edexcel

INTERNATIONAL ADVANCED LEVEL

Chemistry

SAMPLE ASSESSMENT MATERIALS

Pearson Edexcel International Advanced Subsidiary in Chemistry (XCH01)

Pearson Edexcel International Advanced Level in Chemistry (YCH01)

For first teaching in September 2013
First examination January 2014

ALWAYS LEARNING

PEARSON

Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Sample Assessment Material
Time: 1 hour 30 minutes

Paper Reference
WCH01/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or 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.*

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.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

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

Turn over ▶

S45360A

S 4 5 3 6 0 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 Which of the following quantities, used in the calculation of the lattice energy of lithium oxide, Li_2O, has a negative value?

☒ **A** The enthalpy change of atomization of lithium.

☒ **B** The first ionization energy of lithium.

☒ **C** The first electron affinity of oxygen.

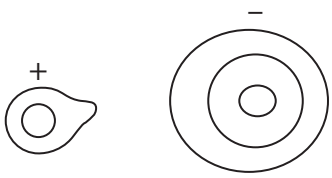
☒ **D** The second electron affinity of oxygen.

(Total for Question 1 = 1 mark)

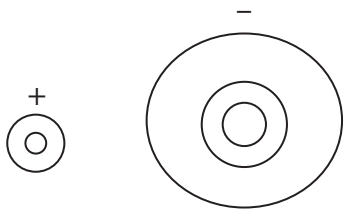
2 Which of the diagrams below best represents the shapes of the electron contours in sodium fluoride?

☒ **A**

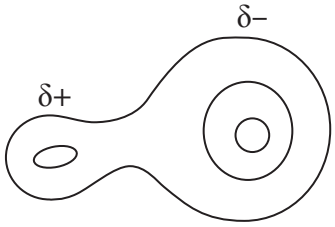
☒ **B**



☒ **C**



☒ **D**



(Total for Question 2 = 1 mark)

3 Which of the equations below represents the first electron affinity for oxygen?

☒ **A** $O_2(g) + 2e^- \rightarrow 2O^-(g)$

☒ **B** $O_2(g) - 2e^- \rightarrow 2O^-(g)$

☒ **C** $\frac{1}{2}O_2(g) + e^- \rightarrow O^-(g)$

☒ **D** $O(g) + e^- \rightarrow O^-(g)$

(Total for Question 3 = 1 mark)

4 Which pair of ions is isoelectronic?

☒ **A** Ca^{2+} and O^{2-}

☒ **B** Na^+ and O^{2-}

☒ **C** Li^+ and Cl^-

☒ **D** Mg^{2+} and Cl^-

(Total for Question 4 = 1 mark)

5 A drop of sodium manganate(VII) solution is placed at the centre of a piece of moist filter paper on a microscope slide. The ends of the paper are clipped to a 30 V DC power supply. After a few minutes,

☒ **A** a purple colour has moved towards the positive terminal.

☒ **B** a purple colour has moved towards the negative terminal.

☒ **C** an orange colour has moved towards the positive terminal.

☒ **D** an orange colour has moved towards the negative terminal.

(Total for Question 5 = 1 mark)

6 How many moles of **ions** are present in 20 cm^3 of 0.050 mol dm^{-3} calcium chloride solution, $CaCl_2(aq)$?

☒ **A** 0.0050

☒ **B** 0.0030

☒ **C** 0.0020

☒ **D** 0.0010

(Total for Question 6 = 1 mark)

7 The Avogadro constant is 6.0×10^{23} mol^{-1}. The number of **atoms** in 1 mol of dinitrogen tetroxide, N_2O_4, is

☒ **A** 3.6×10^{24}

☒ **B** 1.8×10^{24}

☒ **C** 6.0×10^{23}

☒ **D** 1.0×10^{23}

(Total for Question 7 = 1 mark)

8 The equation for the complete combustion of ethane is

$$2C_2H_6(g) + 7O_2(g) \rightarrow 4CO_2(g) + 6H_2O(l)$$

What volume of oxygen, measured at room temperature and pressure, is needed to completely burn 0.1 mol of ethane?

[The volume of 1 mol of any gas measured at room temperature and pressure is 24 dm^3]

☒ **A** 2.4 dm^3

☒ **B** 4.8 dm^3

☒ **C** 8.4 dm^3

☒ **D** 16.8 dm^3

(Total for Question 8 = 1 mark)

9 A sample of swimming pool water contains 0.482 parts per million (ppm) of chlorine. This is equal to a percentage of

☒ **A** 0.000482

☒ **B** 0.0000482

☒ **C** 0.00000482

☒ **D** 0.000000482

(Total for Question 9 = 1 mark)

10 Bromine has two isotopes with relative isotopic masses 79 and 81. Which of the following values for mass/charge ratio could correspond to a peak in the mass spectrum of bromine, Br_2? You should assume the ions detected have a single positive charge.

☒ **A** 79.9

☒ **B** 80

☒ **C** 159

☒ **D** 160

(Total for Question 10 = 1 mark)

11 The first five ionization energies of an element, **X**, are shown in the table.

Ionization energy	1st	2nd	3rd	4th	5th
Value / kJ mol^{-1}	631	1235	2389	7089	8844

What is the mostly likely formula of the oxide that forms when **X** burns in oxygen?

☒ **A** X_2O

☒ **B** XO

☒ **C** X_2O_3

☒ **D** XO_2

(Total for Question 11 = 1 mark)

12 Which of the following has the largest ionic radius?

☒ **A** S^{2-}

☒ **B** Cl^-

☒ **C** K^+

☒ **D** Ca^{2+}

(Total for Question 12 = 1 mark)

13 Which of the following is a major effect caused by increased carbon dioxide levels arising from the burning of fossil fuels?

☒ **A** Melting of polar ice caps.

☒ **B** Damage to the ozone layer.

☒ **C** Increased acid rain.

☒ **D** Increased skin cancer.

(Total for Question 13 = 1 mark)

14 Which of the following compounds shows geometric (*E-Z* or *cis-trans*) isomerism?

☒ **A** but-1-ene

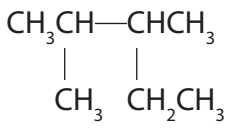
☒ **B** 2-methylbut-1-ene

☒ **C** but-2-ene

☒ **D** 2-methylbut-2-ene

(Total for Question 14 = 1 mark)

15 What is the systematic name for the compound with the following formula?



☒ **A** 2-methyl-3-ethylbutane

☒ **B** 1,2,3-trimethylbutane

☒ **C** 2,3-dimethylpropane

☒ **D** 2,3-dimethylpentane

(Total for Question 15 = 1 mark)

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

16 This question is about the reaction of methane with bromine in sunlight.

(1)

$$CH_4 + Br_2 \rightarrow CH_3Br + HBr$$

(a) This reaction is best described as

☒ **A** electrophilic addition.

☒ **B** electrophilic substitution.

☒ **C** free radical addition.

☒ **D** free radical substitution.

(b) One of the steps in the mechanism of this reaction is

(1)

$\bullet CH_3 + Br\bullet \rightarrow CH_3Br$

This step is

☒ **A** initiation.

☒ **B** propagation.

☒ **C** termination.

☒ **D** reduction.

(c) This reaction produces a mixture of products.

Which of the following is most likely to form, as well as bromomethane?

(1)

☒ **A** ethane

☒ **B** propane

☒ **C** butane

☒ **D** pentane

(d) When human skin is overexposed to sunlight, it is likely to lead to skin cancer.

What is the radiation in sunlight that leads to skin cancer?

(1)

☒ **A** microwaves

☒ **B** infrared

☒ **C** visible light

☒ **D** ultraviolet

(Total for Question 16 = 4 marks)

17 Which equation represents the reaction for which the enthalpy change, ΔH, is the mean bond energy of the C-F bond?

☒ **A** $CF_4(g) \rightarrow C(g) + 4F(g)$

☒ **B** $\frac{1}{4}CF_4(g) \rightarrow \frac{1}{4}C(g) + F(g)$

☒ **C** $C(g) + 4F(g) \rightarrow CF_4(g)$

☒ **D** $\frac{1}{4}C(g) + F(g) \rightarrow \frac{1}{4}CF_4(g)$

(Total for Question 17 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

18 The radioactive isotope iodine-131, $^{131}_{53}I$, is formed in nuclear reactors providing nuclear power. Naturally occurring iodine contains only the isotope, $^{127}_{53}I$.

(a) Complete the table to show the number of protons and neutrons in these two isotopes.

(2)

Isotope	$^{131}_{53}I$	$^{127}_{53}I$
Number of protons		
Number of neutrons		

(b) When iodine-131 decays, one of its neutrons emits an electron and forms a proton. Identify the new element formed by name or symbol.

(1)

.....

(c) The problem with radioactive iodine is that it accumulates in humans in the thyroid gland. Its absorption can be reduced by taking an appropriate daily dose of a soluble iodine compound.

Suggest a suitable iodine compound which could be used.

(1)

.....

(d) Nuclear power stations are often proposed as suitable alternatives to those burning coal, gas or oil.

Suggest a country where, because of its location, the dangers of nuclear power may outweigh the advantages. Justify your answer.

(1)

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.....

(Total for Question 18 = 5 marks)

19 This question is about the elements arsenic to rubidium which have atomic numbers 33 to 37.

The first ionization energies, E_{m1}, of these elements are given in the table.

Element	As	Se	Br	Kr	Rb
E_{m1} / kJ mol^{-1}	947	941	1140	1351	403

(a) Write the equation, with state symbols, which represents the first ionization energy of arsenic.

(2)

(b) Suggest the formulae of the hydrides of arsenic and selenium.

(2)

(c) (i) Complete the electronic configuration for an arsenic and a selenium atom using the electrons-in-boxes notation.

(2)

		4s	4p		
As	[Ar] 3d^{10}	↑↓			
Se	[Ar] 3d^{10}	↑↓			

*(ii) Explain why the first ionization energy of selenium is lower than that of arsenic.

(2)

*(d) Explain why the first ionization energy of krypton is higher than that of selenium.

(2)

*(e) Explain why the first ionization energy of rubidium is lower than that of krypton.

(2)

(f) Which of the elements, arsenic to rubidium, is likely to have atoms with the smallest atomic radius?

(1)

(Total for Question 19 = 13 marks)

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20 Copper(II) sulfate solution, $CuSO_4(aq)$, can be made by adding an excess of solid copper(II) oxide, CuO, to boiling dilute sulfuric acid. This is an exothermic reaction.

The balanced equation for this reaction is

$$CuO(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + H_2O(l)$$

(a) (i) Complete the ionic equation for this reaction, including state symbols.

(2)

$CuO(s) +$

(ii) Calculate the mass of copper(II) oxide needed, if a 10% excess is required, when 0.020 mol of sulfuric acid is completely reacted.

[Relative atomic masses: Cu = 63.5 and O = 16.0]

(2)

(b) (i) Suggest, with a reason, how the copper(II) oxide should be added to the boiling sulfuric acid.

(2)

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(ii) When the reaction is complete, the excess copper(II) oxide is removed by filtration.

To prepare crystals of copper(II) sulfate-5-water, $CuSO_4.5H_2O$, the resulting solution is boiled to remove excess water.

How would you know when sufficient water had been removed?

(1)

.....

.....

.....

.....

(iii) After cooling the solution, crystals form. State the colour of the crystals.

(1)

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(iv) The crystals all have the same shape. What does this indicate about the arrangement of the ions?

(1)

.....

.....

(c) (i) Calculate the molar mass of copper(II) sulfate-5-water, $CuSO_4.5H_2O$. Remember to include the appropriate units in your answer. You will need to use the Periodic Table as a source of data.

(2)

(ii) Calculate the percentage yield if 2.7 g of copper(II) sulfate-5-water is obtained from 0.020 mol of sulfuric acid.

(2)

(iii) What is the most likely reason for the yield being well below 100%?

(1)

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(d) When the crystals are heated, they turn white. On adding water, they return to their original colour. Suggest a use for this reaction.

(1)

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.....

(Total for Question 20 = 15 marks)

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21 Sodium hydrogencarbonate decomposes on heating to form sodium carbonate. It is difficult to measure the enthalpy change of this reaction directly.

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

One method of determining this enthalpy change is to react known amounts of sodium hydrogencarbonate and sodium carbonate, separately, with excess dilute hydrochloric acid.

(a) 0.010 mol of solid sodium hydrogencarbonate was added to 25 cm^3 of dilute hydrochloric acid. A temperature rise of 11 °C was measured using a thermometer graduated at 1 °C intervals.

(i) Calculate the heat energy produced by this reaction using the equation:

Energy transferred in joules = mass × 4.18 × change in temperature

(1)

(ii) Calculate the standard enthalpy change for the reaction when one mole of sodium hydrogencarbonate reacts with hydrochloric acid.

Remember to include a sign and units with your answer which should be given to three significant figures.

(2)

*(b) The standard enthalpy change for the reaction between sodium carbonate and dilute hydrochloric acid is found by a similar method to be

$\Delta H^{\ominus} = -321.6$ kJ mol^{-1}

Complete the Hess energy cycle below by adding the missing arrow and entities. Use it to calculate the standard enthalpy change for the decomposition of two moles of sodium hydrogencarbonate as in the equation below.

Remember to show your reasoning clearly.

(5)

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

2HCl(aq)

..... ( ) + ... ( ) + ... ( )

(c) The uncertainty for each thermometer reading is ± 0.5 °C.
Calculate the percentage error in the temperature rise of 11 °C.

(1)

(d) Sodium hydrogencarbonate is used in cooking. Suggest what it is used for and how it works.

(2)

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.....

(Total for Question 21 = 11 marks)

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22 This question is about ethene and its reactions.

Ethene is produced in industry by cracking.

(a) (i) Write the equation for the cracking of dodecane, $C_{12}H_{26}$, to produce one mole of ethene as the only alkene product.

(1)

(ii) Draw a labelled diagram of the apparatus and materials you would use to crack dodecane and collect a sample of the gaseous alkene in the laboratory.

(4)

(b) Draw a diagram to show the regions of electron density in both parts of the double bond between the carbon atoms in ethene. Label each region with appropriate symbols.

(2)

(c) (i) Give the name and structural formula for the product of the reaction between ethene and bromine, $Br_2(l)$.

(2)

Name .....

Formula

(ii) Give the mechanism for the reaction between ethene and bromine.

(3)

(d) Give the displayed formula for the organic product of the reaction between ethene and acidified potassium manganate(VII).

(1)

(e) (i) Write a balanced equation for the formation of poly(ethene) from ethene, showing the structure of the polymer clearly.

(2)

(ii) Comment on the atom economy of the reaction in (e)(i).

(1)

.....

.....

(Total for Question 22 = 16 marks)

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

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

Mark Scheme (SAM)

Pearson Edexcel International Advanced Subsidiary in Chemistry

Unit 1: The Core Principles of Chemistry

General marking guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- 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 may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed-out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of Quality of Written Communication, are being assessed. The strands are as follows:
    i. ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
    ii. select and use a form and style of writing appropriate to purpose and to complex subject matter
    iii. organise information clearly and coherently, using specialist vocabulary when appropriate.

Using the Mark Scheme

Examiners should NOT give credit for incorrect or inadequate answers, but allow 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 still be creditworthy.

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.
Bold	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)(transfer error)(consequential) 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. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions that involve the writing of continuous prose require candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities. Questions where Quality of Written Communication is likely to be particularly important are indicated (Quality of Written Communication) in the mark scheme, but this does not preclude others.

Section A

Question Number	Answer	Mark
1	C	**(1)**

Question Number	Answer	Mark
2	C	**(1)**

Question Number	Answer	Mark
3	D	**(1)**

Question Number	Answer	Mark
4	B	**(1)**

Question Number	Answer	Mark
5	A	**(1)**

Question Number	Answer	Mark
6	B	**(1)**

Question Number	Answer	Mark
7	A	**(1)**

Question Number	Answer	Mark
8	C	**(1)**

Question Number	Answer	Mark
9	B	**(1)**

Question Number	Answer	Mark
10	D	**(1)**

Question Number	Answer	Mark
11	C	**(1)**

Question Number	Answer	Mark
12	A	**(1)**

Question Number	Answer	Mark
13	A	**(1)**

Question Number	Answer	Mark
14	C	**(1)**

Question Number	Answer	Mark
15	D	**(1)**

Question Number	Answer	Mark
16(a)	D	**(1)**

Question Number	Answer	Mark
16(b)	C	**(1)**

Question Number	Answer	Mark
16(c)	A	**(1)**

Question Number	Answer	Mark
16(d)	D	**(1)**

Question Number	Answer	Mark
17	B	**(1)**

Total for Section A = 20 Marks

Section B

Question Number	Acceptable Answer	Mark
18(a)	<table><tr><td>Isotope</td><td>$^{131}I_{53}$</td><td>$^{127}I_{53}$</td></tr><tr><td>Number of protons</td><td>53</td><td>53</td></tr><tr><td>Number of neutrons</td><td>78</td><td>74</td></tr></table>	**(2)**

Question Number	Acceptable Answer	Reject	Mark
18(b)	Xenon/Xe/$_{54}$Xe/Xe$_{54}$ $^{131}_{54}Xe$	$^{130}Xe_{54}$ Xe^- Iodine/I with or without numbers Hydrogen/H with or without numbers Te	**(1)**

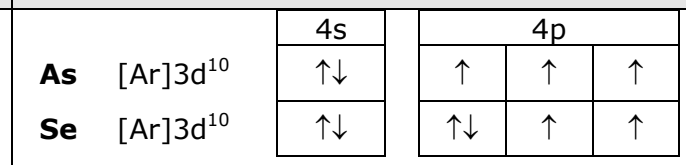
Question Number	Acceptable Answer	Reject	Mark
18(c)	Potassium iodide/KI Accept any soluble, non-toxic iodide or iodate. Wrong name, correct formula. **(0)** Correct name, wrong formula. **(0)**	HI KI_3 Wrong formulae, e.g. CaI, MgI Wrong name, e.g. calcium idodate BaI_2 (toxic) AgI (insoluble) Potassium iodine	**(1)**

Question Number	Acceptable Answer	Reject	Mark
18(d)	Country /ALLOW state **and** justification Both needed for 1 mark For example, Japan/New Zealand/California etc. Country/state at risk from earthquake/tsunami/flooding. Further examples: Italy at risk from volcanoes. Afghanistan/middle eastern/African countries at risk from terrorist/(nuclear) weapon threat/war zone/political instability/abuse of nuclear power. USA/America/Jamaica at risk from hurricanes/tornadoes. California San Andreas Fault	Population density Landslide Too hot Surrounded by other countries Antarctica	**(1)**

Total for Question 18 = 5 Marks

Question Number	Acceptable Answer	Reject	Mark
19(a)	**First mark:** $As(g) - e^{(-)} \rightarrow As^{+}(g)$ OR $As(g) \rightarrow As^{+}(g) + e^{(-)}$ **Second mark:** All species gaseous. A reasonable attempt at an ionization energy. Examples: $As(g) + e^{(-)} \rightarrow As^{+}(g)$ $As(g) - e^{(-)} \rightarrow As^{-}(g)$ $As^{2+}(g) - e^{(-)} \rightarrow As^{3+}(g)$ IGNORE state symbol of electron. ALLOW upper case/large AS in arsenic. ALLOW $As(g) + e^{(-)} \rightarrow As^{+}(g) + 2e^{(-)}$ **(2)**	$As(g) + e^{(-)} \rightarrow As(g)$ (electron affinity)	**(2)**

Question Number	Acceptable Answer	Reject	Mark
19(b)	**First mark:** AsH_3/H_3As **Second mark:** H_2Se/SeH_2 IGNORE charges. ALLOW upper case/large S in arsenic. **N.B.** if two or more answers are given for one element, mark that element on a plus/minus basis.	SE for selenium	**(2)**

Question Number	Acceptable Answer	Mark
19(c)(i)	 One mark for each row. Arrows may be half-headed. Arrows must be in same direction if in singly occupied boxes (can be down). ALLOW two arrows for Se in any 4p box. For selenium two arrows must show opposite spins.	(2)

Question Number	Acceptable Answer	Mark
*19(c)(ii) Quality of Written Communication	**For parts c(ii), d and e, it is important to keep in mind the two elements involved in each part: As and Se** **First mark:** EITHER In Se, (spin) pairing has occurred (for the first time in that p sub-shell). OR Electron removed from orbital containing two electrons. ALLOW sub-shell for orbital. **Second mark:** EITHER (Increase in) repulsion (so electron lost more easily). OR Half-filled (sub-) shell/allow orbital (particularly) stable (in As). ALLOW orbital for sub-shell. Mark each point independently. IGNORE reference to distance from nucleus and shielding.	(2)

Question Number	Acceptable Answer	Reject	Mark
***19(d) Quality of Written Communication**	**Se and Kr** **First mark:** EITHER The nuclear charge is increasing (nuclear must be stated or clearly implied). OR Number of protons/atomic number is increasing. **(1)** **Second mark:** (Outermost) electron is closer to the nucleus/electron is removed from the same (sub-)shell/electron experiences similar shielding/(atomic) radius is smaller/smaller **atom.** **(1)** ALLOW reverse arguments for selenium. IGNORE Kr has full outer shell.	Ionic radius molecule (unless monatomic)	**(2)**

Question Number	Acceptable Answer	Mark
***19(e) Quality of Written Communication**	**Kr and Rb** Any two from: The **electron** (in Rb) (removed) is further from the nucleus. **(1)** The **electron** is in a higher/new/another/5s (energy quantum) shell/energy level. **(1)** **More** shielded. IGNORE any reference to stability of krypton or larger atomic radius of Rb/full outer shell of Kr. **(1)** It is possible that two answers may be offered together in one sentence, e.g. Rb outer electron is in another shell further from nucleus. **(2)**	**(2)**

Question Number	Acceptable Answer	Reject	Mark
19(f)	Krypton/Kr	Anything else	**(1)**

Total for Question 19 = 13 marks

Question Number	Acceptable Answer	Reject	Mark
20(a)(i)	$CuO(s) + 2H^+(aq) \rightarrow Cu^{2+}(aq) + H_2O(l)$ Left-hand side **(1)**, right-hand side **(1)** If SO_4^{2-} are on both sides, maximum 1 mark. ALLOW correct entities and balancing with no or incorrect state symbols, for 1 mark. ALLOW multiples.	Charges within water molecule	**(2)**

Question Number	Acceptable Answer	Reject	Mark
20(a)(ii)	1.749/1.75/1.7 with or without working scores. **(2)** If answer incorrect look for: Mass = 79.5 x 0.02 OR =1.59 **(1)** OR TE from incorrect mass for 1 mark. Their mass x 1.1= their correct answer to 2/3/4SF (g) **(1)** Accept crossed 7s. ALLOW both ways of writing 4 i.e. if 4 looks like 9.	1.74 1.8	**(2)**

Question Number	Acceptable Answer	Reject	Mark
20(b)(i)	**First mark:** Add in small portions/use a spatula/use a **small** spoon/slowly/gradually. **Second mark:** To prevent (mixture/acid) boiling over/frothing/spilling/splashing/splash back. Mark independently. Bubbles are neutral. IGNORE add carefully/cautiously alone.	Spitting/violent reaction/fizzing Reaction is exothermic alone Bubbles of carbon dioxide	**(2)**

Question Number	Acceptable Answer	Reject	Mark
20(b)(ii)	Dip in glass rod. Remove and allow to cool. See if crystals form. ALLOW any workable suggestion. Examples: See crystals/salt forming around edge of beaker. Depth of colour of solution increases. Solution/colour becomes darker. Solution/colour becomes deeper blue. Dark blue solution. Reduce volume by at least half/until crystals form.	Solution thickens precipitate forming	**(1)**

Question Number	Acceptable Answer	Reject	Mark
20(b)(iii)	Blue	Any mention of green or other colour	**(1)**

Question Number	Acceptable Answer	Reject	Mark
20(b)(iv)	(The ions are arranged in a) regular (way)/lattice. OR The ions are arranged in the same way/have same arrangement/have uniform arrangement. The term 'structure' is neutral and should be ignored. IGNORE statements about ions attracting or repelling.	The ions are arranged in a similar/fixed way	**(1)**

Question Number	Acceptable Answer	Reject	Mark
20(c)(i)	249.6 g mol^{-1} ALLOW 249.5 g mol^{-1}. ALLOW 250 g mol^{-1} value **(1)** units **(1)** Common wrong values are 159.5/6, 185.5/6, 249. ALLOW unit mark with any or no value. ALLOW g/mol for unit.	g/mol^{-1}	**(2)**

Question Number	Acceptable Answer		Mark
20(c)(ii)	Max yield = 249.6 x 0.02 = 4.992(g)	**(1)**	**(2)**
	Percentage yield = $\frac{2.7 \times 100}{4.992}$		
	= (54.0865) = 54%	**(1)**	
	If 249.5 is used = (54.1082) = 54%		
	OR		
	2.7/249.6 = 0.01082	**(1)**	
	Percentage yield = 0.01082 x 100/0.02 = 54%	**(1)**	
	ALLOW TE from any value in (i), and note:		
	159.6 gives 84.6%		
	185.6 gives 72.7%		
	IGNORE SF except one SF.		
	Correct answer, no working scores.	**(2)**	

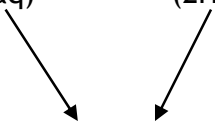
Question Number	Acceptable Answer	Reject	Mark
20(c)(iii)	(Copper(II) sulfate is soluble) so some remains in solution/some remains on the **filter paper.** IGNORE other transfer errors. Incomplete crystallization not all the crystals are formed.	Experimental error/ incomplete reaction Filtering alone Efflorescence	**(1)**

Question Number	Acceptable Answer	Reject	Mark
20(d)	This is a (chemical) test for (the presence of) water. Invisible ink. Moisture/humidity test. Test to see if solutions are aqueous.	Check to see if substance is hydrated Drying agent Quantitative measurements of water content	**(1)**

Total for Question 20 = 15 Marks

Question Number	Acceptable Answer	Reject	Mark
21(a)(i)	25 x 4.18 x 11 = 1149.5 (J) ALLOW 1.1495 **kJ** Otherwise ignore units even if incorrect. IGNORE sign. IGNORE SF except one or two SF.	1149.5 kJ	**(1)**

Question Number	Acceptable Answer	Reject	Mark
21(a)(ii)	-115 kJ mol^{-1} ALLOW -115000 J mol^{-1} Sign with correct value. **(1)** Units and three significant figures. **(1)** Mark independently. ALLOW TE from (i) -114 kJ mol^{-1} (rounding error) scores 1 mark -115.0 kJ mol^{-1} scores 1 mark Values of -4600 and -3.86 are quite common. ALLOW K and j in any case in units.	J or kJ alone	**(2)**

Question Number	Acceptable Answer	Mark
***21(b) Quality of Written Communication**	$2NaHCO_3(s) \rightarrow Na_2CO_3(s)+CO_2(g)+H_2O(l)$ $2HCl(aq)$ $(2HCl(aq))$  $2NaCl(aq) + 2CO_2(g) + 2H_2O(l)$ **First mark:** Arrow from products in top line to lower line and correct entities. **(1)** $NaCl + CO_2 + H_2O$ **Second mark:** **2**$NaCl$**(aq)** + **2**CO_2**(g)** + **2**H_2O**(l)** Correct state symbols and balancing. **(1)** ΔH^o = **+**91.6 OR +91.7 (kJ mol^{-1}) ALLOW no positive sign only if correct working with correct signs given. **(3)**	**(5)**

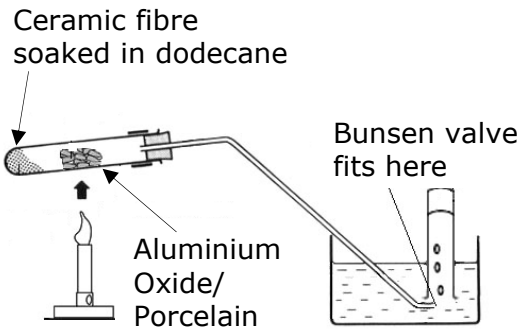
Question Number	Acceptable Answer	Mark
21(b) continued	**Third mark:** Correct use of Hess's Law (in numbers or symbols) consistent with arrow direction. **(1)** **Fourth mark:** **2 x** (-115) = ΔH^o -321.6 Correct multiples and numbers. ALLOW 2 x any number (including -4600 and -3.86) except 2 x +/- 321.6. **(1)** Notice third and fourth marks can be scored by: ΔH^o = 2(-115) - (-321.6) **Fifth mark:** ΔH^o = 2(−115) − (-321.6) = **+**91.6 (kJ mol^{-1}) OR ΔH^o = 2(−114.95) − (-321.6) = **+**91.7 (kJ mol^{-1}) Correct value for their calculation with correct sign. IGNORE SF except 1. ALLOW no positive sign only if correct working with correct signs given. **(1)** Omitting 2 x gives +206.6 (could get 4 marks) -4600 gives -598.4 -3.86 gives +313.88	

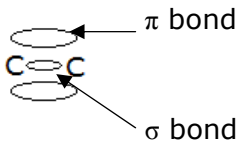
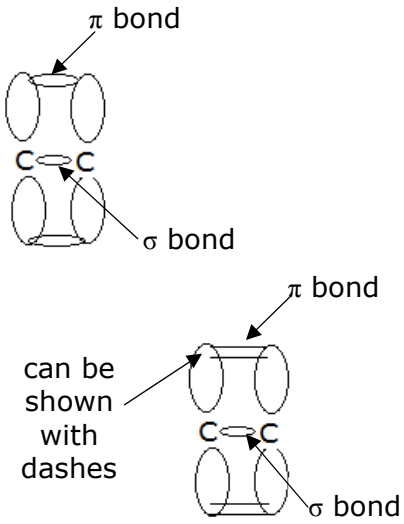
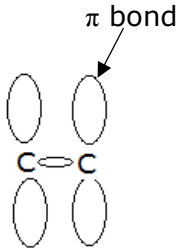
Question Number	Acceptable Answer	Reject	Mark
21(c)	((±) 0.5 x 2 x 100/11)= (±)9.09 (%) ALLOW at 9.0909/9.091/9.1 and 9.	9.10/9.0	**(1)**

Question Number	Acceptable Answer	Reject	Mark
21(d)	**First mark:** It is used as a raising agent/self-raising flour/baking soda/baking powder. OR Causes cakes/(soda) bread to rise/expand. **Second mark:** Carbon dioxide (released on heating causes cakes/bread to rise). OR It reacts with acid to form carbon dioxide (in baking powder) providing bread/cake etc is mentioned. ALLOW Used in cooking green vegetables to keep green colour.	To make pastry rise Bicarbonate of soda Gas Air Neutralising acid foods	**(2)**

Total for Question 21 = 11 Marks

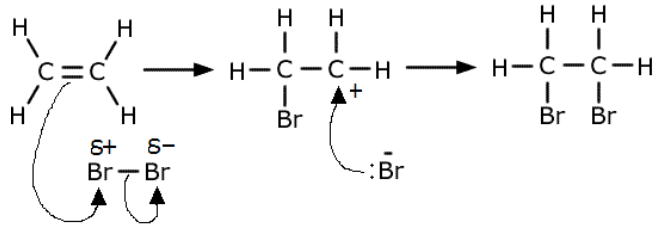
Question Number	Acceptable Answer	Mark
22(a)(i)	$C_{12}H_{26} \rightarrow C_{10}H_{22} + C_2H_4$ IGNORE state symbols even if incorrect. ALLOW displayed and structural formula for ethane.	**(1)**

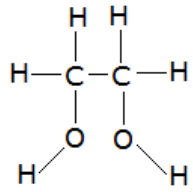
Question Number	Acceptable Answer	Reject	Mark
22 (a)(ii)	Collection over water or in gas syringe **(1)** IGNORE solid bung with delivery tube coming out/accidental sealing in drawing/clamps. This is the only stand-alone mark. **Dependent on diagram, including roughly horizontal tube:** Labelled ceramic fibre/any sort of wool (unless any named metal) (soaked in dodecane). **(1)** Aluminium oxide/porcelain pieces/catalyst/catalyst with incorrect name or incorrect formula/any named metal/anti-bump granules. **(1)** Heat under catalyst/under middle of test tube. **(1)**  	Delivery tube through glassware	**(4)**

Question Number	Acceptable Answer	Reject	Mark
22(b)	 EITHER Diagram of bonds, the single bond must be shown as a region of space and not as a single or double straight line. **(1)** Labelled σ (sigma) and π (pi) in correct places on correctly drawn bonds, i.e. this mark can only be awarded if bonds correctly drawn. **(1)** OR  Labelled pi bond **(1)** Labelled sigma bond **(1)**		**(2)**

Question Number	Acceptable Answer	Mark
22(b) continued	Bonds may be shown by overlap of appropriate orbitals, when any orbital or region of overlap may be labelled. Only one pi lobe/bond need be labelled. Carbons need not be shown. Bonds may be drawn on separate diagrams. IGNORE C-H bonds. IGNORE any additional electron density maps. IGNORE any partial charges.	

