

Please check the examination details below before entering your candidate information

Candidate surname

Other names

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

Centre Number

Candidate Number

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**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 ►

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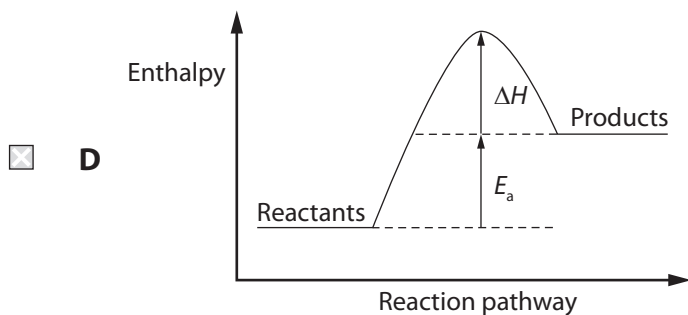
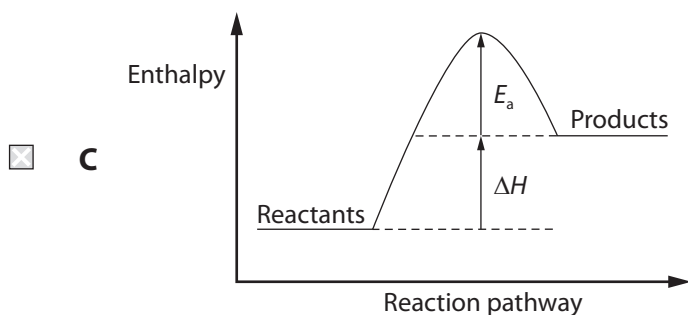
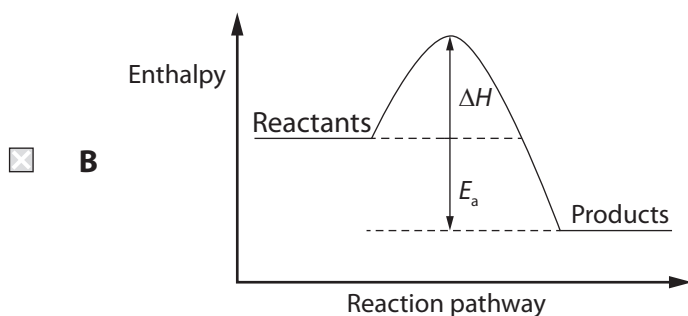
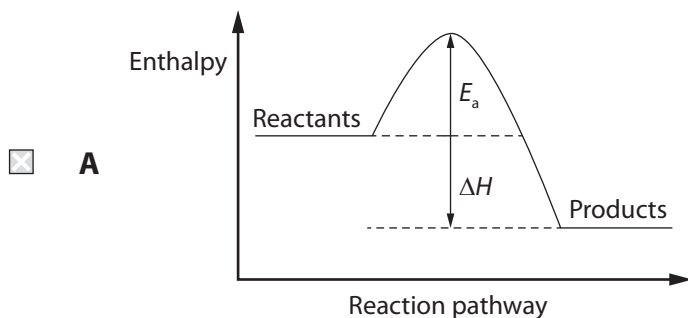
## SECTION A

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?



(Total for Question 1 = 1 mark)

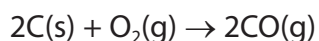


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2 The equation for a reaction is

