edexcel

INTERNATIONAL ADVANCED LEVEL

CHEMISTRY

SAMPLE ASSESSMENT MATERIALS

Pearson Edexcel International Advanced Subsidiary in Chemistry (XCH11)
Pearson Edexcel International Advanced Level in Chemistry (YCH11)
First teaching September 2018
First examination from January 2019
First certification from August 2019 (International Advanced Subsidiary)
and August 2020 (International Advanced Level)

Pearson

Edexcel, BTEC and LCCI qualifications

Edexcel, BTEC and LCCI qualifications are awarded by Pearson, the UK's largest awarding body offering academic and vocational qualifications that are globally recognised and benchmarked. For further information, please visit our qualification website at qualifications.pearson.com. Alternatively, you can get in touch with us using the details on our contact us page at qualifications.pearson.com/contactus

About Pearson

Pearson is the world's leading learning company, with 35,000 employees in more than 70 countries working to help people of all ages to make measurable progress in their lives through learning. We put the learner at the centre of everything we do, because wherever learning flourishes, so do people. Find out more about how we can help you and your learners at qualifications.pearson.com

References to third party material made in this sample assessment materials are made in good faith. Pearson does not endorse, approve or accept responsibility for the content of materials, which may be subject to change, or any opinions expressed therein. (Material may include textbooks, journals, magazines and other publications and websites.)

All information in this document is correct at time of publication.

ISBN 978 1 4469 4657 2

Contents

Introduction

The Pearson Edexcel International Advanced Subsidiary in Chemistry and the Pearson Edexcel International Advanced Level in Chemistry are part of a suite of International Advanced Level qualifications offered by Pearson.

These sample assessment materials have been developed to support these qualifications and will be used as the benchmark to develop the assessment students will take.

General marking guidance

- All candidates must receive the same treatment. Examiners must mark the last candidate in exactly the same way as they mark the first.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than be penalised for omissions.
- Examiners should mark according to the mark scheme – not according to their perception of where the grade boundaries may lie.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification/indicative content will not be exhaustive. However different examples of responses will be provided at standardisation.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, a senior examiner must be consulted before a mark is given.
- Crossed-out work should be marked **unless** the candidate has replaced it with an alternative response.

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:

- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.

( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.

Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.

ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Write your name here

Surname	Other names

Pearson Edexcel
International Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

International Advanced Subsidiary/Advanced Level
Unit 1: Structure, Bonding and Introduction to Organic Chemistry

Sample Assessment Materials for first teaching September 2018

Time: 1 hour 30 minutes

Paper Reference
WCH11/01

You must have:
Scientific calculator, ruler

Total Marks

Instructions

- Use **black** ink or **black** ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*
- **Show all your working in calculations and include units where appropriate.**

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- There is a Periodic Table on the back page of this paper.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

S58309A

1/1/1/1/

S 5 8 3 0 9 A 0 1 2 4

Pearson

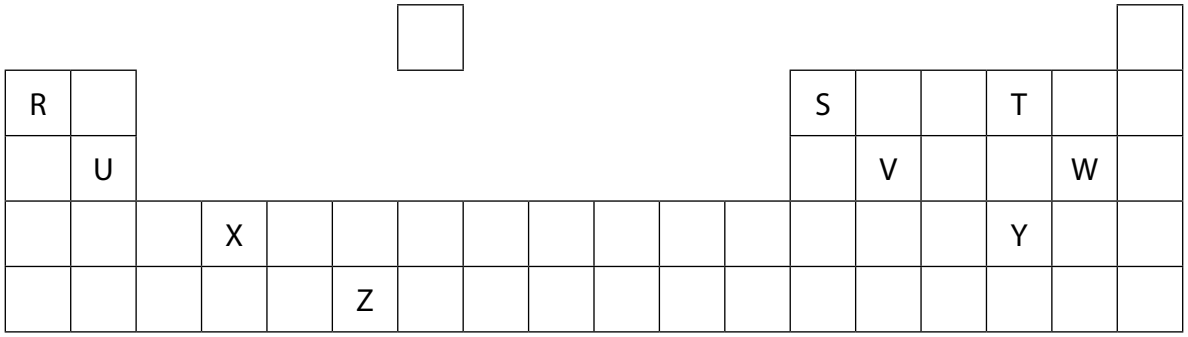
SECTION A

Answer ALL the questions in this section.

You should aim to spend no more than 20 minutes on this section.

For each question, select one answer from A to D and put a cross in the box ☒.
If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 An outline of part of the Periodic Table is shown.
The letters are not the usual symbols of the elements.



(a) Which elements are in the s-block of the Periodic Table?

(1)

☒ **A** R and U

☒ **B** T and Y

☒ **C** V and W

☒ **D** X and Z

(b) Which element has four occupied quantum shells, with six electrons in the outermost shell?

(1)

☒ **A** V

☒ **B** X

☒ **C** Y

☒ **D** Z

(c) In which pair do the ions have the same electronic configuration?

(1)

☒ **A** R^+ and T^{2-}

☒ **B** T^{2-} and Y^{2-}

☒ **C** U^{2+} and T^{2-}

☒ **D** U^{2+} and W^-

(Total for Question 1 = 3 marks)

2 This question is about phosphorus and sulfur.

Which species contains 15 protons, 16 neutrons and 18 electrons?

☒ **A** P^{3-}

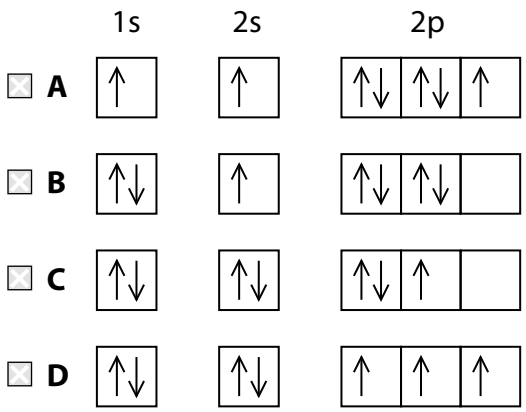
☒ **B** P^{3+}

☒ **C** S^{2-}

☒ **D** S^{2+}

(Total for Question 2 = 1 mark)

3 Which is the electronic configuration of nitrogen?



(Total for Question 3 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

4 A sample of neon contains the following isotopes.

Isotope	Percentage abundance
^{20}Ne	90.92
^{21}Ne	0.26
^{22}Ne	8.82

What is the relative atomic mass of neon to two decimal places?

☒ **A** 20.00

☒ **B** 20.09

☒ **C** 20.18

☒ **D** 21.00

(Total for Question 4 = 1 mark)

5 Data from the mass spectrum of a sample of pure iron is given in the table.

m / *z*	Relative peak height
28	0.1
54	6.3
56	100.0
57	2.4
58	0.3

Which species is most likely to cause the peak at $m/z = 28$?

☒ **A** $^{28}Fe^{+}$

☒ **B** $^{56}Fe^{2+}$

☒ **C** $^{28}Si^{+}$

☒ **D** $^{84}Sr^{3+}$

(Total for Question 5 = 1 mark)

6 Which of these is not a chemical reaction?

☒ **A** cracking

☒ **B** fractional distillation

☒ **C** polymerisation

☒ **D** reforming

(Total for Question 6 = 1 mark)

7 Which of these fuels is obtained from fermented sugar cane?

☒ **A** ethanol

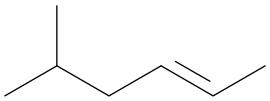
☒ **B** hydrogen

☒ **C** petrol

☒ **D** propane

(Total for Question 7 = 1 mark)

8 What is the systematic name for this compound?



☒ **A** *E*-5-methylhex-2-ene

☒ **B** *Z*-5-methylhex-2-ene

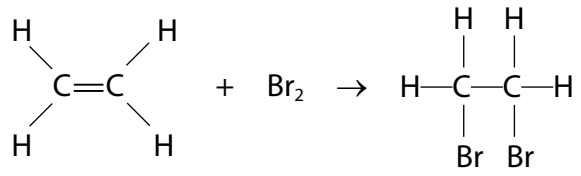
☒ **C** *E*-2-methylpent-4-ene

☒ **D** *Z*-2-methylpent-4-ene

(Total for Question 8 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

9 Ethene reacts with bromine to form 1,2-dibromoethane.



For the ethene molecule, what is the type of bond broken and the type of bond fission occurring in this reaction?

	Bond broken	Bond fission
☒ **A**	π	heterolytic
☒ **B**	π	homolytic
☒ **C**	σ	heterolytic
☒ **D**	σ	homolytic

(Total for Question 9 = 1 mark)

10 There is 0.045 g of solute in 1500 g of a solution.

What is the concentration of the solution in parts per million (ppm)?

☒ **A** 3.00

☒ **B** 6.75

☒ **C** 30.0

☒ **D** 67.5

(Total for Question 10 = 1 mark)

11 What is the concentration, in mol dm^{-3}, of a solution containing 7.84 g of phosphoric(V) acid, H_3PO_4, in 400 cm^3 of solution?

☒ **A** 0.02

☒ **B** 0.08

☒ **C** 0.20

☒ **D** 19.6

(Total for Question 11 = 1 mark)

12 A sample of a hydrocarbon with mass 7.2 g contained 6.0 g of carbon.

What is the empirical formula of the hydrocarbon?

☒ **A** CH_2

☒ **B** C_5H_{12}

☒ **C** C_6H_6

☒ **D** C_7H_6

(Total for Question 12 = 1 mark)

13 Which pair of substances contains the same number of moles at room temperature and pressure (r.t.p.)?

[A_r values Ca = 40, Li = 7, Al = 27, Mg = 24. Molar volume of gas at r.t.p. = 24 $dm^3\ mol^{-1}$]

☒ **A** 24 dm^3 of chlorine, Cl_2, and 20 g of calcium, Ca

☒ **B** 24 dm^3 of oxygen, O_2, and 14 g of lithium, Li

☒ **C** 1.2 dm^3 of hydrogen, H_2, and 2.7 g of aluminium, Al

☒ **D** 1.2 dm^3 of nitrogen, N_2, and 1.2 g of magnesium, Mg

(Total for Question 13 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

14 What are the maximum numbers of electrons in a 2p orbital and in the third quantum shell?

	Maximum number of electrons in a 2p orbital	Maximum number of electrons in the third quantum shell
☒ **A**	2	8
☒ **B**	2	18
☒ **C**	6	8
☒ **D**	6	18

(Total for Question 14 = 1 mark)

15 Water reacts with H^+ ions to form H_3O^+ ions.

Identify the bonding **within** the H_3O^+ ion.

☒ **A** covalent bonding only

☒ **B** covalent and dative covalent bonding only

☒ **C** covalent, dative covalent and ionic bonding

☒ **D** ionic bonding only

(Total for Question 15 = 1 mark)

16 What are the shapes of the $AlCl_3$ and PH_3 molecules?

	Shape of $AlCl_3$ molecule	Shape of PH_3 molecule
☒ **A**	pyramidal	pyramidal
☒ **B**	pyramidal	trigonal planar
☒ **C**	trigonal planar	trigonal planar
☒ **D**	trigonal planar	pyramidal

(Total for Question 16 = 1 mark)

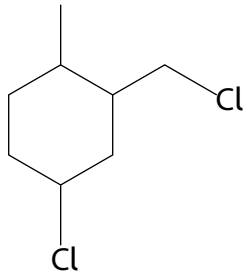
Use this space for any rough working. Anything you write in this space will gain no credit.

17 Which describes the polarity of the C—Cl bond and the polarity of the CCl_4 molecule?

	Polarity of C—Cl bond	Polarity of CCl_4 molecule
☒ **A**	non-polar	non-polar
☒ **B**	non-polar	polar
☒ **C**	polar	polar
☒ **D**	polar	non-polar

(Total for Question 17 = 1 mark)

18 What is the empirical formula of the following molecule?



☒ **A** C_4H_4Cl

☒ **B** C_4H_7Cl

☒ **C** $C_8H_{11}Cl_2$

☒ **D** $C_8H_{14}Cl_2$

(Total for Question 18 = 1 mark)

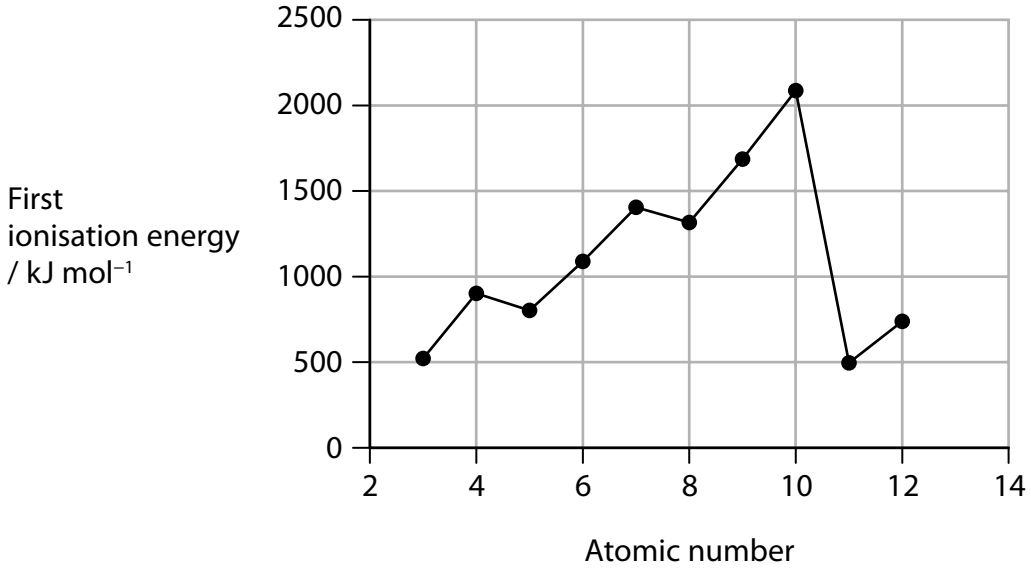
TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions.

Write your answers in the spaces provided.

19 The graph shows the first ionisation energies for the elements with atomic numbers from 3 to 12.



(a) Write the equation for the first ionisation energy of nitrogen. Include state symbols.

(2)

(b) Explain the changes in first ionisation energy for the elements with atomic numbers from 3 to 10.

(4)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(c) Explain why the first ionisation energy of element 11 is lower than that of element 3.

(2)

.....

.....

.....

.....

(Total for Question 19 = 8 marks)

20 This question is about bromine.

(a) Complete the electronic configuration for a bromine atom, using the s, p, d notation.

(1)

[Ar].....

(b) Bromine exists as two isotopes with mass numbers 79 and 81.

(i) Complete the table to show the numbers of subatomic particles in a ^{79}Br atom and a $^{81}Br^-$ ion.

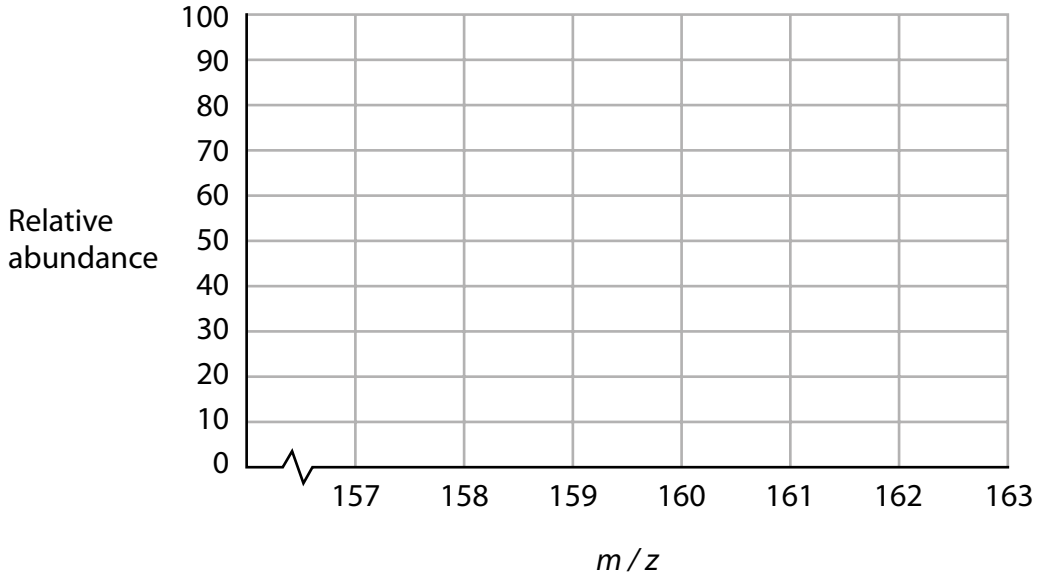
(2)

Species	Protons	Neutrons	Electrons
^{79}Br			
$^{81}Br^-$			

(ii) A sample of bromine contained equal amounts of the two isotopes.

Complete the mass spectrum to show the peaks you would expect for Br_2^+ from this sample of bromine gas.

(2)



(iii) Calculate the number of bromine molecules in 2.00 g of Br_2.

[Avogadro constant = 6.02×10^{23} mol^{-1}]

(2)

Number of molecules = ...

(c) A sample of bromine gas occupied 200 cm^3 at a temperature of 77 °C and a pressure of 1.51×10^5 Pa.

Calculate, using the ideal gas equation, the amount in moles of bromine molecules in this sample.

[$pV = nRT$ $R = 8.31$ J mol^{-1} K^{-1}]

(4)

Amount of bromine molecules = ... mol

(Total for Question 20 = 11 marks)

21 Magnesium is a metal in Group 2 of the Periodic Table. It reacts with chlorine to form the salt magnesium chloride, $MgCl_2$.

(a) Draw a dot-and-cross diagram for magnesium chloride.

Show outer shell electrons only.

(1)

(b) Magnesium conducts electricity when it is in the solid state. Magnesium chloride conducts electricity when it is molten or dissolved in water but not when it is in the solid state.

Explain these observations.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(c) Magnesium chloride can also be made by reacting magnesium oxide with dilute hydrochloric acid.

$$MgO(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l)$$

(i) Write the **ionic** equation, including state symbols, for this reaction.

(1)

(ii) Calculate the minimum volume of 2.00 mol dm^{-3} hydrochloric acid needed to completely react with 2.45 g of magnesium oxide.

(3)

Minimum volume of hydrochloric acid = ... cm^3

(d) A further method for making magnesium chloride is by reacting magnesium carbonate with dilute hydrochloric acid.

$$MgCO_3(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l) + CO_2(g)$$

Calculate the maximum mass of magnesium chloride that could be formed when 2.25 g of magnesium carbonate is added to excess dilute hydrochloric acid.

(2)

Maximum mass magnesium chloride = ... g

(e) Explain why the reaction to make magnesium chloride from magnesium oxide has a higher atom economy than the reaction using magnesium carbonate. No calculation is required.

(2)

.....

.....

.....

.....

(Total for Question 21 = 12 marks)

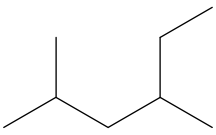
22 The alkanes are a homologous series of saturated hydrocarbons.

(a) Draw the displayed formulae of the three alkanes with molecular formula C_5H_{12}.

(3)

(b) Give the systematic name of compound **P**.

(1)



Compound **P**

Systematic name .....

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(c) The table shows the boiling temperatures of the first four straight-chain alkanes.

Molecular formula of alkane	Boiling temperature / °C
CH_4	−164
C_2H_6	−89
C_3H_8	−42
C_4H_{10}	−0.5

Predict the molecular formula and boiling temperature of the straight-chain alkane that has five carbon atoms in its molecules.

(2)

Molecular formula .....

Boiling temperature .....

(d) Alkanes undergo incomplete combustion when they burn in a limited supply of air.

(i) Write the equation for the incomplete combustion of propane, C_3H_8, to form carbon, carbon monoxide, carbon dioxide and water.
State symbols are not required.

(1)

(ii) Explain the toxicity of carbon monoxide.

(2)

.....

.....

.....

.....

(e) Propane reacts with chlorine in the presence of ultraviolet radiation. The reaction starts when some chlorine molecules are split into free radicals. A mixture of products is formed.

(i) Write the two propagating steps to show how C_3H_7Cl is formed.
Curly arrows are not required.

(2)

(ii) Identify the different C_3H_7Cl molecules that are produced in this reaction.

(1)

.....

.....

(iii) Give a reason why a mixture of C_3H_7Cl molecules is formed.

(1)

.....

.....

(iv) Give a reason why some hexane is formed in this reaction.

(1)

.....

.....

(v) A small amount of a product with molar mass 113 g mol^{-1} is formed.

Deduce the structure and name of a possible product with this molar mass.

(2)

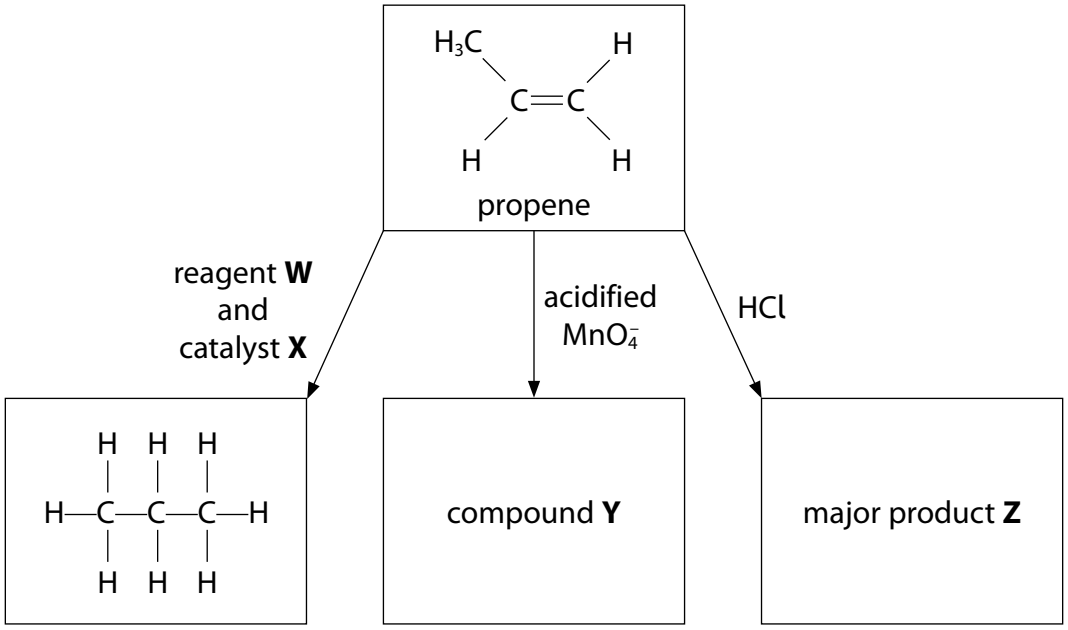
Structure .....

Name .....

(Total for Question 22 = 16 marks)

23 Alkenes contain a double bond between two carbon atoms.

(a) Some reactions of propene are shown.



(i) Give the names of reagent **W** and catalyst **X**.

(2)

Reagent **W** .....

Catalyst **X** .....

(ii) Draw the displayed formula of compound **Y**.

(1)

(iii) Draw the skeletal formula of the major product **Z**.

(1)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

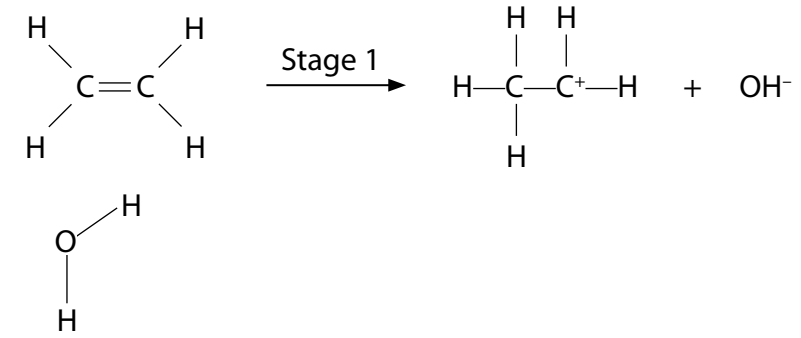
DO NOT WRITE IN THIS AREA

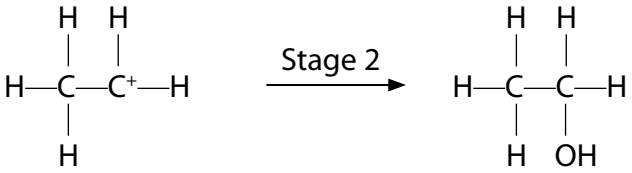
(b) Ethene reacts with steam in the presence of a catalyst to form ethanol.

The mechanism takes place in two stages.

(i) Complete the simplified mechanism for the reaction by adding curly arrows and the relevant dipole.

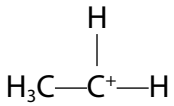
(4)





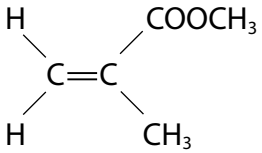
:OH⁻

(ii) Predict the shape of the intermediate ion with reference to the positively-charged carbon. Justify your answer.



(3)

(c) Methyl 2-methylpropenoate has the structure:



Draw a section of the polymer formed from methyl 2-methylpropenoate, showing two repeat units.