Question Number	Acceptable Answer	Reject	Mark
22(c)(i)	1, 2-dibromoethane **(1)** IGNORE punctuation. CH_2BrCH_2Br **(1)** ALLOW displayed/skeletal formula. Mark independently. Bromoethane with CH_2BrCH_3 **(0)**	$C_2H_4Br_2$	**(2)**

Question Number	Acceptable Answer	Mark
22 (c)(ii)	 **First mark:** Arrow from double bond towards nearest bromine atom and arrow from bond between bromine atoms to furthest bromine atom. **Second mark:** Correct formula of carbocation intermediate. **Third mark:** Arrow from anywhere on the brom**ide** ion to positive carbon. ALLOW missing hydrogens if bonds from carbons shown. ALLOW full marks for TE bromoethane formation using HBr and first arrow to H of HBr. ALLOW full marks for TE 1,2 –dibromopropane.	**(3)**

Question Number	Acceptable Answer	Reject	Mark
22(d)	 ALLOW O-H not displayed. ALLOW vertical C bond to any part of OH. Only penalise clear C-H-O/CH-O bond horizontally. IGNORE any name whether correct or not.	Skeletal formula or structural formula	**(1)**

Question Number	Acceptable Answer	Reject	Mark
22(e)(i)	$nCH_2=CH_2 \rightarrow \{CH_2\text{-}CH_2\}_n$ Left side **(1)** Right side extension bonds must be shown. **(1)** Mark independently. Accept $nC_2H_4 \rightarrow \{CH_2\text{-}CH_2\}_n$. Penalise omission of n only once. ALLOW $nCH_2=CH_2 + nCH_2=CH_2 \rightarrow \{CH_2\text{-}CH_2\}_n$ for two marks. ALLOW multiples of C_2H_4 in product.	$(CH_2=CH_2)_n$ N	**(2)**

Question Number	Acceptable Answer	Reject	Mark
22(e)(ii)	**100%** with one of the following: Only one product OR No by-products/no other product OR All reactants form the product OR As addition reaction IGNORE same empirical formula	No product lost/no side reaction(s) All reactants form the products	**(1)**

Total for Question 22 = 16 Marks

Total for Section B = 60 Marks

Total for Paper = 80 Marks

Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced Subsidiary

Unit 2: Application of Core Principles of Chemistry

Sample Assessment Material
Time: 1 hour 30 minutes

Paper Reference
WCH02/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or 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.

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.
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.
- A Periodic Table is printed on the back cover of this paper.

Advice

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

Turn over ▶

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S 4 5 3 6 1 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 Which of the following molecules has the smallest bond angle?

☒ **A** H_2O

☒ **B** NH_3

☒ **C** CH_4

☒ **D** SF_6

(Total for Question 1 = 1 mark)

2 A charged rod is held beside a stream of liquid coming from a burette. Which of the following liquids would NOT be significantly deflected?

☒ **A** H_2O

☒ **B** CCl_4

☒ **C** C_2H_5OH

☒ **D** C_2H_5Br

(Total for Question 2 = 1 mark)

3 Which of the following statements about electronegativity is true?

☒ **A** Non-metals have lower electronegativity than metals.

☒ **B** Electronegativity decreases across a period in the Periodic Table.

☒ **C** Electronegativity decreases going down a group in the Periodic Table.

☒ **D** The bonds between atoms with equal electronegativity are always weak.

(Total for Question 3 = 1 mark)

4 In which series of compounds does the covalent character increase, going from left to right?

☒ **A** $NaCl$, $MgCl_2$, $AlCl_3$, $SiCl_4$

☒ **B** SiO_2, Al_2O_3, MgO, Na_2O

☒ **C** LiI, NaI, KI, RbI

☒ **D** KI, KBr, KCl, KF

(Total for Question 4 = 1 mark)

5 Going down Group 2 from calcium to barium

☒ **A** the first ionization energy of the element increases.

☒ **B** the strength of the metallic bonding increases.

☒ **C** the polarizing power of the 2+ ion decreases.

☒ **D** the stability of the nitrate to heat decreases.

(Total for Question 5 = 1 mark)

6 Fullerenes, graphite and diamond are all forms of carbon. Fullerenes dissolve in petrol, but diamond and graphite do not. This is because

☒ **A** the bonds between the carbon atoms in fullerenes are weaker than in diamond or graphite.

☒ **B** diamond and graphite are giant structures but fullerenes are molecular.

☒ **C** there are delocalized electrons in diamond and graphite but not in fullerenes.

☒ **D** there are covalent bonds in diamond and graphite, but not in fullerenes.

(Total for Question 6 = 1 mark)

7 Sodium chloride is more soluble in water than in hexane because

☒ **A** the intermolecular forces between water molecules are stronger than those between hexane molecules.

☒ **B** hexane molecules cannot fit between the ions in the sodium chloride lattice.

☒ **C** energy is released when the ions in sodium chloride are hydrated.

☒ **D** sodium ions and chloride ions form hydrogen bonds with water.

(Total for Question 7 = 1 mark)

8 Hydrochloric acid and sodium carbonate solution react as shown below.

$$2HCl(aq) + Na_2CO_3(aq) \rightarrow 2NaCl(aq) + CO_2(g) + H_2O(l)$$

Which sample of sodium carbonate solution will be neutralized by 20 cm^3 of 0.05 mol dm^{-3} hydrochloric acid?

	Volume of sodium carbonate/ cm^3	Concentration of sodium carbonate/ mol dm^{-3}
☒ **A**	10	0.05
☒ **B**	40	0.05
☒ **C**	40	0.10
☒ **D**	10	0.10

(Total for Question 8 = 1 mark)

9 A white solid produces oxygen when it is heated, but no other gases. The solid could be

☒ **A** lithium nitrate.

☒ **B** potassium nitrate.

☒ **C** strontium nitrate.

☒ **D** calcium oxide.

(Total for Question 9 = 1 mark)

10 A solid is soluble in water and produces steamy acidic fumes with concentrated sulfuric acid. The solid could be

☒ **A** potassium carbonate.

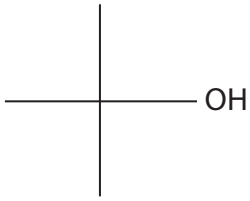
☒ **B** magnesium sulfate.

☒ **C** silver chloride.

☒ **D** sodium chloride.

(Total for Question 10 = 1 mark)

11



The systematic name of the compound with skeletal formula shown above is

☒ **A** 1,1-dimethylethanol.

☒ **B** 2,2-dimethylethanol.

☒ **C** 2-methylpropan-1-ol.

☒ **D** 2-methylpropan-2-ol.

(Total for Question 11 = 1 mark)

12 Samples of 1-chloropropane and 1-bromopropane are warmed with water containing dissolved silver nitrate in the presence of ethanol. The 1-chloropropane reacts more slowly because

☒ **A** the C—Cl bond is more polar than the C—Br bond.

☒ **B** the C—Cl bond is stronger than the C—Br bond.

☒ **C** 1-chloropropane is less soluble than 1-bromopropane.

☒ **D** 1-chloropropane is a weaker oxidizing agent than 1-bromopropane.

(Total for Question 12 = 1 mark)

13 The reaction of 1-chloropropane with water containing dissolved silver nitrate in the presence of ethanol is

☒ **A** a redox reaction.

☒ **B** a nucleophilic substitution.

☒ **C** an electrophilic substitution.

☒ **D** a free radical substitution.

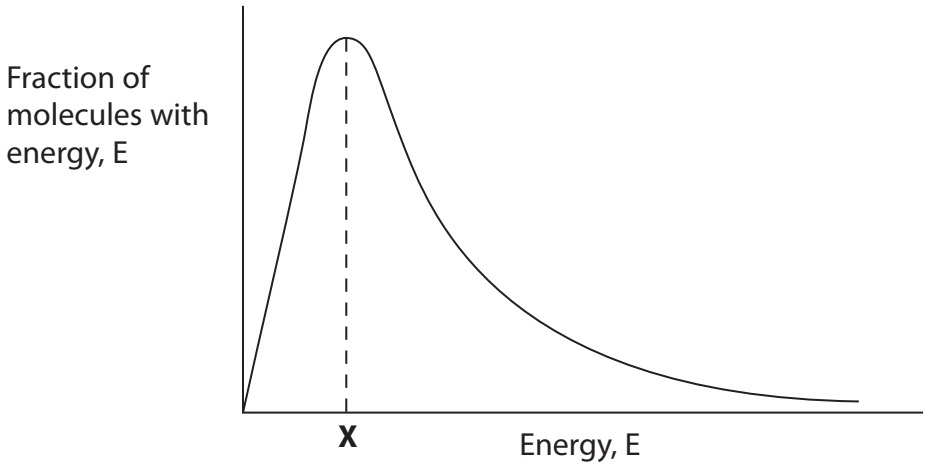
(Total for Question 13 = 1 mark)

14 The compound with formula $CH_3CH(NH_2)CH_3$ can be made by reacting alcoholic ammonia with

- ☒ **A** propane.
- ☒ **B** propene.
- ☒ **C** 2-chloropropane.
- ☒ **D** propan-2-ol.

(Total for Question 14 = 1 mark)

15



The energy marked **X** in the Maxwell-Boltzmann distribution shows

- ☒ **A** the most common energy of the molecules.
- ☒ **B** the activation energy of the reaction.
- ☒ **C** the activation energy of a catalysed reaction.
- ☒ **D** the number of molecules with energy greater than the activation energy.

(Total for Question 15 = 1 mark)

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

16 In the industrial process involving gas phase reactions to produce ammonia, many collisions between molecules are unsuccessful because

☒ **A** gas phase reactions are reversible.

☒ **B** the collisions are not energetic enough to break the bonds in the molecules.

☒ **C** gas phase reactions can only occur when a catalyst is present.

☒ **D** gas phase reactions can only occur when UV light is present.

(Total for Question 16 = 1 mark)

17 The molecular (parent) ion in the mass spectrum of a hydrocarbon containing ^{12}C and ^{1}H only

☒ **A** is the peak with highest relative abundance.

☒ **B** is the peak with highest charge.

☒ **C** is the peak produced by the most stable fragment.

☒ **D** is the peak with highest mass to charge ratio.

(Total for Question 17 = 1 mark)

18 A compound which has major peaks with mass / charge ratio at 29, 57 and 58 in the mass spectrum could be

☒ **A** propanal, CH_3CH_2CHO.

☒ **B** propanone, CH_3COCH_3.

☒ **C** propan-1-ol, $CH_3CH_2CH_2OH$.

☒ **D** propan-2-ol, $CH_3CH(OH)CH_3$.

(Total for Question 18 = 1 mark)

19 Which of the following would **not** be used to assess whether the use of a biofuel produced from a crop of sugar cane is carbon neutral?

The amount of

☒ **A** fuel used to operate farm machinery.

☒ **B** pesticides and fertilisers used.

☒ **C** energy released per tonne of biofuel.

☒ **D** fuel used to process the crop.

(Total for Question 19 = 1 mark)

20 The principal reason why scientists have recommended that chlorofluorocarbons (CFCs) are not used in aerosols is that they cause

☒ **A** global warming.

☒ **B** acid rain.

☒ **C** ozone depletion.

☒ **D** water pollution.

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

21 (a) (i) An alkaline solution is produced when barium reacts with cold water. Write the equation for this reaction, including all state symbols.

(2)

(ii) The reaction in (a)(i) is a redox reaction. State the initial and final oxidation number of any element that changes its oxidation number.

(2)

.....

.....

.....

.....

(b) Dilute hydrochloric acid is added to the solution produced in (a)(i). Write the equation for the reaction which occurs. State symbols are **not** required.

(1)

(c) Dilute sulfuric acid is added to another sample of the solution produced in (a)(i). How would the appearance of the resulting mixture differ from the mixture produced in (b)? Explain this difference.

(2)

Appearance .....

Explanation .....

.....

.....

(d) (i) Two white powders are known to be barium carbonate and magnesium carbonate.

How could you distinguish between the two powders by heating them? [No practical details are required.]

Include the equation for the action of heat on one of these carbonates. State symbols are not required.

(2)

.....

.....

.....

.....

Equation:

(ii) Suggest another test, other than heating or the use of an acid, which could be used to distinguish between magnesium carbonate and barium carbonate. State the results for both compounds.

(2)

Test .....

Result with magnesium carbonate .....

.....

Result with barium carbonate .....

.....

(Total for Question 21 = 11 marks)

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22 (a) The products of the reaction when 2-chlorobutane is heated with sodium hydroxide depend on the conditions.

(i) What condition, other than a suitable temperature and sodium hydroxide concentration, would produce a mixture of but-1-ene and but-2-ene?

(1)

.....

(ii) What type of reaction occurs in (a)(i)?

(1)

.....

(iii) What condition, other than a suitable temperature and sodium hydroxide concentration, would produce butan-2-ol in the reaction of 2-chlorobutane with sodium hydroxide?

(1)

.....

(iv) Suggest the mechanism for the reaction of 2-chlorobutane with hydroxide ions to form butan-2-ol. Use curly arrows to show the movement of electron pairs.

(2)

(b) Phosphorus(V) chloride, PCl_5, can be used to test for the –OH group.

Describe what would be seen when phosphorus(V) chloride is added to butan-2-ol. Give the equation for the reaction. State symbols are not required.

(2)

Observation .....

Equation

(c) A tertiary alcohol, **A**, is an isomer of butan-2-ol.

(i) Butan-2-ol and **A** can be distinguished by warming separate samples with a mixture of potassium dichromate(VI) and sulfuric acid. State the observations which would be made with each alcohol.

(2)

Observation with butan-2-ol .....

.....

Observation with **A** .....

.....

(ii) Give the structural formula of the organic product which forms when butan-2-ol is oxidized.

(1)

(iii) Explain how infrared spectroscopy could be used to detect whether butan-2-ol has been oxidized.

(1)

.....

.....

.....

.....

(Total for Question 22 = 11 marks)

23 The boiling temperatures of fluorine and two of its compounds are given below.

Substance	F_2	CH_3F	HF
T_b/K	85	195	293

(a) A molecule of F_2 has 18 electrons.

Which intermolecular force depends to a large extent on the number of electrons in the molecule?

(1)

(b) Calculate the number of electrons in a molecule of CH_3F.

(1)

(c) Explain why the boiling temperature of CH_3F is greater than that of F_2, referring to the intermolecular forces present.

(1)

(d) Explain why the boiling temperature of HF is the highest in the series.

(2)

(e) Explain why the values of the boiling temperatures for Cl_2, CH_3Cl and HCl do not follow the same trend as F_2, CH_3F and HF.

(1)

.....

.....

.....

(Total for Question 23 = 6 marks)

24 The percentage by mass of tin in a piece of rock containing tin(IV) oxide, SnO_2, was determined as described in the procedure below.

Step 1 A sample of rock, with mass 10.25 g, was crushed and dissolved in sulfuric acid.

Step 2 The solution was treated with a reducing agent to convert the Sn^{4+} to Sn^{2+} ions.

Step 3 50 cm^3 of aqueous iodine solution with concentration 0.250 mol dm^{-3} was added to the solution of Sn^{2+} ions. The following reaction occurred:

$$Sn^{2+}(aq) + I_2(aq) \rightarrow Sn^{4+}(aq) + 2I^-(aq)$$

Step 4 The **excess** iodine was titrated with sodium thiosulfate solution with concentration 0.100 mol dm^{-3}. The volume of sodium thiosulfate solution required was 11.60 cm^3.

(a) Thiosulfate ions react with iodine as shown below.

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

(i) Calculate the number of moles of sodium thiosulfate which were used in **Step 4**.

(1)

(ii) Calculate the number of moles of iodine which reacted with this amount of sodium thiosulfate.

(1)

(iii) Calculate the number of moles of iodine added to the solution of Sn^{2+} ions in **Step 3**.

(1)

(iv) Use your results from (ii) and (iii) to calculate the number of moles of iodine which reacted with the Sn^{2+} ions from the rock.

(1)

(v) Hence calculate the percentage by mass of tin in the rock.

(2)

(b) (i) What change could be made in **Step 4** to improve the reliability of the result?

(1)

.....

.....

.....

(ii) The error each time the burette was read was ± 0.05 cm^3. Calculate the percentage error in the titre value of 11.60 cm^3.

(1)

(iii) How could the percentage error in the titre value be reduced without using a different burette?

(1)

.....

.....

(c) The titration can be carried out with or without an indicator. What colour **change** would be seen at the end-point if an indicator was **not** used? The tin ions are colourless.

(1)

.....

(Total for Question 24 = 10 marks)

TOTAL FOR SECTION B = 38 MARKS

SECTION C

Answer ALL the questions in this section. Write your answers in the spaces provided.

25 (a) Sea water is a source of chemicals. The most abundant chemical dissolved in sea water is sodium chloride. Compounds of magnesium and bromine are also present. Magnesium occurs at 1300 parts per million (ppm) and bromine at 60 ppm by mass.

The solution left after crystallizing sodium chloride from sea water is even richer in bromine, and contains around 2.2 g dm^{-3} of bromine.

Bromine is extracted from this solution by passing in chlorine gas. The mixture is acidified to prevent hydrolysis of bromine by the reaction

$$Br_2(aq) + H_2O(l) \rightleftharpoons 2H^+(aq) + Br^-(aq) + BrO^-(aq)$$

The bromine can be separated by heating the solution to collect bromine vapour which is then condensed, or by blowing air through the solution.

(i) Show by calculation that a solution containing 2.2 g dm^{-3} of bromine is richer in bromine than one containing 60 ppm.

[Assume that the mass of 1 dm^3 of the bromine solution is 1000 g]

(1)

(ii) Write an ionic equation, including state symbols, for the reaction in which chlorine gas reacts with bromide ions in solution to produce bromine.

(2)

(iii) What would be observed when the reaction in (ii) occurs?

(1)

(iv) Explain why the addition of an acid, such as hydrochloric acid, prevents hydrolysis of bromine.

(2)

(v) Assuming the hydrolysis of bromine is endothermic, explain how an increase in temperature would affect the equilibrium position for the hydrolysis of bromine.

(2)

(vi) Use your knowledge of activation energy to explain why an increase in temperature increases the rate of hydrolysis of bromine.

(1)

(vii) Use the equation for the hydrolysis of bromine to show that it is a disproportionation reaction.

$$Br_2(aq) + H_2O(l) \rightleftharpoons 2H^+(aq) + Br^-(aq) + BrO^-(aq)$$

(2)

(b) At the surface of the sea, there is a dynamic equilibrium between carbon dioxide gas in air and dissolved carbon dioxide in the surface sea water.

$$CO_2(g) \rightleftharpoons CO_2(aq)$$

(i) State **two** features of a system which has reached dynamic equilibrium.

(2)

1. .....

.....

.....

2. .....

.....

.....

*(ii) Carbon dioxide dissolves more easily in seawater than in pure water because seawater contains carbonate ions, $CO_3^{2-}(aq)$, and the following reaction occurs.

$$CO_2(aq) + H_2O(l) + CO_3^{2-}(aq) \rightleftharpoons 2HCO_3^-(aq)$$

Explain how an increase in concentration of carbonate ions in sea water affects the amount of carbon dioxide gas in the atmosphere.

(2)

.....

.....

.....

.....

(iii) Carbon dioxide and water vapour both contain polar bonds.

What effect does infrared radiation have on the bonds in these molecules?

(1)

.....

.....

.....

*(iv) Outline the mechanism by which molecules such as carbon dioxide and water cause global warming.

(2)

*(v) Without water vapour in the atmosphere, the earth would be many degrees colder than it is at present. Why are many climate change scientists more concerned about warming due to carbon dioxide in the atmosphere, than warming due to the presence of water vapour? Refer to the difference between anthropogenic climate change and natural climate change in your answer.

(4)

(Total for Question 25 = 22 marks)

TOTAL FOR SECTION C = 22 MARKS
TOTAL FOR PAPER = 80 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

Mark Scheme (SAM)

Pearson Edexcel International Advanced Subsidiary in Chemistry

Unit 2: Application of Core Principles of Chemistry

General marking guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- 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 may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed-out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of Quality of Written Communication, are being assessed. The strands are as follows:
    i. ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
    ii. select and use a form and style of writing appropriate to purpose and to complex subject matter
    iii. organise information clearly and coherently, using specialist vocabulary when appropriate.

Using the Mark Scheme

Examiners should NOT give credit for incorrect or inadequate answers, but allow 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 still be creditworthy.

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.
Bold	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)(transfer error)(consequential) 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. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions that involve the writing of continuous prose require candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where Quality of Written Communication is likely to be particularly important are indicated (Quality of Written Communication) in the mark scheme, but this does not preclude others.

Section A

Question Number	Answer	Mark
1	D	**(1)**

Question Number	Answer	Mark
2	B	**(1)**

Question Number	Answer	Mark
3	C	**(1)**

Question Number	Answer	Mark
4	A	**(1)**

Question Number	Answer	Mark
5	C	**(1)**

Question Number	Answer	Mark
6	B	**(1)**

Question Number	Answer	Mark
7	C	**(1)**

Question Number	Answer	Mark
8	A	**(1)**

Question Number	Answer	Mark
9	B	**(1)**

Question Number	Answer	Mark
10	D	**(1)**

Question Number	Answer	Mark
11	D	**(1)**

Question Number	Answer	Mark
12	B	**(1)**

Question Number	Answer	Mark
13	B	(1)

Question Number	Answer	Mark
14	C	(1)

Question Number	Answer	Mark
15	A	(1)

Question Number	Answer	Mark
16	B	(1)

Question Number	Answer	Mark
17	D	(1)

Question Number	Answer	Mark
18	A	(1)

Question Number	Answer	Mark
19	C	(1)

Question Number	Answer	Mark
20	C	(1)

Total for Section A = 20 Marks

Section B

Question Number	Acceptable Answer	Reject	Mark
21(a)(i)	$Ba(s) + 2H_2O(l) \rightarrow Ba(OH)_2(aq) + H_2(g)$ OR $Ba(s) + 2H_2O(l) \rightarrow Ba^{2+}(aq) + 2OH^-(aq) + H_2(g)$ **First mark:** Correct products. **Second mark:** State symbols and balancing.	Ba_2 $H_2O(aq)$ BaO_2	**(2)**

Question Number	Acceptable Answer	Reject	Mark
21(a)(ii)	**First mark:** Ba(increases in ON) from 0 to +2. **Second mark:** H (decreases in ON) from +1 to 0. TE from (a)(i). Stand-alone marks.	Inclusion of oxygen changes will lose 1 mark.	**(2)**

Question Number	Acceptable Answer	Mark
21(b)	$Ba(OH)_2 + 2HCl \rightarrow BaCl_2 + 2H_2O$ IGNORE state symbols even if incorrect. ALLOW $H^+ + OH^- \rightarrow H_2O$ TE from (a)(i): $BaO + 2HCl \rightarrow BaCl_2 + H_2O$	**(1)**

Question Number	Acceptable Answer	Reject	Mark
21(c)	**White** precipitate/**white** solid/**white** crystals (rather than colourless solution). **(1)** Barium sulfate is insoluble (whereas barium chloride is soluble). **(1)** Stand-alone marks.	'Cloudy' alone	**(2)**

Question Number	Acceptable Answer	Reject	Mark
21(d)(i)	**If flame test is described in (d)(i) then award appropriate marks for (d)(ii).** **A correct decomposition equation given in (d)(i) would score 1 mark.** **Allow valid discussion of thermal stability appearing in (d)(ii) for mark in (d)(i).** Barium carbonate is more thermally stable (than magnesium carbonate)/requires more heating/needs a higher temperature/decomposes more slowly/produces carbon dioxide more slowly. OR Reverse argument ($MgCO_3$ decomposes faster). ALLOW $BaCO_3$ does not decompose on heating but $MgCO_3$ does. **(1)** $MCO_3 \rightarrow MO + CO_2$ Where M stands for Mg or Ba. **(1)** IGNORE state symbols even if incorrect.	Just 'barium' Just 'produces more carbon dioxide' Just 'magnesium'	**(2)**

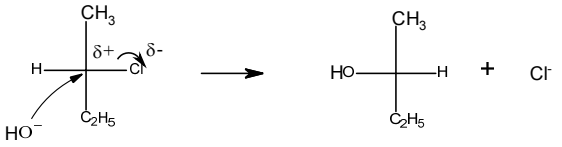
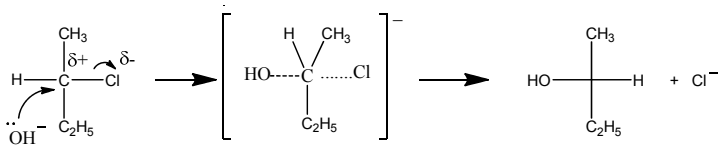
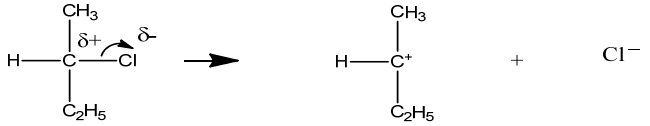
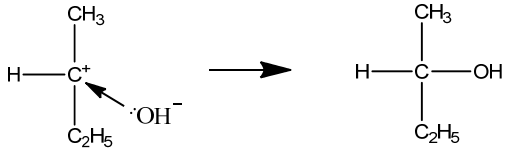
Question Number	Acceptable Answer	Reject	Mark
21(d)(ii)	Flame test or description of: Mg does not colour flame. ALLOW colourless/clear. **(1)** Ba: (pale/apple) green flame. **(1)** Stand-alone marks.	Magnesium gives white/bright flame 'Blue-green' Instrument analysis	**(2)**

Total for Question 21 = 11 Marks

Question Number	Acceptable Answer	Reject	Mark
22(a)(i)	Alcohol/ethanol (as solvent for NaOH) IGNORE heat/pressure.	Any other reagents	**(1)**

Question Number	Acceptable Answer	Mark
22(a)(ii)	Elimination	**(1)**

Question Number	Acceptable Answer	Reject	Mark
22(a)(iii)	Water (as solvent for NaOH)/aqueous (NaOH)/aqueous (ethanol)	Aqueous silver nitrate	**(1)**

Question Number	Acceptable Answer	Reject	Mark
22(a) (iv)	  ALLOW   Arrow from OH^- to appropriate C (connected/previously connected) to Cl. **(1)** Arrow from C-Cl bond to Cl producing Cl^-. **(1)** ACCEPT three dimensional diagrams ; displayed formulae; CH_3CH_2 for C_2H_5 Use of C_4H_9Cl as formula can score 1 for arrow from C-Cl bond to Cl. Lone pair on hydroxide ion need not be shown. ALLOW solid lines instead of dotted lines in the transition state.	OH without charge Cl (chlorine radical)	**(2)**

Question Number	Acceptable Answer	Reject	Mark
22(b)	Steamy/misty/white **and** fumes/gas. **(1)** IGNORE fizzing. $CH_3CH_2CH(OH)CH_3 + PCl_5 \rightarrow CH_3CH_2CHClCH_3 + HCl + POCl_3$ **(1)** ALLOW C_4H_9OH and $C_4H_9C.l$ ALLOW PCl_3O. ACCEPT displayed formulae. ALLOW missing bracket in alcohol. Stand-alone marks.	White smoke Solid $CH_3CH_2CH_2CH_2OH$ $C_4H_{10}O$	**(2)**

Question Number	Acceptable Answer	Reject	Mark
22(c)(i)	With butan-2-ol: (change from orange) to green/blue. **(1)** With **A**: remains orange/no change. **(1)** ALLOW 'no reaction'. Any reference to 'yellow': maximum 1 mark.	Reference to gas given off or formation of precipitate Green-blue Just 'nothing'	**(2)**

Question Number	Acceptable Answer	Mark
22(c)(ii)	$CH_3CH_2COCH_3$ ALLOW displayed or skeletal.	**(1)**

Question Number	Acceptable Answer	Reject	Mark
22(c)(iii)	Absorption/peak/trough for O-H/C-O/OH bond/alcohol CO bond would disappear. OR Absorption/peak/trough for C=O/CO ketone bond would appear.	Just OH/CO Just 'alcohol peak' Just 'ketone peak'	**(1)**

Total for Question 22 = 11 Marks

Question Number	Acceptable Answer	Reject	Mark
23(a)	London (forces)/van der Waals' (forces)/temporary dipole-induced dipole (attractions)/dispersion/forces/ instantaneous dipole-dipole	Dipole-dipole Permanent dipole-dipole Just abbreviations, e.g. ID-ID, VdW	**(1)**

