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

Friday 25 May 2018 – Morning
Time: 1 hour 30 minutes

Paper Reference
WCH02/01

Candidates must have: Scientific calculator

Total Marks

Instructions

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

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.
- Check your answers if you have time at the end.
- Show all your working in calculations and give units where appropriate.

Turn over ▶

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5/4/5/2/1/

P 5 1 6 0 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 species does **not** have a trigonal pyramidal structure?

☒ **A** $AlCl_3$

☒ **B** NH_3

☒ **C** H_3O^+

☒ **D** PCl_3

(Total for Question 1 = 1 mark)

2 Which molecule contains three atoms in a straight line?

☒ **A** BF_3

☒ **B** CH_4

☒ **C** H_2O

☒ **D** SF_6

(Total for Question 2 = 1 mark)

3 Which compound has the greatest ionic character?

☒ **A** Sodium bromide

☒ **B** Sodium chloride

☒ **C** Sodium fluoride

☒ **D** Sodium iodide

(Total for Question 3 = 1 mark)

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

4 Which best represents the position of the bonding pair of electrons and the dipole of hydrogen chloride?

	Position of bonding electrons	Dipole
☒ **A**	H—:Cl	$\overset{\delta+}{H}—\overset{\delta-}{Cl}$
☒ **B**	H:—Cl	$\overset{\delta+}{H}—\overset{\delta-}{Cl}$
☒ **C**	H—:Cl	$\overset{\delta-}{H}—\overset{\delta+}{Cl}$
☒ **D**	H:—Cl	$\overset{\delta-}{H}—\overset{\delta+}{Cl}$

(Total for Question 4 = 1 mark)

5 When a system is at equilibrium, it is **always** true that

☒ **A** molecules of reactants stop changing into molecules of products.

☒ **B** the concentrations of reactants and products are equal.

☒ **C** the concentrations of reactants and products are constant.

☒ **D** the activation energies of the forward and reverse reactions are equal.

(Total for Question 5 = 1 mark)

6 An oxidising agent

☒ **A** gains electrons and is oxidised.

☒ **B** loses electrons and is oxidised.

☒ **C** gains electrons and is reduced.

☒ **D** loses electrons and is reduced.

(Total for Question 6 = 1 mark)

7 Which trend is correct for the Group 2 metals as the atomic number **increases**?

☒ **A** The atomic radius decreases.

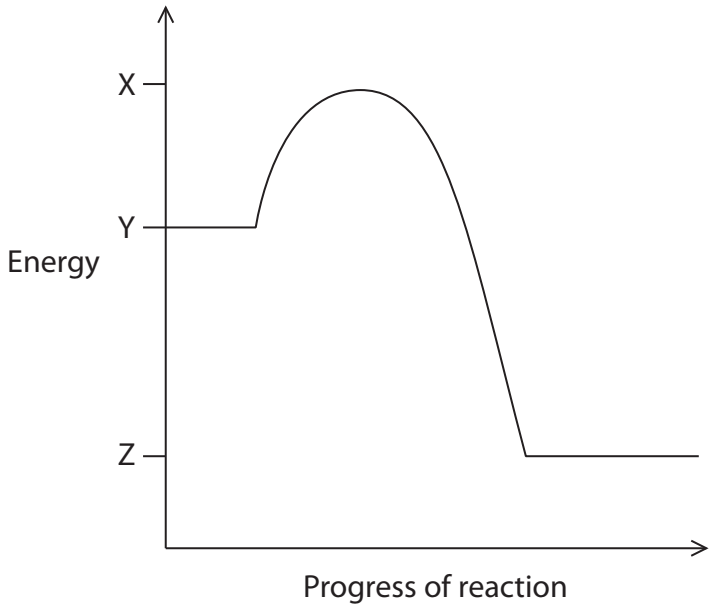
☒ **B** The electronegativity increases.

☒ **C** The first ionisation energy decreases.

☒ **D** The thermal stability of their nitrates decreases.