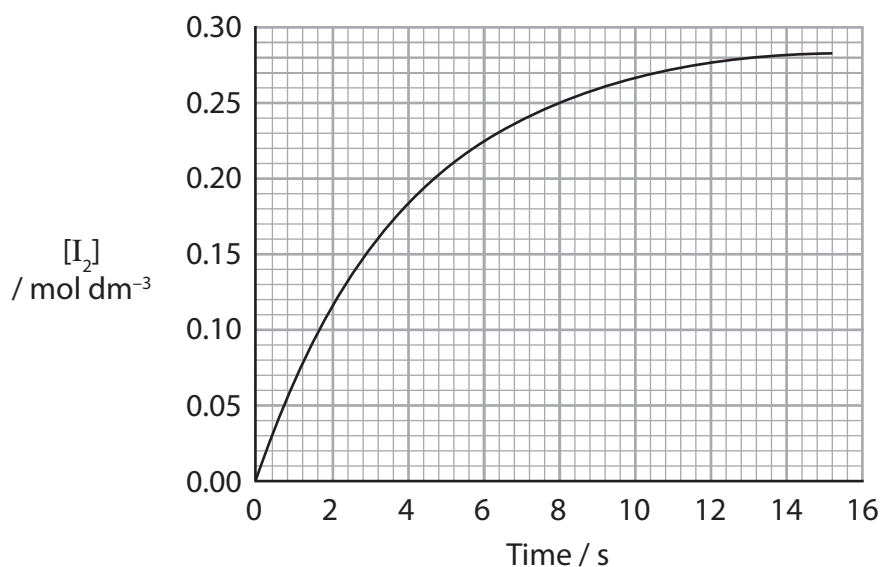


Which is the correct symbol for the enthalpy change for this reaction?

- A  $\Delta_{\text{at}}H$
- B  $\Delta_{\text{c}}H$
- C  $\Delta_{\text{f}}H$
- D  $\Delta_{\text{r}}H$

(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  $\text{mol dm}^{-3} \text{s}^{-1}$ , at 8 seconds?

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

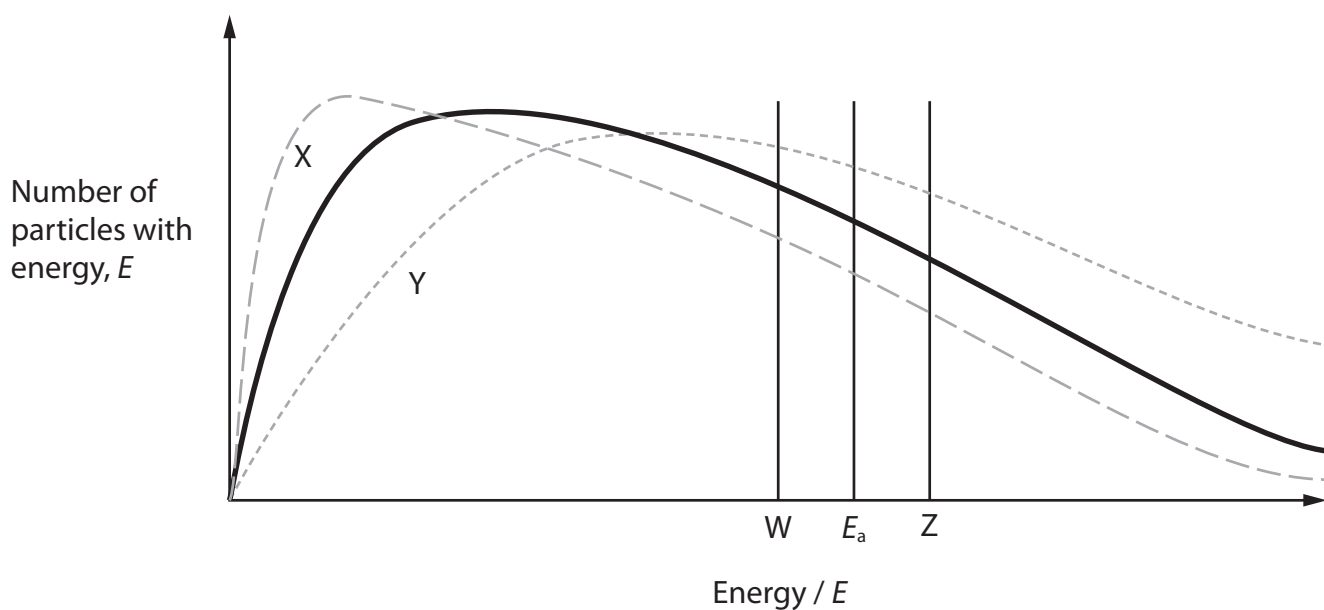
(Total for Question 3 = 1 mark)

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- 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
<input type="checkbox"/> A	X	W
<input type="checkbox"/> B	X	Z
<input type="checkbox"/> C	Y	W
<input type="checkbox"/> D	Y	Z

(Total for Question 4 = 1 mark)

- 5 What is the oxidation number of chromium in  $\text{Na}_2\text{Cr}_2\text{O}_7$ ?