Question Number	Acceptable Answer	Mark
23(b)	18/eighteen	**(1)**

Question Number	Acceptable Answer	Reject	Mark
23(c)	(Permanent) dipole-dipole attractions (also) present.	Hydrogen bonds Reference to CH_3F having more electrons than F_2	**(1)**

Question Number	Acceptable Answer	Mark
23(d)	**First mark:** Hydrogen bonds (also) present. **Second mark:** Which are stronger/which require more energy to break than dipole-dipole/London forces/van der Waals' forces/or strongest intermolecular force.	**(2)**

Question Number	Acceptable Answer	Reject	Mark
23(e)	HCl does not have hydrogen bonds (between molecules) IGNORE references to electronegativity	Just 'chlorine does not have hydrogen bonds'	**(1)**

Total for Question 23 = 6 Marks

Question Number	Acceptable Answer	Mark
24(a)(i)	**In (a) any units given must be correct.** **Penalise once only.** **IGNORE SF except 1SF. Penalise once only.** **TE throughout.** ((0.1x11.6)/(1000) = 1.16 x 10^{-3}/0.00116/0.0012/1.2 x 10^{-3}(mol)	**(1)**

Question Number	Acceptable Answer	Reject	Mark
24(a)(ii)	(1.16 x 10^{-3} / 2) = 5.8x10^{-4}/0.00058 (mol I_2 react with thiosulfate) 6.0x 10^{-4} if 1.2 x 10^{-3} used	6 x 10^{-4}	**(1)**

Question Number	Acceptable Answer	Reject	Mark
24(a)(iii)	((50x0.25)/1000) = 1.25x10^{-2}/12.5x10^{-3} /0.0125 (mol)	0.012	**(1)**

Question Number	Acceptable Answer	Reject	Mark
24(a)(iv)	= Answer to (a)(iii) - answer to a(ii) (1.25 x 10^{-2} **-** 5.8x10^{-4}) = 1.192 x10^{-2} /0.01192 (mol reacted with tin) 1.19 x10^{-2} /0.0119 (mol) if 6.0x 10^{-4} used ALLOW 1.2 x 10^{-2}/0.012 (mol)	 1.20 x 10^{-2}	**(1)**

Question Number	Acceptable Answer	Mark
24(a)(v)	Mass of tin = answer to (a)(iv) x118.7/ = 1.414904/ 1.415 g **(1)** % tin = $\frac{1.415 \times 100}{10.25}$ = 13.803941 = 13.8 % **(1)** TE from mass if only 1 error in its calculation. 13.83/13.8% if 1.194 x 10^{-2} used If answer to(a)(iv) = 5.8 x 10^{-4} mol I_2 this gives 0.068846 g Sn and 0.67167 % Sn scores. **(2)** Correct answer without working scores. **(2)** ALLOW **(1)** for 17.5% of SnO_2	**(2)**

Question Number	Acceptable Answer	Reject	Mark
24(b)(i)	Divide solution into separate portions for titration.	Just 'repeat the titration' Use starch	**(1)**

Question Number	Acceptable Answer	Reject	Mark
24(b)(ii)	$\frac{0.05 \times 2 \times 100}{11.6}$ = (±) 0.86% ALLOW 0.9%.	 0.90%	**(1)**

Question Number	Acceptable Answer	Reject	Mark
24(b)(iii)	Use more dilute thiosulfate (to make titration reading bigger)/Use a larger volume or moles of excess iodine.	Use more rock	**(1)**

Question Number	Acceptable Answer	Reject	Mark
24(c)	(Pale) yellow/straw coloured to colourless.	Clear for colourless Blue/black to colourless Orange/grey/brown	**(1)**

Total for Question 24 = 10 Marks

Total for Section B = 38 Marks

Section C

Question Number	Acceptable Answer	Mark
25(a)(i)	2.2 g in 1000 g = 2200 g per 1 000 000 g/2200 (ppm) (greater than 60) OR 60ppm = 0.060 (g dm^{-3}) (less than 2.2) OR 2.2g dm^{-3} = 0.22% which is more than 60ppm = 0.006% (Both values needed as neither is given in question) OR 2.2 ÷ 1000 = 2.2 x 10^{-3} and 60 ÷ 1000000 = 6 x 10^{-5}	**(1)**

Question Number	Acceptable Answer	Mark
25(a)(ii)	Cl_2 (g/aq) + $2Br^-$ (aq) → $2Cl^-$ (aq) + Br_2 (aq) Correct species. **(1)** Balancing and state symbols. **(1)**	**(2)**

Question Number	Acceptable Answer	Reject	Mark
25(a)(iii)	(Colourless to) yellow/orange/brown/red-brown colour (or any combination of these colours) appears.	Effervescence	**(1)**

Question Number	Acceptable Answer	Mark
25(a)(iv)	Addition of hydrochloric acid increases the concentration of H^+ . **(1)** Equilibrium shifts to the left/favours the backwards reaction/H^+ combines with Br^- **and** BrO^- to make H_2O and Br_2 **(1)** OR The equilibrium will not produce H^+. **(1)** So forward reaction will not occur. **(1)** Stand-alone marks.	**(2)**

Question Number	Acceptable Answer	Mark
25(a)(v)	**First mark:** The equilibrium shifts to the right/favours the forward reaction. **Second mark:** To absorb added heat (energy)/in the endothermic/positive ΔH.	**(2)**

Question Number	Acceptable Answer	Reject	Mark
25(a)(vi)	Greater proportion of/more molecules with energy more than (or equal to) activation energy/sufficient energy to react (at higher temperature). ALLOW particles. ALLOW 'overcome' for 'more than'.	Atoms Lowers activation energy Just 'more successful collisions'	**(1)**

Question Number	Acceptable Answer	Mark
25(a)(vii)	**First mark:** Bromine (atoms) are (simultaneously) oxidized from 0 to +1 in BrO^-. **Second mark:** And reduced to -1 in Br^-.	**(2)**

Question Number	Acceptable Answer	Reject	Mark
25(b)(i)	**First mark:** The forward and backward reactions occur at the same **rate.** **Second mark:** The concentrations or amounts or moles of reactants and products remain constant/intensive or macroscopic properties (e.g. colour) are constant. IGNORE reference to 'closed system'.	Concentrations of products and reactants are the same	**(2)**

Question Number	Acceptable Answer	Mark
*25(b)(ii) Quality of Written Communication	Equilibrium shifts to the right so more $CO_2(g)$ dissolves/equilibrium shifts to the right so reducing the concentration of $CO_2(aq)$. **(1)** So amount of CO_2 in atmosphere/gaseous decreases. **(1)** Second mark depends on first unless qualified by a near miss.	**(2)**

Question Number	Acceptable Answer	Reject	Mark
25(b)(iii)	(Bonds) bend/stretch/vibrate (more)/bonds change polarity or dipole (moment)	Molecules vibrate Bonds break	**(1)**

Question Number	Acceptable Answer	Reject	Mark
25(b)(iv) Quality of Written Communication	**First mark:** Infrared radiation/heat is absorbed by greenhouse gases/by carbon dioxide and water. And one of the following for the **second mark**: When energy from the sun is (re-)emitted from the earth's surface (allow 'reflected'). OR IR/heat cannot escape from earth's atmosphere. OR IR/heat is (re-)emitted back to the earth.	IR absorbed from the sun UV radiation	**(2)**

Question Number	Acceptable Answer	Reject	Mark
25(b) (v) Quality of Written Communication	**First mark:** Anthropogenic climate change is caused by human activity. **Second mark:** Natural climate change is caused by volcanic eruptions etc. Up to any three of the following to a maximum of 4 marks: Water vapour levels always relatively constant/water levels fluctuate normally /water levels vary only to a small extent. CO_2 levels increasing due to (fossil) fuel combustion/deforestation/industrial revolution. CO_2 **molecules** absorb more IR radiation than H_2O **molecules** OR CO_2 **molecules** have a greater 'greenhouse effect' than H_2O **molecules.** Increase in CO_2 levels has accompanied rise in global temperatures. Concern due to melting of ice packs/rising sea levels/flooding/change in sea pH etc.	Reference to UV Reference to ozone depletion negates this mark	**(4)**

Total for Question 25 = 22 marks

Total for Section C = 22 Marks

Total for Paper = 80 marks

Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced Subsidiary

Unit 3: Chemistry Laboratory Skills I

Sample Assessment Material
Time: 1 hour 15 minutes

Paper Reference
WCH03/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or 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.*

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.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

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

Turn over ▶

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PEARSON

Answer ALL the questions. Write your answers in the spaces provided.

1 Tests were carried out on compounds **X**, **Y** and **Z**. Complete the tables below.

(a) Compound **X** is a white, water-soluble solid.

	Test	Observation	Inference (Name or formula)	
(i)	Flame test	Lilac flame	.....	**(1)**
(ii)	To a solution of **X**, add barium chloride solution and acidify with hydrochloric acid	.....	Sulfate ions absent	**(1)**
(iii)	To a solution of **X**, add dilute nitric acid followed by	.....	Iodide ions present	**(2)**
(iv)	Add concentrated aqueous ammonia solution to the mixture remaining from test (iii)	.....	Confirms presence of iodide ions	**(1)**

(v) The **formula** of **X** is: .....

(1)

(b) Compound **Y** is a white solid that is insoluble in water.

	Test	Observation	Inference (Name or formula)	
(i)	Flame test	Yellow-red (brick red) flame	.....	**(1)**
(ii)	Add dilute hydrochloric acid to **Y** Bubble the gas through	The mixture fizzed and the solid ..... It turned milky	 CO_2 evolved	**(2)**

(iii) The **formula** of **Y** is: .....

(1)

(c) **Z** is a colourless organic liquid with only one functional group. **Z** is completely miscible with water to form a neutral solution.

	Test	Observation	Inference
(i)	Add bromine water to **Z**	No colour change	..... (1)
(ii)	Add solid phosphorus(V) chloride, PCl_5, to **Z**	Misty fumes (of hydrogen chloride)	..... (1)
(iii)	Warm **Z** with potassium dichromate(VI) solution and dilute sulfuric acid	Colour changes from orange to green	**Z** could be ..... or ..... (2)

(d) The composition by mass of **Z** is C 60.0%, H 13.3%, O 26.7%.

(i) Calculate the empirical formula of **Z**.

(2)

(ii) The molecular formula of **Z** is the same as its empirical formula. Give the **displayed** formulae of the two possible isomers of **Z**.

(2)

(Total for Question 1 = 18 marks)

2 An experiment to determine the enthalpy change of reaction between aqueous copper(II) sulfate and zinc was carried out as follows.

1. 50.0 cm^3 of copper(II) sulfate solution, of concentration 1.00 mol dm^{-3}, was placed in a polystyrene cup.
2. The temperature of the solution was measured with a 0 – 110 °C thermometer and was found to be 23.0 °C.
3. Zinc powder with a mass of 5 g (an excess) was added to the solution with vigorous stirring and the highest temperature recorded was 69.5 °C.

(a) (i) Write the **ionic** equation for the reaction between zinc and aqueous copper(II) ions, including state symbols.

(2)

(ii) Calculate the quantity of heat energy produced in the experiment above, giving your answer in J. (Assume that the heat capacity of the mixture is 4.18 J g^{-1} $°C^{-1}$ and its density is 1.00 g cm^{-3}.) Use the expression

energy transferred in joules = mass × specific heat capacity × temperature change

(2)

(iii) Calculate the number of moles of copper(II) sulfate used in the experiment.

(1)

(iv) Use your answers from (a)(ii) and (a)(iii) to calculate the enthalpy change for the reaction in kJ mol^{-1}. Give your answer to **three** significant figures and include the appropriate sign.

(2)

(b) The thermometer used in this experiment gave an uncertainty in each temperature reading of ±0.5 °C.

(i) State the maximum temperature difference in this experiment that could have been obtained using this thermometer.

(1)

(ii) What is the percentage error in the temperature change using this thermometer?

(1)

(c) **Using the same equipment**, together with a stop clock, suggest a procedure that would improve the accuracy of this experiment by obtaining a more accurate temperature change. You must use the same mass of zinc powder and the same volume of 1.00 mol dm^{-3} copper(II) sulfate solution.

(4)

(Total for Question 2 = 13 marks)

3 Chloroalkanes and bromoalkanes can be made from alcohols by reaction of the alcohol with sodium chloride or bromide, in the presence of 50% aqueous sulfuric acid.

Iodoalkanes cannot be made from sodium iodide and sulfuric acid; red phosphorus and iodine can be used instead as the halogenating agent.

(a) (i) What would you **see** if concentrated sulfuric acid was added to solid sodium iodide? Give **two** observations.

(2)

1. .....

.....

2. .....

.....

(ii) Explain why sodium iodide and sulfuric acid cannot be used to make iodoalkanes from alcohols.

(2)

.....

.....

.....

.....

(b) Give the equation for the reaction between phosphorus and iodine to form phosphorus(III) iodide. State symbols are not required.

(1)

(c) A preparation of 1-iodobutane is given in outline below.

Procedure

1. Suitable quantities of red phosphorus and butan-1-ol are placed in a round-bottomed flask fitted with a reflux condenser.
2. The mixture is heated until it boils gently and then the heat source is removed.
3. A suitable quantity of powdered iodine is added in small portions down the condenser at a rate which just maintains gentle boiling. The reaction should be allowed to subside after each addition.
4. After the addition of iodine is complete, the mixture is heated under reflux for 30 – 60 minutes, until little or no iodine is visible.
5. The apparatus is allowed to cool and the condenser rearranged for distillation.
6. The crude 1-iodobutane is distilled off until the residue in the distilling flask is about one-fifth of its original volume. Double its volume of water is added and the distillation continued until no more oily drops condense into the receiver.
7. The crude 1-iodobutane is separated and washed with dilute sodium thiosulfate solution and then with dilute sodium carbonate solution.
8. The organic layer is separated and allowed to stand over anhydrous calcium chloride.

(i) What does the manner in which the iodine is added in **step 3** suggest about the nature of the reaction?

(1)

.....

(ii) Completion of **step 4** requires that 'little or no iodine is visible'. State what you would look for in this step to ensure that this is true.

(1)

.....

.....

(iii) Draw the apparatus that is used in **step 6** for distillation.

(3)

(iv) Suggest why the first washing of the product in **step 7** is with dilute sodium thiosulfate solution rather than with water alone.

(1)

(v) State why calcium chloride used in **step 8** must be anhydrous.

(1)

(vi) To complete the preparation, after decanting the mixture from the calcium chloride, there should be a **step 9**. What is this step?

(1)

(d) Chloroalkanes can be made from an alcohol and phosphorus(V) chloride, PCl_5. The equation for the reaction of butan-1-ol with PCl_5 is

$$CH_3CH_2CH_2CH_2OH + PCl_5 \rightarrow CH_3CH_2CH_2CH_2Cl + HCl + POCl_3$$

This reaction is not suitable for the manufacture of 1-chlorobutane on a large scale.

(i) In a laboratory preparation of 1-chlorobutane, 95.0 g of butan-1-ol was used. Calculate the maximum mass of 1-chlorobutane that could be obtained.

(Assume the molar masses are, in g mol^{-1}, butan-1-ol = 74.0, 1-chlorobutane = 92.5)

(2)

(ii) In practice, 95.3 g of 1-chlorobutane was obtained. Calculate the percentage yield.

(1)

(iii) Give **one** reason why the actual yield is lower than the maximum possible yield.

(1)

.....

.....

(iv) Give **two** reasons why this reaction would not be used industrially to make 1-chlorobutane.

(2)

.....

.....

.....

.....

(Total for Question 3 = 19 marks)

TOTAL FOR PAPER = 50 MARKS

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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

Mark Scheme (SAM)

Pearson Edexcel International Advanced Subsidiary in Chemistry

Unit 3: Chemistry Laboratory Skills I

General marking guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- 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 may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed-out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of Quality of Written Communication, are being assessed. The strands are as follows:
    i. ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
    ii. select and use a form and style of writing appropriate to purpose and to complex subject matter
    iii. organise information clearly and coherently, using specialist vocabulary when appropriate.

Using the Mark Scheme

Examiners should NOT give credit for incorrect or inadequate answers, but allow 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 still be creditworthy.

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.
Bold	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)(transfer error)(consequential) 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. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Question Number	Acceptable Answer	Reject	Mark
1(a)(i)	Potassium (ions)/K^+	K/incorrect formula Name with incorrect formula, e.g. 'Potassium, K'	**(1)**

Question Number	Acceptable Answer	Reject	Mark
1(a)(ii)	No precipitate forms/no change/no reaction/colourless **solution.** ALLOW clear for colourless.	White precipitate dissolves. Just 'dissolves'	**(1)**

Question Number	Acceptable Answer	Reject	Mark
1(a)(iii)	Silver nitrate (solution)/$AgNO_3$ ALLOW acidified silver nitrate. **(1)** Yellow precipitate/solid ALLOW yellow suspension. **(1)** Second mark depends on first mark (use of silver nitrate).	Pale yellow precipitate	**(2)**

Question Number	Acceptable Answer	Reject	Mark
1(a)(iv)	(Precipitate) does not dissolve/(precipitate) is insoluble/(precipitate) becomes paler in colour. ALLOW 'no change/no reaction'. ALLOW mark for insoluble even if wrong reagent is used in (a)(iii) to form a **precipitate** regardless of colour. Mark can only be given if there is a **precipitate** in (a)(iii).	Grey solid	**(1)**

Question Number	Acceptable Answer	Reject	Mark
1(a)(v)	KI Consequential on cation other than K^+ in (a)(i). ALLOW K^+I^-	Just potassium iodide Formula based on cation with incorrect charge or anion other than iodide	(1)

Question Number	Acceptable Answer	Reject	Mark
1(b)(i)	Calcium (ions)/Ca^{2+} ALLOW +2 for 2+.	Ca/incorrect formula Name with incorrect formula, e.g. 'Calcium, Ca'	(1)

Question Number	Acceptable Answer	Reject	Mark
1(b)(ii)	Dissolved/disappeared (1) Limewater/calcium hydroxide (solution) /$Ca(OH)_2$ ((aq)) (1)	Melted	(2)

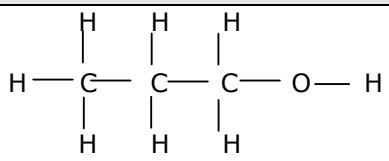
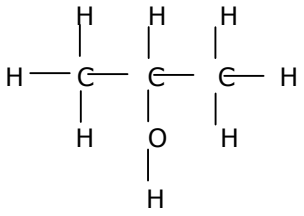
Question Number	Acceptable Answer	Reject	Mark
1(b)(iii)	$CaCO_3$ ALLOW $Ca(HCO_3)_2$. TE on incorrect metal ion in b(i) if correct formula given e.g $SrCO_3$, Na_2CO_3.	Name Formula based on cation with incorrect charge, e.g Ca_2CO_3 or anion other than carbonate or hydrogencarbonate	(1)

Question Number	Acceptable Answer	Reject	Mark
1(c)(i)	No double bonds between C atoms /C=C absent/not an alkene/**Z** is saturated/only single bonds between C atoms. ALLOW not an alkene or alkyne.	Just 'no double bonds' Just 'single bond(s)' alkane or any other functional group stated even if alcohol	**(1)**

Question Number	Acceptable Answer	Reject	Mark
1(c)(ii)	Alcohol/(−)OH/ROH/hydroxyl group present. ALLOW (−)COH.	OH^-/hydroxide for hydroxyl CHO Carboxylic acid Phenol	**(1)**

Question Number	Acceptable Answer	Reject	Mark
1(c)(iii)	Primary/1° alcohol **(1)** Secondary/2° alcohol **(1)** ALLOW **Not** a tertiary alcohol for 1 mark. ALLOW propan-1-ol **(1)** propan-2-ol **(1)**	Just 'alcohol' Tertiary alcohols Other specific examples Alcohol and carboxylic acid	**(2)**

Question Number	Acceptable Answer	Reject	Mark
1(d)(i)	<table><tr><td>C 60.0 ÷ 12</td><td>= 5.0</td><td>3</td></tr><tr><td>H 13.3 ÷ 1</td><td>= 13.3</td><td>8</td></tr><tr><td>O 26.7 ÷ 16</td><td>= 1.67</td><td>1</td></tr></table> Ratio 5.0: 13.3: 1.67 **(1)** C_3H_8O **(1)** Correct answer without working scores 2 marks. Correct answer with incorrect working (e.g. mole calculations inverted) scores 1 mark. No TE on incorrect ratios.	C_3H_7OH	**(2)**

Question Number	Acceptable Answer	Reject	Mark
1(d)(ii)	 **(1)**  **(1)**	C-H-O	**(2)**
	ALLOW – OH for the hydroxyl group, but bond should go from C to O in propan-1-ol. IGNORE poorly placed OH in propan-2-ol. ALLOW skeletal formulae/structural formulae both correct – 1 mark. ALLOW TE from 1(d)(i), e.g. if a different number of carbon atoms is given in 1di then allow 2 different isomers drawn displayed correctly.	C_3H_7OH	

Total for Question 1 = 18 Marks

Question Number	Acceptable Answer	Reject	Mark
2(a)(i)	$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$ First mark for correct species in a balanced equation. ALLOW hexaqua ions providing the equation is balanced. IGNORE reversible arrows. **(1)** Second mark for states. Consequential on a reasonable attempt at the equation, including for a full equation or unbalanced equation. For example, ALLOW as reasonable Zn with 1+ instead of 2+ Sulfate ions shown correctly but not cancelled out. **(1)**	Sulfate ions not cancelled out Reversed equation Zn and Cu metal both shown as ions	**(2)**

Question Number	Acceptable Answer	Reject	Mark
2(a)(ii)	q = 50.0 x 4.18 x 46.5 **(1)** = 9718.5 (J)/9.7185 kJ **(1)** **Correct answer with no working scores (2)** IGNORE sf except 1 (i.e. allow 9719/9720 /9700 or 9.719/9.72/9.7 **kJ**) IGNORE sign of q if given. If mass used 55.0g and q = 55.0 x 4.18 x 46.5 = 10690.35 (J) **(1)** If mass used is 5g and q = 5 x 4.18 x 46.5 = 971.85(J) **(1)**	9718	**(2)**

Question Number	Acceptable Answer	Mark
2(a)(iii)	$\frac{50.0 \times 1}{1000}$ = 0.05 (mol) Mark is for final answer.	**(1)**

Question Number	Acceptable Answer	Mark
2(a)(iv)	ΔH = -9718.5 ÷ (0.050 x 1000) = -194.370 (kJ mol^{-1}) = **-194** (kJ mol^{-1}) ALLOW = -194000 **J mol^{-1}** **First mark:** Value, ignore sign and sf. Only penalise units if value is in J (mol^{-1}) without stating this **(1)** TE (a)(ii) ÷ ((a)(iii) x 1000) Using 10690.5 gives - 2138810J = **-214** kJ mol^{-1}. **Second mark:** Sign and 3 sf. **(1)** **This mark depends on a correct calculation method.**	**(2)**

Question Number	Acceptable Answer	Mark
2(b)(i)	47.5 (°C)	**(1)**

Question Number	Acceptable Answer	Reject	Mark
2(b)(ii)	(1.0 x 100) ÷ 46.5 = 2.1505376 = (±) **2.15/2.2/2** (%) IGNORE sf. ALLOW answer with 47.5 in the denominator which gives 2.1052631 = (±) **2.11/2.1/2** (%). ALLOW TE on value (b)(i).	2.0 and 2.1 2.0 and 2.2	**(1)**

Question Number	Acceptable Answer	Reject	Mark
2(c)	**First mark:** Measure the temperature (of copper(II) sulfate) every minute/at realistic time interval (15 seconds to 1 minute) for, e.g., 2-4 minutes before adding zinc. OR measure temperature (of copper(II) sulfate) before adding zinc. **(1)** **Second mark:** Measure temperature each minute/at realistic time intervals (after adding zinc) for several minutes. **(1)** **N.B.** these readings may be started after the maximum temperature is reached/after reaction has stopped and taken until the mixture has cooled to room temperature. Intervals should be chosen to allow at least 4 readings on cooling section of curve. **Third mark:** Plot a temperature – time graph/plot a graph using measurements (of temp and time) obtained. **(1)** This mark can be awarded if first two marks are insufficient for credit. **Fourth mark:** **Extrapolate** to find ΔT/ maximum temperature (at the time of mixing). OR use properly described intersecting lines to find maximum temperature. **(1)** ALLOW third and fourth marking points to be shown on annotated diagrams/graph. **If zinc is added in small portions or over a period of time only first and third marks can be awarded.** (since measurements of cooling will be incorrect and there is no definite time when reaction starts.)	Readings more often than every 15 s	**(4)**

Total for Question 2 = 13 Marks

Question Number	Acceptable Answer	Reject	Mark
3(a)(i)	Any two from: Misty/steamy fumes **(1)** Purple/violet fumes **(1)** ALLOW purple gas/vapour. Brown or black solution/liquid/solid OR grey/grey-black solid **(1)** Yellow solid/deposit **(1)** ALLOW yellow precipitate. IGNORE effervescence, bubbles, colour change, coloured fumes, solid disappears, description of smells, identification of products even if incorrect, follow-on tests, e.g. effect on potassium dichromate paper.	White fumes Steamy white Smoke Yellow fumes Yellow liquid	**(2)**

Question Number	Acceptable Answer	Reject	Mark
3(a)(ii)	There is little/no HI formed (which is the reagent needed). **(1)** Because HI is **oxidized** (to iodine)/because iodide ions are **oxidized** (to iodine)/sulfuric acid is oxidizing/HI **reduces** sulfuric acid/iodide ions **reduce** sulfuric acid. **(1)** Must mention oxidation or reduction correctly for second mark. IGNORE 'an elimination reaction would occur'. ALLOW 'HI is oxidized to iodine' for both marks.	Iodide **ions** react with sulfuric acid Sulfuric acid oxidizes **iodine** HI is **reduced** to iodine	**(2)**

Question Number	Acceptable Answer	Reject	Mark
3(b)	$2P + 3I_2 \rightarrow 2PI_3$ OR $P + 3/2I_2 \rightarrow PI_3$ OR $P_4 + 6I_2 \rightarrow 4PI_3$ ALLOW reversible sign. IGNORE state symbols even if incorrect.	Equations with ions I for I_2	**(1)**

Question Number	Acceptable Answer	Reject	Mark
3(c)(i)	Exothermic ALLOW fast/vigorous/violent.	Dangerous Reactive (In)flammable Volatile	**(1)**

Question Number	Acceptable Answer	Reject	Mark
3(c)(ii)	(Very) pale purple/yellow/straw coloured OR Colourless mixture/is decolourised OR Co purple colour	Clear for colourless No (grey) solid remains Add starch	**(1)**

Question Number	Acceptable Answer	Reject	Mark
3(c)(iii)	Diagram to show: Distillation flask and still-head and heat. **(1)** (no need for a thermometer) ALLOW appropriate tubing as alternative to still head. ALLOW heating with electrical, water bath, Bunsen or just arrow. IGNORE thermometer and position, tap funnel in still head, absence of reagents in flask Condenser sloping downwards **(1)** With water entering at the bottom and suitable receiver (e.g. flask or beaker) **(1)**	Conical flask	**(3)**

Question Number	Acceptable Answer	Reject	Mark
3(c)(iv)	This removes/reacts with (any residual) iodine. OR Removes excess iodine/I_3^-.	Removes acid Removes impurities Removes iodide Removes ions (other than I_3^-) Just reduces iodine to iodide	**(1)**

Question Number	Acceptable Answer	Reject	Mark
3(c)(v)	Anhydrous calcium chloride/it is drying agent OR anhydrous salt needed to remove water/hydrated salt will not remove water Allow moisture for water and absorb for remove.	Just 'calcium chloride is a drying agent'	**(1)**

Question Number	Acceptable Answer	Reject	Mark
3(c)(vi)	Distillation/re-distillation (over a narrow range of temperature) (either side of the boiling temperature of 1-iodobutane). ALLOW fractional distillation. IGNORE filtering before distillation and any temperatures given.	Recrystallisation Just 'purification'	**(1)**

Question Number	Acceptable Answer	Mark
3(d)(i)	(95.0 ÷ 74.0) x 92.5 g **(1)** = 118.75/118.8/119 g **(1)** ALLOW 118.77 (from use of 1.284) 3, 4 or 5 sf in final answer Correct final answer scores 2 marks. OR Rounding errors by dividing 95.0 ÷ 74.0 as a first step: e.g. (95.0 ÷ 74.0)=1.28, followed by 1.28 x 92.5 = 118.4/118 **(1)** e.g. (95.0 ÷ 74.0) = 1.3 followed by 1.3 x 92.5 = 120.25/120.3/120 **(1)**	**(2)**

Question Number	Acceptable Answer	Reject	Mark
3d(ii)	95.3 ÷ 3(d)(i) (95.3 ÷ 118.75) x 100 = 80.2563 = **80.25/80.3** % Many candidates give the answer to 3 d(i) to 3sf, e.g. 119 but keep the full answer in their calculator, resulting in an answer of 80.25 which is correct and should be allowed. TE from 3(d)(i).	80.2	**(1)**

Question Number	Acceptable Answer	Reject	Mark
3d(iii)	**One** of: Handling/transfer losses Competing reactions/(unwanted) side reaction/by-products form Incomplete reaction	Just 'losses'/spillage Impure reagents Loss by evaporation Other products form Not enough PCl_5 to react	**(1)**

Question Number	Acceptable Answer	Reject	Mark
3d(iv)	**Two** of: Low atom economy IGNORE 'low percentage/80% yield'. Phosphorus(V) chloride expensive. Disposal of unwanted materials expensive or difficult. No (large scale) use for $POCl_3$. Difficult/expensive to separate required product. No credit for: Slow/time consuming Exothermic Not efficient High energy use Competing reactions Non-renewable reactants HCl toxic/acidic Unwanted products	Just Atom economy not 100% Just 'It' would be expensive Anything to do with environmental friendliness or the ozone layer or the end of life on Earth.	**(2)**

Total for Question 3 = 19 Marks

Total for Paper = 50 Marks

Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced

Unit 4: General Principles of Chemistry I – Rates, Equilibria and Further Organic Chemistry (including synoptic assessment)

Sample Assessment Material
Time: 1 hour 40 minutes

Paper Reference
WCH04/01

You must have: Data Booklet

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or 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.*

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.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

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

Turn over ▶

S45363A

S 4 5 3 6 3 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 The overall equation for a reaction between two chemicals, M and N, is

$$M + 2N \rightarrow P + Q$$

(a) This reaction occurs spontaneously at room temperature. Which of the following **must** be true?

