

Please check the examination details below before entering your candidate information

Candidate surname

Other names

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

Centre Number

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Candidate Number

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**Friday 11 October 2019**

Morning (Time: 1 hour 30 minutes)

Paper Reference **WCH12/01**

**Chemistry**

**International Advanced Subsidiary Level**

**Unit 2: Energetics, Group Chemistry, Halogenoalkanes and Alcohols**

**Candidates must have: Scientific calculator**  
**Data Booklet**  
**Ruler**

Total Marks

## Instructions

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

## Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- 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.
- There is a Periodic Table 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.
- Check your answers if you have time at the end.

Turn over ►

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**Pearson**

## SECTION A

Answer ALL the questions in this section.

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

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

- 1 Lithium carbonate decomposes on heating.



What is the maximum volume, in  $\text{dm}^3$ , measured at room temperature and pressure (r.t.p.), of gas produced from 3.69 g of lithium carbonate?

[ $M_r$   $\text{Li}_2\text{CO}_3 = 73.8$       Molar volume of a gas at r.t.p. =  $24.0 \text{ dm}^3 \text{ mol}^{-1}$ ]

- A 24.0  
 B 12.0  
 C 1.20  
 D 0.83

(Total for Question 1 = 1 mark)

- 2 A sample of 1,2-dichloroethane,  $\text{CH}_2\text{ClCH}_2\text{Cl}$ , contains only the isotopes  $^1\text{H}$ ,  $^{12}\text{C}$ ,  $^{35}\text{Cl}$  and  $^{37}\text{Cl}$ .

How many molecular ion peaks are there in its mass spectrum?

- A 1  
 B 2  
 C 3  
 D 4

(Total for Question 2 = 1 mark)

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

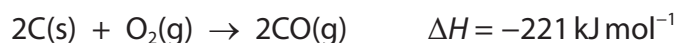
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- 3 Under certain conditions, graphite burns to form carbon monoxide.



Which of these is correct?

- A  $\Delta_c H$  (carbon) =  $-221 \text{ kJ mol}^{-1}$
- B  $\Delta_f H$  (carbon monoxide) =  $-221 \text{ kJ mol}^{-1}$
- C  $\Delta_c H$  (carbon) =  $-110.5 \text{ kJ mol}^{-1}$
- D  $\Delta_f H$  (carbon monoxide) =  $-110.5 \text{ kJ mol}^{-1}$

(Total for Question 3 = 1 mark)

- 4 What are the strongest interactions **between** molecules in solid hydrogen iodide, HI?

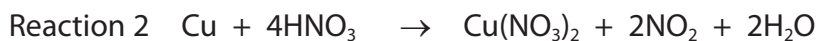
- A covalent bonds
- B hydrogen bonds
- C ionic bonds
- D London forces

(Total for Question 4 = 1 mark)

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5 Equations for four reactions of copper or its compounds are shown.



(a) Which is a disproportionation reaction?

(1)

- A Reaction 1
- B Reaction 2
- C Reaction 3
- D Reaction 4

(b) Which is an acid-base reaction?

(1)

- A Reaction 1
- B Reaction 2
- C Reaction 3
- D Reaction 4

(Total for Question 5 = 2 marks)

6 Which statement is correct?

- A barium carbonate is less stable to heat than magnesium carbonate
- B barium hydroxide is less soluble in water than magnesium hydroxide
- C barium sulfate is less soluble in water than magnesium sulfate
- D barium metal is less reactive with water than magnesium metal

(Total for Question 6 = 1 mark)

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



7 Which statement is **not** correct?

- A chlorine is more electronegative than bromine
- B chlorine is more reactive than bromine
- C chloride ions are stronger reducing agents than bromide ions
- D chloride ions are stronger reducing agents than fluoride ions

(Total for Question 7 = 1 mark)

8 A white solid **X** produces a red colour in a flame test.

When aqueous silver nitrate and nitric acid are added to a solution of **X**, a cream precipitate is formed which dissolves in concentrated aqueous ammonia.

What is the formula of **X**?

- A  $\text{SrBr}_2$
- B  $\text{NaBr}$
- C  $\text{LiCl}$
- D  $\text{BaI}_2$

(Total for Question 8 = 1 mark)

9 Exactly  $50.0 \text{ cm}^3$  of  $2.00 \text{ mol dm}^{-3}$  nitric acid reacts with  $50.0 \text{ cm}^3$  of  $1.00 \text{ mol dm}^{-3}$  barium hydroxide to form a neutral solution of barium nitrate.

(a) What is the concentration, in  $\text{mol dm}^{-3}$ , of barium nitrate in the solution?

