

P 8 1 8 0 5 A

SECTION A

Answer ALL the questions in this section in the Answer Book.

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

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

1 Which compound contains chlorine with an oxidation number of (III)?

- A NaClO_2
- B $\text{Ca}(\text{ClO})_2$
- C $\text{Mg}(\text{ClO}_3)_2$
- D HClO_4

(Total for Question 1 = 1 mark)

2 Group 1 nitrates decompose on heating.

(a) Which is the correct observation for the decomposition of lithium nitrate?

(1)

- A brown fumes
- B brown solid
- C colourless choking gas
- D misty fumes

2 (b) Which is the correct observation for the gas that is evolved during the decomposition of sodium nitrate?

(1)

- A produces a squeaky pop with a lighted splint
- B relights a glowing splint
- C turns damp universal indicator paper blue
- D turns damp universal indicator paper red

(Total for Question 2 = 2 marks)

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

3 Barium nitrate is used in fireworks.

What colour would be seen from barium nitrate in an ignited firework?

- A yellow
- B red
- C lilac
- D green

(Total for Question 3 = 1 mark)

4 A compound of iodine and oxygen contains 79.9% iodine by mass.

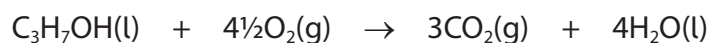
What is a possible formula of the compound?

[Data: A_r O = 16.0 I = 126.9]

- A I_2O
- B I_2O_4
- C I_2O_5
- D I_2O_6

(Total for Question 4 = 1 mark)

5 Propan-1-ol undergoes complete combustion in oxygen, as shown in the equation.



What is the **change** in the volume of gas, in dm^3 , when 0.050 mol of propan-1-ol fully combusts at room temperature and pressure (r.t.p.)?

[Data: One mole of any gas occupies $24.0 dm^3$ at r.t.p.]

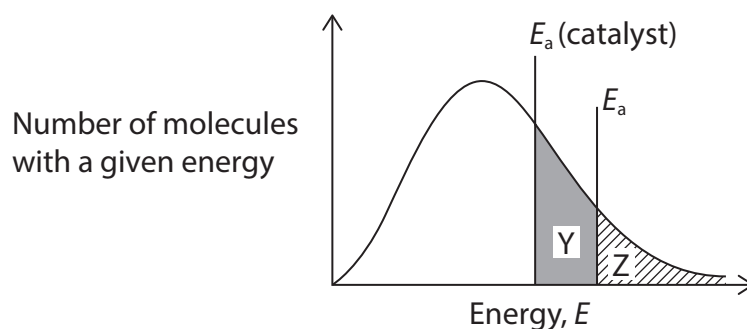
- A 1.2
- B 1.8
- C 3.6
- D 5.4

(Total for Question 5 = 1 mark)

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

- 6 The Maxwell–Boltzmann distribution of molecular energies for gaseous molecules illustrates the effect of changing reaction conditions.

(a) The diagram shows the values of E_a with and without a catalyst.



Which area indicates the **increase** in the number of molecules that can react in the presence of a catalyst?

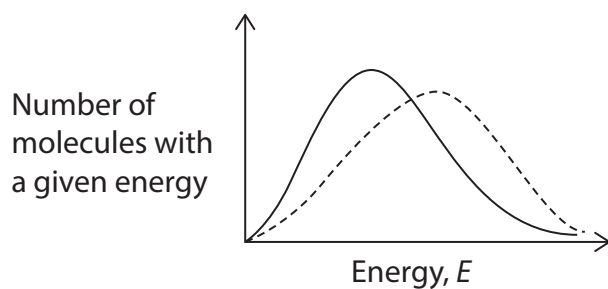
(1)

- A Y
- B $Y - Z$
- C $Y + Z$
- D Z

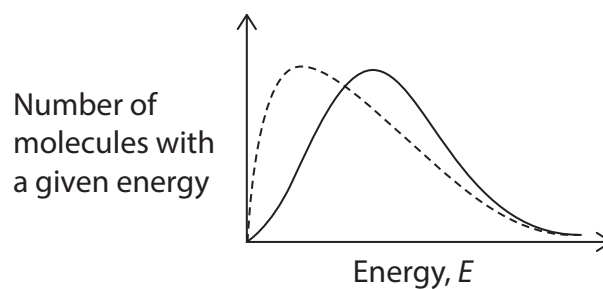
- 6 (b) Which diagram shows the new curve when the number of molecules is halved?

