found in many fruits especially when they are unripe. It can be obtained from lemon juice which contains about 6–10% citric acid by mass. It crystallises with one molecule of water which is lost at 130 °C, it then melts at 153 °C.

$$\begin{array}{l} CH_2COOH \\ | \\ C(OH)COOH \\ | \\ CH_2COOH \end{array}$$

citric acid

(a) Citric acid is a tribasic acid. Suggest the meaning of **tribasic**.

____

____ [2]

(b) The extraction of citric acid from lemon juice involves boiling the juice to coagulate proteins and then neutralising the acids present with calcium carbonate.

(i) Explain whether there would be an effect on citric acid when the lemon juice solution is boiled.

____ [1]

(ii) Write the equation for the reaction of citric acid with excess calcium carbonate.

____ [2]

(iii) Citric acid is reformed when the calcium citrate is reacted with sulfuric acid. Write the equation for this reaction.

____ [2]

(c) Citric acid may be synthesised from glycerol by the following reactions.

$$
\begin{array}{ccccccccccc}
CH_2OH & & CH_2Cl & & CH_2Cl & & CH_2Cl & & CH_2CN & & CH_2COOH \\
| & \text{A} & | & \text{B} & | & \text{C} & | & \text{KCN} & | & \text{D} & | \\
CHOH & \rightarrow & CHOH & \rightarrow & CO & \rightarrow & C(OH)CN & \rightarrow & C(OH)CN & \rightarrow & C(OH)COOH \\
| & & | & & | & & | & & | & & | \\
CH_2OH & & CH_2Cl & & CH_2Cl & & CH_2Cl & & CH_2CN & & CH_2COOH
\end{array}
$$

Name reagents A, B, C and D.

Examiner Only	
Marks	Remark

A ______________________________ [1]

B ______________________________ [1]

C ______________________________ [1]

D ______________________________ [1]

(d) Citric acid has many uses. Most are based on its acidic properties.

(i) Write the equation for the complete dissociation of citric acid.

______________________________ [1]

(ii) If the first dissociation constant for citric acid has a pK_a value of 3.05 calculate the pH of a 60 g dm^{-3} aqueous solution of citric acid.

____

____

____

______________________________ [4]

Examiner Only	
Marks	Remark

(e) Citric acid contains an hydroxyl group which means that it can react as an alcohol. Explain whether citric acid is a primary, secondary or tertiary alcohol.

____

____ [2]

(f) When heated, citric acid eliminates a molecule of water to form aconitic acid.

$$
\begin{array}{lcl}
CH_2COOH & & CHCOOH \\
| & & \| \\
C(OH)COOH & \rightarrow & C - COOH \quad + \quad H_2O \\
| & & | \\
CH_2COOH & & CH_2COOH \\
 & & \\
 & & \text{aconitic acid}
\end{array}
$$

Draw and label the E and Z isomers of aconitic acid.

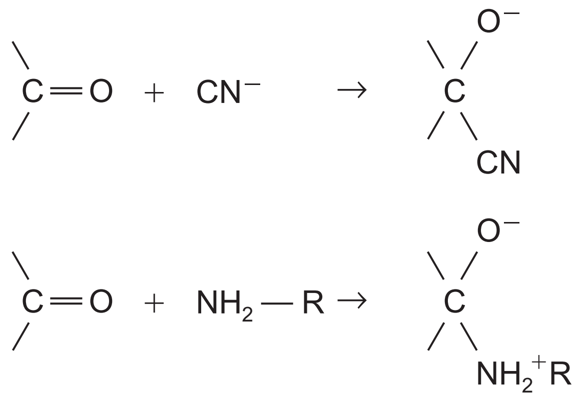
[3]

BLANK PAGE

(Questions continue overleaf)

Examiner Only	
Marks	Remark

14 Nucleophiles react with carbonyl compounds to form addition products which may then undergo a series of reactions. Both the cyanide ion and amino compounds act as nucleophiles with the initial reaction for both nucleophiles being:



(a) Define the term **nucleophile**.

____

____ [2]

(b) Explain why the carbonyl group is susceptible to attack by a nucleophile.

____

____ [1]

(c) Draw a flow scheme to show the mechanism for the reaction of hydrogen cyanide with methanal.

[2]

(d) The reaction of carbonyl compounds with amino compounds is used as a means of identifying the carbonyl compound. Initially, the reaction of carbonyl compounds with hydrazine, NH_2NH_2, was used. Later it was the reaction with phenylhydrazine and today it is the reaction with 2,4-dinitrophenylhydrazine.

(i) Write the equation for the reaction of propanone with hydrazine.

____ [2]

(ii) Suggest the first step in the mechanism for the reaction of propanone with hydrazine.

[1]

(iii) Draw the structural formula for 2,4-dinitrophenylhydrazine.

[1]

(iv) In terms of intermolecular forces suggest the advantages of using 2,4-dinitrophenylhydrazine compared to hydrazine when preparing derivatives of the carbonyl compound.

____

____

____

____ [3]

Examiner Only	
Marks	Remark

Examiner Only

Marks	Remark

(e) Hydroxylamine, NH_2OH, may be used to form oximes which were also used for identification purposes. Write the equation for the condensation reaction of propanal with hydroxylamine.

____ [2]

(f) Aldehydes can be distinguished from ketones using the following reagents.

(i) Complete the following table.

reagent	**formula of metal/ion before test**	**formula of metal/ion after a positive test**
Fehling's solution		
Tollen's reagent		

[2]

(ii) Which reagent(s) will give a positive test for ethanal?

____ [1]

(g) Technological methods have removed the need to form derivatives for identification purposes. Outline how they can be used to determine the identity of an organic compound.

____

____

____

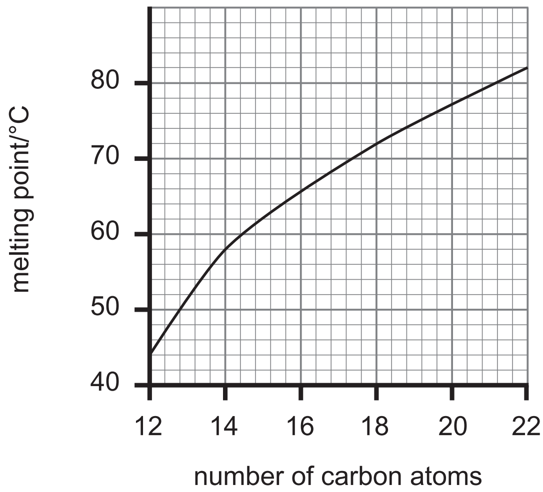
____

____ [3]

BLANK PAGE

(Questions continue overleaf)

15 The higher carboxylic acids which occur in nature have straight chains and usually contain an even number of carbon atoms.
The melting points of some of the acids are shown below.



(a) **(i)** What is the general formula of a carboxylic acid?

____ [1]

(ii) Explain why there is a gradual increase in melting point of the acids.

____

____ [2]

(iii) Giving full experimental details explain how you would determine the melting point of one of these acids.

____

____

____

____

____

____ [4]

Quality of written communication [2]

Examiner Only	
Marks	Remark

(b) Palmitic acid, $C_{15}H_{31}COOH$, forms the triglyceride palmitin when it reacts with glycerol.

Examiner Only	
Marks	Remark

(i) What is the empirical formula for palmitic acid?

______________________________ [1]

(ii) Write the equation for the reaction of palmitic acid with glycerol.

[2]

(iii) Explain what is meant by the term **saponification value**.

____

____

______________________________ [3]

(iv) Calculate the saponification value of palmitin which has a relative molecular mass of 806.

____

____

____

______________________________ [3]

Examiner Only

Marks	Remark

(c) Palmitin is described as a "saturated fat".

(i) Explain the meaning of the term **saturated**.

____

____ [2]

(ii) Explain whether palmitin has an iodine value.

____

____ [2]

(iii) Explain whether palmitin, present in foods, contributes to a healthy or an unhealthy diet.

____

____

____

____

____

____ [3]

(d) Palmitin may be hydrolysed. Name **two** chemicals, with very different pH values, which may be used to carry out the hydrolysis.

____ [2]

THIS IS THE END OF THE QUESTION PAPER

Rewarding Learning

ADVANCED
General Certificate of Education
January 2013

Chemistry

Assessment Unit A2 1

assessing

Periodic Trends and Further Organic, Physical and Inorganic Chemistry

[AC212]

MONDAY 14 JANUARY, AFTERNOON

MARK SCHEME

Section A

			AVAILABLE MARKS
1	D		
2	A		
3	A		
4	C		
5	B		
6	A		
7	A		
8	A		
9	D		
10	D		
[2] for each correct answer		[20]	20
		Section A	**20**

Section B

AVAILABLE MARKS

11 **(a)** Entropy is the (degree of) disorder (in a system) [1]

(b) Despite the drop in temperature which means ΔH is positive
there is a (great) increase in entropy [1]
because of the carbon dioxide produced
hence ΔG is negative and the reaction is spontaneous [1] [2]

(c) $\Delta G = \Delta H - T\Delta S$
if ΔS is –ve then $-T\Delta S$ is +ve [1]
(ΔH is +ve i.e. both are +ve)
then ΔG must be +ve and the reaction is not possible/feasible [1] [2]

(d) **(i)**

	N_2	+	$3H_2$	$\rightleftharpoons$	$2NH_3$
Mol before equilibrium	1.0		3.0		0
Mol after equilibrium	1.0 – 0.75		3.0 – 2.25		1.5
	0.25		0.75		1.5

Nitrogen = 0.25/2.5 = 0.1
Hydrogen = 0.75/2.5 = 0.3
Ammonia = 1.5/2.5 = 0.6 [2]

(ii) Nitrogen = $0.1 \times 3 \times 10^7$ Pa
Hydrogen = $0.3 \times 3 \times 10^7$ Pa
Ammonia = $0.6 \times 3 \times 10^7$ Pa

Nitrogen = 3×10^6 Pa
Hydrogen = 9×10^6 Pa
Ammonia = 1.8×10^7 Pa units needed [2]

(iii) $K_p = (1.8 \times 10^7)^2/3 \times 10^6 \times (9 \times 10^6)^3 = 1.48 \times 10^{-13}\ Pa^{-2}$ [2] 11

12	**(a)**				AVAILABLE MARKS

name	formula	approximate pH of solution	bonding in structure of chloride
sodium chloride	*NaCl*	*7*	*ionic*
magnesium chloride	*$MgCl_2$*	*6*	*ionic*
aluminium chloride	*Al_2Cl_6*	*1 or 2*	*covalent/coordinate*
phosphorus pentachloride	*PCl_5*	*1 or 2*	*covalent or covalent + ionic*

