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

SECTION A

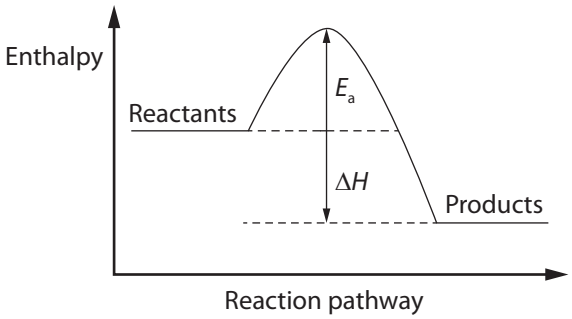
Answer ALL questions. Write your answers in the spaces provided.

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

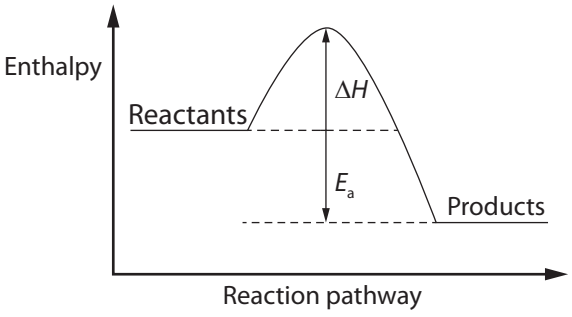
For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

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

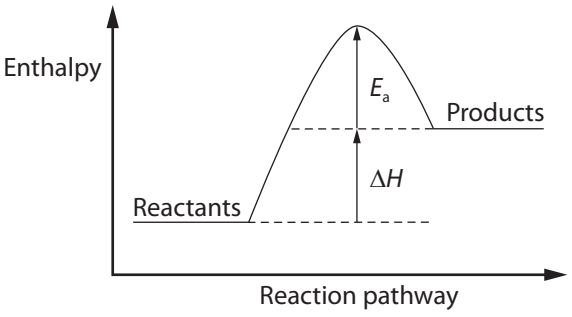
☒ **A**



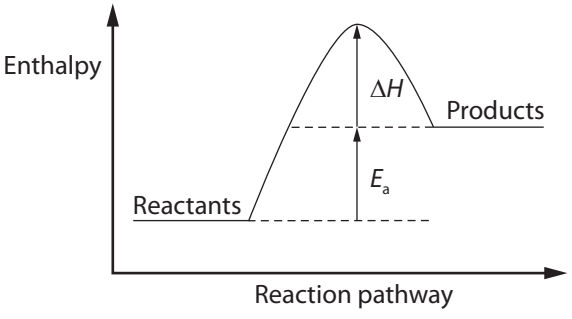
☒ **B**



☒ **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

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

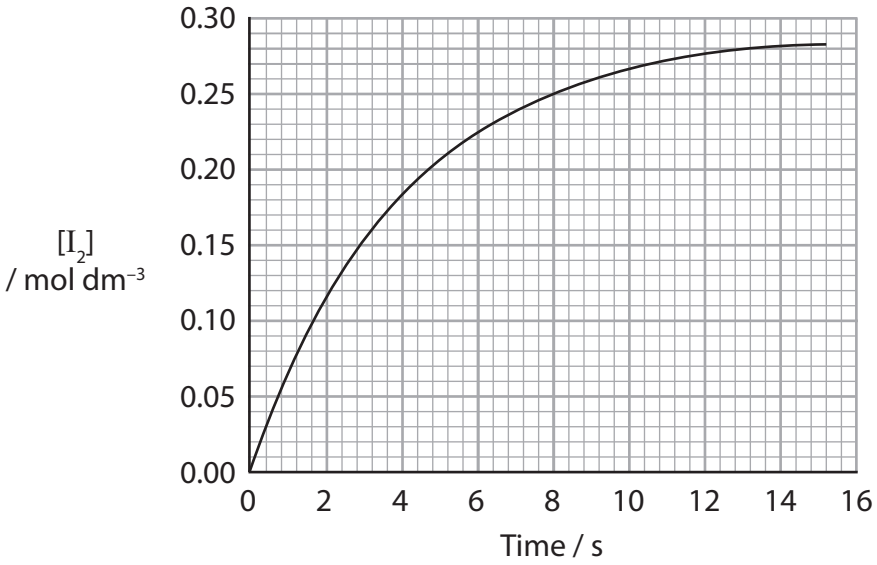
$$2C(s) + O_2(g) \rightarrow 2CO(g)$$

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.