(1)

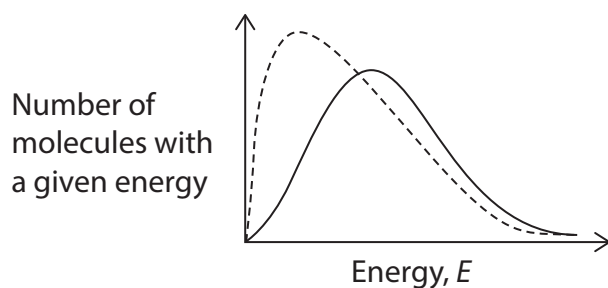
Old curve —————
New curve - - - - -



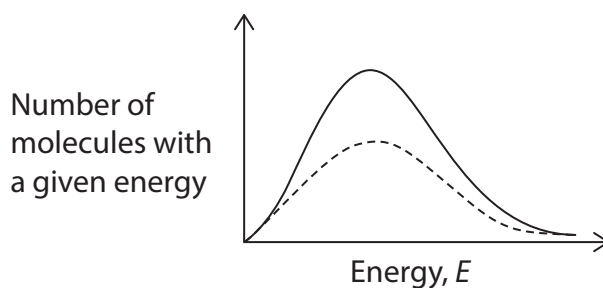
A



B



C



D

(Total for Question 6 = 2 marks)

- 7 Reforming of natural gas is one industrial process used to produce hydrogen. The equation for this process is shown.



- (a) What is the percentage atom economy by mass for the production of hydrogen in this process?

(1)

- A 5.9%
- B 8.8%
- C 17.6%
- D 75.0%

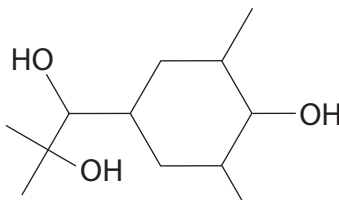
- 7 (b) Which change will increase the yield of hydrogen?

(1)

- A adding more carbon monoxide gas
- B increase in pressure
- C increase in temperature
- D use of a catalyst

(Total for Question 7 = 2 marks)

- 8 The skeletal formula of an alcohol is shown.

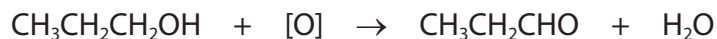


What is the classification of the alcohol groups in this molecule?

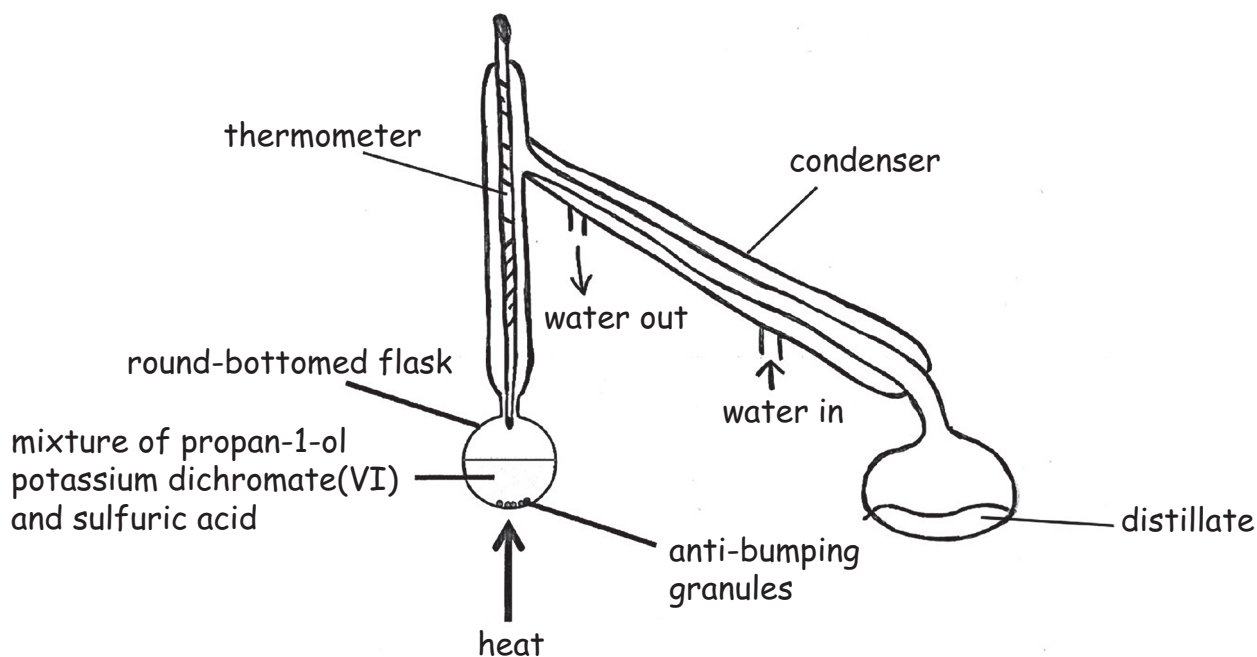
- A all secondary
- B all tertiary
- C one primary, one secondary and one tertiary
- D two secondary and one tertiary

(Total for Question 8 = 1 mark)

- 9 Propan-1-ol oxidises to form propanal when distilled with acidified potassium dichromate(VI). The equation for this oxidation is shown.