(2)

(Total for Question 23 = 13 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS

BLANK PAGE

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
							1.0 H hydrogen 1										(18) 4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series

Unit 1 - Mark scheme

Question number	Answer	Mark
1(a)	A R and U	1

Question number	Answer	Mark
1(b)	C Y	1

Question number	Answer	Mark
1(c)	C U^{2+} and T^{2-}	1

Question number	Answer	Mark
2	A P^{3-}	1

Question number	Answer	Mark
3	D 	1

Question number	Answer	Mark
4	C 20.18	1

Question number	Answer	Mark
5	B $^{56}Fe^{2+}$	1

Question number	Answer	Mark
6	B fractional distillation	1

Question number	Answer	Mark
7	A ethanol	1

Question number	Answer	Mark
8	A E-5-methylhex-2-ene	1

Question number	Answer	Mark
9	A π, heterolytic	1

Question number	Answer	Mark
10	C 30.0	1

Question number	Answer	Mark
11	C 0.20	1

Question number	Answer	Mark
12	B C_5H_{12}	1

Question number	Answer	Mark
13	D 1.2 dm^3 of nitrogen, N_2, and 1.2 g of magnesium, Mg	1

Question number	Answer	Mark
14	B 2 electrons in a 2p orbital, 18 electrons in the third quantum shell	1

Question number	Answer	Mark
15	B covalent and dative covalent bonding only	1

Question number	Answer	Mark
16	D $AlCl_3$ trigonal planar, PH_3 pyramidal	1

Question number	Answer	Mark
17	D C-Cl bond polar, CCl_4 molecule non-polar	1

Question number	Answer	Mark
18	B (C_4H_7Cl)	1

Question number	Answer	Additional guidance	Mark
19(a)	• correct species in equation (1) • correct state symbols (1)	Examples of equation: $N(g) \rightarrow N^{+}(g) + e^{(-)}$ or $N(g) - e^{(-)} \rightarrow N^{+}(g)$	2

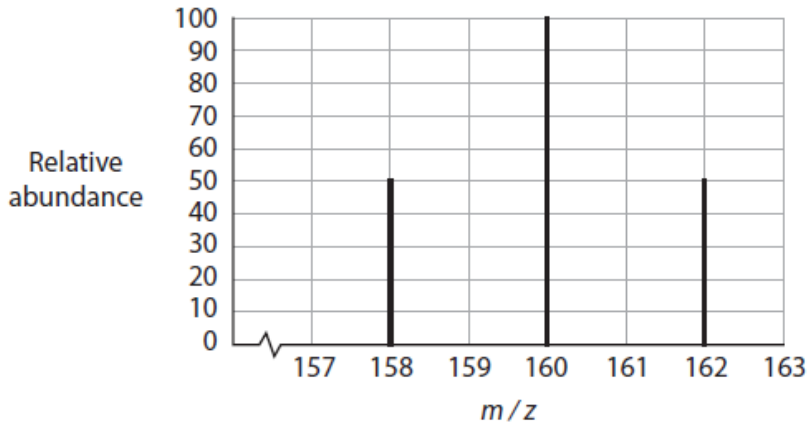
Question number	Answer	Additional guidance	Mark
19(b)	An explanation that makes reference to the following points: • general increase across a period/atomic numbers 3-10 due to increase in nuclear charge (1) • the (outer) electrons are added to the same quantum shell or the shielding is the same. (1) Irregularities: • atom with atomic number 5 has lower IE than atom with atomic number 4 as the (2)p electron is better shielded than the (2)s electron (so requires less energy to be removed) (1) • atom with atomic number 8 has lower IE than atom with atomic number 7 as there is repulsion between the pair of electrons in the 2(p) orbital (so less energy is required to remove one of them). (1)	Allow increase in effective nuclear charge Accept reverse arguments Accept names for atomic numbers Allow the 2p sub-shell is further from the nucleus than the 2s orbital Allow a half-filled p sub shell is more stable	4

Question number	Answer	Additional guidance	Mark
19(c)	An explanation that makes reference to the following points: • (decrease down a group due to) (there is an increase in nuclear charge from 3 to 11 but this is offset by) the outer electron is in a higher quantum shell/higher energy level (1) • therefore further from the nucleus/better shielded. (1)		2

Question number	Answer	Additional guidance	Mark
20(a)	• $[Ar]3d^{10}4s^{2}4p^{5}$	Allow $4s^{2}3d^{10}4p^{5}$ Ignore $1s^{2}2s^{2}2p^{6}3s^{2}3p^{6}$ for (Ar) written out but do not allow incorrect electronic configuration for Ar	1

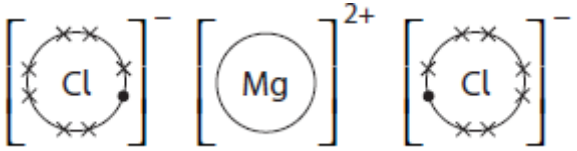
Question number	Answer	Additional guidance	Mark
20(b)(i)		1 mark for each row correct	2

Species	Protons	Neutrons	Electrons	
^{79}Br	35	44	35	(1)
$^{81}Br^{-}$	35	46	36	(1)

Question number	Answer	Additional guidance	Mark
20(b)(ii)	 • lines at 158 and 160 and 162 (1) • relative abundances 50:100:50 (1)	Allow relative abundances in any ratio 1:2:1, e.g. 25:50:25	2

Question number	Answer	Additional guidance	Mark
20(b)(iii)	• calculation of amount (mol) of Br_2 (1) • calculation of molecules of Br_2 (1)	Example of calculation: Amount of Br_2 = $\frac{2.00}{160}$ = 0.0125 (mol) Molecules of Br_2 = $0.0125 \times 6.02 \times 10^{23}$ = 7.525×10^{21} or Amount of Br_2 = $\frac{2.00}{(2 \times 79.9)}$ = 0.012516 (mol) Molecules of Br_2 = $0.012516 \times 6.02 \times 10^{23}$ = 7.5344×10^{21} TE on amount Br_2 Correct answer with no working scores both marks Ignore SF except 1 SF	**2**

Question number	Answer	Additional guidance	Mark
20(c)	• conversion of volume to m^3 (1) • conversion of temperature to K (1) • rearrangement of expression (1) • evaluation to give n (1)	Example of calculation: Volume of bromine = $\frac{200}{1 \times 10^6}$ = 2.00×10^{-4} m^3 77+273 = 350 $1.51 \times 10^5 \times 2.00 \times 10^{-4} = n \times 8.31 \times 350$ TE on volume bromine $n = \frac{1.51 \times 10^5 \times 2.00 \times 10^{-4}}{8.31 \times 350}$ $n = 1.03834 \times 10^{-2}$ Ignore SF except 1SF Correct answer with no working scores full marks	4

Question number	Answer	Additional guidance	Mark
21(a)	• dot-and-cross diagram, including charges	Example of diagram:  Allow no electrons or 8 electrons on outer shell of Mg Allow any combination of dots or crosses for electrons Ignore missing square brackets	1

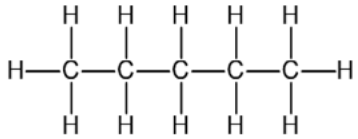
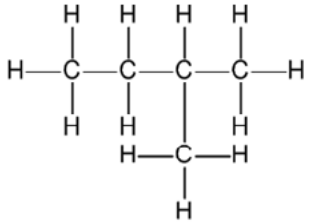
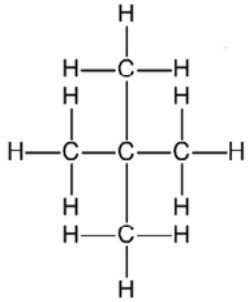
Question number	Answer		Additional guidance	Mark
21(b)	An explanation that makes reference to the following points: • identification of charge carriers: magnesium – electrons **and** magnesium chloride – ions • magnesium conducts electricity when solid because delocalised electrons can flow through • magnesium chloride does not conduct when solid because the ions cannot move **and** it does conduct electricity when molten or dissolved in water as the ions can move.	(1) (1) (1)		3

Question number	Answer	Additional guidance	Mark
21(c)(i)	• correct balanced ionic equation with state symbols	Examples of equation: $MgO(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2O(l)$ or $MgO(s) + 2H_3O^+(aq) \rightarrow Mg^{2+}(aq) + 2H_2O(l)$	1

Question number	Answer	Additional guidance	Mark
21(c)(ii)	• calculation of moles of MgO (1) • calculation of moles of HCl (1) • calculation of volume of HCl (1)	Example of calculation: moles MgO = $\frac{2.45}{40.3}$ = 0.060794 moles HCl = 2 × 0.060794 = 0.121588 volume HCl = 0.121588 × $\frac{1000}{2.00}$ = 60.794 cm^3 Ignore SF except 1 SF Allow use of A_r(Mg) = 24 (61.25 cm^3) Correct answer with no working scores full marks	3

Question number	Answer	Additional guidance	Mark
21(d)	Either • calculation of moles of $MgCO_3$ (1) • calculation of mass of $MgCl_2$ (1) or • use of both molar masses (1) • calculation of mass of $MgCl_2$ (1)	Example of calculation: moles $MgCO_3 = \frac{2.25}{84.3} = 0.02669$ mass $MgCl_2 = 0.02669 \times 95.3 = 2.5436$ (g) or 84.3 g $MgCO_3$ makes 95.3 g $MgCl_2$ so 2.25 g $MgCO_3$ makes $\frac{95.3}{84.3} \times 2.25 = 2.5436$ (g) $MgCl_2$ Ignore SF except 1 SF Allow use of A_r(Mg) = 24 (2.5446 g) Correct answer with no working scores full marks	2

Question number	Answer	Additional guidance	Mark
21(e)	An explanation that makes reference to the following points: • (in the reaction with magnesium oxide) there are fewer waste products/no carbon dioxide is released/water is the only waste product (1) • so the molar mass of all products is lower/the denominator of the equation for atom economy is lower (1) or • 1 mol of magnesium compound produces 1 mol of magnesium chloride (1) • but the M_r of magnesium carbonate is greater than the M_r of magnesium oxide/carbon dioxide is an additional waste product from magnesium carbonate. (1)	Ignore calculations Allow reverse arguments	**2**

Question number	Answer	Additional guidance	Mark
22(a)	•  (1) •  (1) •  (1)	Allow CH_3 in branches Allow 2 marks for 3 correct structural or skeletal formulae or any combination of these	3

Question number	Answer	Additional guidance	Mark
22(b)	• 2,4-dimethylhexane	Ignore punctuation errors	1

Question number	Answer	Additional guidance	Mark
22(c)	• molecular formula: C_5H_{12} (1) • boiling temperature 25 – 40 °C (1)	Allow any temperature or range within the given range	2

Question number	Answer	Additional guidance	Mark
22(d)(i)	• $C_3H_8 + 3½O_2 \rightarrow C + CO + CO_2 + 4H_2O$	Allow multiples Ignore state symbols, even if incorrect	1

Question number	Answer	Additional guidance	Mark
22(d)(ii)	An explanation that makes reference to the following points: • (carbon monoxide) reacts with haemoglobin (in the blood) (1) • preventing it from carrying oxygen (around the body). (1)	Allow forms carboxyhaemoglobin	2

Question number	Answer	Additional guidance	Mark
22(e)(i)	• $C_3H_8 + Cl\bullet \rightarrow C_3H_7\bullet + HCl$ (1) • $C_3H_7\bullet + Cl_2 \rightarrow C_3H_7Cl + Cl\bullet$ (1)	Allow equations in either order Penalise missing • once only	2

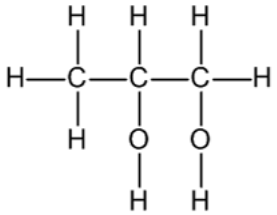
Question number	Answer	Additional guidance	Mark
22(e)(ii)	• the products are 1-chloropropane and 2-chloropropane	Allow any unambiguous formulae Ignore molecular formulae	1

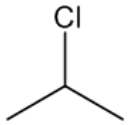
Question number	Answer	Additional guidance	Mark
22(e)(iii)	• the chlorine free radical can remove a hydrogen from either the end carbon atoms or the central carbon atom		1

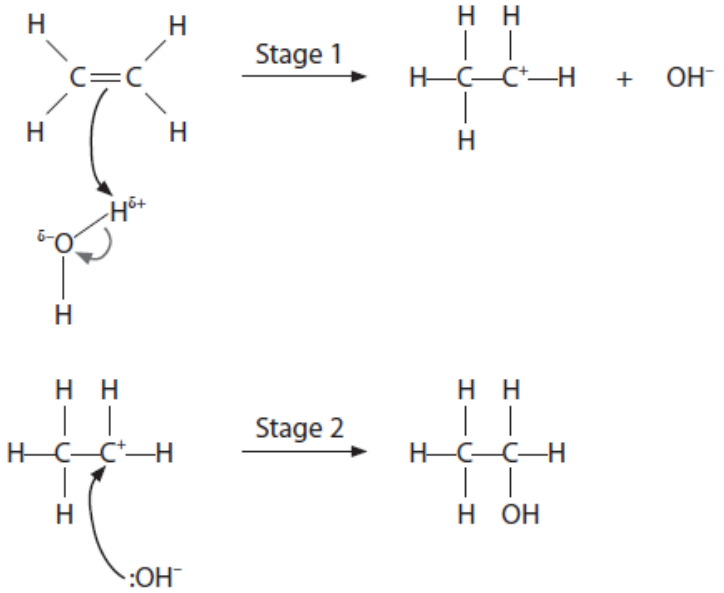
Question number	Answer	Additional guidance	Mark
22(e)(iv)	• two propyl (free) radicals react together or • $C_3H_7\bullet + C_3H_7\bullet \rightarrow C_6H_{14}$	Ignore just '(two free) radicals react together' Do not allow molecules/ions	1

Question number	Answer	Additional guidance	Mark
22(e)(v)	• structure (1) • corresponding name (1)	Examples of structures and names: $CH_3CH_2CHCl_2$ 1,1-dichloropropane $CH_3CHClCH_2Cl$ 1,2-dichloropropane $CH_3CCl_2CH_3$ 2,2-dichloropropane $CH_2ClCH_2CH_2Cl$ 1,3-dichloropropane Allow displayed, structural or skeletal formulae or any combination of these	2

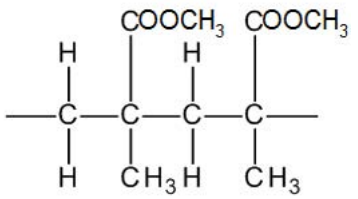
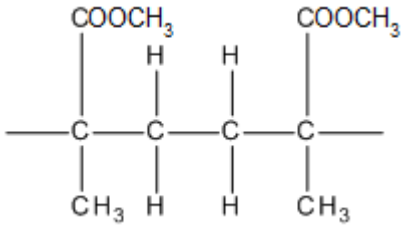
Question number	Answer	Additional guidance	Mark
23(a)(i)	• (reagent **W**) hydrogen/H_2 (1) • (catalyst X) nickel (1)	Allow nickel, Ni/platinum, Pt/palladium, Pd	2

Question number	Answer	Additional guidance	Mark
23(a)(ii)	• 	Allow OH Do not allow C-H-O	1

Question number	Answer	Additional guidance	Mark
23(a)(iii)	• 		1

Question number	Answer	Additional guidance	Mark
23(b)(i)	• correct dipole ($O^{\delta-} - H^{\delta+}$) (1) • curly arrow from C=C to H in H_2O (1) • curly arrow from O-H bond to O (1) • curly arrow from lone pair on O of OH^- to C^+ (1)	Example of mechanism: 	4

Question number	Answer	Additional guidance	Mark
23(b)(ii)	• trigonal planar (1) • 3 bond pairs/electron pairs (around the carbon atom) (1) • bond pairs/electron pairs arranged to minimise repulsion (1)	Allow M1 and M2 shown on a diagram Allow bond pairs/electron pairs as far apart as possible	3

Question number	Answer	Additional guidance	Mark
23(c)	• 4 carbon backbone with continuation bonds (1) • all side chains correct (1)	Example of polymer:  or  Allow CO_2CH_3 in side chains Allow CH_3 and $COOCH_3$ groups above or below the carbon chain Ignore square brackets and n Any structure with C=C scores 0	**2**

Write your name here

Surname	Other names

Pearson Edexcel
International Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

International Advanced Subsidiary/Advanced Level
Unit 2: Energetics, Group Chemistry, Halogenoalkanes and Alcohols

Sample Assessment Materials for first teaching September 2018

Time: 1 hour 30 minutes

Paper Reference **WCH12/01**

You must have:
Data Booklet, scientific calculator, ruler

Total Marks

Instructions

- Use **black** ink or **black** ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*
- **Show all your working in calculations and include units where appropriate**.

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- In questions marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate.
- There is a Periodic Table on the back page of this paper.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

S58310A

1/1/1/

S 5 8 3 1 0 A 0 1 2 6

Pearson

SECTION A

Answer ALL the questions in this section.

You should aim to spend no more than 20 minutes on this section.

For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Which alkane has the highest boiling temperature?

☒ **A** 2,2-dimethylpropane

☒ **B** 2-methylbutane

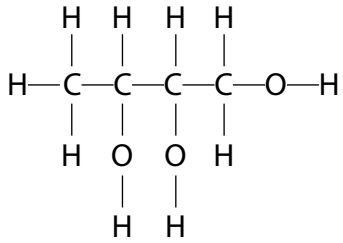
☒ **C** butane

☒ **D** pentane

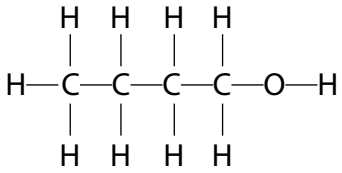
(Total for Question 1 = 1 mark)

2 Which is the order of **increasing** boiling temperature?

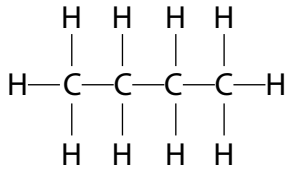
W =



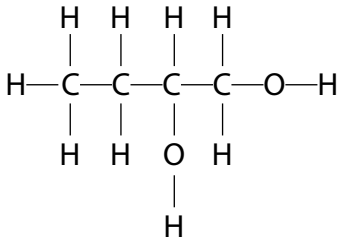
X =



Y =



Z =



☒ **A** Y Z X W

☒ **B** Y X Z W

☒ **C** W X Z Y

☒ **D** X W Y Z

(Total for Question 2 = 1 mark)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

3 Which statement is **not** explained by hydrogen bonding?

☒ **A** all Group 1 hydroxides are soluble in water

☒ **B** many simple alcohols are soluble in water

☒ **C** the density of ice is less than the density of liquid water at 0 °C

☒ **D** the melting temperature of water is abnormally high

(Total for Question 3 = 1 mark)

4 Which compound is hydrolysed most rapidly?

☒ **A** 1-chloropropane

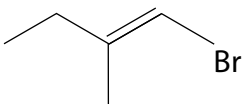
☒ **B** 1-chlorobutane

☒ **C** 2-chloro-2-methylpropane

☒ **D** 2-chlorobutane

(Total for Question 4 = 1 mark)

5 Give the systematic name for the following molecule.



☒ **A** *E*-1-bromo-2-methylbut-2-ene

☒ **B** *E*-2-methyl-1-bromobut-1-ene

☒ **C** *E*-1-bromo-3-methylpent-2-ene

☒ **D** *E*-1-bromo-2-methylbut-1-ene

(Total for Question 5 = 1 mark)

6 1-bromobutane reacts with alkali:

$CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_2Br + OH^- \rightarrow CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_2OH + Br^-$

The mechanism and type of reaction is:

☒ **A** electrophilic addition

☒ **B** electrophilic substitution

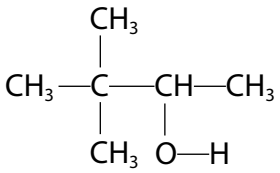
☒ **C** nucleophilic addition

☒ **D** nucleophilic substitution

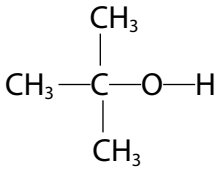
(Total for Question 6 = 1 mark)

7 Which of the following compounds could be oxidised to a carboxylic acid by refluxing with potassium dichromate(VI) and dilute sulfuric acid?

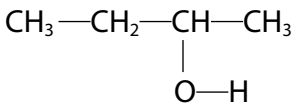
☒ **A**



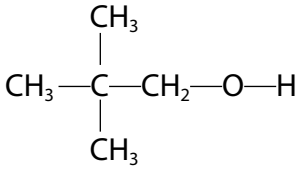
☒ **B**



☒ **C**



☒ **D**



(Total for Question 7 = 1 mark)

8 A student made the following statements about trends going **down** Group 2.
Which statement is correct?

☒ **A** the thermal stability of the nitrates decreases

☒ **B** the thermal stability of the carbonates decreases

☒ **C** the solubility of hydroxides increases

☒ **D** the solubility of sulfates increases

(Total for Question 8 = 1 mark)

9 A colourless solid, Q, was warmed with sodium hydroxide solution. A gas was evolved which turned damp red litmus paper blue. What is solid Q?

☒ **A** $NaNO_3$

☒ **B** NH_4Cl

☒ **C** NaCl

☒ **D** $Ca(NO_3)_2$

(Total for Question 9 = 1 mark)

10 Which test is used to show that sodium chloride solution contains chloride ions?

☒ **A** damp blue litmus paper turns red

☒ **B** damp blue litmus paper is bleached

☒ **C** dilute hydrochloric acid followed by silver nitrate solution gives a white precipitate

☒ **D** dilute nitric acid followed by silver nitrate solution gives a white precipitate

(Total for Question 10 = 1 mark)

11 Compound X gives a red flame test colour and a white precipitate on addition of dilute hydrochloric acid followed by barium chloride solution. Which compound is X?

☒ **A** calcium chloride

☒ **B** lithium sulfate

☒ **C** potassium sulfate

☒ **D** strontium chloride

(Total for Question 11 = 1 mark)

12 Which process explains the flame colour produced by the compounds of Group 1 elements?

☒ **A** absorption of visible light energy as electrons are promoted to higher energy levels

☒ **B** absorption of visible light energy as electrons are removed from gaseous atoms

☒ **C** emission of visible light energy as electrons return to lower energy levels

☒ **D** emission of visible light energy as electrons are added to gaseous ions

(Total for Question 12 = 1 mark)

13 When chlorine is reacted with hot concentrated potassium hydroxide, the chlorine undergoes disproportionation.

What are the oxidation states of chlorine in the products?

☒ **A** –1 and +3

☒ **B** –1 and +5

☒ **C** +1 and –1

☒ **D** +1 and +5

(Total for Question 13 = 1 mark)

14 What are the gaseous products formed, other than water vapour, when concentrated sulfuric acid is added to potassium bromide?

☒ **A** bromine and sulfur dioxide only

☒ **B** bromine, hydrogen bromide and hydrogen sulfide only

☒ **C** bromine, hydrogen bromide and sulfur dioxide only

☒ **D** bromine, hydrogen bromide, sulfur dioxide and hydrogen sulfide only

(Total for Question 14 = 1 mark)

15 Zinc metal reacts with copper(II) sulfate solution. The equation for the reaction is:

$$Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s) \qquad \Delta_r H = -210\,kJ\,mol^{-1}.$$

(a) What is the temperature rise, in °C, when excess zinc powder is added to 50 cm^3 of copper(II) sulfate solution containing 0.0025 mol of copper(II) ions?

[Assume the specific heat capacity of the solution is 4.2 $J\,g^{-1}\,°C^{-1}$].

(1)

☒ **A** 2.5

☒ **B** 10.5

☒ **C** 25.0

☒ **D** 44.1

(b) The reaction of zinc with copper(II) sulfate is best classified as:

(1)

☒ **A** disproportionation

☒ **B** neutralisation

☒ **C** redox

☒ **D** thermal decomposition

(Total for Question 15 = 2 marks)

16 Magnesium metal reacts with hydrochloric acid. Which change in condition would have no effect on the initial rate of this reaction?

☒ **A** an increase in the volume of acid solution

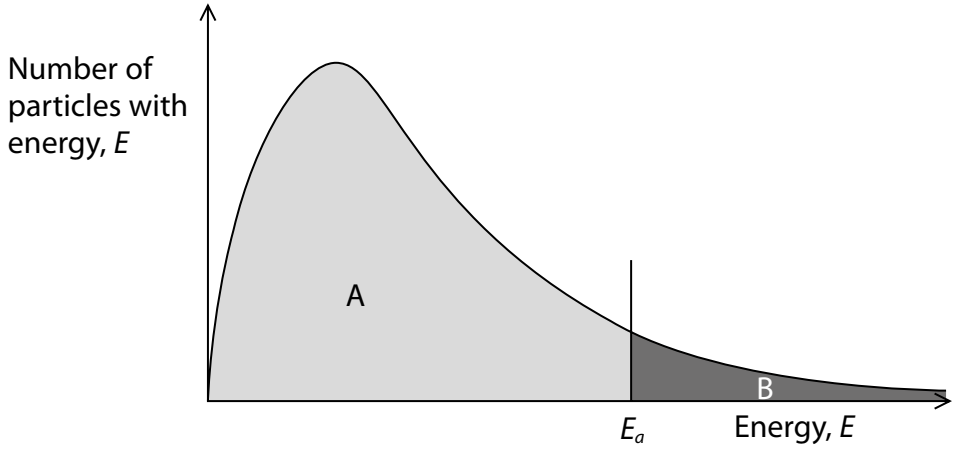
☒ **B** a decrease in the temperature of the acid solution

☒ **C** an increase in the surface area of the magnesium

☒ **D** a decrease in the concentration of the acid solution

(Total for Question 16 = 1 mark)

17 The diagram shows the general shape of a Maxwell-Boltzmann distribution curve for the particles present in a reaction mixture.



(a) How does the peak change when the temperature of the reaction mixture is decreased?

(1)

	Peak position	Peak height
☒ **A**	shifted left	higher
☒ **B**	shifted right	higher
☒ **C**	shifted left	lower
☒ **D**	shifted right	lower

(b) The activation energy of an uncatalysed reaction is represented by the vertical line, E_a, on the horizontal axis. The shaded areas A and B are the areas under the curve on either side of the line E_a.

How do the two shaded areas change, if at all, when a catalyst is added?

(1)

	Area A	Area B
☒ **A**	increases	decreases
☒ **B**	decreases	increases
☒ **C**	no change	no change
☒ **D**	increases	increases

(Total for Question 17 = 2 marks)

18 The equilibrium reaction shown in the equation was studied by placing the components into a sealed glass container.

$$2NO_2(g) \rightleftharpoons N_2O_4(g)$$

At equilibrium, which of the following statements is **not** true?

☒ **A** the concentrations of the $NO_2(g)$ and $N_2O_4(g)$ both remain constant

☒ **B** the total number of molecules is constant

☒ **C** the forward and reverse reactions have both stopped

☒ **D** the rate of the forward reaction is equal to the rate of the reverse reaction

(Total for Question 18 = 1 mark)

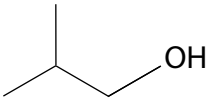
TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions.

Write your answers in the spaces provided.

19 2-methylpropan-1-ol has the skeletal formula:



(a) 2-methylpropan-1-ol can be converted to 1-bromo-2-methylpropane.

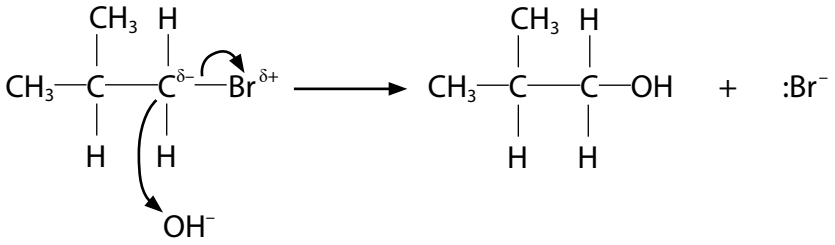
Give the reagents and conditions used for this reaction.

(2)

Reagents .....

Conditions .....

(b) 1-bromo-2-methylpropane can be converted back to 2-methylpropan-1-ol by heating with aqueous alkali. A student suggested the following mechanism for the reaction.



Identify and correct the three mistakes in the mechanism shown.

(3)

.....

.....

.....

.....

.....

.....

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(c) 1-bromo-2-methylpropane can be converted to 2-methylpropene.

Give the reagents and conditions used for this reaction.

(2)

Reagents .....

Conditions .....

(Total for Question 19 = 7 marks)

20 Ethanedioic acid is a solid diprotic acid. A student used ethanedioic acid in a titration to find the concentration of a potassium hydroxide solution.

The equation for the reaction is:

$$2KOH + (COOH)_2 \rightarrow (COOK)_2 + 2H_2O$$

(a) Calculate the mass of ethanedioic acid that should be used to make 1000 cm^3 of a 0.0500 mol dm^{-3} solution in water.

Give your answer to an appropriate number of significant figures.

[Molar mass of ethanedioic acid = 90.0 g mol^{-1}].

(2)

(b) A student decided to check to see if phenolphthalein was a suitable indicator for this titration. The student measured 400 cm^3 of the 0.0500 mol dm^{-3} ethanedioic acid into a beaker and added a few drops of phenolphthalein indicator.

Calculate the minimum mass of solid potassium hydroxide that should be added to produce a colour change.

(2)

*(c) A student used a 0.0500 mol dm^{-3} solution of ethanedioic acid to find an accurate concentration of a potassium hydroxide solution which was known to have an approximate concentration of 0.1 mol dm^{-3}.

Describe a procedure to obtain reliable titration results using standard laboratory equipment.

(6)

(Total for Question 20 = 10 marks)

21 Sodium hydrogencarbonate can be decomposed to sodium carbonate by heating to about 300 °C.

The equation for the reaction is:

$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(l)$$

(a) Give a reason why it is **not** possible to measure the enthalpy change for this reaction directly.

(1)

.....

.....

.....

(b) (i) State what is meant by the standard enthalpy change of formation.

(2)

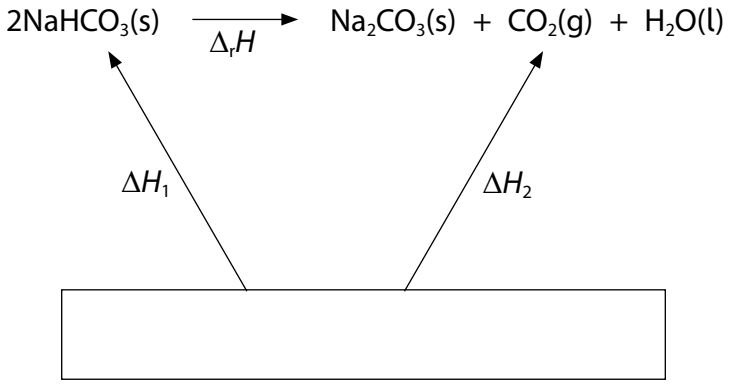
.....

.....

.....

(ii) Complete the Hess cycle that you would use to determine the enthalpy change for this reaction from the standard enthalpy changes of formation.

(2)



(iii) Calculate the standard enthalpy change for the thermal decomposition of sodium hydrogencarbonate, using the information in the table and your completed cycle. Include a sign and units in your answer.

(4)

Compound	Standard enthalpy change of formation, $\Delta_f H^{\ominus}$ / kJ mol^{-1}
$NaHCO_3(s)$	–950.8
$Na_2CO_3(s)$	–1130.7
$CO_2(g)$	–393.5
$H_2O(l)$	–285.8

(iv) Use your answer to (b)(iii) to draw an enthalpy level diagram for this reaction, labelling the axes provided.

