New Specification

Rewarding Learning

Centre Number

71	

Candidate Number

ADVANCED
General Certificate of Education
2010

Chemistry

Assessment Unit A2 2

assessing

Analytical, Transition Metals, Electrochemistry and Further Organic Chemistry

[AC222]

AC222

TUESDAY 1 JUNE, AFTERNOON

TIME

2 hours.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all 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 **16(b)**.
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	

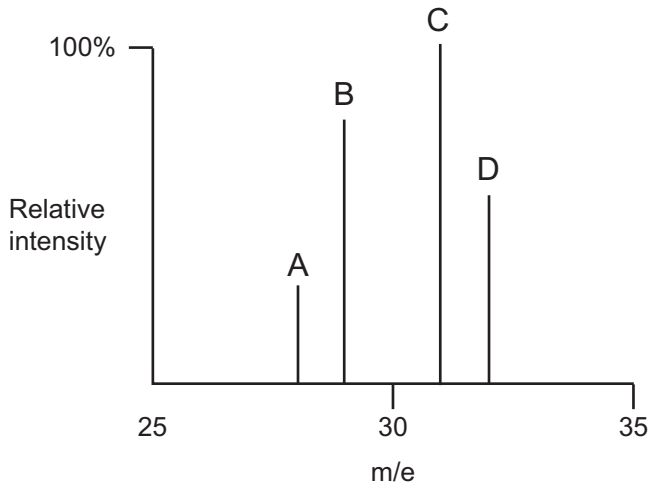
Total Marks	

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 The mass spectrum of methanol is shown below.
Which one of the following is the base peak?



2 Which one of the following represents the electronic configuration for the Fe^{3+} ion?

A $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5$
B $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^3\ 4s^2$
C $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^4\ 4s^1$
D $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^6\ 4s^2$

3 Which one of the following formulae **cannot** be determined by colorimetry?

A $[Cu(NH_3)_4(H_2O)_2]^{2+}$
B $[Fe(SCN)(H_2O)_5]^{2+}$
C $[Ni(NH_3)_4(H_2O)_2]^{2+}$
D $[Zn(NH_3)_4(H_2O)_2]^{2+}$

4 The standard electrode potentials for a series of redox equations are listed below.

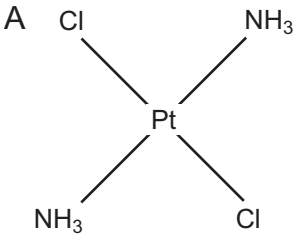
	$E^{\ominus}$/V
$Mn^{2+}(aq) + 2e^- \rightleftharpoons Mn(s)$	–1.19
$Fe^{2+}(aq) + 2e^- \rightleftharpoons Fe(s)$	–0.44
$Ni^{2+}(aq) + 2e^- \rightleftharpoons Ni(s)$	–0.25
$I_2(s) + 2e^- \rightleftharpoons 2I^-(aq)$	+0.54
$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$	+0.77
$Ag^+(aq) + e^- \rightleftharpoons Ag(s)$	+0.80

Which one of the elements listed will reduce $Fe^{3+}(aq)$ to $Fe^{2+}(aq)$, but not to Fe(s)?

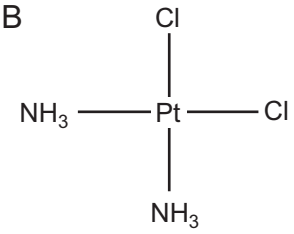
A Iodine
B Manganese
C Nickel
D Silver

5 Which one of the following represents the structure of cisplatin?

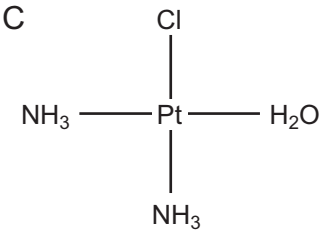
A



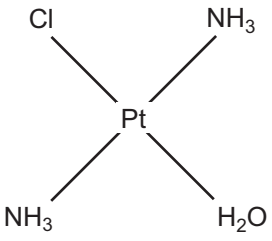
B



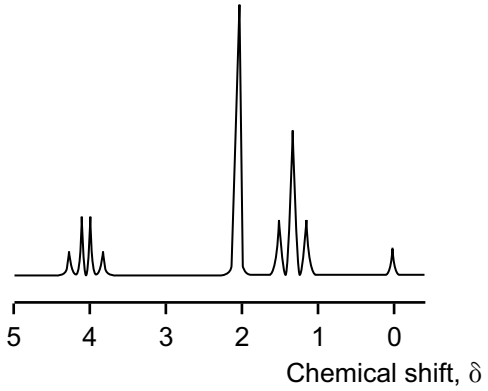
C



D



6 The nmr spectrum of a compound **X** is shown below.



Which one of the following is **X**?

A $CH_3CH_2CH_2COOH$
B $CH_3CH_2COOCH_2CH_3$
C $CH_3COOCH_2CH_3$
D CH_3CH_2COOH

7 A green solid was dissolved in water and the resulting solution divided into two portions. Sodium hydroxide solution was added to one of the portions and ammonia solution to the other. The results are summarised in the table below.

Solution added	Few drops of solution	Excess solution
Sodium hydroxide solution	Green precipitate	No effect
Ammonia solution	Green precipitate	Dissolves to form a blue solution

Which one of the following ions was present in the green solid?

A Cr^{3+}
B Cu^{2+}
C Fe^{2+}
D Ni^{2+}

8 Which one of the following is the colour of chrome alum crystals?

A Black
B Green
C Orange
D Violet

9 25.0 cm^3 of hydrogen peroxide solution were added to excess acidified potassium iodide solution and the resulting solution made up to 500 cm^3.
25.0 cm^3 of the diluted solution reacted with 36.4 cm^3 of sodium thiosulphate solution of concentration 0.10 $mol\,dm^{-3}$.
Which one of the following is the concentration of the undiluted hydrogen peroxide?

A 0.07 $mol\,dm^{-3}$
B 0.15 $mol\,dm^{-3}$
C 1.46 $mol\,dm^{-3}$
D 2.91 $mol\,dm^{-3}$

10 Which one of the following pairs of monomers will **not** combine to form a polymer?

A $HOOC(CH_2)_4COOH$ and $H_2N(CH_2)_6NH_2$
B $H_2N(CH_2)_6NH_2$ and $H_2N(CH_2)_6NH_2$
C CH_2CH_2 and CH_2CH_2
D $HOOC(CH_2)_4COOH$ and $HO(CH_2)_2OH$

Section B

Answer **all seven** questions in this section

Examiner Only	
Marks	Remark

11 (a) Complete the table below by giving the name of the indicator and the colour change at the end point.

Titration	Indicator	Colour change	
		from	to
Edta added to magnesium ions			
Thiosulphate ions added to iodine			

[6]

(b) Some iron tablets, used to treat anaemia, contain iron(II) fumarate ($FeC_4H_2O_4$).

Five of these iron tablets were dissolved in dilute sulphuric acid and the solution made up to 250 cm^3 with distilled water. On titration 25.0 cm^3 of this solution reacted with 18.7 cm^3 of 0.01 mol dm^{-3} acidified potassium manganate(VII) solution.

(i) Write the equation for the reaction of iron(II) ions with acidified manganate(VII) ions.

_____ [2]

(ii) What is the colour change at the end point of the titration?

From _____ to _____ [2]

(iii) Calculate the mass of iron(II) fumarate in each tablet.

_____

_____

_____

_____

_____ [4]

Examiner Only	
Marks	Remark

12 (a) Polythene is a typical addition polymer.

(i) State the conditions necessary for the formation of HD polythene.

Temperature: _____

Pressure: _____

Catalyst: _____ [3]

(ii) Making reference to their structures, explain the difference in flexibility between HD and LD polythene.

_____

_____

_____ [2]

(b) Polyethylene terephthalate is a polyester.

(i) Draw the repeating unit for polyethylene terephthalate.

[2]

(ii) Give **one** use for polyethylene terephthalate.

_____ [1]

Examiner Only	
Marks	Remark

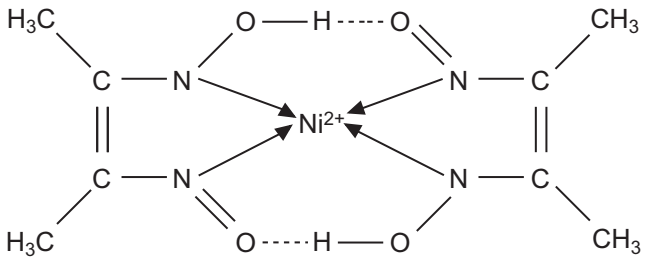
13 Transition metals form complex ions with ligands.

(a) Explain what is meant by the term **polydentate ligand**.

_____

_____ [2]

(b) The complex below is formed when dimethylglyoxime is added to a solution of hydrated nickel(II) ions.



(i) What is the co-ordination number of the nickel(II) ion?

_____ [1]

(ii) Suggest the shape around the central nickel(II) ion.

_____ [1]

(iii) What type of bonds in the complex are represented by each of the following?

—— _____

----- _____

→ _____ [3]

(c) Explain in terms of entropy why dimethylglyoxime displaces the water ligands in the hydrated nickel(II) ion to form the nickel(II) dimethylglyoxime complex.

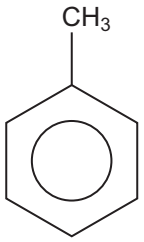
_____

_____

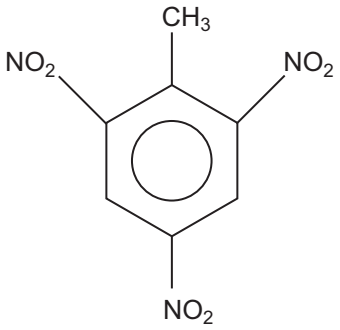
_____ [2]

Examiner Only	
Marks	Remark

14 The explosive trinitrotoluene (TNT) is prepared by the nitration of methylbenzene (toluene).



Toluene



TNT

(a) Suggest a systematic name for TNT.

_____ [1]

(b) TNT burns to form a mixture of carbon dioxide, nitrogen and water.

Write an equation for the complete combustion of TNT.

_____ [2]

(c) TNT is prepared from toluene by using the same nitrating mixture as is used to nitrate benzene.

(i) Name the acids present in the nitrating mixture.

_____ [2]

(ii) Write an equation for the formation of the nitrating species.

_____ [2]

(iii) What name is given to the nitrating species?

_____ [1]

Examiner Only

Marks	Remark

(d) The mechanism for nitrating toluene is similar to that for nitrating benzene.

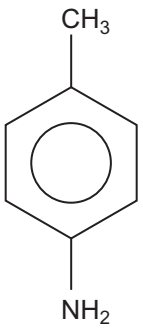
(i) What name is given to this mechanism?

_____ [2]

(ii) Draw the mechanism for the mononitration of toluene.

[2]

(e) 4-nitrotoluene can be converted to toluidine.



Toluidine

(i) Name the reagents which could be used to convert 4-nitrotoluene to toluidine.

_____

_____ [2]

(ii) A salt of toluidine is formed during the reduction. How can toluidine be liberated from this salt?

_____ [1]

Examiner Only

Marks	Remark

Examiner Only	
Marks	Remark

(f) Toluidine is used in the manufacture of dyes.
The first step in the process is to convert the toluidine to its diazonium ion using nitrous acid.

(i) Write an equation for the formation of nitrous acid from sodium nitrite.

_____ [1]

(ii) What conditions are necessary for the reaction between toluidine and nitrous acid to form the diazonium ion?

_____ [1]

(iii) Write an equation for the conversion of toluidine to its diazonium ion.

_____ [2]

(g) One dye is made by reacting the toluidine diazonium ion with phenol.

(i) What name is given to this type of reaction?

_____ [1]

(ii) Draw the structure of the dye formed.

[2]

(iii) Explain why this dye is coloured.

_____

_____

_____

_____ [3]

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(Questions continue overleaf)

15 Vanadium and chromium are typical transition metals.

Examiner Only	
Marks	Remark

(a) Explain, in terms of electronic structure, what is meant by a **transition metal**.

_____

_____ [1]

(b) Vanadium(V) oxide acts as a heterogeneous catalyst in the conversion of sulphur dioxide to sulphur trioxide in the manufacture of sulphuric acid.

(i) Write the equation for the conversion of sulphur dioxide to sulphur trioxide.

_____ [1]

(ii) What is meant by a **heterogeneous** catalyst?

_____ [1]

(iii) Explain, in terms of chemisorption, how vanadium(V) oxide acts as a catalyst in this reaction.

_____

_____

_____

_____ [3]

(c) An acidified solution of ammonium vanadate(V) undergoes a series of reductions when it is stirred with zinc.

Examiner Only

Marks	Remark

(i) Complete the table below, giving the colour of $VO^{2+}(aq)$ and $V^{3+}(aq)$ formed at the different stages of the reduction.

Ion	Colour
$VO_2^+(aq)$	Yellow
$VO^{2+}(aq)$	
$V^{3+}(aq)$	
$V^{2+}(aq)$	Violet

[2]

(ii) Chromium will also reduce ammonium vanadate(V).

	$E^{\ominus}$/V
$Cr^{3+}(aq) + 3e^- \rightleftharpoons Cr(s)$	–0.74
$VO_2^+(aq) + 2H^+(aq) + e^- \rightleftharpoons VO^{2+}(aq) + H_2O(l)$	+1.00

Write an equation for the reaction between chromium and $VO_2^+(aq)$ ions and calculate the e.m.f. of the reaction.