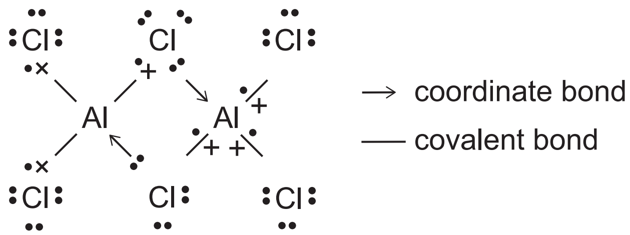
[5]

(b) sodium +1 magnesium +2 aluminium +3 phosphorus +5 chlorine –1 [2]
error [–1]

(c) $PCl_5 + H_2O \rightarrow POCl_3 + 2HCl$
or
$PCl_5 + 4H_2O \quad H_3PO_4 + 5HCl$ [2]

(d) **(i)** Two molecules joined together [1]

(ii)



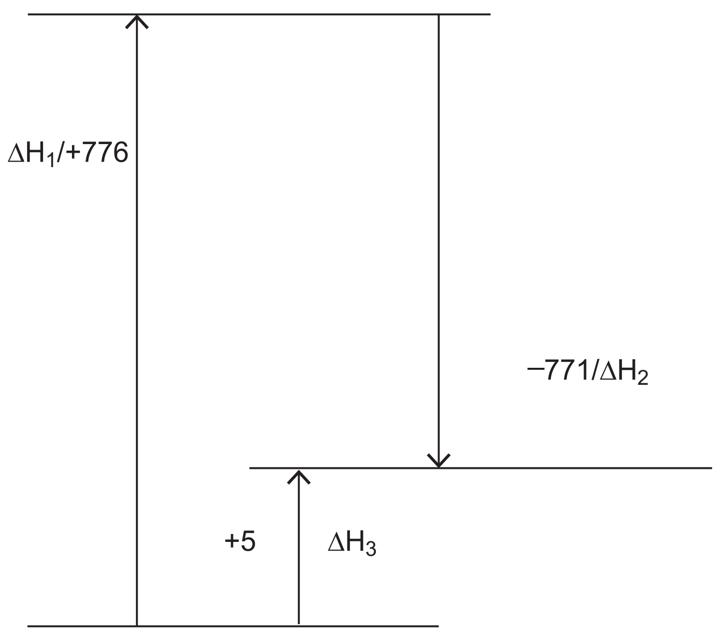
[3]

(e) Magnesium chloride is formed from a weak(er) base and a strong acid [1]
sodium chloride is formed from a strong(er) base and a strong acid [1] [2]
or Mg^{2+} polarises H_2O [2]

(f) **(i)** Lattice enthalpy/energy [1]

(ii) Hydration enthalpy/energy [1]

(iii) No need to write the symbols on the lines



[3]

or an equivalent Hess Law diagram.

(iv) $\Delta H_3 = -771 + 776 = +5$ (kJ) [1]

21

AVAILABLE MARKS

13 (a) One molecule of citric acid/contains three –COOH [1]
or donates three protons [1] per molecule [1] [2]

(b) (i) No effect
e.g. citric acid melts at 153 °C [1]

(ii)

$$\begin{array}{l} \mathrm{CH_2COOH} \\ \;| \\ \mathrm{2C(OH)COOH} \\ \;| \\ \mathrm{CH_2COOH} \end{array} + \mathrm{3CaCO_3} \rightarrow \mathrm{Ca_3}\left(\begin{array}{l} \mathrm{CH_2COO} \\ | \\ \mathrm{C(OH)COO} \\ | \\ \mathrm{CH_2COO} \end{array}\right)_2 + \mathrm{3CO_2} + \mathrm{3H_2O}$$

[2]

(iii)

$$\mathrm{Ca_3}\left(\begin{array}{l} \mathrm{CH_2COO} \\ | \\ \mathrm{C(OH)COO} \\ | \\ \mathrm{CH_2COO} \end{array}\right)_2 + \mathrm{3H_2SO_4} \rightarrow 2\begin{array}{l} \mathrm{CH_2COOH} \\ | \\ \mathrm{C(OH)COOH} \\ | \\ \mathrm{CH_2COOH} \end{array} + \mathrm{3CaSO_4}$$

[2]

(c) A Hydrogen chloride/phosphorus pentachloride/$SOCl_2$ [1]
B (acidified) potassium dichromate etc [1]
C hydrogen cyanide [1]
D named dilute $HCl/H_2SO_4/HNO_3$ or conc HCl
or NaOH/KOH followed by acid [1]

(d) (i)

$$\begin{array}{l} \mathrm{CH_2COOH} \\ | \\ \mathrm{C(OH)COOH} \\ | \\ \mathrm{CH_2COOH} \end{array} \rightarrow \begin{array}{l} \mathrm{CH_2COO^-} \\ | \\ \mathrm{C(OH)COO^-} \\ | \\ \mathrm{CH_2COO^-} \end{array} + 3H^+$$

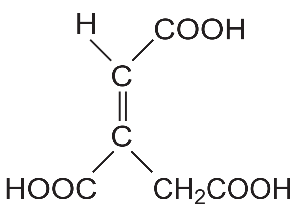
[1]

(ii) Citric acid = $C_6H_8O_7$ = $6 \times 12 + 8 \times 1 + 7 \times 16 = 72 + 8 + 112$
$= 192$

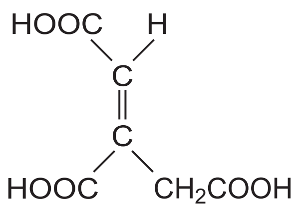
60 g of citric acid = 60/192 mole in 1000 cm^3 water = 0.31 M
$8.9 \times 10^{-4} = [H^+]^2/[HX]$
$[H^+]^2 = 8.9 \times 10^{-4} \times 0.31 = 2.76 \times 10^{-4}$
$[H^+] = 1.66 \times 10^{-2}$
pH = 1.78 [4]

(e) Tertiary alcohol group [1]
carbon attached to the oxygen is attached to three carbons [1] [2]

(f)



E structure



Z structure

[3]

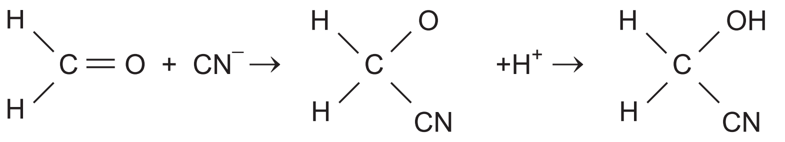
21

AVAILABLE MARKS

14 **(a)** An ion or molecule with a lone pair of electrons that attacks regions of low electron density [2]

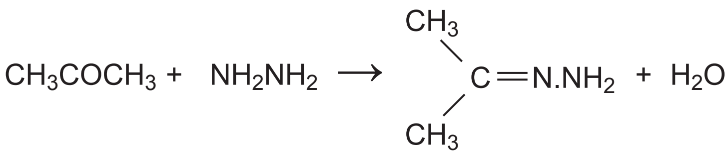
(b) The nucleophile is attracted to the $\delta+$ on the carbon atom [1]

(c)



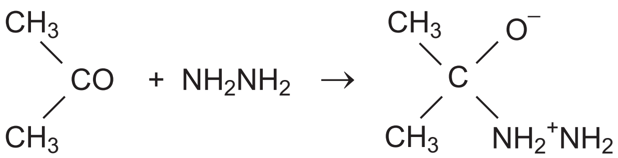
[2]

(d) **(i)**



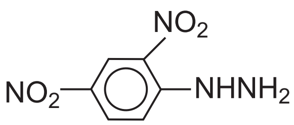
[2]

(ii)



[1]

(iii)



[1]

(iv) 2,4-dinitrophenylhydrazine is large/large mass [1]
it has polar groups [1]
hence van der Waals forces larger in the derivative [1]
polar forces larger [1]
hydrazone is more likely to precipitate from solution/be a solid [1]
more likely to have a high melting point [1]

To a maximum of [3] [3]

(e) $CH_3CH_2CHO + NH_2OH \longrightarrow CH_3CH_2CH{=}NOH + H_2O$ [2]

(f) **(i)**

reagent	formula of metal/ion before test	formula of metal/ion after a positive test
Fehling's solution	Cu^{2+}	Cu^{+}
Tollen's reagent	Ag^{+}	Ag

[2]

(ii) Fehling's and Tollen's [1]

(g) Infrared spectrum [1]
specific frequencies for specific bonds [1]
mass spectrometry [1]
molecular ion pattern [1]

To a maximum of [3] [3]

20

AVAILABLE MARKS

15 (a) (i) $C_nH_{2n}O_2$ [1]

(ii) There is an increase in mass [1]
van der Waals forces increase [1] [2]

(iii) Al block/water/oil bath [1] + melting point tube/sealed capillary tube [1]
heat slowly/e.g. one degree every 10 seconds [1]
$\left.\begin{array}{l}\text{note when the solid starts to melt [1]}\\\text{note when the solid stops melting [1]}\end{array}\right\}$ m.pt range [1]

To a maximum of [4] [4]

Quality of written communication [2]

(b) (i) $C_8H_{16}O$ [1]

(ii)

$$\begin{array}{lclcll} CH_2OH & & C_{15}H_{31}COOH & & CH_2OCOC_{15}H_{31} & \\ | & & & & | & \\ CHOH & + & C_{15}H_{31}COOH & \rightarrow & CHOCOC_{15}H_{31} & + \quad 3H_2O \\ | & & & & | & \\ CH_2OH & & C_{15}H_{31}COOH & & CH_2OCOC_{15}H_{31} & \end{array}$$

[2]

(iii) Number of milligrams of [1]
potassium hydroxide [1]
required to react with 1 g of fat/oil [1] [3]

(iv) Moles of palmitin = 1/806 = 0.00124 mole
moles of KOH required = 3 × 0.00124 = 0.00372
mass of KOH required = 56 × 0.00372 = 0.208 g
= 208 mg [3]

(c) (i) Contains no double bonds [1]
of the type C═C [1] [2]

(ii) No iodine value [1]
no C═C bonds [1] [2]

(iii) Increased levels of cholesterol [1]
leading to increased level of heart disease [1]
saturated fats are useful for
insulation [1]/energy [1]/protection [1] (max. [2])
all to a maximum of [3] [3]

(d) Sodium/potassium hydroxide [1]
any hydrochloric/dilute sulfuric acid 1] [2] 27

Section B	**100**
Total	**120**

Centre Number

71	

Candidate Number

Rewarding Learning

ADVANCED
General Certificate of Education
2013

Chemistry

Assessment Unit A2 1

assessing

Periodic Trends and Further Organic, Physical and Inorganic Chemistry

[AC212]

AC212

THURSDAY 23 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 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**. Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 120.
Quality of written communication will be assessed in Question **14(b)(iii)**.
In Section A all questions carry equal marks, i.e. **two** marks 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 in this question paper.