(Total for Question 7 = 1 mark)

8 Consider the following reaction profile.



The activation energy of the forward reaction has a value of

☒ **A** X minus Y.

☒ **B** Y minus X.

☒ **C** Y minus Z.

☒ **D** Z minus Y.

(Total for Question 8 = 1 mark)

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

9 A white solid gives a lilac flame colour. The solid reacts with water, forming a strongly alkaline solution.

The solid could be

☒ **A** calcium oxide.

☒ **B** potassium oxide.

☒ **C** calcium chloride.

☒ **D** potassium chloride.

(Total for Question 9 = 1 mark)

10 Which of the following is an isomer of 2,2-dimethylpentan-1-ol?

☒ **A** $CH_3CH_2CH_2CH(CH_3)CH_2OH$

☒ **B** $(CH_3)_3CCH(CH_3)CH_2OH$

☒ **C** $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2OH$

☒ **D** $(CH_3)_2CHC(CH_3)_2CH_2CH_2OH$

(Total for Question 10 = 1 mark)

11 Which of the following hydroxides is the most soluble in water?

☒ **A** Barium hydroxide

☒ **B** Calcium hydroxide

☒ **C** Magnesium hydroxide

☒ **D** Strontium hydroxide

(Total for Question 11 = 1 mark)

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

12 Under suitable conditions, a mixture of carbon monoxide and hydrogen reacts to form water and a mixture of hydrocarbons.

$$n\text{CO} + (2n + 1)\text{H}_2 \rightarrow n\text{H}_2\text{O} + \text{hydrocarbons}$$

What is the general formula for the hydrocarbons produced?

☒ **A** C_nH_{2n-2}

☒ **B** C_nH_{2n}

☒ **C** C_nH_{2n+1}

☒ **D** C_nH_{2n+2}

(Total for Question 12 = 1 mark)

13 A protective layer of ozone, O_3, exists in the atmosphere. This protection mainly arises from ozone's ability to

☒ **A** absorb ultraviolet radiation.

☒ **B** reflect ultraviolet radiation.

☒ **C** break down chlorofluorocarbons.

☒ **D** reflect chlorofluorocarbons.

(Total for Question 13 = 1 mark)

14 Consider the following equation.

$$ClO_3^-(aq) + 6H^+(aq) + ne^- \rightarrow Cl^-(aq) + 3H_2O(l)$$

What value of *n* is required to balance the above equation?

☒ **A** 4

☒ **B** 5

☒ **C** 6

☒ **D** 7

(Total for Question 14 = 1 mark)

15 The conversion of butanoic acid into butan-1-ol is an example of

☒ **A** elimination.

☒ **B** substitution.

☒ **C** oxidation.

☒ **D** reduction.

(Total for Question 15 = 1 mark)

16 Compound **X** forms compound **Y** in the reaction shown in the equation.
No knowledge of this reaction is required.

$$\underset{\text{compound } \mathbf{X}}{C_7H_6O_3} + C_2H_4O_2 \rightarrow \underset{\text{compound } \mathbf{Y}}{C_9H_8O_4} + H_2O$$

What mass of compound **X** is required to produce 8.4 g of compound **Y**, if the yield is 40%?

[Molar masses / g mol^{-1}: $C_7H_6O_3 = 138$ $C_9H_8O_4 = 180$]

☒ **A** 3.4 g

☒ **B** 6.4 g

☒ **C** 16.1 g

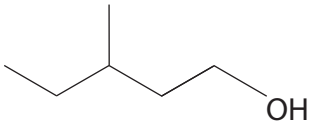
☒ **D** 21.0 g

(Total for Question 16 = 1 mark)

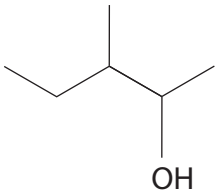
Use this space for any rough working. Anything you write in this space will gain no credit.