- A +1
- B +2
- C +3
- D +6

(Total for Question 5 = 1 mark)



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
<input type="checkbox"/> A	oxidised	reduced
<input type="checkbox"/> B	oxidised and reduced	unchanged
<input type="checkbox"/> C	reduced	oxidised
<input type="checkbox"/> 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)



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  $\text{CH}_3\text{CHICH}_3$   
 B  $\text{CH}_3\text{CHBrCH}_3$   
 C  $\text{CH}_3\text{CHClCH}_3$   
 D  $\text{CH}_3\text{CHFCH}_3$

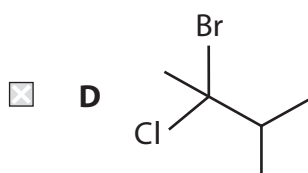
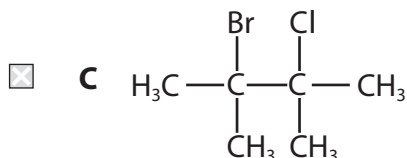
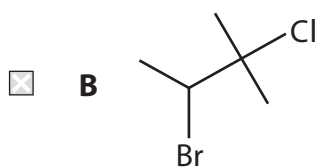
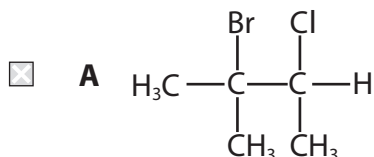
(b) Which of these halogenoalkanes reacts the **fastest**?

(1)

- A  $\text{CH}_3\text{CHBrCH}(\text{CH}_3)\text{CH}_3$   
 B  $\text{CH}_3\text{CH}_2\text{CBr}(\text{CH}_3)\text{CH}_3$   
 C  $\text{CH}_3\text{CH}(\text{CH}_2\text{Br})\text{CH}_2\text{CH}_3$   
 D  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{Br}$

(Total for Question 9 = 2 marks)

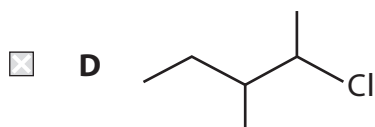
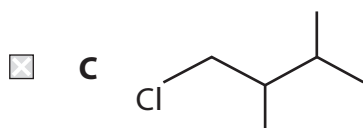
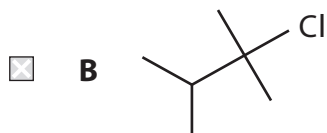
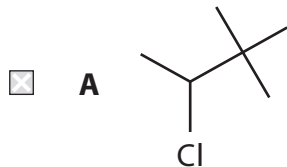
10 What is the structure of 2-bromo-3-chloro-2-methylbutane?



(Total for Question 10 = 1 mark)



11 Which structure represents a primary halogenoalkane?



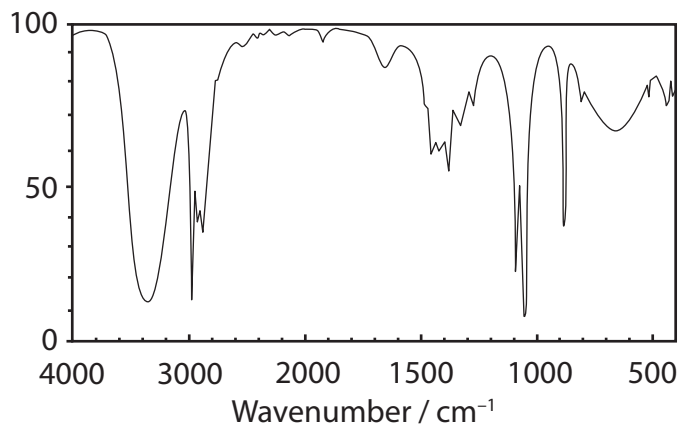
(Total for Question 11 = 1 mark)