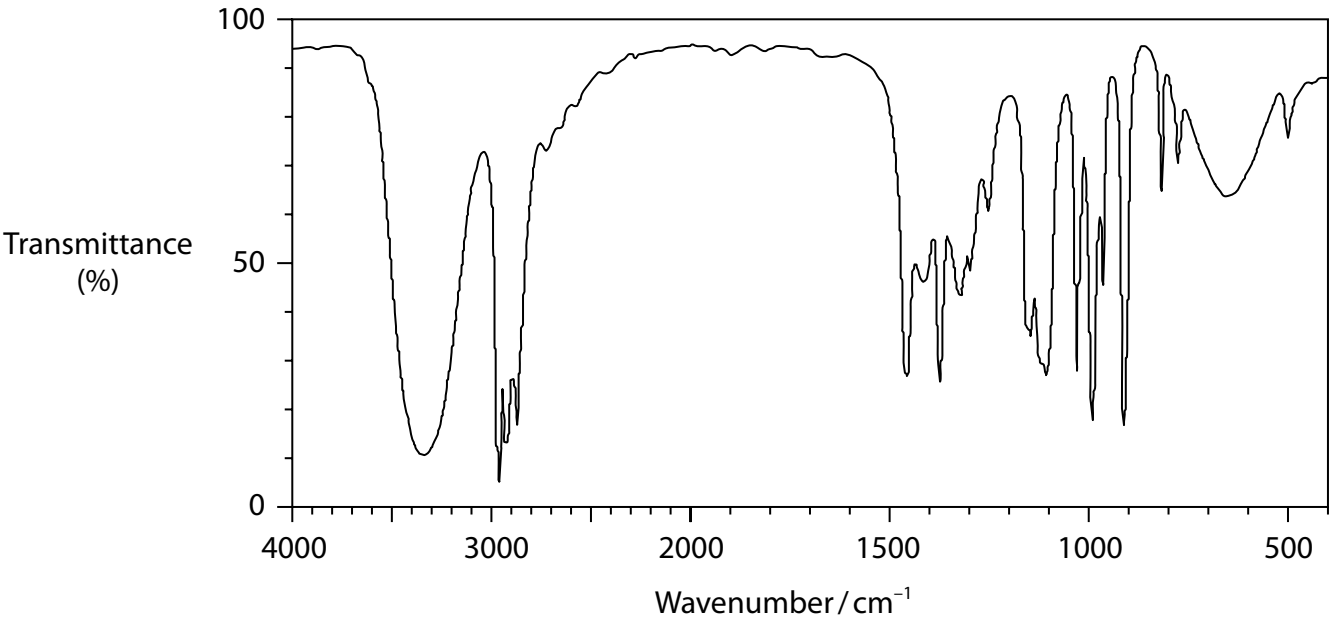
(2)

(Total for Question 21 = 11 marks)

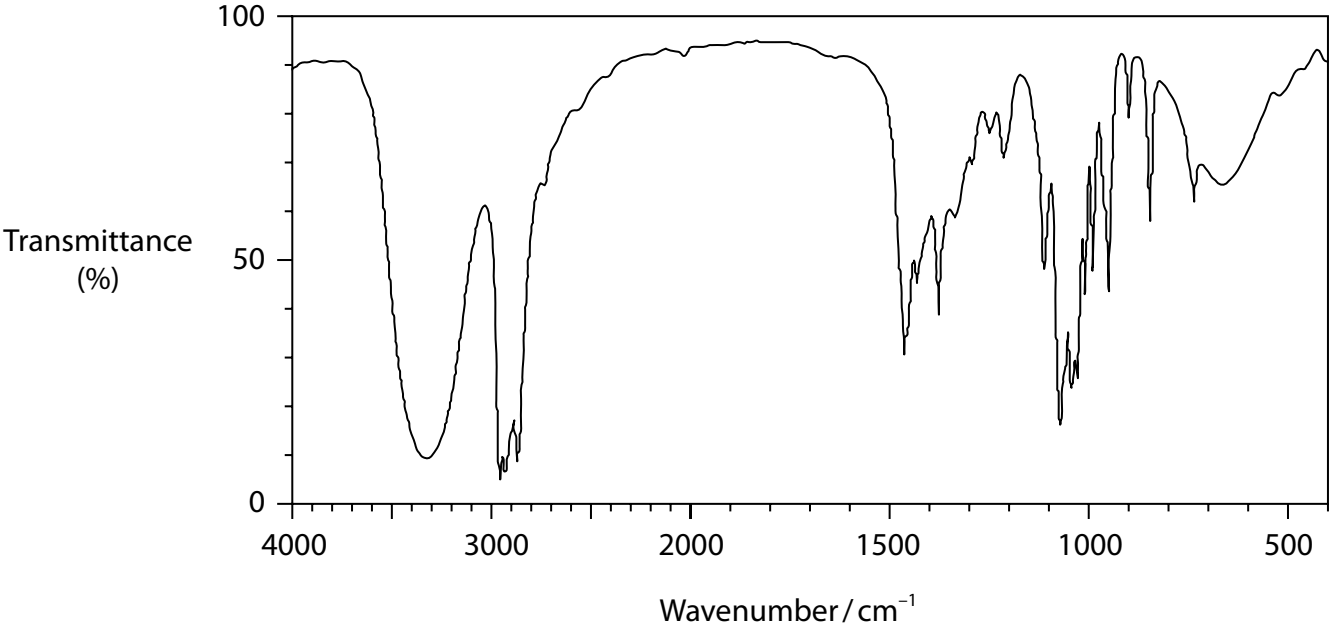
22 Three compounds, A, B and C, each have the same molecular formula $C_4H_{10}O$ and are known to be alcohols.

(a) The infrared spectra of compounds A, B and C are shown.

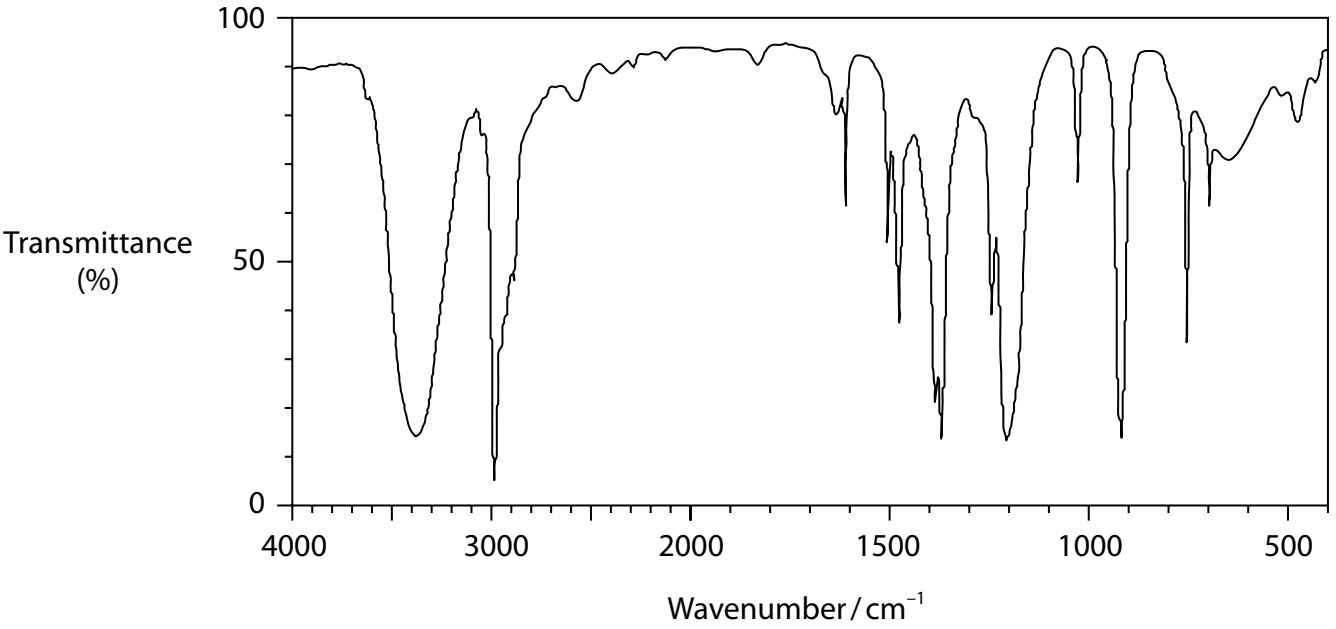
Compound A



Compound B



Compound C



(i) Identify one feature, common to all three infrared spectra, which shows that A, B and C are all alcohols.

(1)

.....

.....

(ii) State, giving a reason for your answer, if it is possible to identify each of these three alcohols on the basis of the infrared spectra alone.

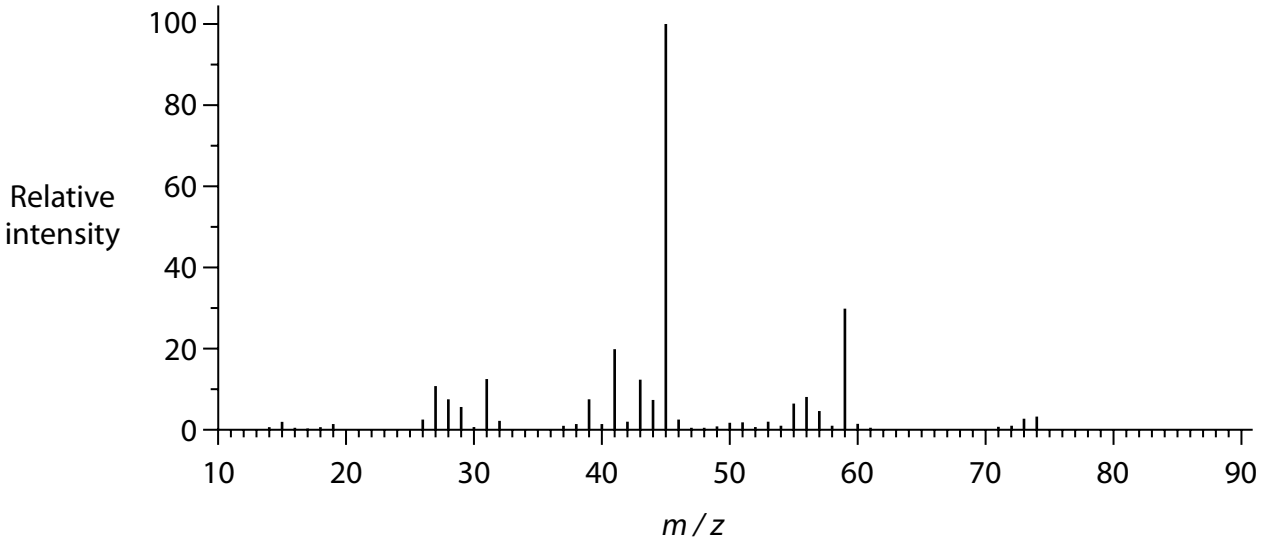
(1)

.....

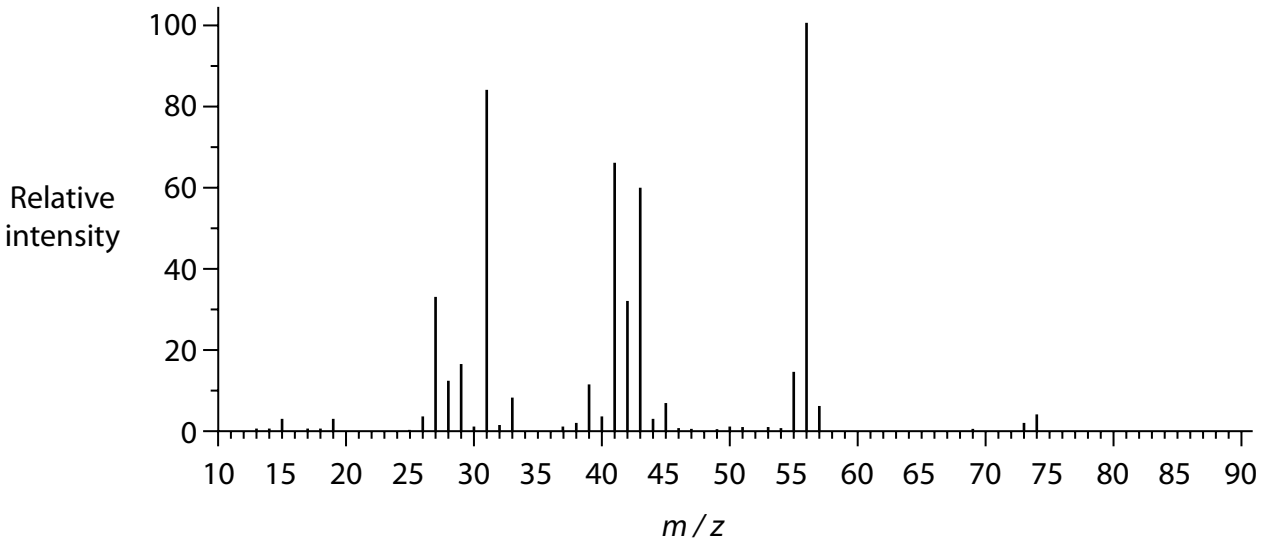
.....

(b) The mass spectra of the compounds A, B and C are shown.

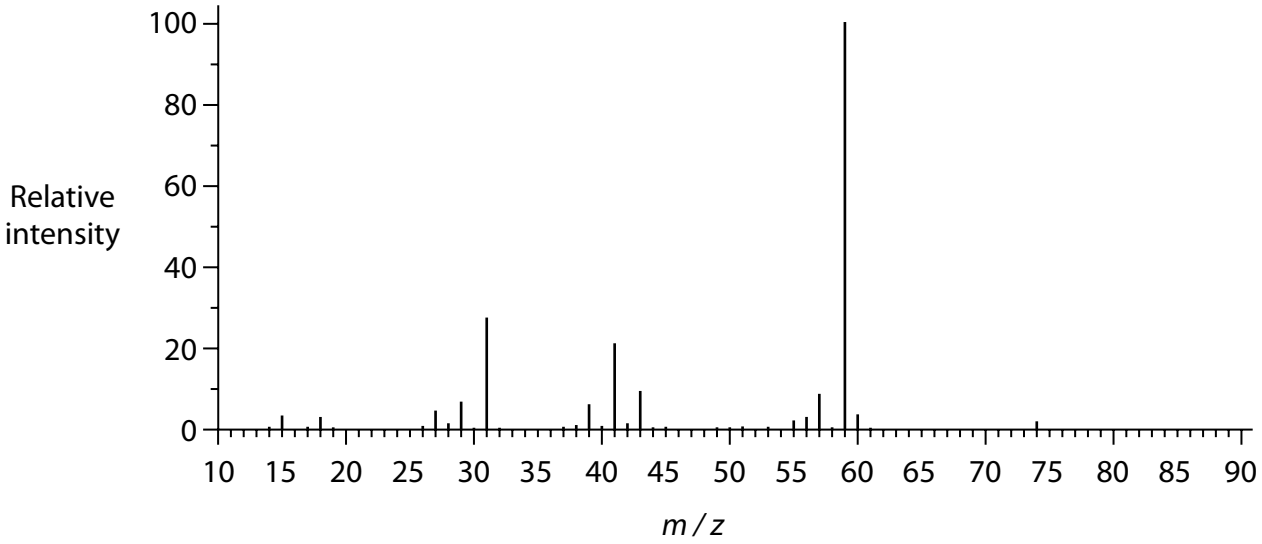
Compound A



Compound B



Compound C



(i) Identify one feature common to the mass spectra of compounds A, B and C which shows that the molecular formula is $C_4H_{10}O$.

(1)

.....

.....

(ii) Using the fragmentation patterns, a student proposed that:

compound A is butan-2-ol
compound B is butan-1-ol
compound C is 2-methylpropan-2-ol

State how the appearance in the spectra of the following peaks supports the student's conclusion.

(3)

the fragment causing the peak at $m/z = 45$ for compound A

.....

.....

the fragment causing the peak at $m/z = 31$ for compound B

.....

.....

the fragment causing the peak at $m/z = 59$ for compound C

.....

.....

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

(c) To help with the identification of compounds A and B, the student decided to mix each of them with potassium dichromate(VI) and dilute sulfuric acid solutions, and then distil the mixture immediately.

(i) Identify, by name and structural formula, the organic compound present at the conclusion of each of these two oxidation reactions.

(3)

Organic compound used	Name of oxidation product	Structural formula of oxidation product
A, butan-2-ol		
B, butan-1-ol		

(ii) To identify A and B, the student decided that one further chemical test should be used on their oxidation products.

Give a suitable reagent and expected observations that could be used to distinguish between the oxidation products of A and B.

(3)

(Total for Question 22 = 12 marks)

TOTAL FOR SECTION B = 40 MARKS

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

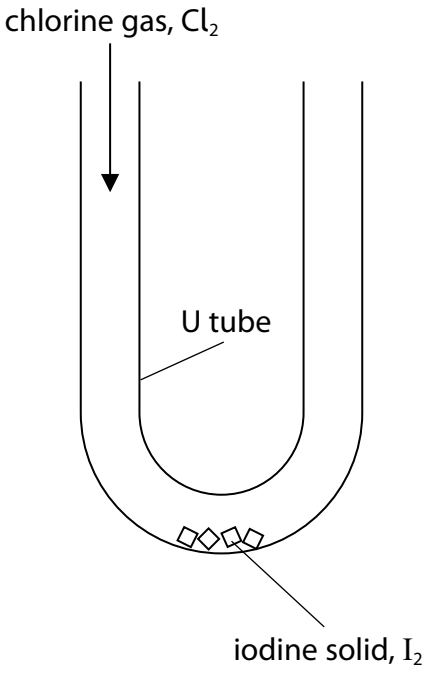
SECTION C

Answer ALL the questions.

Write your answers in the spaces provided.

23 Iodine monochloride, ICl, is a covalent compound produced by the reaction of iodine with chlorine. Iodine monochloride is a dark brown liquid at room temperature.

The equipment shown can be used to pass chlorine over solid iodine to produce iodine monochloride.



When excess chlorine is passed through the U tube, the iodine monochloride reacts to produce iodine trichloride in an equilibrium reaction.

(a) Write a chemical equation for the reaction of iodine with chlorine to produce iodine monochloride. Include state symbols.

(2)

(b) The iodine monochloride molecule has a permanent dipole. Complete the following table using the electronegativity data from your Data Booklet and hence show the dipole on the diagram of the iodine monochloride molecule.

(1)

Element	Electronegativity
Cl	
I	

I — Cl

(c) Iodine monochloride reacts with propene to form two isomeric products. This is an addition reaction that is similar to the reaction of propene with hydrogen halides.

(i) Draw the skeletal formulae of both isomers.

(2)

(ii) Explain which of these isomers is the major product.

(3)

(d) The equation for the reaction between iodine monochloride and chlorine is:

$$\underset{\text{brown liquid}}{ICl(l)} + Cl_2(g) \rightleftharpoons \underset{\text{yellow solid}}{ICl_3(s)}$$

(i) State and justify **one** precaution that must be taken when preparing iodine trichloride.

(2)

.....

.....

.....

.....

(ii) Give the oxidation number of iodine in both iodine-containing compounds in the equilibrium.

(1)

I in ICl .....

I in ICl_3 .....

(iii) Iodine trichloride can also be made by reacting potassium chlorate(V) with iodine in hydrochloric acid. The equation for the reaction is

$$KClO_3 + I_2 + 6HCl \rightarrow KCl + 2ICl_3 + 3H_2O$$

By considering oxidation numbers for chlorine, explain whether or not this reaction is a disproportionation.

(2)

.....

.....

.....

.....

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

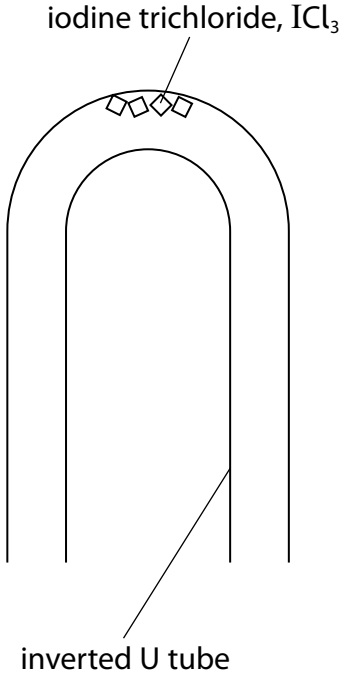
DO NOT WRITE IN THIS AREA

(e) Chlorine gas has a molar volume of 24 000 cm^3 mol^{-1} under the conditions used in this reaction.

(i) Show that the density of chlorine gas is approximately 3 g dm^{-3}.

(2)

(ii) Air has an average density of 1.25 g dm^{-3}. If the U-tube used in 23(d) is inverted, as shown in the diagram, the solid yellow iodine trichloride produced in the equilibrium reaction turns to a brown liquid.



Explain this observation.

(3)

(f) A mass of 0.64 g of iodine reacted with fluorine to form 1.31 g of a fluoride of iodine.

Calculate the empirical formula of this compound of iodine and fluorine.

(2)

(Total for Question 23 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS
TOTAL FOR PAPER = 80 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
							1.0 H hydrogen 1										(18) 4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series

Unit 2 - Mark scheme

Question number	Answer	Mark
1	D pentane	1

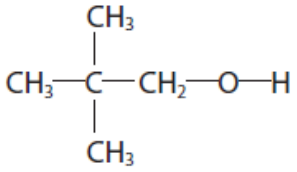
Question number	Answer	Mark
2	B Y X Z W	1

Question number	Answer	Mark
3	A all Group 1 hydroxides are soluble in water	1

Question number	Answer	Mark
4	C 2-chloro-2-methylpropane	1

Question number	Answer	Mark
5	D *E*-1-bromo-2-methylbut-1-ene	1

Question number	Answer	Mark
6	D nucleophilic substitution	1

Question number	Answer	Mark
7	 D	1

Question number	Answer	Mark
8	C The solubility of hydroxides increases	1

Question number	Answer	Mark
9	B NH_4Cl	1

Question number	Answer	Mark
10	D dilute nitric acid followed by silver nitrate solution gives a white precipitate	1

Question number	Answer	Mark
11	B lithium sulfate	1

Question number	Answer	Mark
12	C emission of visible light energy as electrons return to lower energy levels	1

Question number	Answer	Mark
13	B -1 and +5	1

Question number	Answer	Mark
14	C bromine, hydrogen bromide and sulfur dioxide only	1

Question number	Answer	Mark
15(a)	A 2.5 °C	1

Question number	Answer	Mark
15(b)	C redox	1

Question number	Answer	Mark
16	A an increase in the volume of acid solution	1

Question number	Answer	Mark
17(a)	A peak position shifted left, peak height higher	1

Question number	Answer	Mark
17(b)	B area A decreases, area B increases	1

Question number	Answer	Mark
18	C the forward and reverse reactions have both stopped	1

Question number	Answer		Additional guidance	Mark
19(a)	• KBr/potassium bromide **and** (50%) sulfuric acid	(1)	Both needed for M1 Ignore acid concentration Allow HBr (dry) PBr_3/Phosphorus(III) bromide PBr_5/Phosphorus(V) bromide	**2**
	• (heat under) reflux	(1)	Do not allow just heat M2 conditional on correct or near correct M1	

Question number	Answer		Additional guidance	Mark
19(b)	• C-Br dipole reversed	(1)	Allow in any order	**3**
	• OH^- to C arrow reversed	(1)		
	• lone pair missing (from OH^-)	(1)		

Question number	Answer		Additional guidance	Mark
19(c)	• KOH/potassium hydroxide	(1)	Allow NaOH/sodium hydroxide Ignore OH^- / alkali	**2**
	• ethanol(ic)/alcohol(ic) **and** heat (under reflux)	(1)	M2 dependent on M1	

Question number	Answer		Additional guidance	Mark
20(a)			Example of calculation:	**2**
	• calculation of number of moles	(1)	0.0500 cm^3 (× 1000 ÷ 1000) = 0.0500 (mol)	
	• evaluation to 2/3 SF	(1)	(0.0500 × 90.0) = 4.50 (g)	

Question number	Answer	Additional guidance	Mark
20(b)	An answer that make reference to the following points: • moles of ethanedioic acid (1) • moles of potassium hydroxide and mass of potassium hydroxide. (1)	Example of calculation: Moles acid = $400 \times 0.0500 \div 1000 = 2.00 \times 10^{-2}$ Moles KOH = $2.00 \times 10^{-2} \times 2 = 4.00 \times 10^{-2}$ mol $4.00 \times 10^{-2} \times 56.1 = 2.24(4)$ g Correct answer with no working scores 2 Ignore SF except 1 SF	**2**

<table>
<tr><th>Question number</th><th>Answer</th><th>Additional guidance</th><th>Mark</th></tr>
<tr><td>20(c)</td><td>This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.
Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.
The following table shows how the marks should be awarded for indicative content.
<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5-4</td><td>3</td></tr>
<tr><td>3-2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table>
The following table shows how the marks should be awarded for structure and lines of reasoning.
<table>
<tr><th></th><th>Number of marks awarded for structure and sustained lines of reasoning</th></tr>
<tr><td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout.</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning.</td><td>1</td></tr>
<tr><td>Answer has no linkages between points and is unstructured.</td><td>0</td></tr>
</table></td><td>Guidance on how the mark scheme should be applied.

The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points that is partially structured with some linkages and lines of reasoning, scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).

If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).

In general, it would be expected that 5 or 6 indicative points would get 2 reasoning marks, and 3 or 4 indicative points would get 1 mark for reasoning, and 0, 1 or 2 indicative points would score zero marks for reasoning.

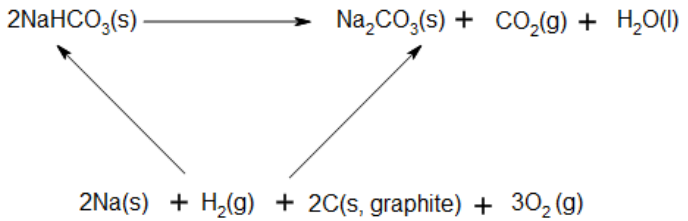
If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded, do not deduct mark(s).

Comment: Look for the indicative marking points first, then consider the mark for the structure of the answer and sustained line of reasoning.</td><td>6</td></tr>
</table>

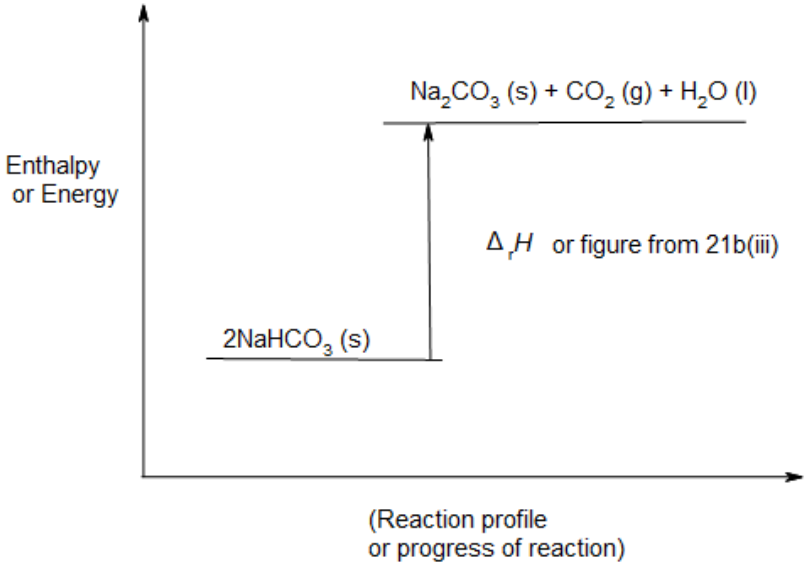
Question number	Answer	Additional guidance	Mark
20(c) ***Cont.***	Indicative points: • rinse glassware with appropriate solutions • fill the burette with potassium hydroxide solution, ensuring there are no air bubbles • use a pipette **and** pipette filler to transfer 25.0 cm^3 / 10 cm^3 of acid to a conical flask • (add indicator to the acid in the conical flask and) carry out a range finder/rough titration • add potassium hydroxide drop by drop near the end point • repeat titrations **until** concordant/within ± 0.2 cm^3 .	Do not award just 'rinse with distilled water'. Alternative IP 2 to 5 if acid (solution) used in burette: • fill the burette with (ethanedioic) acid solution, ensuring there are no air bubbles • use a pipette **and** pipette filler to transfer 25.0 cm^3 of potassium hydroxide solution to a conical flask • (add indicator to the potassium hydroxide in the conical flask and) carry out a range finder/rough titration • add (ethanedioic) acid drop by drop near the end point.	