17 Which alcohol can be oxidised by acidified potassium dichromate(VI) to form a ketone?

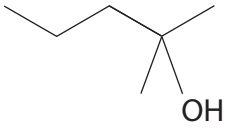
☒ **A**



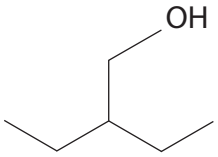
☒ **B**



☒ **C**



☒ **D**



(Total for Question 17 = 1 mark)

18 An experiment requires 500 cm^3 of a solution with a **nitrate** ion concentration of 0.100 mol dm^{-3}.

This is prepared by diluting a 0.250 mol dm^{-3} calcium nitrate solution, $Ca(NO_3)_2(aq)$, with water.

What volume of this calcium nitrate solution will be needed?

☒ **A** 50 cm^3

☒ **B** 100 cm^3

☒ **C** 200 cm^3

☒ **D** 400 cm^3

(Total for Question 18 = 1 mark)

19 A mass of 1.60 g of an anhydrous metal sulfate was dissolved in water.

Addition of excess barium chloride solution resulted in the precipitation of 2.33 g of barium sulfate.

[Molar mass of $BaSO_4$ = 233 g mol^{-1}]

The original substance could be

☒ **A** calcium sulfate.

☒ **B** copper(II) sulfate.

☒ **C** magnesium sulfate.

☒ **D** sodium sulfate.

(Total for Question 19 = 1 mark)

20 The concentration of a solution of iodine can be determined by titration with a solution of sodium thiosulfate.

The sulfur-containing **product** of this reaction is

☒ **A** $Na_2S_2O_3$

☒ **B** $Na_2S_4O_6$

☒ **C** Na_2SO_3

☒ **D** $Na_2S_2O_8$

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

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

21 This question is about the chemistry of Group 7.

(a) Silver nitrate solution is added to an aqueous solution containing two different halide ions. A mixture of two different precipitates, **A** and **B**, is formed.
When concentrated ammonia solution is then added, precipitate **A** remains and precipitate **B** dissolves completely.

(i) Identify, by name or formula, the halide ion in **A**.

(1)

.....

(ii) Identify, by name or formula, **one** possible halide ion in **B**.

(1)

.....

(iii) Write an **ionic** equation, including state symbols, for the formation of precipitate **A**.

(2)

(b) Concentrated sulfuric acid is added to solid potassium chloride.

A reaction occurs in which steamy fumes are formed.

(i) Give the **formula** of the steamy fumes.

(1)

.....

(ii) Write an equation for this reaction. State symbols are not required.

(1)

(c) When concentrated sulfuric acid is added to solid potassium bromide, a redox reaction occurs. A mixture of products is formed, including sulfur dioxide as the **only** reduction product.

(i) Give the oxidation number of sulfur in

(2)

sulfuric acid.....

sulfur dioxide.....

(ii) Complete the **ionic** equation for this redox reaction.

State symbols are not required.

(2)

H_2SO_4 + ...H^+ + ...Br^- → + + ...H_2O

(d) When concentrated sulfuric acid is added to solid potassium iodide, a redox reaction occurs producing two reduction products other than sulfur dioxide.

Identify these two **reduction** products. In each case, give an observation that indicates the presence of the product.

(4)

First reduction product.....

Observation.....

Second reduction product.....

Observation.....

(Total for Question 21 = 14 marks)

22 Hydromagnesite is a mineral containing magnesium carbonate.

A student crushed some hydromagnesite and added a sample of mass 0.936 g to excess dilute hydrochloric acid.

(a) Give a reason why the mineral was crushed before being added to the acid.