- (a) A student drawing of the distillation apparatus is shown.



Which is **not** a mistake in the diagram of distillation?

(1)

- A thermometer bulb positioned too far down
 - B still head sealed around the thermometer
 - C closed entry and exit to the condenser so water cannot flow
 - D no vent for gases to escape after the condenser
- 9 (b) Which absorption in the infrared spectrum confirms the formation of propanal?

Use your Data Booklet.

(1)

- A O–H stretching at 3637 cm^{-1}
- B C–H stretching at 2960 cm^{-1}
- C C–H stretching at 2825 cm^{-1}
- D C=O stretching at 1710 cm^{-1}

(Total for Question 9 = 2 marks)

10 This question is about compounds with the molecular formula C_4H_9Br .

(a) Which reagent(s) is/are used to form 1-bromobutane from butan-1-ol?

(1)

- A** $Br_2(aq)$ only
- B** $KBr(aq)$ only
- C** $Br_2(aq)$ and $KBr(s)$
- D** 50% $H_2SO_4(aq)$ and $KBr(s)$

10 (b) The structural isomers 1-bromobutane and 2-bromobutane can be distinguished by their fragmentation patterns using mass spectrometry.

Which m/z ion peak would be expected **only** in the spectrum of 1-bromobutane?

(1)

- A** 15
- B** 29
- C** 43
- D** 57

(Total for Question 10 = 2 marks)

11 Red phosphorus and iodine react with ethanol to produce iodoethane.

The relevant equations are shown.



In an experiment using excess iodine and ethanol, the percentage yield is 45.0%, giving 0.0750 mol of iodoethane.

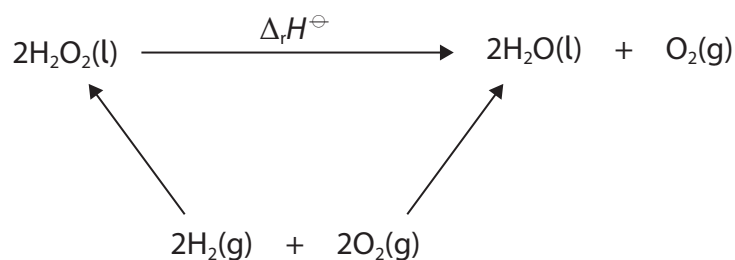
What mass of red phosphorus is used?

[Data: A_r P = 31.0]

- A** 5.17 g
- B** 2.33 g
- C** 1.72 g
- D** 0.775 g

(Total for Question 11 = 1 mark)

- 12** Hydrogen peroxide decomposes into water and oxygen.
An enthalpy cycle for this decomposition reaction is shown.



What is the enthalpy change, $\Delta_r H^\ominus$, in kJ mol^{-1} , for this reaction?

[Data: $\Delta_f H^\ominus [\text{H}_2\text{O}_2(\text{l})] = -188 \text{ kJ mol}^{-1}$ $\Delta_f H^\ominus [\text{H}_2\text{O}(\text{l})] = -286 \text{ kJ mol}^{-1}$]

- A** -384
- B** -196
- C** -98
- D** +90

(Total for Question 12 = 1 mark)

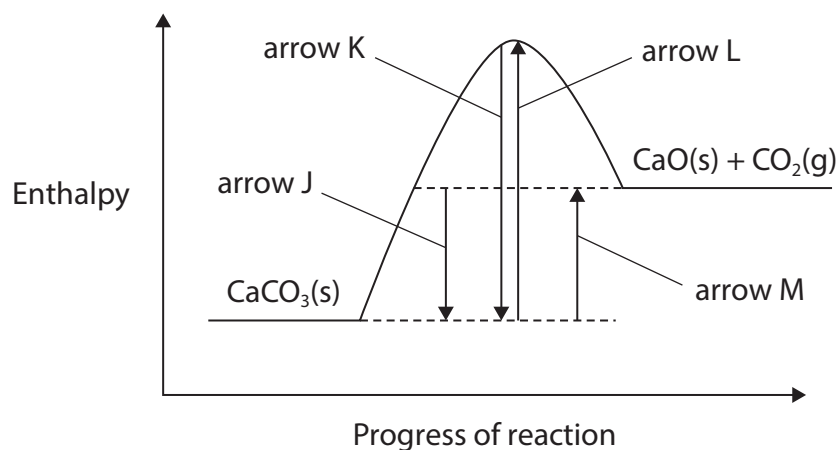
- 13** Which equation represents the standard enthalpy change of atomisation for ozone, O_3 ?