Question number	Answer	Additional guidance	Mark
21(a)	• hard to measure the temperature change when you're heating something or • heat losses due to high temperatures involved or • at 300 °C/high temperatures the water will be gaseous	Allow it is difficult to measure the temperature of a solid	**1**

Question number	Answer	Additional guidance	Mark
21(b)(i)	An answer that makes reference to the following points: • (the enthalpy change when) one mole of the substance (is formed) • from its elements in their standard states (under standard conditions).		**2**

Question number	Answer	Additional guidance	Mark
21(b)(ii)	A diagram that includes: • all species correct (1) • all state symbols correct and species balanced. (1)	 Do not penalise missing graphite	2

Question number	Answer	Additional guidance	Mark
21(b)(iii)	• correct application of Hess's law (1) • correct figures used (1) • correct calculation (1) • units and sign (1)	Example of calculation: $\Delta_r H = -\Delta H_1 + \Delta H_2$ or $\Delta_f H\ (Na_2CO_3) + \Delta_f H\ (CO_2) + \Delta_f H\ (H_2O) = 2\Delta_f H(NaHCO_3) + \Delta_r H$ $-1130.7 + (-285.8) + (-393.5) = 2 \times (-950.8) + \Delta_r H$ $\Delta_r H = 91.6$ $\Delta_r H = +91.6$ kJ mol^{-1} Correct answer with no working scores (4) TE from M1 TE from incorrect M2	4

Question number	Answer	Additional guidance	Mark
21(b)(iv)	• products energy level above reactants **and** arrow (1) • label on vertical arrow **and** vertical axis label (1)	 Allow reactants/products in place of chemical formulae Horizontal axis label not required Direction of arrow and endothermic/exothermic diagram must agree with sign in 21b(iii) Allow a correct exothermic enthalpy level diagram for an exothermic answer in 21b(iii)	2

Question number	Answer	Additional guidance	Mark
22(a)(i)	• peak in the range 3750 – 3200 cm^{-1} and O-H (stretching) bond in alcohols	Must identify the bond and give the wavenumber range Allow peak at ~3375 cm^{-1}	1

Question number	Answer	Additional guidance	Mark
22(a)(ii)	• not possible - All three contain the same bonds or possible - the fingerprint regions differ/by comparing the spectra to reference spectra	No mark for unjustified answer	1

Question number	Answer	Additional guidance	Mark
22(b)(i)	• (all show) parent/molecular ion peak at 74	Allow peak furthest to the right/highest m/z peak at 74 Do not award just 'peak at 74'	1

Question number	Answer	Additional guidance	Mark
22(b)(ii)	• fragment $^{+}CH_3CHOH$ = 45 (1) • fragment $^{+}CH_2OH$ = 31 (1) • fragment $^{+}(CH_3)_2COH$ = 59 (1)	Ignore missing charge on fragments	3

<table>
<tr><th>Question number</th><th>Answer</th><th>Additional guidance</th><th>Mark</th></tr>
<tr><td>22(c)(i)</td><td>
<table>
<tr><th>Organic compound used</th><th>Name of oxidation product</th><th>Structural formula of oxidation product</th></tr>
<tr><td>A</td><td>Butanone

and</td><td>$CH_3CH_2COCH_3$</td></tr>
<tr><td>B</td><td>Butanal (1)</td><td>$CH_3CH_2CH_2CHO$</td></tr>
</table>
(1)

(1)
</td><td>Allow displayed or skeletal formulae

1 mark for 2 correct names and 1 mark for each correct formula</td><td>3</td></tr>
</table>

Question number	Answer	Additional guidance	Mark
22(c)(ii)	An answer that makes reference to the following points: • reagent: Benedict's/Fehling's (1) • (oxidation product of) compound A: no change (1) • (oxidation product of) compound B: (Benedict's/Fehlings test) red precipitate. (1)	Allow Tollens' or iodine + alkali (Tollens' reagent) silver mirror with (oxidation product of) B. No reaction with (oxidation product of) A (iodine + alkali) yellow precipitate (iodoform) with (oxidation product of) A. No reaction with oxidation product of B If (butanoic) acid in (c)(i), allow reagent: sodium carbonate/sodium hydrogencarbonate (solution) Observations: (oxidation product of) compound B: bubbles/fizzes	3

Question number	Answer	Additional guidance	Mark
23(a)	• balanced equation (1) • all states correct (1)	$I_2(s) + Cl_2(g) \rightarrow 2ICl(l)$ Accept multiples	2

Question number	Answer	Additional guidance	Mark
23(b)	• correct electronegativity values and correct dipole diagram	Cl = 3.0 **and** I = 2.5 δ+ I — Cl δ- Do not award full charges	1

Question number	Answer	Additional guidance	Mark
23(c)(i)	• 1 mark each correct formula	 Allow 1 mark for 2 correct non-skeletal formulae	2

Question number	Answer	Additional guidance	Mark
23(c)(ii)	An explantion that makes reference to the following points: • identification of correct isomer (1) • iodine is δ+ and is attacked by the π electrons (1) • more stable secondary carbocation formed. (1)	2-chloro-1-iodopropane	**3**

Question number	Answer	Additional guidance	Mark
23(d)(i)	An answer that makes reference to the following points: • carry out in fume cupboard (1) • chlorine is toxic. (1)	Allow fume hood or similar description Do not allow 'harmful'	**2**

Question number	Answer	Additional guidance	Mark
23(d)(ii)	• I in ICl = +1 I in ICl_3 = +3	Both needed for the mark	**1**

Question number	Answer	Additional guidance	Mark
23(d)(iii)	• +5 **and** -1 to -1 (and -1) (1) • not disproportionation because the chlorine has not undergone both oxidation and reduction (1)		**2**

Question number	Answer		Additional guidance	Mark
23(e)(i)	• correct method	(1)	$Cl_2 = 2 \times 35.5 = 71$ $71 \div 24000$	2
	• answer with units	(1)	$= 0.0029583$ g cm^{-3} $= 3$ g dm^{-3}	

Question number	Answer		Additional guidance	Mark
23(e)(ii)	An explanation that makes reference to the following points: • chlorine (gas) is more dense than air	(1)		3
	• chlorine (gas) removed (from the equilibrium)	(1)		
	• position of equilibrium moves to the LHS (more brown liquid/ICl).	(1)		

Question number	Answer		Additional guidance	Mark
23(f)	• calculation of mols of iodine and fluorine	(1)	Mols of iodine = $0.64 \div 126.9 = 5.04 \times 10^{-3}$ Mols of fluorine = $(1.31-0.64) \div 19 = 3.53 \times 10^{-2}$	2
	• calculation of whole number ratio and formula	(1)	Ratio 1:7 therefore formula IF_7	

Write your name here

Surname	Other names

Pearson Edexcel
International Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

International Advanced Subsidiary/Advanced Level
Unit 3: Practical Skills in Chemistry I

Sample Assessment Materials for first teaching September 2018

Time: 1 hour 20 minutes

Paper Reference **WCH13/01**

You must have:
Scientific calculator, ruler

Total Marks

Instructions

- Use **black** ink or **black** ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*
- **Show all your working in calculations and include units where appropriate**.

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- There is a Periodic Table on the back page of this paper.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

S58311A

1/1/1/

S 5 8 3 1 1 A 0 1 1 6

Pearson

Answer ALL questions.

Write your answers in the spaces provided.

1 The enthalpy change for the reaction between zinc and copper(II) sulfate solution can be determined using the procedure shown.

The equation for the reaction is:

$$Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$$

Procedure

Step **1** Weigh about 5 g of zinc powder. This is an excess.

Step **2** Measure 50 cm^3 of 1.0 mol dm^{-3} copper(II) sulfate solution into a polystyrene cup.

Step **3** Start a stop clock. Stir the solution continuously with a thermometer and measure the temperature of the solution each minute for 3 minutes.

Step **4** At **exactly** 3.5 minutes, add the zinc powder to the copper(II) sulfate solution.

Step **5** Continue to stir the mixture and read the temperature each minute from 4 to 10 minutes.

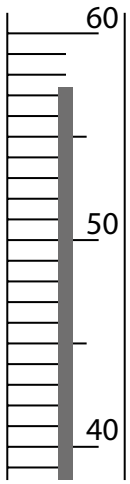
(a) (i) Name the **most** suitable piece of apparatus for measuring 50 cm^3 of copper(II) sulfate solution.

(1)

.....

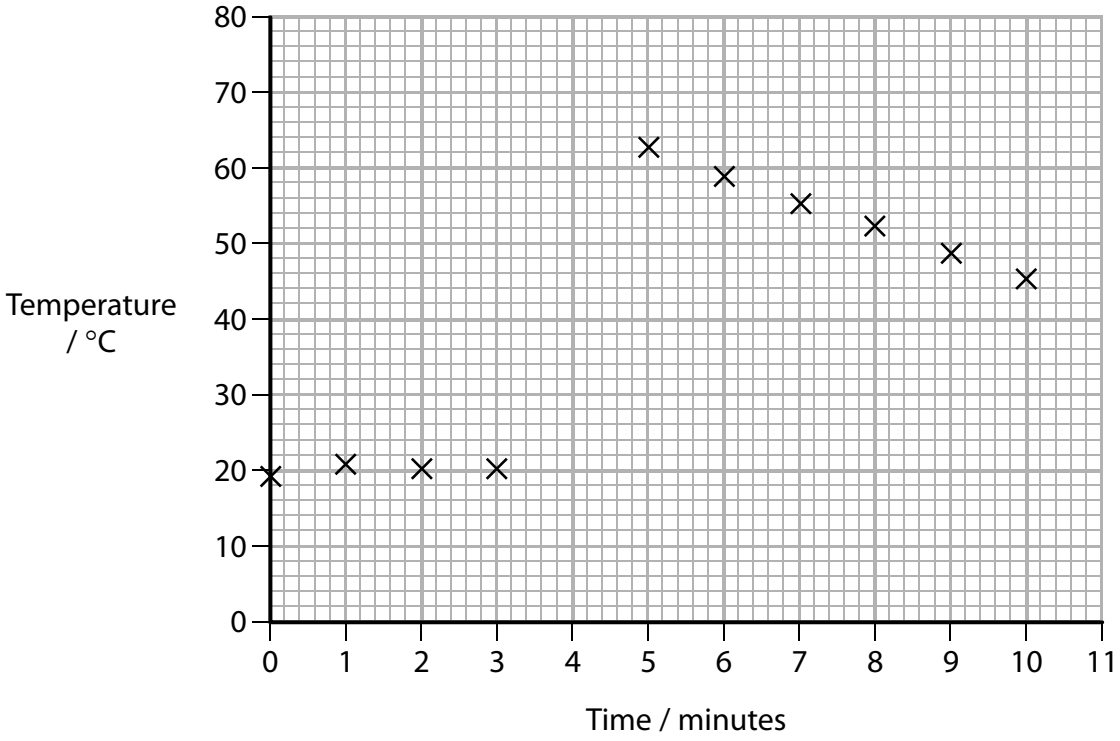
(ii) The diagram shows part of the thermometer at 4 minutes. Record the temperature in the table of results **and** plot the point on the graph.

(1)



Results

Time / minutes	0	1	2	3	4	5	6	7	8	9	10
Temperature / °C	19.0	20.5	20.0	20.0		62.5	58.5	55.0	52.0	48.5	45.0



(b) The maximum temperature change for the reaction, ΔT, is estimated by drawing two lines of best fit on the graph and extrapolating them.

(i) Give the reason why the point you plotted in (a)(ii) should **not** be included in the lines of best fit.

(1)

.....

.....

(ii) Estimate the maximum temperature change, ΔT.
Show your working on the graph.

(3)

ΔT = ... °C

(iii) Give a reason why the temperature of the solution is measured for 3 minutes **before** adding the zinc.

(1)

.....

.....

(iv) Give the main reason why the temperature of the solution is measured over a period of time **after** adding the zinc.

(1)

.....

.....

(c) (i) Use the value you have obtained for the temperature rise (ΔT) in (b)(ii) to calculate the heat energy produced in the reaction between zinc and copper(II) sulfate solution. Include units with your answer.

(Assume the specific heat capacity of the solution to be 4.2 $J\,g^{-1}\,°C^{-1}$ and the density of the solution to be 1.0 $g\,cm^{-3}$.)

(1)

(ii) The solution contained 0.050 mol of copper(II) sulfate.
Calculate the enthalpy change, ΔH, for the reaction between zinc and copper(II) sulfate solution.
Give your answer to an appropriate number of significant figures and include a sign and units.

(3)

(d) Suggest one improvement to the **procedure**, other than changing the measuring equipment or repeating the experiment, which would give a more accurate result.

(1)

.....

.....

(Total for Question 1 = 13 marks)

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

2 A student was given five boiling tubes, each containing one aqueous solution:

dilute hydrochloric acid, HCl(aq)

potassium carbonate, K_2CO_3(aq)

sodium iodide, NaI(aq)

dilute nitric acid, HNO_3(aq)

sodium chloride, NaCl(aq).

The solutions were labelled **A**, **B**, **C**, **D** and **E**, but not necessarily in this order.

The student carried out three tests on each solution.

Test 1

- The student put about 2 cm^3 of each solution into separate test tubes.
- The student added one spatula measure of solid sodium carbonate, Na_2CO_3, to each test tube.
- Observations were recorded in Table 1, in the column labelled Test 1.

Test 2

- The student put about 1 cm^3 of each solution into separate test tubes.
- The student added an equal volume of aqueous silver nitrate solution, $AgNO_3$, to each test tube.
- Observations were recorded in Table 1, in the column labelled Test 2.

Test 3

- To the final mixture in each test tube from Test 2, the student added about 1 cm^3 of dilute nitric acid, HNO_3.
- Observations were recorded in Table 1, in the column labelled Test 3.

Solution	Test 1	Test 2	Test 3
A	effervescence	no reaction	unchanged
B	no reaction	yellow precipitate	unchanged
C	no reaction	white precipitate	unchanged
D	effervescence	white precipitate	unchanged
E	no reaction	white precipitate	effervescence

Table 1

(a) (i) Identify each of the solutions from the observations recorded in Table 1. Write the letter that corresponds to each solution in Table 2.

(3)

Solution	Letter
dilute hydrochloric acid, HCl(aq)	
potassium carbonate, K_2CO_3(aq)	
sodium iodide, NaI(aq)	
dilute nitric acid, HNO_3(aq)	
sodium chloride, NaCl(aq)	

Table 2

(ii) State how you use the observations to distinguish between potassium carbonate and sodium chloride solutions.

(1)

.....

.....

.....

(b) The student suggested that a flame test could also be used to help to distinguish between potassium carbonate solution and sodium chloride solution. State how the flame colours would differ.

(1)

.....

.....

(c) A further chemical test was carried out on the precipitates from Test 3 to confirm the identity of the original solution.

Give this test, and its result, which would distinguish between sodium iodide solution and sodium chloride solution.

(2)

.....

.....

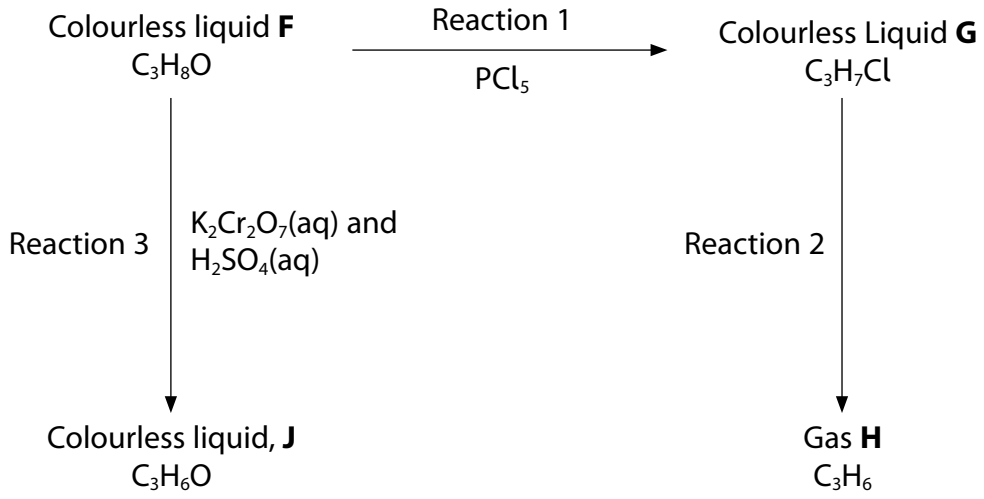
.....

.....

(Total for Question 2 = 7 marks)

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

3 This question is about the reaction sequence involving compound **F**, which has the molecular formula C_3H_8O.



(a) In reaction 1, misty fumes were observed.

(i) Identify, by name or formula, the misty fumes.

(1)

.....

(ii) State what can be deduced about compound **F** from this observation.

(1)

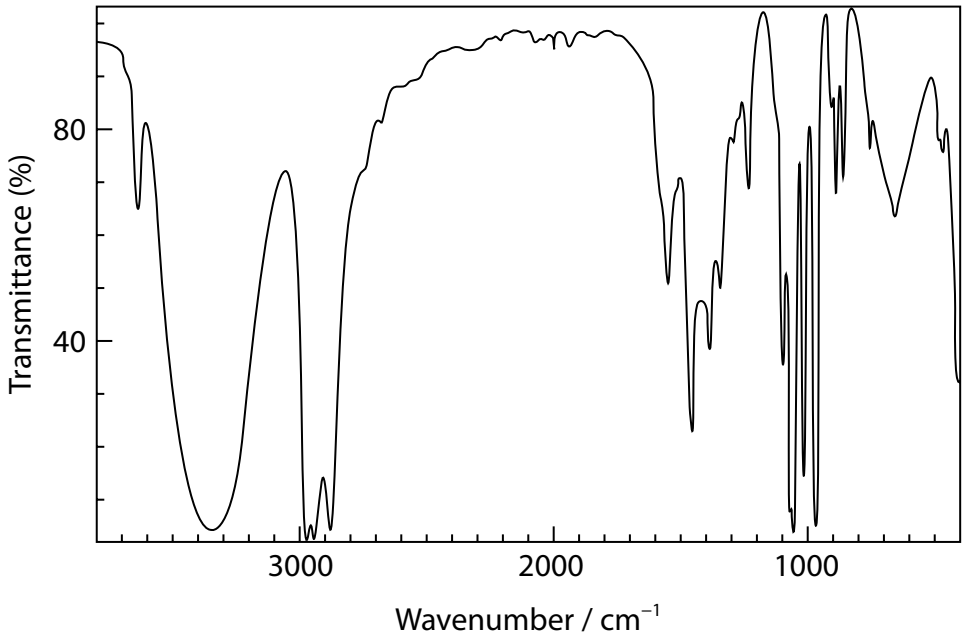
.....

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(b) The infrared spectrum of liquid **F** is shown.



Give the wavenumber range of the absorption which confirms your deduction in (a)(ii).

(1)

.....

(c) Gas **H**, C_3H_6, was formed in Reaction 2. The functional group present in **H** was identified by shaking a sample of **H** in a test tube with a few drops of bromine dissolved in a non-polar organic solvent.

(i) Give the colour change observed for this reaction.

(1)

From .....

To .....

(ii) Write an equation for the reaction of C_3H_6 with bromine.

(1)

(d) Reaction 3 was carried out by slowly adding a solution of acidified potassium dichromate(VI) to liquid **F** in a cooled flask. The flask was set up for distillation and gently heated. The product, **J**, was distilled directly out of the reaction mixture.

(i) Draw a diagram of the apparatus suitable for the distillation of **J** from the reaction mixture.

(3)

(ii) Draw the structures of two possible isomers of **J**, C_3H_6O, in the boxes.

(2)

(e) The identity of **J** can be confirmed by spectroscopy and by chemical tests.

(i) The infrared spectrum of **J** has absorbances at 2716 and 2893 cm^{-1}.

Identify the bond responsible for these absorbances, and hence the functional group in **J**.

(1)

(ii) Give a chemical test and its expected result to confirm the identity of **J**.

(2)

(f) Name compound **F**.

(1)

(Total for Question 3 = 14 marks)

4 A class of students carried out experiments to determine the value of **x** in the formula of hydrated sodium carbonate, $Na_2CO_3.xH_2O$.

Hydrated sodium carbonate was heated until no more water of crystallisation remained. Anhydrous sodium carbonate, Na_2CO_3, was formed.

$$Na_2CO_3.xH_2O \rightarrow Na_2CO_3 + xH_2O$$

The students were given the following instructions:

- weigh a sample of the hydrated sodium carbonate in a pre-weighed crucible
- heat the crucible containing the sample to remove the water of crystallisation
- allow the crucible to cool and then reweigh the crucible.

A student's results are shown in Table 3.

(a) Complete Table 3.

(2)

Measurement	Value / g
Mass of crucible empty	19.36
Mass of crucible + hydrated sodium carbonate	26.06
Mass of crucible + anhydrous sodium carbonate	21.98
Mass of hydrated sodium carbonate	
Mass of anhydrous sodium carbonate	
Mass of water removed	

Table 3

(b) (i) Calculate the number of moles of water removed on heating the hydrated sodium carbonate.

(1)

(ii) Calculate the number of moles of anhydrous sodium carbonate, Na_2CO_3, formed after heating.

(2)

(iii) Use your answers from (b)(i) and (b)(ii) to calculate the value of **x**. Give your answer to **three** significant figures.

(2)

(c) **Each** use of the balance to find a mass reading in the table has a maximum uncertainty of ±0.005 g.

Calculate the percentage error in the measurement of the mass of the crucible and hydrated sodium carbonate (26.06 g) before heating.

(1)

(d) The Data Book value for **x** is 10.

One student obtained a value for **x** of 8.63 and another student obtained a value for **x** of 10.79.

Explain the practical errors that could have led to each of these values.

(4)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(e) Devise an experiment involving a titration that could be used to determine the value of **x** in $Na_2CO_3.xH_2O$.

List the essential steps in the practical procedure.

You are not expected to explain how the data is used to calculate **x**.

(4)

(Total for Question 4 = 16 marks)

TOTAL FOR PAPER = 50 MARKS

The Periodic Table of Elements

1 (1)	2 (2)											3 (13)	4 (14)	5 (15)	6 (16)	7 (17)	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

Elements with atomic numbers 112-116 have been reported but not fully authenticated

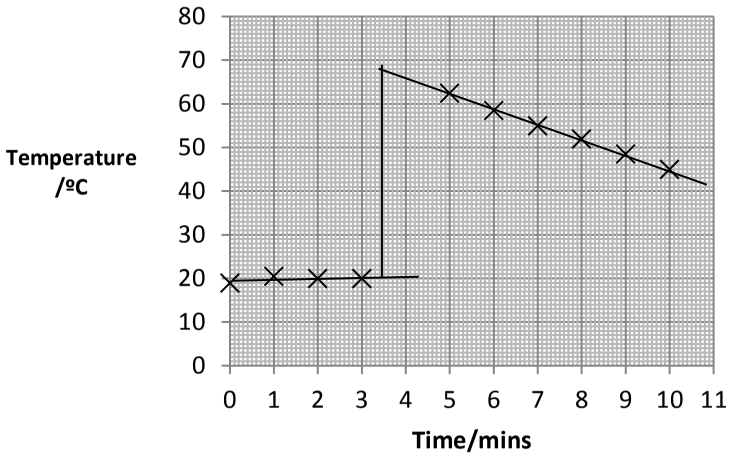
* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

Unit 3 - Mark scheme

Question number	Answer	Additional guidance	Mark
1(a)(i)	• 50 cm^3 measuring cylinder	Allow 100 cm^3 measuring cylinder Do not award beaker/pipette/burette Do not award any other size of measuring cylinder or just 'measuring cylinder'	1

Question number	Answer	Additional guidance	Mark
1(a)(ii)	• 57.5 °C in the table and point plotted on the graph	Allow just 'correctly plotted point'	1

Question number	Answer	Additional guidance	Mark
1(b)(i)	• reaction is still underway	Examples of acceptable answers: the reaction is incomplete energy is still being produced the reaction is slow Do not award just 'it does not fit with the lines of best fit'	1

Question number	Answer		Additional guidance	Mark
1(b)(ii)				3
	• a straight line drawn through the first four points from 0 to 3 mins and a straight line drawn through last six points from 5 to 10 mins	(1)		
	• temperatures (68 °C ± 1 °C, 20 °C) measured using a vertical line at 3.5 minutes	(1)	Allow for any indication on the graph, or if correct answer (48 °C ±1 °C) given	
	• value for ΔT on a vertical line (48 °C ±1 °C)	(1)	Allow ΔT value if the vertical line is drawn other than 3.5 minutes	

Question number	Answer	Additional guidance	Mark
1(b)(iii)	• to ensure equilibration with the surroundings or • to take account of changing initial temperature of solution or • to check that the temperature is constant/steady		1

Question number	Answer	Additional guidance	Mark
1(b)(iv)	• to allow for cooling/heat loss or • to apply a cooling correction	Allow mention of drawing a cooling curve Ignore reference to the extrapolation to allow the reaction to go to completion to obtain the maximum temperature rise	1

Question number	Answer	Additional guidance	Mark
1(c)(i)	• correct value and corresponding units	Example of calculation: $(50 \times 4.2 \times \Delta T) = 10080$ J/10.08 kJ Allow TE for: ΔT heat energy (kJ) 46 9.66 47 9.87 49 10.29 50 10.50 Ignore SF, except 1 SF	1

Question number	Answer	Additional guidance	Mark
1(c)(ii)	• calculation of enthalpy change per mol (1) • answer to 1 or 2 SF (1) • negative sign **and** units (1)	Example of calculation: Answer to (c)(i) ÷ 0.05 ΔT ΔH /kJ mol^{-1} 46 -190 47 -200 48 -200 49 -210 50 -210 Correct answer with no working scores 3	3

Question number	Answer	Additional guidance	Mark
1(d)	• use a lid for the polystyrene cup or • putting insulation around the cup		1

Question number	Answer	Additional guidance	Mark
2(a)(i)	<table><tr><th>Solution</th><th>Letter</th></tr><tr><td>dilute hydrochloric acid, HCl(aq)</td><td>D</td></tr><tr><td>potassium carbonate, K_2CO_3(aq)</td><td>E</td></tr><tr><td>sodium iodide, NaI(aq)</td><td>B</td></tr><tr><td>dilute nitric acid, HNO_3(aq)</td><td>A</td></tr><tr><td>sodium chloride, NaCl(aq)</td><td>C</td></tr></table> • All 5 correct (3)	3 or 4 correct scores (2) 1 or 2 correct scores (1)	**3**

Question number	Answer	Additional guidance	Mark
2(a)(ii)	• (both give a white precipitate with silver nitrate) but the carbonate fizzes with added nitric acid (and dissolves) whereas chloride does not	There must be a comparison	**1**

Question number	Answer	Additional guidance	Mark
2(b)	• potassium ions/compounds give a lilac flame sodium ions/compounds give a (persistent) yellow/ yellow-orange/orange flame		**1**

Question number	Answer	Additional guidance	Mark
2(c)	An answer that makes reference to the following points: • ammonia solution (1) • silver chloride/white precipitate dissolves and silver iodide/yellow precipitate does not dissolve (1) or • (pour off liquid) add concentrated sulfuric acid (1) • silver chloride gives steamy fumes and silver iodide gives purple vapour. (1)	Ignore concentration of ammonia Allow **only** silver chloride/white precipitate dissolves	2

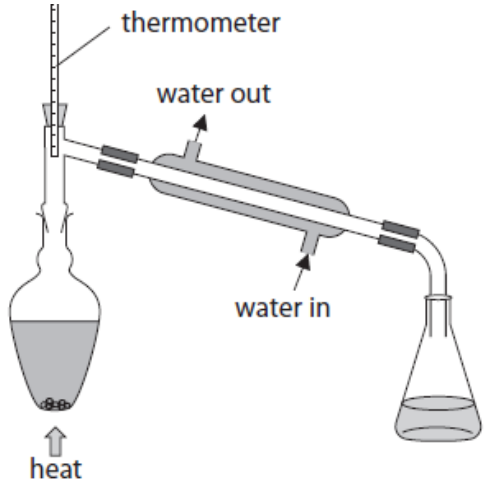
Question number	Answer	Additional guidance	Mark
3(a)(i)	• (misty fumes are) HCl/HCl(g)/hydrogen chloride or • HCl(aq)/hydrochloric acid		1

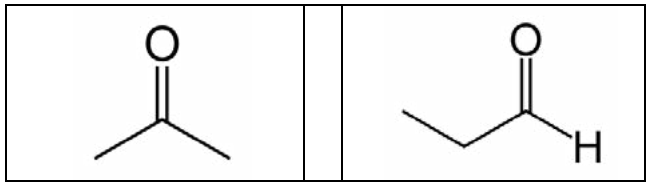
Question number	Answer	Additional guidance	Mark
3(a)(ii)	• (shows presence of) -OH/hydroxyl(l) group or • alcohol	Do not award OH^-/hydroxide group Ignore carboxylic acid	1

Question number	Answer	Additional guidance	Mark
3(b)	• 3750 - 3200 (cm^{-1})/3200 - 3750 (cm^{-1})	Allow a range within the range as long as it includes 3350 (cm^{-1})	1

Question number	Answer	Additional guidance	Mark
3(c)(i)	• from yellow-orange/orange/brown and to colourless	Ignore clear	1

Question number	Answer	Additional guidance	Mark
3(c)(ii)	• $CH_3CHCH_2 + Br_2 \rightarrow CH_3CHBrCH_2Br$ or • $C_3H_6 + Br_2 \rightarrow C_3H_6Br_2$	Allow any mixture of molecular, displayed and structural formulae Do not award for both bromine unambiguously on carbon 1 or on carbons 1 and 3	1

Question number	Answer	Additional guidance	Mark
3(d)(i)	Diagram to show: • round-bottomed/pear-shaped flask and still-head and heat (no need for a thermometer) (1) • condenser with a separate inner tube sloping downwards (1) • with water entering at the bottom and leaving at the top and suitable receiver (e.g. flask or beaker). (1)	Example of diagram:  Allow heating with electrical, water bath, Bunsen burner or just arrow Ignore thermometer and position, tap funnel in still head, absence of reagents/anti-bumping granules in flask Max 2 for gap before condenser Max 2 for sealed apparatus	**3**

Question number	Answer	Additional guidance	Mark
3(d)(ii)	•  (1) (1)	Accept displayed, skeletal or structural formulae or a mixture of these Allow in either order Allow aldehyde with or without -H in the skeletal formulae	2

Question number	Answer	Additional guidance	Mark
3(e)(i)	• C–H in aldehyde/propanal	Not just C–H	1

Question number	Answer	Additional guidance	Mark
3(e)(ii)	An answer that makes reference to the following points: • Fehling's/Benedict's test (and heat) (1) • red precipitate / solid (with aldehyde). (1)	Accept: Tollens' reagent (and warm) (1) Silver mirror (with aldehyde) (1) Allow: acidified potassium dichromate (and heat) (1) orange to green (with aldehyde) (1)	2

Question number	Answer	Additional guidance	Mark
3(f)	• propan-1-ol		1

Question number	Answer	Additional guidance	Mark
4(a)	mass of hydrated sodium carbonate: 6.70 mass of anhydrous sodium carbonate: 2.62 mass of water removed / g: 4.08 • all 3 numbers correct (2)	Do not award 6.7 Any 1 or 2 correct (1)	2

Question number	Answer	Additional guidance	Mark
4(b)(i)	• calculation of moles of water	Example of calculation: $\frac{4.08}{18}$ = 0.22666667 (mol) Ignore SF except 1 TE on mass of water in table	1

Question number	Answer	Additional guidance	Mark
4(b)(ii)	• calculation of relative formula mass of Na_2CO_3 (1) • calculation of moles of Na_2CO_3 (1)	Example of calculation: 106 = $\frac{2.62}{106}$ = 0.02471698 (mol) Ignore SF except 1 SF TE on mass of Na_2CO_3	2

Question number	Answer	Additional guidance	Mark
4(b)(iii)	• calculation of X (1) • answer to 3 SF (1)	Example of calculation: = answer to 4(b)(i) / answer to 4(b)(ii) = 0.22666667 / 0.02471698 (= 9.17048) 9.17	**2**

Question number	Answer	Additional guidance	Mark
4(c)	• calculation of percentage uncertainty	Example of calculation: $\frac{2 \times 0.0005}{26.06} \times 100 = (\pm)0.0384(\%)$ Ignore SF	**1**

Question number	Answer	Additional guidance	Mark
4(d)	An explanation that makes reference to: • 8.63 is too low because not enough water has been removed (1) • because it's not been heated long/strongly enough (1) • 10.79 is too high because apparently too much water has been removed/some extra material has been lost (1) • because solid has been lost from the crucible. (1)	Accept hydrated sodium carbonate has lost water in storage Ignore reference to impurities in the sodium carbonate Do not award measurement errors	**4**

Question number	Answer		Additional guidance	Mark
4(e)	An answer that makes reference to: • dissolve known mass of solid to form a known volume of solution • titrate with hydrochloric acid solution of known concentration • use of methyl orange indicator (and colour change) • repeat to obtain concordant titre values.	(1) (1) (1) (1)	Accept prepare a solution of sodium carbonate of known concentration Allow sulfuric/nitric acid Allow use of phenolphthalein Do not award: use of litmus or UI Allow within 0.2 cm^3	4

Write your name here

Surname	Other names

Pearson Edexcel
International Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

International Advanced Level
Unit 4: Rates, Equilibria and Further Organic Chemistry

Sample Assessment Materials for first teaching September 2018

Time: 1 hour 45 minutes

Paper Reference **WCH14/01**

You must have:
Data Booklet, scientific calculator, ruler

Total Marks

Instructions

- Use **black** ink or **black** ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*
- **Show all your working in calculations and include units where appropriate**.

