www.dynamicpapers.com

Please check the examination details below before entering your candidate information

| Candidate surname | Other names |
|---|---|
| | |

**Pearson Edexcel**
**International Advanced Level**

Centre Number | Candidate Number

**Time** 1 hour 30 minutes

**Paper reference** **WCH12/01**

# Chemistry

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

**You must have:**
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.*
- Show all your working in calculations and include units where appropriate.

## Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- In 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.
- Try to answer every question.
- Check your answers if you have time at the end.
- Good luck with your examination.

*Turn over* ▶

P64624A

©2021 Pearson Education Ltd.

1/1/1/1/1/1/1/1

P 6 4 6 2 4 A 0 1 2 8

Pearson

www.dynamicpapers.com

## SECTION A

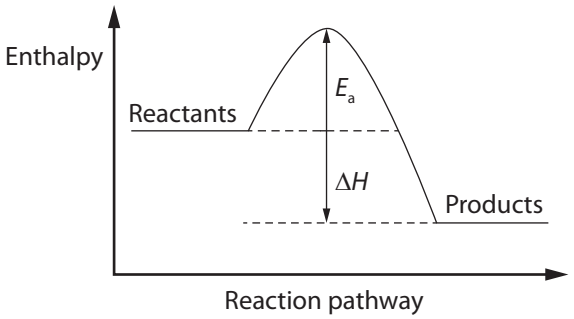
**Answer ALL questions. Write your answers in the spaces provided.**

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

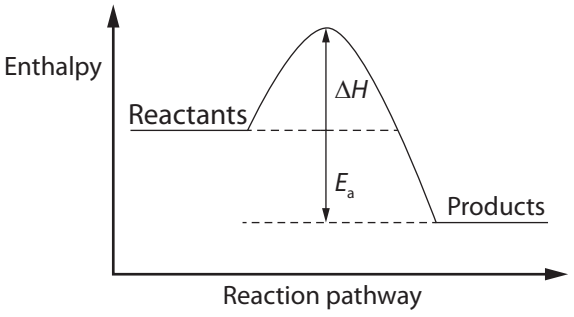
**For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.**

**1** Which is the correctly labelled reaction profile for an exothermic reaction?

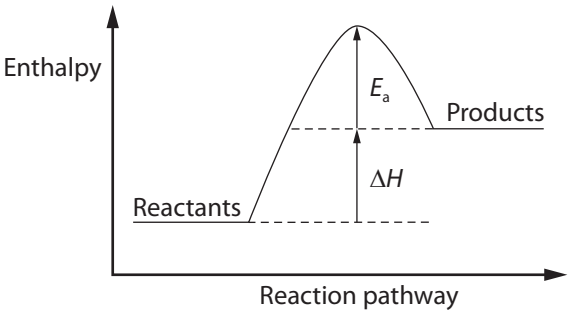
☒ **A**



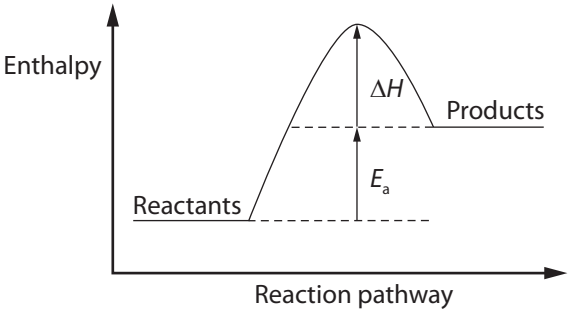

☒ **B**




☒ **C**




☒ **D**




**(Total for Question 1 = 1 mark)**

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

www.dynamicpapers.com

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

**2** The equation for a reaction is

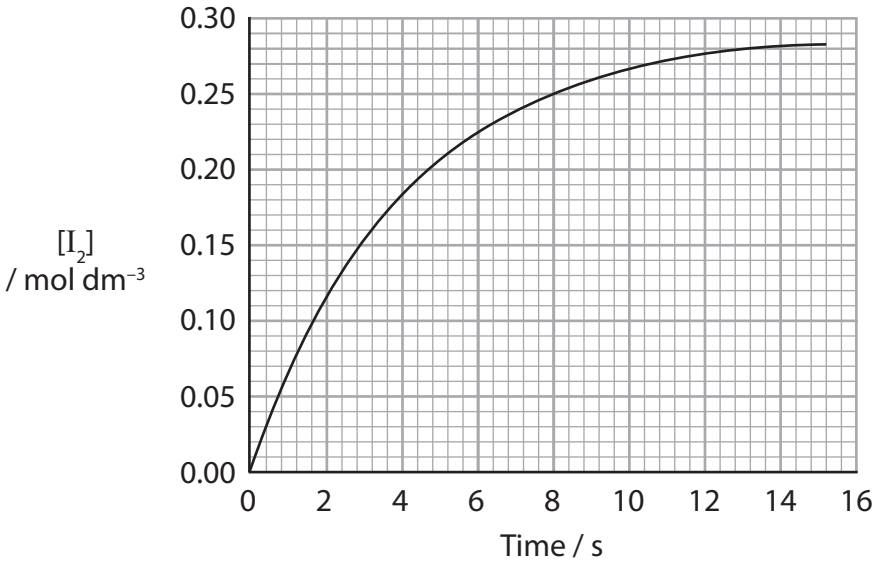
$$2C(s) + O_2(g) \rightarrow 2CO(g)$$

Which is the correct symbol for the enthalpy change for this reaction?