(1)

☒ **A** $\Delta H^{\ominus}_{reaction}$ is positive.

☒ **B** $\Delta H^{\ominus}_{reaction}$ is negative.

☒ **C** $\Delta S^{\ominus}_{total}$ is positive.

☒ **D** $\Delta S^{\ominus}_{total}$ is negative.

(b) The reaction above occurs in two stages via an intermediate, T.

$$M + N \rightarrow T \qquad \text{slow}$$

$$N + T \rightarrow P + Q \qquad \text{fast}$$

From this it can be deduced that the rate equation for the reaction between M and N is

(1)

☒ **A** rate = k[M][N]

☒ **B** rate = k[M][N]^2

☒ **C** rate = k[M][T]

☒ **D** rate = k[N][T]

(Total for Question 1 = 2 marks)

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

2 Calcium carbonate decomposes at high temperature to form calcium oxide and carbon dioxide:

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

Calcium carbonate is **thermodynamically** stable at room temperature because for this reaction

- ☒ **A** the activation energy is high.
- ☒ **B** the enthalpy change, ΔH, is positive.
- ☒ **C** entropy change of the system (ΔS_{system}) is positive.
- ☒ **D** entropy change of the system (ΔS_{system}) is negative.

(Total for Question 2 = 1 mark)

3 2-methylpropane has a smaller standard molar entropy at 298 K than butane. The best explanation for this is that 2-methylpropane has

- ☒ **A** a lower boiling temperature.
- ☒ **B** a higher standard molar enthalpy change of formation.
- ☒ **C** fewer ways of distributing energy quanta.
- ☒ **D** more ways of distributing energy quanta.

(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) For the equilibrium reaction between hydrogen and iodine

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

increasing the pressure of the system

(1)

☒ **A** has no effect on the rate or the position of equilibrium.

☒ **B** increases the rate but does not affect the position of equilibrium.

☒ **C** increases the rate and shifts the equilibrium to the right.

☒ **D** increases the rate and shifts the equilibrium to the left.

(b) The equation for the equilibrium reaction between hydrogen and iodine may also be written as

$$\tfrac{1}{2}H_2(g) + \tfrac{1}{2}I_2(g) \rightleftharpoons HI(g)$$

This change to the equation, compared to that in part (a),

(1)

☒ **A** has no effect on the value of the equilibrium constant.

☒ **B** halves the value of the equilibrium constant.

☒ **C** doubles the value of the equilibrium constant.

☒ **D** square roots the value of the equilibrium constant.

(Total for Question 4 = 2 marks)

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

5 The first stage in the manufacture of nitric acid is the oxidation of ammonia:

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g) \quad \Delta H = -906 \text{ kJ mol}^{-1}$$

(a) In modern industrial plants this reaction is carried out at a pressure of around 3 atm. Which of the following statements is **incorrect**? The raised pressure

(1)

☒ **A** helps push the reactants through the reactor.

☒ **B** shifts the position of equilibrium to the right.

☒ **C** increases the cost of the reactor.

☒ **D** increases the energy cost of this part of the process.

(b) A platinum-rhodium alloy catalyst is used in this reaction. Which of the following statements is **incorrect**? The catalyst

(1)

☒ **A** lowers the activation energy of the reaction.

☒ **B** has no effect on the equilibrium constant for the reaction.

☒ **C** alters the enthalpy change of the reaction.

☒ **D** reduces the energy cost of this part of the process.

(c) The operating temperature of this reaction is about 900 °C. The use of a high temperature

(1)

☒ **A** increases the rate of the reaction and the equilibrium yield.

☒ **B** increases the rate of the reaction and decreases the equilibrium yield.

☒ **C** decreases the rate of the reaction and the equilibrium yield.

☒ **D** decreases the rate of the reaction and increases the equilibrium yield.

(Total for Question 5 = 3 marks)

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

6 Ammonium chloride decomposes on heating:

$$NH_4Cl(s) \rightleftharpoons NH_3(g) + HCl(g)$$

The equilibrium constant, K_p, for this reaction equals

☒ **A** $P_{NH_3} \times P_{HCl}$

☒ **B** $\dfrac{1}{P_{NH_3} \times P_{HCl}}$

☒ **C** $\dfrac{P_{NH_3} \times P_{HCl}}{P_{NH_4Cl}}$

☒ **D** $\dfrac{P_{NH_4Cl}}{P_{NH_3} \times P_{HCl}}$

(Total for Question 6 = 1 mark)

7 The dissociation constant of water, K_w, increases with increasing temperature. When the temperature increases, water

☒ **A** remains neutral.

☒ **B** dissociates less.

☒ **C** becomes acidic.

☒ **D** becomes alkaline.

(Total for Question 7 = 1 mark)

8 The reaction between concentrated sulfuric acid and pure ethanoic acid is

$$CH_3COOH + H_2SO_4 \rightleftharpoons CH_3COOH_2^+ + HSO_4^-$$

The Brønsted-Lowry acids in this equilibrium are

☒ **A** CH_3COOH and H_2SO_4

☒ **B** $CH_3COOH_2^+$ and HSO_4^-

☒ **C** H_2SO_4 and $CH_3COOH_2^+$

☒ **D** CH_3COOH and HSO_4^-

(Total for Question 8 = 1 mark)

9 An aqueous solution of ethanoic acid is gradually diluted. Which of the following statements is **incorrect**?

☒ **A** The pH decreases.

☒ **B** The value of K_a is unchanged.

☒ **C** The concentration of ethanoic acid molecules decreases.

☒ **D** The proportion of ethanoic acid molecules which dissociates increases.

(Total for Question 9 = 1 mark)

10 Methyl orange and phenolphthalein are both acid-base indicators. In the titration of a strong acid against a weak alkali

☒ **A** methyl orange is a suitable indicator but phenolphthalein is not.

☒ **B** phenolphthalein is a suitable indicator but methyl orange is not.

☒ **C** both phenolphthalein and methyl orange are suitable indicators.

☒ **D** neither phenolphthalein nor methyl orange is a suitable indicator.

(Total for Question 10 = 1 mark)

11 Select the word that best describes the effect of a chiral molecule on the plane of plane-polarized light. The plane of polarization of light is

☒ **A** reflected.

☒ **B** refracted.

☒ **C** resolved.

☒ **D** rotated.

(Total for Question 11 = 1 mark)

12 An organic compound reacts with **both** acidified potassium dichromate(VI) **and** lithium tetrahydridoaluminate (lithium aluminium hydride). The organic compound could be

☒ **A** a primary alcohol.

☒ **B** an aldehyde.

☒ **C** a ketone.

☒ **D** a carboxylic acid.

(Total for Question 12 = 1 mark)

13 Ketones react with

- ☒ **A** both 2,4-dinitrophenylhydrazine solution and Tollens' reagent.
- ☒ **B** 2,4-dinitrophenylhydrazine solution but not with Tollens' reagent.
- ☒ **C** Tollens' reagent but not with 2,4-dinitrophenylhydrazine solution.
- ☒ **D** neither Tollens' reagent nor 2,4-dinitrophenylhydrazine solution.

(Total for Question 13 = 1 mark)

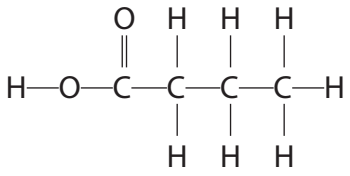
14 Ethanoic acid, CH_3COOH, may be prepared from ethanenitrile, CH_3CN. This reaction is best described as

- ☒ **A** reduction.
- ☒ **B** oxidation.
- ☒ **C** hydrolysis.
- ☒ **D** condensation.

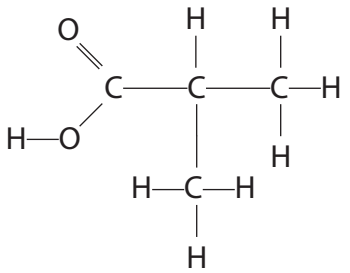
(Total for Question 14 = 1 mark)

15 Propanoic acid reacts with methanol to form an ester. The structure of the ester is

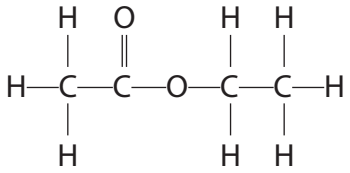
☒ **A**



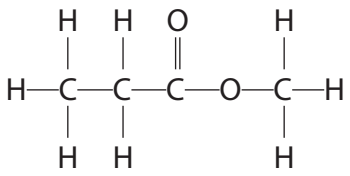
☒ **B**



☒ **C**



☒ **D**



(Total for Question 15 = 1 mark)

16 The boiling temperature of ethanoic acid is very much higher than that of butane although these molecules have similar numbers of electrons. This is because ethanoic acid has

☒ **A** stronger covalent bonds.

☒ **B** stronger ionic bonds.

☒ **C** greater London forces.

☒ **D** hydrogen bonding.

(Total for Question 16 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

17 The equation for the combustion of hydrogen is

$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(l)$$

(a) Use the standard molar entropies on page 2 and page 25 of the data booklet to calculate the standard entropy change of the system ($\Delta S^{\ominus}_{system}$) for this reaction.

Note that the standard molar entropies of the elements are given **per atom** so that the standard molar entropy of oxygen, $S^{\ominus}[\frac{1}{2}O_2(g)] = +102.5$ J mol^{-1} K^{-1}.

(3)

(b) The standard enthalpy change for the combustion of hydrogen is –285.8 kJ mol^{-1}. Use this value to calculate the entropy change of the surroundings for the combustion of hydrogen at 298 K. Give your answer to **3** significant figures and include a sign and units.

(3)

(c) Use your answers to (a) and (b) to calculate the total entropy change ($\Delta S^{\ominus}_{total}$) for the combustion of 1 mol of hydrogen. Include a sign and units in your answer.

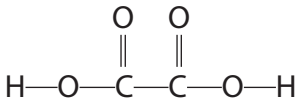
(2)

*(d) By considering both the thermodynamic stability and the kinetic inertness of a mixture of hydrogen and oxygen, explain why hydrogen does not react with oxygen unless ignited.

(2)

(Total for Question 17 = 10 marks)

18 Ethanedioic acid, $H_2C_2O_4$, is a dicarboxylic acid which occurs in many plants, for example in rhubarb leaves, and is used as a rust remover and strong descaler. The structure of ethanedioic acid is shown below.



Ethanedioic acid is a much stronger acid than carboxylic acids such as ethanoic acid, having a pK_a of 1.38. The hydrogenethanedioate ion, $HC_2O_4^-$, is a weaker acid than ethanedioic acid, having a pK_a of 4.28, although slightly stronger than ethanoic acid.

(a) (i) Write an equation for the reaction of the hydrogenethanedioate ion with water to form an acidic solution. Include state symbols in your equation.

(2)

(ii) Write the expression for the acid dissociation constant, K_a, of the weak acid, $HC_2O_4^-$.

(1)

(iii) A solution containing hydrogenethanedioate ions behaves as a typical weak acid. Use your answer to (a)(ii) and the pK_a of the hydrogenethanedioate ion to calculate the pH of a 0.050 mol dm^{-3} solution of sodium hydrogenethanedioate, $NaHC_2O_4$.

(3)

(b) (i) State **two** approximations used in the calculation of pH in (a)(iii).

(2)

1. .....

.....

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2. .....

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*(ii) Explain why the calculation of the pH of a solution of sodium hydrogenethanedioate gives a more accurate value than a similar calculation for ethanedioic acid.

(2)

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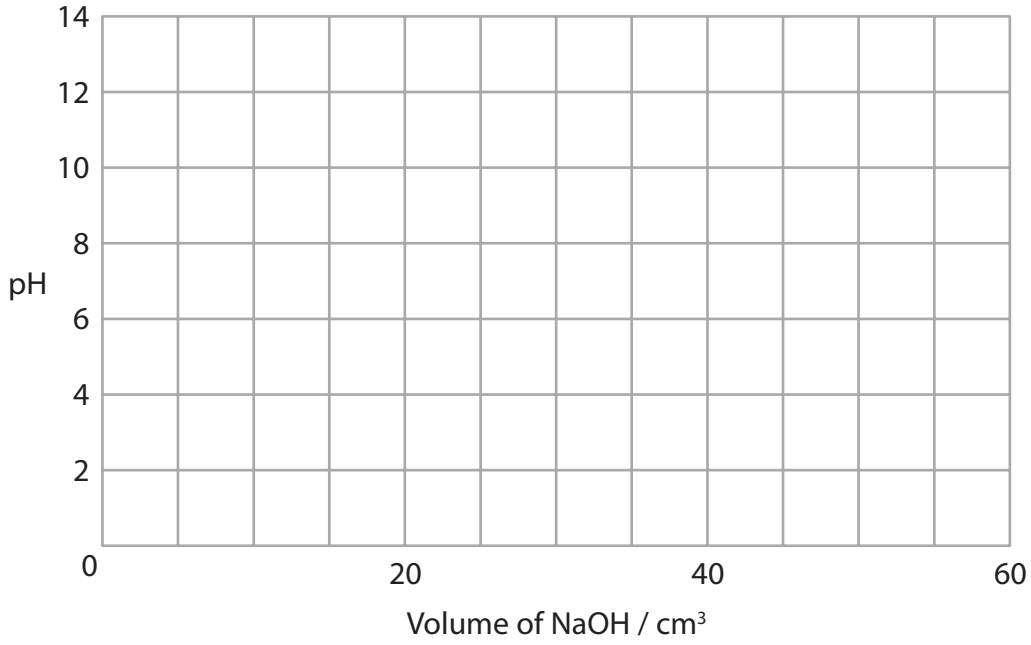
(c) 25 cm^3 of a 0.050 mol dm^{-3} solution of sodium hydrogenethanedioate was titrated with a sodium hydroxide solution of the same concentration.

(i) On the axis below, sketch the curve for this titration.

(3)



*(ii) When 25 cm^3 of a 0.050 mol dm^{-3} solution of **ethanedioic acid** is titrated with sodium hydroxide solution of the same concentration using phenolphthalein as the indicator, the end point is 50 cm^3.

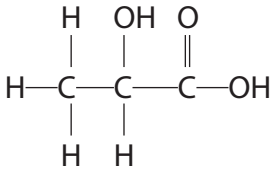
When methyl yellow indicator is used, the colour changes at around 25 cm^3.

Using the information given at the start of the question and quoting data from page 19 of your data booklet, suggest why these volumes are different.

(2)

(Total for Question 18 = 15 marks)

19 2-hydroxypropanoic acid, lactic acid, is a chiral molecule which is found in muscles and in sour milk. The 2-hydroxypropanoic acid formed in muscles is optically active but that in sour milk is not.



2-hydroxypropanoic acid

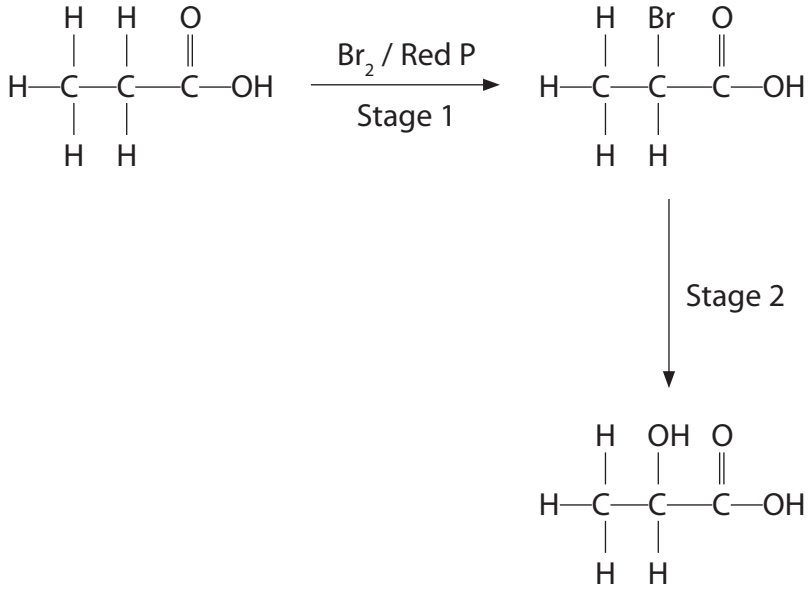
(a) (i) Explain the term **chiral**, stating the feature of 2-hydroxypropanoic acid that makes it chiral. Label this feature on the formula above.

(3)

(ii) What is the difference between the 2-hydroxypropanoic acid formed in muscles and that found in sour milk which gives rise to the difference in optical activity?

(2)

(b) 2-hydroxypropanoic acid may be prepared in the laboratory from propanoic acid in a two-stage sequence in which 2-bromopropanoic acid is formed as an intermediate:



(i) Stage 2 of this sequence was carried out in two steps. Identify the reagent required for each step in Stage 2.

(2)

First step .....

Second step .....

(ii) When an optically active isomer of 2-bromopropanoic acid is used in Stage 2, the resulting 2-hydroxypropanoic acid is also optically active. State and explain what this indicates about the mechanism of the first reaction in Stage 2.

(3)

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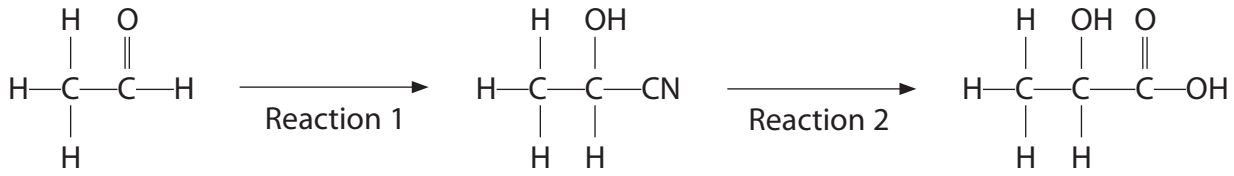
(c) 2-hydroxypropanoic acid may also be prepared from ethanal in the following sequence:



(i) Name the mechanism and type of reaction occurring in Reaction 1.

(2)

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(ii) Identify the attacking species in Reaction 1.

(1)

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(iii) Give the first step of the mechanism of Reaction 1, showing the formation of the intermediate.

(2)

*(iv) Explain, by referring to the mechanism in (c)(iii), why the 2-hydroxypropanoic acid formed from ethanal shows no optical activity.

(3)

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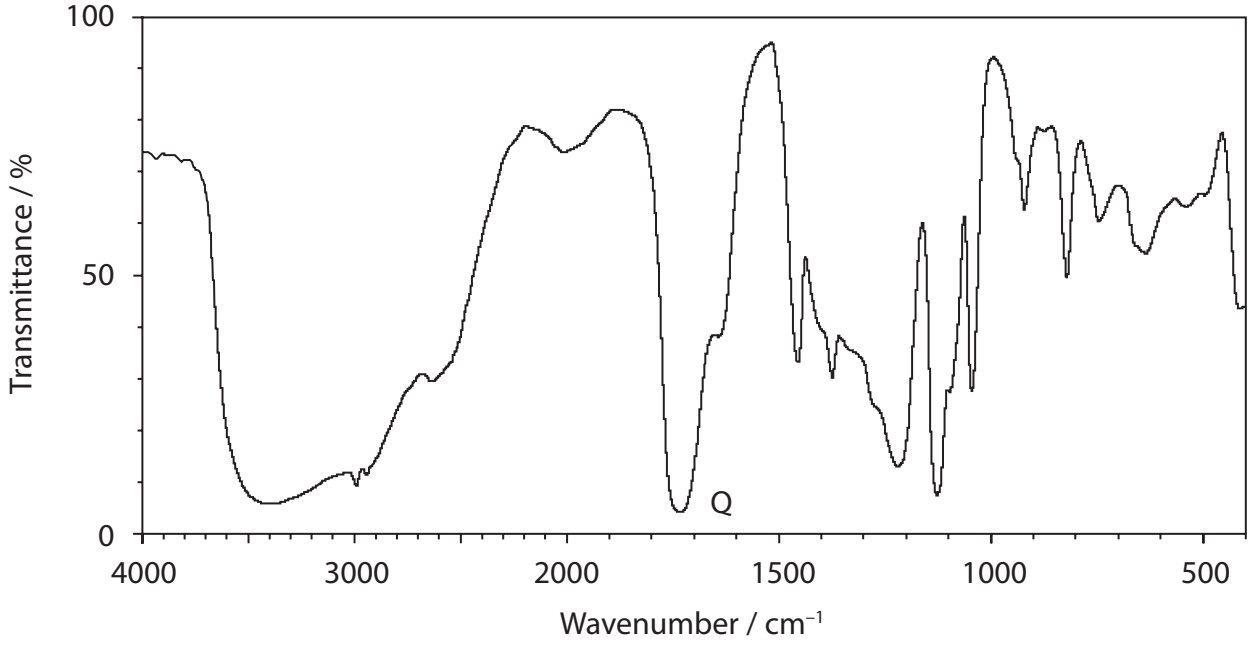
(d) The infrared spectrum of 2-hydroxypropanoic acid is shown below.



(i) Give the wavenumber of the peak that is present in the infrared spectrum of 2-hydroxypropanoic acid but will not be present in the infrared spectrum of ethanal, identifying the group most likely to be responsible for this peak. Use the data on pages 5 and 6 of the data booklet.

(1)

.....

.....

.....

*(ii) Identify the bond responsible for absorption peak Q in the spectrum. By considering the wavenumber of this peak, and the data on pages 5 and 6 of the data booklet, explain whether this peak **alone** can be used to distinguish between ethanal and 2-hydroxypropanoic acid.

(3)

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.....

(e) Ethanal and 2-hydroxypropanoic acid can be distinguished by the use of chemical tests. Give two suitable tests **not** involving indicators. For each test, state the observation associated with a positive result.

(4)

Test which is positive for ethanal but not for 2-hydroxypropanoic acid.

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.....

Test which is positive for 2-hydroxypropanoic acid but not for ethanal.

.....

.....

.....

.....

(Total for Question 19 = 26 marks)

TOTAL FOR SECTION B = 51 MARKS

SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

20 The ionic equation for the reaction of ammonium peroxodisulfate (persulfate), $(NH_4)_2S_2O_8$, with potassium iodide, KI, is

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

(a) In a series of experiments to determine the rate equation for this reaction, 10 cm^3 of 0.0050 mol dm^{-3} sodium thiosulfate was mixed with 20 cm^3 of $(NH_4)_2S_2O_8$ solution and 5 drops of starch solution. 20 cm^3 of KI solution was added with mixing and the time taken for the solution to darken was noted. The initial concentrations of the $(NH_4)_2S_2O_8$ and KI solutions and the times for the mixture to darken are shown below.

Experiment Number	Initial concentration / mol dm^{-3}		Time for solution to darken / s
	$S_2O_8^{2-}$	I^-	
1	0.10	0.20	35
2	0.05	0.20	69
3	0.10	0.10	70

(i) Explain the purpose of the sodium thiosulfate solution.

(2)

(ii) Use the data in the table to deduce the rate equation for the reaction between $S_2O_8^{2-}$ and I^- ions. Explain, by referring to the data, how you arrived at your answer.

(3)

(b) A further experiment was carried out to confirm the order of the reaction with respect to iodide ions. $(NH_4)_2S_2O_8$ was mixed with KI to form a solution in which the initial concentration of $(NH_4)_2S_2O_8$ was 2.0 mol dm^{-3} and that of KI was 0.025 mol dm^{-3}. The concentration of iodine was measured at various times until the reaction was complete.

(i) Outline a method, **not** involving sampling the mixture, which would be suitable for measuring the iodine concentrations in this experiment. Experimental details are not required but you should state how you would use your measurements to obtain iodine concentrations.

(3)

(ii) Explain why the initial concentration of $(NH_4)_2S_2O_8$ is much higher than that of KI.

(1)

(iii) State how the initial rate of reaction may be obtained from the results of this type of experiment.

(2)

(iv) In such an experiment a student calculated the initial rate of reaction to be 8.75×10^{-5} mol dm^{-3} s^{-1}. Use this value, the initial concentrations in (b) and the rate equation that you obtained in (a)(ii), to calculate the rate constant for this reaction. Include units in your answer.

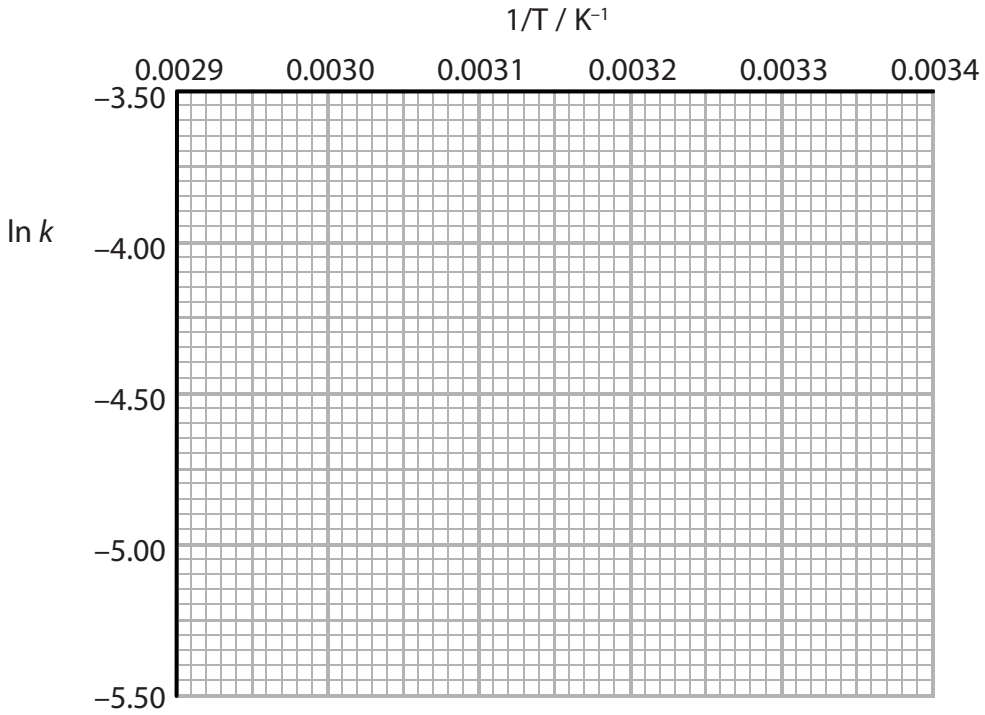
(2)

(c) Using the method outlined in (b), the rate constant for this reaction was determined at various temperatures. The data from these experiments are shown in the table below. Note that none of the temperatures corresponds to that used in (b) and that the rate constant is given in appropriate units.

Temperature T / K	Rate constant *k*	ln *k*	1/T / K^{-1}
300	0.00513	–5.27	0.00333
310	0.00833	–4.79	0.00323
320	0.0128	–4.36	0.00313
330	0.0201	–3.91	0.00303
340	0.0301	–3.50	0.00294

(i) Use the data in the table to plot a graph of ln *k* (on the y axis) against 1/T (on the x axis) and draw a best fit line through the points.

(2)



(ii) Determine the gradient of the best fit line in (c)(i) and use this value to calculate the activation energy, E_a, of the reaction, stating the units.

(4)

The rate constant of a reaction, *k*, is related to the temperature, T, by the expression

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

(Total for Question 20 = 19 marks)

TOTAL FOR SECTION C = 19 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

Mark Scheme (SAM)

Pearson Edexcel International Advanced Level in Chemistry

Unit 4: General Principles of Chemistry I – Rates, Equilibria and Further Organic Chemistry

General marking guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- 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 may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed-out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of Quality of Written Communication, are being assessed. The strands are as follows:
    i. ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
    ii. select and use a form and style of writing appropriate to purpose and to complex subject matter
    iii. organise information clearly and coherently, using specialist vocabulary when appropriate.

Using the Mark Scheme

Examiners should NOT give credit for incorrect or inadequate answers, but allow 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 still be creditworthy.

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.
Bold	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)(transfer error)(consequential) 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. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions that involve the writing of continuous prose require candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where Quality of Written Communication is likely to be particularly important are indicated (Quality of Written Communication) in the mark scheme, but this does not preclude others.