- A** $\text{O}_3(\text{g}) \rightarrow 3\text{O}(\text{g})$
- B** $\text{O}_3(\text{g}) \rightarrow \text{O}_2(\text{g}) + \text{O}(\text{g})$
- C** $\text{O}_3(\text{g}) \rightarrow 1\frac{1}{2}\text{O}_2(\text{g})$
- D** $\frac{1}{3}\text{O}_3(\text{g}) \rightarrow \text{O}(\text{g})$

(Total for Question 13 = 1 mark)

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

- 14** The reaction profile diagram for the thermal decomposition of calcium carbonate is shown.



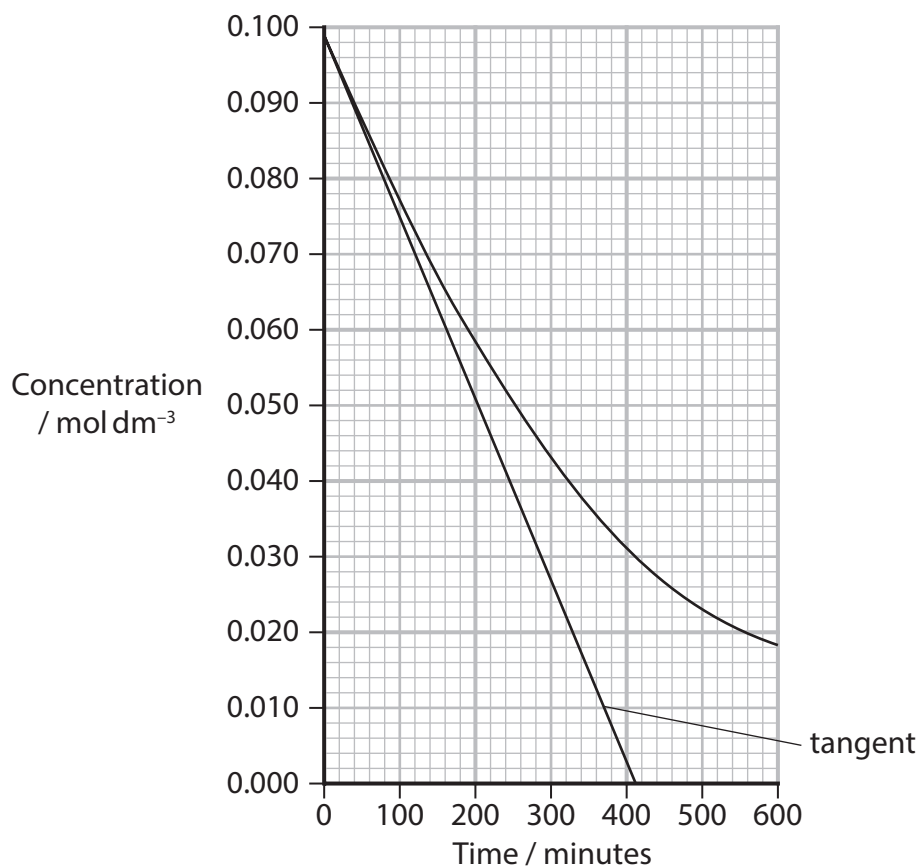
Which arrow indicates the activation energy for the decomposition reaction?

- A** arrow J
- B** arrow K
- C** arrow L
- D** arrow M

(Total for Question 14 = 1 mark)

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

- 15 The graph for the hydrolysis of 2-bromo-2-methylpropane over time is shown.
A tangent is drawn for the initial rate.



What is the initial rate of reaction in **mol dm⁻³ s⁻¹**?