- ☒ **A** $\Delta_{at}H$
- ☒ **B** $\Delta_c H$
- ☒ **C** $\Delta_f H$
- ☒ **D** $\Delta_r H$

**(Total for Question 2 = 1 mark)**

**3** The graph shows how the concentration of iodine changes with time in a reaction.




What is the value for the rate of reaction, in mol $dm^{-3}$ $s^{-1}$, at 8 seconds?

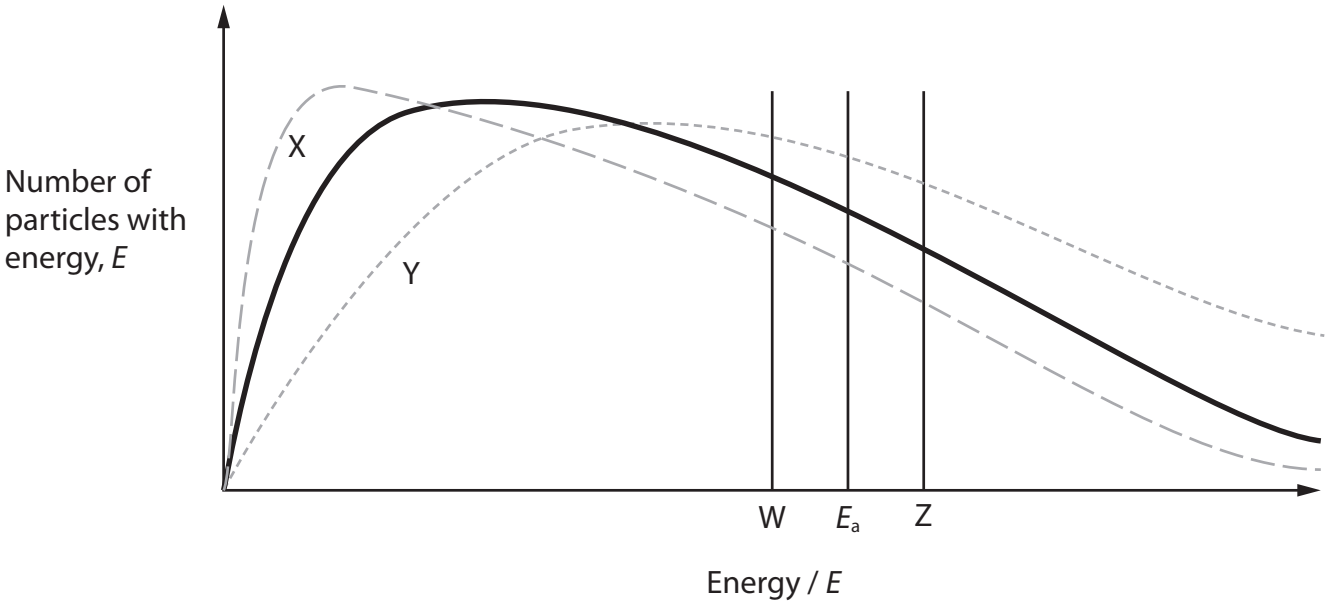
- ☒ **A** 0.01
- ☒ **B** 0.02
- ☒ **C** 0.03
- ☒ **D** 0.25

**(Total for Question 3 = 1 mark)**

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

www.dynamicpapers.com

**4** The solid line on the graph below shows the Maxwell–Boltzmann distribution for an uncatalysed reaction. $E_a$ is the activation energy of this reaction.




Which row shows the correct Maxwell–Boltzmann curve and activation energy for the reaction at a higher temperature with a catalyst?

| | Maxwell-Boltzmann curve | Activation energy |
|---|---|---|
| ☒ **A** | X | W |
| ☒ **B** | X | Z |
| ☒ **C** | Y | W |
| ☒ **D** | Y | Z |

**(Total for Question 4 = 1 mark)**

**5** What is the oxidation number of chromium in $Na_2Cr_2O_7$?

☒ **A** +1

☒ **B** +2

☒ **C** +3

☒ **D** +6

**(Total for Question 5 = 1 mark)**

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

www.dynamicpapers.com

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

**6** In an oxide of nitrogen, the oxidation number of nitrogen is +4.

Which is the formula of the oxide?