_____

e.m.f. _____ [3]

(d) Potassium chromate(VI), K_2CrO_4 can be prepared by oxidising a solution of chromium(III) ions.

Examiner Only	
Marks	Remark

(i) Name a suitable oxidising agent.

_____ [1]

(ii) Give the colour change on oxidising the chromium(III) ions to chromate(VI) ions.

from: _____

to: _____ [2]

(iii) Chromate(VI) and dichromate ions are involved in the following equilibrium:

$$2CrO_4^{2-}(aq) + 2H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(l)$$

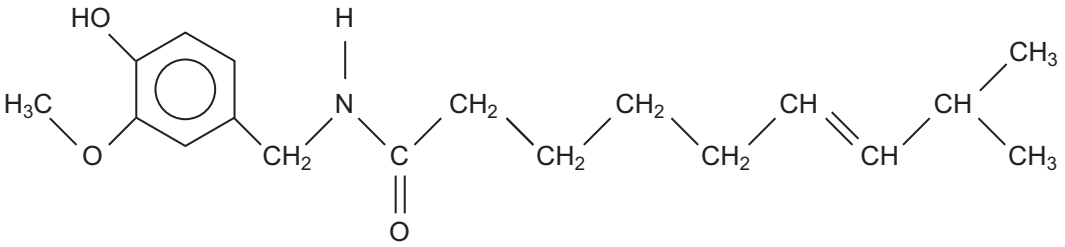
State and explain the colour change when sodium hydroxide solution is added to this equilibrium.

_____

_____

_____ [3]

16 The burning sensation felt when eating chilli peppers is caused by capsaicin.



Capsaicin

(a) Capsaicin is used in pepper sprays at a concentration of 5% by mass per volume (5 g in 100 cm^3).

(i) What is the molecular formula of capsaicin?

_____ [1]

(ii) Calculate the concentration of capsaicin in mol dm^{-3} of the pepper spray.

_____

_____

_____ [3]

(b) A sample of capsaicin extracted from chilli peppers will contain a large number of organic impurities.

Describe how you would use two-way paper chromatography to show that the sample contained capsaicin.

_____

_____

_____

_____

_____

_____ [4]

Quality of written communication [2]

Examiner Only

Marks	Remark

Examiner Only	
Marks	Remark

17 Proteins are formed from amino acids.

(a) (i) Describe the primary, secondary and tertiary structure of proteins.

Primary: _____

_____ [1]

Secondary: _____

_____ [2]

Tertiary: _____

_____ [2]

(ii) Explain why some proteins can act as enzymes.

_____

_____

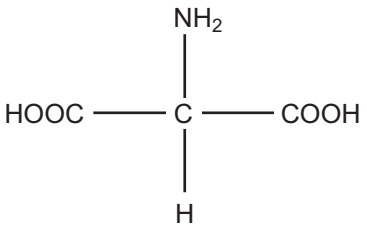
_____ [2]

(iii) Explain why the efficiency of most enzymes is lowered at 60 °C.

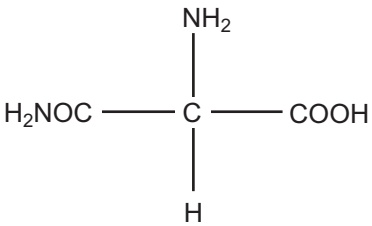
_____

_____ [2]

(b) Aspartic acid and asparagine are amino acids.



Aspartic acid



Asparagine

(i) Suggest how aspartic acid could be converted to asparagine.

_____ [1]

Examiner Only	
Marks	Remark

(ii) Write an equation for the reaction between aspartic acid and asparagine to form a dipeptide.

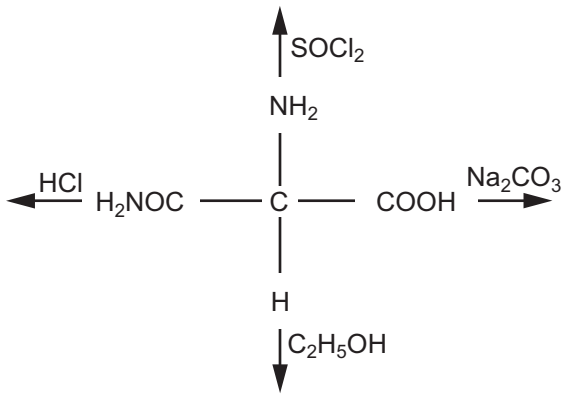
_____ [2]

(iii) Amino acids dissolve in water to form a dipolar ion (zwitterion).

Draw the structure of the dipolar ion formed by asparagine.

[1]

(iv) Complete the following flow diagram to show the structure of the organic product formed.



[4]

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**

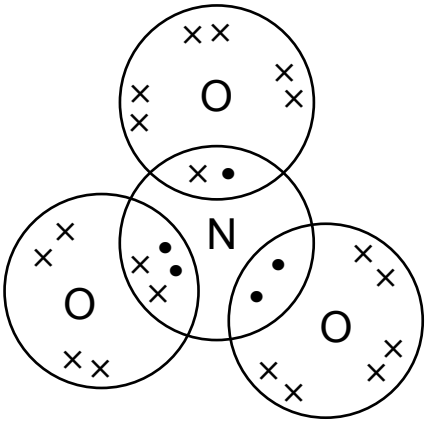
AVAILABLE MARKS

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 = $(2 \times 14 / 80) \times 100$

= 35%

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

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

(ii) = 0.05×10^{-3}g per cm^3

= 0.05 g per dm^3

= 0.05/62

= 8.06×10^{-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]

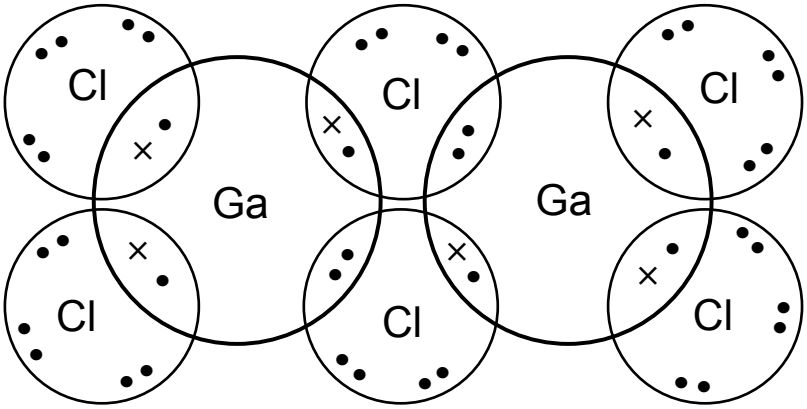
(iii) PCl_5 or $PCl_4^+PCl_6^-$ [1]

(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]

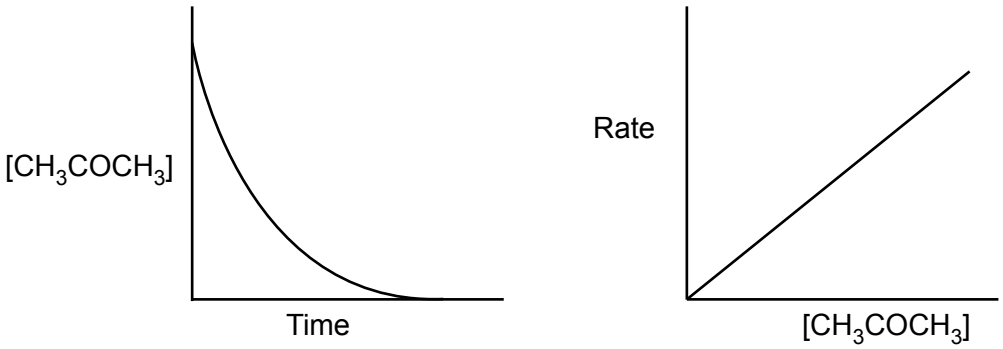
unbalanced [–1]

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

(ii) rate constant [1]

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

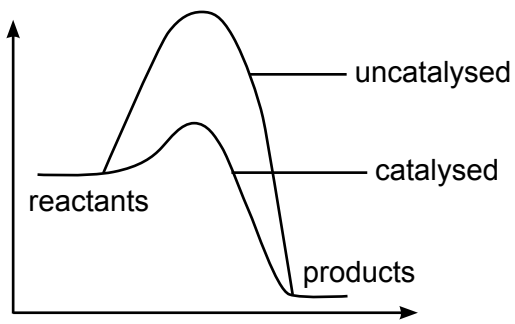
(iii)



[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 = $50 \times 0.4 / 1000 = 0.02$ gives 0.01 mol PbI_2

moles PbI_2 formed = $3.8 / 461 = 0.00824$

% yield = $(0.00824 / 0.01) \times 100$

$= 82.4\%$

award [3] for correct answer

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

27

AVAILABLE MARKS

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

(b) (i) $1s^2 2s^2 2p^6$ [1]
$1s^2 2s^2 2p^6 3s^2 3p^6$ [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) $+148 + 738 + 1451 + 242 - 696 = -642 + \Delta H_{latt}$
$\Delta H_{latt} = +2525\ (kJmol^{-1})$
each error [–1] [2]

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

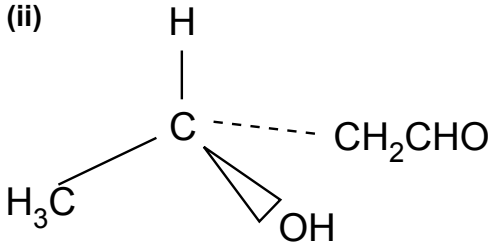
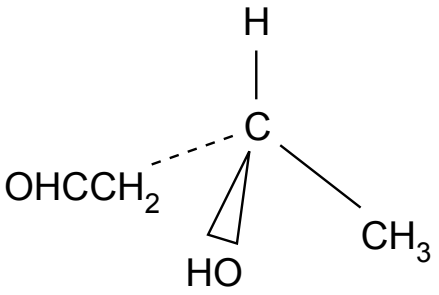
$CH_3CH_2CH_2COOH + PCl_5 \rightarrow CH_3CH_2CH_2COCl + POCl_3 + HCl$ [1] [2]

(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 $SO_2 = 1.5 / 3.5 \times 150 = 64.285$
partial pressure $Cl_2 = 64.285$
partial pressure $SO_2Cl_2 = 0.5 / 3.5 \times 150 = 21.43$
$K_p = PP(SO_2) \times PP(Cl_2) / PP(SO_2Cl_2)$
$= (64.285)^2 / 21.43$
= 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**

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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]

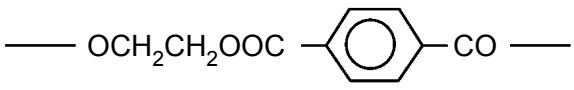
(ii) Colourless [1] to pink [1] [2]

(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]

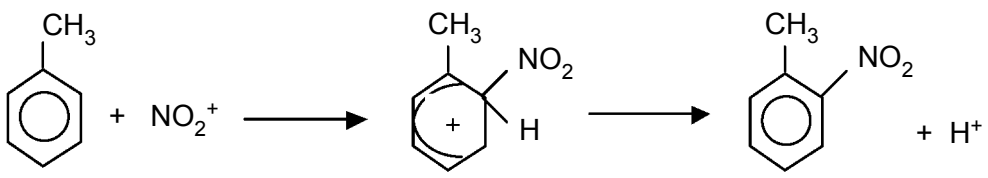
(ii) High density: (little branching/high crystallinity)/low flexibility
or
Low density: (high branching/low crystallinity)/high flexibility [2]

(b) (i)



2 marks ([–1] for each mistake) [2]

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

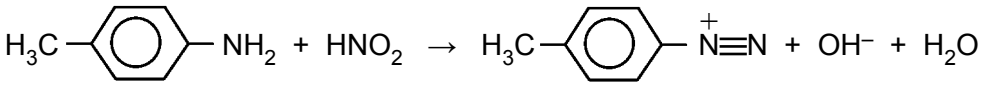
		AVAILABLE MARKS
13 **(a)**	Polydentate ligand: a ligand with more than one lone pair of electrons which forms more than one central bond (with a coordinate/dative metal) [2]	
(b) **(i)**	4 [1]	
(ii)	Square planar [1]	
(iii)	—— : Covalent bond [1] ----- : Hydrogen bond [1] ⟶ : Dative/Co-ordinate bond [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)	$2C_7H_5N_3O_6 + 10\frac{1}{2}\text{or}\ \frac{21}{2}O_2 \rightarrow 14CO_2 + 3N_2 + 5H_2O$ 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]

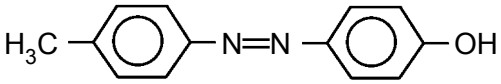
(iii)



([–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)	