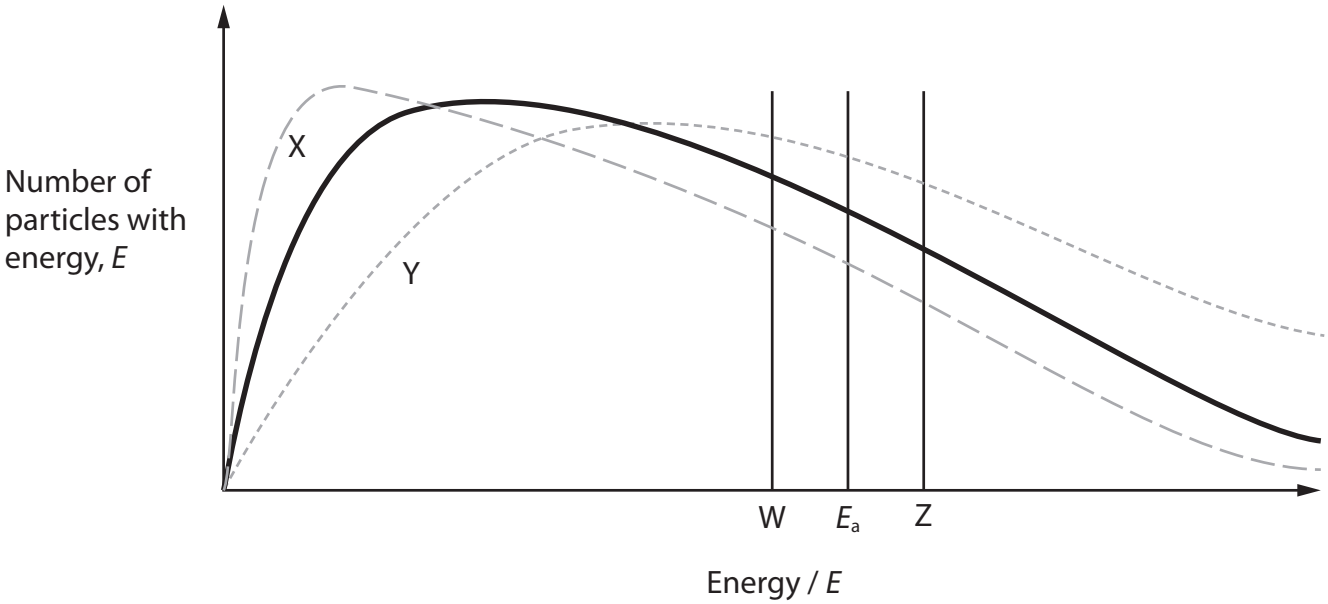
What is the value for the rate of reaction, in mol dm^{-3} s^{-1}, at 8 seconds?

- ☒ **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.

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

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)

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** $CH_3CH_2CBr(CH_3)CH_3$

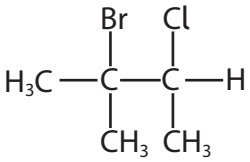
☒ **C** $CH_3CH(CH_2Br)CH_2CH_3$

☒ **D** $CH_3CH_2CH_2CH_2CH_2Br$

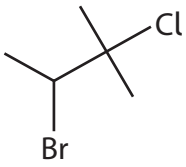
(Total for Question 9 = 2 marks)

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

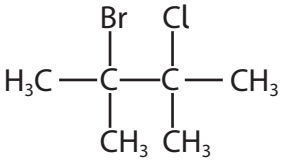
☒ **A**



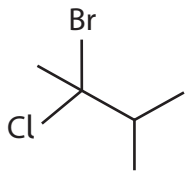
☒ **B**



☒ **C**



☒ **D**



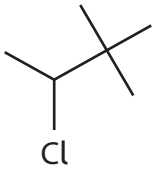
(Total for Question 10 = 1 mark)

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

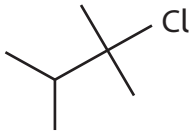
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