☒ **A** $N_2O$

☒ **B** $N_2O_3$

☒ **C** $N_2O_4$

☒ **D** $N_2O_5$

**(Total for Question 6 = 1 mark)**

**7** Hydrogen peroxide, $H_2O_2$, breaks down into water and oxygen.

In terms of oxidation and reduction, how do hydrogen and oxygen change in this reaction?

| | Hydrogen | Oxygen |
|---|---|---|
| ☒ **A** | oxidised | reduced |
| ☒ **B** | oxidised and reduced | unchanged |
| ☒ **C** | reduced | oxidised |
| ☒ **D** | unchanged | oxidised and reduced |

**(Total for Question 7 = 1 mark)**

**8** Several factors may affect ionisation energies:

I) the number of protons increases

II) the outer electron is further from the nucleus

III) the amount of shielding increases

IV) the number of unpaired outer electrons increases

Which factors explain the **decrease** in ionisation energy as Group 1 is descended?

☒ **A** I and II

☒ **B** II and III

☒ **C** III and IV

☒ **D** I, II, III and IV

**(Total for Question 8 = 1 mark)**

www.dynamicpapers.com

**9** Separate samples of some halogenoalkanes were dissolved in ethanol and a few drops of silver nitrate solution added. The faster the reaction of the halogenoalkane, the quicker a precipitate forms.

(a) Which of these halogenoalkanes reacts the **fastest**?

**(1)**

☒ **A** $CH_3CHICH_3$

☒ **B** $CH_3CHBrCH_3$

☒ **C** $CH_3CHClCH_3$

☒ **D** $CH_3CHFCH_3$

(b) Which of these halogenoalkanes reacts the **fastest**?

**(1)**

☒ **A** $CH_3CHBrCH(CH_3)CH_3$

☒ **B** $CH_3CH_2CBr(CH_3)CH_3$

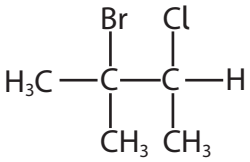
☒ **C** $CH_3CH(CH_2Br)CH_2CH_3$

☒ **D** $CH_3CH_2CH_2CH_2CH_2Br$

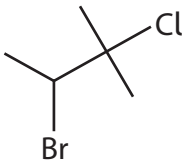
**(Total for Question 9 = 2 marks)**

**10** What is the structure of 2-bromo-3-chloro-2-methylbutane?

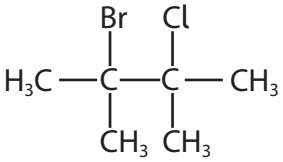
☒ **A**



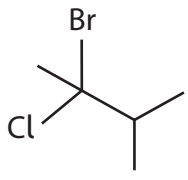

☒ **B**




☒ **C**




☒ **D**



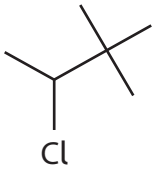

**(Total for Question 10 = 1 mark)**

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

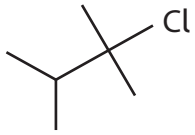
www.dynamicpapers.com

**11** Which structure represents a primary halogenoalkane?

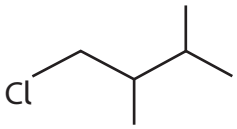
☒ **A**



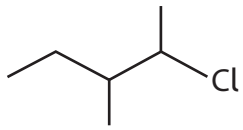

☒ **B**




☒ **C**




☒ **D**




**(Total for Question 11 = 1 mark)**

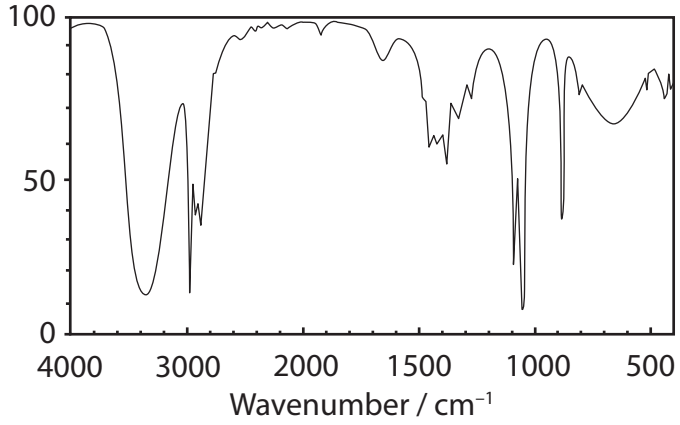
**Use this space for any rough working. Anything you write in this space will gain no credit.**