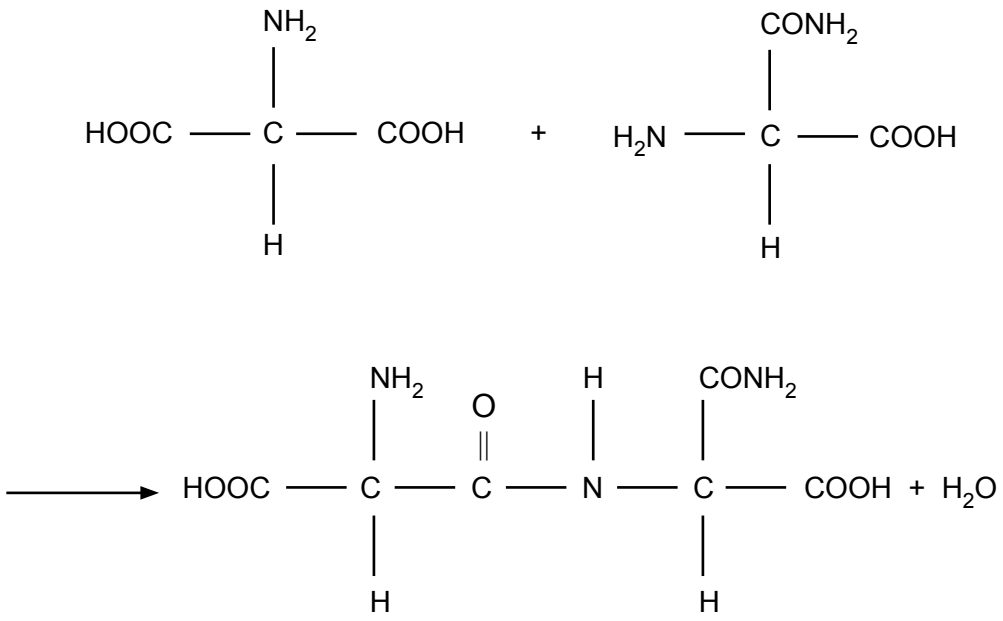
([1] each) [2]

				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

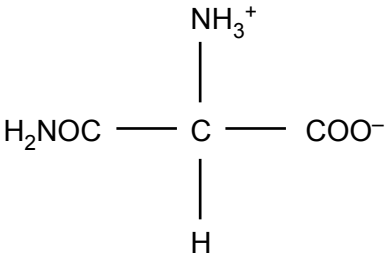
(b) (i) React with ammonia and heat the ammonium salt [1]

(ii)



([–1] for each mistake) [2]

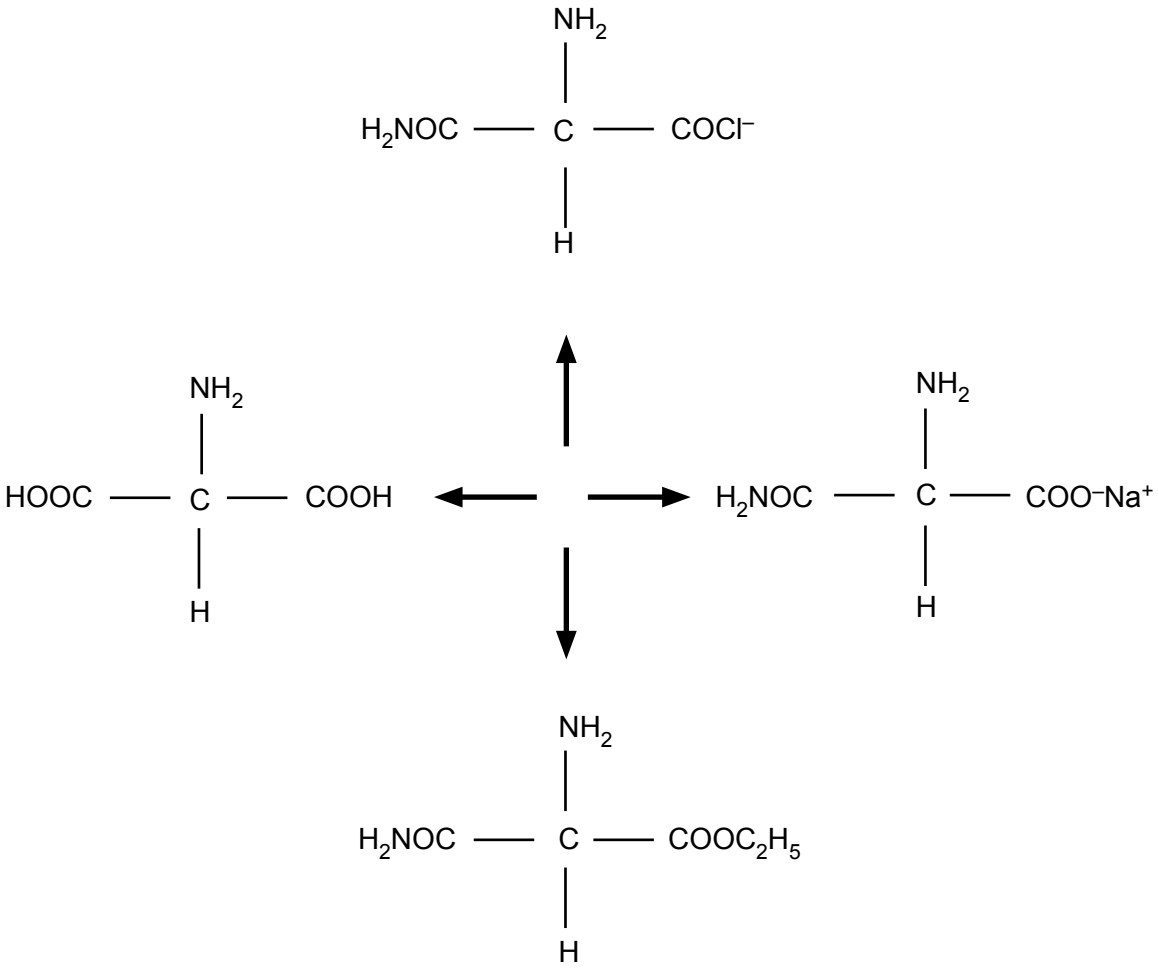
(iii)



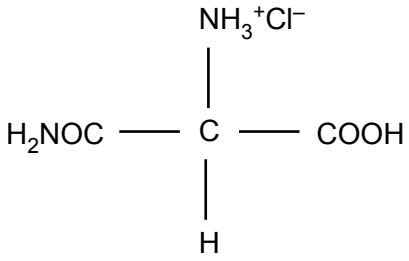
[1]

	AVAILABLE MARKS

(iv)



or



([1] each) [4] 17

Section B **100**

Total **120**

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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) **2** IO_3^- + **12** H^+ + **10** e^- $\longrightarrow$ I_2 + **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)

∴ 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

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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

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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:

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(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]

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

(d) (i) **2** IO_3^- + **12** H^+ + **10** e^- $\longrightarrow$ I_2 + **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 $NaIO_3$ 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

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General Certificate of Education
2011

Chemistry

Assessment Unit A2 2

assessing

Analytical, Transition Metals, Electrochemistry and Further Organic Chemistry

[AC222]

AC222

FRIDAY 27 MAY, AFTERNOON

TIME

2 hours.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all fifteen** questions.
Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10. Keep in sequence when answering.
Answer **all five** questions in **Section B**. 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(d)(iii)**.
In Section A all questions carry equal marks, i.e. **two** marks for each question.
In Section B the figures 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

Examiner Only	
Marks	Remark

For each of the 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 Chlorine has two isotopes, chlorine-35 and chlorine-37.
Which one of the following is the number of peaks found in the mass spectrum of chlorine gas?

A 2
B 3
C 4
D 5

2 The mechanism for the nitration of benzene is described as

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

3 Copper(II) ions form a coloured complex with the ligand L. The following absorbances were recorded on mixing different volumes of 0.05 M copper(II) sulfate and 0.1 M ligand L.

volume of 0.05 M $CuSO_4(aq)/cm^3$	volume of 0.1 M $L(aq)/cm^3$	absorbance
3.0	7.0	0.412
4.0	6.0	0.457
5.0	5.0	0.406
6.0	4.0	0.335
7.0	3.0	0.251

Which one of the following is the cation to ligand ratio in this complex?

A 1:2
B 1:3
C 2:3
D 3:2

Examiner Only	
Marks	Remark

4 In which one of the following is a metal in the +2 state?

A $[Ag(NH_3)_2]^+$
B $[Co(NH_3)_5Br]^{2+}$
C $K_4Fe(CN)_6$
D $K_2Cr_2O_7$

5 An organic compound X contains carbon, hydrogen and oxygen only. When 1.29 g of X is burnt completely, 3.30 g of carbon dioxide and 1.35 g of water are formed. Which one of the following is the empirical formula of X?

A CH_2O
B C_2H_6O
C C_4H_8O
D $C_5H_{10}O$

6 Which one of the following is the relative molecular mass of 2,4-dichloro-3,5-dimethylphenol?

A 190
B 191
C 192
D 196

7 Given the following standard electrode potentials:

	$E^{\ominus}$/V
$V^{3+}(aq) + e^- \rightarrow V^{2+}(aq)$	−0.26
$SO_4^{2-}(aq) + 2H^+(aq) + 2e^- \rightarrow SO_3^{2-}(aq) + H_2O(l)$	+0.17
$VO^{2+}(aq) + 2H^+(aq) + e^- \rightarrow V^{3+}(aq) + H_2O(l)$	+0.34
$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$	+0.77
$VO_2^+(aq) + 2H^+(aq) + e^- \rightarrow VO^{2+}(aq) + H_2O(l)$	+1.00

Which one of the following reagents will convert $V^{3+}(aq)$ to $VO^{2+}(aq)$?

A Aqueous iron(II) ions
B Aqueous iron(III) ions
C Aqueous sulfate ions in acidic solution
D Aqueous sulfite ions

Examiner Only	
Marks	Remark

8 Which one of the following is the volume of water which must be added to $30.0\,cm^3$ of $0.25\,mol\,dm^{-3}$ sulfuric acid to produce $0.05\,mol\,dm^{-3}$ sulfuric acid?

A $30\,cm^3$
B $120\,cm^3$
C $150\,cm^3$
D $270\,cm^3$

9 Which one of the following is the total number of electrons involved in bonding in benzene?

A 12
B 18
C 24
D 30

10 The concentration of aqueous magnesium ions may be determined by titration with standard edta using Eriochrome Black T as indicator. Which one of the following is the colour change at the end point?

A Blue to green
B Blue to red
C Red to blue
D Red to green

Section B

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

Examiner Only	
Marks	Remark

11 Lysine (2,6-diaminohexanoic acid) has the formula

$$H_2N(CH_2)_4CH(NH_2)COOH$$

The molecule is optically active and may undergo polymerisation.

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

_____ [2]

(ii) Draw the 3D structure of lysine labelling the asymmetric carbon with an asterisk (*).

[2]

(b) Explain why lysine has a relatively high melting point.

_____

_____

_____ [2]

(c) Write the formula of the organic ion present when lysine is dissolved in an alkaline solution.

_____ [1]

(d) Draw the structure of a dimer formed when two molecules of lysine react.

[2]

(e) A mixture of amino acids may be separated using paper chromatography.

(i) Explain the term **R_f value** as applied to paper chromatography.

_____ [1]

(ii) Explain, in terms of partition, what a low R_f value indicates about a particular amino acid.

_____

_____ [2]

(f) An amino acid was found to have the following composition by mass:

element	% composition
N	10.5
C	36.1
H	5.3
O	48.1

Deduce the empirical formula for this amino acid.

_____

_____

_____

_____ [3]

Examiner Only

Marks	Remark

12 Chromium is a transition metal which was discovered by Louis Vauquelin in 1797. He was able to detect traces of chromium in precious gems, such as ruby and emerald.

Examiner Only	
Marks	Remark

(a) State the electronic structure of a chromium atom and explain why the arrangement is stable.

_____

_____ [2]

(b) Chromium(III) oxide, Cr_2O_3, can be reduced to the metal by heating with aluminium powder according to the equation:

$$2Al(s) + Cr_2O_3(s) \rightarrow 2Cr(s) + Al_2O_3(s)$$

Calculate the percentage yield when 42.5 g of chromium are obtained from a reaction between 25 g of aluminium and 100 g of chromium(III) oxide.

_____

_____

_____

_____

_____ [3]

(c) Chromium trioxide, CrO_3, is formed by the reaction between excess concentrated sulfuric acid and a concentrated solution of potassium dichromate. Potassium sulfate and water are formed as by-products.

Write the equation for this reaction.

_____ [2]

Examiner Only	
Marks	Remark

(d) A data book lists the following standard electrode potentials:

$Cr^{3+}(aq) + e^- \rightarrow Cr^{2+}(aq)$ $-0.41\,V$
$Ag^+(aq) + e^- \rightarrow Ag(s)$ $+0.80\,V$

(i) Cr^{2+} can reduce silver ions to silver atoms. Write the equation for this reduction.

_____ [1]

(ii) Deduce the electrode potential for this change.

_____ [1]

(e) Chrome alum is a double salt prepared by the reduction of potassium dichromate, $K_2Cr_2O_7$, using a suitable reducing agent.

(i) Name a suitable reducing agent.

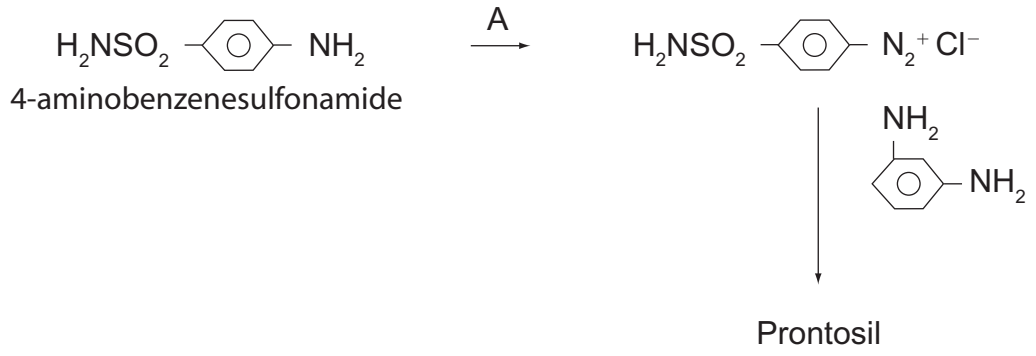
_____ [1]

(ii) State the colour and formula of crystalline chrome alum.