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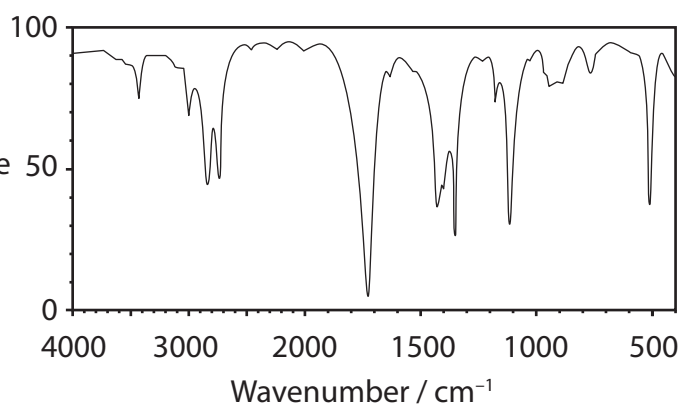


12 Which could be the infrared spectrum of  $\text{CH}_2=\text{CHCH}_2\text{OH}$ ?

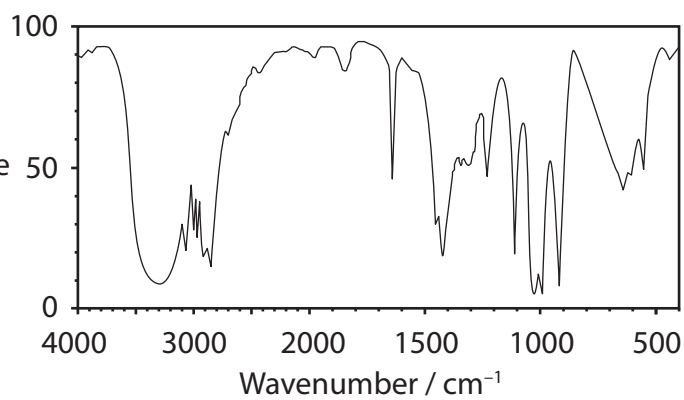
A % Transmittance



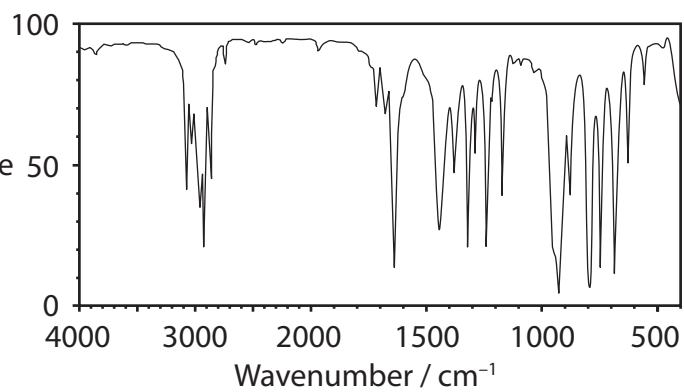
B % Transmittance



C % Transmittance



D % Transmittance



(Total for Question 12 = 1 mark)