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

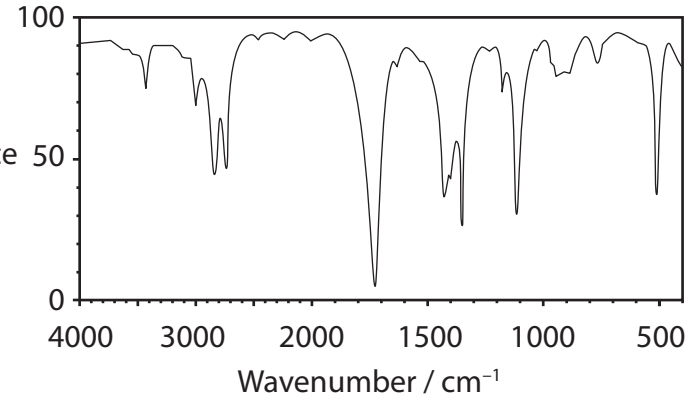
www.dynamicpapers.com

**12** Which could be the infrared spectrum of $CH_2=CHCH_2OH$?

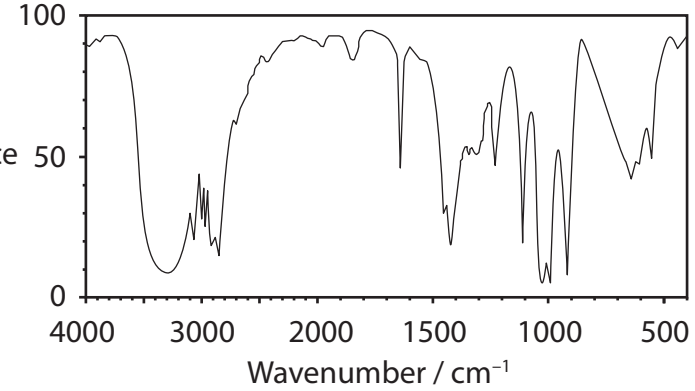
☒ **A**



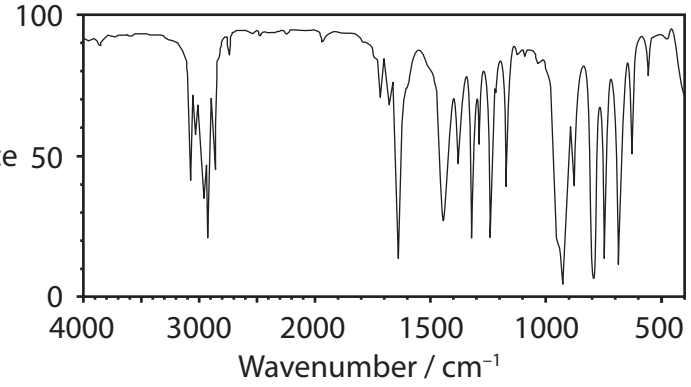

☒ **B**




☒ **C**




☒ **D**



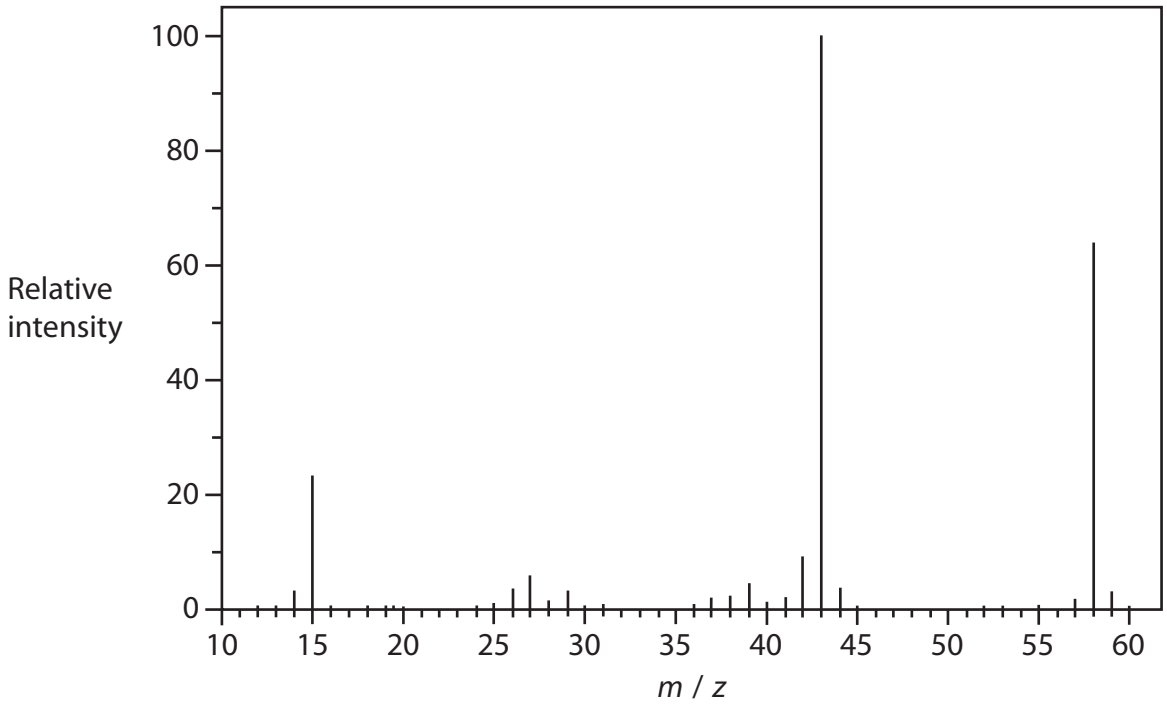

**(Total for Question 12 = 1 mark)**

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

www.dynamicpapers.com

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

**13** The mass spectrum of propanone is shown.




Which fragment is most likely to produce the peak at $m / z = 43$?