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- In questions marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically showing how the points that you make are related or follow on from each other where appropriate.
- There is a Periodic Table on the back page of this paper.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

S58312A

1/1/1/1/

S 5 8 3 1 2 A 0 1 2 8

Pearson

SECTION A

Answer ALL the questions in this section.

You should aim to spend no more than 20 minutes on this section.

For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Which compound has the highest boiling temperature?

☒ **A** butanal

☒ **B** butan-1-ol

☒ **C** butanone

☒ **D** butanoic acid

(Total for Question 1 = 1 mark)

2 Which reaction does **not** produce a carboxylic acid?

☒ **A** hydrolysis of an acyl chloride with cold water

☒ **B** hydrolysis of an ester by refluxing with dilute hydrochloric acid

☒ **C** hydrolysis of a nitrile by refluxing with aqueous potassium hydroxide

☒ **D** oxidation of a primary alcohol by refluxing with excess acidified potassium dichromate

(Total for Question 2 = 1 mark)

3 The organic product of the reaction of ethanoyl chloride with ammonia gas is:

☒ **A** ammonium ethanoate

☒ **B** ethanamide

☒ **C** ethanenitrile

☒ **D** methanenitrile

(Total for Question 3 = 1 mark)

4 Which compound gives a pale yellow precipitate on warming with a solution of iodine and sodium hydroxide?

☒ **A** CH_3OH

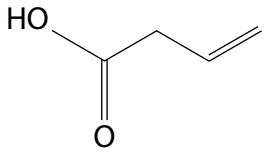
☒ **B** $CH_3CH_2CH_2CHO$

☒ **C** $CH_3CH_2COCH_3$

☒ **D** $CH_3CH_2COCH_2CH_3$

(Total for Question 4 = 1 mark)

5 Lithium tetrahydridoaluminate(III), $LiAlH_4$, is used to reduce the compound shown.



The product formed is:

☒ **A** a saturated alcohol

☒ **B** a saturated carboxylic acid

☒ **C** an unsaturated alcohol

☒ **D** an unsaturated ketone

(Total for Question 5 = 1 mark)

6 Carboxylic acids and acyl chlorides both react with alcohols to produce esters. Acyl chlorides are often preferred to carboxylic acids for this reaction because the yield of the ester is usually higher.
Which of the following statements is the best explanation for the higher yield?

☒ **A** acyl chlorides react to remove any water produced

☒ **B** the reaction is not reversible

☒ **C** the reaction is less exothermic

☒ **D** the reaction has a higher atom economy

(Total for Question 6 = 1 mark)

7 Polyesters can be made by the reaction of:

☒ **A** diprotic carboxylic acids with a primary alcohol

☒ **B** diprotic carboxylic acids with diols

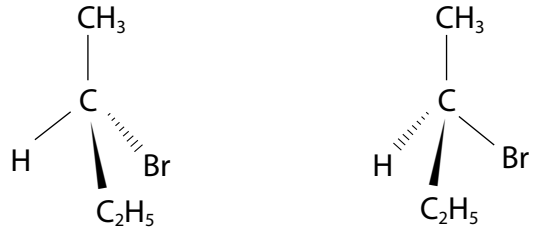
☒ **C** monoprotic carboxylic acids with triols

☒ **D** monoprotic carboxylic acids with a secondary alcohol

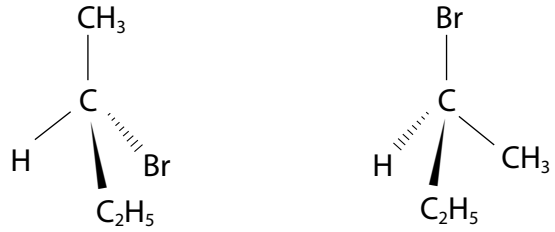
(Total for Question 7 = 1 mark)

8 When mixed in equimolar quantities, which pair of molecules will **not** rotate the plane of plane-polarised light?

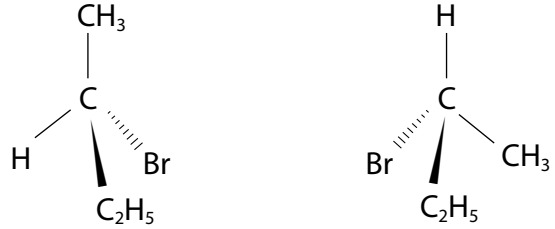
☒ **A**



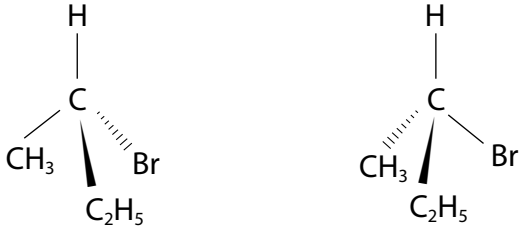
☒ **B**



☒ **C**



☒ **D**



(Total for Question 8 = 1 mark)

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

9 In gas chromatography (GC), which one of the following would **increase** the retention time for an alcohol?

☒ **A** increasing the flow rate of the mobile phase

☒ **B** increasing the polarity of the stationary phase

☒ **C** decreasing the polarity of the stationary phase

☒ **D** increasing the polarity of the mobile phase

(Total for Question 9 = 1 mark)

10 Iodine was dissolved in an organic solvent, trichloromethane, and the resulting solution added to an equal volume of deionised water. The mixture was then shaken, producing two immiscible solutions: iodine in water and iodine in trichloromethane.

At equilibrium, the equation for the reaction can be written as:

$$I_2(\text{trichloromethane}) \rightleftharpoons I_2(\text{aq})$$

(a) What is the expression for this equilibrium constant, K_c?

(1)

☒ **A** $K_c = \dfrac{[I_2(\text{trichloromethane})]}{[I_2(\text{aq})]}$

☒ **B** $K_c = \dfrac{(I_2(\text{aq}))}{(I_2(\text{trichloromethane}))}$

☒ **C** $K_c = \dfrac{I_2(\text{aq})}{I_2(\text{trichloromethane})}$

☒ **D** $K_c = \dfrac{[I_2(\text{aq})]}{[I_2(\text{trichloromethane})]}$

(b) Which statement describes what is happening at equilibrium?

(1)

☒ **A** iodine molecules move from the water to the trichloromethane layer only

☒ **B** iodine molecules move from the trichloromethane to the water layer only

☒ **C** iodine molecules move from the water to the trichloromethane and from the trichloromethane to the water layer.

☒ **D** there is no movement of individual iodine molecules

(Total for Question 10 = 2 marks)

11 Calcium oxide is manufactured by heating limestone at 1000 °C for 30 minutes.

The equation for the reaction is:

$$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g) \qquad \Delta_r H = +178\,kJ\,mol^{-1}$$

(a) The numerical value of the equilibrium constant for this reaction is increased by:

(1)

- ☒ **A** allowing the carbon dioxide to escape
- ☒ **B** increasing the heating time
- ☒ **C** increasing the temperature
- ☒ **D** reducing the pressure

(b) Which is the correct expression for the equilibrium constant, K_c, for this reaction?

(1)

- ☒ **A** $K_c = [CO_2]$
- ☒ **B** $K_c = \dfrac{1}{[CO_2]}$
- ☒ **C** $K_c = \dfrac{[CaCO_3]}{[CaO][CO_2]}$
- ☒ **D** $K_c = \dfrac{[CaO][CO_2]}{[CaCO_3]}$

(Total for Question 11 = 2 marks)

12 The equation for the dissociation of water is:

$$H_2O(l) \rightleftharpoons H^+(aq) + OH^-(aq)$$

The ionic product of water, K_w, varies with temperature.

Temperature/ °C	K_w / mol^{2}dm^{-6}
25	1.01×10^{-14}
30	1.47×10^{-14}
50	5.48×10^{-14}
100	7.16×10^{-14}

What is the pH of pure water at 60 °C?

☒ **A** approximately 6.5

☒ **B** exactly 7

☒ **C** approximately 7.4

☒ **D** greater than 7.4

(Total for Question 12 = 1 mark)

13 Iodine reacts with propanone under acid conditions. The reaction is first order with respect to propanone, first order with respect to hydrogen ions and zero order with respect to iodine.

What are the units of the rate constant?

☒ **A** $dm^3\ mol^{-1}\ s^{-1}$

☒ **B** $mol\ dm^{-3}\ s^{-1}$

☒ **C** s^{-1}

☒ **D** $mol^{-2}\ dm^6\ s^{-1}$

(Total for Question 13 = 1 mark)

14 The halogenoalkane, 2-bromobutane, can be hydrolysed using aqueous sodium hydroxide.

Which technique can be used to follow the progress of this reaction?

- ☒ **A** colorimetry
- ☒ **B** measurement of gas volume change
- ☒ **C** measurement of mass change
- ☒ **D** titration of quenched samples

(Total for Question 14 = 1 mark)

15 What can be deduced from the position of the activation energy on a Maxwell-Boltzmann distribution curve?

- ☒ **A** number of particles in the rate determining step
- ☒ **B** number of successful collisions per second
- ☒ **C** order of reaction
- ☒ **D** proportion of particles with sufficient energy to react

(Total for Question 15 = 1 mark)

16 Which indicator should be used to determine the end point in a titration of a strong acid with a weak base?

- ☒ **A** universal indicator
- ☒ **B** methyl orange
- ☒ **C** phenolphthalein
- ☒ **D** litmus

(Total for Question 16 = 1 mark)

17 Which substance has the highest standard molar entropy?

- ☒ **A** ethane(g)
- ☒ **B** water(s)
- ☒ **C** water(l)
- ☒ **D** water(g)

(Total for Question 17 = 1 mark)

18 The element sulfur can exist in two solid, interchangeable, structural forms known as rhombic sulfur and monoclinic sulfur.

$$S(s, \text{rhombic}) \rightleftharpoons S(s, \text{monoclinic}) \qquad \Delta S_{total} = -0.307\ J\ K^{-1}\ mol^{-1}$$

The value of ΔS_{total} is for the forward reaction. What can be concluded from this information?

☒ **A** monoclinic sulfur will change quickly into rhombic sulfur

☒ **B** rhombic sulfur could change into monoclinic sulfur but nothing can be deduced about the rate

☒ **C** there can be no change of structural form as they are both solids

☒ **D** monoclinic sulfur could change into rhombic sulfur but nothing can be deduced about the rate

(Total for Question 18 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions.

Write your answers in the spaces provided.

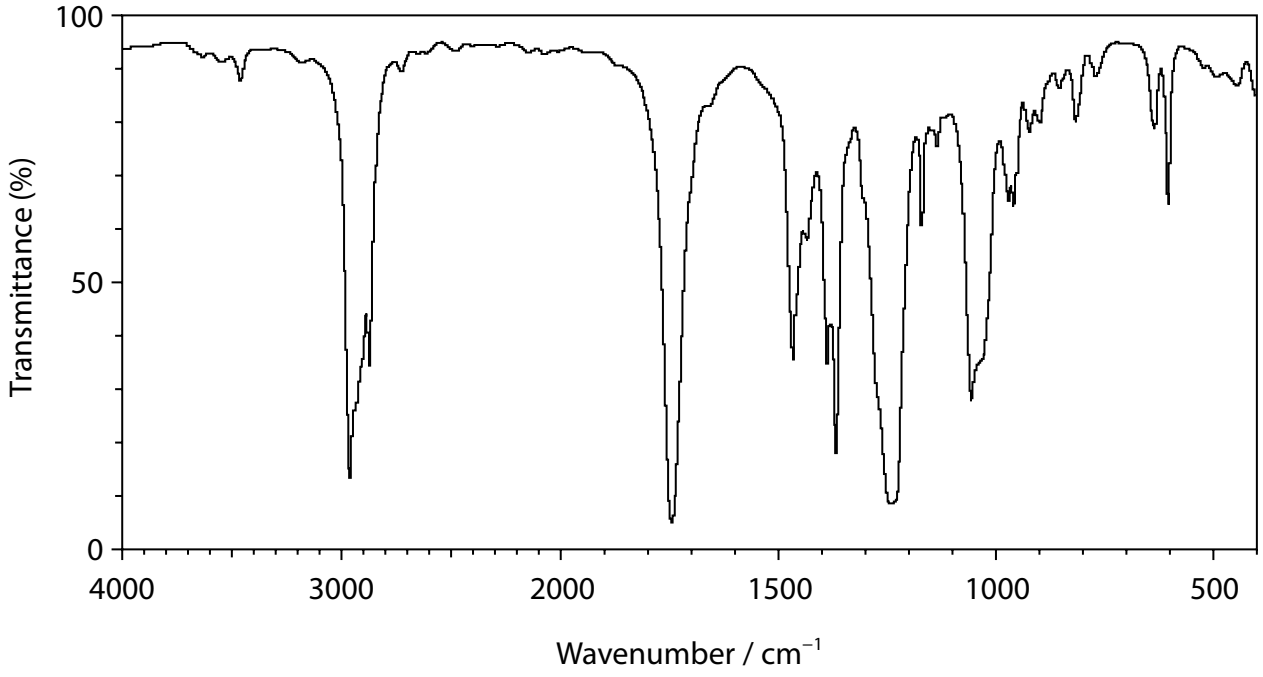
19 One of the compounds responsible for the characteristic smell of bananas is 3-methylbutyl ethanoate.
The structural formula of this compound is:

$$CH_3COOCH_2CH_2CH(CH_3)_2$$

(a) Draw the **skeletal** formula for 3-methylbutyl ethanoate.

(1)

(b) The infrared spectrum of a sample of 3-methylbutyl ethanoate is shown below.



(i) Use this spectrum to identify one peak resulting from a bond in the ester group of 3-methylbutyl ethanoate. Include the relevant bond and its wavenumber range.

(1)

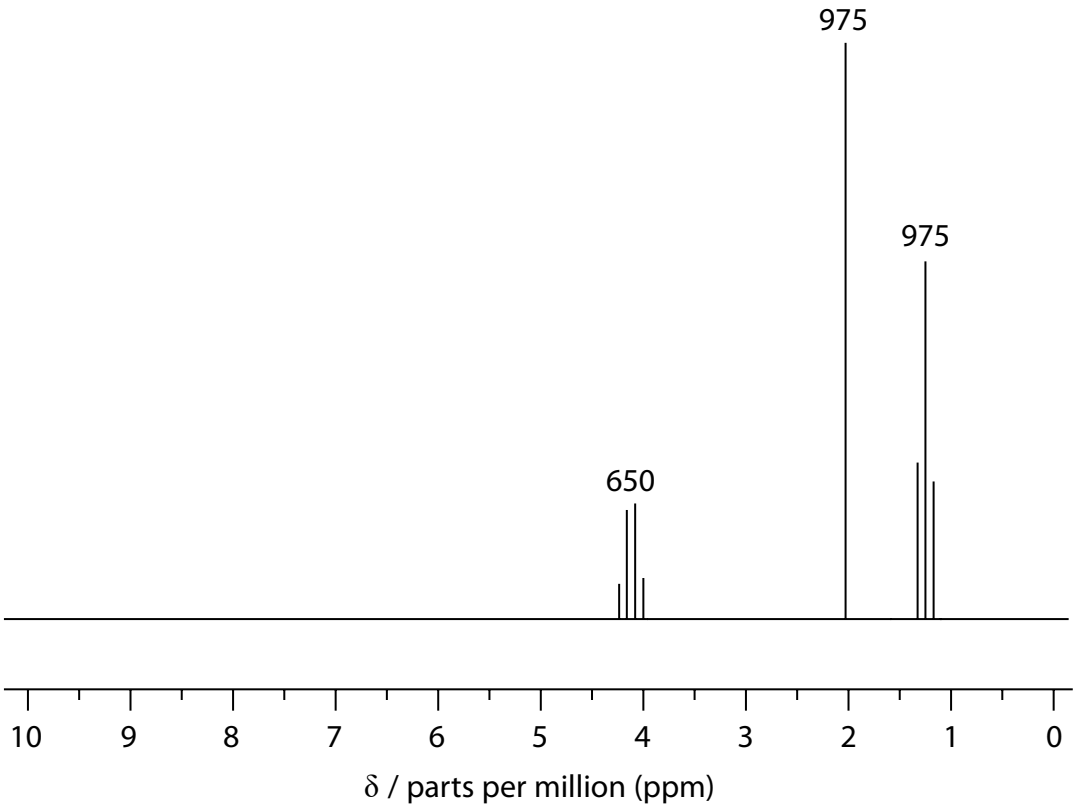
(ii) 3-methylbutyl ethanoate was synthesised by reacting a suitable carboxylic acid with an alcohol.

Show that its infrared spectrum confirms there is no alcohol remaining in the sample.

(1)

*(c) The high resolution proton nuclear magnetic resonance (NMR) spectrum of a different ester, ethyl ethanoate, $CH_3COOCH_2CH_3$, is shown.

The numbers over each peak represent their approximate relative areas.



Show that the structure of ethyl ethanoate is consistent with this NMR spectrum, using all the data in the spectrum.

(6)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(d) Ethyl ethanoate has three isomers which are also esters.

(i) Draw the structures of these three isomers.

(2)

(ii) Explain to what extent it is possible to distinguish between the three isomers using carbon-13 NMR spectroscopy.

(2)

(Total for Question 19 = 13 marks)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

20 This question is about acids.

(a) Calculate the pH of the following acidic solutions. Give your answers to **two** decimal places.

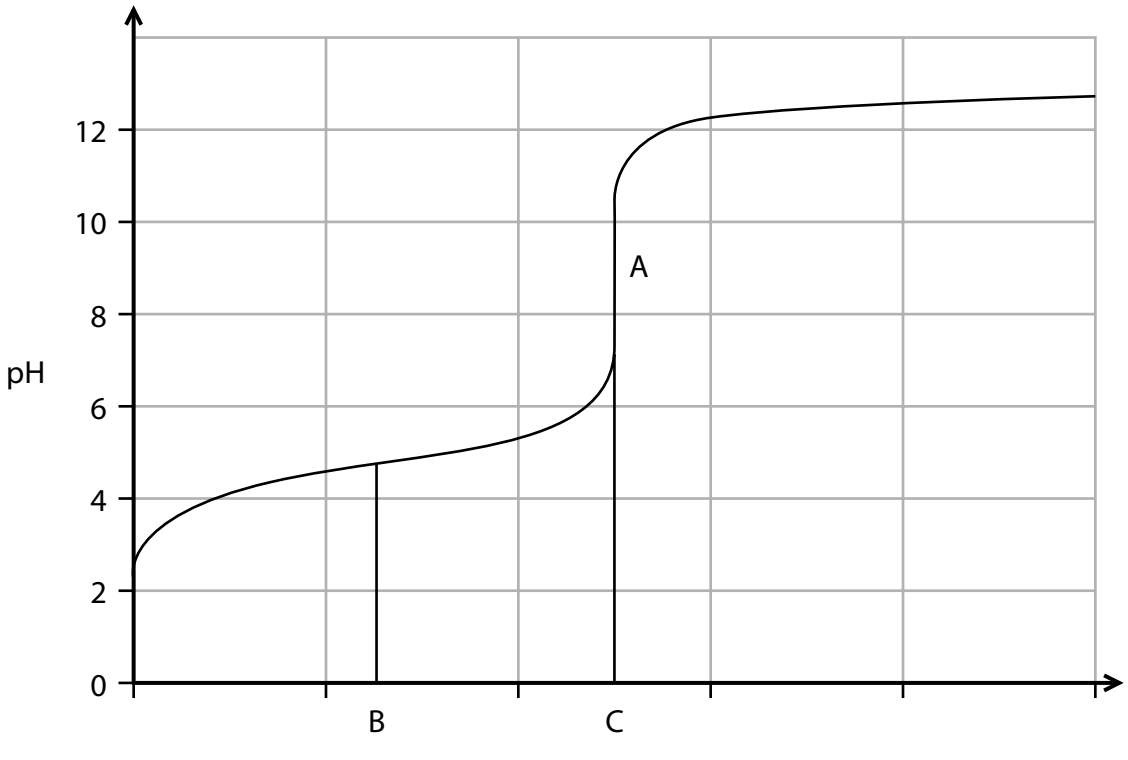
(i) 0.14 mol dm^{-3} solution of hydrochloric acid

(1)

(ii) 0.14 mol dm^{-3} solution of ethanoic acid ($K_a = 1.76 \times 10^{-5}$ mol dm^{-3})

(3)

(b) The graph shows the titration curve for a weak acid with a strong base. The equivalence point is A and the volume of alkali added at the equivalence point is C. Volume B is half of volume C.



(i) Use the graph to determine the dissociation constant, K_a, of the weak acid.

(3)

(ii) Explain the rapid rise in pH from 2.8 to 4 at the start of the titration.

(2)

(c) In another experiment, 10 cm^3 of 1.0 mol dm^{-3} sodium hydroxide was added to 30 cm^3 1.0 mol dm^{-3} propanoic acid ($K_a = 1.3 \times 10^{-5}$ mol dm^{-3}).

(i) Calculate the pH of the resulting solution.

(3)

(ii) State one assumption you have made in this calculation.

(1)

.....

.....

.....

(Total for Question 20 = 13 marks)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

21 The mechanism for the rapid decomposition of hydrogen peroxide, H_2O_2, in the presence of iodide ions, is:

$$H_2O_2 + I^- \rightarrow IO^- + H_2O \qquad \text{equation 1}$$

$$H_2O_2 + IO^- \rightarrow I^- + H_2O + O_2 \qquad \text{equation 2}$$

(a) Write the overall equation for the reaction and hence state the role of the iodide ions.

(2)

.....

.....

(b) In further experiments, a student calculated the rate constant for the decomposition of hydrogen peroxide at two different temperatures.

Temperature/ °C	Rate constant (k) / $dm^3\ mol^{-1}\ s^{-1}$
22.0	4.90×10^{-4}
47.0	2.92×10^{-3}

The rate constant (k) is related to the temperature, T, (in Kelvin) by the following equation:

$$\ln k = -\frac{E_a}{R} \times \frac{1}{T} + \text{constant} \qquad R = 8.31\,J\,K^{-1}\,mol^{-1}$$

Use the data in the table to calculate the activation energy, E_a, for the reaction by a non-graphical method.
Give your answer in $kJ\,mol^{-1}$ and to an appropriate number of significant figures.
Include a sign in your answer.

(4)

(c) If acid conditions are used, the decomposition of hydrogen peroxide proceeds by a different mechanism. The equation for this reaction is:

$$H_2O_2 + 2I^- + 2H^+ \rightarrow I_2 + 2H_2O$$

This reaction is first order with respect to both iodide ions and hydrogen peroxide.

The progress of this reaction is usually followed by adding a fixed quantity of sodium thiosulfate solution and a little starch solution to the reaction mixture, then timing the appearance of a blue-black colour. This is known as a clock reaction.

(i) Explain the formation of the blue-black colour and why its appearance is delayed.

(3)

(ii) Although the oxidation of thiosulfate ions ($S_2O_3^{2-}$) by hydrogen peroxide is thermodynamically favourable, it does not take place in this clock reaction. Suggest a reason for this.

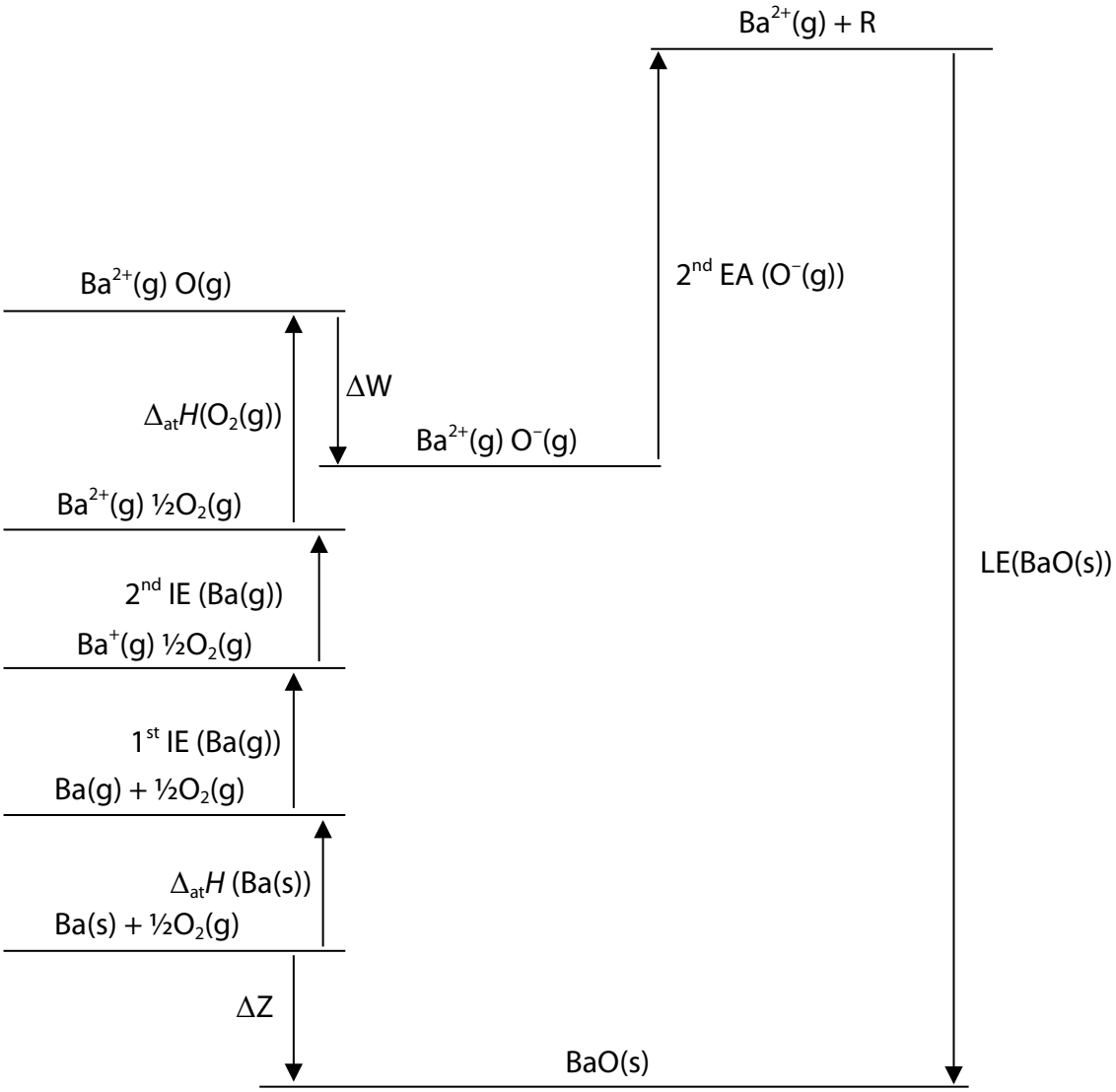
(1)

(Total for Question 21 = 10 marks)

22 Barium oxide is an ionic compound that reacts with water to form barium hydroxide.

(a) A Born-Haber cycle for barium oxide, BaO, is shown.