(1)

- A 0.05
- B 0.50
- C 1.00
- D 2.00

(b) The volume of the nitric acid is measured using a burette. Each burette reading has an uncertainty of  $\pm 0.05 \text{ cm}^3$ .

What is the percentage uncertainty in measuring  $50.00 \text{ cm}^3$  of the nitric acid?

(1)

- A  $\pm 0.40\%$
- B  $\pm 0.20\%$
- C  $\pm 0.10\%$
- D  $\pm 0.05\%$

(Total for Question 9 = 2 marks)



10 Which of these products are formed when chlorine is passed through cold, dilute aqueous sodium hydroxide?

- A NaCl and NaClO
- B NaClO and NaClO<sub>3</sub>
- C NaCl and NaClO<sub>3</sub>
- D NaClO and NaClO<sub>4</sub>

(Total for Question 10 = 1 mark)

11 Potassium iodide reacts with concentrated sulfuric acid.

Which of the following is **not** a product?

- A H<sub>2</sub>S
- B I<sub>2</sub>
- C S
- D SO<sub>3</sub>

(Total for Question 11 = 1 mark)

12 Sodium thiosulfate solution reacts with hydrochloric acid to produce solid sulfur.

Which change would be expected to **increase** the time taken for sulfur to appear?

- A increasing the concentration of the hydrochloric acid
- B decreasing the concentration of the sodium thiosulfate
- C increasing the temperature
- D adding a catalyst

(Total for Question 12 = 1 mark)

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



13 The equation for a reversible reaction is shown.



What effect will each change have on the rate of reaction and the equilibrium yield of phosphorus(V) chloride?

(a) Increasing the temperature at constant pressure.

(1)

	Effect on rate of reaction	Effect on yield of $\text{PCl}_5(\text{g})$
<input type="checkbox"/> A	increase	decrease
<input type="checkbox"/> B	decrease	decrease
<input type="checkbox"/> C	increase	increase
<input type="checkbox"/> D	decrease	increase

(b) Increasing the pressure at constant temperature.

(1)

	Effect on rate of reaction	Effect on yield of $\text{PCl}_5(\text{g})$
<input type="checkbox"/> A	increase	decrease
<input type="checkbox"/> B	decrease	decrease
<input type="checkbox"/> C	increase	increase
<input type="checkbox"/> D	decrease	increase

(Total for Question 13 = 2 marks)

14 A chloroalkane is heated with dilute aqueous sodium hydroxide and the pure organic product is obtained.

When the organic product is warmed with acidified potassium dichromate(VI) solution, there is no change in colour.

The chloroalkane could be

- A 1-chlorobutane
- B 2-chloro-2-methylpropane
- C 1-chloro-2-methylpropane
- D 2-chlorobutane

(Total for Question 14 = 1 mark)



15 This question is about two isomeric alcohols and two isomeric carbonyl compounds.

propan-1-ol,  $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$       and      propan-2-ol,  $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$

propanal,  $\text{CH}_3\text{CH}_2\text{CHO}$       and      propanone,  $\text{CH}_3\text{COCH}_3$

(a) Which reaction is possible?

(1)

- A reducing propan-1-ol to propanal
- B oxidising propan-1-ol to propanal
- C reducing propanal to propanone
- D oxidising propan-1-ol to propanone

(b) Which compound would be expected to give a significant peak at  $m/z = 31$  in its mass spectrum?