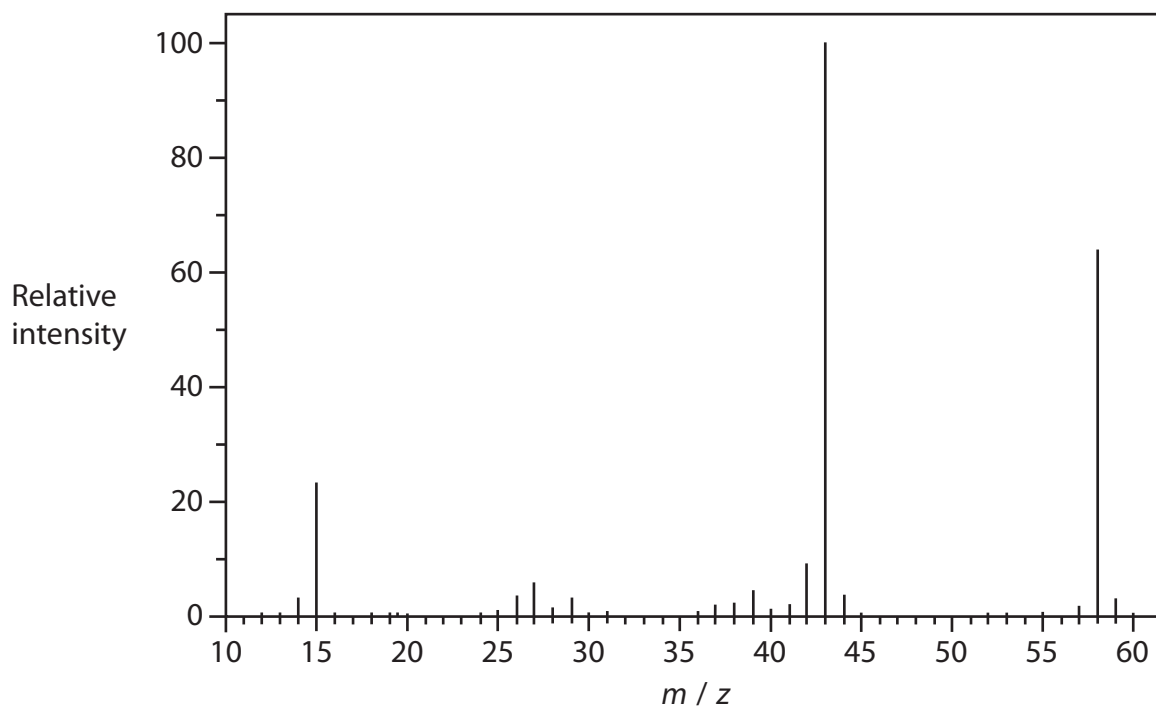


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13 The mass spectrum of propanone is shown.



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

- A  $\text{CH}_3\text{CH}_2\text{CH}_2^+$
- B  $\text{CH}_3\text{CO}^+$
- C  $\text{CH}_2\text{CHO}^+$
- D  $\text{CHCH}_2\text{O}^+$

(Total for Question 13 = 1 mark)

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

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

- A  $13.1 \text{ cm}^3$
- B  $52.5 \text{ cm}^3$
- C  $97.5 \text{ cm}^3$
- D  $136.9 \text{ cm}^3$

(Total for Question 14 = 1 mark)



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

Some pellets were dissolved to make 350 cm<sup>3</sup> of 0.25 mol dm<sup>-3</sup> solution.

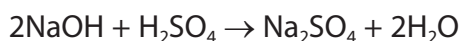
[ $M_r$  value: NaOH = 40]

How many pellets were dissolved?

(1)

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

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



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)

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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  $\text{dm}^3$ , of hydrogen gas will be produced when 3.00 g of lithium is reacted with water at room temperature and pressure (r.t.p.)?



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

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

(Total for Question 17 = 1 mark)

**TOTAL FOR SECTION A = 20 MARKS**



11  
Turn over

## SECTION B

Answer ALL questions.

Write your answers in the spaces provided.