11 Which structure represents a primary halogenoalkane?

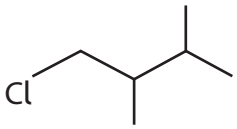
☒ **A**



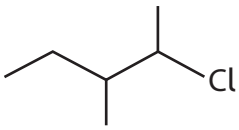
☒ **B**



☒ **C**



☒ **D**

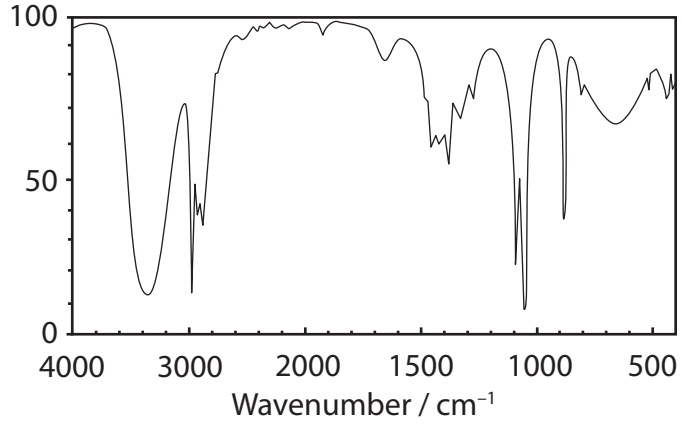


(Total for Question 11 = 1 mark)

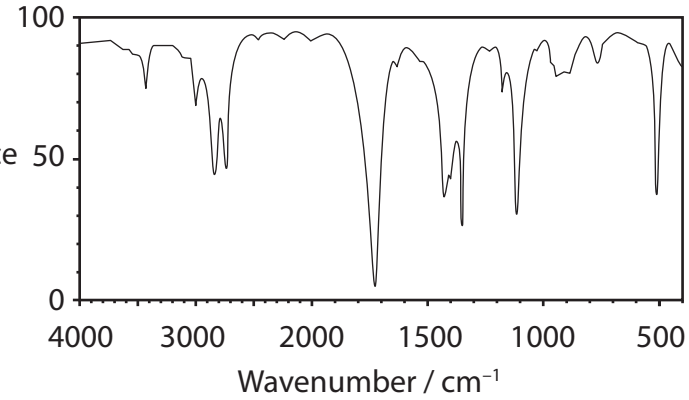
Use this space for any rough working. Anything you write in this space will gain no credit.