For Examiner's use only	
Question Number	**Marks**
Section A	
1–10	
Section B	
11	
12	
13	
14	
15	
16	
Total Marks	

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 is the conjugate acid of the hydrogenphosphate(V) ion, HPO_4^{2-}?

A H_3PO_4

B $H_3PO_4^-$

C $H_2PO_4^-$

D PO_4^{3-}

2 Which one of the following terms does **not** describe the reaction below?

$$C_2H_5OH + CH_3COOH \rightleftharpoons CH_3COOC_2H_5 + H_2O$$

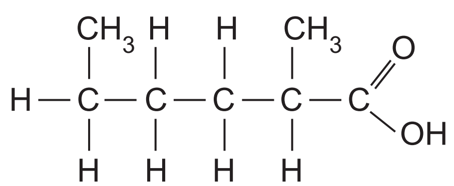
A Condensation

B Esterification

C Hydration

D Reversible

3 Which one of the following is the systematic name for the carboxylic acid shown below?



A 1,4-dimethylpentanoic acid

B 2,5-dimethylpentanoic acid

C 2-methylhexanoic acid

D 5-methylhexanoic acid

4 Which one of the following solid compounds exhibits covalent bonding?

A Aluminium oxide

B Magnesium chloride

C Sodium chloride

D Sulfur trioxide

5 Which one of the following solutions has a pH of 1?

A 0.1 M HCl

B 0.1 M H_2SO_4

C 0.2 M HCl

D 0.2 M H_2SO_4

6 A gaseous mixture contains 0.10 g hydrogen and 6.35 g iodine, at a pressure of 30 kPa. Which one of the following is the partial pressure of hydrogen?

A 10 kPa

B 20 kPa

C 30 kPa

D 47 kPa

7 Which one of the following molecules can exist as E–Z isomers?

A $CH_3CH_2CHCH_2$

B $CH_3CH(OH)COOH$

C $CH_3CH_2CHCHCH_3$

D $CH_3CH_2CH(OH)CH_2CH_3$

8 Which one of the following salts would produce a neutral solution when dissolved in water?

A Ammonium chloride

B Potassium chloride

C Potassium ethanoate

D Sodium carbonate

9 10.0 g of benzoic acid were dissolved in 50.0 cm^3 of ether. The partition coefficient, K_d, for benzoic acid between ether and water is 18.0. Which one of the following is the volume of water required to extract 1.0 g of benzoic acid?

A 3.2 cm^3

B 50.0 cm^3

C 100.0 cm^3

D 162.0 cm^3

10 Which one of the following gases present in the atmosphere does **not** act as a greenhouse gas?

A Argon

B Carbon dioxide

C Methane

D Water vapour

Section B

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

Examiner Only	
Marks	Remark

11 The oxides of the Period 3 elements exhibit different properties in terms of their reactions with acids, bases and water.

(a) Name a basic oxide from Period 3.

____ [1]

(b) Write the formula for an amphoteric oxide from Period 3.

____ [1]

(c) Sulfur dioxide is an acidic oxide. Write an equation for the reaction of sulfur dioxide with excess sodium hydroxide solution.

____ [2]

(d) State the type of bonding and structure found in silicon dioxide.

____

____ [2]

(e) Name one Period 3 oxide which does not react with water.

____ [1]

(f) Chlorine(VII) oxide reacts with water. Write an equation for this reaction.

____ [2]

(g) Phosphorus(V) oxide also reacts with water according to the equation:

$$P_4O_{10} + 6H_2O \rightarrow 4H_3PO_4$$

Name the product.

____ [1]

12 Pentyl ethanoate is the ester formed from pentan-1-ol and ethanoic acid.

Examiner Only	
Marks	Remark

$$CH_3COOH + C_5H_{11}OH \rightleftharpoons CH_3COOC_5H_{11} + H_2O$$

(a) Draw the structure of pentyl ethanoate showing all the bonds present.

[1]

(b) 1.1 g of pentan-1-ol and 1.2 g of ethanoic acid were mixed. Equilibrium was established at 298 K.

(i) Write an expression for the equilibrium constant, K_c, for this reaction.

[1]

(ii) At equilibrium 0.6 g of ethanoic acid remained. Calculate the value of K_c.

____

____

____

____

____

______________________________ [4]

(iii) K_c for the reaction at 330 K is 6.47 and at 350 K the value is 8.31. State whether the reaction is exothermic or endothermic and explain your answer.

____

____

______________________________________ [2]

Examiner Only	
Marks	Remark

13 Gunpowder is a mixture of potassium nitrate, carbon and sulfur. The explosive effect of gunpowder is caused by the rapid production of a large volume of gas from a small mass of solid.

Examiner Only	
Marks	Remark

(a) $2KNO_3(s) + S(s) + 3C(s) \rightarrow K_2S(s) + N_2(g) + 3CO_2(g)$

(i) State the oxidation numbers of each element in the equation before and after reaction.

____

____ [2]

(ii) Explain, in terms of oxidation numbers, why this reaction is a redox reaction.

____

____ [2]

(b) A sample of gunpowder was prepared using the following quantities.

6 g of potassium nitrate
1 g of carbon
1 g of sulfur

Calculate the total volume of gas produced from the explosion of this mixture at 20 °C and one atmosphere pressure.

____

____

____

____ [4]

(c) The table below gives the standard enthalpy of formation, $\Delta H_f^{\ominus}$, values for potassium nitrate, potassium sulfide and carbon dioxide.

	$\Delta H_f^{\ominus}$/kJ mol^{-1}
KNO_3	−493
K_2S	−418
CO_2	−394

Using Hess's Law, calculate the enthalpy change for the explosion of gunpowder in kJ.

____

____

____

____

____ [3]

(d) The standard entropy values, $S^{\ominus}$, for the reactants and products in the explosion of gunpowder are given below.

	$S^{\ominus}$/J K^{-1} mol^{-1}
KNO_3	172
S	32
C	5.7
K_2S	115
N_2	191
CO_2	214

(i) Calculate the standard entropy change for the explosion of gunpowder.

____

____

____

____ [2]

(ii) Explain why this reaction is feasible at all temperatures.

____

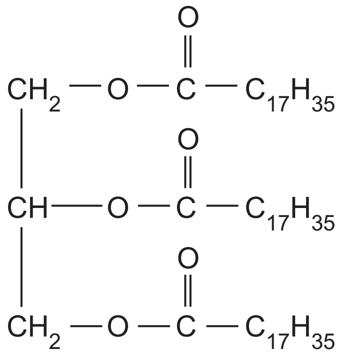
____

____ [2]

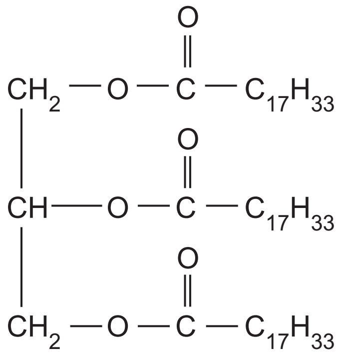
Examiner Only	
Marks	Remark

14 The structures of glyceryl tristearate and glyceryl trioleate are shown below.

Examiner Only	
Marks	Remark



glyceryl tristearate



glyceryl trioleate

(a) Saponification of glyceryl tristearate can be carried out using sodium hydroxide or potassium hydroxide.

(i) Write an equation for the saponification of glyceryl tristearate using sodium hydroxide.

[3]

(ii) Write the molecular formula for glyceryl tristearate and calculate its relative molecular mass.

Molecular formula: ______________________________

Relative Molecular Mass: ____________________________ [2]

(iii) Define the term **saponification value**.

____

____ [2]

(iv) Calculate the saponification value of glyceryl tristearate.

____

____

____

____ [4]

(b) The iodine value of a fat or oil may be determined experimentally. The iodine value of glyceryl trioleate is 86.2 whereas the value for glyceryl tristearate is 0.

(i) What is meant by the term **iodine value**?

____

____ [2]

(ii) Explain why the iodine value of glyceryl tristearate is 0.

____

____ [1]

(iii) Describe, giving practical details, how you would determine the iodine value of a fat or oil. Details of the calculation are not required.

____

____

____

____

____

____

____

____

____ [6]

Quality of written communication [2]

(iv) Suggest why glyceryl tristearate is a solid at room temperature and pressure whereas glyceryl trioleate is a liquid.

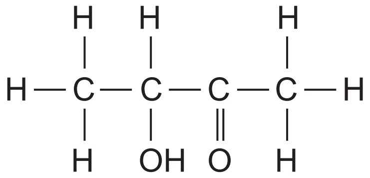
____

____

____ [2]

Examiner Only	
Marks	Remark

15 Acetoin is found naturally in butter and is added to foods to give a buttery taste. It is also added to some cigarettes to improve flavour. The structure of acetoin is shown below.



(a) (i) State the systematic name for acetoin.

____ [2]

(ii) Explain why acetoin is soluble in water.

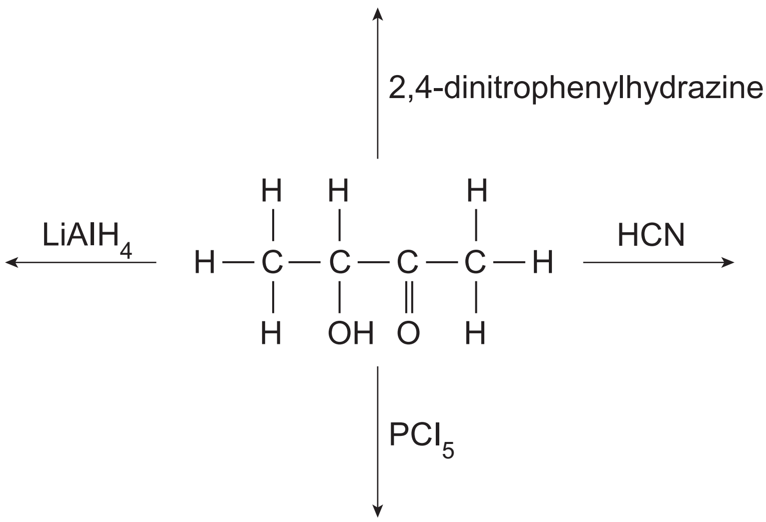
____

____ [2]

(iii) The scheme below shows some of the reactions of acetoin. Complete the scheme to show the structure of the organic product for each reaction.