Section A

Question Number	Answer	Mark
1(a)	C	(1)
1(b)	A	(1)

Question Number	Answer	Mark
2	B	(1)

Question Number	Answer	Mark
3	C	(1)

Question Number	Answer	Mark
4(a)	B	(1)
4(b)	D	(1)

Question Number	Answer	Mark
5(a)	B	(1)
5(b)	C	(1)
5(c)	B	(1)

Question Number	Answer	Mark
6	A	(1)

Question Number	Answer	Mark
7	A	(1)

Question Number	Answer	Mark
8	C	(1)

Question Number	Answer	Mark
9	A	(1)

Question Number	Answer	Mark
10	A	(1)

Question Number	Answer	Mark
11	D	(1)

Question Number	Answer	Mark
12	B	(1)

Question Number	Answer	Mark
13	B	(1)

Question Number	Answer	Mark
14	C	(1)

Question Number	Answer	Mark
15	D	(1)

Question Number	Answer	Mark
16	D	(1)

Total for Section A = 20 Marks

Section B

Question Number	Acceptable Answer	Reject	Mark
17(a)	Units are not required in (a) or (c) but if used should be correct. Penalise incorrect units in (a), (b) and (c) once only. IGNORE Case of J and K. Order of units. **First mark:** 65.3/130.6 **and** 69.9 (J mol^{-1} K^{-1}) **(1)** **Second mark:** ΔS = 69.9 - (130.6 + 102.5) **(1)** **Third mark:** ΔS = -163.2 = - 163 (J mol^{-1} K^{-1}) **(1)** Correct answer with no working scores 3 IGNORE SF except 1 SF TE at each stage. If 65.3 used instead of 130.6 penalise once (answer is then ΔS = - 97.9 (J mol^{-1} K^{-1}).	+163 or any positive answer	**(3)**

Question Number	Acceptable Answer	Reject	Mark
17(b)	$\Delta S_{surroundings}$= - ΔH/T or just numbers **(1)** = +285800/298 = +959.06 = +959 J mol^{-1} K^{1}/ +0.959 kJ $mol^{-1}K^{-1}$ Correct value to 3SF. **(1)** Correct units and positive sign. **(1)** Correct answer with no working scores 3.	Answer with no sign	**(3)**

Question Number	Acceptable Answer	Mark
17(c)	$\Delta S_{total} = \Delta S_{system} + \Delta S_{surroundings}$ **(1)** Allow $\Delta S_{reaction}$ for ΔS_{system} ΔS_{total} = answer (a) + answer (b) = -163.2 + 959 = (+)795.8 = (+)796 (J mol^{-1} K^{-1}) If $\Delta S_{surroundings}$=+959.06 then ΔS_{total} = +795.9 **(1)** Correct answer with no working scores 2. Ignore SF except 1 SF. TE on values in (a) and (b). No TE on incorrect equation. If answer to (a) = -97.9 (J mol^{-1} K^{-1}) ΔS_{total} = (+)861.1 (J mol^{-1} K^{-1})	**(2)**

Question Number	Acceptable Answer	Reject	Mark
17(d) Quality of Written Communication	A mixture of hydrogen and oxygen is **thermodynamically** unstable **because** ΔS_{total} is positive. OR Reaction between hydrogen and oxygen is **thermodynamically** feasible **because** ΔS_{total} is positive. ALLOW ΔS for ΔS_{total} **(1)** No TE on negative ΔS_{total} from (c). The mixture is kinetically inert /stable or reaction is (very) slow **because** the activation energy is (very) high. **(1)** Mixture/reaction is **kinetically** inert/stable but **thermodynamically** unstable/feasible scores 1 mark. IGNORE References to spark/flame providing the (activation) energy for reaction.	Reference to the stability of individual elements	**(2)**

Total for Question 17 = 10 Marks

Question Number	Acceptable Answer	Mark
18(a)(i)	$HC_2O_4^-(aq) + H_2O(l) \rightleftharpoons C_2O_4^{2-}(aq) + H_3O^+(aq)$ (or →) ALLOW $H_2O(aq)$ Equation **(1)** states **(1)** ALLOW for 1 mark. $HC_2O_4^-(aq) \rightleftharpoons C_2O_4^{2-}(aq) + H^+(aq)$ States mark is not stand-alone but can be awarded if the equation has a minor error, e.g. an incorrect charge.	**(2)**

Question Number	Acceptable Answer	Reject	Mark
18(a)(ii)	$K_a = [C_2O_4^{2-}]\,[H_3O^+]/[HC_2O_4^-]$ OR $K_a = [C_2O_4^{2-}]\,[H^+]/[HC_2O_4^-]$ No TE on incorrect equation in (a)(i). Penalise incorrect charges in (i) and (ii) once only.	$K_a = [H^+]^2/[HC_2O_4^-$ $[H^+][A^-]/[HA]$	**(1)**

Question Number	Acceptable Answer	Mark
18 (a)(iii)	No TE on (a)(ii) $K_a = 10^{-4.28}$ OR 5.24807×10^{-5} (mol dm^{-3}) **(1)** $K_a = [H^+]^2/[HC_2O_4^-]$ $K_a = [H^+]^2/0.050$ $[H^+] = \sqrt{(0.05 \times 10^{-4.28})} = 1.61988 \times 10^{-3}$ (mol dm^{-3}) **(1)** TE on incorrect K_a value. pH = -log 1.61988×10^{-3} = 2.7905 = 2.8 **(1)** For final mark TE on algebraic/arithmetical errors providing pH ≥ 1..3 Correct answer with no working scores 3. IGNORE SF except 1 SF.	**(3)**

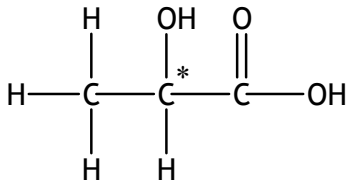
Question Number	Acceptable Answer	Reject	Mark
18(b)(i)	IGNORE explanations. **First mark:** $HC_2O_4^-$/hydrogenethanedioate ion ionization negligible. ALLOW Acid for $HC_2O_4^-$. Slight/partial/incomplete/does not dissociate for negligible. OR $[HC_2O_4^-]_{equilibrium} = [HC_2O_4^-]_{initial}/0.050$ (mol dm^{-3}) **(1)** **Second mark:** $[H^+]$ due to ionization of water negligible OR auto ionization of water negligible OR $[H^+]$ only due to ionization of $HC_2O_4^-$/acid OR $[C_2O_4^{2-}] = [H^+]$ **(1)** IGNORE references to temperature and to HA and A^-. Penalise omission of [] in discussion once only.	Use of $NaHC_2O_4$ for $HC_2O_4^-$ OR Sodium hydrogen-ethanedioate for hydrogen-ethanedioate ion throughout this item	**(2)**

Question Number	Acceptable Answer	Reject	Mark
18(b)(ii) Quality of Written Communication	**First mark:** Ethanedioic acid is a (much) stronger acid (than hydrogenethanedioate ion/sodium hydrogenethanedioate). OR Ethanedioic acid has a (much) smaller pK_a (than hydrogenethanedioate). OR Ionization/dissociation of ethanedioic acid is (much) greater (than hydrogenethanedioate). OR Reverse arguments. IGNORE $NaHC_2O_4$ ionization negligible. **Second mark:** Approximation of negligible ionization invalid/incorrect. OR $[H_2C_2O_4]_{equilibrium}$ not equal to $[H_2C_2O_4]_{initial}$ No TE on 18(a)(iii). IGNORE Second ionization occurs.	Ethanedioic acid is a strong acid/ fully dissociated Just 'approximation invalid'	**(2)**

Question Number	Acceptable Answer	Reject	Mark
18(c)(i)	Start pH at 2.8 ALLOW 2-4 **(1)** Vertical section at 25 cm^3 within pH range 6-11 and 2.5-4 units long. **(1)** End pH (approaching) value in range 12-13 (asymptotically). **(1)**	Deviation from vertical Maximum before final pH	**(3)**

Question Number	Acceptable Answer	Mark
18(c)(ii) Quality of Written Communication	**First mark:** Methyl yellow range = 2.9-4 and the phenolphthalein range = 8.2-10. ALLOW pK_{in} (methyl yellow) = 3.5 and pK_{in} (phenolphthalein) = 9.3. **(1)** **Second mark:** (The volumes are different) because ethanedioic acid is dibasic/diprotic/has two **replaceable/acidic** hydrogen atoms. ALLOW dicarboxylic (acid) (therefore there are two stages to the neutralization). OR Methyl yellow range coincides with neutralization of first proton and phenolphthalein range coincides with neutralization of second proton. **(1)**	**(2)**

Total for Question 18 = 15 Marks

Question Number	Acceptable Answer	Reject	Mark
19(a)(i)	A chiral molecule is non-superimposable on its mirror image/3D molecule with no plane of symmetry. **(1)** 2-hydroxypropanoic acid has a carbon atom which is asymmetric/has **four** different groups attached. **(1)** **Middle** carbon labelled in any clear way. **(1)** e.g.  ALLOW asymmetric C described but not labelled. IGNORE references to rotation of plane polarized light.	Just 'non-superimposable' Just 'no plane of symmetry' Molecules for groups	**(3)**

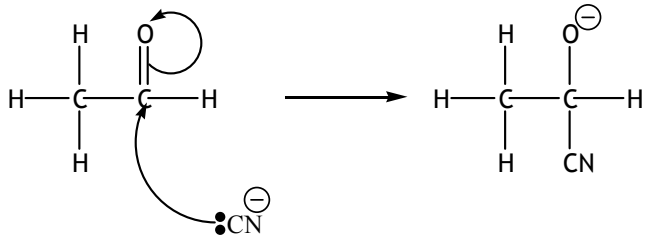
Question Number	Acceptable Answer	Reject	Mark
19(a)(ii)	2-hydroxypropanoic acid formed in muscles is a single (allow pure) enantiomer/(optical) isomer. ALLOW Unequal mixture of enantiomers/(optical) isomers. **(1)** 2-hydroxypropanoic acid formed in milk is a racemic mixture/equimolar mixture of the two enantiomers/racemate. **(1)** If milk and muscles are reversed but the rest is correct, one mark is awarded.	Just 'not a racemic mixture' Just 'a mixture of enantiomers'	**(2)**

Question Number	Acceptable Answer	Reject	Mark
19(b)(i)	**First step** NaOH(aq)/KOH(aq) or names **(1)** Second mark dependent on first being correct. **Second step** HCl(aq)/hydrochloric acid/H_2SO_4(aq)/sulfuric acid ALLOW HNO_3/nitric acid/dil HCl/(dil) H_2SO4/(dil) HNO_3 or any strong acid (name or formula) including HBr((aq)) and HI((aq)). **(1)** IGNORE Omission of (aq) and references to temperature. Ethanolic alcoholic solutions. ALLOW One mark for correct two reagents in the wrong order. One mark for 'alkali/OH^- followed by acid/H^+/H_3O^+'.	OH^-/alkali H^+/H_3O^+/acid	**(2)**

Question Number	Acceptable Answer	Reject	Mark
19(b)(ii)	**First mark:** (stand-alone) A racemic mixture is not formed. OR More of one enantiomer/(optical) isomer is formed. OR Only one enantiomer/(optical) isomer is formed. **(1)** **Second mark:** (stand-alone) (Some of the) reaction is S_N2. **(1)** **Third mark:** (stand-alone) Nucleophile/OH^- only attacks from one side of the molecule/from the opposite side to leaving group. **(1)** ALLOW Use of 'intermediate' for 'transition state' in description of S_N2. Reverse argument based on S_N1 forming a racemic mixture.	Carbocation (for molecule)	**(3)**

Question Number	Acceptable Answer	Reject	Mark
19(c)(i)	Nucleophilic **(1)** Addition **(1)**	S_N1/S_N2	**(2)**

Question Number	Acceptable Answer	Reject	Mark
19(c)(ii)	Cyanide (ion)/CN^- /$C\equiv N^-$/$:C\equiv N^-$/^-CN	HCN/ $C\equiv N$	**(1)**

Question Number	Acceptable Answer	Reject	Mark
19(c) (iii)	 Both curly arrows. **(1)** Intermediate **(1)** ALLOW Omission of lone pair. Curly arrow from anywhere on nucleophile including from charge or nitrogen. Formation of charged canonical form followed by attack of cyanide ion. IGNORE $\delta+/\delta-$ even if unbalanced.	Omission of charges (penalise once only) Full charges on ethanal –C–NC in inter-mediate	**(2)**

Question Number	Acceptable Answer	Reject	Mark
19(c)(iv) Quality of Written Communication	Racemic mixture/equal amounts of the two enantiomers/racemate formed. **(1)** Stand-alone mark. CHO/aldehyde group is (trigonal) planar. **(1)** ALLOW ethanal/molecule is (trigonal) planar. Cyanide (ion)/CN^-/nucleophile attacks (equally) from above or below/either side (of the molecule). **(1)** Penalise use of intermediate/ion for aldehyde group **once** only. Third mark cannot be awarded if the reaction is described as a nucleophilic substitution.	Intermediate/ carbonyl group/CO is planar Two positions Intermediate	**(3)**

Question Number	Acceptable Answer	Reject	Mark
19(d)(i)	Any value/range within the range 3750-2500 cm^{-1} due to O–H/OH/–OH. IGNORE COOH/CO_2H/carboxylic acid.	Wavenumbers alone OH in alcohol	**(1)**

Question Number	Acceptable Answer	Reject	Mark
19(d)(ii) Quality of Written Communication	These three marks are stand-alone. Q is due to C=O. **(1)** The (C=O) aldehyde range is 1740-1720 cm^{-1} **and** (C=O) carboxylic acid range is 1725-1700 cm^{-1} **(1)** So the peaks/absorptions cannot be used to distinguish these two compounds because they overlap. OR The (broad) absorption Q covers both the aldehyde and the carboxylic acid. ranges **(1)** ALLOW 'too close'/'quite similar' for 'overlap'.	Carboxylic acid/COOH group Just 'cannot be used to distinguish the compounds'	**(3)**

<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th>Reject</th><th>Mark</th></tr>
<tr><td>19(e)</td><td>
If reagent incorrect, observation mark can only be awarded for a near miss.

Test positive for ethanol
<table>
<tr><th>Reagent (1)</th><th>Observation (1)</th></tr>
<tr><td>Tollens’</td><td>Silver mirror/black /grey ppt</td></tr>
<tr><td>Fehling’s/ Benedict’s</td><td>Red-brown ppt</td></tr>
<tr><td>2,4-DNP(H)/Brady’s reagent</td><td>Orange/red/yellow ppt
ALLOW brick-red ppt</td></tr>
</table>
Test positive for 2-hydroxypropanoic acid
<table>
<tr><th>Reagent(1)</th><th>Observation(1)</th></tr>
<tr><td>PCl_5/Phosphorus (V)chloride/ phosphorus pentachloride</td><td>Steamy fumes*
ALLOW gas evolved turns (blue) litmus/UI red</td></tr>
<tr><td>Named metal carbonate (solution)</td><td>Effervescence
ALLOW gas/CO_2 evolved turns lime water cloudy</td></tr>
<tr><td>Sodium hydrogencarbonate (solution)</td><td>Effervescence
ALLOW gas/CO_2 evolved turns lime water cloudy</td></tr>
<tr><td>Magnesium (and water)</td><td>Effervescence</td></tr>
<tr><td>Ethanol and H_2SO_4/named strong acid</td><td>Sweet/fruity/pear drops/glue smell</td></tr>
<tr><td>Ethanoic acid and H_2SO_4/named strong acid</td><td>Sweet/fruity/pear drops/glue smell</td></tr>
</table>
ALLOW
Na and effervescence/gas evolved pops with a lighted splint for2-hydroxypropanoic acid.
(2)
ALLOW fizzing/bubbling for effervescence.

IGNORE names of product.

IF two tests given for one substance both must be correct for full marks.
*misty fumes/white fumes/gas for fumes
</td><td>Iodine in alkali/iodoform test

Acidified potassium dichromate

Smoke
Just ‘fumes’

Any indicator as sole test

Incorrect formulae of reagents</td><td>(4)</td></tr>
</table>

Total for Question 19 = 26 Marks

Total for Section B = 51 Marks

Section C

Question Number	Acceptable Answer	Reject	Mark
20(a)(i)	(Sodium thiosulfate) (rapidly) reacts with/reduces the iodine (as it is formed) **(1)** So prevents the starch-iodine colour appearing until a fixed amount of reaction has occurred. ALLOW (for second mark) So prevents the starch-iodine colour appearing until all the thiosulfate has reacted. OR Moles of iodine reacted/thiosulfate ÷ time is (approximately) proportional to the (initial) rate of reaction. **(1)** ALLOW Use of 'thio' for thiosulfate.	Iodide/I^-	**(2)**

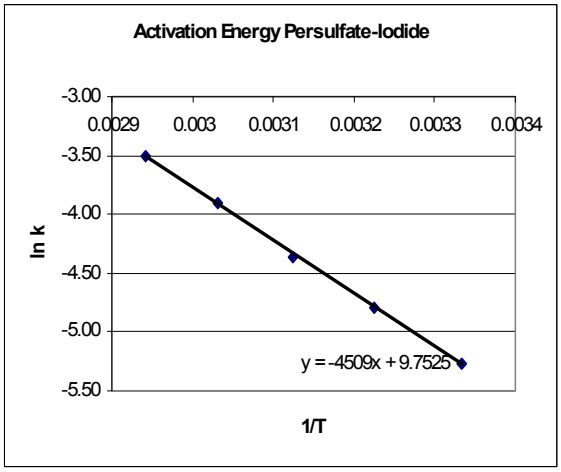
Question Number	Acceptable Answer	Reject	Mark
20(a)(ii)	(From 2 to 1) **$[S_2O_8^{2-}]$** doubles ($[I^-]$ unchanged) and rate doubles/time halves so order wrt **$S_2O_8^{2-}$** = 1 **(1)** (From 3 to 1) **$[I^-]$** doubles ($[S_2O_8^{2-}]$ unchanged) and rate doubles/time halves so order **wrt I^-** = 1 OR (if first mark awarded) (From 3 to 2) **$[I^-]$** doubles ($[S_2O_8^{2-}]$ halved) and rate unchanged so order **wrt I^-** = 1 **(1)** Penalise omission of concentration/square brackets once only. Rate = $k[S_2O_8^{2-}][I^-]$ **(1)** Third mark stand-alone if no working and TE on incorrect orders. IGNORE case of k.	Rate equation =	**(3)**

Question Number	Acceptable Answer	Reject	Mark
20(b)(i)	**First mark:** Colorimetry/Use a colorimeter. **(1)** **Second mark:** Measure transmittance/absorbance (at various times). **(1)** **Third mark:** (Use a calibration curve to) convert transmittance/absorbance into concentration. OR Transmittance/absorbance proportional to concentration. ALLOW Colorimetry may be used because iodine (solution) is coloured (and other reagents are colourless)/to measure intensity of the iodine colour. **(1)** ALLOW (for the same three marks) Electrical conductivity. Measured at various times/(use a calibration curve to) convert conductivity into concentration. Conductivity reduces as reaction proceeds because 3 mol ions converted to 2 mol ions /fewer ions on right-hand side.	Sampling methods calorimeter pH meter Just conductivity changes	**(3)**

Question Number	Acceptable Answer	Reject	Mark
20(b)(ii)	$[(NH_4)_2S_2O_8]$ / $[S_2O_8^{2-}]$/[peroxodisulfate]/[persulfate] remains (approximately) unchanged during the reaction. OR $[KI]/ I^-]$ is the only variable.	$(NH_4)_2S_2O_8$ in excess. $[(NH_4)_2S_2O_8]$ etc does not affect the rate Only $[KI]/[I^-]$ affects the rate	**(1)**

Question Number	Acceptable Answer	Mark
20(b) (iii)	Plot a graph of concentration (of iodine/I_2) (on the y axis) against time. **(1)** Measure the initial gradient/gradient at t=0. **(1)** 'Plot a graph and measure the initial gradient/gradient at t=0' alone scores second mark.	**(2)**

Question Number	Acceptable Answer	Reject	Mark
20(b) (iv)	TE on 20(a)(ii) on numerical answer and appropriate units. $8.75 \times 10^{-5} = k \times 2.0 \times 0.025$ $k = 8.75 \times 10^{-5}/(2.0 \times 0.025)$ $= 1.75 \times 10^{-3}$ **(1)** $dm^3\ mol^{-1}\ s^{-1}$ **(1)** ALLOW units in any order. Correct answer including units with no working scores 2.	1 SF	**(2)**

Question Number	Acceptable Answer	Mark
20(c)(i)	 Use the overlay to mark the graph. At least 4 points within the circles on the overlay. **(1)** Best fit line on points given. **(1)**	**(2)**

Question Number	Acceptable Answer	Mark
20(c)(ii)	Gradient = -(-3.50 - -5.27)/ (0.00333 - 0.00294) = (-)4538 = (-)4500 ALLOW Values from (-)4300 to (-)4700. **(1)** Gradient value negative. **(1)** E_a = -gradient x R = - -4538 x 8.31 = (+)37700 J mol^{-1} (= (+)38 kJ mol^{-1}) **(1)** TE on value of gradient even if it is positive -4300 gives 35.7; -4700 gives 39.1 Correct units. **(1)** Correct answer from the gradient calculation with units scores final 2 marks. **BUT** correct answer with units but no gradient calculation scores units mark only.	**(4)**

Total for Section C = 19 Marks

Total for Paper = 90 Marks

Write your name here

Surname	Other names

Pearson Edexcel
International Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry
Advanced
Unit 5: General Principles of Chemistry II – Transition Metals and Organic Nitrogen Chemistry (including synoptic assessment)

Sample Assessment Material
Time: 1 hour 40 minutes

Paper Reference
WCH05/01

You must have: Data Booklet

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or 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.*

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.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

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

Turn over ▶

S45364A

S 4 5 3 6 4 A 0 1 3 2

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 The following data are provided.

	$E^{\ominus}$ / V
$ClO^-(aq) + H_2O(l) + e^- \rightleftharpoons \frac{1}{2}Cl_2(aq) + 2OH^-(aq)$	+0.40
$Cl_2(aq) + 2e^- \rightleftharpoons 2Cl^-(aq)$	+1.36

What is the value of $E^{\ominus}_{cell}$ in which the following disproportionation reaction occurs?

$$Cl_2(aq) + 2OH^-(aq) \rightarrow ClO^-(aq) + Cl^-(aq) + H_2O(l)$$

☒ **A** $+ \frac{1.36}{2} - 0.40$ V

☒ **B** $+ \frac{1.36}{2} + 0.40$ V

☒ **C** $+ 1.36 - 0.40$ V

☒ **D** $+ 1.36 + 0.40$ V

(Total for Question 1 = 1 mark)

2 Which of the following is always proportional to $E^{\ominus}_{cell}$ for a chemical reaction?

☒ **A** $\Delta H_{reaction}$

☒ **B** ΔS_{system}

☒ **C** $\Delta S_{surroundings}$

☒ **D** ΔS_{total}

(Total for Question 2 = 1 mark)

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

3 The electrode system based on the half-equation below has the standard electrode potential +1.51 V.

$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightleftharpoons Mn^{2+}(aq) + 4H_2O(l)$ $\quad E^{\ominus} = +1.51$ V

Which of the following statements about this electrode system is correct?

☒ **A** Changing the concentration of $Mn^{2+}(aq)$ would cause a change in the electrode potential.

☒ **B** $Mn^{2+}(aq)$ is acting as an oxidizing agent.

☒ **C** The electrode used is made of manganese.

☒ **D** When connected to a standard hydrogen electrode, the resulting cell voltage would be +0.51 V.

(Total for Question 3 = 1 mark)

4 Consider the following reaction.

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

Which of the following ions could catalyse this reaction?

☒ **A** Zn^{2+}

☒ **B** Al^{3+}

☒ **C** Fe^{2+}

☒ **D** Na^+

(Total for Question 4 = 1 mark)

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

5 EDTA ions form a complex with aqueous nickel(II) ions as shown by the equation

$$[Ni(H_2O)_6]^{2+}(aq) + (EDTA)^{4-}(aq) \rightleftharpoons Ni(EDTA)^{2-}(aq) + 6H_2O(l)$$

Aqueous nickel(II) ions also form a complex ion with ammonia as shown by the equation

$$[Ni(H_2O)_6]^{2+}(aq) + 6NH_3(aq) \rightleftharpoons [Ni(NH_3)_6]^{2+}(aq) + 6H_2O(l)$$

Aqueous nickel(II) ions form a more stable complex with EDTA ions than with ammonia because

☒ **A** six ammonia ligands cause steric hindrance around the central nickel(II) ion.

☒ **B** EDTA ions carry a negative charge whereas ammonia molecules do not.

☒ **C** there is a large increase in entropy when aqueous nickel(II) ions react with EDTA ions, but not when aqueous nickel(II) ions react with ammonia.

☒ **D** ammonia molecules tend to evaporate from the solution of the complex whereas EDTA ions do not.

(Total for Question 5 = 1 mark)

6 The hydrolysis of a transition metal cation can be represented by the following equation

$$[M(H_2O)_6]^{n+}(aq) + H_2O(l) \rightleftharpoons [M(H_2O)_5OH]^{(n-1)+}(aq) + H_3O^+(aq)$$

In this reaction

☒ **A** the solvent H_2O is acting as an acid by donating a proton to the metal cation.

☒ **B** the pH of the solution will be lower if the value of n is 2 instead of 3.

☒ **C** the equilibrium position lies further to the right if the value of n is 3 instead of 2.

☒ **D** the oxidation state of the metal in the cation has decreased from n to (n – 1).

(Total for Question 6 = 1 mark)

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

7 In aqueous solution, manganate(VI) ions disproportionate into manganate(VII) ions and manganese(IV) oxide when carbon dioxide is bubbled through the solution. The ionic equation for the reaction is

$$3MnO_4^{2-}(aq) + 4H^+(aq) \rightarrow 2MnO_4^-(aq) + MnO_2(s) + 2H_2O(l)$$

The role of the carbon dioxide is to

☒ **A** lower the pH of the solution.

☒ **B** raise the pH of the solution.

☒ **C** oxidize the manganate(VI) ions.

☒ **D** reduce the manganate(VI) ions.

(Total for Question 7 = 1 mark)

---

8 Which of the following shows the correct oxidation states of **chromium** in the ions given?

	$[Cr(OH)_6]^{3-}$	CrO_4^{2-}	$[Cr(H_2O)_6]^{2+}$
☒ **A**	−3	−2	+2
☒ **B**	−3	+10	+2
☒ **C**	+3	+8	+6
☒ **D**	+3	+6	+2

(Total for Question 8 = 1 mark)

---

9 Transition metals are often used as heterogeneous catalysts. Which of the following processes does **not** occur during such a catalysed reaction?

☒ **A** Adsorption of reactant molecules on the surface of the metal.

☒ **B** Bond breaking in the reactant molecules.

☒ **C** Desorption of product molecules from the surface of the metal.

☒ **D** An overall change in the oxidation number of the metal.

(Total for Question 9 = 1 mark)

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10 Consider the equation below.

$$[Cu(H_2O)_6]^{2+}(aq) + 4NH_3(aq) \rightleftharpoons [Cu(NH_3)_4]^{2+}(aq) + 6H_2O(l)$$

This reaction is best described as

☒ **A** acid-base.

☒ **B** redox.

☒ **C** addition.

☒ **D** ligand exchange.

(Total for Question 10 = 1 mark)

11 Which of the following will **not** reduce an acidified solution of potassium dichromate(VI)?

☒ **A** $(CH_3)_2C(OH)CH_3$

☒ **B** $FeSO_4$

☒ **C** $CH_3CH_2CH(OH)CH_3$

☒ **D** Zn

(Total for Question 11 = 1 mark)

12 The total number of isomers of dibromobenzene, $C_6H_4Br_2$, containing a benzene ring is

☒ **A** 2

☒ **B** 3

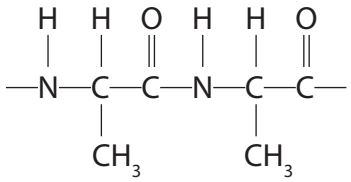
☒ **C** 4

☒ **D** 5

(Total for Question 12 = 1 mark)

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

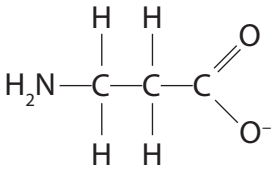
13 A section of the polypeptide made from a single amino acid is shown below.



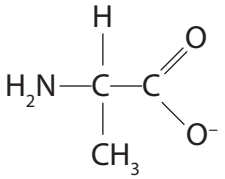
The polypeptide was heated with excess dilute sodium hydroxide solution until no further change took place.

Which of the following products is formed?

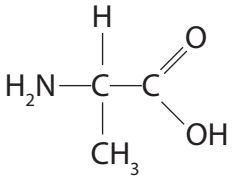
☒ **A**



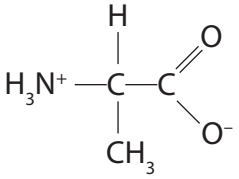
☒ **B**



☒ **C**



☒ **D**

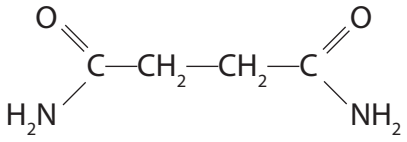


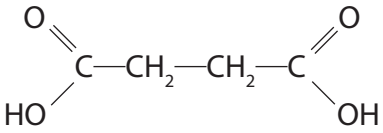
(Total for Question 13 = 1 mark)

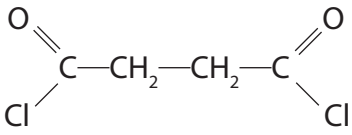
Use this space for any rough working. Anything you write in this space will gain no credit.

14 Which of the following pairs of compounds could form a polyamide?

☒ **A** $Cl—CH_2—CH_2—Cl$ and $H_2N—CH_2—CH_2—NH_2$

☒ **B** $HO—CH_2—CH_2—OH$ and 

☒ **C**  and $CH_3—CH_2—NH_2$

☒ **D**  and $H_2N—CH_2—CH_2—NH_2$

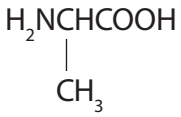
(Total for Question 14 = 1 mark)

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

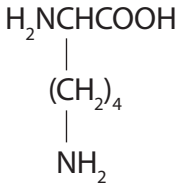
15 Which of the following amino acids is optically active and produces an approximately neutral solution when dissolved in water?

☒ **A** H_2NCH_2COOH

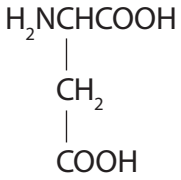
☒ **B**



☒ **C**



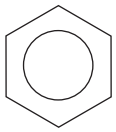
☒ **D**



(Total for Question 15 = 1 mark)

16 Which of the following is **not** planar?

☒ **A**



☒ **B** CCl_4

☒ **C** BF_3

☒ **D** $[Pt(NH_3)_2Cl_2]$

(Total for Question 16 = 1 mark)

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

17 A 50 cm^3 sample of a gaseous hydrocarbon required exactly 250 cm^3 of oxygen for complete combustion. A volume of 150 cm^3 of carbon dioxide was produced.

[All volume measurements were made at the same temperature and pressure.]

Which of the following is the correct formula of the hydrocarbon?

☒ **A** C_3H_4

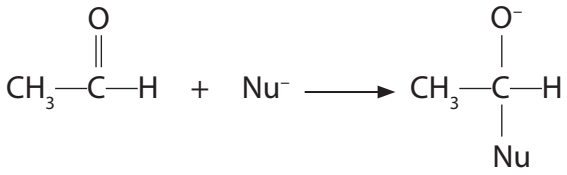
☒ **B** C_3H_8

☒ **C** C_5H_{10}

☒ **D** C_5H_{12}

(Total for Question 17 = 1 mark)

18 The first step of a nucleophilic addition reaction to a carbonyl group by a nucleophile, Nu^-, is shown below.



The above step is possible because the

☒ **A** nucleophile bonds to the δ+ carbon atom and the carbonyl oxygen accepts an electron pair from the double bond.

☒ **B** nucleophile bonds to the δ+ carbon atom and the carbonyl oxygen accepts one electron from the double bond.

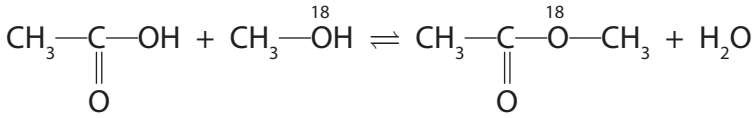
☒ **C** methyl group donates electrons to the carbonyl carbon atom.

☒ **D** C═O bond is weak.

(Total for Question 18 = 1 mark)

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

19 In a reaction carried out between ethanoic acid and methanol, the methanol was labelled with the ^{18}O isotope. The ^{18}O was found to be in the organic product of the reaction



From the above information it can be deduced that the mechanism involves

☒ **A** free radical substitution.

☒ **B** breaking the C—O bond in the ethanoic acid.

☒ **C** nucleophilic attack by ethanoic acid on methanol.

☒ **D** breaking the C—^{18}O bond in methanol.

(Total for Question 19 = 1 mark)

20 The hydride ion, H^-, is a strong reducing agent, a good nucleophile and a strong base.

Which of the following changes could **not** be brought about by the hydride ion?