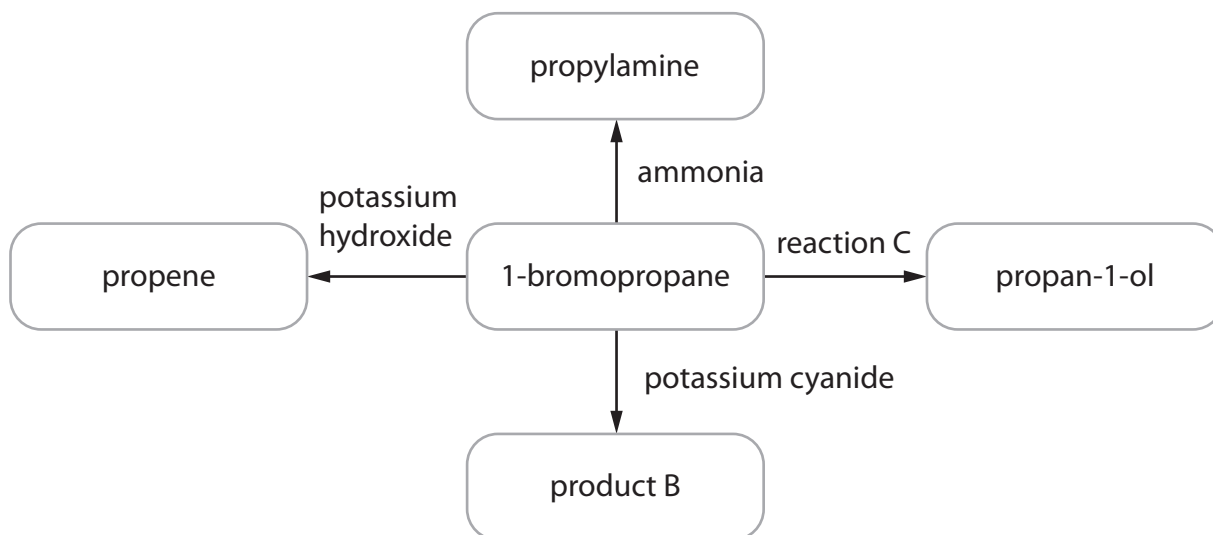
18 1-bromopropane is used for spot removal when 'dry cleaning' clothes.

(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)

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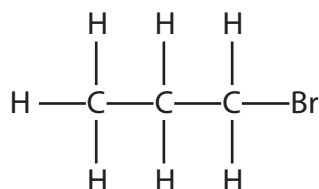
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(iv) Complete the mechanism for the reaction that occurs between ammonia and 1-bromopropane to form propylamine,  $\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2$ .

Include curly arrows, and relevant lone pairs and dipoles.

(4)



(Total for Question 18 = 9 marks)



13  
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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<sup>3</sup> of 0.20 mol dm<sup>-3</sup> sulfuric acid.

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

(3)

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(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
3	39.6
4	41.8
5	40.8
6	40.2
7	39.4
8	38.6

← Mg added





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

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

(2)

$$\Delta T = \dots\dots\dots$$

(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 =  $4.18 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1}$ ]

(4)

(Total for Question 19 = 13 marks)

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**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)

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Handwriting practice area with 20 sets of horizontal lines. Each set consists of a solid top line, a dashed middle line, and a solid bottom line.




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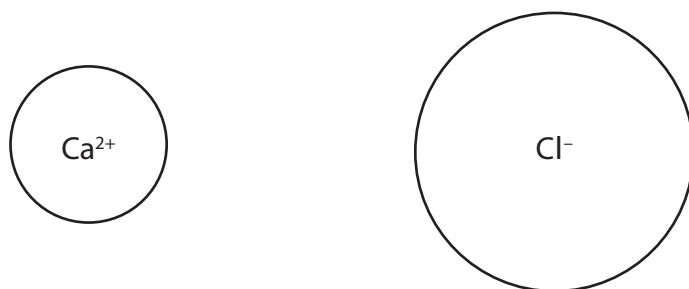


19  
Turn over

(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)

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



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21 Magnesium oxalate,  $\text{MgC}_2\text{O}_4$ , decomposes on heating to form magnesium carbonate and carbon monoxide.



(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)

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(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)

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

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**TOTAL FOR SECTION B = 40 MARKS**

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## SECTION C

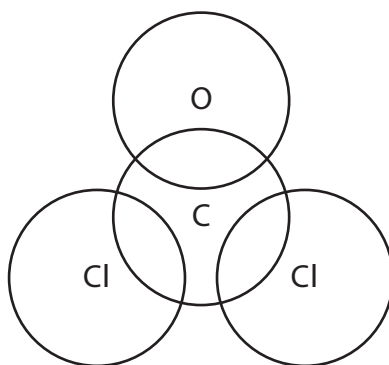
Answer all the questions. Write your answers in the spaces provided.