- A 4.0×10^{-6}
- B 2.4×10^{-4}
- C 4.0×10^3
- D 2.4×10^5

(Total for Question 15 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

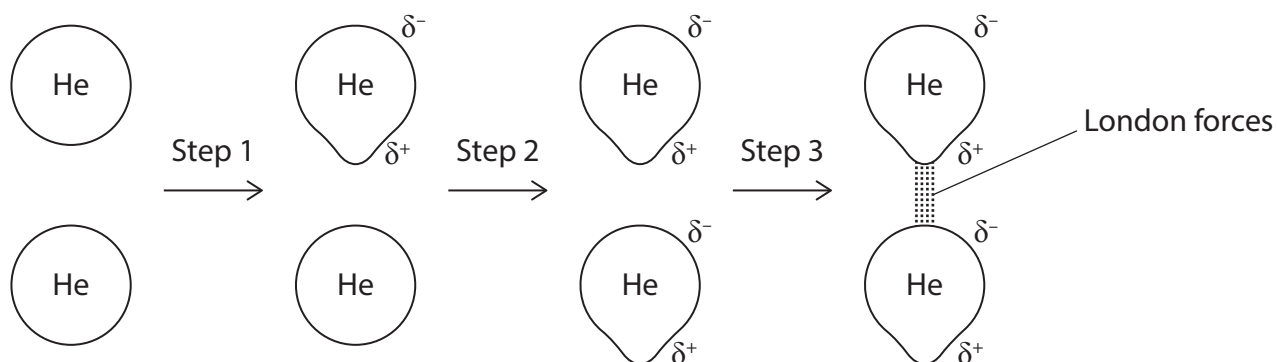
Answer ALL the questions. Write your answers in the spaces provided in the Answer Book.

16 The physical properties of Group 0 elements (the noble gases) and Group 6 hydrides provide evidence for intermolecular forces.

(a) State why Group 0 elements provide evidence only for London forces and not for other intermolecular forces.

(2)

16 (b) Rapid small changes in the electron density and interactions between two helium atoms over time can be represented by the steps in the diagram.



Describe how this diagram illustrates how London forces arise.

(4)

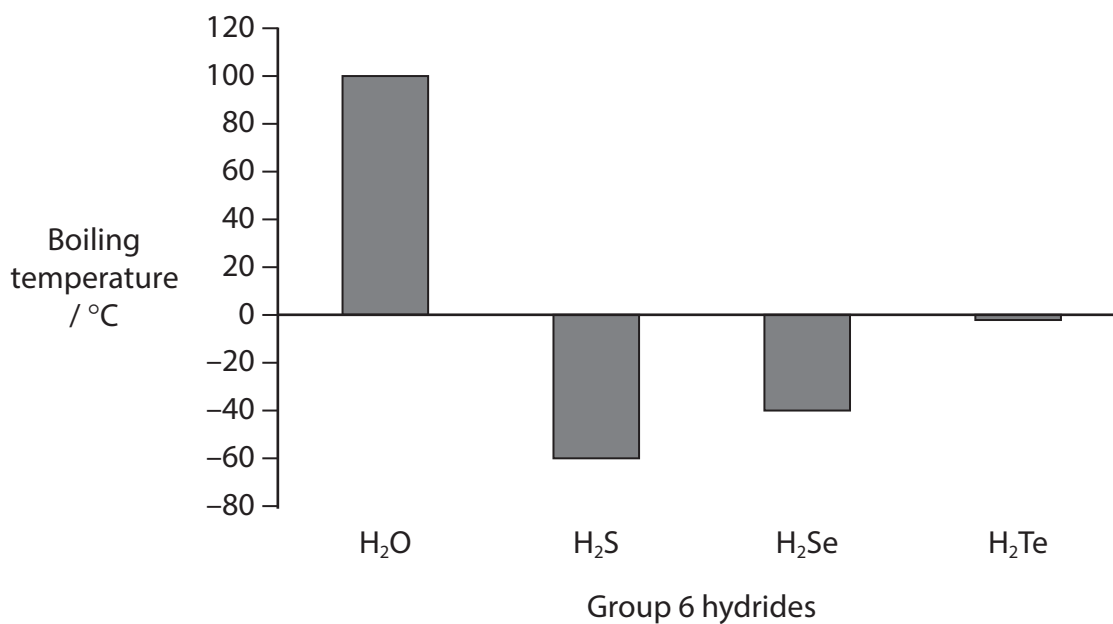
16 (c) Data for the first five elements in Group 0 are shown in the table.

Group 0	Helium	Neon	Argon	Krypton	Xenon
Number of electrons	2	10	18	36	54
Boiling temperature / K	4	27	87	121	166

Explain how the trend in boiling temperature provides evidence for London forces.

(2)

16 (d) A graph of the boiling temperatures for the first four Group 6 hydrides is shown.



Discuss how the graph of boiling temperatures for these Group 6 hydrides provides evidence for hydrogen bonding.

Include a comparison of the strength of these bonds to London forces.

(4)

(Total for Question 16 = 12 marks)

17 This is a question about Group 7 elements and their compounds.

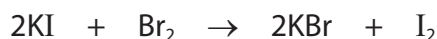
(a) Iodine can react with sodium hydroxide solution, as shown.



Explain, with reference to oxidation numbers, why this reaction is an example of disproportionation.

(2)

17 (b) Bromine is more reactive than iodine, which can be demonstrated by the displacement reaction shown.



Describe the advantage of adding an organic solvent, such as cyclohexane, when carrying out this demonstration with aqueous solutions.