- ☒ **A** $CH_3CH_2CH_2^+$
- ☒ **B** $CH_3CO^+$
- ☒ **C** $CH_2CHO^+$
- ☒ **D** $CHCH_2O^+$

**(Total for Question 13 = 1 mark)**

**14** A 4.00 mol $dm^{-3}$ solution of an acid is used to prepare dilute solutions of the acid.

What volume of water is required to make up 150 $cm^3$ of 0.35 mol $dm^{-3}$ solution of the acid?

- ☒ **A** 13.1 $cm^3$
- ☒ **B** 52.5 $cm^3$
- ☒ **C** 97.5 $cm^3$
- ☒ **D** 136.9 $cm^3$

**(Total for Question 14 = 1 mark)**

www.dynamicpapers.com

**15** (a) A pellet of sodium hydroxide has a mass of 0.700 g.

Some pellets were dissolved to make 350 $cm^3$ of 0.25 mol $dm^{-3}$ solution.

[$M_r$ value: NaOH = 40]

How many pellets were dissolved?

**(1)**

- ☒ **A** 4
- ☒ **B** 5
- ☒ **C** 8
- ☒ **D** 125

(b) 25.0 $cm^3$ of the sodium hydroxide solution prepared in (a) was placed in a conical flask and titrated with sulfuric acid.

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

Calculate the number of moles of sulfuric acid that reacted.

**(1)**

- ☒ **A** 0.0031
- ☒ **B** 0.0063
- ☒ **C** 0.013
- ☒ **D** 0.044

(c) Phenolphthalein indicator was used for the titration in (b).

What was the colour change at the endpoint?

**(1)**

- ☒ **A** colourless → pink
- ☒ **B** pink → colourless
- ☒ **C** orange → yellow
- ☒ **D** yellow → orange

**(Total for Question 15 = 3 marks)**

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

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

www.dynamicpapers.com

**16** Which silver halides are soluble in **concentrated** aqueous ammonia?

- ☒ **A** AgBr and AgI
- ☒ **B** AgCl and AgI
- ☒ **C** AgCl and AgBr
- ☒ **D** AgCl only

**(Total for Question 16 = 1 mark)**

**17** What volume, in $dm^3$, of hydrogen gas will be produced when 3.00 g of lithium is reacted with water at room temperature and pressure (r.t.p.)?

$$2Li + 2H_2O \rightarrow 2LiOH + H_2$$

[Molar volume of gas at r.t.p. = 24.0 $dm^3\ mol^{-1}$]

- ☒ **A** 0.217
- ☒ **B** 0.435
- ☒ **C** 5.22
- ☒ **D** 10.4

**(Total for Question 17 = 1 mark)**

**TOTAL FOR SECTION A = 20 MARKS**

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

www.dynamicpapers.com

**SECTION B**

**Answer ALL questions.**

**Write your answers in the spaces provided.**

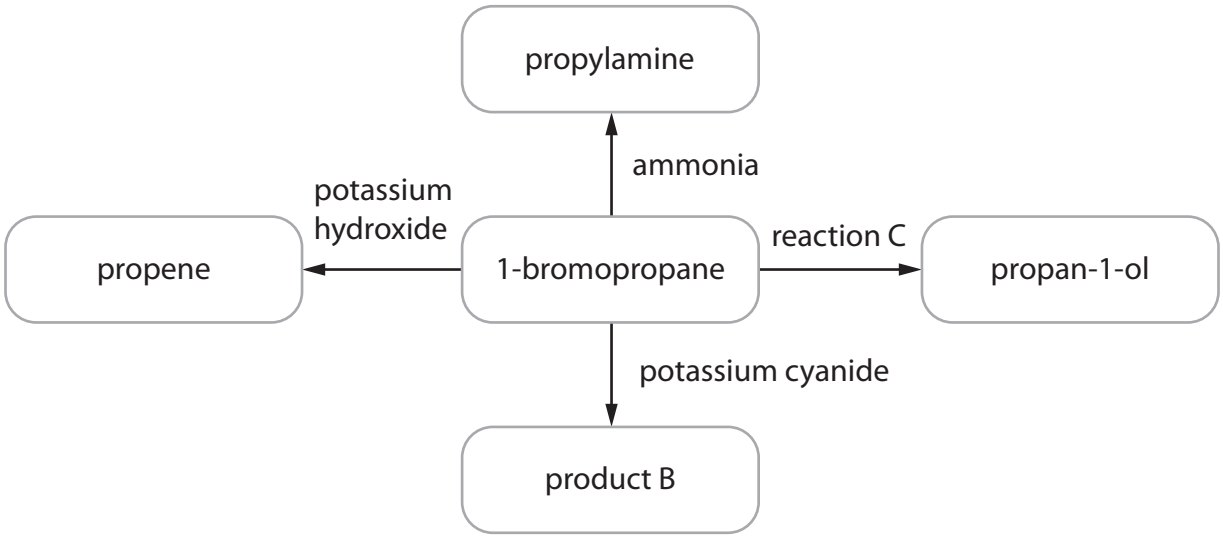
**18** 1-bromopropane is used for spot removal when 'dry cleaning' clothes.