[4]

Examiner Only	
Marks	Remark



(iv) Suggest the name of the mechanism for the reaction of acetoin with hydrogen cyanide.

____ [2]

(b) Acetoin undergoes mild oxidation when warmed with acidified potassium dichromate. The table below gives kinetics data for an experiment involving the oxidation of acetoin.

[acetoin] $mol\,dm^{-3}$	**$[H^+]$ $mol\,dm^{-3}$**	**$[Cr_2O_7^{2-}]$ $mol\,dm^{-3}$**	**rate of reaction $mol\,dm^{-3}\,s^{-1}$**
0.1	1.0	0.1	4.36×10^{-3}
0.2	1.0	0.1	1.74×10^{-2}
0.2	2.0	0.2	6.98×10^{-2}
0.2	2.0	0.4	1.40×10^{-1}

(i) Using [O] to represent the oxidising agent write an equation for the oxidation of acetoin.

____ [2]

(ii) What colour change would be observed when acetoin is oxidised using acidified potassium dichromate?

____ [2]

(iii) Using the information in the table above determine the order of reaction with respect to each of the reactants below:

acetoin ____

H^+ ____

$Cr_2O_7^{2-}$ ____ [2]

(iv) Write a rate equation for the reaction.

____ [1]

Examiner Only
Marks | Remark

(v) Determine the value of the rate constant and state its units.

[2]

(c) Acetoin is optically active.

(i) Explain what is meant by the term **optically active**.

[2]

(ii) Explain, in terms of structure, why acetoin is optically active.

[2]

(iii) Draw the two optical isomers of acetoin below.

[2]

(iv) Explain why a mixture of the two isomers of acetoin may **not** exhibit any optical activity.

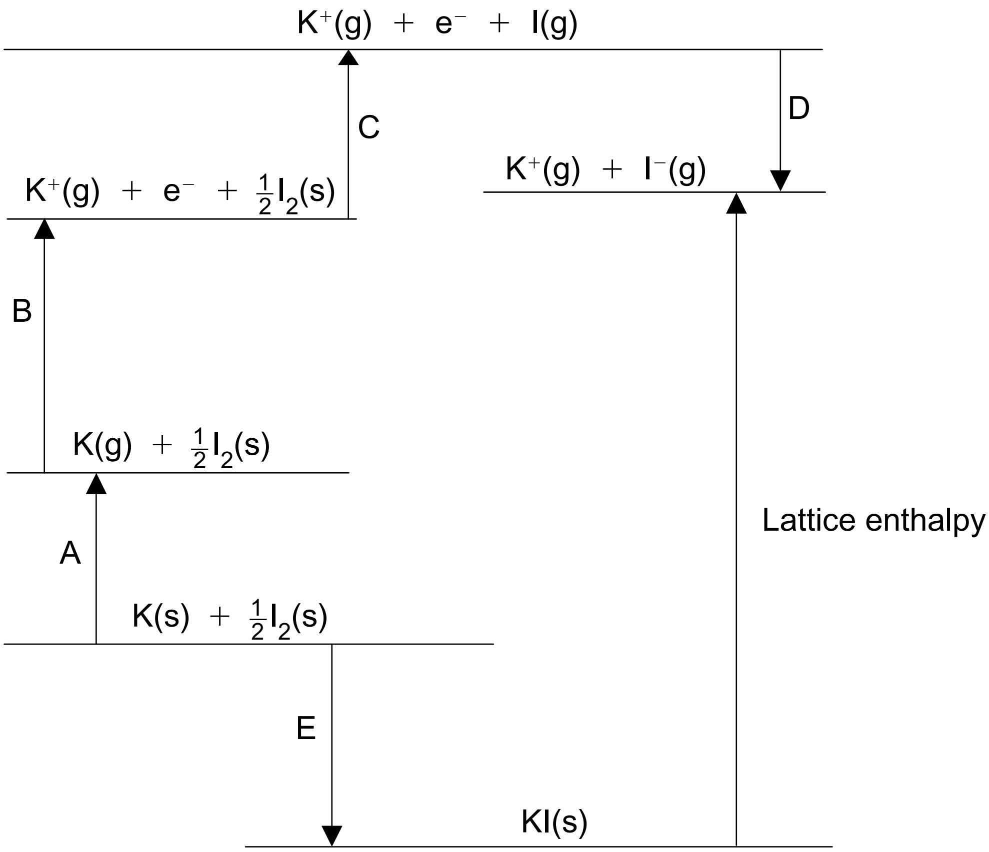
[2]

Examiner Only	
Marks	Remark

BLANK PAGE

(Questions continue overleaf)

16 A Born-Haber cycle for potassium iodide is shown below. The lattice enthalpy is labelled. Other enthalpy changes are shown by the letters A to E.



(a) For the following questions state which letter (A to E) represents the enthalpy changes:

Standard enthalpy of formation of potassium iodide

____ [1]

First electron affinity of iodine

____ [1]

First ionisation energy of potassium

____ [1]

Enthalpy of atomisation of potassium

____ [1]

Examiner Only	
Marks	Remark

(b) Calculate the lattice enthalpy of potassium iodide using the following data.

	$kJ\ mol^{-1}$
A	+89.5
B	+420.0
C	+106.6
D	−295.4
E	−327.6

____

____

__________________________________ $kJ\ mol^{-1}$ [2]

(c) (i) Potassium chloride has a lattice enthalpy of $+710\,kJ\ mol^{-1}$ and that for potassium bromide is $+679\,kJ\ mol^{-1}$. State **three** other enthalpy changes in a Born-Haber cycle for these compounds which would be different.

____

____

____ [3]

(ii) Explain why the enthalpy changes given in **(c)(i)** are different for each compound.

____

____

____ [3]

Examiner Only
Marks	Remark

(d) Potassium chloride is very soluble in water.

(i) Write an equation, including state symbols, to represent potassium chloride dissolving in water.

____ [2]

(ii) The enthalpy change of hydration for the potassium ion is $-305\ \text{kJ mol}^{-1}$ and the value for the chloride ion is $-384\ \text{kJ mol}^{-1}$. Using the lattice enthalpy value stated in **(c)(i)** for potassium chloride, calculate the enthalpy change when one mole of potassium chloride is dissolved in water.

____

____

____ [2]

THIS IS THE END OF THE QUESTION PAPER

Examiner Only	
Marks	Remark

113079

Rewarding Learning

ADVANCED
General Certificate of Education
2013

Chemistry

Assessment Unit A2 1

assessing

Periodic Trends and Further Organic, Physical and Inorganic Chemistry

[AC212]

THURSDAY 23 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.

Section A

		AVAILABLE MARKS
1 C		
2 C		
3 C		
4 D		
5 A		
6 B		
7 C		
8 B		
9 C		
10 A		
[2] for each correct answer	[20]	20
	Section A	**20**

Section B

AVAILABLE MARKS

11 **(a)** sodium oxide **or** magnesium oxide **or** aluminium oxide [1]

(b) Al_2O_3 [1]

(c) $SO_2 + 2NaOH \rightarrow Na_2SO_3 + H_2O$ [2]

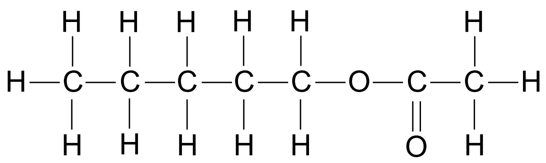
(d) covalent [1]
giant/macromolecular [1] [2]

(e) aluminium oxide/silicon dioxide [1]

(f) $Cl_2O_7 + H_2O \rightarrow 2HClO_4$ [2]

(g) phosphoric acid/phosphoric(V) acid [1] 10

12 **(a)**



[1]

(b) **(i)** $K_c = \dfrac{[C_5H_{11}OOCCH_3][H_2O]}{[C_5H_{11}OH][CH_3COOH]}$ [1]

(ii) converting g to mols

	$C_5H_{11}OH$	$+ CH_3COOH$	$\rightleftharpoons C_5H_{11}OOCCH_3$	$+ H_2O$
initial moles	0.0125	0.02	0	0
equilibrium moles	0.0025	0.01	0.01	0.01

$K_c = \dfrac{(0.01)(0.01)}{(0.0025)(0.01)} = 4$ [−1] for each error [4]

(iii) endothermic [1]
more product/reaction moves to RHS [1] [2] 8

AVAILABLE MARKS

13 (a) (i)

K	+1	+1
N	+5	0
O	−2	−2
C	0	+4
S	0	−2

[2]

(ii) N reduced from +5 to 0
C oxidised from 0 to +4
S reduced from 0 to −2
oxidation and reduction occurring simultaneously [2]

(b) n $KNO_3 = \frac{6}{101} = 0.059$ 2

n $C = \frac{1}{12} = 0.0833$ 3 limiting.

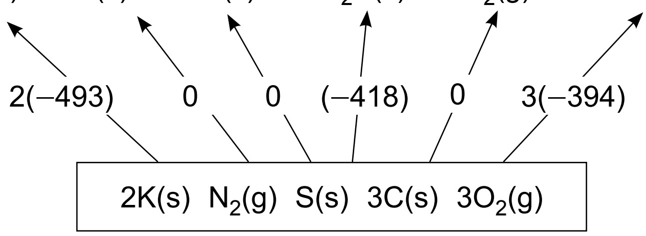
n $S = \frac{1}{32} = 0.03125$ 1

(3 : 1) n $N = \frac{0.0833}{3} = 0.0278$

(3 : 3) n $CO_2 = 0.0833$

$0.0278 + 0.0833 = 0.111 \times 24 = 2.67\ dm^3$ [4]

(c) $2KNO_3(s) + S(s) + 3C(s) \rightarrow K_2S(s) + N_2(g) + 3CO_2(g)$



$\Delta H_r = -2(-493) + (-418) + 3(-394)$
$= -614$ kJ
[−1] for each error

or

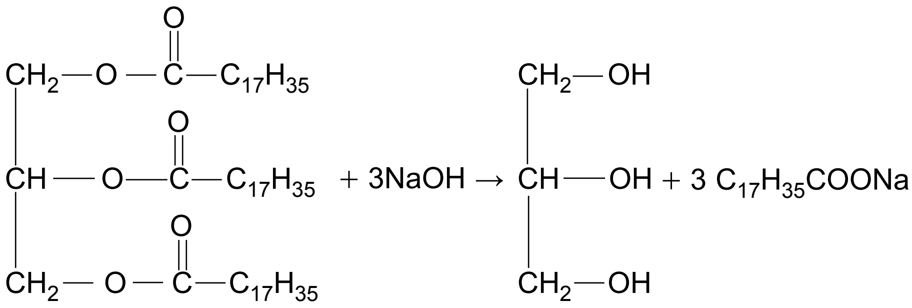
$2KNO_3(s) \rightarrow 2K(s) + N_2(g) + 3O_2(g)$ $+2 \times 493$
$2K(s) + S(s) \rightarrow K_2S(s)$ -418
$3C(s) + 3O_2(g) \rightarrow 3CO_2(g)$ -3×394