☒ **A** CH_3CHO to CH_3CH_2OH

☒ **B** C_2H_5Br to C_2H_6

☒ **C** $CH_2{=}CH_2$ to C_2H_6

☒ **D** CH_3COOH to CH_3COO^-

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

21 Hydrogen-oxygen fuel cells can operate in acidic or alkaline conditions. One such commercial cell uses porous platinum electrodes in contact with concentrated aqueous potassium hydroxide solution, KOH(aq).

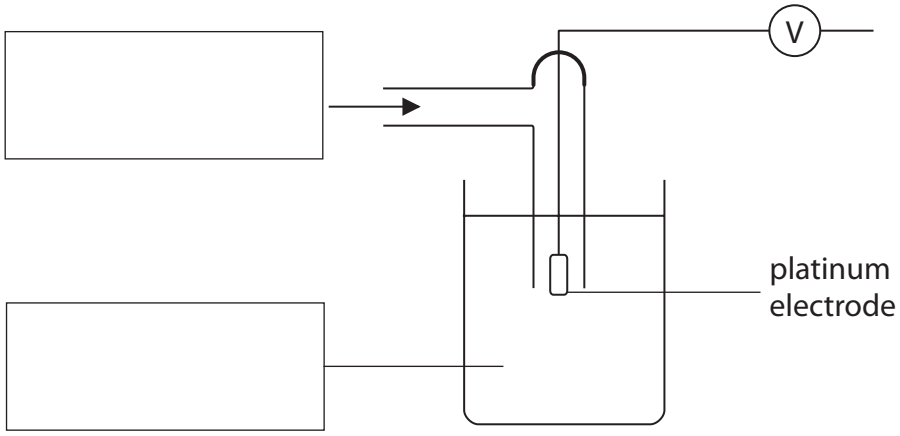
(a) Use relevant standard electrode potential values, on pages 15 and 17 of the Data Booklet, to complete the table below in which two $E^{\ominus}$ values are missing.

(2)

Half-equation	$E^{\ominus}$ / V
$2H_2O(l) + 2e^- \rightleftharpoons 2OH^-(aq) + H_2(g)$	−0.83
$2H^+(aq) + 2e^- \rightleftharpoons H_2(g)$	0.00
$O_2(g) + 2H_2O(l) + 4e^- \rightleftharpoons 4OH^-(aq)$	
$O_2(g) + 4H^+(aq) + 4e^- \rightleftharpoons 2H_2O(l)$	

(b) (i) Fill in the boxes to identify, by name or formula, the substances used in the **standard** hydrogen electrode.

(2)



(ii) State **three** conditions that are necessary for a standard hydrogen electrode.

(2)

1. .....

2. .....

3. .....

(c) Write appropriate half-equations and use them to derive an overall equation for the reaction which occurs when an **alkaline** hydrogen-oxygen fuel cell operates.

(2)

(d) Use the $E^{\ominus}$ values from the table in part (a) to calculate the $E^{\ominus}_{cell}$ for a hydrogen-oxygen fuel cell operating in alkaline conditions.

(1)

(e) Suggest why the $E^{\ominus}_{cell}$ for a hydrogen-oxygen fuel cell, operating in **acidic** conditions, is identical to that of an alkaline fuel cell.

(1)

(f) Give **one** reason (other than cost implications) why the platinum electrodes are made by coating porous material with platinum rather than by using platinum rods.

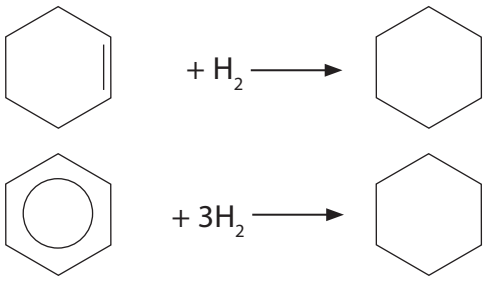
(1)

(g) Suggest **one** disadvantage of using a hydrogen-oxygen fuel cell compared with a rechargeable battery when providing electrical energy for a motor vehicle.

(1)

(Total for Question 21 = 12 marks)

22 (a) Equations for the catalytic hydrogenation of cyclohexene and of benzene are shown below.



$+ H_2 \longrightarrow$ $\Delta H = -120$ kJ mol^{-1}

$+ 3H_2 \longrightarrow$ $\Delta H = -208$ kJ mol^{-1}

(i) What is the type of reaction in both of these hydrogenations?

(1)

.....

*(ii) The enthalpy of hydrogenation of benzene might be expected to be −360 kJ mol^{-1}. Explain why this is **not** the actual value.

(2)

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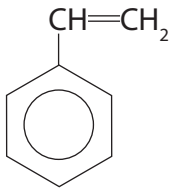
(iii) Complete the following equation for the total hydrogenation of phenylethene. Suggest a value for the enthalpy change of this reaction.

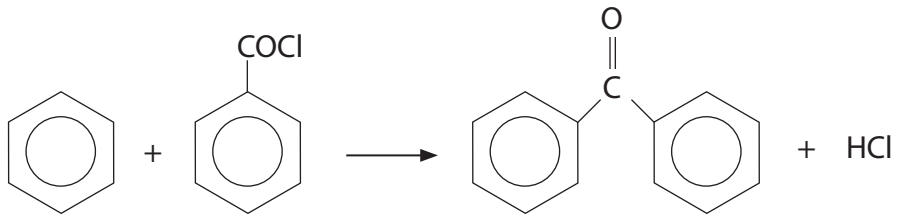
(3)



$+$ ..... $H_2 \rightarrow$

$\Delta H =$ ..... kJ mol^{-1}

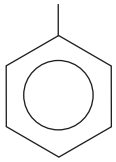
(b) The compound benzophenone is used as a sunscreen. It can be prepared from benzene, in the presence of aluminium chloride by the following reaction.



benzene + compound **A** benzophenone

(i) Complete the diagram below by showing the **displayed** formula of the –COCl group in compound **A**.

(1)



(ii) Classify the type and mechanism of the reaction between benzene and compound **A**.

(1)

.....

(iii) Give the names of the two chemists associated with the type of reaction described in (b)(ii).

(1)

..... and .....

(iv) Give the mechanism for the reaction between benzene and compound **A** in the presence of an aluminium chloride catalyst.

Start by showing the equation for the generation of the species which then attacks the benzene ring.

(4)

Equation to show generation of species attacking the benzene ring:

Rest of the mechanism:

(v) Suggest the essential property of a substance that will be used as a sunscreen.

(1)

.....

.....

(c) (i) The identity of a sample of benzophenone can be confirmed by recording its infrared and proton nmr spectra.

Identify **two** different bonds that would produce an absorption in the infrared spectrum of benzophenone. Use the Data Booklet to suggest the wavenumber of each of these absorptions.

(4)

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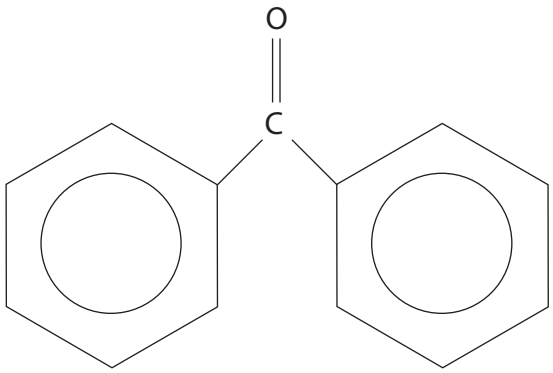
(ii) In benzophenone there are three different hydrogen environments, X, Y and Z, that produce signals in the ratio 2:2:1 respectively in the proton nmr spectrum.

Identify, **on the structure drawn below**, the positions of all the hydrogen atoms in each environment, labelling the different environments **X**, **Y** and **Z**.

(2)



benzophenone

(Total for Question 22 = 20 marks)

23 A scientist investigated the typical behaviour of primary amines.

(a) Amines such as butylamine, $CH_3CH_2CH_2CH_2NH_2$, and phenylamine, $C_6H_5NH_2$, both behave as bases.

(i) Which feature of an amine molecule allows it to act as a base?

(1)

.....

.....

(ii) The scientist reacted butylamine with two different acids.

Give the **formulae** of the salts that are formed when butylamine reacts with

(2)

sulfuric acid, H_2SO_4 .....

ethanoic acid, CH_3COOH .....

(b) Phenylamine, $C_6H_5NH_2$, is formed by the reduction of nitrobenzene, $C_6H_5NO_2$.

Give the reagents that are used for this reduction.

(2)

.....

.....

(c) Phenylamine was reacted with a mixture of sodium nitrite, $NaNO_2$, and hydrochloric acid at a temperature between 0 °C and 5 °C. A diazonium ion was formed. In a second step, the scientist reacted the diazonium ion with phenol, under suitable conditions. A precipitate of 4-hydroxyazobenzene (4-hydroxyphenylazobenzene) was formed.

(i) Draw the structure of the diazonium ion, clearly displaying the functional group present in the ion.

(1)

(ii) Draw the structural formula of 4-hydroxyazobenzene.

(1)

(iii) State a condition, other than a suitable temperature, required for the reaction of the diazonium ion with phenol and give a use for 4-hydroxyazobenzene.

(2)

Condition required:

.....

Use for 4-hydroxyazobenzene:

.....

(d) The scientist repeated the first step in experiment (c), but the temperature was allowed to rise above 10 °C. Under these conditions, the diazonium ion reacted with water to produce phenol. An unreactive gas, of molar mass 28.0 g mol^{-1}, was also formed along with one other product.

Use this information to write the equation for the reaction of the diazonium ion with water.

(2)

(e) The impure sample of 4-hydroxyazobenzene formed in part (c) may be purified by recrystallization. During this process

- the solid is dissolved in the minimum volume of hot solvent
- the mixture is then filtered whilst still hot
- the filtrate is cooled in an ice bath to produce crystals of 4-hydroxyazobenzene
- the crystals are removed by filtration and dried.

(i) Why is the "minimum volume of hot solvent" used?

(1)

.....

.....

.....

(ii) The impure 4-hydroxyazobenzene may contain both insoluble and soluble impurities. Describe how

(2)

I. insoluble impurities are removed during recrystallization

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II. soluble impurities are removed during recrystallization

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(iii) How would you check the purity of 4-hydroxyazobenzene after recrystallization, other than by using spectroscopy?

(1)

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(Total for Question 23 = 15 marks)

TOTAL FOR SECTION B = 47 MARKS

SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

24

Titanium is the seventh most abundant metal in the Earth's crust and occurs principally as rutile (impure titanium(IV) oxide, TiO_2).

Early attempts to extract the metal from its oxide by reduction with heated carbon failed because the compound titanium carbide is formed. In 1910, however, pure titanium was made by heating titanium(IV) chloride with sodium.

Titanium has a high melting temperature and a density of 4.50 g cm^{-3}. Titanium is as strong as steel, but is about 40% less dense and is therefore suitable for use in the aircraft industry. Titanium metal resists corrosion as it has an impervious coating of titanium(IV) oxide. The metal adheres well to bone, is not rejected by the body and is in demand for the manufacture of replacement joints.

Titanium has two common oxidation states, +3 and +4. Solutions containing the $[Ti(H_2O)_6]^{3+}(aq)$ ion, such as titanium(III) chloride, are purple in colour and are readily oxidized by the oxygen in air to colourless titanium(IV) ions. An aqueous solution of titanium(III) chloride is a strong reducing agent. Titanium(IV) chloride, $TiCl_4$, is a colourless liquid with a boiling temperature of 136 °C. This compound is used, in conjunction with organic compounds of aluminium, as a catalyst for the polymerization of propene to poly(propene). Titanium(IV) chloride is hydrolysed by water to give titanium(IV) oxide, TiO_2 and hydrogen chloride gas.

Titanium(IV) oxide is a white, non-toxic solid at room temperature. It is used as a white pigment in paint, largely replacing toxic lead compounds which were used previously. Titanium(IV) oxide reacts with concentrated sulfuric acid to form a salt and water. Titanium(IV) oxide also reacts with aqueous potassium hydroxide solution, under suitable conditions, to form a compound with formula $K_2Ti(OH)_6$.

(a) (i) Write the equation for the reaction which occurs during the manufacture of titanium from titanium(IV) chloride as described in the article above. State symbols are not required.

(1)

(ii) Explain, by stating the changes of oxidation numbers, why the reaction in (i) is classified as a redox reaction.

(2)

.....

.....

.....

.....

(b) Complete the electronic configurations of

(2)

Ti [Ar] .....

Ti^{3+} [Ar] .....

Ti^{4+} [Ar] .....

(c) Use your answer to (b) to explain why titanium is

(i) a *d*-block element

(1)

.....

.....

.....

(ii) a transition element

(1)

.....

.....

.....

*(d) (i) Explain why the hexaaquatitanium(III) ion, $[Ti(H_2O)_6]^{3+}$, is coloured.

(3)

(ii) Explain briefly why titanium(IV) compounds are colourless.

(1)

*(e)(i) Titanium(IV) oxide has a melting temperature of 1830 °C. Use this data, plus information in the article at the start of the question, to compare the structure and bonding in titanium(IV) oxide with that in titanium(IV) chloride. Hence explain why these two compounds change state at very different temperatures.

(4)

(ii) Give the term used to describe an oxide, such as titanium(IV) oxide, which can react with both acids and bases.

(1)

(iii) Using information in the article, write the equation for the reaction between titanium(IV) oxide and aqueous potassium hydroxide solution. State symbols are not required.

(1)

(iv) Titanium(IV) chloride is one of the catalysts used in the polymerization of propene to form poly(propene).

Give the displayed formula of the repeat unit of poly(propene).

(1)

(f) The concentration of a solution of titanium(III) chloride can be determined by titration with a solution of hydrogen peroxide, H_2O_2, in acidic conditions. The end-point of the reaction is when the solution of titanium(III) chloride in the flask goes colourless.

(i) Complete the ionic half-equation to show the reduction of hydrogen peroxide.

(1)

$$H_2O_2 + 2H^+ + \text{.....} \rightarrow \text{.....}$$

*(ii) One mole of hydrogen peroxide reacts with two moles of titanium(III) chloride.

In an experiment, 5.00 cm^3 of a sample of titanium(III) chloride solution was transferred to a volumetric flask and made up to 250 cm^3 of an aqueous solution. A 25.0 cm^3 portion of this diluted solution was acidified and titrated with a 0.0200 mol dm^{-3} solution of hydrogen peroxide, H_2O_2. The mean titre was 22.50 cm^3.

Calculate the concentration of the **original** titanium(III) chloride solution, in mol dm^{-3}.

(3)

(iii) Use information in the article to suggest why this titration gives a value that is lower than the true value for the concentration of titanium(III) chloride solutions.

(1)

.....

.....

(Total for Question 24 = 23 marks)

TOTAL FOR SECTION C = 23 MARKS
TOTAL FOR PAPER = 90 MARKS

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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											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** radius 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

Mark Scheme (SAM)

Pearson Edexcel International Advanced Level in Chemistry

Unit 5: General Principles of Chemistry II – Transition Metals and Organic Nitrogen Chemistry

General marking guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- 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 may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed-out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of Quality of Written Communication, are being assessed. The strands are as follows:
    i. ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
    ii. select and use a form and style of writing appropriate to purpose and to complex subject matter
    iii. organise information clearly and coherently, using specialist vocabulary when appropriate.

Using the Mark Scheme

Examiners should NOT give credit for incorrect or inadequate answers, but allow 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 still be creditworthy.

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.
Bold	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)(transfer error)(consequential) 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. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions that involve the writing of continuous prose require candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where Quality of Written Communication is likely to be particularly important are indicated (Quality of Written Communication) in the mark scheme, but this does not preclude others.

Section A

Question Number	Answer	Mark
1	C	(1)

Question Number	Answer	Mark
2	D	(1)

Question Number	Answer	Mark
3	A	(1)

Question Number	Answer	Mark
4	C	(1)

Question Number	Answer	Mark
5	C	(1)

Question Number	Answer	Mark
6	C	(1)

Question Number	Answer	Mark
7	A	(1)

Question Number	Answer	Mark
8	D	(1)

Question Number	Answer	Mark
9	D	(1)

Question Number	Answer	Mark
10	D	(1)

Question Number	Answer	Mark
11	A	(1)

Question Number	Answer	Mark
12	B	(1)

Question Number	Answer	Mark
13	B	(1)

Question Number	Answer	Mark
14	D	(1)

Question Number	Answer	Mark
15	B	(1)

Question Number	Answer	Mark
16	B	(1)

Question Number	Answer	Mark
17	B	(1)

Question Number	Answer	Mark
18	A	(1)

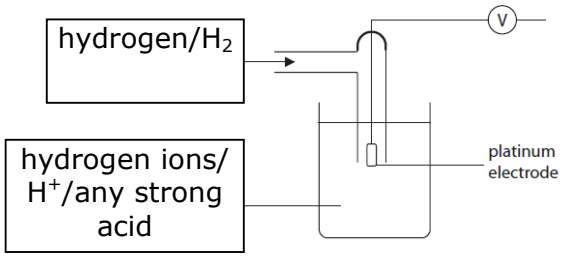
Question Number	Answer	Mark
19	B	(1)

Question Number	Answer	Mark
20	C	(1)

Total for Section A = 20 Marks

Section B

Question Number	Acceptable Answer	Reject	Mark
21(a)	<table><tr><th>Half-equation</th><th>$E^{\ominus}$/V</th></tr><tr><td></td><td></td></tr><tr><td></td><td></td></tr><tr><td></td><td>+0.4(0)</td></tr><tr><td></td><td>+1.23</td></tr></table> **One mark** for each correct value. Penalise omission of + once only.	+2.46	**(2)**

Question Number	Acceptable Answer	Reject	Mark
21(b)(i)	 **First mark:** Hydrogen/H_2(g)/H_2 IGNORE Any pressure value quoted **Second mark:** Name or formula of any strong acid (e.g. HCl/H_2SO_4) ALLOW hydrogen ions/H^+(aq)/H^+. IGNORE Any acid concentration value quoted. IGNORE State symbols for ANY formula of hydrogen and/or acid, even if incorrect. IGNORE any references to platinum.	H(g)/H for hydrogen gas 'HCL'/HSO_4 Just 'acidic'	**(2)**

Question Number	Acceptable Answer	Reject	Mark
21(b)(ii)	1 atm/100 kPa/101 kPa/1 bar 1 mol dm^{-3} ($[H^+]$/[HCl]) ALLOW '1 molar'/'1M' 298 K/25°C ALLOW '°K' All **THREE** conditions correct = **2 marks.** Any **TWO** conditions correct = **1 mark.** IGNORE References to 'standard conditions'. References to Pt/catalyst. ALLOW 0.5 mol dm^{-3} H_2SO_4. INSTEAD of the 1 mol dm^{-3} ($[H^+]$/[HCl]).	Wrong pressure units Incorrect concentration units (e.g. '1 mol'/1 mol^{-1} dm^3 for $[H^+]$) 273 K/0°C/'room temperature'	**(2)**

Question Number	Acceptable Answer	Reject	Mark
21(c)	**First mark:** Mentions/some evidence for the use of BOTH equations 1 AND 3 from the table in any way, even if reversed or left unbalanced for example: $O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$ AND $4OH^-(aq) + 2H_2(g) \rightarrow 4H_2O(l) + 4e^-$ **(1)** ALLOW $\rightleftharpoons$ for $\rightarrow$ **Second mark:** (Adds the above half-equations cancelling $4e^-$ to get.) $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$ OR $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$ **(1)** ALLOW $\rightleftharpoons$ for $\rightarrow$ but must have H_2 and O_2 on left. Mark the second scoring point independently. Award this mark if the correct equation is seen, no matter how it is derived. ALLOW MULTIPLES OF EQUATIONS IN ALL CASES. IGNORE any state symbols, even if incorrect. ALLOW equilibrium sign $\rightleftharpoons$ used in **ANY** of the above equations instead of the full arrows.	Equations involving H^+ **If** $e^-/OH^-/H^+$/two surplus H_2O molecules remain in this final equation **(0)** for 2nd mark	**(2)**

Question Number	Acceptable Answer	Reject	Mark
21(d)	$E^{\ominus}_{cell}$ = +0.40 - (-0.83) (V) = (+)1.23 (V) + sign NOT required in final answer Correct answer with or without working scores. **(1)** No ECF from any incorrect $E^{\ominus}$ values used.	**-**1.23 (V)	**(1)**

Question Number	Acceptable Answer	Reject	Mark
21(e)	Reaction/equation is the same OR Reaction/equation for both is $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$. ALLOW $\rightleftharpoons$ for $\rightarrow$ IGNORE state symbols even if incorrect. ALLOW statements such as 'they both produce water from hydrogen and oxygen'/'reactants and products are the same'. ALLOW multiples of the **equation.**	'Electrode potentials don't change' **Just** same product/water is produced **Just** same reactants are oxidized and reduced Same reaction but in **reverse** scores **(0)**	**(1)**

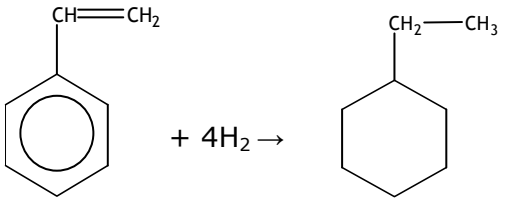
Question Number	Acceptable Answer	Mark
21(f)	To **increase** the **surface area**/to increase the number of active sites.	**(1)**

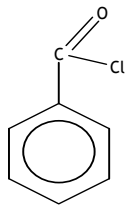
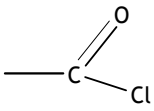
Question Number	Acceptable Answer	Reject	Mark
21(g)	Any one of: Storage (problems) Hydrogen/oxygen/the gases have to be stored under pressure Leakage (of hydrogen/of oxygen/of gas) Transport(ation) problems Hard to carry/lack of portability Hydrogen flammable inflammable Hydrogen explosive (Fuel cell) costly/expensive Needs (regular) re-filling Needs continual replenishment of H_2 and O_2 Lack of availability (of hydrogen/fuel) Hydrogen is made from fossil fuels/hydrogen is made by electrolysis/hydrogen is made from natural gas/hydrogen is made from non-renewable resources. ALLOW water is a greenhouse gas/ fuel cell(s) have short(er) lifespan/ fuel cells have to be (regularly) replaced. IGNORE references to 'danger' or 'safety' or 'hazardous'. Any arguments in terms of **voltage** output. References to hydrogen-oxygen fuel cell cannot be recharged.	'Fuel cell can only be used once' scores **(0)**	**(1)**

Total for Question 21 = 12 Marks

Question Number	Acceptable Answer	Reject	Mark
22(a)(i)	Addition/reduction/free-radical addition. IGNORE references to 'hydrogenation'.	Redox Electrophilic addition Nucleophilic addition	**(1)**

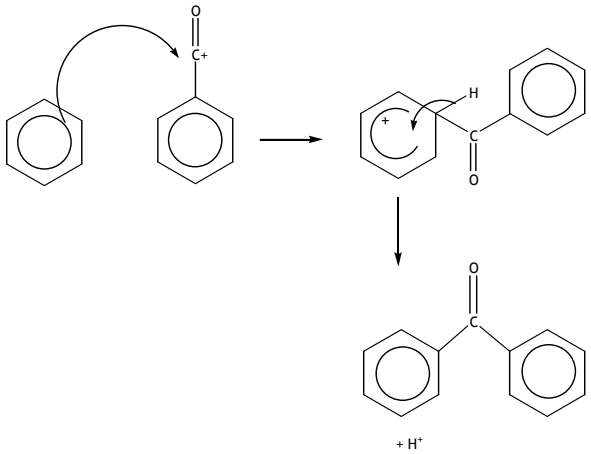
Question Number	Acceptable Answer	Mark
***22(a)(ii) Quality of Written Communication**	**First mark:** **Delocalisation** (of π/p electrons in benzene ring). **(1)** IGNORE reference to 'resonance' **Second mark:** Results in more **energy** needed to **break** the **bonds** in benzene (compared with three separate π bonds). **(1)** ALLOW confers **stability** on the molecule/makes benzene **more stable** (than expected) IGNORE Reference to carbon-carbon bond lengths Values of any enthalpy changes. Mark the two points independently.	**(2)**

Question Number	Acceptable Answer	Mark
22(a) (iii)	 (Δ*H*=) **-328 (**kJ mol^{-1}) **First mark**: For '4' **Second mark**: product as above/correct skeletal formula of product ALLOW Side chain written as $-C_2H_5$. **Third mark**: **-**328 (kJ mol^{-1}) **N.B.** **One** H_2 added showing a consequential correct product with only side chain reduced and consequential Δ*H* = **-**120 (kJ mol^{-1}) scores. **(2)** **Three** H_2 added showing a consequential correct product with only the benzene ring reduced and Δ*H* = **-**208 (kJ mol^{-1}) scores. **(2)** **Five** H_2 added with fully correct product drawn and Δ*H* = **-** 448 (kJ mol^{-1}) scores. **(2)** **Three and a half** H_2 added showing a fully correct product and Δ*H* = **-**268/**-**293(.3)(kJ mol^{-1}) scores. **(2)** **N.B.** mark scoring points independently	**(3)**

Question Number	Acceptable Answer	Mark
22(b)(i)	 Mark awarded for displaying 	(1)

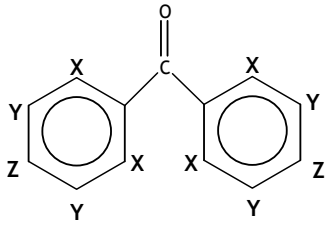
Question Number	Acceptable Answer	Mark
22(b)(ii)	Electrophilic substitution **BOTH** words needed. **IGNORE references to acylation and/or Friedel-Crafts.**	(1)

Question Number	Acceptable Answer	Mark
22(b)(iii)	Friedel **and** Crafts **BOTH** names are needed for this mark **.**	(1)

Question Number	Acceptable Answer	Mark
22(b) (iv)	**First mark:** **C_6H_5COCl** + $AlCl_3$ → **$C_6H_5CO^+$** + $AlCl_4^-$ **+** can be anywhere on the C_6H_5CO in the equation for the first mark.  ($AlCl_4^-$ + H^+ → HCl + $AlCl_3$) **N.B.** If ethanoyl chloride or any other acid chloride or the generic RCOCl is used **instead** of benzoyl chloride, no first mark can be awarded but the 2nd, 3rd and 4th marks can be awarded consequentially. **Second mark**: First curly arrow, as shown, to start from inside the hexagon to the correct C+ carbon (i.e. not to the benzene ring)**.** **N.B.** the + must be on the C of the C=O/CO for this mark **Third mark:** Intermediate correctly drawn. **N.B. +** can be shown anywhere in the ring or at the C atom where electrophile is bonded. The 'horseshoe' in the intermediate to cover at least three carbon atoms. **Fourth mark:** Second curly arrow as shown from C—H bond to reform the ring, not from the H atom in this bond **N.B.** products do not have to be shown nor the equation for regeneration of the catalyst given.	**(4)**

Question Number	Acceptable Answer	Reject	Mark
22(b)(v)	Absorbs/reflects/blocks/protects from/shields against/**uv** (light/radiation) IGNORE 'non-toxic'/references to IR	**Adsorbs** UV light	**(1)**

Question Number	Acceptable Answer	Mark
22(c)(i)	Any **TWO** of the following: One mark for identifying the bond by formula as shown and one mark for wavenumber in each matching pair. **UNITS** are not required. Bond / Wavenumber range/wavenumber (cm^{-1}) C=C / 1600/1580/1500/1450 **All four values needed** C=O / 1700–1680 C-H / 3030 C-H / 750/700 **Both values needed** ALLOW correct wavenumber range, or any number within the correct range, **for C=O.** Mark identification of the bond and the wavenumber independently. (e.g. a correct bond with a wrong wavenumber, or vice versa, scores one of the two marks in each case) IGNORE nmr values/chemical shifts.	**(4)**

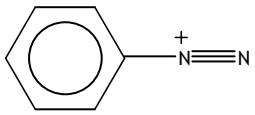
Question Number	Acceptable Answer	Mark
22(c)(ii)	 **First mark:** EITHER Identifies correctly the **three** different proton environments ALLOW If the three different proton environments are shown on only one of the benzene rings. **N.B.** on right-hand ring, clockwise from C=O, positions 2, 3 and 4 And/or 2, 4 and 5 are shown as different environments and/or on left-hand ring, anti-clockwise from C=O, positions 2, 3 and 4 And/or 2, 4 and 5 are shown as different environments. OR Identifies proton Z correctly on both benzene rings. **Second mark:** Fully correct labelling on both rings using the letters **X**, **Y** and **Z.** **N.B. X** and **Y** labels are interchangeable, **Z** is not.	**(2)**

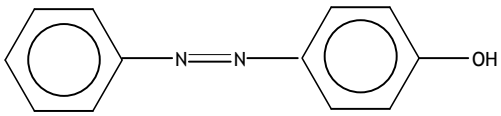
Total for Question 22 = 20 Marks

Question Number	Acceptable Answer	Reject	Mark
23(a)(i)	**Lone pair** (of electrons on the nitrogen atom) ALLOW non-bonded pair (of electrons on the nitrogen atom).	**Lone pairs** **Spare pair**	**(1)**

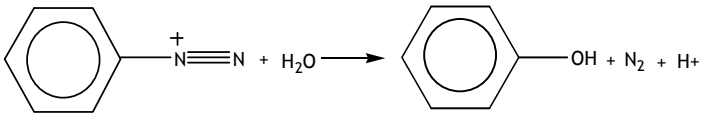
Question Number	Acceptable Answer	Mark
23(a)(ii)	**(with H_2SO_4)** $(C_4H_9NH_3^+)_2SO_4^{2-}$ **(1)** ALLOW $C_4H_9NH_3^+HSO_4^-$ **(with CH_3COOH)** $C_4H_9NH_3^+CH_3COO^-$ **(1)** **CHARGES** not essential. Cation and anion can be in either order. Maximum one mark if formula of the amine is incorrect in either case. ALLOW one mark if only the correct cation is given in each case (i.e. the anion has been omitted in both cases). **N.B.** the correct ions can be shown separately, e.g. $(C_4H_9NH_3^+)_2$ **+** SO_4^{2-} .	**(2)**

Question Number	Acceptable Answer	Reject	Mark
23(b)	Tin/Sn ALLOW Iron/Fe **(1)** (concentrated) **hydrochloric acid** **N.B.** if candidates write 'HCl', there must be some indication of concentrated, e.g. 'conc HCl'/'concentrated HCl'. ALLOW HCl(aq). (Followed by addition of alkali to liberate the free amine) **(1)** Mark the two points independently. **N.B.** do not allow second mark if there is a suggestion that the acid and alkali are added together simultaneously.	$LiAlH_4$ Just 'HCl' 'Dilute' hydrochloric acid/sulfuric acid	**(2)**