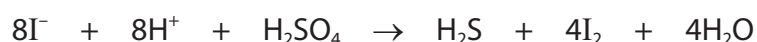
(2)

17 (c) Group 1 halides react with concentrated sulfuric acid to produce the corresponding hydrogen halides. These halides differ in reducing ability.

17 (c) (i) Give a chemical test, and the positive result, to confirm the presence of a gaseous hydrogen halide.

(1)

17 (c) (ii) Iodide ions react with concentrated sulfuric acid to produce hydrogen sulfide, as shown.



Deduce the oxidation and reduction half-equations for this reaction. State symbols are not required.

(2)

(Total for Question 17 = 7 marks)

***18** This question is about halogenoalkanes.

Some data about each carbon–halogen bond are given in the table.

Bond	Mean bond enthalpy / kJ mol^{-1}	Electronegativity difference between the bonded atoms
C—F	+467	1.5
C—Cl	+346	0.5
C—Br	+290	0.3
C—I	+228	0.0

Explain how the values in the table provide evidence for the trend in the rates of hydrolysis of halogenoalkanes.

Include the meaning of each of the terms ‘mean bond enthalpy’ and ‘electronegativity’.

(6)

(Total for Question 18 = 6 marks)

19 This question is about the solubility of Group 2 hydroxides.

(a) A student determined the solubility of strontium hydroxide, $\text{Sr}(\text{OH})_2$, in water.

The student added 3.00 g of anhydrous strontium hydroxide to deionised water and stirred until no more solid dissolved.

The final volume of solution was 250.0 cm^3 .

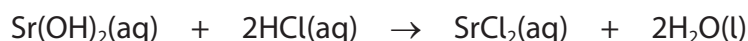
The excess solid was filtered off from the saturated solution, dried and the mass was 0.276 g.

19 (a) (i) Calculate the solubility of strontium hydroxide in mol dm^{-3} .

(3)

19 (a) (ii) The concentration of the saturated solution of strontium hydroxide can be determined by titration with $0.155 \text{ mol dm}^{-3}$ hydrochloric acid.

The equation for the reaction is shown.



Calculate the expected titre, in cm^3 , using your answer from (a)(i), for a 25.0 cm^3 portion of the saturated solution of strontium hydroxide.

Your answer should be given as a value that can be read from a burette.

(3)

19 (b) A 1.00 dm^3 saturated solution of calcium hydroxide is heated from 50°C to 70°C .

Calculate the change in the number of **ions** in 1.00 dm^3 in this solution.

[Data: Solubility of $\text{Ca}(\text{OH})_2$ at $50^\circ\text{C} = 1.47 \text{ g dm}^{-3}$ and at $70^\circ\text{C} = 1.15 \text{ g dm}^{-3}$]

(3)

19 (c) 'Milk of magnesia' is a suspension of magnesium hydroxide in water. The liquid appears white because of the floating solid particles of magnesium hydroxide. Milk of magnesia is used as an antacid to treat excessive stomach acid and to treat constipation.

Milk of magnesia can be obtained from seawater by precipitation of the magnesium ions. A sample of seawater contains 1262 ppm by mass of magnesium ions.

19 (c) (i) Write an **ionic** equation to show the reaction of milk of magnesia with stomach acid.
Include state symbols in your answer.

(1)

19 (c) (ii) To treat constipation, the maximum recommended dose of milk of magnesia is nine 5 cm^3 teaspoons at bedtime.
Each teaspoon contains $4.00 \times 10^2 \text{ mg}$ of magnesium hydroxide.

Calculate the volume of seawater, in **dm^3** , needed to make the maximum adult bedtime dose of milk of magnesia.

[Data: Assume the density of seawater is 1.03 g cm^{-3}]

(4)

(Total for Question 19 = 14 marks)

TOTAL FOR SECTION B = 39 MARKS

SECTION C

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

20

Nucleophiles

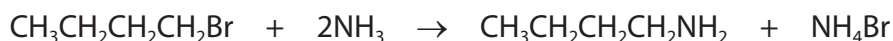
Nucleophiles are species with a lone pair of electrons that is donated to form a covalent bond. They can be molecules or anions.

Some nucleophiles are more reactive than others. For example, iodide ions are stronger nucleophiles than chloride ions.

Ambident nucleophiles are anionic species that can attack from two possible sites and which can give two different products.

Nucleophilic substitution is a very useful reaction mechanism for chemists because it is a way of introducing a new functional group into a molecule.

- (a) Butylamine can be produced from the reaction between 1-bromobutane and excess ammonia in ethanolic solution when heated in a sealed tube.



- 20 (a) (i) Complete the nucleophilic substitution mechanism for this reaction in the Answer Book by adding curly arrows, and relevant lone pairs and dipoles.