$2KNO_3(s) + S(s) + 3C(s) \rightarrow K_2S(s) + N_2(g) + 3CO_2(g)$
$\Delta H = +2 \times 493 - 418 - 3 \times 394$
$= +986 - 418 - 1182$
$= -614$ kJ [3]

(d) (i) $\Delta S^\ominus = \Sigma S^\ominus$ (products) $- \Sigma S^\ominus$ (reactants)
$= 3(214) + 191 + 115 - 2(172) - 32 - 3(5.7)$
$= +554.9\ J\ K^{-1}\ mol^{-1}$
[−1] for each error [2]

(ii) $\Delta G^\ominus < 0$ [1]
(always) exothermic and $\Delta S^\ominus > 0$ [1] [2] 15

14 (a) (i)



[3]

error [–1]

(ii) molecular formula: $C_{57}H_{110}O_6$ [1]
RMM: 890 [1] [2]

(iii) number of mg of KOH to completely hydrolyse 1 g of fat/oil [2]

(iv) moles of glyceryl tristearate $= \frac{1}{890} = 1.1236 \times 10^{-3}$ [1]

moles of KOH required $= 1.1236 \times 10^{-3} \times 3 = 3.3708 \times 10^{-3}$ [1]
mass of KOH $= 3.3708 \times 10^{-3} \times 56 = 0.1888$ g [1]
mg of KOH required = 188.8 [1] [4]

(b) (i) mass of iodine in g [1]
which will react with/saturate 100 g of the fat/oil [1] [2]

(ii) no C=C/saturated [1]

(iii) known mass of oil (and dissolve in a suitable (saturated) solvent) [1]
add Wijs solution and stand in the dark for 30 minutes [1]
add KI(aq) (and water) and titrate (liberated iodine) with standard sodium thiosulfate solution [1]
add starch indicator when pale straw colour [1]
end point reached when changes from blue-black to colourless [1]
repeat using a blank with no oil [1] maximum [6]

Quality of written communication [2]

(iv) Comment on van der Waals forces [1]
Comment on shape/packing [1] [2]

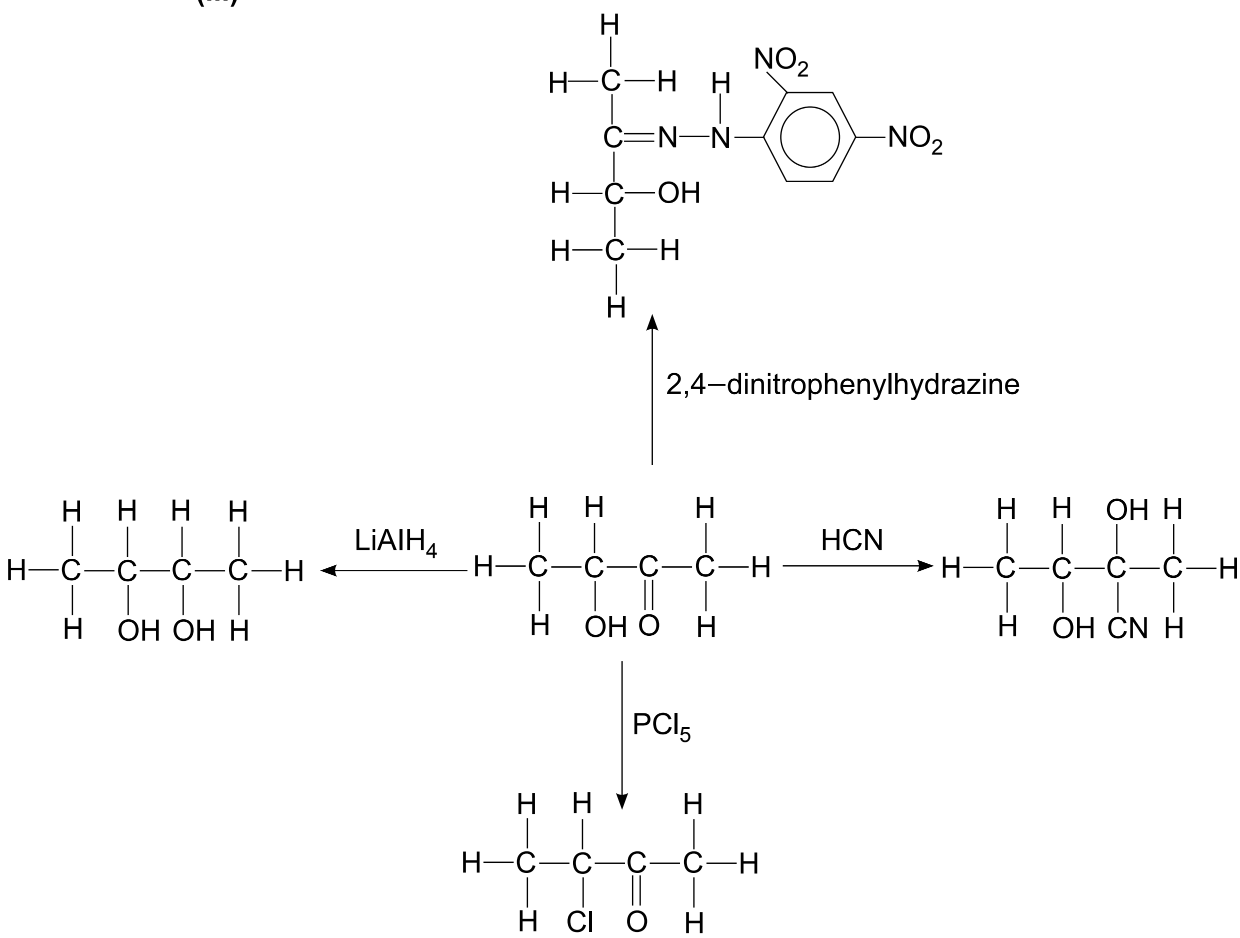
AVAILABLE MARKS: 24

15 (a) (i) 3-hydroxybutanone [2] Award [1] for 2-hydroxybutanone [2]

AVAILABLE MARKS

(ii) hydrogen bonds with water [1]
statement on where H-bond forms [1] [2]

(iii)



[1] for each correct structure [4]

(iv) nucleophilic [1] addition [1] [2]

(b) (i) $CH_3CH(OH)COCH_3 + [O] \rightarrow CH_3COCOCH_3 + H_2O$ [2]

(ii) orange [1] to green [1] [2]

(iii) acetoin order = 2
H^+ order = 1
$Cr_2O_7^{2-}$ order = 1 [2]

(iv) rate = $k[\text{acetoin}]^2[H^+][Cr_2O_7^{2-}]$ [1]

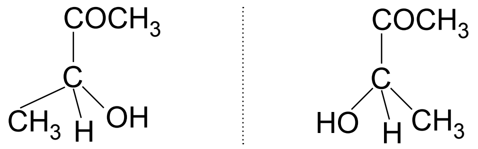
(v) 4.36 [1] $mol^{-3}\ dm^9\ s^{-1}$ [1] [2]
e.g. $4.36 \times 10^{-3} = k[0.1]^2\ [1.0]\ [0.1]$
$4.36 \times 10^{-3} = k \times 10^{-3}$
$k = 4.36$

AVAILABLE MARKS

(c) **(i)** rotates the plane [1] of plane polarised light [1] [2]

(ii) four different groups [1] attached to the same carbon atom [1] [2]
allow [1] for contains a chiral centre

(iii)



[2]

(iv) equal concentrations of isomers [1]
idea that net rotation is zero [1] [2] 27

16 **(a)** standard enthalpy of formation = E [1]
first electron affinity of iodine = D [1]
first ionisation energy of potassium = B [1]
standard enthalpy of atomisation of potassium = A [1] [4]

(b) $-(-327.6) + (+89.5) + (+420.0) + (+106.6) + (-295.4)$
$= +648.3$ [2]

(c) **(i)** enthalpy of atomisation/bond enthalpy (C)
first electron affinity (D)
enthalpy of formation (E) [3]

(ii) enthalpy of atomisation for $Cl_2 > I_2$ because bond energy greater [1]
electron affinity for Cl > Br because the atomic radius is smaller/
shielding [1] enthalpy of formation for KCl > KBr because chlorine
is more reactive [1] [3]

(d) **(i)** $KCl(s) + aq \rightarrow K^+(aq) + Cl^-(aq)$ [2]

(ii) $+710 - 305 - 384 = +21$ (kJ mol^{-1}) [2] 16

Section B	**100**
Total	**120**

Rewarding Learning

Centre Number	
71	

Candidate Number

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
January 2014

Chemistry

Assessment Unit AS 1

assessing

Basic Concepts in Physical and Inorganic Chemistry

[AC112]

AC112

THURSDAY 9 JANUARY, 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**. Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 100.
Quality of written communication will be assessed in Question **12(d)(iv)**.
In Section A all questions carry equal marks, i.e. **two** marks 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 in this question paper.

For Examiner's use only	
Question Number	**Marks**
Section A	
1–10	
Section B	
11	
12	
13	
14	
15	
16	
Total Marks	

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 An element in the Periodic Table has the following successive ionisation energies ($kJ\ mol^{-1}$).

590 1145 4912 6474 8144 10496 12320

In which one of the following groups is this element found?

A Group I

B Group II

C Group III

D Group IV

2 Which one of the following is the oxidation number of hafnium in HfF_7^{3-}?

A -3

B $+3$

C -4

D $+4$

3 Boron consists of the isotopes $^{10}_{5}B$ and $^{11}_{5}B$. The relative atomic mass of the element is 10.80. Which one of the following is the approximate ratio of the number of lighter atoms to heavier atoms?