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

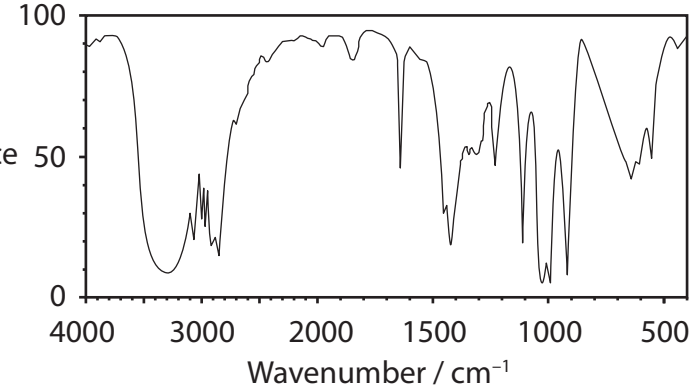
☒ **A**



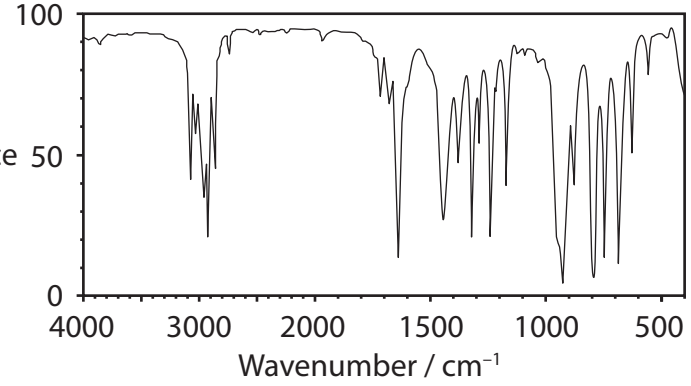
☒ **B**



☒ **C**



☒ **D**

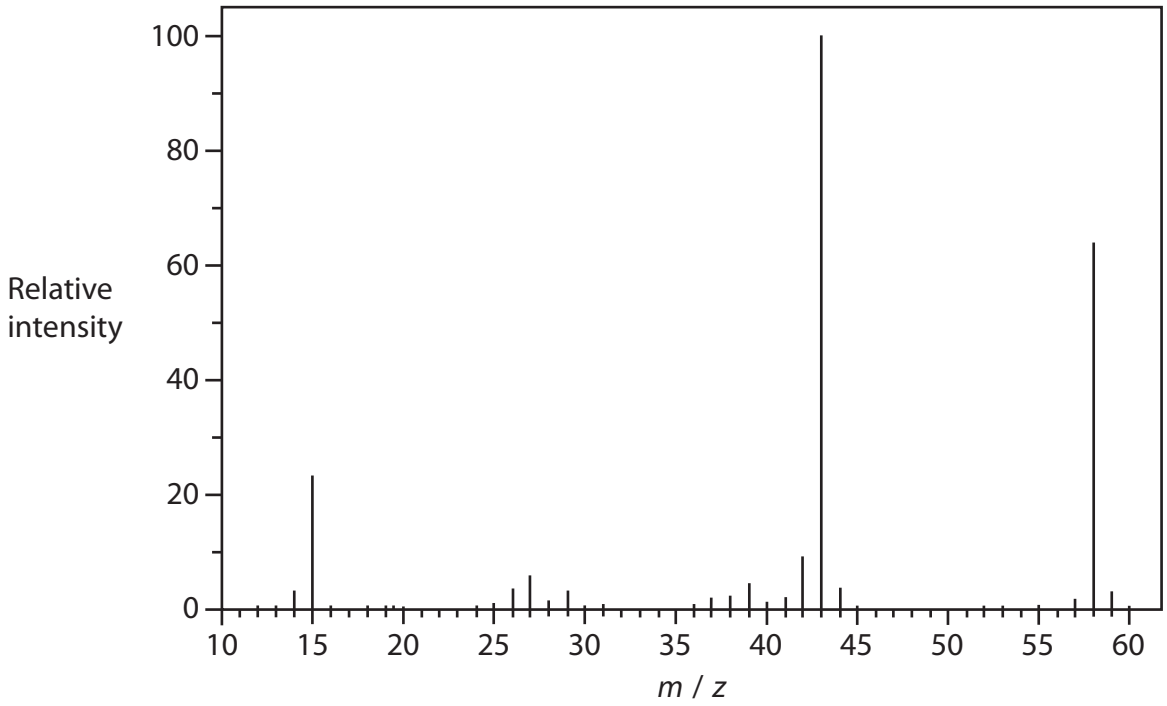


(Total for Question 12 = 1 mark)

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

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)

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

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

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

SECTION B

Answer ALL questions.

Write your answers in the spaces provided.

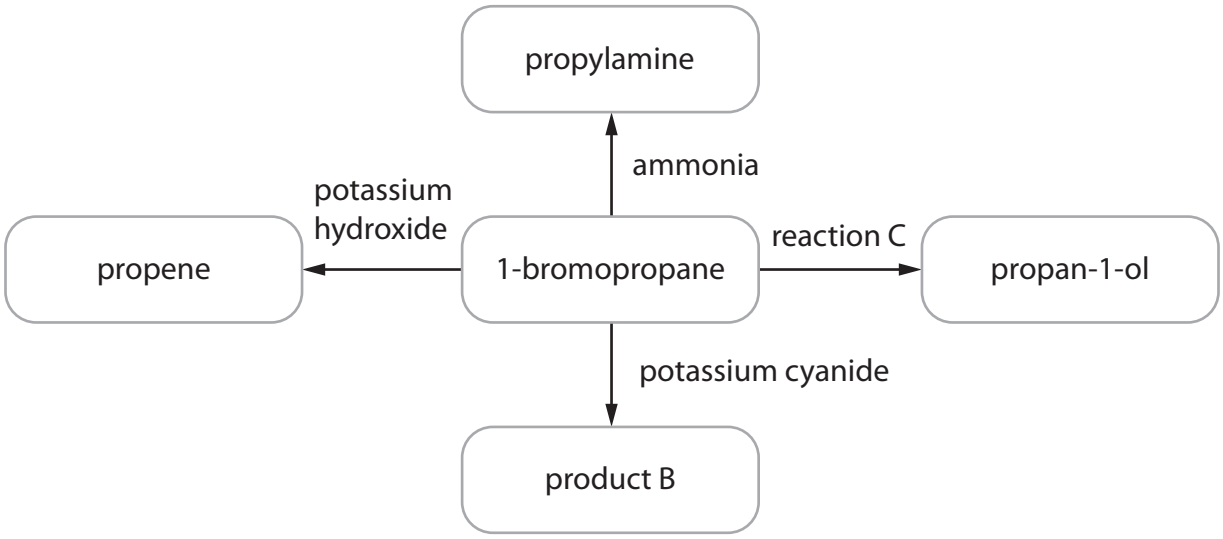
18 1-bromopropane is used for spot removal when 'dry cleaning' clothes.