(4)

- 20 (a) (ii) Give a reason why the tube needs to be sealed.

(1)

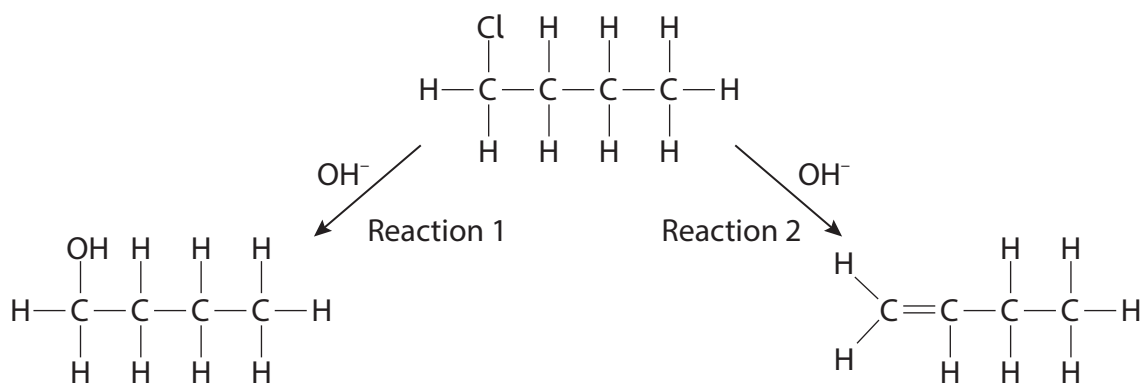
- 20 (a) (iii) Use of aqueous ammonia instead of ethanolic ammonia can result in a different product.

Suggest the identity of the product and why it forms.

(2)

- 20 (b) The cyanide ion, CN^- , in potassium cyanide is a nucleophile that reacts with halogenoalkanes to produce nitriles.
- 20 (b) (i) Give the **name** of the organic product from the reaction of the cyanide ion with 1-bromobutane. (1)
- 20 (b) (ii) State why the introduction of the nitrile functional group using the cyanide ion is useful to chemists. (1)
- 20 (b)(iii) Complete the dot-and-cross diagram in the Answer Book for the cyanide ion. Use crosses (x) for the carbon electrons, dots (•) for the nitrogen electrons and an asterisk (*) for the electron gained from potassium. (1)
- 20 (b)(iv) The cyanide ion is an *ambident* nucleophile.
- Suggest the reason for this, and the structure of the **different** product formed from the reaction of 1-bromobutane with cyanide ions. (2)

20 (c) The hydroxide ion can react with 1-chlorobutane in two different ways, as shown.

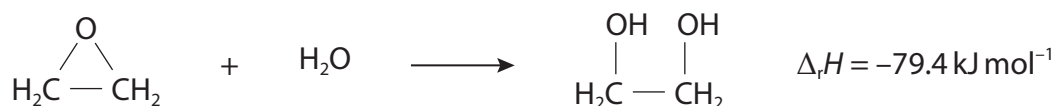


Explain whether the hydroxide ion is acting as a nucleophile in one or both of the reactions shown.
Justify your answer.

(4)

20 (d) Epoxyethane reacts with weak nucleophiles such as water and alcohols.

20 (d) (i) The overall equation for the hydrolysis of epoxyethane is shown.



After checking the bond enthalpies involved, one student was surprised that this reaction was exothermic. The teacher asked the student to look more closely at the structure of epoxyethane.

Suggest explanations for:

- why the student did not expect the reaction to be exothermic
- which part of the epoxyethane structure the teacher was asking the student to look at.

(4)

20 (d) (ii) The reaction of epoxyethane with ethanol gives a product with the molecular formula $C_4H_{10}O_2$.

Suggest the **skeletal** formula of this product.

(1)

(Total for Question 20 = 21 marks)

TOTAL FOR SECTION C = 21 MARKS
TOTAL FOR PAPER = 80 MARKS

Please check the examination details below before entering your candidate information

Candidate surname		Other names	
Centre Number		Candidate Number	

Pearson Edexcel International Advanced Level

Monday 11 May 2026

Afternoon (Time: 1 hour 30 minutes)

Paper reference **WCH12/01A**

Chemistry

International Advanced Subsidiary/Advanced Level

UNIT 2: Energetics, Group Chemistry, Halogenoalkanes and Alcohols

Answer Book

You must have:
Question Paper, Scientific calculator, Data Booklet, ruler

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.*
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).