A 1:3

B 1:4

C 1:9

D 4:1

4 Which one of the following equations shows hydrogen peroxide, H_2O_2, behaving as a reducing agent?

A $2Fe^{2+} + H_2O_2 + 2H^+ \rightarrow 2Fe^{3+} + 2H_2O$

B $2I^- + H_2O_2 + 2H^+ \rightarrow I_2 + 2H_2O$

C $MnO_2 + 2H^+ + H_2O_2 \rightarrow Mn^{2+} + 2H_2O + O_2$

D $PbS + 4H_2O_2 \rightarrow PbSO_4 + 4H_2O$

5 The electronegativity values, not in order, for caesium, cobalt, fluorine and nitrogen are listed below. Which one of the following is the value for the cobalt atom?

A 0.70

B 1.80

C 3.00

D 4.00

6 Which one of the following molecules is linear?

A CH_3CH_3

B CO_2

C H_2O_2

D H_2Te

7 Which one of the following is the reason why water boils at 100 °C while the hydrides of the other Group VI elements boil below 0 °C?

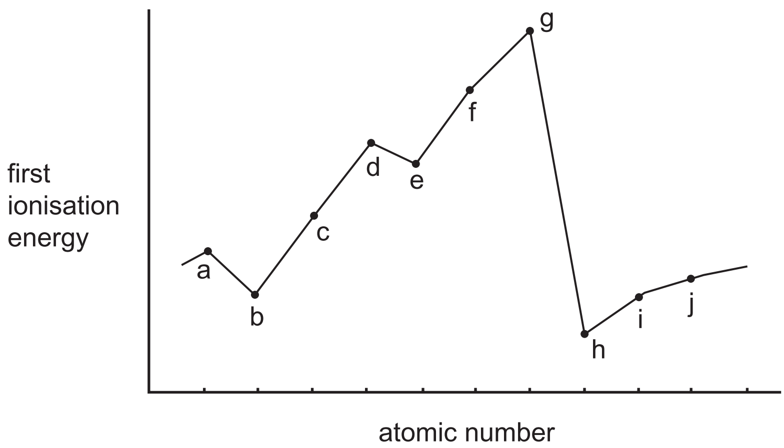
A Hydrogen bonding between water molecules

B Ionic bonding in water molecules

C The lower molar mass of water molecules

D The stability of the bonding in water molecules

8 The first ionisation energy is shown against increasing atomic number.



Which one of the following shows a Group I element together with a Group VII element?

	Group I	Group VII
A	b	f
B	b	g
C	h	f
D	h	g

9 Which one of the following properties is a characteristic of astatine?

A It has an electronegativity value greater than that of iodine.

B It is a solid at room temperature and pressure.

C It oxidises bromide ions to bromine.

D Its hydride exhibits more hydrogen bonding than hydrogen iodide.

10 3.12 g of MCl_2 were dissolved in water and made up to one litre of solution. 25.0 cm^3 of this solution reacts with 7.5 cm^3 of 0.100 M silver nitrate solution.

$$MCl_2(aq) \rightarrow M^{2+}(aq) + 2Cl^-(aq)$$
$$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$$

Which one of the following Group II elements is M?

A barium

B calcium

C magnesium

D strontium

Section B

Answer **all six** questions in this section.

11 Complete the following table about the silver halides.

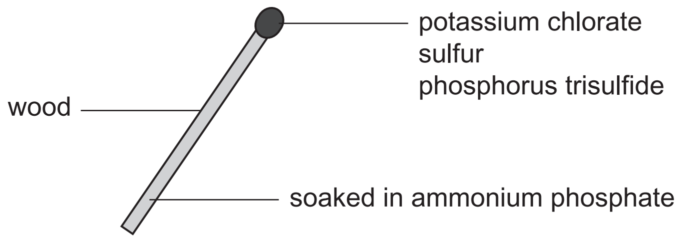
silver halide	formula	colour	ionic/ covalent	soluble in dilute ammonia solution	soluble in concentrated ammonia solution
silver fluoride	AgF	white	ionic	yes	yes
silver chloride					
silver bromide					
silver iodide					

[4]

Examiner Only	
Marks	Remark

12 The creation of the friction match took many years and involved a variety of chemicals based on phosphorus.

The modern match is shown below. The head is a mixture of potassium chlorate, sulfur and phosphorus trisulfide held together by glue. The wood is soaked in ammonium phosphate which acts as a fire retardant.



(a) Potassium chlorate reacts with the sulfur to form potassium chloride and sulfur dioxide as shown by the following equation.

$$2KClO_3 + 3S \rightarrow 2KCl + 3SO_2$$

(i) Deduce the oxidation number for each element in the reactants.

____ [1]

(ii) Deduce the oxidation number for each element in the products.

____ [1]

(iii) Explain, using these oxidation numbers, why this is a redox reaction.

____

____ [1]

(b) Potassium chlorate, $KClO_3$, is manufactured using the reaction between chlorine and potassium hydroxide.

(i) Write the equation for the reaction.

____ [2]

(ii) State the conditions under which the reaction is carried out.

____ [1]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

(c) Phosphorus trisulfide is easily ignited. It provides the heat to initiate the reaction between potassium chlorate and sulfur.

(i) Phosphorus has an oxidation number of $+3$ in phosphorus trisulfide. State the formula of phosphorus trisulfide.

____ [1]

(ii) Suggest whether phosphorus trisulfide is ionic or covalent. Explain your reasons.

____

____ [1]

(iii) Name the **two** products formed when phosphorus trisulfide is completely burnt. No oxidation numbers are needed.

____

____ [2]

(d) Ammonium phosphate is an ionic compound consisting of ammonium and phosphate ions, PO_4^{3-}.

(i) Write the formula of the ammonium ion.

____ [1]

(ii) Name and draw the shape of the ammonium ion stating the interbond angle.

____ [3]

(iii) Write the formula of ammonium phosphate.

____ [1]

Examiner Only	
Marks	Remark

(iv) State and explain **three** physical properties you would expect ammonium phosphate to have.

____

____

____

____

____

____

____

____ [3]

Quality of written communication [2]

13 Francium is found in Group I of the Periodic Table and was discovered by Marguerite Perey in 1939 in the Curie Laboratory in France. It was isolated from uranium ore. Since then it has been synthesised by the nuclear reaction of oxygen atoms with gold atoms. It exists as 34 isotopes.

In the Periodic Table it has an atomic number of 87 and is given a relative atomic mass of 223.

(a) Francium is found in period 7 of the Periodic Table and is regarded as an s-block element.

Suggest the subshell occupied by the outermost electron in a francium atom.

____ [1]

(b) Francium was first synthesised according to the following equation.

$$^{197}Au + {}^{18}O \rightarrow {}^{210}Fr + 5n$$

The symbol n represents a neutron.

(i) What is the relative mass of a neutron?

____ [1]

(ii) Using the relative mass of the neutron from part **(i)** show, by calculation, that the equation is balanced according to mass.

____

____ [2]

(iii) Why are electrons not used when balancing the equation according to mass?

____

____ [1]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

(c) Francium is one of the least electronegative elements in the Periodic Table.

(i) Explain the meaning of the term **electronegativity**.

____

____ [2]

(ii) State how electronegativity values change on going across a period.

____ [1]

(d) Francium has a melting point of 27 °C and would melt in the hand just as caesium does. It has the highest electrical conductivity of the alkali metals.

(i) Explain, in terms of metallic bonding, why francium has a low melting point.

____

____ [2]

(ii) Explain, in terms of metallic bonding, why francium has the highest electrical conductivity.

____

____ [2]

(e) Francium loses electrons when it reacts with chlorine and the chlorine gains these electrons.

(i) Write the equation for the loss of an electron from a francium atom.

____ [1]

(ii) Write the equation for the formation of chloride ions from a chlorine molecule.

____ [1]

(iii) Write the equation for the reaction of francium with chlorine.

____ [1]

(iv) Francium chloride exists as a lattice structure similar to that of NaCl. Explain the term **lattice structure**.

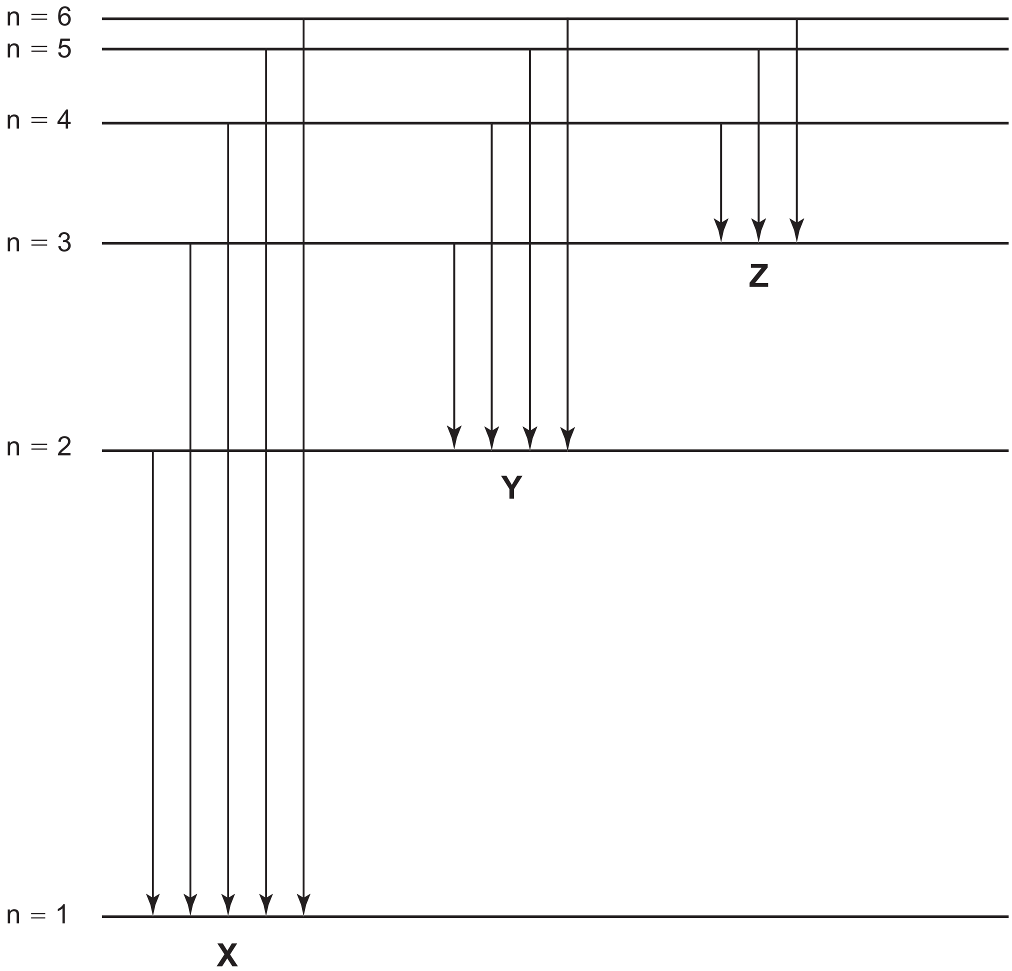
____

____ [1]

Examiner Only	
Marks	Remark

14 The energy levels of a hydrogen atom are shown below and the arrows indicate the transition of electrons between successive energy levels.