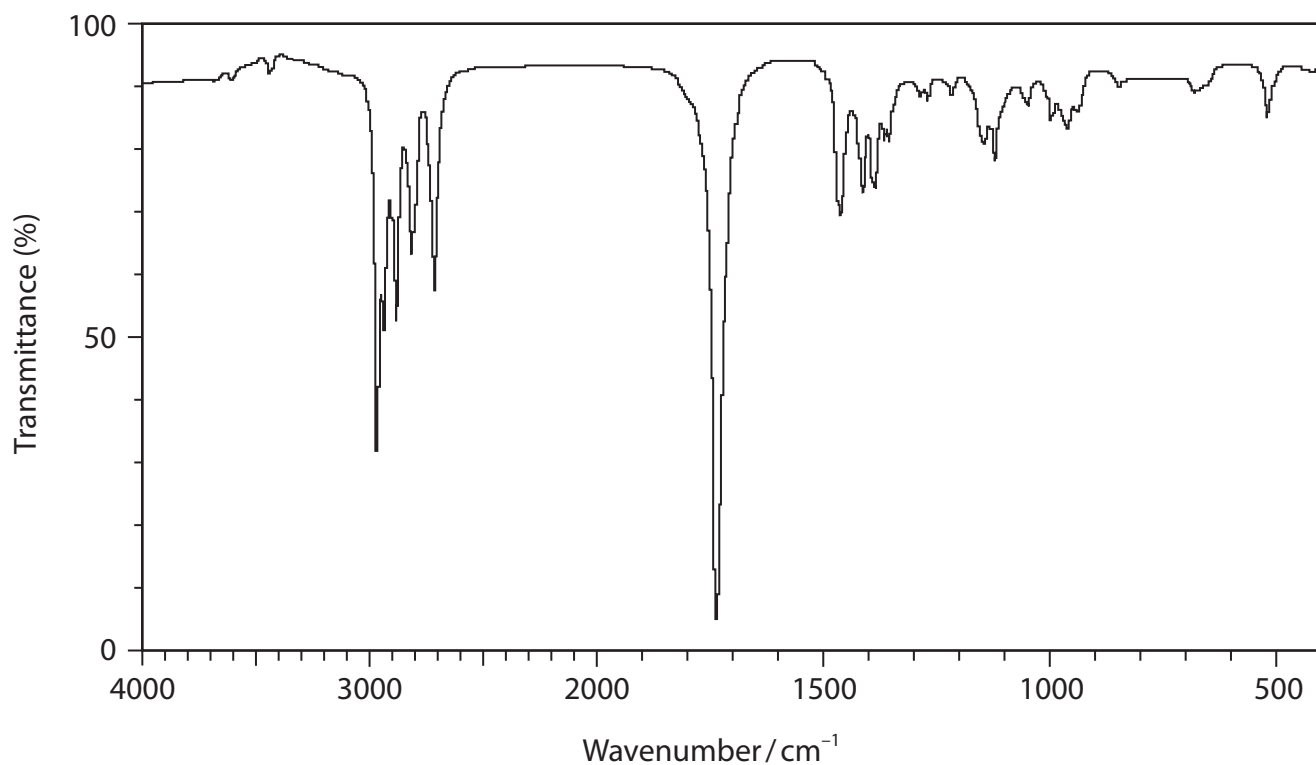
(1)

- A propan-1-ol
- B propan-2-ol
- C propanal
- D propanone





(c) The infrared spectrum of one of the four compounds is shown.



Identify the compound, using the infrared absorptions from the Data Booklet.

(1)

- A propan-1-ol
- B propan-2-ol
- C propanal
- D propanone

(Total for Question 15 = 3 marks)

**TOTAL FOR SECTION A = 20 MARKS**



## SECTION B

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

16 Group 2 hydroxides,  $M(OH)_2$ , are used to neutralise acids.

- (a) Write an equation for the reaction of calcium with cold water.  
State symbols are not required.

(1)

- (b) Explain why a saturated solution of calcium hydroxide is more alkaline than a saturated solution of magnesium hydroxide.

(2)

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- (c) A solution was tested for the presence of carbonate ions.

Dilute hydrochloric acid was added to the solution and the gas given off was bubbled through limewater (aqueous calcium hydroxide). A white precipitate formed.

- (i) Write the **ionic** equation for the formation of the gas.  
State symbols are not required.

(1)

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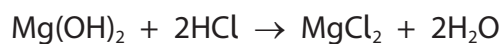
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- (ii) Write the equation for the formation of the precipitate.  
Include state symbols.

(2)

- (d) Magnesium hydroxide can be used to neutralise hydrochloric acid in the stomach to relieve acid indigestion.



Calculate the minimum mass of magnesium hydroxide needed to neutralise 0.150 mol of hydrochloric acid.

Give your answer to an appropriate number of significant figures.

(3)

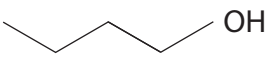
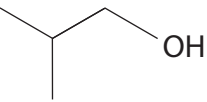
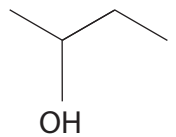
(Total for Question 16 = 9 marks)



17 Biobutanol is a possible alternative to bioethanol as an additive to petrol.

(a) (i) Complete the table for the four isomers of  $C_4H_9OH$  which are alcohols.

(3)

Skeletal formula	Name	Classification	Boiling temperature/ $^{\circ}C$
	butan-1-ol	primary	117
			108
			99
	2-methylpropan-2-ol		82

(ii) Explain the difference in boiling temperature between butan-1-ol and 2-methylpropan-2-ol.

(2)

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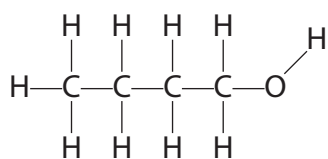
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(iii) The displayed formula of butan-1-ol is shown.

Complete the diagram to show the strongest intermolecular force between **two** molecules of butan-1-ol. Include the intermolecular bond angle.