(a) 1-bromopropane does not occur naturally but can be made from propan-1-ol.

Identify the reagent or reagents you would use to make 1-bromopropane from propan-1-ol.

**(1)**

(b) Some reactions of 1-bromopropane are shown.




(i) Give the conditions for the formation of propene.

**(1)**

(ii) Give the **molecular** formula of product B.

**(1)**

(iii) Name the type and mechanism of the reaction taking place in reaction C.

**(2)**

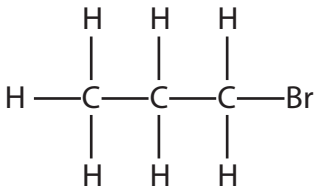
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

(iv) Complete the mechanism for the reaction that occurs between ammonia and 1-bromopropane to form propylamine, $CH_3CH_2CH_2NH_2$.

Include curly arrows, and relevant lone pairs and dipoles.

**(4)**



**(Total for Question 18 = 9 marks)**

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

www.dynamicpapers.com

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

**BLANK PAGE**

www.dynamicpapers.com

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

**19** Magnesium reacts with sulfuric acid in an exothermic reaction.

(a) Write an equation for the reaction.
Include state symbols in your answer.

**(2)**

(b) A student carried out an experiment to determine the enthalpy change of the reaction.

A sample of 0.50 g of magnesium powder was added to 25 $cm^3$ of 0.20 mol $dm^{-3}$ sulfuric acid.

Calculate the number of moles of magnesium and of sulfuric acid that **reacted**.
Justify your answer.