(1)

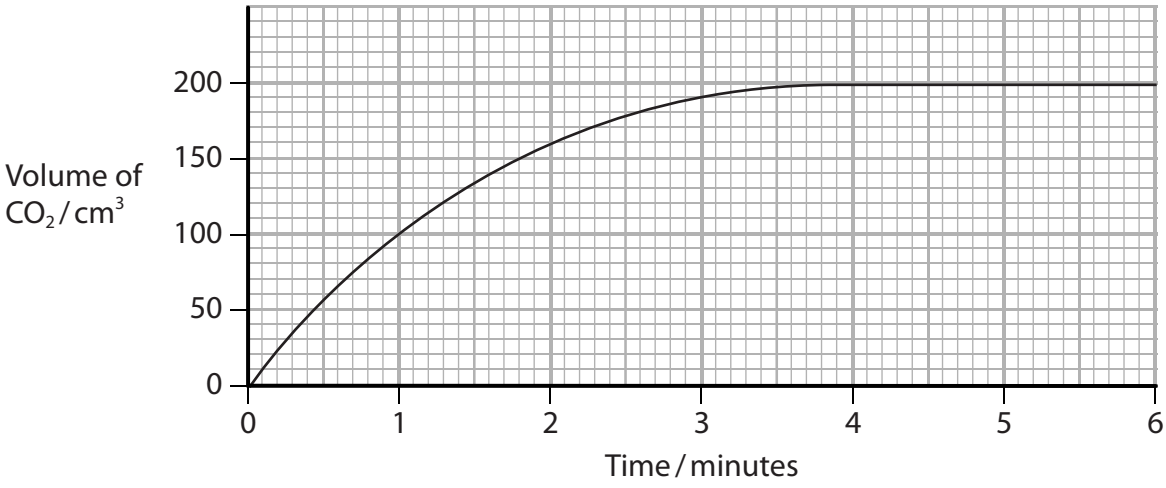
.....

.....

(b) Write the equation for the reaction between magnesium carbonate and dilute hydrochloric acid. Include state symbols in your equation.

(2)

(c) The gas formed in the reaction was collected in a gas syringe.
The volume of gas was measured at regular intervals for 6 minutes.
A graph of the student's results is shown.



Describe the changes in the rate of reaction during the experiment.
Explain these changes in terms of collisions.

(3)

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(d) (i) Use information from the graph to calculate the number of moles of magnesium carbonate that reacted with the dilute hydrochloric acid.

[The molar volume of a gas = 24 000 cm^3 mol^{-1} under the conditions of the experiment.]

(2)

(ii) Calculate the mass of magnesium carbonate that reacted and hence the percentage by mass of magnesium carbonate in the hydromagnesite.

(2)

Mass of magnesium carbonate = ... g

Percentage by mass of magnesium carbonate = ... %

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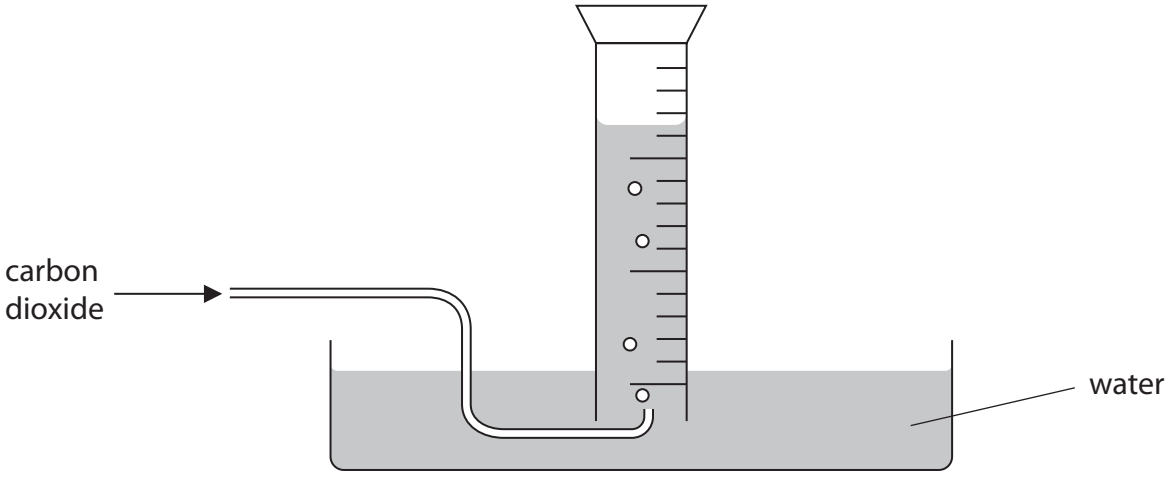
(e) Another student decided to carry out a similar experiment. This student did not have a gas syringe and therefore collected the carbon dioxide over water in an inverted measuring cylinder, as shown in the diagram.