Question Number	Acceptable Answer	Reject	Mark
23(c)(i)	 **N.B.** if the above structure is drawn, the + charge must be on the N connected directly to the benzene ring. ALLOW —N=N^+ on ring. IGNORE Cl^-.	N_2^+ on ring	**(1)**

Question Number	Acceptable Answer	Mark
23(c)(ii)		**(1)**

Question Number	Acceptable Answer	Mark
23(c)(iii)	**(Conditions)** (Presence of) NaOH/KOH/alkali/OH^- **(1)** ALLOW 'Alkaline (conditions)' or 'base' or 'high pH'. IGNORE Any references to temperature. **(Use)** Dye/pigment/colouring/indicator/in foodstuff/in paint/methyl orange **(1)** IGNORE Any reference to medicines.	**(2)**

Question Number	Acceptable Answer	Mark
23(d)	 ALLOW The + sign to be on either N atom in the benezenediazonium ion. OR $C_6H_5N_2^+ + H_2O \rightarrow C_6H_5OH + N_2 + H^+$ OR $C_6H_5N_2Cl + H_2O \rightarrow C_6H_5OH + N_2 + HCl$ OR $C_6H_5N_2^+ + 2H_2O \rightarrow C_6H_5OH + N_2 + H_3O^+$ OR $C_6H_5N_2^+Cl^- + H_2O \rightarrow C_6H_5OH + N_2 + HCl$ **N.B.** —C_6H_5 can be written or drawn **First mark:** for **N_2** **(1)** **Second mark:** for rest of the equation correct **(1)** IGNORE State symbols, even if incorrect.	**(2)**

Question Number	Acceptable Answer	Mark
23(e)(i)	(Otherwise) too much (product) remains in solution OR If excess (solvent) is used, crystals might not form ALLOW To avoid losing (too much) product (in the filtrate when crystallization occurs). To maximise the yield. Will crystallize better from a concentrated solution/will recrystallize (better) when cold. IGNORE References to a 'saturated solution' or references to 'dilution' or references to the time taken for crystals to form.	**(1)**

Question Number	Acceptable Answer	Mark
23(e)(ii)	**(Insoluble impurities removed)** By **hot** filtration/During the **first** filtration/During the **second** step in the process. **(1)** **(Soluble impurities removed)** By remaining in solution/Left in filtrate/Removed when washed (with cold solvent). **(1)**	**(2)**

Question Number	Acceptable Answer	Reject	Mark
23(e)(iii)	Measure the melting temperature/melting point **and** compare with data/known value (from a data book/literature/internet/database) (BOTH points needed for the mark). OR The melting point is sharp (just this statement is needed for the mark). ALLOW Any form of chromatography. IGNORE References to any types of spectroscopy.	**(0)** If reference to determination of the boiling point is made	**(1)**

Total for Question 23 = 15 Marks

Total for Section B = 47 Marks

Question Number	Acceptable Answer	Mark
24(a)(i)	$TiCl_4 + 4Na \rightarrow 4NaCl + Ti$ IGNORE State symbols, even if incorrect. ALLOW Multiples. Reversible arrows.	**(1)**

Question Number	Acceptable Answer	Mark
24(a)(ii)	Ti **reduced** as oxidation number decreases from **+4 to 0**/changes from **+4 to 0.** **(1)** Na **oxidized** as oxidation number increases from **0 to +1**/changes from **0 to +1.** **(1)** ALLOW Correct oxidation numbers only for one mark. **N.B.** max (1) if no + sign included. ALLOW **'4+'** and/or **'1+'** given instead of **+4** and **+1.** **N.B.** if any of the oxidation numbers are wrong, award max (1) for the idea that during oxidation the oxidation number increases **AND** during reduction the oxidation number decreases. IGNORE References to loss and /or gain of electrons.	**(2)**

Question Number	Acceptable Answer	Mark
24(b)	(Ti [Ar]) $3d^2$ $4s^2$/$4s^2$ $3d^2$ **(1)** (Ti^{3+} [Ar]) $3d^1$ /$3d^1$ $4s^0$ (Ti^{4+} [Ar]) 'nil'/$3d^0$ $4s^0$ /$3d^0$ space left blank by candidate BOTH Ti^{3+} and Ti^{4+} correct for second mark. **(1)** Mark CQ on Ti electron configuration for the second mark. ALLOW Upper case (e.g. 'D' for 'd' in electronic configurations). Subscripts for numbers of electrons. Full correct electronic configurations $1s^2$ $2s^2$.	**(2)**

Question Number	Acceptable Answer	Reject	Mark
24(c)(i)	**(d-block element)** EITHER Ti has (two) electrons in the 3d subshell/ Ti has a partially filled d-subshell/ Ti has a partially filled d-orbital/ Ti has electrons in d-orbital(s)/ Ti has electrons in d-subshell (During the build up of its atoms) last added/valence electron is in a d-subshell/d-orbital. OR (During the build up of its atoms) last added/valence electron is in a d-subshell/d-orbital.	**Outer/highest energy** electrons are in a d-orbital/**Outer/highest energy** electrons are in a d-subshell Electrons in the 'd-block'/ 'electrons in the d-shell'	**(1)**

Question Number	Acceptable Answer	Mark
24(c)(ii)	(Transition element) Forms one (or more stable) **ions**/forms **Ti^{3+}** (ions) which have. Incomplete d-orbital(s)/an incomplete d-subshell/a partially filled d-subshell/an unpaired d electron IGNORE references to variable oxidation states.	**(1)**

Question Number	Acceptable Answer	Reject	Mark
***24(d)(i) Quality of Written Communication**	**First mark:** d-subshell splits/d-orbital**s** split (in energy by ligands)/d energy level(s) split(s) **(1)** **Second mark:** Absorbs light (in visible region) **(1)** **Third mark:** Electron transitions from lower to higher energy/electron(s) jump from lower to higher energy. OR Electron(s) promoted (within d). **(1)** Mark independently **N.B.** maximum of (1) mark (i.e. the first mark only) if refers to electrons falling back down again.	d-**orbital/**d-**shell** splits Absorbs **purple** light	**(3)**

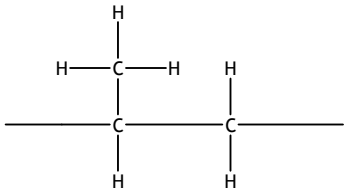
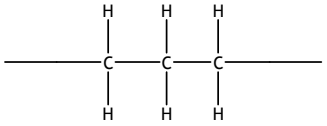
Question Number	Acceptable Answer	Mark
24(d)(ii)	No d-electrons/empty d-subshell	**(1)**

Question Number	Acceptable Answer	Reject	Mark
***24(e)(i) Quality of Written Communication**	**TiO_2 'Structure' mark** EITHER Giant (structure) OR Lattice (structure) **(1)** IGNORE Whether stated as ionic or covalent for this mark. **TiO_2 'Bonding' mark** EITHER **Strong** (electrostatic) attraction between ions. ALLOW **Strong** ionic bonds/ionic bonds require a lot of energy to break. OR **Strong** covalent bonds/covalent bonds require a lot of energy to break. **(1)** **$TiCl_4$ 'Structure' mark** (Simple) molecules/(small) molecules /molecular. **(1)** **$TiCl_4$ 'Bonding' mark** **Weak** London/dispersion/van der Waals' forces (between molecules)/ London/dispersion/van der Waals' forces (between molecules) require little energy to break. **(1)**	TiO_2 (small) molecules/simple molecular For TiO_2 mention of any type of intermolecular forces between molecules of TiO_2 $TiCl_4$ giant structure Covalent bonds broken (on melting) in $TiCl_4$ Ionic bonding in $TiCl_4$ Hydrogen bonding **(0)** for this mark	**(4)**

Question Number	Acceptable Answer	Mark
24(e)(i) continued	**N.B.** if candidate assumes TiO_2 and $TiCl_4$ are both simple molecular, can score last mark for saying that the named intermolecular forces in TiO_2 are stronger. IGNORE (Permanent) dipole-dipole forces. Mark the four scoring points independently.	

Question Number	Acceptable Answer	Mark
24(e)(ii)	Amphoteric ALLOW Recognisable spellings.	**(1)**

Question Number	Acceptable Answer	Mark
24(e)(iii)	$TiO_2 + 2H_2O + 2KOH \rightarrow K_2Ti(OH)_6$ OR $TiO_2 + 2H_2O + 2OH^- \rightarrow Ti(OH)_6^{2-}$ IGNORE state symbols even if incorrect.	**(1)**

Question Number	Acceptable Answer	Reject	Mark
24(e)(iv)	 **MUST** have continuation bonds at each end. ALLOW CH_3 IGNORE n and any brackets.	 **Two** (or more) repeat units shown.	**(1)**

Question Number	Acceptable Answer	Mark
24(f)(i)	(H_2O_2 + $2H^+$ +) **$2e^{(-)}$ → $2H_2O$** **BOTH** $2e^{(-)}$ **and 2**H_2O needed for the mark.	**(1)**

Question Number	Acceptable Answer	Mark
***24(f)(ii) Quality of Written Communication**	(Moles H_2O_2 = 0.0200 x 22.50/1000) = 4.5 x 10^{-4} mol H_2O_2 **(1)** (Moles Ti^{3+} reacting in 25.0 cm^3) = 9.0 x 10^{-4} mol Ti^{3+} **(1)** (Moles Ti^{3+} in 250 cm^3) = 9.0 x 10^{-3} mol Ti^{3+} **(1)** (Original concentration of Ti^{3+}= 9.0 x 10^{-3}/0.00500) = 1.8 (mol dm^{-3}) **(1)** 1.8 (mol dm^{-3}) with or without working scores **(3)** **N.B.** if mole ratio H_2O_2 : Ti^{3+} is 1:1 final answer for concentration of Ti^{3+} is 0.9 (mol dm^{-3}) scores. Overall **(2)** If mole ratio H_2O_2 : Ti^{3+} is 2:1 final answer for concentration of Ti^{3+} is 0.45 (mol dm^{-3}) scores. Overall **(2)** If candidate forgets to multiply number. of moles of Ti^{3+} by 10 then answer is 0.18 (moldm^{-3}) this scores. **(2)** If volume of H_2O_2 used is 25.0 no first mark, but can score two marks if final answer CQ is 2(.0) (mol dm^{-3}).	**(3)**

Question Number	Acceptable Answer	Reject	Mark
24(f)(iii)	(It/titanium(III)/Ti^{3+}) **oxidized** (by oxygen in the air) ALLOW 'It is a **strong** reducing agent'	Hydrolysis	**(1)**

Total for Question 24 = 23 marks

Total for Section C = 23 marks

Total for Paper = 90 marks

Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number	Candidate Number

Chemistry

Advanced

Unit 6: Chemistry Laboratory Skills II

Sample Assessment Material
Time: 1 hour 15 minutes

Paper Reference
WCH06/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or 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.*

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.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

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

Turn over ▶

S45365A

S 4 5 3 6 5 A 0 1 1 6

PEARSON

Answer ALL the questions. Write your answers in the spaces provided.

1 (a) Compound **Z** is a crystalline solid that contains a nickel cation and one type of anion. Complete the table below.

	Test	Observation	Inference
(i)	Add dilute sulfuric acid to compound **Z**	Bubbles of a colourless gas are released. The gas turns limewater milky and a ..... coloured solution is formed **(1)**	Name of gas released is ..... Formula of anion in **Z** is ..... **(2)** Formula of the complex ion formed is $[Ni(H_2O)_6]^{2+}(aq)$
(ii)	Add concentrated hydrochloric acid to the solution containing $[Ni(H_2O)_6]^{2+}$ ions	Yellow-brown solution forms	Formula of the complex ion formed is ..... **(1)**
(iii)	Add a few drops of dilute aqueous ammonia to the solution containing $[Ni(H_2O)_6]^{2+}$ ions	Green precipitate forms	Formula of the precipitate formed is ..... **(1)**
(iv)	Add excess dilute aqueous ammonia to the solution containing $[Ni(H_2O)_6]^{2+}$ ions until no further change is observed	.... **(1)**	Formula of the complex ion formed is $[Ni(NH_3)_6]^{2+}$

(b) A 10.0 cm^3 sample of a solution containing $[Ni(H_2O)_6]^{2+}$ ions was titrated with a solution of concentration 0.010 mol dm^{-3} with respect to the ligand $EDTA^{4-}$ ions. The equation for the reaction is

$$[Ni(H_2O)_6]^{2+} + EDTA^{4-} \rightarrow [Ni(EDTA)]^{2-} + 6H_2O$$

(i) The mean titre of the solution containing $EDTA^{4-}$ ions was 24.20 cm^3. Use this information, and the equation above, to calculate the concentration in mol dm^{-3} of the solution containing $[Ni(H_2O)_6]^{2+}$ ions.

(2)

(ii) Assuming the total error in the measurement of the mean titre is ±0.10 cm^3, calculate the percentage error in this titre.

(1)

(iii) A similar solution, containing the same concentration of $[Ni(H_2O)_6]^{2+}$ ions, also contained a small amount of an impurity, copper(II) sulfate.

Suggest what effect this impurity would have on the titre. Justify your answer.

(2)

.....

.....

.....

.....

(Total for Question 1 = 11 marks)

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2 A colourless liquid, compound **X**, was extracted from raspberries. **X** has the molecular formula $C_{10}H_{12}O_2$ and contains a benzene ring.

(a) What would you expect to see if a sample of compound **X** was burned in air?

(1)

.....

.....

(b) A series of tests was carried out on compound **X**. In each test, state what you can deduce about the structure of compound **X** from the results described.

(i) **X** forms a white precipitate with aqueous bromine solution.

(1)

.....

.....

(ii) **X** forms an orange precipitate with 2,4-dinitrophenylhydrazine.

(1)

.....

.....

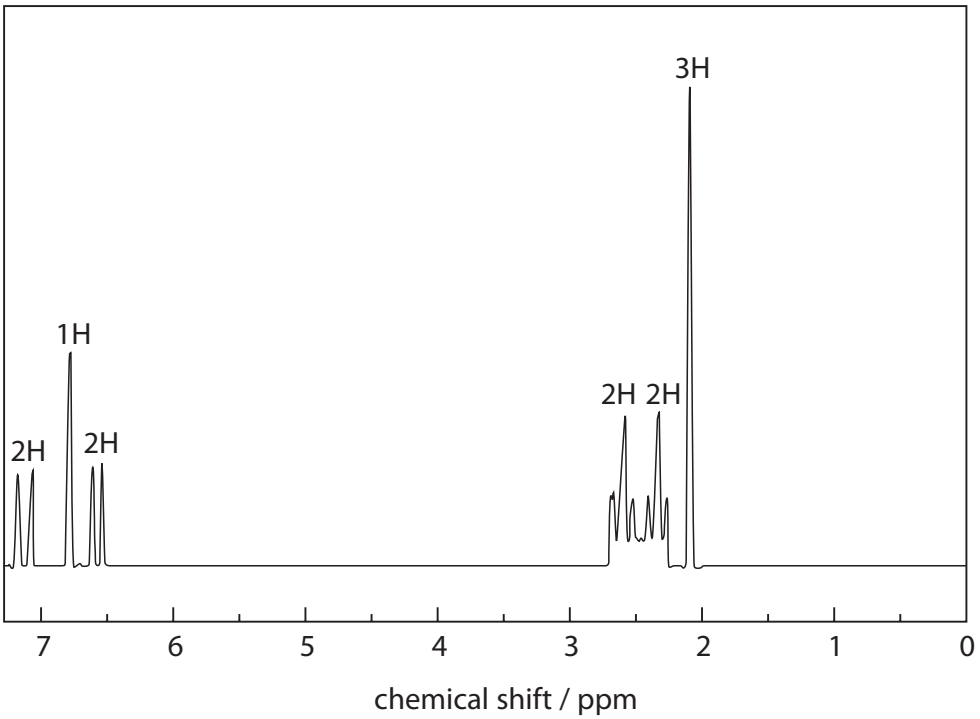
(iii) Fehling's (or Benedict's) solution remains blue when warmed with compound **X**.

(1)

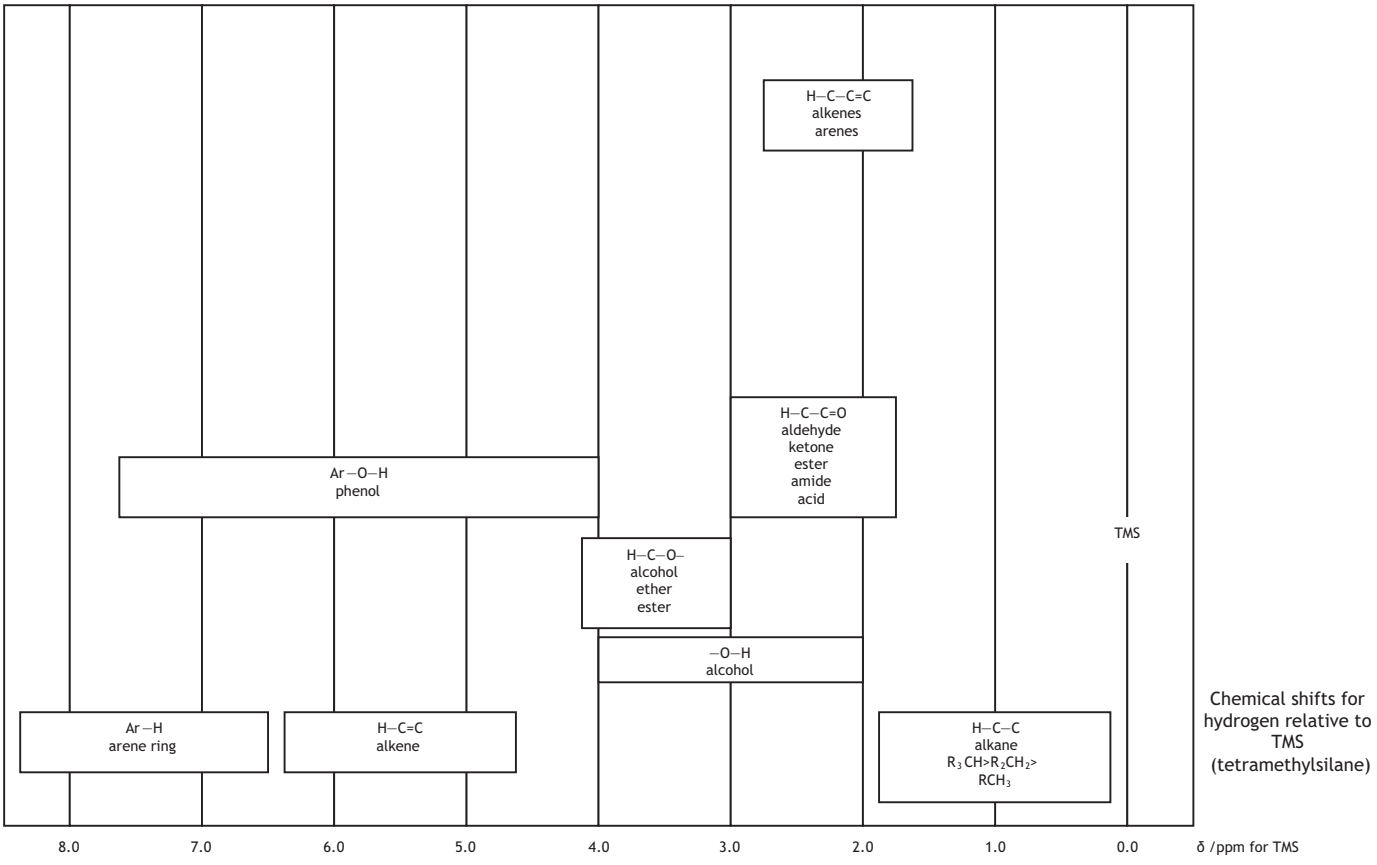
.....

.....

(c) The high resolution proton nmr spectrum of compound **X** is shown below. This spectrum shows that there are six different proton environments in the molecule of **X**. The relative number of hydrogen atoms in each environment is indicated on the spectrum. Use this spectrum, the data below and your answers to (a) and (b) to help answer the questions that follow.



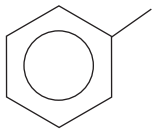
Nuclear Magnetic Resonance



(i) Which hydrogen atoms in compound **X** are most likely to have caused the peaks at 6.5 ppm and 7.2 ppm?

(1)

(ii) Compound **X** has a side chain containing four carbon atoms attached to the benzene ring. Show all the atoms on this side chain and label each hydrogen environment on the side chain with its splitting pattern.



(3)

(iii) Suggest the structural formula of **X**.

(1)

(d) Compound **X** can be extracted from raspberries by steam distillation. Draw a labelled diagram of the apparatus you could use to carry out this steam distillation.

(3)

(Total for Question 2 = 12 marks)

3 Glucose can be oxidized using acidified potassium manganate(VII). The kinetics of the reaction can be studied using the procedure outlined below.

1. Measured volumes of glucose solution, sulfuric acid and water were added to a conical flask.
2. A measured volume of potassium manganate(VII) solution was added to the flask. The mixture was gently swirled and a stopwatch started.
3. The time taken for the mixture in the flask to change colour was recorded and the initial rate of the reaction was then calculated.
4. The experiment was repeated using different volumes of the solutions.

The results of the experiments are shown in the table below.

Experiment	Glucose / cm^3	Sulfuric acid / cm^3	Potassium manganate(VII) / cm^3	Water / cm^3	Initial rate / mol dm^{-3} s^{-1}
A	20.0	20.0	10.0	0.0	1.0×10^{-5}
B	20.0	20.0	5.0	5.0	5.0×10^{-6}
C	10.0	20.0	10.0	10.0	9.8×10^{-6}
D	10.0	10.0	10.0	20.0	4.9×10^{-6}

(a) (i) Which piece of equipment should be used to measure out the volumes used in each experiment? Justify your choice.

(2)

.....

.....

.....

.....

(ii) What colour change would you see in step 3?

(2)

From ..... to .....

(iii) Explain why water was added to the flask in experiments B, C and D.

(1)

.....

.....

(iv) Suggest a technique that could be used to continuously monitor the change in concentration of potassium manganate(VII) during the reaction.

(1)

.....

.....

(v) State the order with respect to glucose, sulfuric acid and potassium manganate(VII) and hence write the rate equation for the reaction.

(3)

(b) Experiment A was repeated at different temperatures and the time taken for the potassium manganate(VII) to change colour was recorded. The results were processed to find values of 1/temperature and ln (rate constant) and these are shown in the table below.

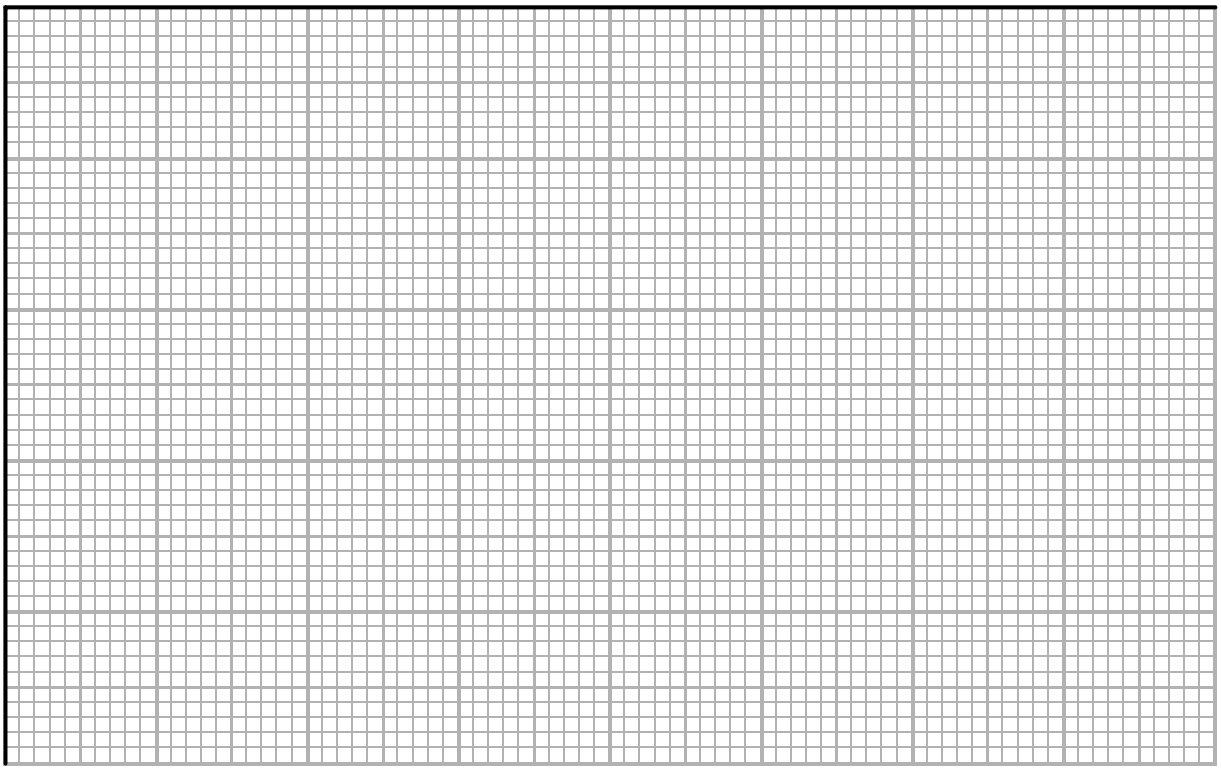
Experiment	1 / temperature / K^{-1}	ln (rate constant)
E	3.00×10^{-3}	−1.60
F	3.10×10^{-3}	−2.60
G	3.21×10^{-3}	−3.75
H	3.35×10^{-3}	−5.20

(i) Plot a graph of ln (rate constant) against 1 / temperature on the axes below.

(3)

1 / temperature / K^{-1}

ln (rate constant)



(ii) Calculate the gradient of the graph.

(1)

(iii) Use your answer to (ii) and the relationship below to calculate the activation energy, E_a, for this reaction. Include a sign and units in your answer.

$$\text{Gradient} = \frac{-E_a}{R}$$

$R = 8.31\ \text{J K}^{-1}\ \text{mol}^{-1}$

(2)

(Total for Question 3 = 15 marks)

4 The procedure outlined below can be used to extract caffeine from tea.

1. Add 25 g of tea, 10 g of calcium carbonate and 250 cm^3 of water to a large beaker.
2. Gently boil the mixture for 15 minutes.
3. While the mixture is still warm, filter using suction filtration.
4. Transfer the filtrate to a separating funnel and separate the caffeine from the aqueous mixture using solvent extraction, with dichloromethane as the solvent.
5. Dry the extract.
6. Remove the solvent.

[Density of dichloromethane = 1.32 g cm^{-3}]

(a) (i) Outline how to carry out the solvent extraction in **step 4**, to obtain a solution of caffeine dissolved in dichloromethane.

(3)

(ii) How would you dry the extract in **step 5**? Include the name of a suitable drying agent in your answer.

(2)

.....

.....

.....

.....

(b) (i) The solvent dichloromethane is harmful and can enter the body through inhalation and skin absorption. Suggest a possible way to minimise each of these risks when using dichloromethane.

(2)

Inhalation .....

.....

Skin absorption .....

.....

(ii) Suggest a suitable way to remove the solvent in **step 6**.

(1)

.....

.....

(c) The extraction can also be carried out using liquid carbon dioxide. Suggest an advantage of using this rather than dichloromethane.

(1)

.....

.....

.....

(d) A student carrying out this extraction obtained 85 mg of caffeine. Calculate the percentage by mass of caffeine obtained from the sample of tea used.

(2)

(e) Caffeine obtained in this way is often a pale green solid, due to impurities. State the name of another technique you could use to further purify the caffeine.

(1)

.....

.....

(Total for Question 4 = 12 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)
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	4.0 He helium 2
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

Mark Scheme (SAM)

Pearson Edexcel International Advanced Level in Chemistry

Unit 6: Chemistry Laboratory Skills II

General marking guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- 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 may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed-out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of Quality of Written Communication, are being assessed. The strands are as follows:
    i. ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
    ii. select and use a form and style of writing appropriate to purpose and to complex subject matter
    iii. organise information clearly and coherently, using specialist vocabulary when appropriate.

Using the Mark Scheme

Examiners should NOT give credit for incorrect or inadequate answers, but allow 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 still be creditworthy.