**(3)**

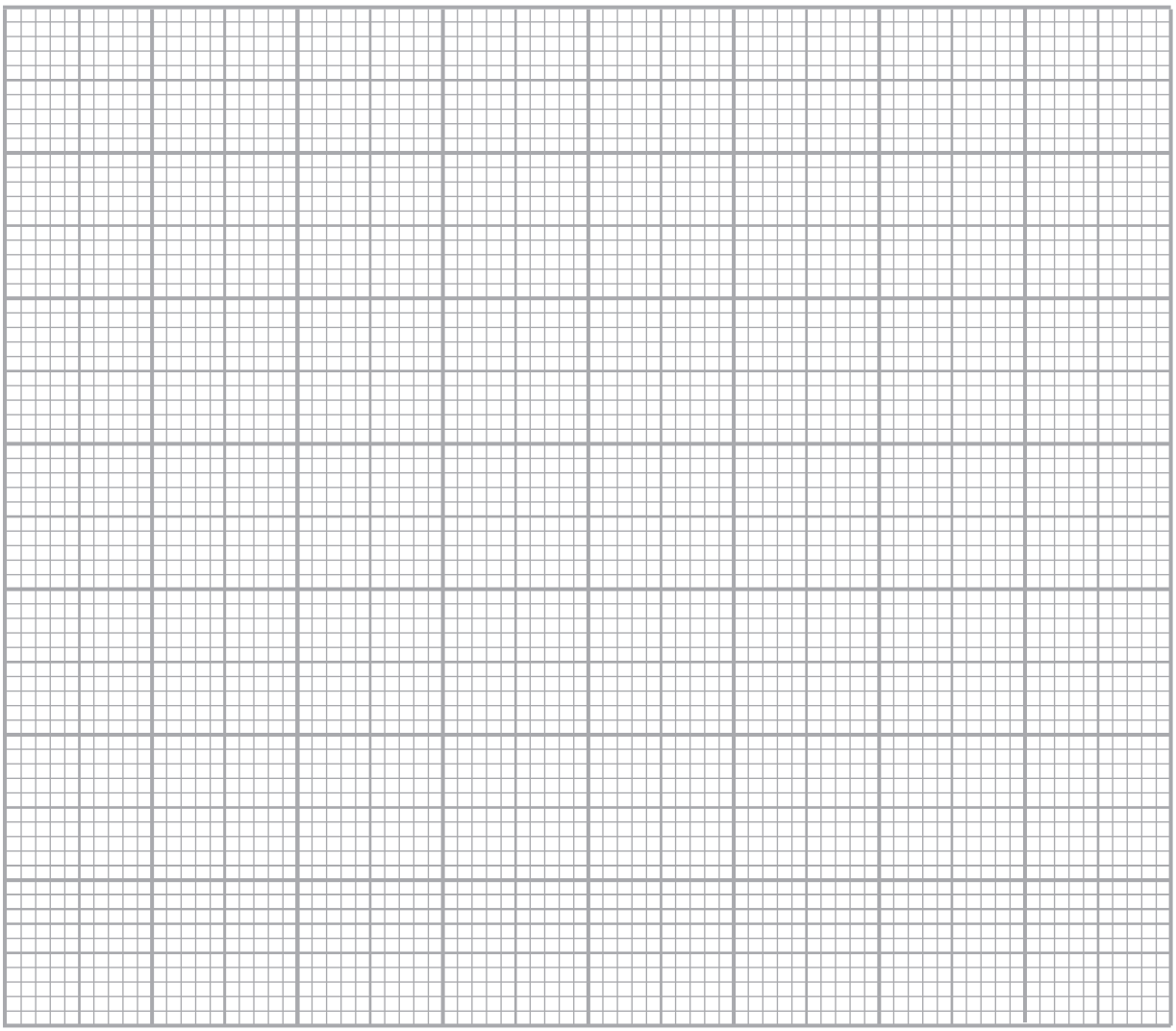
www.dynamicpapers.com

(c) (i) The results obtained are given in the table.

Plot the results on the grid.

**(2)**

| Time / minutes | Temperature / °C | |
|---|---|---|
| 0 | 22.2 | |
| 1 | 22.0 | |
| 2 | 22.0 | ← Mg added |
| 3 | 39.6 | |
| 4 | 41.8 | |
| 5 | 40.8 | |
| 6 | 40.2 | |
| 7 | 39.4 | |
| 8 | 38.6 | |



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

www.dynamicpapers.com

(ii) Use your graph to determine the maximum change in temperature.

You **must** show your working on the graph.

**(2)**

$\Delta T =$ .....

(d) Calculate the standard molar enthalpy change for the reaction, using your answers to (b) and (c)(ii).

Include a sign and units in your answer.

[Specific heat capacity of solution = 4.18 J $g^{-1}$ $°C^{-1}$]

**(4)**

**(Total for Question 19 = 13 marks)**

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

www.dynamicpapers.com

**20** This question is about the forces between molecules and ions.

*(a) Some data for three small molecules are shown.

| Molecule | $M_r$ | Boiling temperature / °C |
|---|---|---|
| Fluorine | 38.0 | −188 |
| Hydrogen chloride | 36.5 | −85 |
| Methanol | 32.0 | 65 |

Explain the large variation in boiling temperatures, given the small range in $M_r$ values.

Detailed descriptions of the forces involved are not required.

**(6)**

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

www.dynamicpapers.com

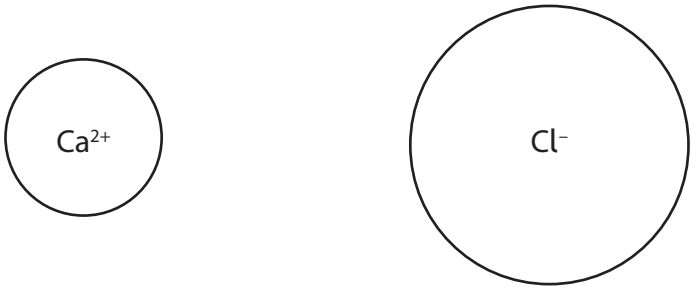
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

(b) Calcium chloride is soluble in water.

Complete the diagram to show how water molecules interact with each ion.
You may use  to represent a water molecule.

**(2)**




(c) Explain why bromine is a liquid but iodine is a solid at room temperature.

Detailed explanations of the forces involved are not required.

**(2)**

**(Total for Question 20 = 10 marks)**

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

www.dynamicpapers.com

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

**21** Magnesium oxalate, $MgC_2O_4$, decomposes on heating to form magnesium carbonate and carbon monoxide.

$$MgC_2O_4(s) \rightarrow MgCO_3(s) + CO(g)$$

(a) A 6.0 g sample of magnesium oxalate was heated for three minutes but the decomposition was only 70 % complete.

Calculate the total mass of solid that remains.

**(4)**

(b) In practice, magnesium carbonate also decomposes on stronger heating.

Describe and explain the trend in the thermal decomposition of Group 2 carbonates.

**(3)**

www.dynamicpapers.com

(c) Suggest why a pure sample of magnesium carbonate will **not** be produced from the decomposition of magnesium oxalate even if the sample is heated for longer.

**(1)**

.....

.....

.....

.....

**(Total for Question 21 = 8 marks)**

**TOTAL FOR SECTION B = 40 MARKS**

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

www.dynamicpapers.com

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

## SECTION C

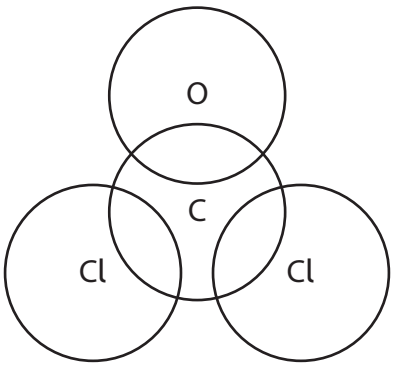
**Answer all the questions. Write your answers in the spaces provided.**

**22** Phosgene ($COCl_2$) is a colourless gas used in the pharmaceutical industry.

Phosgene has a boiling temperature of 8 °C and is extremely toxic.