Examiner Only	
Marks	Remark



The electromagnetic spectrum is shown below.

Radio waves	Microwaves	Infrared	Visible	Ultraviolet	X-rays	Gamma rays

Energy increases →

(a) Write the equation that relates energy to frequency, explain the meanings of the symbols used and state the units in which they are measured.

____

____

____

____ [3]

(b) There are three series of lines. The first series **X** occurs in the ultraviolet region of the electromagnetic spectrum.

(i) In which part of the electromagnetic spectrum does the second series, **Y**, occur?

____ [1]

(ii) Suggest in which part of the electromagnetic spectrum the third series, **Z**, occurs.

____ [1]

(iii) What happens to the atom when its electron passes from energy level n = 1 to an infinite energy level?

____

____ [1]

(c) **(i)** Use the energy level diagram below to show the ground state of a sodium atom. Use arrows to represent the sodium electrons.

3s ______________

2p ______________

2s ______________

1s ______________ [2]

(ii) What is the predominant colour in the emission spectrum of sodium?

____ [1]

Examiner Only	
Marks	Remark

15 Iron reacts with dilute hydrochloric acid to form iron(II) chloride, $FeCl_2$, and hydrogen. The solution deposits crystals of hydrated iron(II) chloride.

Examiner Only	
Marks	Remark

(a) Write the ionic equation, with state symbols, for the reaction of iron with hydrochloric acid.

____ [2]

(b) A solution of iron(II) ions is oxidised by chlorine water to form iron(III) ions.

(i) Write the ionic equation for the reaction.

____ [1]

(ii) Describe the colour of the solution after the reaction has taken place.

____ [1]

(iii) Explain whether iron(II) ions would react with bromine water.

____

____ [1]

(c) Iron(II) chloride is extremely soluble in water. 69 g of the anhydrous solid dissolve in 100 cm^3 of water at 20 °C. Assuming there is no volume change calculate the molarity of the resulting solution.

____

____

____ [3]

(d) 14.1 g of the hydrated iron(II) chloride crystals contain 6.5 g of water.
Use these figures to calculate the formula of the crystals.

Examiner Only	
Marks	Remark

mass of iron(II) chloride

____

moles of iron(II) chloride

____

moles of water

____

ratio of moles of water to moles of iron(II) chloride

____

formula of iron(II) chloride crystals

____ [5]

16 Sulfur forms the following fluorides:

sulfur difluoride	SF_2
sulfur tetrafluoride	SF_4
sulfur hexafluoride	SF_6

Sulfur hexafluoride is the best known and can be used as a safe electrical insulator. The other fluorides are toxic.

(a) Draw the dot and cross diagrams showing the outer electrons only for each of the fluorides.

[3]

(b) **(i)** State the **octet rule**.

____

____ [2]

(ii) Explain whether sulfur is obeying the octet rule in each fluoride.

____

____

____ [2]

(c) Sulfur difluoride has the same shape as a water molecule but the bond angle is 6° smaller. Draw and name the shape of sulfur difluoride, stating its bond angle.

____ [3]

Examiner Only	
Marks	Remark

(d) The sulfur hexafluoride molecule has an octahedral shape.

(i) State the bond angle(s) in the sulfur hexafluoride molecule.

____ [1]

(ii) Explain why sulfur hexafluoride has an octahedral shape.

____

____ [2]

(iii) Explain why sulfur hexafluoride is a non-polar molecule.

____

____ [1]

(e) Sulfur tetrafluoride has a boiling point of –38 °C whereas sulfur hexafluoride has a boiling point of –64 °C.

(i) Which compound has the higher boiling point?

____ [1]

(ii) Explain, in terms of mass, which compound has the greater van der Waals forces.

____

____ [1]

(iii) Explain, in terms of intermolecular forces, the difference in boiling points.

____

____ [2]

THIS IS THE END OF THE QUESTION PAPER

Examiner Only	
Marks	Remark

114554

Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
January 2014

Chemistry

Assessment Unit AS 1

assessing

Basic Concepts in Physical and Inorganic Chemistry

[AC112]

THURSDAY 9 JANUARY, 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

			AVAILABLE MARKS
1	B		
2	D		
3	B		
4	C		
5	B		
6	B		
7	A		
8	C		
9	B		
10	A		
[2] for each correct answer		[20]	20
		Section A	**20**

Section B

AVAILABLE MARKS

11 Each mistake is [–1]

AgCl	white	ionic	yes	yes		
AgBr	cream	ionic	no	yes		
AgI	yellow	ionic	no	no	[4]	4

12 **(a)** **(i)** K = +1; Cl = +5; O = –2; S = 0 [1]

(ii) K = +1; Cl = –1; O = –2; S = +4 [1]

(iii) Cl oxidation number goes down and S oxidation number goes up [1]

(b) **(i)** $6KOH + 3Cl_2 \rightarrow KClO_3 + 5KCl + 3H_2O$ [2]

(ii) hot and concentrated (potassium hydroxide solution) [1]

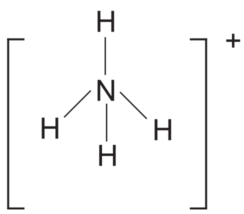
(c) **(i)** P_2S_3 [1]

(ii) covalent as both elements are non-metals/covalent as small difference in electronegativity between P and S [1]

(iii) phosphorus trioxide or pentoxide/phosphorus oxide [1]
sulfur oxide or sulfur dioxide [1] [2]

(d) **(i)** NH_4^+ [1]

(ii) tetrahedral [1]
109º/109.5° [1]



[1] [3]

(iii) $(NH_4)_3PO_4/PO_4(NH_4)_3$ [1]

(iv) melting point which is high because of attraction between ions [1]
boiling point which is high because of attraction between ions [1]
electrical conductivity which is high in solution or molten because ions can move [1]
solubility, ions are surrounded by H_2O molecules [1]
3 from 4 [3]

Quality of written communication [2] 20

						AVAILABLE MARKS
13	(a)	$7s^1$			[1]	
	(b)	(i)	1		[1]	
		(ii)	LHS = 197 + 18 = 215 RHS = 210 + 5 × 1 = 215		[2]	
		(iii)	electrons have negligible mass/one two thousandth relative mass		[1]	
	(c)	(i)	the extent to which an atom attracts the bonding electrons in a covalent bond		[2]	
		(ii)	electronegativity increases across a period		[1]	
	(d)	(i)	sea of positive ions surrounded by electrons attraction between positive ions and electrons is weak	[1] [1]	[2]	
		(ii)	electrons move and conduct/carry electricity large radius of Fr means less attraction for electrons	[1] [1]	[2]	
	(e)	(i)	$Fr \rightarrow Fr^+ + e$		[1]	
		(ii)	$Cl_2 + 2e \rightarrow 2Cl^-$		[1]	
		(iii)	$2Fr + Cl_2 \rightarrow 2FrCl$		[1]	
		(iv)	regular arrangement of (francium and chloride) ions		[1]	16

AVAILABLE MARKS

14 **(a)** E = hf
E is energy, h is Planck's constant, f is frequency
E in joules, h in J s, f in Hz or s^{-1} [3]

(b) **(i)** visible [1]

(ii) infrared [1]

(iii) the atom has ionised/lost the electron [1]

(c) **(i)** ↑

⇅ ⇅ ⇅

⇅

⇅ [2]

(ii) yellow/orange [1] 9

15 **(a)** $Fe(s) \quad + \quad 2H^+(aq) \rightarrow Fe^{2+}(aq) \quad + \quad H_2(g)$ [2]

(b) **(i)** $2Fe^{2+} + Cl_2 \rightarrow 2Fe^{3+} + 2Cl^-$ [1]

(ii) yellow/orange [1]

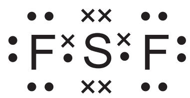
(iii) yes, bromine is a sufficiently powerful oxidising agent [1]

(c) $FeCl_2$ = 56 + 2 × 35.5 = 127
69 g = 69/127 = 0.54 mol
= 5.4 M [3]

(d) mass of iron(II) chloride = 14.1 – 6.5 = 7.6
moles of iron(II) chloride = 7.6/127 = 0.0598
moles of water = 6.5/18 = 0.36
ratio of moles = 0.36:0.0598 = 6.02
$FeCl_2.6H_2O$ [5] 13

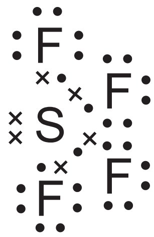
AVAILABLE MARKS

16 **(a)** SF_2



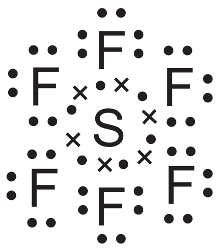
[1]

SF_4



[1]

SF_6

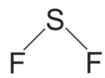


[1] [3]

(b) **(i)** when forming a compound an atom tends to gain, lose or share electrons in its outer shell to achieve 8 [2]

(ii) SF_2 yes; SF_4 no; SF_6 no, there are 10 and 12 electrons around S [2]

(c) shape



[1]

bent [1]

104.5° – 6° = 98.5° [1] [3]

(d) **(i)** 90° [1]

(ii) the six bonds repel each other [1]

as far apart from each other as possible [1] [2]

(iii) the molecule is symmetrical

or dipoles cancel [1]

(e) **(i)** sulfur tetrafluoride [1]

(ii) sulfur hexafluoride has the greatest mass hence the greatest van der Waals [1]

(iii) SF_4 is polar (SF_6 is non-polar) [1]

polar forces greater than van der Waals [1] [2] 18

Section B	**80**
Total	**100**

Rewarding Learning

Centre Number

71	

Candidate Number

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2014

Chemistry

Assessment Unit AS 2

assessing

Module 2: Organic, Physical and Inorganic Chemistry

[AC122]

AC122

TUESDAY 17 JUNE, 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 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**. Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 100.
Quality of written communication will be assessed in Question **13(b)(ii)**.
In Section A all questions carry equal marks, i.e. **two** marks 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 in this question paper.