_____

_____ [2]

(f) Chrome alum may be used as a mordant in dyeing, binding the dye molecules to the fibre. The dye Prontosil is prepared by the following sequence:



4-aminobenzenesulfonamide

Prontosil

(i) Deduce the empirical formula for 4-aminobenzenesulfonamide.

_____ [1]

(ii) Name the reagents required for step A.

_____ [1]

(iii) State and explain the condition necessary for the first step.

_____

_____ [2]

(iv) Suggest a structure of the dye Prontosil which is formed by a coupling reaction.

[2]

(v) Explain why Prontosil is coloured.

_____

_____

_____

_____ [3]

Examiner Only	
Marks	Remark

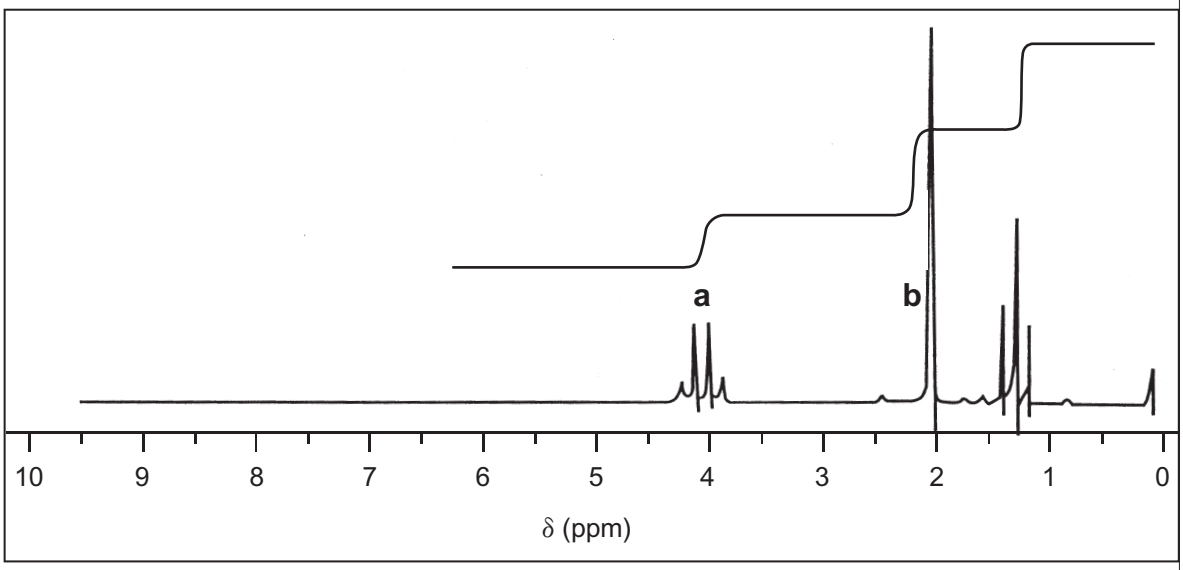
Examiner Only	
Marks	Remark

13 The first person to extract ethanoic acid from vinegar was the alchemist Jabir ibn Hayyan Geber (c. 721–815 AD). However the pure compound was not produced for another ten centuries.

(a) The mass spectrum of ethanoic acid shows a distinct peak at m/e = 59. State the formula of the species giving rise to this peak.

_____ [1]

(b) Ethanoic acid reacts with ethanol to form the ester ethyl ethanoate, $CH_3COOC_2H_5$. The n.m.r. spectrum of ethyl ethanoate consists of three sets of peaks as shown below.



(i) Explain the peak integrations.

_____

_____

_____ [2]

(ii) Explain the chemical shifts.

_____

_____

_____ [2]

(iii) Explain the splitting pattern **a**.

_____

_____ [1]

(iv) Explain why **b** is a singlet.

_____

_____ [1]

(c) Ethanoic acid can be converted to ethanamide via the thermal decomposition of the ammonium salt.

(i) Write the equation for the reaction of ethanoic acid with ammonia.

_____ [1]

(ii) Write the equation for the thermal decomposition.

_____ [1]

(iii) Ethanamide is hydrolysed by either hydrochloric acid or sodium hydroxide to form different organic products. State the formula of the organic product in each case.

hydrochloric acid _____

sodium hydroxide _____ [2]

Examiner Only

Marks	Remark

Examiner Only	
Marks	Remark

(d) Ethanamide can be converted to an amine in the following sequence.

$$CH_3CONH_2 \xrightarrow{A} CH_3CN \xrightarrow{B} CH_3CH_2NH_2$$

(i) Give the formula of reagents A and B.

A _____

B _____ [2]

(ii) Write the equation for the reaction of an unknown amine, RNH_2, with ethanoyl chloride.

_____ [1]

(iii) Describe how you would identify the unknown amine using the pure N-substituted amide. Include relevant practical steps.

_____

_____

_____

_____

_____

_____

_____ [4]

Quality of written communication. [2]

(e) 1,2-diaminoethane (en) is a bidentate ligand forming stable complex ions with transition metal ions.

(i) Explain the term **bidentate**.

_____

_____ [2]

(ii) Hexaaquanickel(II) ions react with en in solution. Write the equation for this reaction in which all the water ligands are replaced.

_____ [2]

(iii) Explain why this ligand replacement takes place.

_____

_____ [2]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

14 Iron is a transition metal which fulfils vital biological, industrial and chemical roles.

(a) The most common oxidation states of iron in its compounds are +2 and +3. State the electronic structures of the Fe^{2+} and Fe^{3+} ions.

Fe^{2+} _____

Fe^{3+} _____ [2]

(b) Metallic iron is used as a heterogeneous catalyst in the Haber Process to make ammonia.

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

Explain in terms of chemisorption how the reaction takes place.

_____

_____

_____ [3]

(c) Iron filings are used to catalyse the monohalogenation of aromatic compounds such as methylbenzene, $C_6H_5CH_3$.

(i) Draw a flow scheme for the mechanism of the monobromination of methylbenzene to form 4-bromomethylbenzene.

[3]

(ii) Suggest the name of the product formed in the monobromination of 1,4-dimethylbenzene.

_____ [2]

(d) (i) Explain the role of iron(II) in haemoglobin.

_____

_____ [2]

(ii) Explain the effect of the inhalation of carbon monoxide on haemoglobin.

_____ [1]

(e) Aqueous iron(III) ions form a stable complex with the bidentate ligand ethanedioate, $C_2O_4^{2-}$.
The iron(III) ions combine with three ethanedioate ions. Deduce the formula of the complex formed.

_____ [1]

(f) Potassium manganate(VII) oxidises iron(II) ions and ethanedioate ions according to the equations:

$$MnO_4^-(aq) + 5Fe^{2+}(aq) + 8H^+(aq) \rightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O(l)$$

$$2MnO_4^-(aq) + 5C_2O_4^{2-}(aq) + 16H^+(aq) \rightarrow 2Mn^{2+}(aq) + 10CO_2(g) + 8H_2O(l)$$

(i) Describe, with observations, how you could confirm the presence of aqueous iron(III) ions, following the oxidation of iron(II) ions, without interference from manganese(II) ions.

_____

_____

_____ [3]

(ii) 25.0 cm^3 of an acidified iron(II) ethanedioate solution required 32.2 cm^3 of 0.025 mol dm^{-3} of potassium manganate(VII) solution for complete reaction. Calculate the concentration, in mol dm^{-3}, of the iron(II) ethanedioate solution.

_____

_____

_____

_____

_____ [4]

Examiner Only

Marks	Remark

Examiner Only	
Marks	Remark

15 Polymers have become invaluable materials with many familiar names e.g. polythene, Perspex, and nylon.

(a) The manufacture of High Density (HD) polythene was first developed by Ziegler in the 1950s.

(i) State the conditions used to manufacture HD polythene.

_____

_____

_____ [3]

(ii) State and explain the flexibility and softening temperature of HD polythene.

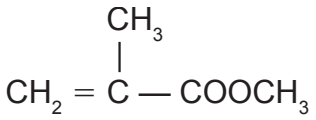
_____

_____

_____

_____ [3]

(b) Perspex is an addition polymer made by polymerisation of methyl 2-methylpropenoate monomer shown below.



Draw a section of the Perspex polymer showing at least two repeating units.

[2]

Examiner Only	
Marks	Remark

(c) Nylon is a condensation polymer made from the two monomers 1,6-diaminohexane and hexanedioic acid.

$H_2N(CH_2)_6NH_2$ $HOOC(CH_2)_4COOH$

1,6-diaminohexane hexanedioic acid

(i) Explain the term **condensation** polymer.

_____

_____ [1]

(ii) Draw the repeat unit in nylon circling the peptide link in the structure.

[3]

(d) Explain why the disposal of polyesters in landfill sites is more environmentally acceptable than the similar disposal of polythene.

_____

_____ [2]

(e) Proteins are natural polymers which act as structural materials.

(i) State what is meant by the primary structure of a protein.

_____ [1]

(ii) Proteins hydrolyse slowly in acid conditions. Suggest how enzymes work to allow the process to occur more quickly.

_____

_____

_____ [2]

THIS IS THE END OF THE QUESTION PAPER

111319

Rewarding Learning

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2011

Chemistry

Assessment Unit A2 2

assessing

Analytical, Transition Metals, Electrochemistry and Further Organic Chemistry

[AC222]

FRIDAY 27 MAY, AFTERNOON

MARK SCHEME

Section A

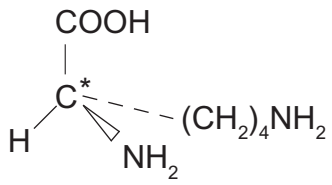
	AVAILABLE MARKS
1 D	
2 B	
3 B	
4 C	
5 D	
6 B	
7 B	
8 B	
9 D	
10 C	
[2] for each correct answer [20]	20
Section A	**20**

Section B

AVAILABLE MARKS

11 **(a)** **(i)** ability to rotate plane [1]
of plane polarised light [1] [2]

(ii)



correct structure (3D) [1]
asymmetric carbon labelled correctly [1] [2]

(b) zwitterion/ionic [1]
strong attractions between oppositely charged ions/molecules [1] [2]

(c) $H_2N(CH_2)_4CH(NH_2)COO^-$ [1]

(d) $H_2N(CH_2)_4CH(NH_2)CONH(CH_2)_4CH(NH_2)COOH$/
$H_2N(CH_2)_4CH(NH_2)CONHCH(CH_2)_4NH_2$
|
COOH [2]

(e) **(i)** distance travelled by solute
divided by distance travelled by solvent (front) [1]

(ii) more soluble in water/stationary phase [1]
than mobile phase/solvent [1] [2]

(f)

	N	C	H	O
	10.5	36.1	5.3	48.1
÷RAM	0.75	3.01	5.3	3.01
÷0.75	1	4	7	4

empirical formula = $C_4H_7O_4N$ (each error [−1], cet) [3]

15

12 **(a)** $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$ [1]
half-filled d subshell stable [1] [2]

(b) moles Al = 25/27 = 0.926
moles Cr_2O_3 = 100/152 = 0.658
2 moles Al = 1 mole Cr_2O_3 therefore Cr_2O_3 in excess
1 mole Al = 1 mole Cr
0.926 mole Al = 0.926 mole Cr
mass Cr = 0.926 × 52 = 48.15 g
% yield = 42.5 × 100/48.15 = 88.3%
Award [3] for correct answer.
Each error [−1], carry error through [3]

(c) $K_2Cr_2O_7 + H_2SO_4 \rightarrow K_2SO_4 + 2CrO_3 + H_2O$ [2]
unbalanced [−1]

(d) **(i)** $Cr^{2+} + Ag^+ \rightarrow Cr^{3+} + Ag$ [1]

(ii) 0.8 −(−0.41) = (+)1.21 (V) [1]

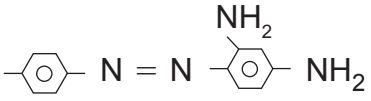
(e) **(i)** ethanol/alcohol [1]

(ii) purple/violet [1]
$K_2SO_4.Cr_2(SO_4)_3.24H_2O$ [1] [2]

(f) **(i)** $C_6SN_2H_8O_2$ [1]

(ii) sodium nitrite and hydrochloric acid [1]

(iii) ≤10 °C [1]
diazonium ion decomposes above this [1] [2]

(iv) H_2NSO_2  NH_2

structure [2], each error [−1] [2]

(v) highly conjugated/delocalised [1]
electronic energy levels close together [1]
(electron transitions) absorb visible light [1] [3]

AVAILABLE MARKS

21

13 (a) CH_3COO^+ [1]

(b) (i) ratio 2 : 3 : 3 or 3 : 2 : 3 [1]
$CH_3 : CH_2 : CH_3$/no. of Hs in each environment [1] [2]

(ii) high value quartet near electronegative O
lowest CH_3 from CH_2CH_3
intermediate singlet proximity to COO
all three [2]
errors [−1] [2]

(iii) (quartet) due to split by three chemically equivalent H (n + 1) [1]

(iv) no H on adjacent atom (to split signal) [1]