Explain the effect that collecting the carbon dioxide over water would have on the volume of gas collected and hence on the percentage of magnesium carbonate in hydromagnesite. Assume that the gas syringe and the measuring cylinder can be read to the same accuracy.

(2)

(Total for Question 22 = 12 marks)

23 This question is about chemical equilibrium.

(a) The gases nitrogen dioxide, NO_2 and dinitrogen tetroxide, N_2O_4 form an equilibrium mixture at room temperature.

$$\underset{\text{brown}}{2NO_2(g)} \rightleftharpoons \underset{\text{colourless}}{N_2O_4(g)} \qquad \Delta H = -58\,\text{kJ mol}^{-1}$$

*(i) A gas syringe containing an equilibrium mixture of these gases is compressed by pushing in the plunger and then allowed to stand with the plunger in the new position.

Predict how the **appearance** of the equilibrium mixture would change during this procedure.

Justify your answer.

(3)

(ii) State and explain the effect of an increase in temperature on this equilibrium.

(1)

*(b) When potassium dichromate(VI), $K_2Cr_2O_7$, is dissolved in water, an equilibrium is set up. The position of the equilibrium is well to the left and the solution is an orange colour.

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

Aqueous alkali is added and the solution turns a yellow colour.

Explain this observation.

(2)

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(Total for Question 23 = 6 marks)

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24 This question is about the reactions and properties of 1-bromobutane.

(a) 1-bromobutane can be converted into butan-1-ol in a one-step reaction.

(i) State the reagents and conditions required for this reaction.

(2)

Reagents: ..... Conditions: .....

(ii) Draw the mechanism for this reaction.

Include curly arrows, and relevant dipoles and lone pairs.

(4)

(b) Explain why 1-bromobutane is much less soluble in water than in butan-1-ol.
A detailed description of the forces involved is not required.

(3)

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(Total for Question 24 = 9 marks)