(a) Complete the dot-and-cross diagram to show the bonding in phosgene.

**(2)**




(b) Phosgene can be formed from carbon monoxide and chlorine, using a catalyst of activated carbon.

$$CO(g) + Cl_2(g) \rightleftharpoons COCl_2(g) \qquad \Delta_r H = -107.6 \text{ kJ mol}^{-1}$$

(i) State and explain how the reaction conditions could be changed to maximise the **equilibrium** yield of phosgene in this reaction.

**(4)**

www.dynamicpapers.com

(ii) The standard enthalpy change of formation for phosgene is $\Delta_f H = -220.1$ kJ mol$^{-1}$.

Complete the Hess cycle and determine the standard enthalpy change of formation for carbon monoxide. Use the data from (b)(i).

Include state symbols in your cycle.

**(4)**

$$CO(g) \quad + \quad Cl_2(g) \longrightarrow COCl_2(g)$$

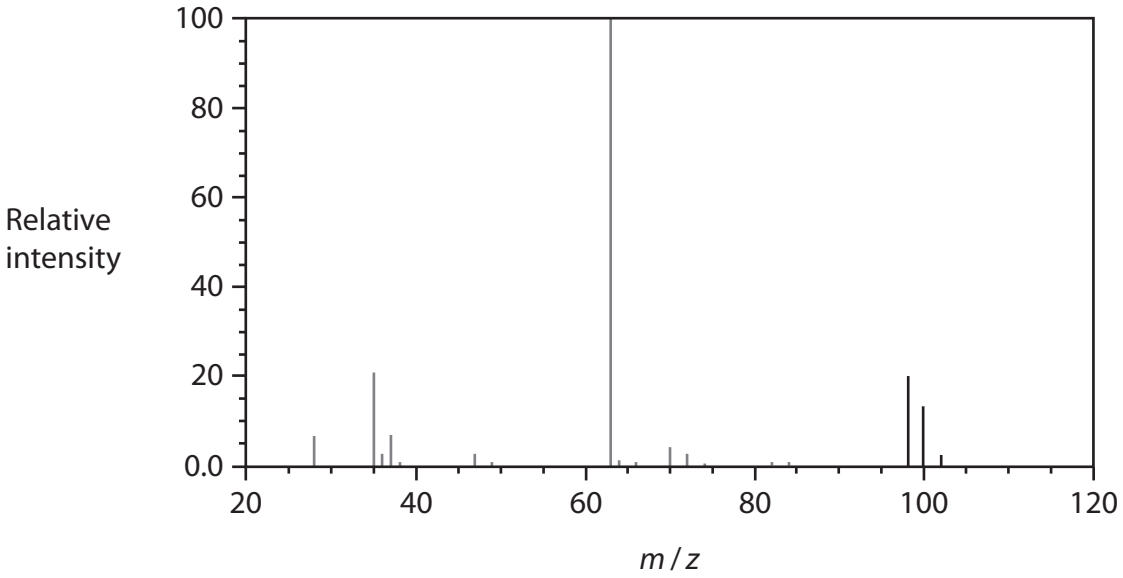
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

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

(c) The mass spectrum of a sample of phosgene is shown.

The peak at $m / z = 65$ has been omitted.




(i) Give the reason for the **ratio** of peak heights at $m / z$ values of 102, 100 and 98.

**(2)**

.....

.....

.....

.....

(ii) Suggest an identity for the peak at $m / z = 63$.

**(1)**

.....

(iii) The peak at $m / z = 65$ has been omitted.

Draw **on the mass spectrum** the peak at $m / z = 65$, showing its relative intensity.

**(1)**

(d) Use your Data Booklet to suggest the wavenumber of a strong absorbance you would expect to see in the infrared spectrum for phosgene. Justify your answer.

**(2)**

.....

.....

.....

www.dynamicpapers.com

(e) In UV light, trichloromethane ($CHCl_3$, boiling temperature 61°C) reacts with oxygen to form phosgene and hydrogen chloride.

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

**(1)**

(ii) In a closed bottle, the rate of this reaction decreases with time.

Give a reason for this.

**(1)**

.....

.....

(iii) Suggest a precaution that should be taken when opening a bottle of trichloromethane.

**(1)**

.....

.....

(iv) Trichloromethane can be used as an anaesthetic.

Suggest whether an old bottle of trichloromethane can still be used for medical treatment, giving a reason for your answer.

**(1)**

.....

.....

.....

**(Total for Question 22 = 20 marks)**

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

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

www.dynamicpapers.com

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

**BLANK PAGE**

# 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<br>atomic symbol<br>name<br>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 |

www.dynamicpapers.com

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