For Examiner's use only	
Question Number	**Marks**
Section A	
1–10	
Section B	
11	
12	
13	
14	
15	
16	
17	
Total Marks	

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 Equal volumes of 1-chlorobutane and 1-iodobutane are warmed with aqueous silver nitrate in the presence of ethanol. Which one of the following is the reason why the 1-chlorobutane reacts more slowly?

A The C–Cl bond is more polar than the C–I bond

B The C–Cl bond is stronger than the C–I bond

C The C–I bond is more polar than the C–Cl bond

D The C–I bond is stronger than the C–Cl bond

2 Which one of the following is correct as Group II is descended?

	Solubility of hydroxides	**Solubility of sulfates**
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

3 Which one of the following is the colour of the flame produced when a barium compound is placed in a blue Bunsen burner flame?

A Crimson

B Green

C Lilac

D Orange

4 Which one of the following shows the effect on the yield of ammonia in the Haber process?

	Pressure increase	Temperature increase
A	yield decreases	yield decreases
B	yield decreases	yield increases
C	yield increases	yield decreases
D	yield increases	yield increases

5 Which one of the following mixtures will react to produce a compound with molecular formula C_4H_7N?

A 1-bromobutane and ammonia

B 1-bromobutane and potassium cyanide

C 1-bromopropane and ammonia

D 1-bromopropane and potassium cyanide

6 The reaction shown below

$$C_2H_5Br + KOH \rightarrow C_2H_4 + KBr + H_2O$$

is an example of

A dehydration.

B elimination.

C free radical substitution.

D nucleophilic substitution.

7 Which one of the following is the mass of magnesium required to react with 50.0 cm^3 of 0.1 mol dm^{-3} hydrochloric acid?

A 0.005 g

B 0.060 g

C 0.120 g

D 0.240 g

8 Which one of the following lists the compounds in order of increasing boiling point?

A $CH_3CH_2CH_3$ CH_3CH_2F CH_3CH_2OH

B $CH_3CH_2CH_3$ CH_3CH_2OH CH_3CH_2F

C CH_3CH_2F CH_3CH_2OH $CH_3CH_2CH_3$

D CH_3CH_2OH CH_3CH_2F $CH_3CH_2CH_3$

9 When an organic compound was reacted with chlorine, the organic product was found to have a relative molecular mass which had increased by 69. Which one of the following is the reaction mechanism?

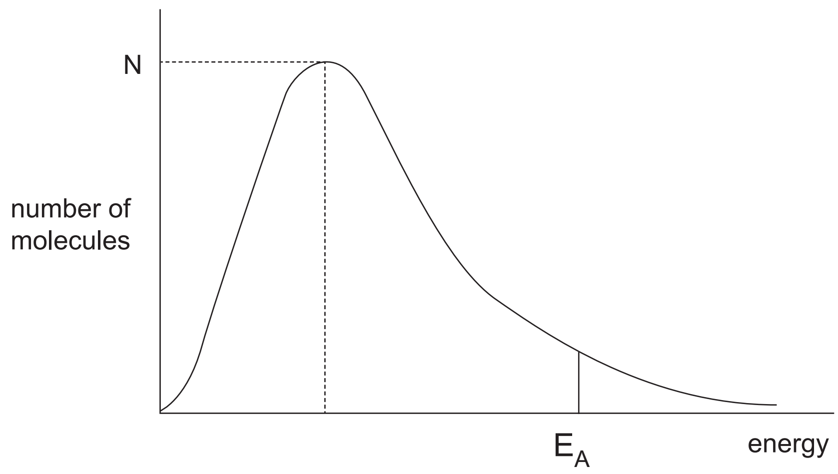
A elimination

B electrophilic addition

C free radical substitution

D nucleophilic substitution

10 The Maxwell–Boltzmann distribution for a reaction mixture is shown below. N is the number of molecules with the most probable energy and E_A is the activation energy.



Which one of the following shows the effect on E_A and on N of increasing the temperature?

	E_A	N
A	constant	decreases
B	constant	increases
C	decreases	decreases
D	decreases	increases

Section B

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

Examiner Only	
Marks	Remark

11 Butan-1-ol is used to prepare 1-bromobutane according to the following equation:

$$C_4H_9OH + HBr \rightarrow C_4H_9Br + H_2O$$

(a) (i) Give an equation to explain the term **percentage yield**.

percentage yield =

[1]

(ii) Assuming a 40% yield, what mass of butan-1-ol would be required to produce 5.48 g of 1-bromobutane?

moles of 1-bromobutane

____

moles of butan-1-ol

____

mass of butan-1-ol

____ [3]

(b) (i) Give an equation to explain the term **atom economy**.

atom economy =

[1]

(ii) Calculate the atom economy for the formation of 1-bromobutane from butan-1-ol.

____

____ [1]

12 Qualitative analysis can be used to distinguish between aqueous solutions containing different metal ions.

Examiner Only

Marks	Remark

(a) For each of the following pairs of metal ions, give an aqueous reagent which can be used to distinguish between the aqueous solutions and state the expected observations for each ion.

(i) Iron(II) ions and iron(III) ions.

Reagent ____ [1]

Observations ____

____

____ [2]

(ii) Aluminium ions and zinc ions.

Reagent ____ [1]

Observations ____

____

____ [2]

(b) Addition of an aqueous solution of potassium chromate can be used to test for the presence of barium ions.

(i) What is observed when barium ions react with chromate ions?

____ [1]

(ii) Write an ionic equation, including state symbols, for the reaction of barium ions with chromate ions.

____ [2]

13 The fluorohydrocarbon below exists in two stereoisomeric forms.

$$CH_3CH_2CH{=}CFCH_2CH_3$$

(a) Name this fluorohydrocarbon using IUPAC rules.

____ [2]

(b) (i) Draw and label the structures of the E and Z isomers of this fluorohydrocarbon.

[1]

(ii) Explain why one of the structures you have drawn is classified as the Z isomer.

____

____

____

____

____ [3]

Quality of written communication [2]

Examiner Only	
Marks	Remark

(c) (i) Draw a structural isomer of the fluorohydrocarbon which does **not** exist as stereoisomers.

Examiner Only	
Marks	Remark

[1]

(ii) Explain, in terms of the structure of this molecule, why it does not exist as stereoisomers.

____

____ [2]

14 Propene reacts with hydrogen bromide to form two isomers, the major product being 2-bromopropane.

Examiner Only	
Marks	Remark

(a) Explain why hydrogen bromide is attracted to propene.

____

____

____ [2]

(b) Suggest flow schemes for the mechanisms of the reaction of hydrogen bromide with propene to form 1-bromopropane and 2-bromopropane, showing the structure of both intermediates.

[4]

(c) (i) Suggest how you would separate a mixture of 1-bromopropane and 2-bromopropane.

____ [1]

(ii) Suggest how you would use infra-red spectroscopy to identify an unknown sample of bromopropane as either 1-bromopropane or 2-bromopropane.

____

____ [1]

Examiner Only

Marks	Remark

(d) Suggest why 2-bromopropane is the major product.

____ [1]

(e) Name the mechanism of these reactions.

____ [1]

(f) Propene undergoes addition polymerisation to form polypropene.
Draw the structure of polypropene showing **three** repeating units.

[2]

Examiner Only	
Marks	Remark

15 Under a particular set of conditions incomplete combustion of propane occurred according to the following equation:

$$C_3H_8(g) + 4O_2(g) \rightarrow CO_2(g) + 2CO(g) + 4H_2O(l)$$

The total volume of gases produced occupied a volume of 9000 dm^3. The molar gas volume, under these conditions, is 30 dm^3.

(a) Define the term **molar gas volume**.

____

____ [2]

(b) (i) Calculate the number of moles of carbon monoxide produced in this combustion.

____

____ [2]

(ii) Calculate the number of moles of oxygen used in this combustion.

____

____ [1]

(iii) Calculate the mass of propane, in kg, burned.

____

____ [3]

(iv) Calculate the number of molecules of propane burned.

____

____ [1]

(c) Under a different set of conditions, methane undergoes incomplete combustion to produce carbon dioxide and carbon monoxide in a 2:1 ratio. Write an equation for this incomplete combustion.

____ [2]

Examiner Only	
Marks	Remark

16 Butane is sold commercially as "bottled gas". It undergoes complete combustion according to the following equation:

$$2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$$

and has a standard enthalpy of combustion of –2876.5 kJ mol^{-1}.

(a) Calculate the amount of energy released for every kilogram of carbon dioxide released.

____

____

____ [3]

(b) Hess's Law can be used to calculate enthalpy changes, such as the standard enthalpy of formation of butane, which cannot be measured by experiment.

(i) Define the term **standard enthalpy of formation**.

____

____ [3]

(ii) Write an equation, with state symbols, which represents the standard enthalpy of formation of butane.

____ [2]

(iii) Use the standard enthalpy of combustion of butane and the following data to calculate the standard enthalpy of formation of butane.

	Standard enthalpy of combustion (kJ mol^{-1})
Carbon (C)	–393.5
Hydrogen (H_2)	–285.8

____

____

____

____ [3]

17 The formula for ethylene glycol is shown below:

$$\begin{array}{l} CH_2OH \\ | \\ CH_2OH \end{array}$$

(a) Use IUPAC rules to give the systematic name of ethylene glycol.

____ [1]

(b) What is the empirical formula of ethylene glycol?

____ [1]

(c) Ethylene glycol reacts vigorously with an *excess* of ethanoyl chloride.

(i) Suggest **two** observations in this reaction.

____

____ [2]

(ii) Name the type of reaction occurring.

____ [1]

(iii) Draw the structure of the organic product.

[2]

(iv) Suggest a test for the inorganic product formed in this reaction.

____

____ [2]

Examiner Only	
Marks	Remark

Examiner Only

Marks	Remark

(d) Ethylene glycol contains primary alcohol groups. When heated under reflux with excess acidified potassium dichromate the solution changes from orange to green.

(i) Why are the alcohol groups in ethylene glycol classified as primary?

____

____ [1]

(ii) Name the type of reaction occurring.

____ [1]

(iii) Draw the structure of the organic product.

[1]

(iv) Name the functional group present in the organic product.

____ [1]

(v) What would be the most significant difference between the infra-red spectrum of the organic product and that of ethylene glycol?

____

____ [1]

(e) Write an equation for the reaction of ethylene glycol with an excess of phosphorus pentachloride.

[2]

Examiner Only	
Marks	Remark

(f) Explain, in terms of structure, why an iodoform test does not give a positive result with ethylene glycol.

____

____ [1]

(g) The boiling point of ethylene glycol is 197 °C and that of ethanol is 78 °C. Explain this large difference in boiling points.

____

____

____ [3]

THIS IS THE END OF THE QUESTION PAPER

178936