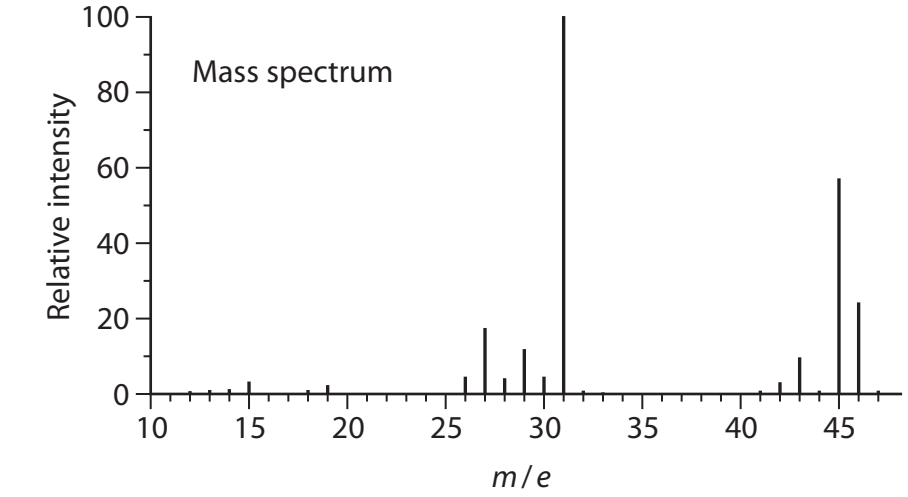
TOTAL FOR SECTION B = 41 MARKS

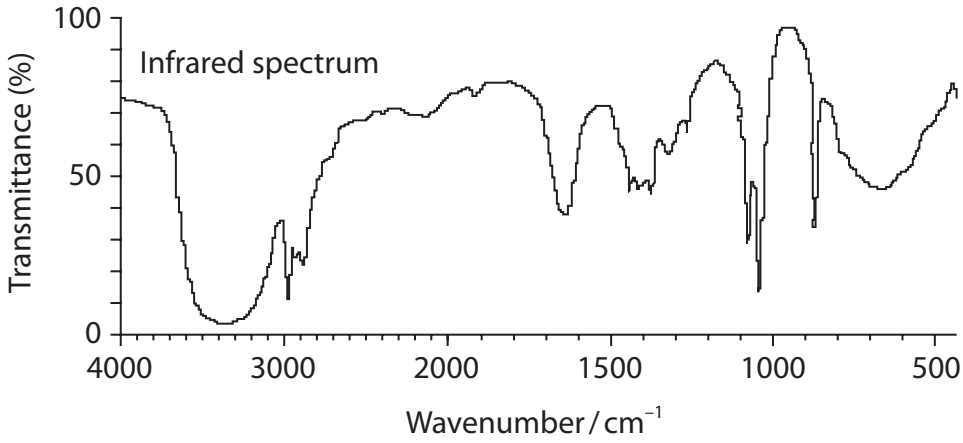
SECTION C

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

25 Organic compounds can be analysed using physical methods such as mass spectrometry and infrared spectroscopy, chemical tests and quantitative measurements.

The mass spectrum and infrared spectrum of ethanol, C_2H_5OH, are shown.





Some infrared data are given in the table below.

Bond stretching vibration	Wavenumber / cm^{-1}
C—H, alkane	2962–2853
C—H, alkene	3100–3010
O—H (weak), carboxylic acids	3300–2500
O—H (broad), alcohols	3750–3200

(a) (i) State what can be deduced about ethanol from the presence of the peak at $m/e = 46$ in the mass spectrum.

(1)

(ii) Identify the species responsible for the peak at $m/e = 31$ in the mass spectrum of ethanol, and state how it is formed.

(2)

(iii) Identify **one** feature of the infrared spectrum which confirms the functional group in ethanol.

Include the appropriate wavenumber range in your answer.

(1)

(b) Chemical tests are often used to identify functional groups in organic molecules.

*(i) Explain the meaning of the term **functional group**.

(2)

(ii) The reaction of sodium metal with ethanol can be used to confirm the presence of the functional group in ethanol.

Give the equation for the reaction of sodium with ethanol. State symbols are not required.

(2)

(c) A carboxylic acid **E** was investigated by quantitative and qualitative methods.
E was known to have one of the following structures:

Structure **1** $CH_3CH_2CH{=}CHCOOH$ Molar mass = 100 g mol^{-1}

Structure **2** $HOOCCH_2CH_2COOH$ Molar mass = 118 g mol^{-1}

A sample of 1.20 g of **E** was burned in excess oxygen.
A mass of 1.79 g of carbon dioxide was formed.

(i) Calculate the mass of carbon present in the sample of **E**.

(2)

Mass of carbon = ... g

(ii) The mass of hydrogen present in the sample is 0.0610 g.

Deduce the mass of oxygen in the sample.

(1)

Mass of oxygen = ... g

(iii) Use the information from parts (c)(i) and (c)(ii) to calculate the empirical formula of **E**.

(2)

(iv) Deduce the identity of **E**. Give a reason for your answer by referring to the information at the start of (c) and your answer to (c)(iii).

(1)

.....

.....

(v) Describe a **qualitative** chemical test that would distinguish between Structure **1** and Structure **2**. State the expected results.

(2)

Test: .....

Results for Structure **1**: .....

Results for Structure **2**: .....

(vi) Draw the **displayed** formula of a compound that can be oxidised to form Structure **2**.

(1)

*(vii) Explain why a molecule of Structure **1** can show geometric isomerism.

(2)

(Total for Question 25 = 19 marks)

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

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