(c) (i) $CH_3COOH + NH_3 \rightarrow CH_3COONH_4$ [1]

(ii) $CH_3COONH_4 \rightarrow CH_3CONH_2 + H_2O$ [1]

(iii) acid: CH_3COOH [1]
alkaline: CH_3COONa [1] [2]

(d) (i) A: P_4O_{10} [1]
B: $LiAlH_4$ [1] [2]

(ii) $RNH_2 + CH_3COCl \rightarrow CH_3CONHR + HCl$ [1]

(iii) determine melting point/description of apparatus
heat slowly
record temperature when melting starts and stops/range
compare to tables
Any four [4]

Quality of written communication [2]

(e) (i) two coordinate (dative) bonds
formed by lone pairs [2]

(ii) $[Ni(H_2O)_6]^{2+} + 3en \rightarrow [Ni(en)_3]^{2+} + 6H_2O$ [2]
unbalanced [1]

(iii) increase in entropy [1]
4 particles to 7 particles [1] [2]

AVAILABLE MARKS

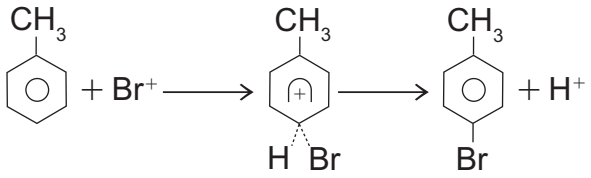
26

AVAILABLE MARKS

14 **(a)** Fe^{2+}: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$ [1]
Fe^{3+}: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$ [1] [2]

(b) molecules adsorbed/attached to surface [1]
weakens bonds/alignment/bonds formed with surface [1]
lowers activation energy [1] [3]

(c) **(i)**



Each error [−1] [3]

(ii) 2-bromo-1,4-dimethylbenzene [2]
Each error [−1]

(d) **(i)** oxygen forms bond with Fe^{2+} [1]
carried around the body [1] [2]

(ii) CO combines irreversibly [1]

(e) $[Fe(C_2O_4)_3]^{3-}$ [1]

(f) **(i)** thiocyanate ions/hydroxide ions/NH_3(aq) [1]
blood red/rust/brown [1]
solution/ppt [1] [3]

(ii) 1 mole $MnO_4^- = 5$ moles Fe^{2+}
2 moles $MnO_4^- = 5$ moles $C_2O_4^{2-}$
$\Rightarrow$ 3 moles $MnO_4^- = 5$ moles FeC_2O_4
Number of moles iron(II) ethanedioate $= \dfrac{32.2 \times 0.025}{1000}$
$= 8.05 \times 10^{-4}$
Number of moles $MnO_4^- = 8.05 \times 10^{-4} \times \frac{5}{3}$
$= 1.34 \times 10^{-3}$ in 25.0 cm^3
Concentration $MnO_4^- = 1.34 \times 10^{-3} \times 40 = 0.0536$
$= 0.054$ mol dm^{-3}
Award [4] directly for correct answer
Each error [−1], carry error through [4]

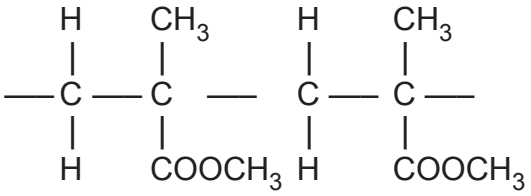
21

15 (a) (i)

Ziegler	Philips	
50–75º	150–180º	[1]
1–10 atms./low	30–40 atms.	[1]
$TiCl_4$/aluminium (Ziegler catalyst)	Cr_2O_3	[1] [3]

(ii) rigid and high softening temperature [1]
little branching [1]
pack close together/crystalline/strong intermolecular forces [1] [3]

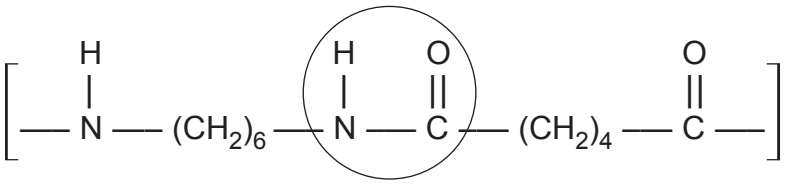
(b)



Structure [2]

(c) (i) **(**polymerisation involves) loss of water/small molecule [1]

(ii)



structure [2]
peptide link [1] [3]

(d) polyesters are biodegradable [1]
as they can be hydrolysed [1] [2]

(e) (i) sequence of amino acids [1]

(ii) lock and key/active site [1]
lowers activation energy/lower energy pathway [1] [2]

Section B 100

Total 120

AVAILABLE MARKS

17

Rewarding Learning

Centre Number

71	

Candidate Number

ADVANCED
General Certificate of Education
2012

Chemistry

Assessment Unit A2 2

assessing

Analytical, Transition Metals, Electrochemistry and Further Organic Chemistry

[AC222]

AC222

WEDNESDAY 23 MAY, 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 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 **16(c)(i)**.
In Section A all questions carry equal marks, i.e. **two** marks for each question.
In Section B the figures 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 applies to the ligand substitution reaction shown?

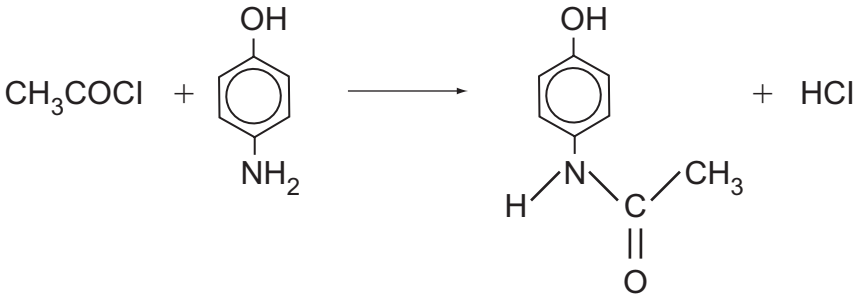
$$[Ni(H_2O)_6]^{2+} + 3en \rightarrow [Ni(en)_3]^{2+} + 6H_2O$$

	Change in Coordination Number	$\Delta S^{\ominus}$
A	6 to 3	negative
B	6 to 3	positive
C	none	negative
D	none	positive

2 Which one of the following lists the compounds in order of increasing base strength?

A ethanamide, methylamine, phenylamine
B ethanamide, phenylamine, methylamine
C methylamine, ethanamide, phenylamine
D phenylamine, ethanamide, methylamine

3 The reaction of 4-hydroxyphenylamine to produce paracetamol is shown below.



If the reaction has an 80% yield, 10.9 g of 4-hydroxyphenylamine produces

A 12.1 g of paracetamol.
B 13.6 g of paracetamol.
C 15.1 g of paracetamol.
D 18.9 g of paracetamol.

4 Which one of the following methods may be used to separate a mixture of amino acids obtained from protein hydrolysis?

A distillation
B recrystallisation
C solvent extraction
D thin-layer chromatography

5 Which one of the following is a correct statement about the stereochemistry of the complex $[Pt(NH_3)_2Cl_2]$?

A It is square planar and has cis/trans isomers.
B It is square planar and has two optical isomers.
C It is tetrahedral and has cis/trans isomers.
D It is tetrahedral and has two optical isomers.

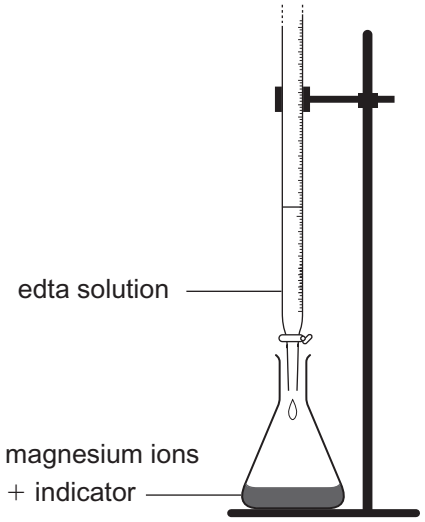
6 25.0 cm^3 of potassium iodate(V) solution were added to excess potassium iodide solution dissolved in sulfuric acid. The iodine liberated required 30.0 cm^3 of 0.05 mol dm^{-3} $Na_2S_2O_3$ solution. Which one of the following is the concentration of the potassium iodate(V) solution?

A 0.01 mol dm^{-3}
B 0.02 mol dm^{-3}
C 0.04 mol dm^{-3}
D 0.05 mol dm^{-3}

7 Which one of the following gives the ground state electronic configuration for the copper atom and the copper(II) ion?

	copper atom	copper(II) ion
A	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^9\ \ 4s^2$	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^9$
B	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^9\ \ 4s^2$	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^7\ 4s^2$
C	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^1$	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^8\ 4s^1$
D	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^1$	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^9$

8 The diagram below shows the titration of a solution of magnesium ions with edta using Eriochrome Black T as indicator.



What is the colour change at the end point?

A blue to red
B green to blue
C red to green
D red to blue

9 Which one of the following statements about glycine is **not** correct?

A It has a relatively high melting point.
B It contains 32% carbon by mass.
C It exists as optical isomers.
D It is soluble in water.

10 Which one of the following statements about propanamide is **not** correct?

A It produces an M+1 peak at 73 in its mass spectrum.
B It can be dehydrated to form propanenitrile.
C It has the molecular formula C_3H_7NO.
D It is a weaker base than ammonia.

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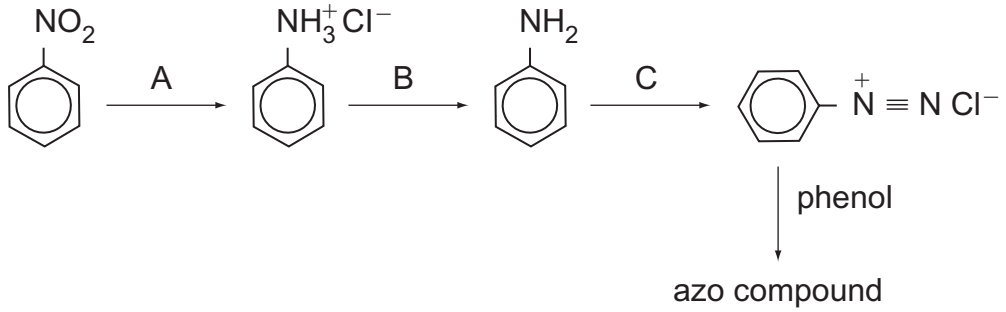
(Questions continue overleaf)

Section B

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

Examiner Only	
Marks	Remark

11 The amino group is found in amines. Phenylamine is used in the synthesis of azo compounds. Consider the following sequence of steps:



(a) (i) Give the names of the reagents used in the following steps.

A _____ [2]

B _____ [1]

C _____ [2]

(ii) Give the conditions used in step C and name the product.

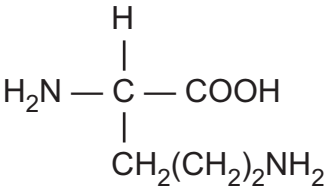
_____

_____ [2]

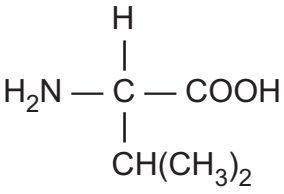
(iii) Draw the structure of the azo compound. Describe its appearance and name the compound.

_____ [3]

(b) Amino acids, such as lysine and valine, also contain the amino group.



lysine



valine

(i) Draw the zwitterion of valine.

[1]

(ii) Draw the structure of lysine when it is dissolved in an *excess* of a strong acid.

[2]

(iii) Draw the structures of the **two** dipeptides which can be formed from one molecule of glycine and one molecule of alanine. Circle the peptide link in each structure.

[3]

Examiner Only	
Marks	Remark

12 Standard electrode potentials can be used to predict the feasibility of reactions.

	$E^{\ominus}$/V
$Na^+(aq) + e^- \rightleftharpoons Na(s)$	−2.71
$Mg^{2+}(aq) + 2e^- \rightleftharpoons Mg(s)$	−2.37
$Al^{3+}(aq) + 3e^- \rightleftharpoons Al(s)$	−1.66
$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$	−0.76
$Cr^{3+}(aq) + e^- \rightleftharpoons Cr^{2+}(aq)$	−0.41
$2H^+(aq) + 2e^- \rightleftharpoons H_2(g)$	0.00
$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$	+0.77

(a) Define the term **standard electrode potential**.

_____

_____

_____ [3]

(b) From the table, select the species which is the most powerful reducing agent.

_____ [1]

(c) Write the equation for the reaction of aluminium with aqueous zinc ions and calculate the e.m.f.

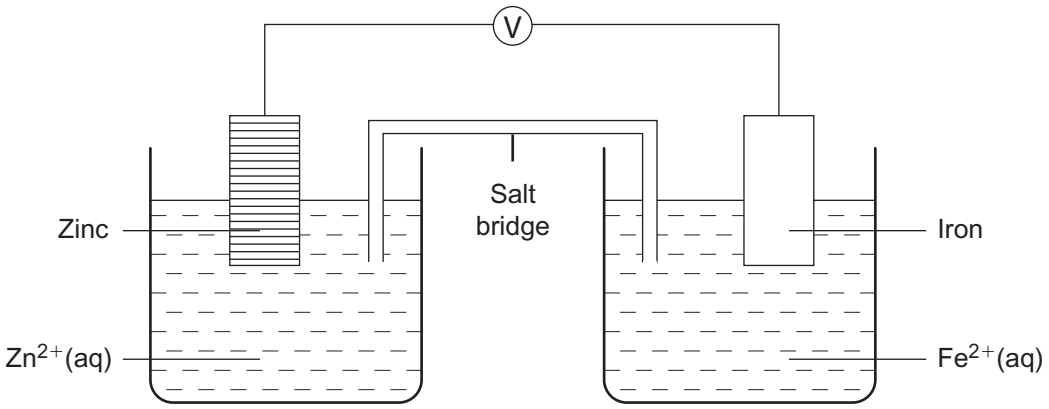
_____

_____

_____ [3]

Examiner Only	
Marks	Remark

(d) Under standard conditions, the e.m.f. of the cell shown below is +0.32 V.