Information

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

Advice

- Read each question carefully before you start to answer it.
- Show all your working in calculations and include units where appropriate.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ►

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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

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(Total for Question 1 = 1 mark)

2 (a)

(1)

- ☐ A
- ☐ B
- ☐ C
- ☐ D

2 (b)

(1)

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(Total for Question 2 = 2 marks)

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DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



3☐ **A**☐ **B**☐ **C**☐ **D****(Total for Question 3 = 1 mark)****4**☐ **A**☐ **B**☐ **C**☐ **D****(Total for Question 4 = 1 mark)****5**☐ **A**☐ **B**☐ **C**☐ **D****(Total for Question 5 = 1 mark)**

P 8 7 9 2 6 A 0 3 2 4

6 (a)

(1)

- ☐ A
☐ B
☐ C
☐ D

6 (b)

(1)

- ☐ A
☐ B
☐ C
☐ D

(Total for Question 6 = 2 marks)

7 (a)

(1)

- ☐ A
☐ B
☐ C
☐ D

7 (b)

(1)

- ☐ A
☐ B
☐ C
☐ D

(Total for Question 7 = 2 marks)



8☐ **A**☐ **B**☐ **C**☐ **D****(Total for Question 8 = 1 mark)****9 (a)****(1)**☐ **A**☐ **B**☐ **C**☐ **D****9 (b)****(1)**☐ **A**☐ **B**☐ **C**☐ **D****(Total for Question 9 = 2 marks)**

10 (a)

(1)

- ☐ A
☐ B
☐ C
☐ D

10 (b)

(1)

- ☐ A
☐ B
☐ C
☐ D

(Total for Question 10 = 2 marks)

11

- ☐ A
☐ B
☐ C
☐ D

(Total for Question 11 = 1 mark)

12

- ☐ A
☐ B
☐ C
☐ D

(Total for Question 12 = 1 mark)



13

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(Total for Question 13 = 1 mark)

14

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(Total for Question 14 = 1 mark)

15

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(Total for Question 15 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS



SECTION B

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

16 (a)

(2)

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.....

.....

16 (b)

(4)

Step 1

.....

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Step 2

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Step 3

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DO NOT WRITE IN THIS AREA



16 (c)

(2)

16 (d)

(4)

(Total for Question 16 = 12 marks)



17 (a)

(2)

17 (b)

(2)

17 (c) (i)

(1)

17 (c) (ii)

(2)

Oxidation half-equation

Reduction half-equation

(Total for Question 17 = 7 marks)



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*18

(6)

Handwriting practice area with 20 horizontal dotted lines.



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(Total for Question 18 = 6 marks)



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19 (a) (i)

(3)

19 (a) (ii)

(3)



19 (b)

(3)

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19 (c) (i) (1)

19 (c) (ii) (4)

(Total for Question 19 = 14 marks)

TOTAL FOR SECTION B = 39 MARKS

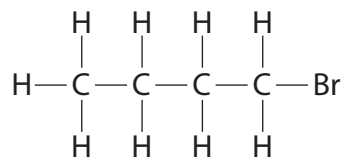


SECTION C

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

20 (a) (i)

(4)



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DO NOT WRITE IN THIS AREA



20 (a) (ii)

(1)

20 (a) (iii)

(2)

20 (b) (i)

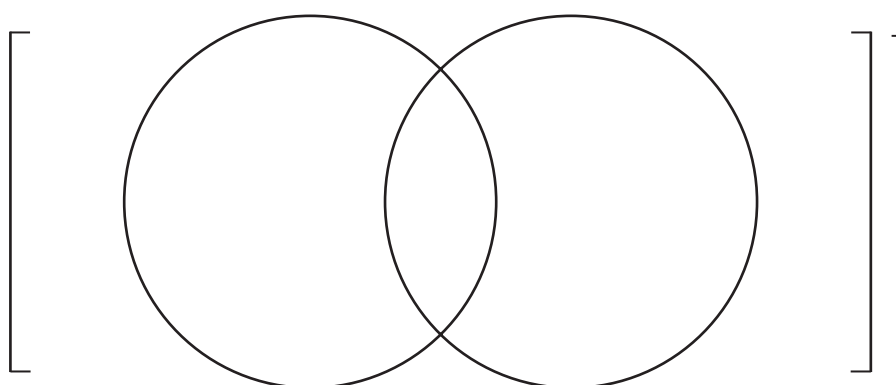
(1)

20 (b) (ii)

(1)

20 (b) (iii)

(1)



20 (b)(iv)

(2)

Reason

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Product

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20 (c)

(4)

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20 (d) (i)

(4)

[illegible]

20 (d) (ii)

(1)

(Total for Question 20 = 21 marks)

TOTAL FOR SECTION C = 21 MARKS
TOTAL FOR PAPER = 80 MARKS



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24

P 8 7 9 2 6 A 0 2 4 2 4

* Lanthanide series

* Actinide 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
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	mercurium	101	254	No	nobelium	102	257	Lr	lawrencium	103

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