22 Phosgene ( $\text{COCl}_2$ ) is a colourless gas used in the pharmaceutical industry.

Phosgene has a boiling temperature of  $8^\circ\text{C}$  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.



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

(4)

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

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)



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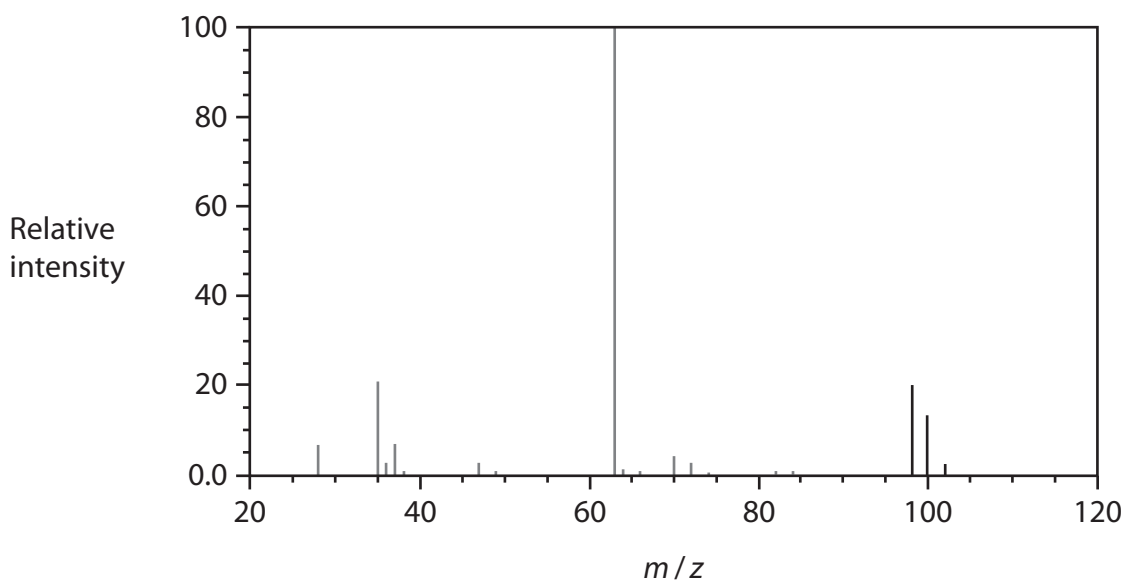
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(c) The mass spectrum of a sample of phosgene is shown.

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)



(e) In UV light, trichloromethane ( $\text{CHCl}_3$ , boiling temperature  $61^\circ\text{C}$ ) 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**



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# The Periodic Table of Elements