Calculate the standard electrode potential for the iron half-cell.

_____

_____ [1]

Examiner Only	
Marks	Remark

13 Nuclear magnetic resonance spectroscopy (nmr) is an important analytical technique.

(a) In the question below, draw one possible structure for each of the compounds A, B, C and D.

(i) Compounds A and B are isomers with the molecular formula $C_4H_8O_2$. Both have a triplet, a singlet and a quartet in their nmr spectrum.

A B

[2]

(ii) Compound C has the molecular formula C_6H_{12} and has only one peak in its nmr spectrum.

[1]

(iii) Compound D has the molecular formula $C_5H_{13}N$. It is a tertiary amine with three types of chemically equivalent hydrogen atom which exist in the ratio of 6:6:1 and produce a doublet in the nmr spectrum.

[1]

(b) Mass spectrometry is another important analytical technique.

2-chloropropanoic acid produces molecular ion peaks at 108 and 110. It also produces a significant fragment peak at 91.

(i) Suggest why there are **two** molecular ion peaks.

_____

_____ [2]

(ii) Identify the fragment ion.

_____ [2]

(iii) Complete the table giving the integration values and the splitting of each peak in the nmr spectrum of 2-chloropropanoic acid:

	Peak 1	**Peak 2**	**Peak 3**
Integration	3		
Splitting			singlet

[4]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

14 Iron(II) ions are part of the structure of haemoglobin. Many people supplement their diet by taking "iron tablets" which contain hydrated iron(II) sulfate, $FeSO_4.7H_2O$.

(a) "Iron tablets" with a total mass of 8.00 g were dissolved in dilute sulfuric acid and the solution was made up to 250 cm^3 in a volumetric flask. 25.0 cm^3 portions of this solution were titrated with 0.02 mol dm^{-3} acidified potassium manganate(VII). The average titre was found to be 24.0 cm^3.

(i) Write the equation for the reaction of acidified manganate(VII) ions with iron(II) ions.

_____ [2]

(ii) What is the colour change at the end point of this titration?

_____ [2]

(iii) Calculate the percentage of hydrated iron(II) sulfate in the tablets.

_____

_____

_____

_____

_____

_____

_____ [5]

(b) The $[Fe(H_2O)_6]^{3+}$ ion behaves as a Brønsted acid by the loss of one hydrogen ion.

(i) Write an equation to show $[Fe(H_2O)_6]^{3+}$ behaving as a Brønsted acid.

_____ [2]

(ii) Write the expression for the acid dissociation constant of the $[Fe(H_2O)_6]^{3+}$ ion.

_____ [1]

(iii) What is observed when sodium hydroxide solution is added to a solution containing $[Fe(H_2O)_6]^{3+}$ ions?

_____

_____ [2]

(iv) Describe a different chemical test, including observations, which can be used to detect the presence of low concentrations of $[Fe(H_2O)_6]^{3+}$ ions. Give the formula of any new complex formed.

_____

_____

_____

_____ [4]

(c) With reference to the iron(II) ions in haemoglobin, explain why breathing carbon monoxide can result in death.

_____

_____

_____ [2]

Examiner Only	
Marks	Remark

15 Benzene is toxic and carcinogenic, however, the reactions of aromatic compounds can be studied in the laboratory using other substances such as methyl benzoate.

Examiner Only	
Marks	Remark

(a) The electrons in the π bonds in benzene are delocalised. Draw two structures for benzene to show the p-orbitals before and after delocalisation.

before after

[2]

(b) Nitration of methyl benzoate can be achieved using a "nitrating mixture" of concentrated nitric and sulfuric acids.

(i) Write an equation to show how these two acids react when mixed.

_____ [2]

(ii) Name the ion, produced in this reaction, which attacks the methyl benzoate molecule.

_____ [1]

(iii) Draw a flow scheme to show the mechanism of the mononitration of methyl benzoate and name the mechanism.

Name of mechanism _____ [4]

(iv) Name the organic product of this reaction.

_____ [1]

(v) Describe the appearance of this organic product.

_____

_____ [2]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

16 Transition metals form coloured complex ions and exist in a range of oxidation states.

(a) In terms of electron structures, explain why zinc is not a transition metal.

_____

_____

_____ [2]

(b) The VO_2^+ ion can be reduced to V^{2+} using zinc in the presence of an acid. Zinc is oxidised to form Zn^{2+} ions.

(i) Write a half-equation for the reduction of VO_2^+ to V^{2+}.

_____ [2]

(ii) Combine the above half-equation with the following oxidation half-equation:

$$Zn \longrightarrow Zn^{2+} + 2e^-$$

to give the ionic equation for the reaction.

_____ [2]

(iii) When this reduction is carried out in the laboratory a series of colour changes are observed. Complete the following table:

Ion	Colour
VO_2^+	
	Blue
	Green
V^{2+}	

[4]

(c) Potassium dichromate ($K_2Cr_2O_7$) can be prepared by the oxidation of a chromium(III) salt such as hydrated chromium(III) chloride, $CrCl_3.6H_2O$.

Examiner Only	
Marks	Remark

(i) Describe the preparation of potassium dichromate from hydrated chromium(III) chloride. Include all observations.

[6]

Quality of written communication [2]

(ii) When 13.33 g of hydrated chromium(III) chloride were used, 2.93 g of potassium dichromate were obtained. Calculate the percentage yield.

[4]

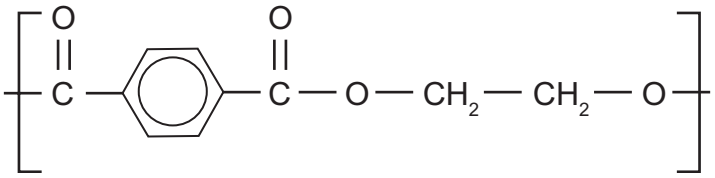
Examiner Only	
Marks	Remark

17 Polymers are long chain molecules produced by addition or condensation reactions. Polyesters and polyamides are the two main types of condensation polymer.

(a) The polyamide nylon-6,6 is made by a condensation reaction between 1,6-diaminohexane and hexanedioic acid. Draw a section of the polymer showing **two** repeating units.

[3]

(b) The repeating unit of the polymer PET is shown below:



(i) Draw the structure of the smaller of the two monomers.

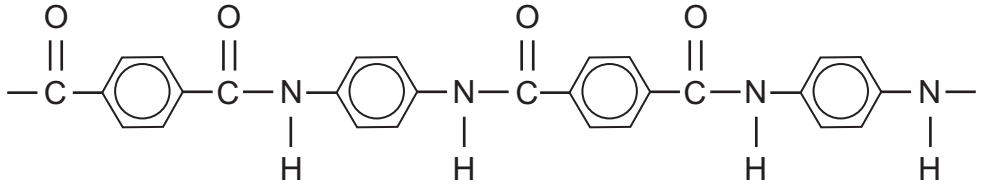
[1]

(ii) Name this monomer.

_____ [1]

Examiner Only	
Marks	Remark

(c) Kevlar is a polyamide used in bulletproof jackets. A section of the polymer chain is shown below:



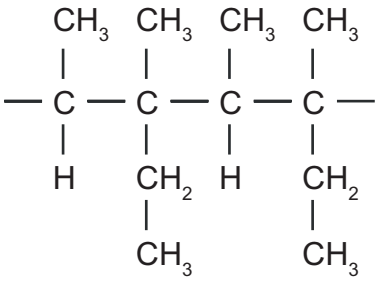
(i) How many repeating units are shown?

_____ [1]

(ii) Give the structures of the two monomers which can be used to produce Kevlar.

[2]

(d) A section of an addition polymer is shown below:



Name the monomer used to produce this polymer.

_____ [2]

THIS IS THE END OF THE QUESTION PAPER

112075

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2012

Chemistry

Assessment Unit A2 2

assessing

Analytical, Transition Metals, Electrochemistry and Further Organic Chemistry

[AC222]

WEDNESDAY 23 MAY, AFTERNOON

MARK SCHEME

Section A

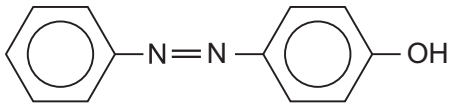
	AVAILABLE MARKS
1 D	
2 B	
3 A	
4 D	
5 A	
6 A	
7 D	
8 D	
9 C	
10 A	
[2] for each correct answer [20]	20
Section A	**20**

Section B

AVAILABLE MARKS

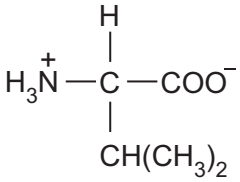
11 **(a)** **(i)** A tin/concentrated hydrochloric acid [2]
B sodium hydroxide [1]
C sodium nitrite/hydrochloric acid [2] [5]

(ii) 0–10°C [1]
benzenediazonium chloride [1] [2]

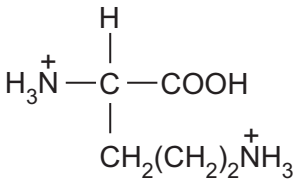
(iii) 

[1]

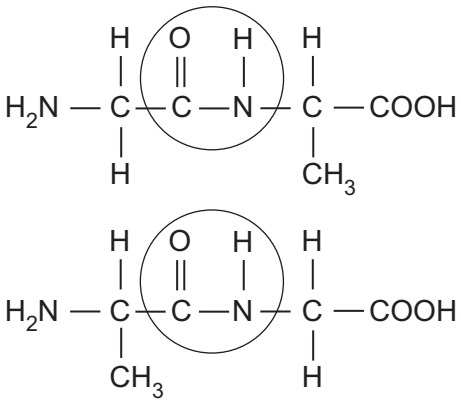
orange solid [1]
4-hydroxyazobenzene/4-hydroxyphenylazobenzene [1] [3]

(b) **(i)** 

[1]

(ii) 

[2]

(iii) 

[3] 16

AVAILABLE MARKS

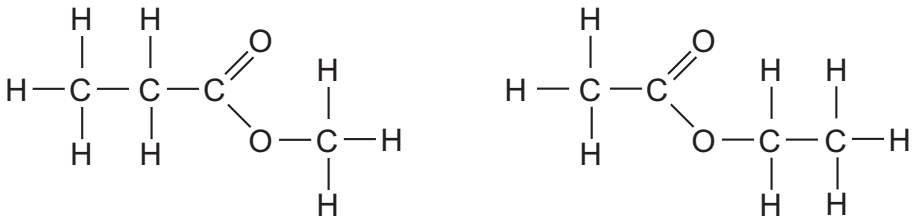
12 **(a)** The potential difference [1] measured
when a half-cell is connected to a hydrogen electrode [1]
under standard conditions [1] [3]

(b) Na(s) [1]

(c) $2Al + 3Zn^{2+} \rightarrow 2Al^{3+} + 3Zn$ [2]
$-0.76 - (-1.66)$
$+ 1.66 - 0.76 = +0.90$ V [1] [3]

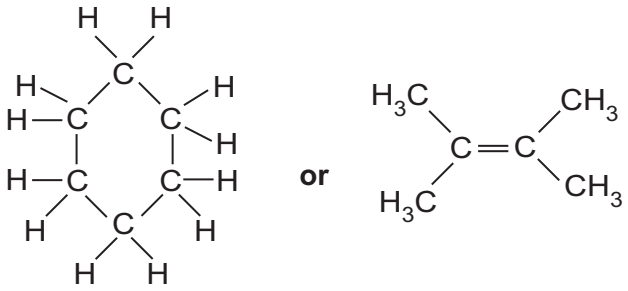
(d) $+0.32 = x - (-0.76)$
-0.44 V [1] 8

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



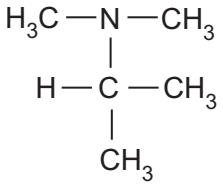
[2]

(ii)



[1]

(iii)



[1]

(b) **(i)** 2 isotopes [1] of chlorine [1]
or ^{35}Cl and ^{37}Cl [1] [2]

(ii) $C_3H_4{}^{35}ClO^+$ [2]

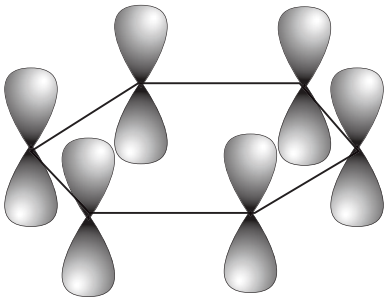
(iii)

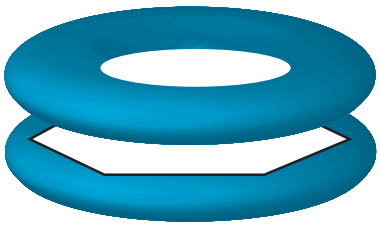
	Peak 1	Peak 2	Peak 3
		1 [1]	**1 [1]**
	Doublet [1]	**Quartet [1]**	