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.
Bold	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)(transfer error)(consequential) 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. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Question Number	Acceptable Answer	Reject	Mark
1(a)(i)	Green IGNORE qualifications of green such as light/dark/emerald. **(1)** Carbon dioxide ALLOW CO_2. **(1)** CO_3^{2-} ALLOW HCO_3^- **(1)**	Blue-green Turquoise	**(3)**

Question Number	Acceptable Answer	Mark
1(a)(ii)	$[NiCl_4]^{2-}$ ALLOW -2 for 2- $NiCl_4^{2-}$ $[Ni(Cl)_4]^{2-}$ $Ni(Cl)_4^{2-}$ $[Ni(H_2O)_2Cl_4]^{2-}$ $[NiCl_6]^{4-}$	**(1)**

Question Number	Acceptable Answer	Mark
1(a)(iii)	$Ni(OH)_2$/$Ni(H_2O)_4(OH)_2$/ $Ni(OH)_2$ $(H_2O)_4$/ $[Ni(H_2O)_4(OH)_2]$/ $[Ni(OH)_2$ $(H_2O)_4]$	**(1)**

Question Number	Acceptable Answer	Reject	Mark
1(a)(iv)	Blue solution (forms) ALLOW lavender blue solution and any other shade of blue. OR (Green) precipitate dissolves.	Blue-green Precipitate dissolves to give incorrect coloured solution	**(1)**

Question Number	Acceptable Answer	Mark
1(b)(i)	24.2/1000 x 0.01 = 2.42 x 10^{-4} (mol) **(1)** Concentration of $[Ni(H_2O)_6]^{2+}$ ions = 2.42 x 10^{-4} x 100 = 0.0242 (mol dm^{-3}) **(1)** ALLOW TE on number of moles. Correct answer alone scores both marks. IGNORE significant figures except 1.	**(2)**

Question Number	Acceptable Answer	Reject	Mark
1(b)(ii)	0.1/24.2 x 100 = (±) 0.413% /(±) 0.41 % /(±) 0.4%	4 or more SF	**(1)**

Question Number	Acceptable Answer	Reject	Mark
1(b)(iii)	(Mean) titre would be greater. **(1)** $EDTA^{(4-)}$ would also complex to/react with Cu^{2+}/$[Cu(H_2O)_6]^{2+}$/$CuSO_4$ /copper ions/copper sulphate. **(1)** Both marks are stand alone.	More needed to react with unspecified impurity	**(2)**

Total for Question 1 = 11 Marks

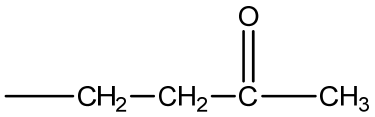
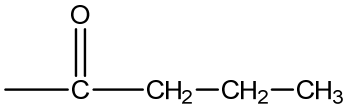
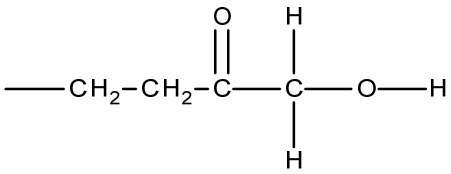
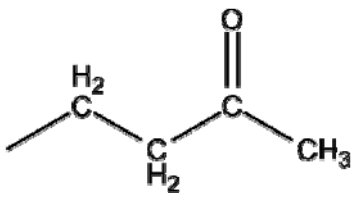
Question Number	Acceptable Answer	Reject	Mark
2(a)	Smoky/sooty flame IGNORE reference to yellow flame.	White smoke	**(1)**

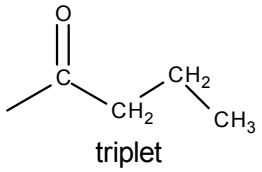
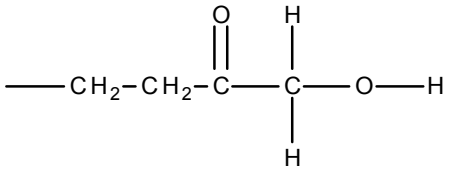
Question Number	Acceptable Answer	Reject	Mark
2(b)(i)	It contains a phenol group/has OH attached to benzene ring. ALLOW hydrox**yl** group attached to benzene ring. ALLOW 'is a phenol'. ALLOW drawn benzene ring with OH.	Just OH group Hydrox**ide** group	**(1)**

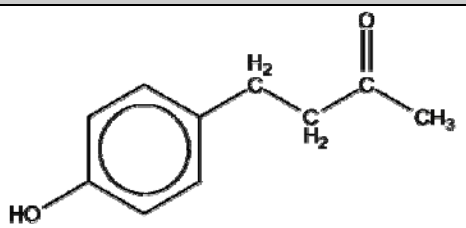
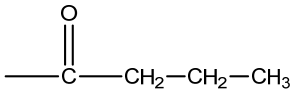
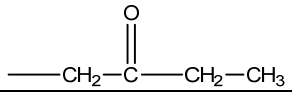
Question Number	Acceptable Answer	Reject	Mark
2(b)(ii)	It could be an aldehyde or a ketone/contains a carbonyl group. ALLOW C=O.	Either aldehyde or ketone on its own	**(1)**

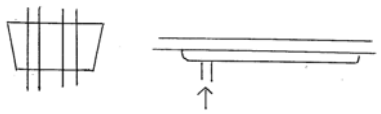
Question Number	Acceptable Answer	Mark
2(b)(iii)	**X** is a ketone ALLOW aromatic ketone. ALLOW R-CO-R. ALLOW not an aldehyde if both ketone and aldehyde mentioned in b(ii).	**(1)**

Question Number	Acceptable Answer	Reject	Mark
2(c)(i)	(Hydrogen atoms/protons on) benzene ring/phenyl group/arene ring.	Hydrogen atoms in phenol	**(1)**

Question Number	Acceptable Answer	Reject	Mark
2(c)(ii)	To score any marks in this question the side chain must be: (a)  OR (b)  OR (c)  Ketone on correct carbon Structure (a) or structure (c) **(1)** ALLOW displayed or skeletal ALLOW $CH_2CH_2COCH_3$ IGNORE presence or position of OH on the benzene ring  triplet triplet singlet Both triplets labelled. **(1)** Singlet labelled. **(1)**	Any other side chain scores zero for 2c(ii)	**(3)**

Question Number	Acceptable Answer	Mark
2(c)(ii) continued	ALLOW If the side chain is (b) the triplet CH_2 next to the C=O correctly labelled scores one mark.  triplet **(1)** If the side chain is (c) the triplets, both labelled, score the mark.  triplet triplet **(1)**	

Question Number	Acceptable Answer	Reject	Mark
2(c)(iii)	 IGNORE position of OH and side chain on the ring. ALLOW displayed or skeletal. ALLOW $C_6H_4(OH)CH_2CH_2COCH_3$. ALLOW TE if one of the following side chains is carried forward from 2c(ii):  OR 	TE for any other side chain	**(1)**

Question Number	Acceptable Answer	Reject	Mark
2(d)	Steam source with delivery tube to flask with the steam passing into the liquid in the flask. IGNORE incorrectly positioned safety vents in the steam generator. OR Flask being heated and containing water (and raspberries). **(1)** Condenser with water jacket in correct position and with correct direction of water flow shown. **(1)** Collection vessel. **(1)** Minus 1mark if apparatus does not work (e.g. sealed or leaky joints)  Correctly drawn reflux apparatus scores 1 mark. IGNORE fractionating columns. Collection vessel may be any shape of flask, test tube or cylinder.	Steam delivered above the liquid in the flask Unlabelled liquid in the flask	**(3)**

Total for Question 2 = 12 Marks

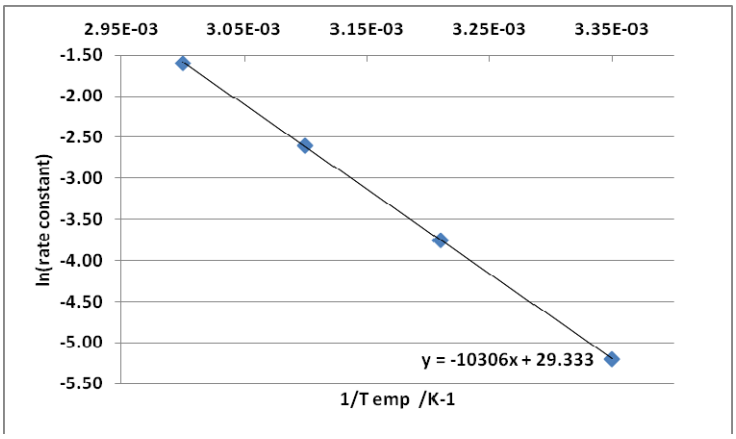
Question Number	Acceptable Answer	Reject	Mark
3(a)(i)	Burette/(graduated/volumetric) pipette **(1)** Allows accurate/precise measurement. **(1)** OR Measuring cylinder. **(1)** Allows you to do multiple experiments quickly/accurate enough (to determine orders). **(1)** IGNORE Ease of use. Cylinder allows variety of different volumes to be measured.	Dropping/teat pipette	**(2)**

Question Number	Acceptable Answer	Reject	Mark
3(a)(ii)	Pink/purple **(1)** To colourless **(1)** Reverse order scores 1 mark.	Lilac Clear for colourless	**(2)**

Question Number	Acceptable Answer	Reject	Mark
3(a)(iii)	To keep the (overall) volume constant/50 cm^3 OR So the concentration of each reactant is proportional to the volume used.	Any other volume quoted	**(1)**

Question Number	Acceptable Answer	Reject	Mark
3(a)(iv)	(Monitor change in concentration of MnO_4^- using) colorimetry. OR Titrate with reducing agent/named reducing agent, e.g. Fe^{2+}.	Just observing the intensity of the colour Electrical conductivity pH meter Just 'titrate'	**(1)**

Question Number	Acceptable Answer	Reject	Mark
3(a)(v)	0 order with respect to glucose 1st order with respect to sulfuric acid 1st order with respect to potassium manganate (VII) All 3 correct scores 2 marks 2 correct scores 1 mark 0 or 1 correct scores 0 marks **(2)** Rate/r/R = $k[MnO_4^-][H^+]([C_6H_{12}O_6]^0)$ **(1)** ALLOW full formulae or names in rate equation. If formulae given they must be correct. ALLOW 'K' for 'k'. ALLOW TE from incorrect orders for last mark.	Rate equation for rate	**(3)**

Question Number	Acceptable Answer	Mark
3(b)(i)	 Suitable linear scales. **(1)** IGNORE units. Points plotted correctly. **(1)** Straight line of best fit drawn. **(1)**	**(3)**

Question Number	Acceptable Answer	Reject	Mark
3(b)(ii)	Gradient = -10300 ALLOW any value in the range -9600 to -11000 IGNORE units even if incorrect	Positive gradient	**(1)**

Question Number	Acceptable Answer	Reject	Mark
3(b)(iii)	E_A = (-) gradient from b(ii) x 8.31 **(1)** E_A = Value to at least 2 significant figures with units. **(1)** Units must be correct. Correct value: E_A = -(-10300) x 8.31 = 85593 J mol^{-1}/85.6 kJ mol^{-1} Correct answer with no working scores both marks.	Negative E_A	**(2)**

Gradient	E_A/ kJmol^{-1}
-9600	79.8
-9700	80.6
-9800	81.4
-9900	82.3
-10000	83.1
-10100	83.9
-10200	84.8
-10300	85.6
-10400	86.4
-10500	87.3
-10600	88.1
-10700	88.9
-10800	89.7
-10900	90.6
-11000	91.4

Total for Question 3 = 15 Marks

Question Number	Acceptable Answer	Reject	Mark
4(a)(i)	Any **three** from: Shake/mix. **(1)** Release pressure/open stopper (from time to time). **(1)** Remove lower/dichloromethane layer by opening tap/using teat pipette. OR Decant the top layer/remove top layer with teat pipette. To score this mark it must be clear that the bottom layer is the layer required. **(1)** Repeat extraction with additional solvent. **(1)**	Just 'add the dichloromethane' Just 'separate the liquids'	**(3)**

Question Number	Acceptable Answer	Reject	Mark
4(a)(ii)	Add named drying agent (anhydrous) calcium chloride/magnesium sulfate/sodium sulphate. **(1)** ALLOW silica gel. IGNORE desiccators. (Allow to stand) decant/filter (to separate drying agent) **(1)** Both marks are stand alone.	Sulfuric acid KOH NaOH Heat with drying Agent Dry with filter paper	**(2)**

Question Number	Acceptable Answer	Mark
4(b)(i)	Carry out in fume cupboard/hood chamber/well-ventilated lab. **(1)** IGNORE gas/face masks. Wear (protective) gloves. **(1)** IGNORE lab coat and eye protection.	**(2)**

Question Number	Acceptable Answer	Reject	Mark
4(b)(ii)	Distillation/evaporate under reduced pressure/rotary evaporation. ALLOW fractional distillation. IGNORE recrystallisation.	Just evaporate	**(1)**

Question Number	Acceptable Answer	Reject	Mark
4(c)	CO_2 is less harmful/not harmful/ less hazardous/not hazardous/ less irritant/not irritant/ non-flammable/ non-toxic/evaporates easily/easily removed. IGNORE comments regarding ozone layer or global warming.	Just CO_2 safer/less risky	**(1)**

Question Number	Acceptable Answer	Reject	Mark
4(d)	85mg = 0.085g **(1)** % caffeine = 0.085/25 x 100 = 0.34% **(1)** ALLOW TE on incorrect mass. Correct answer alone scores both marks. IGNORE significant figures except 1 mark.	% caffeine>100%	**(2)**

Question Number	Acceptable Answer	Reject	Mark
4(e)	Recrystallisation ALLOW column chromatography. ALLOW sublimation.	Distillation	**(1)**

Total for Question 4 = 12 marks

Total for Paper = 50 marks

Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced

Unit 7: Chemistry Practical Examination

Sample Assessment Materials for first teaching September 2016

Time: 2 hours

Paper Reference **WCH07/01**

You do not need any other materials.

Total Marks

Instructions

- Use **black** ink or 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.*

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.*
- A Periodic Table is printed on the back cover of this paper.
- Candidates may use a scientific calculator.

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.
- You should take all the usual safety precautions when working in a chemistry laboratory.

Turn over ▶

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S 5 1 0 5 7 A 0 1 1 2

PEARSON

Answer ALL the questions. Write your answers in the spaces provided.

1 You are provided with samples of compounds **A**, **B** and **C**.
A and **B** are inorganic compounds containing one cation and one anion.
C is an organic compound containing one functional group. The molecules of **C** contain from one to four carbon atoms.

Carry out the following tests, recording your observations and inferences in the spaces provided.

(a) (i) Add a few drops of concentrated hydrochloric acid to about half of the sample of **A** on a watch glass.
Carry out a flame test on the solution formed.
In the inference column, identify the **cation** in **A** by writing its formula.

(2)

Observation	Inference

(ii) Dissolve half of the remaining sample of **A** in about 4 cm^3 of distilled water in a test tube.
Add 6 drops of dilute nitric acid, followed by 6 drops of aqueous silver nitrate.
In the inference column, give the **formula** of the new compound observed on the addition of aqueous silver nitrate.

(2)

Observation	Inference

(iii) Working in a fume cupboard, add about 6 drops of concentrated sulfuric acid to the remaining sample of **A** in a test tube.
Leave the test tube in the fume cupboard.
In the inference column, give the **formula** of **A** based on your observations in (a)(i), (a)(ii) and (a)(iii).

(3)

Observations	Inference

(b) (i) Dissolve the sample of **B** in about 10 cm^3 of distilled water in a boiling tube.
To 4 cm^3 of the solution in a test tube, add 3 cm^3 of dilute aqueous ammonia.
Shake the test tube gently, then allow it to stand for a few minutes.
In the inference column, name the type of reaction that takes place on standing.

(3)

Observations	Inference

(ii) To 4 cm^3 of the solution of **B** in a test tube, add 10 drops of dilute hydrochloric acid, followed by 6 drops of aqueous barium chloride.
In the inference column, give the **formula** of **B** based on your observations in (b)(i) and (b)(ii).

(2)

Observation	Inference

(c) (i) To 3 cm^3 of 2,4-dinitrophenylhydrazine solution in a test tube, add 6 drops of **C** and shake the test tube gently.
In the inference column, state what information this test gives you about the functional group in **C**.

(3)

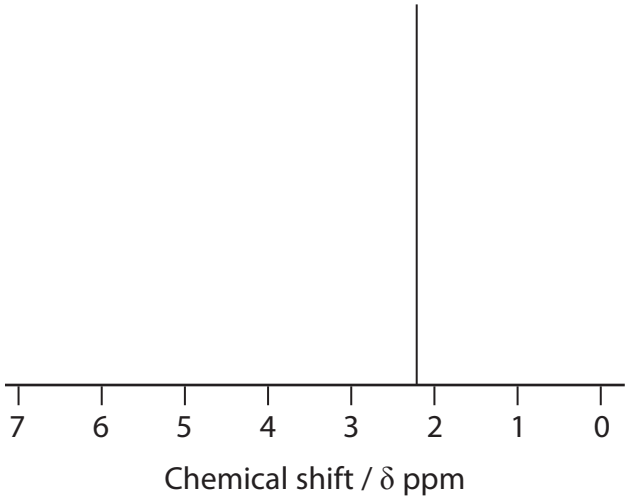
Observation	Inference

(ii) To 2 cm^3 of aqueous sodium hydroxide in a test tube, add 4 drops of **C**, followed by aqueous iodine, drop by drop, until a faint brown colour remains. Allow the test tube to stand for a few minutes.
In the inference column, state what further information this test gives you about **C**.

(2)

Observation	Inference

(iii) The high resolution nmr spectrum of **C** is shown below.



Identify **C** based on your inferences in (c)(i) and (c)(ii), together with information given at the start of this question and the nmr spectrum.
Write the **displayed** formula of **C** in the space below.
Explain how the number of peaks in the spectrum helps you to identify **C**.

(3)

Identity of **C**

Explanation

(Total for Question 1 = 20 marks)

2 In this exercise, you will make up a solution of potassium iodate(V) and then use portions of the solution to liberate iodine from acidified potassium iodide solution.

$$IO_3^-(aq) + 6H^+(aq) + 5I^-(aq) \rightarrow 3I_2(aq) + 3H_2O(l)$$

You will then titrate the iodine against aqueous sodium thiosulfate using starch indicator.

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

You will use your results to calculate the concentration of the sodium thiosulfate solution.

You are provided with:

- a sample of solid **D**, potassium iodate(V), KIO_3, in a stoppered weighing bottle
- solution **E**, aqueous sodium thiosulfate, $Na_2S_2O_3$
- aqueous potassium iodide, KI
- dilute sulfuric acid
- starch solution
- apparatus to carry out the exercise.

Procedure

1. Weigh the weighing bottle labelled **D**. Record the mass, to at least 0.01 g, in **Table 1**.

2. Transfer solid **D** to a 250 cm^3 beaker. Reweigh the stoppered weighing bottle, recording its mass in **Table 1**.

3. Add about 150 cm^3 of distilled water to the beaker. Stir the mixture in the beaker with a glass rod until solid **D** has dissolved.

4. Using a funnel, transfer the solution of **D** into a 250 cm^3 volumetric flask. Rinse the beaker and glass rod with distilled water and add to the volumetric flask. Make the solution in the volumetric flask exactly up to the mark with distilled water. **Stopper the flask, and then shake and invert the flask a number of times to thoroughly mix its contents.**

5. Rinse out and then fill the burette with solution **E**.

6. Rinse out a pipette, fitted with a safety filler, with the solution of **D**. Use the pipette to transfer 25.0 cm^3 of the solution to a 250 cm^3 conical flask.

7. Using a measuring cylinder, add 20 cm^3 of dilute sulfuric acid to the conical flask. Using a different measuring cylinder, add 10 cm^3 of aqueous potassium iodide. Swirl the conical flask to mix the solutions, and then stand it on a white tile under the burette.

8. Titrate the solution in the conical flask with solution **E** until the brown colour has faded to a pale yellow. Now add about 12 drops of starch solution. Continue to titrate until the blue-black colour has disappeared. Record your burette readings and titre, to the nearest 0.05 cm^3, in **Table 2**.

9. Repeat the procedure until you obtain **two** titres that differ by no more than 0.20 cm^3. Record all your burette readings in **Table 2**.

Mass of stoppered weighing bottle + **D**	g
Mass of emptied stoppered weighing bottle	g
Mass of **D**	g

Table 1

(2)

Titration numbers	1	2	3	4	5
Burette reading (final) / cm^3					
Burette reading (initial) / cm^3					
Titre / cm^3					

Table 2

(2)

List the numbers of the titrations that you will use to calculate the mean titre.

(1)

.....

Calculate the mean titre.
Give the value to the nearest 0.05 cm^3 or to two decimal places.

(1)

..... cm^3

Accuracy (6)
Range (3)

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For each of (a) to (c), give your answer to 3 significant figures.
Show your working as fully as possible.

(a) Calculate the number of moles of potassium iodate(V), KIO_3, in 25.0 cm^3 of the solution of **D** you prepared.

[The molar mass of KIO_3 is 214 g mol^{-1}]

(1)

(b) Using your answer to (a), and information given earlier in the question, calculate the number of moles of sodium thiosulfate in the mean titre.

(1)

(c) Using your answer to (b), calculate the concentration of the sodium thiosulfate, in mol dm^{-3}.

(1)

(d) (i) State what colour would you see at the end point, if starch had not been added in step **8**.

(1)

.....

(ii) Explain the colour change that is seen at the end point when starch is used as the indicator.

(1)

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.....

.....

(Total for Question 2 = 20 marks)

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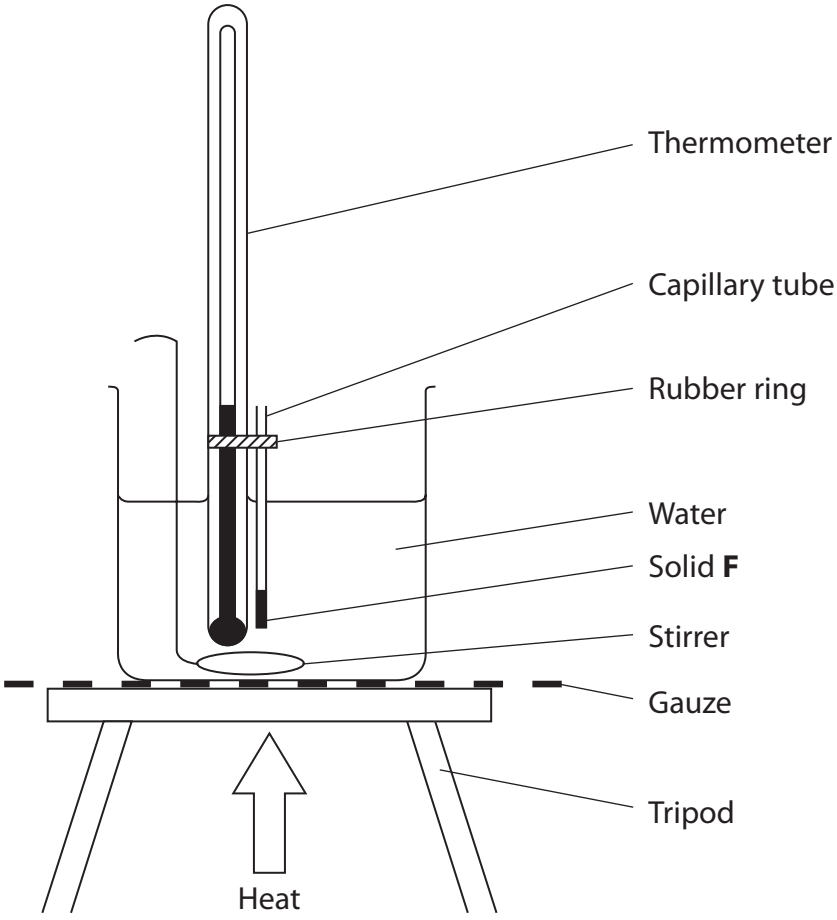
3 You are given:

- a sample of a solid **F**
  F has a melting temperature between 70 °C and 90 °C
- the apparatus to carry out the exercise.

In this exercise you will measure the melting temperature of solid **F**.
Using your value of its melting temperature, you will identify **F**.

Diagram



Procedure

1. Empty the sample of **F** onto a piece of filter paper.
2. Using a mortar and pestle, powder the sample.
3. Push the open end of the capillary tube onto the powdered **F** until about 1 cm of solid has entered the tube. Tap the tube until the solid falls to the bottom of the tube.
4. Attach the capillary tube to a thermometer using a rubber ring so that the solid is next to the bulb of the thermometer. Carefully clamp the thermometer into the water bath as shown in the diagram.
5. Heat the water bath with a small flame until the thermometer reads about 70 °C, stirring all the time. Continue to heat, but even more gently, so that the temperature rises slowly above 70 °C.

6. Observe the solid carefully as the temperature rises. In **Table 3** record the temperature at which **F** begins to melt.

Continue heating and record the temperature in **Table 3** at which **F** is completely melted.

From your temperatures in **Table 3**, estimate the melting temperature of **F**.

	Melting begins	Melting complete	Estimated melting temperature of **F**
Temperature / °C			

Table 3

(6)

(a) **Table 4** lists the melting temperatures of four compounds.
Based on your estimated melting temperature in **Table 3**, suggest which of the four compounds is **F**, by writing an **F** in the appropriate box.

(1)

Compound	Melting temperature / °C	**F**
Phenyl benzoate	71	
Phenylethanoic acid	76	
Ethanamide	82	
1,3-dinitrobenzene	90	

Table 4

(b) Suggest **three** reasons why the experiment may not correctly identify **F**.

(3)

.....

.....

.....

.....

.....

.....

(Total for Question 3 = 10 marks)

TOTAL FOR PAPER = 50 MARKS

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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

* 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

International Advanced Level in Chemistry (WCH07)

Supervisor's Values Form

Centre name:

.....

Centre number: .....

Examination series: .....

This form must be used to record supervisor's values for questions 2 and 3.
The completed form must be included with the examination scripts sent to Pearson Edexcel.
Without this information, the examiner will be unable to assess the candidate's results.

Question 2

Mass of stoppered weighing bottle + **D**	g
Mass of emptied stoppered weighing bottle	g
Mass of **D**	g

Table 1

Titration numbers	1	2	3	4	5
Burette reading (final) / cm^3					
Burette reading (initial) / cm^3					
Titre / cm^3					

Table 2

Question 3

	Melting begins	Melting complete	Estimated melting temperature of **F**
Temperature / °C			

Table 3

Please use the space below to comment on anything you wish to bring to the examiner's attention.

Signed (supervisor): .....

Date: .....

Mark Scheme (SAM)

Pearson Edexcel International Advanced Level in Chemistry

Unit 7: Chemistry Practical Examination

General marking guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- 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.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- 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 may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed-out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of Quality of Written Communication, are being assessed. The strands are as follows:
    i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
    ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
    iii) organise information clearly and coherently, using specialist vocabulary when appropriate.

Using the mark scheme

Examiners should NOT give credit for incorrect or inadequate answers, but allow 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 still be creditworthy.

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.
Bold	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)(transfer error)(consequential) 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. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Question number	Acceptable answers	Reject	Mark
1(a)(i)	**Observation** Lilac/purple **(1)** **Inference** K^+ **(1)** Allow other formula as transferred error (TE) on recorded flame colour, e.g. yellow flame **(0)** Na^+ **(1)**	K/potassium/ potassium ion	**2**

Question number	Acceptable answers	Reject	Mark
1(a)(ii)	**Observation** Cream precipitate **(1)** Allow off-white, pale yellow **Inference** AgBr **(1)** IGNORE state symbol Allow other formula as TE cq on recorded ppte colour, e.g. yellow ppte **(0)** AgI **(1)** white ppte **(0)** AgCl **(1)**	White/yellow	**2**

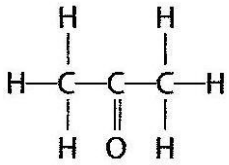
Question number	Acceptable answers	Reject	Mark
1(a)(iii)	**Observations** Effervescence/bubbling/frothing/ steamy fumes/white fumes/misty fumes (Allow gas instead of fumes) **(1)** Brown/orange (vapour/gas) **(1)** **Inference** KBr **(1)** IGNORE state symbol Allow other formula as TE on inferences in (a)(i) and (a)(ii)	White smoke	**3**

Question number	Answer	Reject	Mark
1(b)(i)	**Observations** Green precipitate **(1)** Brown precipitate **(1)** **Inference** Redox/oxidation **(1)**		3

Question number	Answer	Reject	Mark
1(b)(ii)	**Observation** White precipitate **(1)** **Inference** $FeSO_4$ **(1)**		2

Question number	Acceptable answers	Reject	Mark
1(c)(i)	**Observation** Yellow/orange/red **(1)** Precipitate **(1)** **Inference** Carbonyl **(1)** Allow aldehyde or ketone (both needed)	 Just C=O Aldehyde or ketone on their own	3

Question number	Acceptable answers	Reject	Mark
1(c)(ii)	**Observation** (Pale) yellow/cream **and** precipitate IGNORE reference to antiseptic smell **(1)** **Inference** $CH_3C{=}O$/methyl carbonyl **(1)**		2

Question number	Answer	Reject	Mark
1(c)(iii)	Displayed formula of propanone **(1)**  One peak so only one proton environment **(1)** Only C1 to C4 carbonyl with all protons equivalent **(1)**	Structural formula and skeletal formula	**3**

(Total for Question 1 = 20 marks)

Question number	Answer	Mark
2 Table 1	All masses recorded **(1)** To at least 2 dp and subtraction correct **(1)**	**2**

Question number	Answer	Mark
2 Table 2	All initial and final volumes recorded to 2 dp where the 2nd dp is either 0 or 5 (allow one slip) **(1)** Subtractions correct **(1)** Allow loss of 2nd dp in titre if zero	**2**

Question number	Answer	Mark
2 Choice of titres	Chooses two or more concordant titres (within 0.10 cm^3 or 0.20 cm^3 etc.) to calculate mean	**1**

Question number	Answer	Mark
2 Mean titre	Correct averaging of chosen titres to 2 dp or to nearest 0.05 cm^3	**1**

Question number	Answer	Mark
2 Accuracy	Calculate the expected titre for the candidate $= \frac{\text{candidate's mass } \mathbf{D} \times \text{teacher's titre}}{\text{teacher's mass } \mathbf{D}}$ Calculate the difference (d) between the expected titre and the mean titre If the candidate has averaged inappropriate titres or has made a subtraction error in Table 2 then the examiner must calculate a corrected mean before awarding accuracy marks	**6**

d /cm^3	±0.20	±0.40	±0.60	±0.80	±1.00	±2.00
mark	**6**	**5**	**4**	**3**	**2**	**1**

Question number	Answer	Mark
2 Range	Range (r) is difference between outermost titres used by candidate (or examiner) to calculate mean r/cm^3 ±0.20 ±0.30 ±0.50 Mark **3** **2** **1**	**3**

Question number	Answer	Mark
2(a)	In (a) to (c) award the mark for a correct answer to 3 significant figures following any clearly set out method Only penalise SF once in (a) to (c) Moles of KIO_3 = $\frac{\text{Mass of } \mathbf{D}}{214} \times \frac{25.0}{250}$	**1**

Question number	Answer	Mark
2(b)	Moles $Na_2S_2O_3$ = answer to (a) × 6	**1**

Question number	Answer	Mark
2(c)	Concentration of $Na_2S_2O_3$ = $\frac{\text{answer to (b)} \times 1000}{\text{mean titre}}$	**1**

Question number	Answer	Mark
2(d)(i)	(Yellow to) colourless	**1**

Question number	Answer	Mark
2(d)(ii)	When iodine is used up blue-black disappears	**1**

(Total for Question 2 = 20 marks)

Question number	Answer	Mark
3 **Table 3**	Temperature at which melting begins between 75 °C and 81 °C **(1)** Temperature at which melting complete between 82 °C and 85 °C **(1)** Calculate difference (d) between data book value 82 °C or centre value, and the candidate's value of the melting temperature d/°C ±1.0 ±2.0 ±4.0 ±6.0 Mark **4** **3** **2** **1**	**6**

Question number	Answer	Mark
3(a)	**F** is ethanamide TE on estimated melting temperature in **Table 3**	**1**

Question number	Answer	Mark
3(b)	May be other compounds with same melting temperature **(1)** **F** may be impure (so melting temperature inaccurate) **(1)** Difficult to judge when melting begins/ends **(1)** Allow other sensible reasons	**3**

(Total for Question 3 = 10 marks)

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Pearson Education Limited. Registered in England and Wales No. 872828
Registered Office: 80 Strand, London WC2R 0RL
VAT Reg No GB 278 537121

ISBN 978-1-4469-3151-6