Some of the detail is missing. The letters **R**, **W** and **Z** represent some missing information.



(i) Identify the missing detail represented by the following letters.

(2)

R .....

W .....

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(ii) Use the following data to calculate a value for the quantity ΔZ shown on the Born-Haber cycle.
Include a sign and units in your answer.

(3)

Energy quantity	Enthalpy change / kJ mol^{-1}
Enthalpy change of atomisation of barium, $\Delta_{at}H$(Ba(s))	+180.0
Enthalpy change of atomisation of oxygen, $\Delta_{at}H$ (½O_2(g))	+249.2
First ionisation energy of barium, Ist IE (Ba(g))	+503.0
Second ionisation energy of barium, 2nd IE (Ba(g))	+965.0
ΔW	−141.1
Second electron affinity of oxygen, 2nd EA (O^-(g))	+798.0
Lattice energy barium oxide, $\Delta_{LE}H$(BaO(s))	−3054.0

(iii) The table gives some information about the lattice energies of barium oxide and magnesium iodide and shows the % difference between the theoretical and experimental values.

	Lattice energy / kJ mol^{-1}		
	Experimental	**Theoretical**	**% difference**
BaO(s)	−3054	−3029	0.8
MgI_2(s)	−2327	−1944	16.5

Explain why there is closer agreement for barium oxide than for magnesium iodide.

(3)

.....

.....

.....

.....

.....

.....

(b) The table gives some information about Group 2 ions, M^{2+}, and their hydroxides.

Formula of hydroxide	Lattice energy / kJ mol^{-1}	$\Delta_{sol}H$ / kJ mol^{-1}	Solubility / mol per 100 g	Ion	$\Delta_{hyd}HN^{2+}$ / kJ mol^{-1}
$Mg(OH)_2$	–3000	+150	2.0×10^{-5}	Mg^{2+}	–1930
$Ca(OH)_2$	–2640	+140	1.6×10^{-4}	Ca^{2+}	–1580
$Sr(OH)_2$	–2475	+105	3.3×10^{-4}	Sr^{2+}	–1450
$Ba(OH)_2$	–2230		2.4×10^{-4}	Ba^{2+}	–1360

(i) Calculate the enthalpy change of solution, $\Delta_{sol}H$, of $Ba(OH)_2$ using a fully-labelled Hess's cycle.
[The hydration enthalpy of the hydroxide ion, $OH^- = –460\ kJ\ mol^{-1}$.]

(4)

(ii) Explain why strontium hydroxide is slightly soluble in water, even though the enthalpy change of solution is endothermic.

(2)

(Total for Question 22 = 14 marks)

TOTAL FOR SECTION B = 50 MARKS

SECTION C

Answer ALL the questions.

Write your answers in the spaces provided.

23 This question is about the thermodynamics of the reaction:

$$N_2O_4(g) \rightarrow 2NO_2(g) \qquad \Delta H = +57.2\,kJ\,mol^{-1}.$$

Compound	Standard molar entropy at 298 K, $S^{\ominus}$ / J K^{-1} mol^{-1}	Standard molar enthalpy of formation at 298 K, $\Delta_f H^{\ominus}$ / kJ mol^{-1}	Colour
NO_2	+240.0	+33.2	brown
N_2O_4	+304.2		colourless

(a) Calculate the entropy change for the reaction, using the information in the table.
Include a sign and units in your answer.

(2)

(b) Calculate the enthalpy change of formation, $\Delta_f H$, of N_2O_4 (g) at 298 K, using the information in the table and the enthalpy change of the reaction.
Include a sign and units in your answer.

(2)

(c) Calculate the entropy change of the surroundings, $\Delta S_{surroundings}$, at 298 K.
Give your answer to an appropriate number of significant figures.
Include a sign and units in your answer.

(3)

(d) (i) Use your answers to parts (a) and (c) to calculate the total entropy change, ΔS_{total}, for this reaction at 298 K.

(1)

(ii) This reaction can also be written as an equilibrium:

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

Calculate the temperature at which ΔS_{total} is zero for this equilibrium.

(2)

(e) (i) Write the expression for the equilibrium constant, K_p, for this reaction, including the units, if any.

(2)

(ii) In an experiment, 10 mol of $N_2O_4(g)$ was placed in a closed container at 50 °C. At equilibrium, 27% of the $N_2O_4(g)$ had dissociated, and the pressure in the container was 4.0 atm.

Calculate the value of K_p at 50 °C.

(4)

(iii) The total pressure is doubled to 8.0 atm.
State the effect on K_p.

(1)

.....

.....

(iv) The total pressure is doubled to 8.0 atm at constant temperature.
Explain the change in the percentage dissociation of $N_2O_4(g)$ by considering the effect on the partial pressures of $NO_2(g)$ and $N_2O_4(g)$.

(3)

(Total for Question 23 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS
TOTAL FOR PAPER = 90 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
																	(18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series

Unit 4 - Mark scheme

Question number	Answer	Mark
1	D butanoic acid	1

Question number	Answer	Mark
2	C hydrolysis of a nitrile by refluxing with aqueous potassium hydroxide	1

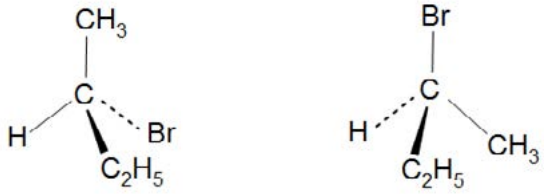
Question number	Answer	Mark
3	B ethanamide	1

Question number	Answer	Mark
4	C $CH_3CH_2COCH_3$	1

Question number	Answer	Mark
5	C an unsaturated alcohol	1

Question number	Answer	Mark
6	B the reaction is not reversible	1

Question number	Answer	Mark
7	B diprotic carboxylic acids with diols	1

Question number	Answer	Mark
8	 B	1

Question number	Answer	Mark
9	B increasing the polarity of the stationary phase	1

Question number	Answer	Mark
10(a)	$K_c = \frac{[I_2(aq)]}{[I_2(trichloromethane)]}$ D	1

Question number	Answer	Mark
10(b)	C iodine molecules move from the water to the trichloromethane and from the trichloromethane to the water layer	1

Question number	Answer	Mark
11(a)	C increase the temperature	1

Question number	Answer	Mark
11(b)	A $[CO_2]$	1

Question number	Answer	Mark
12	A approximately 6.5	1

Question number	Answer	Mark
13	A $dm^3\ mol^{-1}\ s^{-1}$	1

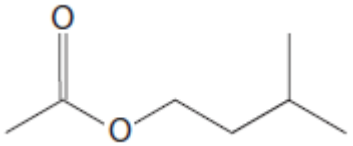
Question number	Answer	Mark
14	D titration of quenched samples	1

Question number	Answer	Mark
15	D proportion of particles with sufficient energy to react	1

Question number	Answer	Mark
16	B methyl orange	1

Question number	Answer	Mark
17	A ethane(g)	1

Question number	Answer	Mark
18	D monoclinic sulfur could change into rhombic sulfur but nothing can be deduced about the rate	1

Question number	Answer	Additional guidance	Mark
19(a)	• 	Must be skeletal formula	1

Question number	Answer	Additional guidance	Mark
19(b)(i)	• C=O peak identified **and** range 1750 – 1735 cm^{-1}	Allow C–O peak identified **and** range 1250 – 1230 cm^{-1}	1

Question number	Answer	Additional guidance	Mark
19(b)(ii)	• Absence of a peak in the range 3750 – 3200 cm^{-1}	Absence of alcoholic O-H peak	1

<table>
<tr><th>Question number</th><th>Answer</th><th>Additional guidance</th><th>Mark</th></tr>
<tr><td>19(c)</td><td>This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.
Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.
The following table shows how the marks should be awarded for indicative content.
<table><tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr><tr><td>6</td><td>4</td></tr><tr><td>5-4</td><td>3</td></tr><tr><td>3-2</td><td>2</td></tr><tr><td>1</td><td>1</td></tr><tr><td>0</td><td>0</td></tr></table>
The following table shows how the marks should be awarded for structure and lines of reasoning.
<table><tr><th></th><th>Number of marks awarded for structure and sustained lines of reasoning</th></tr><tr><td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout.</td><td>2</td></tr><tr><td>Answer is partially structured with some linkages and lines of reasoning.</td><td>1</td></tr><tr><td>Answer has no linkages between points and is unstructured.</td><td>0</td></tr></table></td><td>Guidance on how the mark scheme should be applied.

The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points that is partially structured with some linkages and lines of reasoning scores
4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).

If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).

If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded, do not deduct mark(s).

Comment: Look for the indicative marking points first, then consider the mark for the structure of the answer and sustained line of reasoning.

Some or all the information may be shown on a diagram of the molecule.</td><td>6</td></tr>
</table>

Question number	Answer	Additional guidance	Mark
19(c) ***Cont.***	Indicative points: • three groups of peaks indicates three hydrogen environments • one or two shifts identified (by number) **and** linked to alkanes • three shifts correctly identified **and** linked to alkanes • two (or more) splitting patterns correctly identified • use of n + 1 rule to explain splitting for one (or more) group(s) of protons • areas under peaks/integration numbers linked to numbers of protons in each group.	2.1 (±0.2) = CH_3 next to C=O 4.1 (±0.2) = CH_2 next to C-O- 1.2 (±0.2) = CH_3 next to CH_2 singlet, triplet, quartet ratio of areas = 3:2:3	

Question number	Answer	Additional guidance	Mark
19(d)(i)	An answer that makes reference to the following points: • $HCOOCH_2CH_2CH_3$ • $HCOOCH(CH_3)_2$ • $CH_3CH_2COOCH_3$ All three correct scores two marks, any two correct scores one mark	Allow displayed/skeletal formulae	**2**

Question number	Answer	Additional guidance	Mark
19(d)(ii)	An explanation that makes reference to the following points: • $HCOOCH(CH_3)_2$ has three carbon enviornments (1) whereas • $HCOOCH_2CH_2CH_3$ **and** $CH_3CH_2COOCH_3$ both have four carbon environments. (1)		2

Question number	Answer	Additional guidance	Mark
20(a)(i)	• pH = (0.85387) = 0.85		1

Question number	Answer	Additional guidance	Mark
20(a)(ii)	• re-arrangement of K_a expression (1) • calculation of $[H^+]$ (1) • calculation of pH (1)	Example of calculation: $[H^+]^2 = K_a\,[HA]$ $[H^+]^2 = 1.76 \times 10^{-5} \times 0.14$ $= 2.464 \times 10^{-6}$ $[H^+] = \sqrt{(1.76 \times 10^{-5} \times 0.14)}$ $= 1.5697 \times 10^{-3}$ pH = (2.8042) = 2.8(0) Penalise not to 2DP once only in (a)(i) and (ii) Correct answer with no working scores 3	3

Question number	Answer	Additional guidance	Mark
20(b)(i)	• at half equivalence point, pH = pK_a (1) • reads off pH from graph (1) • calculates K_a (1)	Example of calculation: = 4.8 Allow 4.5 to 5.2 $K_a = 10^{-pH} = 10^{-4.8} =$ 1.6×10^{-5} (mol dm^{-3}) Allow answers in the range 6.3×10^{-6} to 3.2×10^{-5}	3

Question number	Answer	Additional guidance	Mark
20(b)(ii)	• [HA] >>[A-] (1) • ratio [A-]:[HA] changes (significantly) in this region (1)	Allow for 1 mark 'not buffered'	2

Question number	Answer		Additional guidance	Mark
20(c)(i)	• calculation of [HA]/[A-] = 2/1	(1)	Example of calculation: [HA] = 1.0 × 20 ÷ 40 = 0.50 [A^-] = 1.0 × 10 ÷ 40 = 0.25 or any recognition that [HA]/[A^-] = 2/1	3
	• correct calculation of [H^+] = 2.6 × 10^{-5} (mol dm^{-3})	(1)	[H^+] = 2.6 × 10^{-5} (mol dm^{-3})	
	• correct calculation of pH	(1)	pH = 4.6/4.59/4.58 Correct answer with no working scores 3 marks	

Question number	Answer	Additional guidance	Mark
20(c)(ii)	• no H^+ ions come from (ionisation of) water or $[acid]_{initial}$ = $[acid]_{eqm}$		1

Question number	Answer		Additional guidance	Mark
21(a)	• $2H_2O_2 \rightarrow 2H_2O + O_2$ • iodide ions act as a catalyst (as they don't appear in the overall equation)	(1) (1)	Ignore state symbols even if incorrect	2

Question number	Answer		Additional guidance	Mark
21(b)	• converts both temperatures from °C to K	(1)	Example of calculation: 22.0 °C = 295.0 K 47.0 °C = 320.0 K	4
	• correct subtraction	(1)	$\ln\left(\frac{K_1}{K_2}\right) = -\frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$	
	• substitute numbers in equation correctly	(1)	$\ln\left(\frac{4.90 \times 10^{-4}}{1.07 \times 10^{-3}}\right) = -\frac{E_a}{8.31}\left(\frac{1}{295} - \frac{1}{320}\right)$	
	• correct value of E_a	(1)	(+)56.(0) (kJ mol^{-1}) Sign and final answer to 2 or 3 SF Incorrect units loses MP4 Correct answer with no working scores 4	

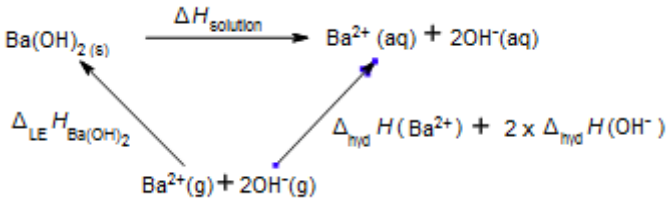
Question number	Answer		Additional guidance	Mark
21(c)(i)	An explanation that makes reference to the following points:			3
	• (blue-black colour is) product of starch-iodine reaction	(1)		
	• the iodine produced reacts (rapidly) with the thiosulfate ions (to reform iodide ions)	(1)		
	• when all of the thiosulfate has reacted, the blue-black colour appears.	(1)		

Question number	Answer	Additional guidance	Mark
21(c)(ii)	• the reaction (between thiosulfate and hydrogen peroxide) is slow	Allow reaction has high E_a	1

Question number	Answer	Additional guidance	Mark
22(a)(i)	• R = $O^{2-}(g)$ (1) • W = first electron affinity O(g) (1)	Allow alternative ways to express electron affinity, e.g. EA State required Do not allow O_2/O^-	2

Question number	Answer	Additional guidance	Mark
22(a)(ii)	• correct application of cycle (1) • correct value (1) • correct sign and units (1)	Example of calculation: $\Delta_f H$ (BaO(s)) = $\Delta_{at}H$(Ba(s))+$\Delta_{at}H$(½O_2(g))+ 1^{st} IE (Ba)(g) +2^{nd} IE (Ba(g))+2^{nd} EA (O(g))+1^{st} EA (O(g)) +$\Delta_{LE}H$ (BaO(s)) or Correct numbers = 180.0+249.2+503+965+798−141.1−3054 (−)499.9/(−)500 (kJ mol^{-1}) Allow TE from incorrect application of cycle Allow TE for incorrect numbers Correct answer with no working scores 3	3

Question number	Answer	Additional guidance	Mark
22(a)(iii)	• ionic radius of Ba^{2+} >> ionic radius of Mg^{2+}/(have) lower charge density (1) **and** Ba^{2+} (ions are) less polarising/(have) lower charge density • iodide ions/I^- are large (1) **and** their electron clouds are easily distorted/polarised (by Group 2 cations) or oxide ions/O^{2-} are small(er) **and** their electron clouds are less easily distorted/polarised • more distortion/covalency leads to greater difference between theoretical and experimental values (1)	Allow reverse argument	**3**

Question number	Answer		Additional guidance	Mark
22(b)(i)			Do not allow energy profile or energy level diagrams	4
	• all arrows in the correct direction	(1)	Species at each corner must be approximately correct	
	• correct formulae at each corner and enthalpies of hydration, and solution and LE correctly identified	(1)	Allow missing minor detail: brackets, position of subscripts, etc. but not absence of subscripts	
	• correct expression or correct substitution of values	(1)	Example of calculation: $\Delta_{sol}H = (\Delta_{hyd}H\,(Ba^{2+}) + 2\Delta_{hyd}H(OH^-)) -$ LE $(Ba(OH)_2)$ or $= (-1360 + (2 \times -460)) - (-2230)$	
	• correct evaluation	(1)	$= -50$ (kJ mol^{-1}) Allow TE from their cycle if $\Delta_{hyd}H(OH^-)$ is not doubled	

Question number	Answer		Additional guidance	Mark
22b(ii)	• entropy (change) of system/ΔS_{system}/$\Delta S_{dissolving}$ is large and positive (and outweighs negative $\Delta S_{surroundings}$ ($-\Delta H/T$))	(1)		2
	• overall entropy change/ΔS_{total} is positive	(1)		
	or			
	• use of $\Delta S_{total} = \Delta S_{surroundings} + \Delta S_{system}$	(1)		
	• $\Delta S_{total} = \Delta S_{surroundings} + (-\Delta H/T)$	(1)	Allow use of ΔG	

Question number	Answer		Additional guidance	Mark
23(a)			Example of calculation:	2
	• use of $\Delta S_{system} = \Delta S_{products} - \Delta S_{reactants}$	(1)	ΔS_{system} = (2 × 240.0) – 304.2	
	• correct value with sign and units	(1)	= +175.8 J K^{-1} mol^{-1}	
			Correct answer with no working scores 2 Allow 3 SF	

Question number	Answer	Additional guidance	Mark
23(b)	• use of $\Delta_r H = 2 \times \Delta_f H(NO_2) - \Delta_f H(N_2O_4)$ (1) • correct value with sign and units (1)	Example of calculation: $\Delta_r H = (2 \times 33.2) - \Delta_f H(N_2O_4) = 57.2$ $\Delta_f H(N_2O_4) = +9.2$ kJ mol^{-1} Correct answer with no working scores 2	**2**

Question number	Answer	Additional guidance	Mark
23(c)	• use of $\Delta S_{surroundings} = -\Delta H/T$ (1) • correct value (1) • answer to 3 SF with correct sign and correct units (1)	Example of calculation: $-(57.2 \times 1000/298)$ $= (-)191.(946)$ -192 J K^{-1} mol^{-1} Allow -0.192 kJ K^{-1} mol^{-1} for M2 and M3 Correct answer to 3 SF with no working scores 3	**3**

Question number	Answer	Additional guidance	Mark
23(d)(i)	• $\Delta S_{total} = \Delta S_{system} + \Delta S_{surroundings}$ • $\Delta S_{total} = +175.8 + (-191.9) = -16(.1)$ (J mol^{-1} K^{-1})	Allow TE from 23a and 23c Allow answers in kJ mol^{-1} K^{-1}	**1**

Question number	Answer		Additional guidance	Mark
23(d)(ii)	• correct expression	(1)	Example of expression and calculation: $\Delta H = T\Delta S_{system}$ or $T = \Delta H/\Delta S_{system}$ or $\Delta S_{system} = \Delta H/T$ or $\Delta S_{total} = \Delta S_{system} + \Delta S_{surroundings} = 0$	2
	• correct evaluation	(1)	$T = 57.2 \times 1000/175.8 = 325.37$ $= 325$ K/52 °C	

Question number	Answer		Additional guidance	Mark
23(e)(i)	• correct expression for K_p	(1)	$K_p = (p_{NO_2})^2/p_{N_2O_4}$ Do not award any square brackets	2
	• units of pressure	(1)	atm	

Question number	Answer		Additional guidance	Mark
23(e)(ii)	• moles of N_2O_4 **and** NO_2 at eqm	(1)	Example of calculation: (mol)N_2O_4 = 7.3, (mol)NO_2 = 5.4.	4
	• total number of moles **and** mole fractions calculated	(1)	Total moles = 12.7 Mole fraction N_2O_4 = 0.575 Mole fraction NO_2 = 0.425 Allow TE from M1	
	• converted to partial pressure	(1)	P N_2O_4 = 2.30 (answers to M2 × 4) NO_2 = 1.70 Allow TE from M2	
	• calculation of K_p	(1)	K_p = 1.26 (atm) Allow TE from M3 Ignore SF except 1 SF	

Question number	Answer	Additional guidance	Mark
23(e)(iii)	• no effect on (the value of) K_p		1

Question number	Answer	Additional guidance	Mark
23(e)(iv)	• double pressure (effect of squaring) increases numerator more than denominator (1) • (but K_p must remain constant therefore) mole fraction of N_2O_4 must increase (relative to mole fraction of NO_2) (1) • (therefore) % dissociation of N_2O_4 decreases (1)		3

Write your name here

Surname	Other names

Pearson Edexcel
International Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

International Advanced Level
Unit 5: Transition Metals and Organic Nitrogen Chemistry

Sample Assessment Materials for first teaching September 2018

Time: 1 hour 45 minutes

Paper Reference **WCH15/01**

You must have:
Data Booklet, scientific calculator, ruler

Total Marks

Instructions

- Use **black** ink or **black** ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*
- **Show all your working in calculations and include units where appropriate**.

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- In questions marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically showing how the points that you make are related or follow on from each other where appropriate.
- There is a Periodic Table on the back page of this paper.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

S58313A

1/1/1/

S 5 8 3 1 3 A 0 1 2 6

Pearson

SECTION A

Answer ALL the questions in this section.

You should aim to spend no more than 20 minutes on this section.

For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 This question is about complex ions.

(a) Which complex ion is square planar?

(1)

☒ **A** $[Cu(H_2O)_2(NH_3)_4]^{2+}$

☒ **B** $[CuCl_4]^{2-}$

☒ **C** $[Pt(NH_3)_2Cl_2]$

☒ **D** $[Ag(NH_3)_2]^{+}$

(b) Which copper complex ion is colourless?

(1)

☒ **A** $[CuCl_2]^{-}$

☒ **B** $[CuCl_4]^{2-}$

☒ **C** $[Cu(H_2O)_6]^{2+}$

☒ **D** $[Cu(H_2O)_2(NH_3)_4]^{2+}$

(c) Which complex ion includes a bond angle of 107°?

(1)

☒ **A** $[Cr(NH_3)_6]^{3+}$

☒ **B** $[CuCl_2]^{-}$

☒ **C** $[CuCl_4]^{2-}$

☒ **D** $[Cr(H_2O)_6]^{2+}$

(Total for Question 1 = 3 marks)

2 Which vanadium ion is yellow in aqueous solution?

- ☒ **A** VO^{2+}
- ☒ **B** VO_2^+
- ☒ **C** V^{3+}
- ☒ **D** V^{2+}

(Total for Question 2 = 1 mark)

3 Which reagent will be **most** effective at shifting the equilibrium towards the chromate(VI) ions?

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

- ☒ **A** hydrochloric acid
- ☒ **B** sulfuric acid
- ☒ **C** sodium hydroxide
- ☒ **D** water

(Total for Question 3 = 1 mark)

4 Which is **not** a bidentate ligand?

- ☒ **A** ethanedioate ion, $C_2O_4^{2-}$
- ☒ **B** ethanoate ion, CH_3COO^-
- ☒ **C** 1,2-diaminoethane, $NH_2CH_2CH_2NH_2$
- ☒ **D** 2-aminoethanoic acid, NH_2CH_2COOH

(Total for Question 4 = 1 mark)

5 A redox titration of iron(II) ions with potassium manganate(VII) is used to determine the amount of iron in iron tablets. The reaction is:

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

(a) Why is no indicator necessary in this redox titration?

(1)

☒ **A** an indicator would interfere with the redox reaction

☒ **B** no suitable indicator changes colour at the end point

☒ **C** the colour change of the iron(II) ions is sufficient

☒ **D** the colour change of the manganate(VII) ions is sufficient

(b) In one such titration, the following equipment was used.

Equipment	Uncertainty for each reading
100 cm^3 measuring cylinder	±1 cm^3
250.0 cm^3 volumetric flask	±0.15 cm^3
25.0 cm^3 pipette	±0.06 cm^3
50.00 cm^3 burette	±0.05 cm^3

Which piece of equipment has the **lowest** measurement uncertainty for this experiment?

(1)

☒ **A** the measuring cylinder to measure 100 cm^3 of sulfuric acid

☒ **B** the volumetric flask to make up the solution of the iron tablet

☒ **C** the pipette to measure out the iron(II) solution

☒ **D** the burette to add a titre volume of 25.00 cm^3

(c) A 25.0 cm^3 portion of an iron(II) tablet solution required 5.00×10^{-5} mol of manganate(VII) ions to react completely. What is the mass of iron, in grams, in the 25.0 cm^3?

(1)

☒ **A** 0.00058

☒ **B** 0.0028

☒ **C** 0.010

☒ **D** 0.014

(Total for Question 5 = 3 marks)

6 A hydrogen-oxygen fuel cell contains an alkaline electrolyte. The half-equation at the anode is:

$$H_2(g) + 2OH^-(aq) \rightarrow 2H_2O(l) + 2e^-$$

What is the half-equation at the cathode?

☒ **A** $\frac{1}{2}O_2(g) + H_2O(l) + 2e^- \rightarrow 2OH^-(aq)$

☒ **B** $O_2(g) + 2H^+(aq) + 2e^- \rightarrow H_2O_2(l)$

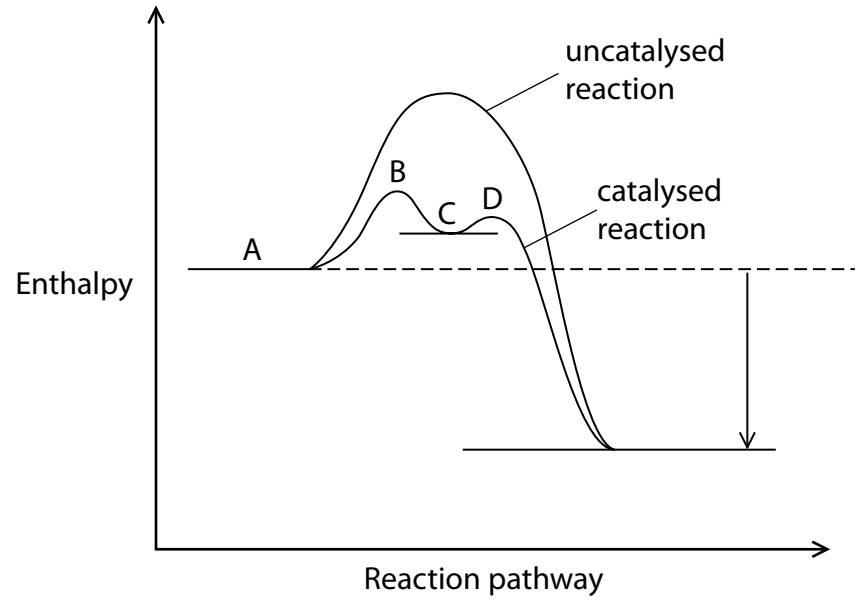
☒ **C** $\frac{1}{2}O_2(g) + 2H^+(aq) + 2e^- \rightarrow H_2O(l)$

☒ **D** $O_2(g) + H_2(g) + 2e^- \rightarrow 2OH^-(aq)$

(Total for Question 6 = 1 mark)

7 In homogeneous catalysis, the catalyst is in the same state as the reactants.

(a) The enthalpy profile diagram for a homogeneously catalysed reaction is



Which label indicates the intermediate species?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) Iodide ions can be oxidised by peroxodisulfate(VI) ions in the reaction shown.

$$2I^-(aq) + S_2O_8^{2-}(aq) \rightarrow I_2(aq) + 2SO_4^{2-}(aq)$$

What property of iron(III) ions enables them to act as homogeneous catalysts for this reaction?