[4] 12

					AVAILABLE MARKS
14	**(a)**	**(i)**	$MnO_4^- + 8H^+ + 5Fe^{2+} \rightarrow Mn^{2+} + 4H_2O + 5Fe^{3+}$	[2]	
		(ii)	colourless to pink	[2]	
		(iii)	moles of manganate(VII) = 0.00048 moles of iron(II) in 25 cm^3 = 0.0024 moles of iron(II) in 250 cm^3 = 0.024 mass of $FeSO_4.7H_2O$ = 0.024 × 278 = 6.672 g % hydrated iron(II) sulfate = 83.4% Each error [–1]	[5]	
	(b)	**(i)**	$[Fe(H_2O)_6]^{3+} \rightleftharpoons [Fe(OH)(H_2O)_5]^{2+} + H^+$	[2]	
		(ii)	$K_a = \dfrac{[Fe(OH)(H_2O)_5{}^{2+}][H^+]}{[Fe(H_2O)_6{}^{3+}]}$	[1]	
		(iii)	a rust/brown [1] precipitate [1]	[2]	
		(iv)	(potassium) thiocyanate solution [1] blood red [1] solution [1] $[Fe(SCN)(H_2O)_5]^{2+}$ [1]	[4]	
	(c)		CO forms a very strong bond with the iron(II) ion in haemoglobin [1] this prevents the transportation of oxygen [1]	[2]	20

15 (a)



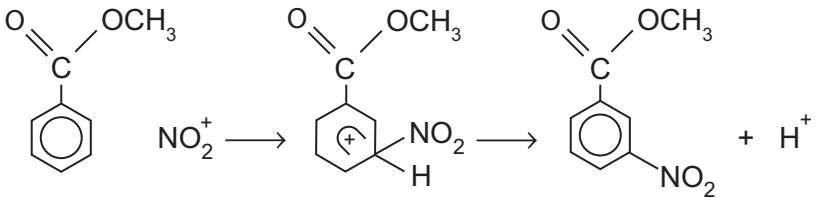


before after [2]

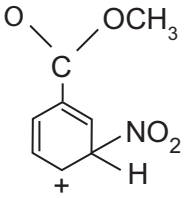
(b) (i) $HNO_3 + 2H_2SO_4 \rightarrow NO_2^+ + H_3O^+ + 2HSO_4^-$ [2]

(ii) nitronium ion [1]

(iii)



or



[3]

electrophilic substitution [1] [4]

(iv) methyl 3-nitrobenzoate [1]

(v) cream [1] solid [1] [2] 12

AVAILABLE MARKS

16 (a) Does not have an incomplete d-subshell in its (stable) ion [1]
Zn^{2+} is $3d^{10}$ [1] [2]

(b) (i) $VO_2^+ + 4H^+ + 3e^- \rightarrow V^{2+} + 2H_2O$ [2]

(ii) $2VO_2^+ + 8H^+ + 3Zn \rightarrow 2V^{2+} + 4H_2O + 3Zn^{2+}$ [2]

(iii)

Ion	Colour
VO_2^+	**Yellow [1]**
VO^{2+} [1]	Blue
V^{3+} [1]	Green
V^{2+}	**Violet [1]**

[4]

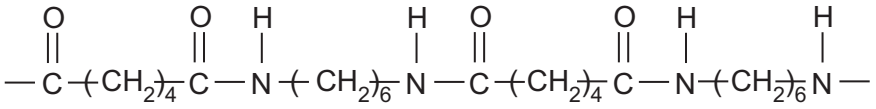
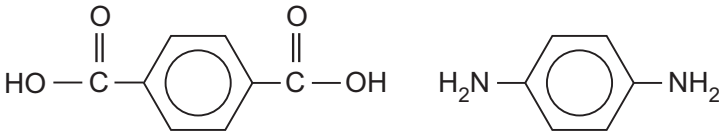
(c) (i) dissolve in water and add (excess) potassium hydroxide [1]
a green-blue precipitate will form and then dissolve to give a deep green solution [1]
add excess hydrogen peroxide and heat [1]
the (green) solution turns yellow [1]
boil the solution (and reduce the volume) [1]
add named acid [1]
orange solution/orange crystals [1]
maximum [6] [6]

Quality of written communication [2]

(ii) moles of chromium(III) chloride hexahydrate = 0.05 [1]
theoretical yield of potassium dichromate = 0.025 mole [1]
actual yield = 0.00997 mole [1]
% yield = 40% [1] [4]

AVAILABLE MARKS

22

			AVAILABLE MARKS
17	**(a)** 		
	Each error [–1]	[3]	
	(b) **(i)** $HOCH_2CH_2OH$	[1]	
	(ii) ethane-1,2-diol	[1]	
	(c) **(i)** 2	[1]	
	(ii) 	[2]	
	(d) 3-methylpent-2-ene	[2]	10
		Section B	**100**
		Total	**120**

Rewarding Learning

Centre Number	
71	

Candidate Number

ADVANCED
General Certificate of Education
2014

Chemistry

Assessment Unit A2 2

assessing

Analytical, Transition Metals, Electrochemistry and Further Organic Chemistry

[AC222]

AC222

TUESDAY 3 JUNE, AFTERNOON

TIME

2 hours.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all fifteen** questions.
Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10. Keep in sequence when answering.
Answer **all five** questions in **Section B**. 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(d)(i)**.
In Section A all questions carry equal marks, i.e. **two** marks for each question.
In Section B the figures 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.

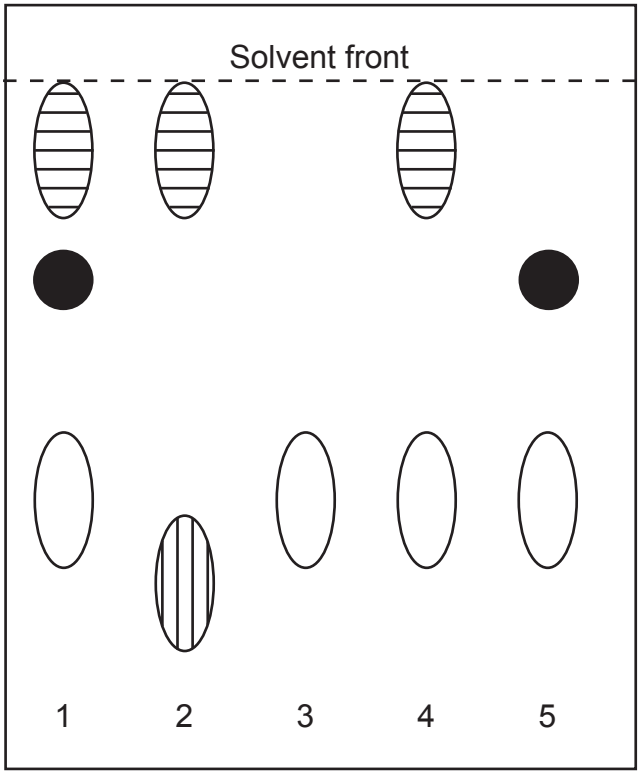
For Examiner's use only	
Question Number	**Marks**
Section A	
1–10	
Section B	
11	
12	
13	
14	
15	
Total Marks	

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 Paper chromatography was used to identify the amino acids in a polypeptide. The hydrolysed polypeptide is at point 1. The starting point for each amino acid or dipeptide is shown at points 2–5 in the chromatogram below.



Which one of the following mixtures makes up the polypeptide?

A 2 + 5

B 3 + 4

C 3 + 5

D 4 + 5

2 Oxygen has three isotopes ^{16}O, ^{17}O and ^{18}O. A sample of oxygen was analysed in a mass spectrometer and three groups of peaks were obtained:

group P corresponding to the ion O_2^+

group Q corresponding to the ion O^{2+}

group R corresponding to the ion O^+

Which one of the following is the order on the mass/charge axis, from left to right of the groups?

A P Q R

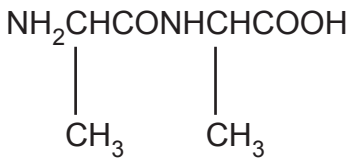
B P R Q

C Q P R

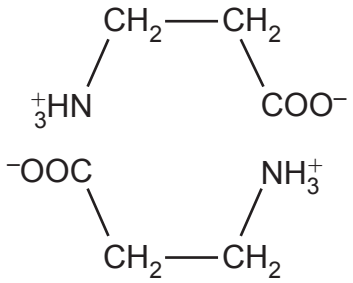
D Q R P

3 Which one of the following compounds is a peptide?

A CH_3CONH_2

B 

C $HOOC(CH_2)_6CONH(CH_2)_4NH_2$

D 

4 When 2.6 g of a metal X are added to copper(II) sulfate solution 4.8 g of copper are obtained. The relative atomic mass of X is 52. Which one of the following cations of X is produced?

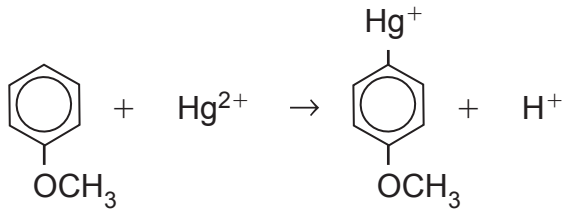
A X^{+}

B X^{2+}

C X^{3+}

D X^{4+}

5 The reaction below shows the mercury(II) ion reacting with anisole.



Which one of the following is the role of the mercury ion?

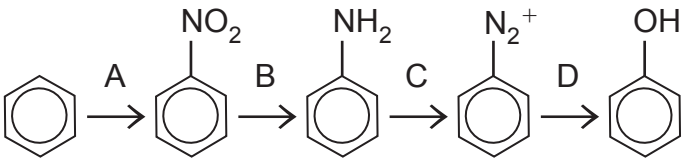
A Catalyst

B Electrophile

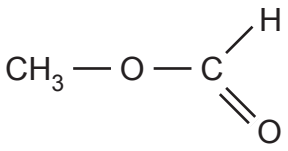
C Nucleophile

D Oxidising agent

6 Which one of the steps in the following synthesis requires the reagent $NaNO_2(s)/HCl(aq)$?



7 The structure below represents an organic compound.



This compound is an example of

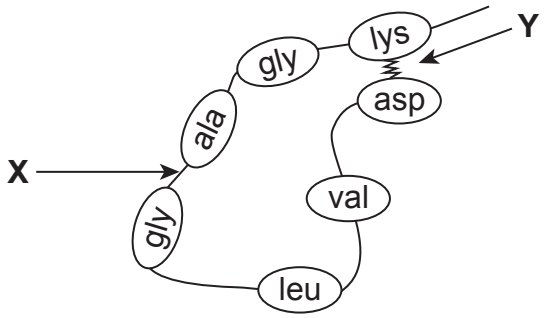
A an acid.

B an aldehyde.

C an ester

D a ketone

8 The following diagram shows a section of a protein chain. The three-letter words represent the names of amino acids.



Different types of bonds are formed at X and Y.

Which one of the following represents the bonds X and Y?

	X	Y
A	hydrogen bond	hydrogen bond
B	hydrogen bond	ionic bond
C	peptide bond	hydrogen bond
D	peptide bond	ionic bond

9 A sample of DDT, $C_{14}H_9Cl_5$ was found to contain 0.120 g of carbon. Which one of the following was the mass of chlorine in the sample?

A 0.127 g

B 0.335 g

C 0.994 g

D 1.01 g

10 Which one of the following industrial processes is catalysed by a metal compound?

A hydrogenation of alkenes

B manufacture of sulfuric acid

C oxidation of ammonia

D reaction of nitrogen with hydrogen

Section B

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

11 Complete the table below to give the colours of the metal ions.

metal ion	colour of aqueous complex
$Cu^{2+}(aq)$	
$Cr^{3+}(aq)$	
$Co^{2+}(aq)$	
$Fe^{3+}(aq)$	

[3]

Examiner Only

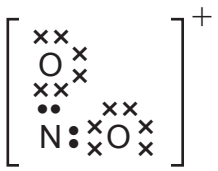
Marks	Remark

Examiner Only	
Marks	Remark

12 Benzene and its derivatives are nitrated by the nitronium ion which is formed when nitric acid reacts with sulfuric acid.

$$HNO_3 + 2H_2SO_4 \rightarrow NO_2^+ + 2HSO_4^- + H_3O^+$$

The nitronium ion has the following electron structure:



(a) (i) How does this structure explain the positive charge on the nitronium ion?

_____

_____ [1]

(ii) Explain whether the nitronium ion is an electrophile or a nucleophile.

_____

_____ [2]

(iii) Draw a flow scheme to show the mechanism for the reaction of benzene with the nitronium ion to form nitrobenzene.

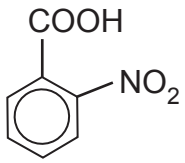
[3]

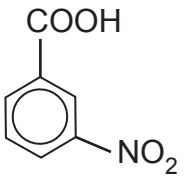
(iv) Explain whether this mechanism is addition or substitution.

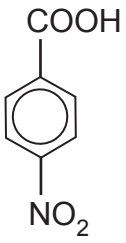
_____

_____ [2]

(b) Benzoic acid is nitrated to produce three products which are shown below together with their melting points and their former names.







ortho-nitrobenzoic acid	*meta*-nitrobenzoic acid	*para*-nitrobenzoic acid
145 °C	174 °C	186 °C

(i) Suggest the systematic names for *ortho*, *meta* and *para* nitrobenzoic acids.

ortho nitrobenzoic acid _____

meta nitrobenzoic acid _____

para nitrobenzoic acid _____ [2]

(ii) Suggest, using hydrogen bonding, why the melting points of these nitrobenzoic acids increase as the nitro group is further away from the carboxylic acid group.