	1	2	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	0 (8)
	6.9 <b>Li</b> lithium 3	9.0 <b>Be</b> beryllium 4	45.0 <b>Sc</b> scandium 21	47.9 <b>Ti</b> titanium 22	50.9 <b>V</b> vanadium 23	52.0 <b>Cr</b> chromium 24	54.9 <b>Mn</b> manganese 25	55.8 <b>Fe</b> iron 26	58.9 <b>Co</b> cobalt 27	58.7 <b>Ni</b> nickel 28	63.5 <b>Cu</b> copper 29	65.4 <b>Zn</b> zinc 30	10.8 <b>B</b> boron 5	12.0 <b>C</b> carbon 6	14.0 <b>N</b> nitrogen 7	16.0 <b>O</b> oxygen 8	19.0 <b>F</b> fluorine 9	20.2 <b>Ne</b> neon 10
	23.0 <b>Na</b> sodium 11	24.3 <b>Mg</b> magnesium 12	88.9 <b>Y</b> yttrium 39	91.2 <b>Zr</b> zirconium 40	92.9 <b>Nb</b> niobium 41	95.9 <b>Mo</b> molybdenum 42	[98] <b>Tc</b> technetium 43	101.1 <b>Ru</b> ruthenium 44	102.9 <b>Rh</b> rhodium 45	106.4 <b>Pd</b> palladium 46	107.9 <b>Ag</b> silver 47	112.4 <b>Cd</b> cadmium 48	27.0 <b>Al</b> aluminium 13	28.1 <b>Si</b> silicon 14	31.0 <b>P</b> phosphorus 15	32.1 <b>S</b> sulfur 16	35.5 <b>Cl</b> chlorine 17	39.9 <b>Ar</b> argon 18
	39.1 <b>K</b> potassium 19	40.1 <b>Ca</b> calcium 20	88.9 <b>Y</b> yttrium 39	91.2 <b>Zr</b> zirconium 40	92.9 <b>Nb</b> niobium 41	95.9 <b>Mo</b> molybdenum 42	[98] <b>Tc</b> technetium 43	101.1 <b>Ru</b> ruthenium 44	102.9 <b>Rh</b> rhodium 45	106.4 <b>Pd</b> palladium 46	107.9 <b>Ag</b> silver 47	112.4 <b>Cd</b> cadmium 48	69.7 <b>Ga</b> gallium 31	72.6 <b>Ge</b> germanium 32	74.9 <b>As</b> arsenic 33	79.0 <b>Se</b> selenium 34	79.9 <b>Br</b> bromine 35	83.8 <b>Kr</b> krypton 36
	85.5 <b>Rb</b> rubidium 37	87.6 <b>Sr</b> strontium 38	138.9 <b>La*</b> lanthanum 57	178.5 <b>Hf</b> hafnium 72	180.9 <b>Ta</b> tantalum 73	183.8 <b>W</b> tungsten 74	186.2 <b>Re</b> rhenium 75	190.2 <b>Os</b> osmium 76	192.2 <b>Ir</b> iridium 77	195.1 <b>Pt</b> platinum 78	197.0 <b>Au</b> gold 79	200.6 <b>Hg</b> mercury 80	114.8 <b>In</b> indium 49	118.7 <b>Sn</b> tin 50	121.8 <b>Sb</b> antimony 51	127.6 <b>Te</b> tellurium 52	126.9 <b>I</b> iodine 53	131.3 <b>Xe</b> xenon 54
	132.9 <b>Cs</b> caesium 55	137.3 <b>Ba</b> barium 56	[227] <b>Ac*</b> actinium 89	178.5 <b>Hf</b> hafnium 72	180.9 <b>Ta</b> tantalum 73	183.8 <b>W</b> tungsten 74	186.2 <b>Re</b> rhenium 75	190.2 <b>Os</b> osmium 76	192.2 <b>Ir</b> iridium 77	195.1 <b>Pt</b> platinum 78	197.0 <b>Au</b> gold 79	200.6 <b>Hg</b> mercury 80	204.4 <b>Tl</b> thallium 81	207.2 <b>Pb</b> lead 82	209.0 <b>Bi</b> bismuth 83	[209] <b>Po</b> polonium 84	[210] <b>At</b> astatine 85	[222] <b>Rn</b> radon 86
	[223] <b>Fr</b> francium 87	[226] <b>Ra</b> radium 88	[227] <b>Ac*</b> actinium 89	[261] <b>Rf</b> rutherfordium 104	[262] <b>Db</b> dubnium 105	[266] <b>Sg</b> seaborgium 106	[264] <b>Bh</b> bohrium 107	[277] <b>Hs</b> hassium 108	[268] <b>Mt</b> meitnerium 109	[271] <b>Ds</b> darmstadtium 110	[272] <b>Rg</b> roentgenium 111	Elements with atomic numbers 112-116 have been reported but not fully authenticated						

1.0 <b>H</b> hydrogen 1
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**Key**

relative atomic mass
<b>atomic symbol</b>
name
atomic (proton) number

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

\* Lanthanide series  
\* Actinide series



DO NOT WRITE IN THIS AREA

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