(1)

☒ **A** they can be oxidised and then reduced

☒ **B** they can gain and then lose electrons

☒ **C** they provide an effective surface for reaction to occur on

☒ **D** they can form complex ion intermediates with a lower activation energy

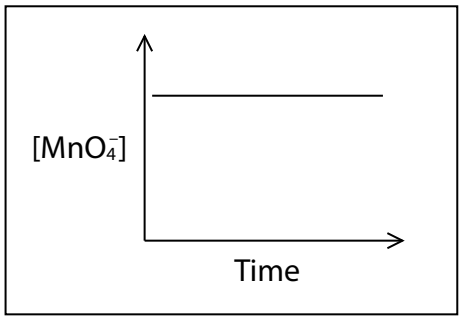
(Total for Question 7 = 2 marks)

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

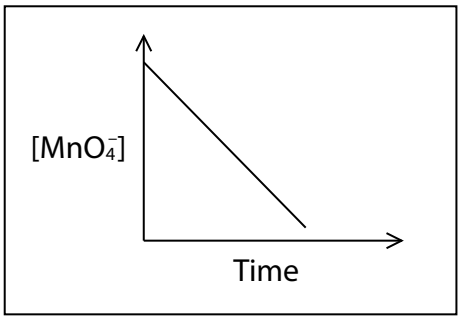
8 Which sketch shows the change in concentration of manganate(VII) ions with time in the reaction?

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

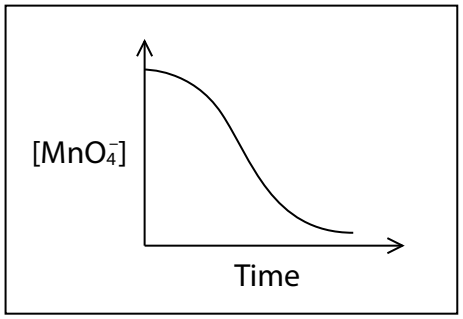
☒ **A**



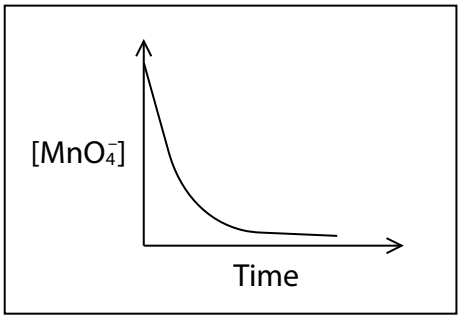
☒ **B**



☒ **C**



☒ **D**



(Total for Question 8 = 1 mark)

9 Identify the correct trend of **increasing** strength as a base.

☒ **A** $C_6H_5—NH_2 < H—NH_2 < CH_3—NH_2$

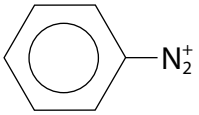
☒ **B** $C_6H_5—NH_2 < CH_3—NH_2 < H—NH_2$

☒ **C** $H—NH_2 < CH_3—NH_2 < C_6H_5—NH_2$

☒ **D** $H—NH_2 < C_6H_5—NH_2 < CH_3—NH_2$

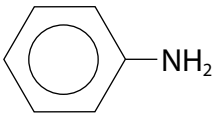
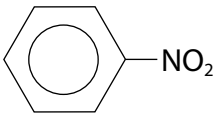
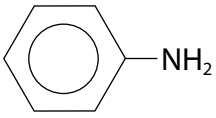
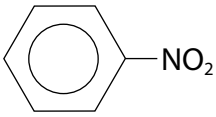
(Total for Question 9 = 1 mark)

10 Azo dyes are made from the benzenediazonium ion.



(a) Benzenediazonium ions can be made from:

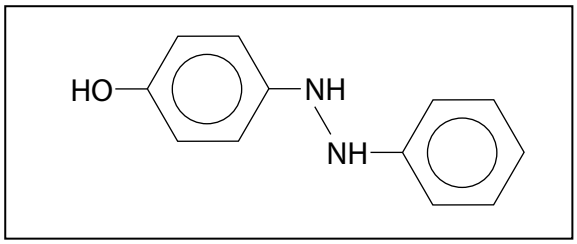
(1)

	Reagent 1	Reagent 2
☒ **A**	HNO_2	
☒ **B**	HNO_2	
☒ **C**	HNO_3	
☒ **D**	HNO_3	

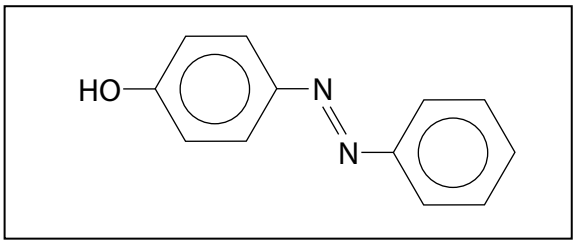
(b) The structure of the azo dye formed when benzenediazonium ions react with phenol is

(1)

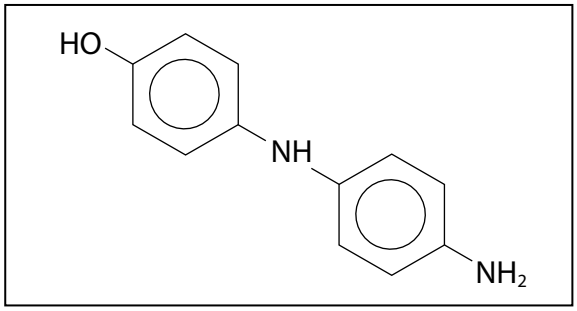
☒ **A**



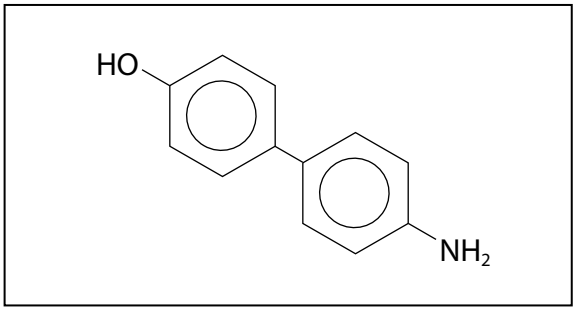
☒ **B**



☒ **C**



☒ **D**



(Total for Question 10 = 2 marks)

11 Which equation shows the two compounds that react to produce ethanamide, CH_3CONH_2, in a single step?

☒ **A** $CH_4 + HCONH_2 \rightarrow CH_3CONH_2 + H_2$

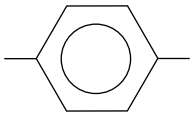
☒ **B** $CH_3COOH + NH_3 \rightarrow CH_3CONH_2 + H_2O$

☒ **C** $CH_3COCl + NH_3 \rightarrow CH_3CONH_2 + HCl$

☒ **D** $CH_3CHO + NH_3 \rightarrow CH_3CONH_2 + H_2$

(Total for Question 11 = 1 mark)

12 What is the number of peaks in a ^{13}C NMR spectrum of 1,4-dimethylbenzene?



☒ **A** 3

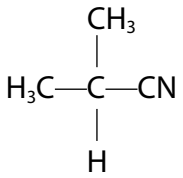
☒ **B** 4

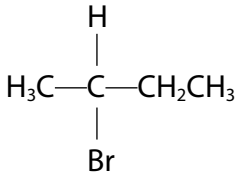
☒ **C** 7

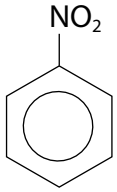
☒ **D** 8

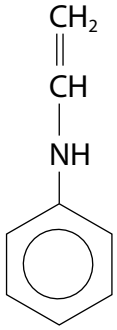
(Total for Question 12 = 1 mark)

13 Which combination of reactants will produce a primary aliphatic amine as the product?

☒ **A**  + Ni/H_2

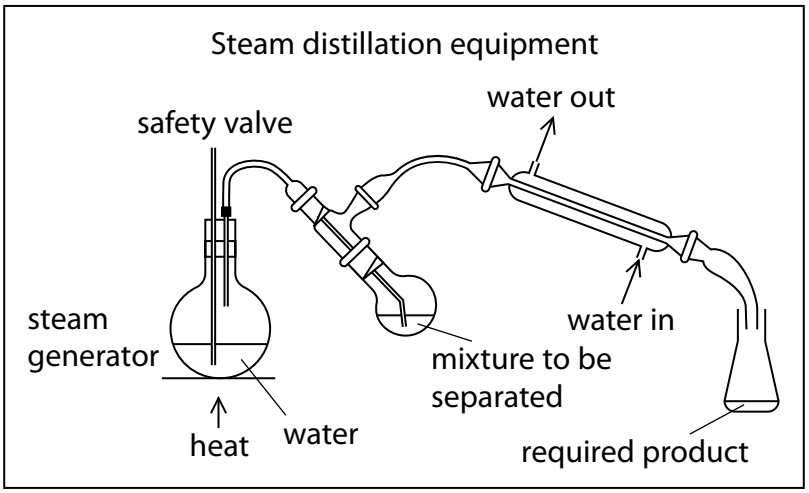
☒ **B**  + CH_3NH_2

☒ **C**  + Sn + conc HCl

☒ **D**  + Ni/H_2

(Total for Question 13 = 1 mark)

14 Steam distillation is a technique used during some organic preparations to separate the product from the reaction mixture.



What benefit is gained from the use of steam distillation compared to other methods of distillation?

- ☒ **A** a pure distillate is produced
- ☒ **B** high distillation temperatures are required
- ☒ **C** it works well for molecules miscible with water
- ☒ **D** it avoids the decomposition of the organic molecule when it distils

(Total for Question 14 = 1 mark)

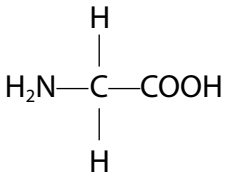
TOTAL FOR SECTION A = 20 MARKS

SECTION B

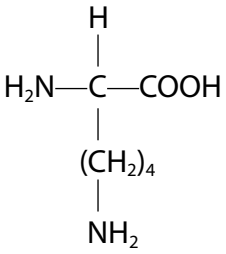
Answer ALL the questions.

Write your answers in the spaces provided.

15 Glycine and lysine are two naturally-occurring amino acids.



glycine



lysine

(a) Write the equation for the reaction of glycine with sodium hydroxide.
State symbols are not required.

(1)

(b) Calculate the volume, in cm^3, of 0.100 mol dm^{-3} hydrochloric acid required to completely react with 1.825 g of lysine.
[M_r of lysine = 146]

(2)

(c) Lysine exists as optically active enantiomers but glycine does not.

(i) Draw three-dimensional diagrams of the two optically active lysine enantiomers.

(2)

(ii) Describe how these optically active enantiomers could be distinguished. Practical details are not required.

(2)

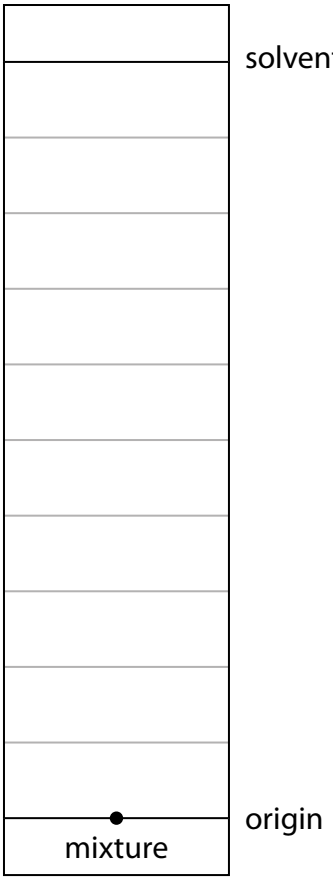
(iii) State why glycine does not exist as enantiomers.

(1)

(d) Chromatography can be used to separate a mixture of glycine and lysine.

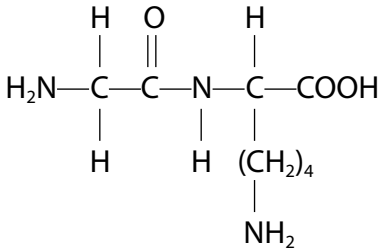
Draw spots to show the location of glycine and lysine on the chromatogram, given that their R_f values are 0.26 and 0.14 respectively.

(1)



(e) Naturally-occurring glycine and lysine can join together to form different dipeptides. Draw a different dipeptide of glycine and lysine.

(1)

Dipeptide 1	Dipeptide 2
	

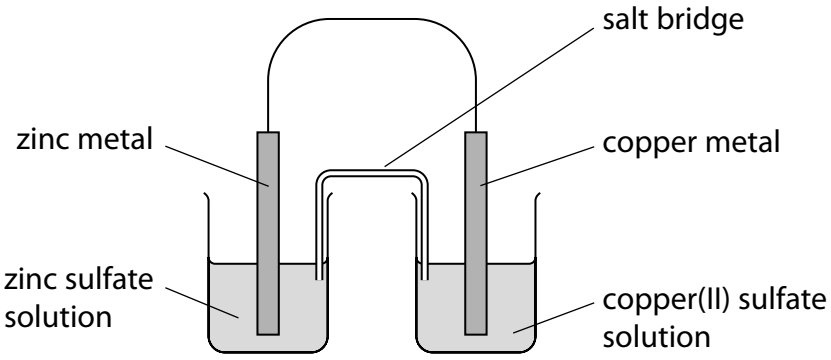
(Total for Question 15 = 10 marks)

16 Standard electrode potentials can be used to show whether or not a reaction is feasible.

(a) State the conditions required, in addition to 1 mol dm^{-3}, for obtaining standard electrode potentials.

(1)

(b) A Daniell cell is a combination of standard zinc and copper electrodes.



The standard electrode potentials measured against a standard hydrogen electrode are shown in the table.

Right-hand electrode system	$E^{\ominus}$/V
$Zn^{2+}(aq) \mid Zn(s)$	–0.76
$Cu^{2+}(aq) \mid Cu(s)$	+0.34

(i) Calculate the standard electrode potential of this cell.

(1)

(ii) Give **three** observations that would be made when current flows for several hours in the Daniell cell.

(2)

(c) Some standard reduction potentials are:

Electrode reaction	$E^{\ominus}$ / V
$Cu^{2+}(aq) + e^- \rightleftharpoons Cu^+(aq)$	+0.15
$Cu^+(aq) + e^- \rightleftharpoons Cu(s)$	+0.52
$Fe^{2+}(aq) + 2e^- \rightleftharpoons Fe(s)$	–0.44
$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$	+0.77

State and justify, in terms of $E^{\ominus}$ cell values, whether copper(I) ions and iron(II) ions will be disproportionate.
Include any equations for reactions which occur.

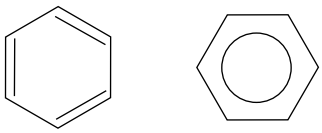
(3)

(d) State one reason why the feasibility determined from standard electrode potentials does not necessarily result in a reaction.

(1)

(Total for Question 16 = 8 marks)

17 Benzene can be represented by either a cyclic triene or with a delocalised ring of electrons.



*(a) Discuss the evidence, including one example from each of spectroscopy, thermochemistry and the type of reaction normally undergone, that supports the view that the better representation of benzene is with a delocalised ring of electrons.

(6)

DO NOT WRITE IN THIS AREA

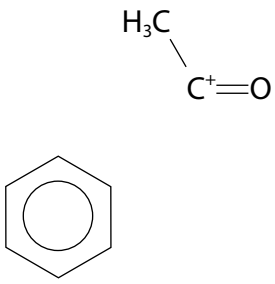
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(b) Benzene can be converted into phenylethanone by a Friedel-Crafts acylation.

(i) Complete the diagram, including curly arrows, to show the mechanism for this reaction.

(4)



(ii) Write an equation to show how the species, CH_3CO^+, could be generated.

(1)

(c) Explain why phenol reacts with bromine more readily than benzene reacts with bromine.

(2)

DO NOT WRITE IN THIS AREA

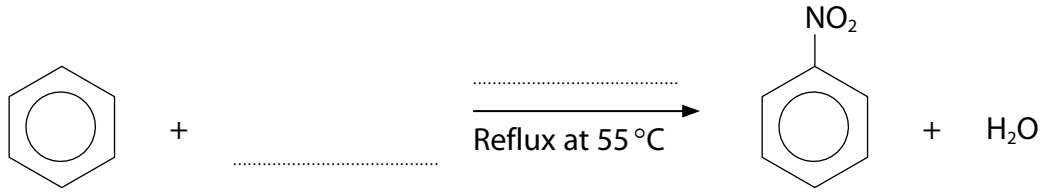
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(d) Benzene can be converted into nitrobenzene.

(i) Complete the flow diagram showing this conversion.

(2)



(ii) Calculate the percentage yield if 0.642 g of nitrobenzene was made from 0.936 g of benzene.

Give your answer to an appropriate number of significant figures.

(3)

(Total for Question 17 = 18 marks)

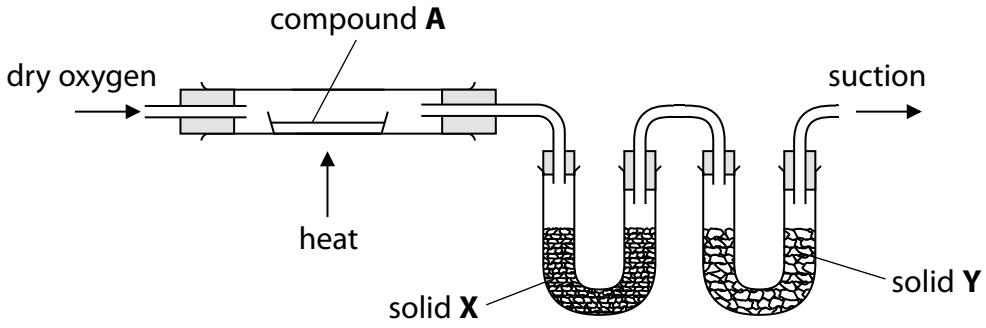
18 Butan-2-ol is a secondary alcohol with four carbon atoms.

(a) Devise a reaction scheme to form butan-2-ol from iodoethane, C_2H_5I, as the only organic compound.

Give reagents, conditions and equations for each of the steps.

(8)

(b) A 1.850 g sample of an organic substance, compound A, that is thought to be butan-2-ol is tested by combustion analysis using the apparatus shown.



absorbs moisture (water)
e.g. anhydrous calcium chloride

absorbs carbon dioxide
e.g. soda lime which is a mixture of calcium hydroxide and sodium hydroxide

(i) Calculate the mass increase of solid X and solid Y that would result if compound A is butan-2-ol.

(4)

(ii) Predict a substance which would give the same mass increase in solids X and Y from combustion analysis as butan-2-ol.
Give a reason for your prediction.

(2)

.....

.....

.....

.....

(Total for Question 18 = 14 marks)

TOTAL FOR SECTION B = 50 MARKS

SECTION C

Answer ALL the questions.

Write your answers in the spaces provided.

19

Brass is a metal alloy containing copper and zinc. The presence of zinc in the alloy makes brass less malleable than copper alone.

Prince's metal is one type of brass. It is used to make imitation gold because of its yellow colour.

The copper content of brass can be analysed by first reacting a known sample of the metal with concentrated nitric acid. The reaction of the copper is:

$$Cu + 4H^+ + 2NO_3^- \rightarrow Cu^{2+} + NO_2 + 2H_2O.$$

(a) Identify the element that is oxidised and the element that is reduced in the reaction shown. Include relevant oxidation numbers.

(2)

(b) Suggest one precaution when carrying out this reaction, other than the use of gloves, goggles and lab coats, clearly stating the hazard concerned.

(2)

(c) The copper ions are then reacted with excess potassium iodide.

$$2Cu^{2+} + 4I^- \rightarrow 2CuI + I_2$$

The iodine formed is analysed by titration with sodium thiosulfate.

$$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$$

A 5.000 g sample of Prince's metal was analysed.
After reaction with concentrated nitric acid, the sample was diluted to 250 cm^3 and then 10.0 cm^3 aliquots or portions were titrated with 0.100 mol dm^{-3} sodium thiosulfate solution.
The mean titre was 22.65 cm^3.

Calculate the percentage of copper, by mass, in this sample of Prince's metal to an appropriate number of significant figures.

(6)

(d) In aqueous solution, copper(II) and zinc ions react differently with sodium hydroxide solution.

Describe the observations when sodium hydroxide solution is added drop by drop (until in excess) to separate samples of these two ions.

Include relevant **ionic** equations with state symbols.

(6)

(e) Explain, in terms of electronic configurations, why copper is classified as a transition element but zinc is not.

(2)

(f) Explain, in terms of their structures, why brass is less malleable than pure copper.

(2)

.....

.....

.....

.....

(Total for Question 19 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS
TOTAL FOR PAPER = 90 MARKS

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

The Periodic Table of Elements

1 (1)	2 (2)											3 (13)	4 (14)	5 (15)	6 (16)	7 (17)	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Key: relative atomic mass / **atomic symbol** / name / atomic (proton) number

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series

Unit 5 - Mark scheme

Question number	Answer	Mark
1(a)	C $[Pt(NH_3)_2Cl_2]$	1

Question number	Answer	Mark
1(b)	A $[CuCl_2]^-$	1

Question number	Answer	Mark
1(c)	D $[Cr(H_2O)_6]^{2+}$	1

Question number	Answer	Mark
2	B VO_2^+	1

Question number	Answer	Mark
3	C sodium hydroxide	1

Question number	Answer	Mark
4	B ethanoate ion, CH_3COO^-	1

Question number	Answer	Mark
5(a)	D the colour change of the reduction of the manganate(VII) ions is sufficient	1

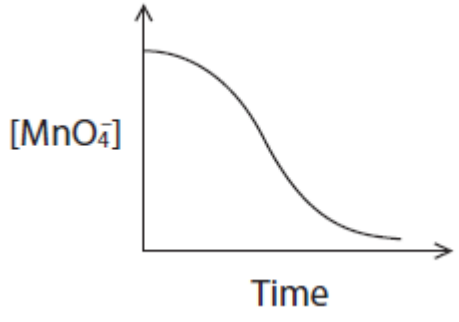
Question number	Answer	Mark
5(b)	B uncertainty 0.06%	1

Question number	Answer	Mark
5(c)	D 0.014	1

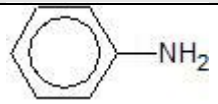
Question number	Answer	Mark
6	A $\frac{1}{2}O_2(g) + H_2O(l) + 2e^- \rightarrow 2OH^-(aq)$	1

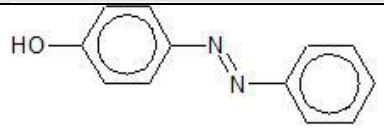
Question number	Answer	Mark
7(a)	C this label indicates the intermediate species	1

Question number	Answer	Mark
7(b)	B they can gain and then lose electrons	1

Question number	Answer	Mark
8	 C	1

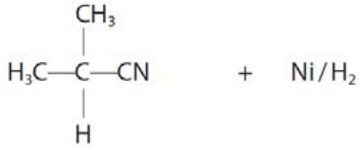
Question number	Answer	Mark
9	A $C_6H_5–NH_2 < H–NH_2 < CH_3–NH_2$	1

Question number	Answer	Mark
10(a)	A HNO_2 	1

Question number	Answer	Mark
10(b)	 B	1

Question number	Answer	Mark
11	C $CH_3COCl + NH_3 \rightarrow CH_3CONH_2 + HCl$	1

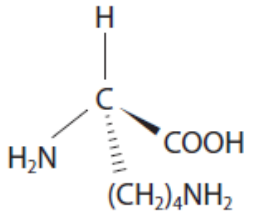
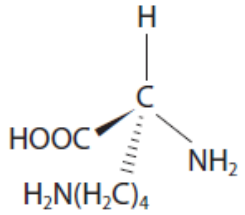
Question number	Answer	Mark
12	A 3	1

Question number	Answer	Mark
13	 A	1

Question number	Answer	Mark
14	D it avoids the decomposition of the organic molecule when it distils	1

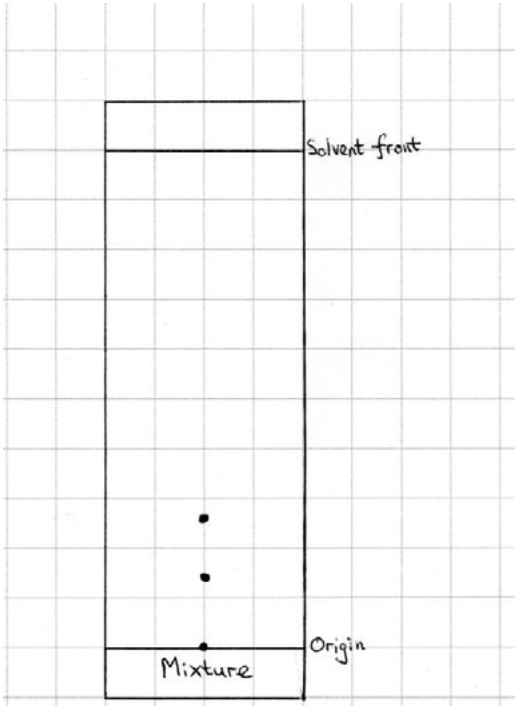
Question number	Answer	Additional guidance	Mark
15(a)	A suitable equation such as: • $NH_2CH_2COOH + NaOH \rightarrow NH_2CH_2COO^{(-)}Na^{(+)} + H_2O$	 Allow zwitterion ionic equation displayed formulae Ignore state symbols even if incorrect Do not award O-Na	1

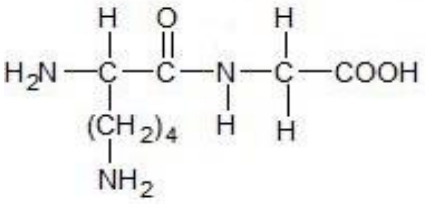
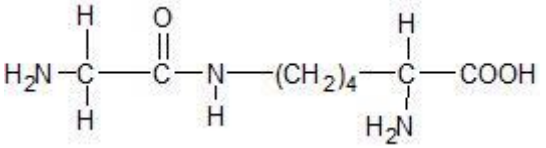
Question number	Answer	Additional guidance	Marks
15(b)	• number of moles of lysine **and** number of moles of HCl (1) • volume of HCl in cm^3 (1)	Example of calculation: n(1.825 ÷ 146=) 0.0125 (mol) n(0.0125 × 2=) 0.025 (mol) V = (0.025 ÷ 0.100) × 1000 = 250 cm^3 Allow answer in dm^3 Allow 1 mark for 125 cm^3	**2**

Question number	Answer	Additional guidance	Marks
15(c)(i)	 (1)  (1)	Structures must be 3-dimensional Allow any orientation	**2**

Question number	Answer	Additional guidance	Marks
15(c)(ii)	A description which includes: • the plane of plane-polarised (monochromatic) light (1) • will be rotated equally but in opposite directions by the two enantiomers/left by one (laevo-rotatory) enantiomer and to the right by the other (dextro-rotatory) enantiomer. (1)	Allow omission of one plane Allow use of d and l/(+) and (−) Do not award use of D and L	**2**

Question number	Answer	Additional guidance	Marks
15(c)(iii)	• glycine does not have a chiral carbon/centre or asymmetric carbon or is superimposable on its mirror image		1

Question number	Answer	Additional guidance	Marks
15(d)	A suitable diagram such as:  	Allow spots of any reasonable size and anywhere within the range for lysine 0.1-0.2 and for glycine 0.2-0.3	1

Question number	Answer	Additional guidance	Marks
15(e)	A diagram such as: • 	Allow: 	1

Question number	Answer	Additional guidance	Marks
16(a)	• 298 K and 100 kPa (of gases)	Accept 25 °C Accept 1 atm	1

Question number	Answer	Additional guidance	Marks
16(b)(i)	• $E^{\ominus}_{cell}$ = (+0.34 − −0.76=) (+)1.10 (V)		1

Question number	Answer	Additional guidance	Marks
16(b)(ii)	An answer to include observations such as: • blue colour of copper(II) sulfate becomes paler • (pink/brown) copper metal deposited (on the electrode surface) • zinc electrode decreases in size.	Observations can be in any order Three observations scores 2 Two observations scores 1	2

Question number	Answer	Additional guidance	Marks
16(c)	A justification that makes reference to the following points: • Iron $E^{\ominus}_{cell}$ = (−0.44 − +0.77 =) −1.21 (V) (1) **and** Copper $E^{\ominus}_{cell}$ = (+0.52 − +0.15 =) +0.37 (V) • $2Cu^{+} \rightarrow Cu^{2+} + Cu$ (1) • comment on copper electrode potential is positive so disproportionation is feasible and iron electrode potential is negative so disproportionation is not feasible. (1)	Ignore: $3Fe^{2+} \rightarrow Fe + 2Fe^{3+}$ Ignore state symbols	3

Question number	Answer	Additional guidance	Marks
16(d)	• High activation energy/physical barrier prevents reaction Reaction is (very) slow Reaction conditions may not be standard		1

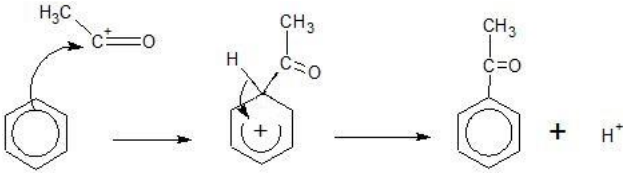
<table>
<tr><th>Question number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>17(a)</td><td>
This question assesses the student's ability to show a coherent and logically structured answer with linkages and fully sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content.
<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5-4</td><td>3</td></tr>
<tr><td>3-2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table>
The following table shows how the marks should be awarded for structure and lines of reasoning.
<table>
<tr><th></th><th>Number of marks awarded for structure of answer and sustained lines of reasoning</th></tr>
<tr><td>Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr>
<tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr>
</table>
</td><td>
Guidance on how the mark scheme should be applied.
The mark for indicative content should be added to the mark for lines of reasoning. For example, a response with four indicative marking points that is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).
If there were no linkages between the points, then the same indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and zero marks for linkages).