_____

_____

_____ [2]

(iii) Each of these nitrobenzoic acids can be reduced to amino compounds. Name the reagent used and explain how the amines can be liberated from the reaction mixture.

_____

_____

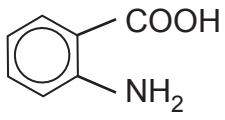
_____ [2]

Examiner Only

Marks	Remark

Examiner Only	
Marks	Remark

(c) The best known aminobenzoic acid is anthranilic acid.



(i) When distilled it is decarboxylated to form phenylamine. Suggest what is meant by the term **decarboxylated** and write an equation for the reaction.

[3]

(ii) Anthranilic acid could be described as an amino acid but it is not part of any protein. Suggest an explanation for this contradictory statement.

[2]

(iii) Anthranilic acid is diazotised to form a diazonium ion. State the condition necessary for this reaction.

[1]

(iv) Suggest the structure of the product when the diazotised anthranilic acid is coupled with phenol.

[2]

(v) Explain why it is not possible to couple diazotised butylamine with phenol.

Examiner Only

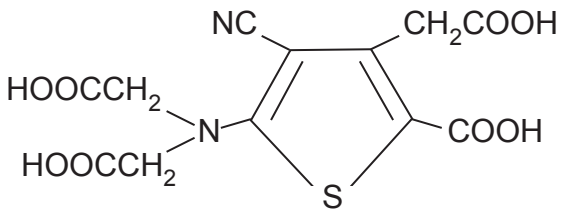
Marks	Remark

_____

_____ [2]

Examiner Only	
Marks	Remark

13 The monostrontium salt of ranelic acid has recently been hailed as the wonder drug which can slow the progress of osteoarthritis, the wear and tear disease that destroys joints, and thus save on costly hip and knee replacements. Strontium ions increase bone density and are currently used to treat osteoporosis.
Ranelic acid is similar in some respects to ethylenediaminetetraacetic acid (edta).



ranelic acid

(a) Both ranelic acid and edta are polydentate ligands.

(i) Explain what is meant by the term **ligand**.

_____

_____ [2]

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

_____

_____ [2]

(iii) Draw a diagram to show the outer electron structure of the nitrile group and use it to suggest why it can or cannot act as a ligand.

_____

_____ [3]

(b) Write the formula of the monostrontium salt of ranelic acid showing the ions present.

[2]

(c) Both edta and ranelic acid form complexes with the ions of Group II metals such as calcium and strontium. Suggest whether edta might be expected to displace ranelic acid from its complex with strontium ions.

[2]

(d) (i) Describe the titration of a standard solution of edta with a solution of magnesium ions, giving experimental details and explaining the colour change.

[5]

Quality of written communication [2]

Examiner Only

Marks	Remark

(ii) A saturated solution of magnesium hydroxide was prepared by dissolving the solid in 1 dm^3 of water and then filtering the solution produced. A 25.0 cm^3 sample was titrated with 0.01 mol dm^{-3} edta solution and a titre of 15.6 cm^3 was required. Calculate the concentration of the magnesium hydroxide solution in mg dm^{-3}.

[4]

(e) Edta is used in treating blood and water. Explain, in each case, what the role of edta is.

(i) The role of edta in treating blood.

[2]

(ii) The role of edta in treating water.

[2]

Examiner Only	
Marks	Remark

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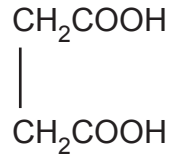
(Questions continue overleaf)

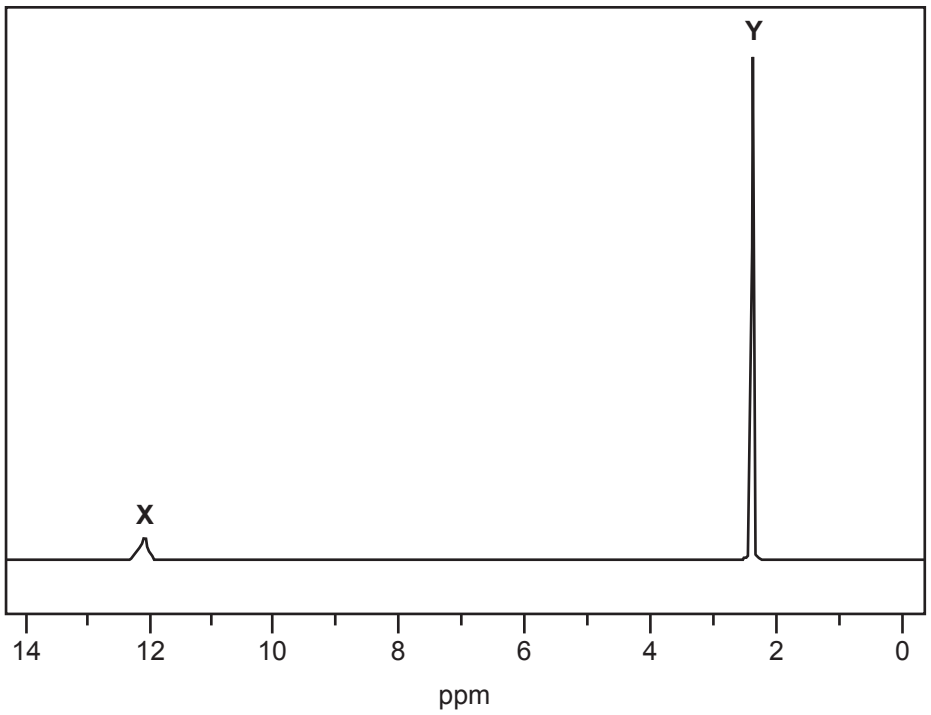
14 Succinic acid is a dicarboxylic acid and was named after the Latin word for amber from which it was first obtained by distillation (Lat: succinum).



succinic acid

It is a crystalline solid with a melting point of 185 °C and is moderately soluble in water and ethanol.

(a) The high resolution nmr spectrum of succinic acid is shown below.



(i) Explain why the CH_2 groups do not interact with each other.

_____

_____ [1]

(ii) Identify which hydrogen atoms give rise to the peaks at X and Y.

X _____ [1]

Y _____ [1]

Examiner Only

Marks	Remark

(iii) Explain why peak X is at a greater chemical shift than Y.

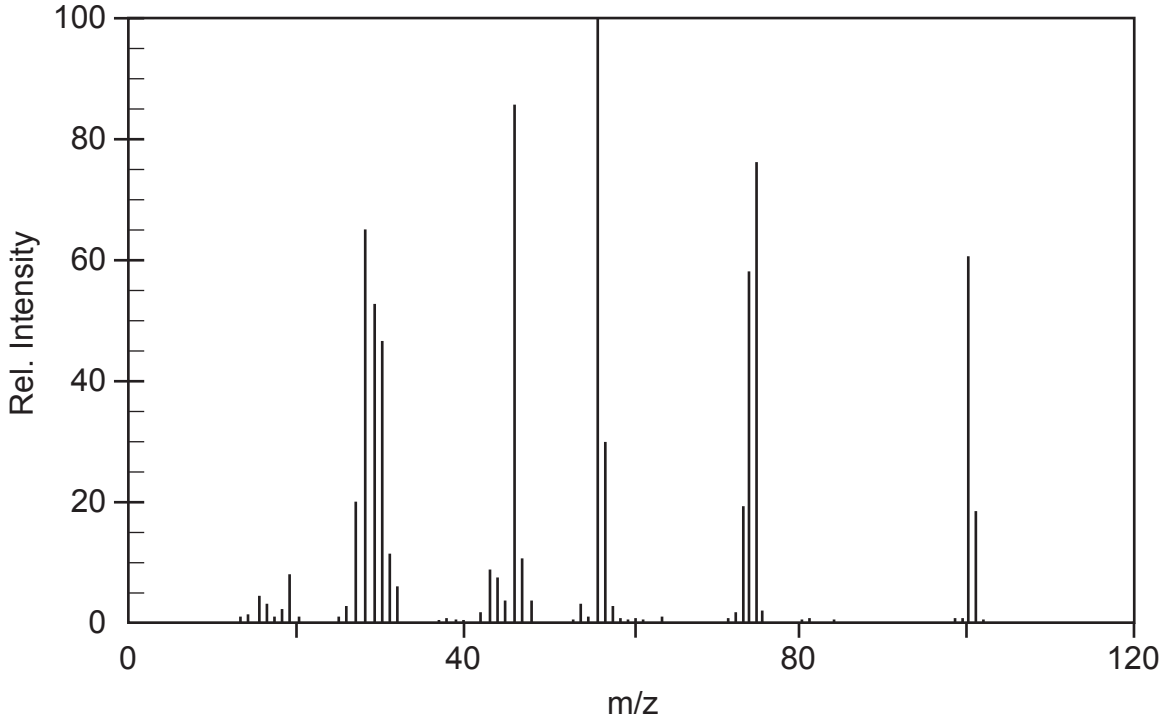
_____

_____ [2]

(iv) Draw the integration curve on the spectrum. [2]

(v) The TMS signal is missing from the spectrum. Draw the TMS signal on the spectrum. [1]

(b) The mass spectrum of succinic acid is shown below.



(i) Explain the meaning of the term **base peak**.

_____

_____ [1]

(ii) Identify the base peak.

_____ [1]

(iii) Suggest formulae for the following m/z values of the fragment ions

45 _____ [1]

100 _____ [1]

Examiner Only

Marks	Remark

Examiner Only	
Marks	Remark

(c) When heated with excess ethane-1,2-diol succinic acid forms polymers known as alkyd resins.

(i) Draw the structure of the polymer showing the repeating unit.

[3]

(ii) What is the name given to this type of polymerisation?

_____ [1]

(iii) Suggest why the polymer is acidic.

_____

_____ [1]

(iv) Explain why this polymer is biodegradable.

_____

_____ [2]

(d) Succinic acid reacts with excess ammonia to form the diammonium salt which, when heated, is dehydrated to form the diamide.

(i) Draw the flow scheme for the reactions above.

[2]

(ii) Name the reagent used to convert an amide into a nitrile.

_____ [1]

(iii) Draw the structure of the product formed when the dinitrile is reacted with excess lithal.

[2]

(e) Succinic acid can be analysed by converting it to the diethyl ester and submitting the ester to GLC analysis.

(i) Why is it better to use the ester rather than the acid in GLC analysis?

_____

_____ [2]

(ii) Explain the results expected if the sample of the ester was 90% pure.

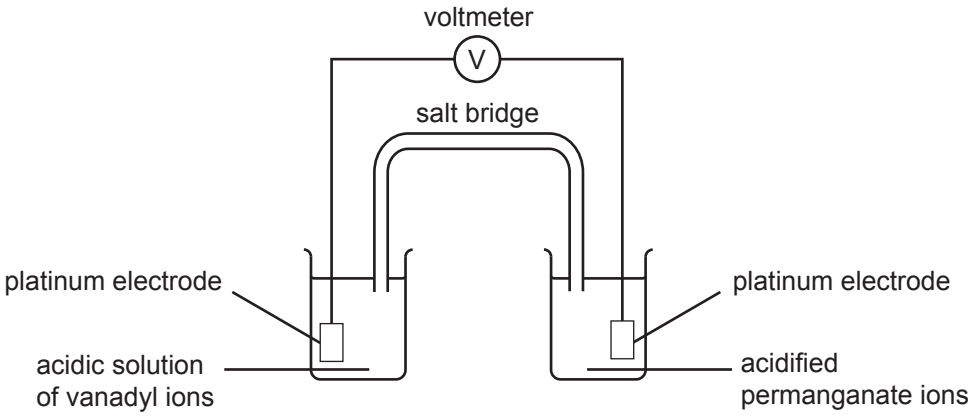
_____

_____ [2]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

15 The cell shown below was set up to investigate the reaction between an acidic solution of vanadyl ions, VO_2^+, with acidified permanganate ions.



The standard electrode potentials for the two systems are shown below:

$[VO_2^+(aq) + 2H^+(aq)], [VO^{2+}(aq) + H_2O(l)]$ Pt $+1.02$ V

$[MnO_4^-(aq) + 8H^+(aq)], [Mn^{2+}(aq) + 4H_2O(l)]$ Pt $+1.51$ V

(a) Explain in which direction the electrons flow in the external circuit.

_____

_____ [2]

(b) The reaction taking place is a redox reaction. Explain, by referring to oxidation numbers in the cell, what is meant by the term **redox**.

_____

_____ [2]

(c) Write the equations for the reactions taking place in the two half-cells and combine them to obtain the overall equation.

_____

_____

_____ [3]

(d) **(i)** Describe the colour change in the vanadyl half-cell.

_____ [2]

(ii) Describe the colour change in the permanganate half-cell.

_____ [2]

(e) Calculate the reading that will be observed on the voltmeter.

_____

_____ [2]

(f) Explain the purpose of the salt bridge and how it works.

_____

_____ [2]

(g) The electrode potentials of the half-cells are measured using a hydrogen electrode. Describe a hydrogen electrode and state the conditions under which it operates.

_____

_____

_____

_____

_____ [4]

Examiner Only	
Marks	Remark

THIS IS THE END OF THE QUESTION PAPER

113075