(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)

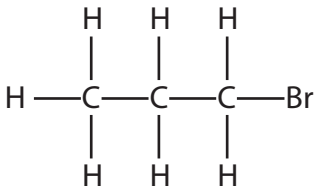
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

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

(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)

BLANK PAGE

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)

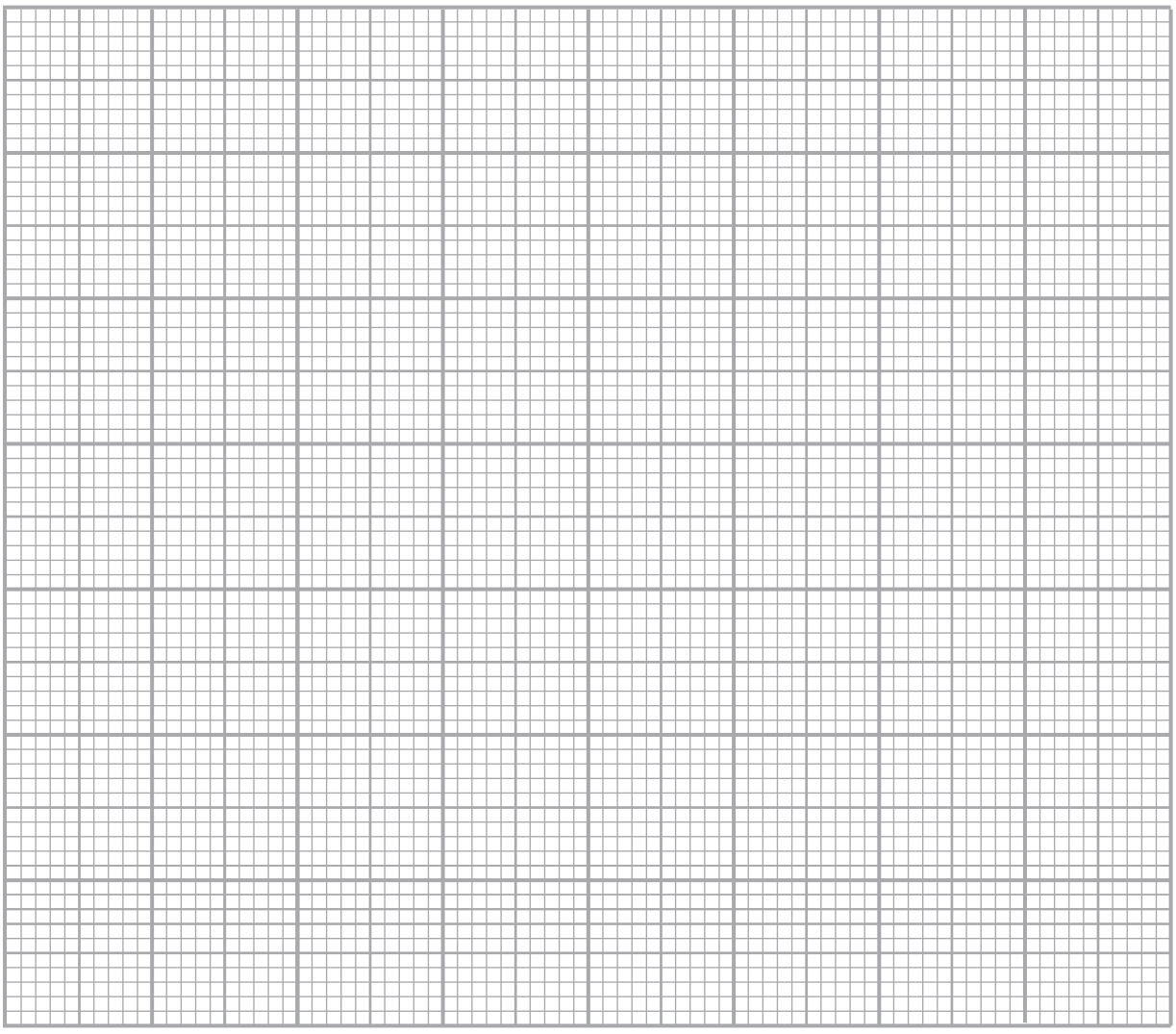
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