If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded, do not deduct mark(s).
</td><td>6</td></tr>
</table>

Question number	Answer	Additional Guidance
17(a) *Cont.*	**Indicative content:** Spectroscopy: (IP 1 and 2) either X-ray diffraction • all C-C bond lengths in benzene are equal • but if it was a cyclic triene then they would alternate in 'short' and 'long' lengths or which is consistent with equivalent C-C bonds with a delocalised ring of electrons or (infrared spectroscopy) • benzene has peaks at 1600, 1580, 1500, 1450 (cm^{-1}) for an aromatic C=C • alkene C=C has a peak at 1669 – 1645 (cm^{-1}). Thermochemistry: (IP 3 and 4) • enthalpy of hydrogenation is less exothermic than expected for a cyclic triene or enthalpy of combustion data • which is consistent with the delocalisation stability of the ring from the ring of electrons Type of reaction: (IP 5 and 6) • benzene undergoes substitution reactions • alkenes undergo addition reactions/decolourise bromine water.	Ignore references to equal/120° bond angles Allow for one indicative point The infrared spectrum for benzene has a peak for an aromatic C=C at a different wavenumber/absorption/frequency to an alkene C=C Allow benzene is more stable by ~150 kJ mol^{-1} Stated enthalpies (of hydrogenation) −205 to −210 kJ mol^{-1} for benzene and −360 kJ mol^{-1} for 3 (localised C=C) double bonds Allow di-substitution There are only 3 isomers of di-substituted compounds (not 4) or some di-substituted compounds are the same, e.g. 1,2 and 1,6

Question number	Answer	Additional guidance	Marks
17(b)(i)	An answer that makes reference to the following points: • electron pair movement from ring to electrophile (1) • formula of intermediate ion (1) • movement of electron pair to reinstate delocalised ring (1) • formulae of products. (1)	Allow arrow that starts from anywhere from within the hexagon 'Horseshoe' to cover at least three carbon atoms and facing the tetrahedral carbon with some part of the positive sign to be inside the 'horseshoe'. Exemplar mechanism:  Do not award dotted bonds unless clearly part of a 3-D structure	4

Question number	Answer	Additional guidance	Marks
17(b)(ii)	• $CH_3COCl + AlCl_3 \rightarrow CH_3CO^+ + AlCl_4^-$	Accept use of $FeCl_3/Fe + 3Cl_2$	1

Question number	Answer	Additional guidance	Marks
17(c)	An explanation that make reference to the following points: • lone pair of electrons on the oxygen atom increases the electron density of the ring (1) • more susceptible to attack by electrophiles. (1)		2

Question number	Answer	Additional guidance	Marks
17(d)(i)	• (reactant) (conc) HNO_3 (1) • (catalyst) (conc) H_2SO_4 (1)	Ignore name Allow name Penalise reference to dilute acid once only	2

Question number	Answer	Additional guidance	Marks
17(d)(ii)	• calculation of molar masses (1) • number of moles of benzene and maximum mass of nitrobenzene (1) • percentage yield of nitrobenzene to 2/3 SF (1)	Example of calculation: M_r of benzene = 78 **and** M_r of nitrobenzene = 123 n(0.936 ÷ 78=) 0.012 (mol) m(0.012 × 123=) 1.476 (g) % = ((0.642 ÷ 1.476) × 100= 43.4959) = 43.5/43% Do not award 44%	3

Question number	Answer		Additional guidance	Marks
18(a)	An answer that makes reference to the following points:		Accept displayed/skeletal formulae	**8**
	• react iodoethane with **aqueous** hydroxide ions	(1)	Accept aqueous sodium hydroxide/ potassium hydroxide	
	• $C_2H_5I + OH^- \rightarrow C_2H_5OH + I^-$	(1)	$C_2H_5I + NaOH \rightarrow C_2H_5OH + NaI$	
	• oxidation of C_2H_5OH with acidified dichromate(VI) under **distillation** conditions	(1)	Accept reference to sodium/ potassium dichromate(VI)	
	• $C_2H_5OH + [O] \rightarrow CH_3CHO + H_2O$	(1)		
	• react iodoethane with magnesium (in **ethoxyethane)**	(1)		
	• $C_2H_5I + Mg \rightarrow C_2H_5MgI$	(1)		
	• reaction of ethylmagnesium iodide with ethanal to form butan-2-ol	(1)		
	• $C_2H_5MgI + CH_3CHO + H_2O \rightarrow C_2H_5CH(OH)CH_3 + Mg(OH)I$	(1)	Allow this to be shown as two separate equations	

Question number	Answer		Additional guidance	Marks
18(b)(i)	• calculation of number of moles of butan-2-ol	(1)	Example of calculation: n=(1.850 ÷ 74 =) 0.025 (mol)	4
	• calculation of number of moles of carbon dioxide and water	(1)	$n(CO_2) = 4 \times 0.025 = 0.100$ (mol) and $n(H_2O) = 5 \times 0.025 = 0.125$ (mol)	
	• calculation of carbon dioxide mass/mass increase of solid X	(1)	$m(CO_2) = 0.100 \times 44 = 4.40$ (g)	
	• calculation of mass of water/mass increase of solid Y	(1)	$m(H_2O) = 0.125 \times 18 = 2.25$ (g)	

Question number	Answer		Additional guidance	Marks
18(b)(ii)	Prediction: • suitable example by name or formula.	(1)	Allow structural /displayed / skeletal formula. Any molecule with the molecular formula $C_4H_{10}O$	2
	Reason: • the same molecular formula as butan-2-ol / is an isomer of butan-2-ol.	(1)	Do not award just '$C_4H_{10}O$'	

Question number	Answer		Additional guidance	Marks
19(a)	• copper is **oxidised** from 0 to +2	(1)	Look at the equation in the question for the correct oxidation number changes if not given on the answer lines Award maximum of one mark if the terms oxidised and reduced are not used or used the wrong way round	2
	• nitrogen is **reduced** from (+)5 to (+)4	(1)		

Question number	Answer	Additional guidance	Mark
19(b)	An answer which makes reference to the following points: • (precaution) carry out in a fume cupboard (1) • (hazard) toxic nitrogen dioxide/NO_2 gas. (1)	Accept the points in either order Do not award 'well-ventilated laboratory/ face masks' Allow poisonous	**2**

Question number	Answer	Additional guidance	Marks
19(c)		Example of calculation:	**6**
	• calculation of the number of moles of thiosulfate (1)	$n(S_2O_3^{2-}) = (22.65 \times 0.100 \div 10000=)$ $= 2.265 \times 10^{-3}$ /0.002265 (mol)	
	• evaluation of the number of moles of iodine (1)	$n(I_2) = (2.265 \times 10^{-3} \div 2=)$ $= 1.1325 \times 10^{-3}$ / 0.0011325 (mol)	
	• evaluation of the number of moles of copper ions in the 10.0 cm^3 aliquot (1)	$n(Cu^{2+}) = (1.1325 \times 10^{-3} \times 2=)$ $= 2.265 \times 10^{-3}$ / 0.002265 (mol)	
	• evaluation of the number of moles of copper ions in 250 cm^3 (1)	$n(Cu^{2+}) = (2.265 \times 10^{-3} \times 25)$ $= 5.6625 \times 10^{-2}$ / 0.056625 (mol)	
	• evaluation of mass of copper ions in sample (1)	$m(Cu^{2+}) = (5.6625 \times 10^{-2} \times 63.5=)$ $= 3.5956875$ (g)	
	• evaluation of percentage of copper in sample to 2/3 SF (1)	% = (3.5956875 ÷ 5.0000 × 100= 71.91375=) = 72/71.9 % Penalise inappropriate rounding once only Correct answer with no working scores 6 marks	

Question number	Answer		Additional guidance	Marks
19(d)	An answer that makes reference to the following points:			6
	• colours of the precipitates formed	(1)	Blue precipitate with copper(II) ions **and** white precipitate with zinc ions	
	• addition of excess sodium hydroxide has no effect on copper precipitate	(1)		
	• but the zinc precipitate dissolves to form colourless solution	(1)	Do not award 'clear'	
	• equation for the formation of a precipitate for either copper(II) or zinc ions	(1)	Example of equations: $[Cu(H_2O)_6]^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(H_2O)_4OH)_2(s) + 2H_2O(l)$ or $[Zn(H_2O)_6]^{2+}(aq) + 2OH^-(aq) \rightarrow Zn(OH)_2(s) + 6H_2O(l)$ or $Cu^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(OH)_2(s)$ or $Zn^{2+}(aq) + 2OH^-(aq) \rightarrow Zn(OH)_2(s)$	
	• equation for the dissolving of the zinc precipitate	(1)	$Zn(OH)_2(s)+2OH^-(aq)\rightarrow[Zn(OH)_4]^{2-}(aq)$	
	• all state symbols correct.	(1)		

Question number	Answer	Additional guidance	Marks
19(e)	An explanation that makes reference to: • copper forms an ion with an incomplete d subshell (1) • but the only ion that zinc forms has a completely filled d subshell. (1)		**2**

Question number	Answer	Additional guidance	Marks
19(f)	A explanation that makes reference to: • the atoms/cations are of different size (in brass) (1) • therefore the layers do not slide over one another so easily. (1)	Ignore movement of the electrons Accept a labelled diagram	**2**

Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

International Advanced Level
Unit 6: Practical Skills in Chemistry II

Sample Assessment Materials for first teaching September 2018

Time: 1 hour 20 minutes

Paper Reference
WCH16/01

You must have:
Scientific calculator, ruler

Total Marks

Instructions

- Use **black** ink or **black** ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*
- **Show all your working in calculations and include units where appropriate.**

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- There is a Periodic Table on the back page of this paper.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

S58314A

1/1/1/

S 5 8 3 1 4 A 0 1 1 2

Pearson

Answer ALL the questions.

Write your answers in the spaces provided.

1 A series of tests was carried out on a pale green inorganic compound **A** which contained two cations and one anion.

(a) Dilute sodium hydroxide solution was added drop by drop to 5 cm^3 of an aqueous solution of **A** until there was no further reaction.

A green precipitate was formed which was filtered off and, after some time, turned into a brown solid.

(i) Give the **formula** of the cation in **A** shown by this test.

(1)

.....

(ii) Give the **formula** of the green precipitate.

(1)

.....

(iii) Identify, by name or formula, the brown solid.

(1)

.....

(iv) State the type of reaction that occurred when the green precipitate turned brown.

(1)

.....

(v) Give the reason why dilute sodium hydroxide is added drop by drop when testing for cations.

(1)

.....

.....

.....

.....

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(b) The filtrate was heated gently and an alkaline gas was given off.

(i) Describe a test and its positive result to show that the gas was alkaline.

(2)

(ii) Describe a further chemical test and its result to confirm that the gas was ammonia.

(2)

(c) A 1 cm^3 sample of an aqueous solution of **A** was acidified with dilute hydrochloric acid and a few drops of barium chloride solution were added. A white precipitate was formed which identified the anion in **A** as the sulfate ion.

(i) State the reason for the addition of dilute hydrochloric acid.

(1)

(ii) Bottles of solid barium chloride have the hazard label:

Give a precaution, other than wearing lab coats and goggles, that would reduce the risk in preparing a solution of barium chloride. Justify your choice.

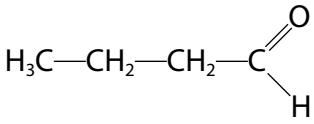
(1)

(d) Suggest a formula for **A**. Do not include water of crystallisation.

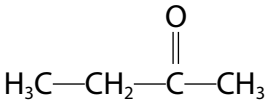
(1)

(Total for Question 1 = 12 marks)

2 A student was asked to investigate two liquids, labelled **X** and **Y**. One liquid was butanal and the other was butanone.



butanal



butanone

(a) Describe a test, including the expected observation, which would be positive for both liquids.

(2)

.....

.....

.....

(b) Describe two chemical tests, including the expected observations, which each give a positive result with butanal and no reaction with butanone.

(4)

Test 1.....

.....

.....

Test 2.....

.....

.....

(c) State what is observed when an alkaline solution of iodine is added to butanone and the mixture warmed.

(1)

.....

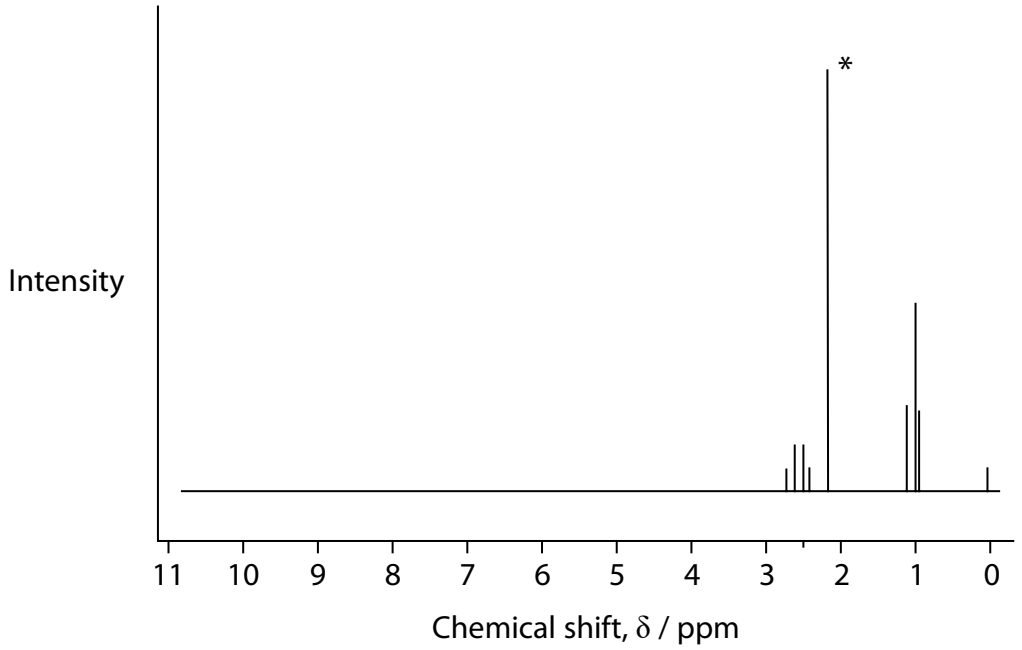
.....

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(d) The high resolution proton nuclear magnetic resonance (NMR) spectrum of **X** is shown.



(i) Deduce the identity of substance **X**. Refer only to the peak with the asterisk(*) which is a singlet with a relative peak area of three.

(3)

(ii) The proton NMR spectrum has a small peak with a chemical shift, $\delta = 0$ parts per million (ppm) which does not result from substance **X**.

Explain the presence of this small peak, identifying the compound responsible.

(2)

(Total for Question 2 = 12 marks)

3 This question is about the preparation of a complex salt of cobalt(III).

The overall equation for the formation of this complex salt is:

$$2HNO_3 + 2Co(NO_3)_2.6H_2O + H_2O_2 + 10NH_3 \rightarrow 2Co(NH_3)_5(H_2O)(NO_3)_3 + 12H_2O.$$

Procedure

Step **1** Add 3.6 g of hydrated cobalt(II) nitrate, $Co(NO_3)_2.6H_2O$, to 2.5 g of ammonium nitrate, NH_4NO_3, in a large beaker.

Step **2** Add just enough hot water to dissolve the two salts.

Step **3** Keeping the beaker warm on a hot plate, add 40 cm^3 of aqueous ammonia.

Step **4** Over a period of about 30 minutes, add a total volume of 25 cm^3 of 3.0% (3.0 g per 100 cm^3) hydrogen peroxide to the mixture. Allow the mixture to cool.

Step **5** Carefully add 40 cm^3 of concentrated nitric acid to the mixture and leave to stand for a further 10 minutes.

Step **6** To precipitate the complex salt, add cold ethanol to the mixture and filter the solid formed under reduced pressure.

Step **7** Recrystallise the complex salt.

(a) (i) The hydrogen peroxide is used to oxidise cobalt(II) to cobalt(III). The reduction half-equation is:

$$H_2O_2 + 2H^+ + 2e^- \rightarrow 2H_2O.$$

Deduce the ionic equation for the reaction of hydrogen peroxide with cobalt(II) ions.

State symbols are not required.

(1)

(ii) Show by calculation that there is sufficient hydrogen peroxide to oxidise all of the cobalt(II) ions.

(4)

(iii) In Step **4**, when an excess of hydrogen peroxide is added, bubbles are seen. The gas relights a glowing splint.
Identify the gas and write an equation for the formation of this gas.

(2)

(b) State the purpose of ethanol in Step **6** and why it is cold.

(2)

(c) Draw a labelled diagram of the apparatus used for filtration under reduced pressure in Step **6**.

(3)

(d) This complex salt can be recrystallised using ethanol as the solvent.

(i) State why the salt is dissolved in the **minimum** volume of hot ethanol.

(1)

(ii) The hot solution is filtered. Name the type of impurities removed in this filtration.

(1)

(iii) The solution is cooled and then filtered. Name the type of impurities removed in this filtration.

(1)

(iv) Describe the final stage required to obtain pure crystals of the complex salt.

(2)

(e) (i) One student found the yield of their complex salt to be 110%.

Suggest a possible reason for this.

(1)

.....

.....

(ii) A second student found the yield of their complex salt to be 80%.

On reweighing their salt after 24 hours, their yield had decreased to 75%.
Suggest a possible reason for this.

(1)

.....

.....

(Total for Question 3 = 19 marks)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

4 A class of students was given an outline method for an experiment to determine the acid dissociation constant, K_a, of propanoic acid.

Step **1** Pipette 25.0 cm^3 of 0.1 mol dm^{-3} propanoic acid into a conical flask.

Step **2** Add 3 or 4 drops of phenolphthalein indicator to the solution in the conical flask.

Step **3** Fill a burette with sodium hydroxide solution.

Step **4** Add the sodium hydroxide solution from the burette to the conical flask until a pale pink colour remains after swirling.

Step **5** Use a pipette to transfer a further 25.0 cm^3 of the propanoic acid to the solution in the conical flask.

Step **6** Use a pH meter to measure the pH of this mixture.

The temperature of all solutions were maintained at 25 °C.

(a) State and justify why, before carrying out Step **1**, the pipette should be rinsed with propanoic acid after rinsing with deionised water.

(1)

(b) State and justify the effect, if any, on the value of K_a calculated if, in Step **3**, there is an air bubble in the tip of the burette.

(1)

(c) At the end of Step **4**, one student had a deep pink coloured solution in their conical flask.
Give a reason for the presence of this colour.

(1)

(d) The measurement uncertainty of the pipette is ±0.06 cm^3.

Calculate the percentage uncertainty when 25.0 cm^3 is added from the pipette.

(1)

(e) Describe how the pH meter should be calibrated before Step **6**.

(1)

(f) One student obtained a value of pH = 4.9 in Step **6**.

Calculate K_a, including units, giving your answer to an appropriate number of significant figures.

(2)

(Total for Question 4 = 7 marks)

TOTAL FOR PAPER = 50 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
							1.0 H hydrogen 1										(18) 4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds damstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

Question number	Answer	Additional guidance	Mark
1(a)(i)	• (cation) $Fe^{2+}/[Fe(H_2O)_6]^{2+}$	Ignore names and any state symbols even if incorrect	1

Question number	Answer	Additional guidance	Mark
1(a)(ii)	• (green precipitate) $Fe(OH)_2/Fe(H_2O)_4(OH)_2$	Ignore names and any state symbols even if incorrect	1

Question number	Answer	Additional guidance	Mark
1(a)(iii)	• iron(III) hydroxide or • $Fe(OH)_3/Fe(H_2O)_3(OH)_3$	Ignore any state symbols even if incorrect Do not award Fe_2O_3	1

Question number	Answer	Additional guidance	Mark
1(a)(iv)	• Oxidation	Allow redox	1

Question number	Answer	Additional guidance	Mark
1(a)(v)	An answer that makes reference to: • if a precipitate is formed then it may dissolve in excess or • the precipitate may be amphoteric and dissolve in excess.	Allow The formation of the precipitate might be overlooked (if the hydroxide is amphoteric / dissolves)	1

Question number	Answer	Additional guidance	Marks
1(b)(i)	A description that makes reference to: • use of (damp) red litmus paper (1) • change from red to blue (shows alkalinity). (1)	Allow universal indicator paper (Yellow) to blue Do not award testing with HCl(g) or result	2

Question number	Answer	Additional guidance	Marks
1(b)(ii)	A description that makes reference to: • use of (conc.) HCl(aq) on a glass rod held in the gas or • use of (conc.) HCl(aq) on a glass stopper held in the gas (1) • formation of white smoke (shows presence of ammonia). (1)	Do not award adding dilute hydrochloric acid Allow white fumes / white solid Ignore reference to indicator and/or smell Do not award steamy fumes	2

Question number	Answer	Additional guidance	Mark
1(c)(i)	• (acid) removes carbonate ions that also give a white precipitate or • prevents other anions forming a white precipitate	Allow sulfite ions for carbonate ions	1

Question number	Answer	Additional guidance	Mark
1(c)(ii)	Route 1: • use of mask/fume cupboard **and** prevent breathing in dust. or Route 2: • use of gloves **and** poison could be irritating to the skin.	 Allow poison could be absorbed by the skin	1

Question number	Answer	Additional guidance	Mark
1(d)	• Any ratio of Fe^{2+}, NH_4^+ and SO_4^{2-} ions that gives a neutral species	Example formula: $Fe(NH_4)_2(SO_4)_2$ Allow separate formulae:$(NH_4)_2SO_4$ **and** $FeSO_4$	1

Question number	Answer	Additional guidance	Marks
2(a)	A description that makes reference to: • addition of Brady's reagent/2,4-dintrophenylhydrazine (1) • formation of orange precipitate. (1)	 Allow 2,4-DNPH/2,4-DNP Colour and state required Allow red/yellow	2

Question number	Answer	Additional guidance	Marks
2(b)	A description of any two of the following tests: Test 1: • (warm with) Tollens' reagent/ammoniacal silver nitrate (1) • formation of silver 'mirror'/solid silver/black solid. (1) or Test 2: • (heat with) addition of Fehling's/Benedict's solution (1) • change (from blue solution) to (brick) red precipitate. (1) or Test 3: • (heat with) addition of acidified potassium dichromate(VI) (1) • colour change (of orange) to green. (1)	Ignore references to spectroscopy Accept description of formation of Tollens' reagent Do not award Fehling's and Benedict's as separate tests Allow acidified dichromate((VI)) ions Accept orange to blue	4

Question number	Answer	Additional guidance	Mark
2(c)	• (pale) yellow precipitate	Allow antiseptic smell Ignore name of precipitate	1

Question number	Answer	Additional guidance	Marks
2(d)(i)	A deduction that makes reference to: • area ratio of three means three equivalent hydrogens/three hydrogens in the same (chemical) environment (1) • (splitting pattern of a singlet) as there are no hydrogens on the adjacent carbon (1) • hence **X** is butanone. (1)	Accept 'proton' for 'hydrogen' Ignore reference to chemical shift Do not award identification unless an attempt at justification is given	**3**

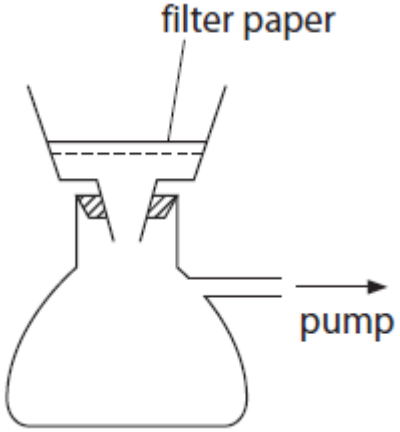
Question number	Answer	Additional guidance	Marks
2(d)(ii)	An explanation that makes reference to: • peak is due to TMS/tetramethylsilane (1) • added to calibrate the NMR machine (1) or • added to provide a reference point/a zero point		**2**

Question number	Answer	Additional guidance	Mark
3(a)(i)	• $2Co^{2+} + H_2O_2 + 2H^+ \rightarrow 2Co^{3+} + 2H_2O$	Allow multiples Ignore state symbols even if incorrect	**1**

Question number	Answer		Additional guidance	Marks
3(a)(ii)	• calculation of number of moles of hydrogen peroxide	(1)	Example of calculation: $n(H_2O_2)$ = (0.75 ÷ 34=) 0.022. (mol)	4
	• calculation of M_r of $Co(NO_3)_2.6H_2O$	(1)	M_r = 290.9	
	• calculation of number of moles of $Co(NO_3)_2.6H_2O$	(1)	0.012375 (mol)	
	• use of mol ratio	(1)	Minimum H_2O_2 needed = 0.012375 ÷ 2 = 0.006188 (mol)	

Question number	Answer		Additional guidance	Marks
3(a)(iii)	• oxygen (gas)	(1)		2
	• $H_2O_2 \rightarrow ½O_2 + H_2O$	(1)	Allow multiples Ignore state symbols even if incorrect	

Question number	Answer		Additional guidance	Marks
3(b)	An answer that makes reference to:			2
	• the salt is less soluble in ethanol (than water)	(1)		
	• solubility decreases with temperature.	(1)		

Question number	Answer	Additional guidance	Marks
3(c)	A labelled diagram that includes: • Buchner/side-armed flask (1) • side-arm connected to pump/water aspirator (1) • funnel with flat filter paper. (1)	Exemplar diagram:  Do not award fluted filter paper	3

Question number	Answer	Additional guidance	Mark
3(d)(i)	An answer that makes reference to: • the smallest amount of product remains in solution (after crystallisation).	Accept: to form a saturated solution. Ignore: to maximise yield.	1

Question number	Answer	Additional guidance	Mark
3(d)(ii)	• insoluble impurities		1

Question number	Answer	Additional guidance	Mark
3(d)(iii)	• soluble impurities		1

Question number	Answer	Additional guidance	Marks
3(d)(iv)	A description including: • the crystals need to be dried (1) • method of drying. (1)	Examples of acceptable methods: between filter papers or in a desiccator or in a warm oven	2

Question number	Answer	Additional guidance	Mark
3(e)(i)	An answer that makes reference to: • the crystals are not dry/the mass of the crystals includes ethanol.		1

Question number	Answer	Additional guidance	Mark
3(e)(ii)	An answer that makes reference to: • the crystals lose ammonia.	Allow loss of water loss of ethanol	1

Question Number	Answer	Additional guidance	Mark
4(a)	• deionised water may be left in the pipette which will dilute the propanoic acid dispensed from it		1

Question Number	Answer	Additional guidance	Mark
4(b)	A statement that makes reference to: • no effect (on K_a) and because the colour change to pale pink is important and not the accurate volume added from the burette.		1

Question Number	Answer	Additional guidance	Mark
4(c)	• too much/excess sodium hydroxide added from the burette	Do not award reference to too much phenolphthalein/indicator added	1

Question Number	Answer	Additional guidance	Mark
4(d)	• calculation of percentage uncertainty	Example of calculation: % = ((0.06 ÷ 25.00) × 100 =) 0.24%	1

Question Number	Answer	Additional guidance	Mark
4(e)	A description that makes reference to: • use of a buffer of known pH.		1

Question Number	Answer	Additional guidance	Marks
4(f)	• evaluation (1) • units and SF (1)	Example of calculation: $K_a = 10^{-pH}$ $= 1.2589 \times 10^{-5}$ $= 1/1.3/1.26 \times 10^{-5}$ mol dm^{-3}	2

edexcel

FOR INFORMATION ABOUT EDEXCEL, BTEC OR LCCI QUALIFICATIONS
VISIT QUALIFICATIONS.PEARSON.COM

PEARSON EDUCATION LIMITED. REGISTERED IN ENGLAND AND WALES NO. 872828
REGISTERED OFFICE: 80 STRAND, LONDON WC2R 0RL
VAT REG NO GB 278 537121

GETTY IMAGES: ALEX BELMONLINSKY

ISBN 978-1-4469-4657-2