(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

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

(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)

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)

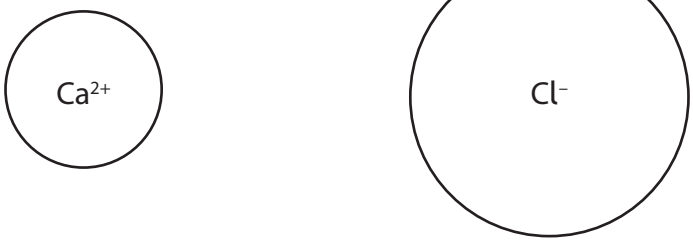
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

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

(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

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)

(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

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

SECTION C

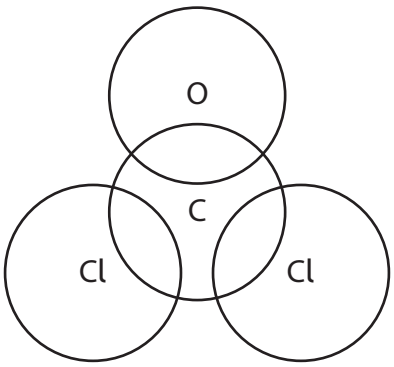
Answer all the questions. Write your answers in the spaces provided.

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)

(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)

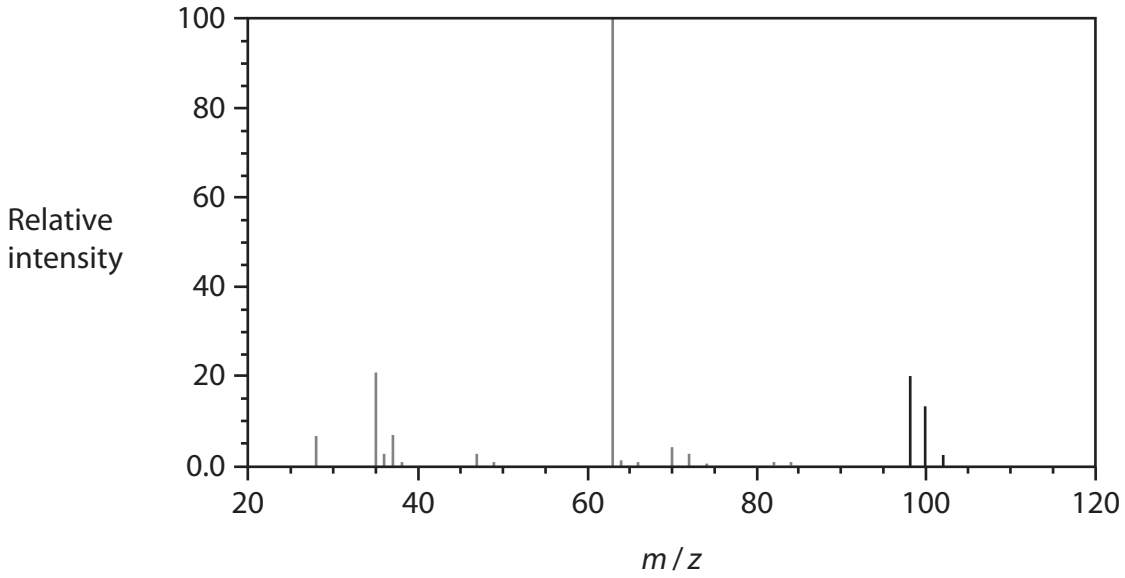
$$CO(g) \quad + \quad Cl_2(g) \longrightarrow COCl_2(g)$$

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

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)

.....

.....

.....

(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

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 atomic symbol name atomic (proton) number								10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	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

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

GradeMax