(2)



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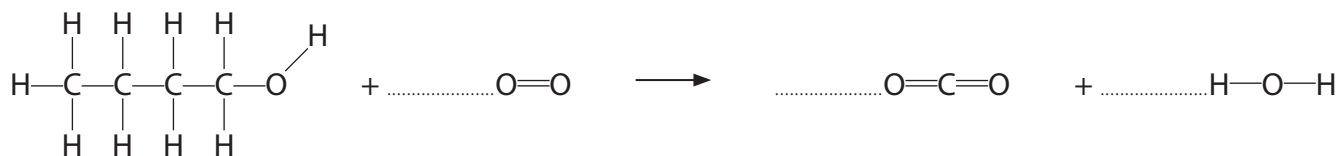
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- (b) (i) Complete the equation for the combustion of butan-1-ol.  
State symbols are not required.

(1)



- (ii) Calculate a value for the enthalpy change of combustion of butan-1-ol using the equation in (b)(i) and the mean bond enthalpies in the table.

(3)

Bond	C—C	C—O	C=O	C—H	O—H	O=O
Mean bond enthalpy/kJ mol <sup>-1</sup>	347	358	805	413	464	498



(iii) A data book value of the molar enthalpy change of combustion of butan-1-ol is  $-2670 \text{ kJ mol}^{-1}$

Give **two** reasons for the difference between this value and the value calculated in (b)(ii).

(2)

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(c) Biobutanol has some advantages over bioethanol.

(i) The combustion of bioethanol releases  $23 \text{ MJ dm}^{-3}$  compared to petrol which releases  $32 \text{ MJ dm}^{-3}$ .

Calculate the energy released in  $\text{MJ dm}^{-3}$  for the combustion of biobutanol.

Biofuel	Formula	$\Delta_c H / \text{kJ mol}^{-1}$	Density / $\text{g cm}^{-3}$
biobutanol	$\text{C}_4\text{H}_9\text{OH}$	-2670	0.810

(2)

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(ii) Biobutanol can be mixed with petrol in any proportion whereas bioethanol cannot.

Petrol is a mixture of liquid alkanes.

Explain why petrol is more miscible with biobutanol than with bioethanol.

(2)

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**(Total for Question 17 = 17 marks)**

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P 6 1 6 5 7 A 0 1 7 2 8

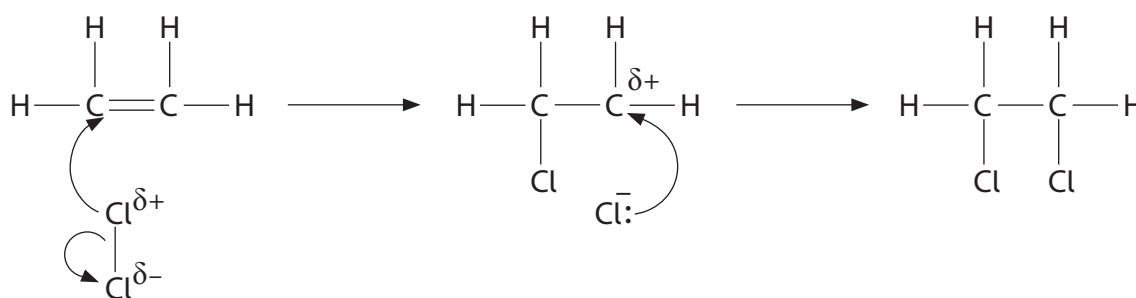
**18** Two different processes can be used for the production of chloroethene ( $\text{CH}_2=\text{CHCl}$ ), which is the monomer for the manufacture of poly(chloroethene).

(a) Process A

Ethene, produced from crude oil, reacts with chlorine gas to form 1,2-dichloroethane. The 1,2-dichloroethane is then thermally cracked to form chloroethene.



(i) A student wrote a mechanism for Reaction 1.



The mechanism contains two mistakes.

Identify each mistake, giving the correction that should be made.

(2)

Mistake 1.....

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Correction.....

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Mistake 2.....

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Correction.....

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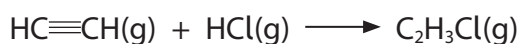


(ii) Write the overall equation for Process **A** and use it to calculate the percentage atom economy by mass for the production of chloroethene.

(3)

(b) Process **B**

In an alternative process, chloroethene is obtained by reacting ethyne ( $\text{HC}\equiv\text{CH}$ ), with hydrogen chloride. Ethyne is produced from coal. This reaction uses a catalyst of mercury(II) chloride which is highly toxic.



The temperature during this reaction is high enough to vaporise the mercury(II) chloride catalyst.

State how Process **A** compares to Process **B** in terms of the percentage atom economy by mass and environmental impact of each process. No calculation is needed.

(2)

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(Total for Question 18 = 13 marks)

**TOTAL FOR SECTION B = 39 MARKS**



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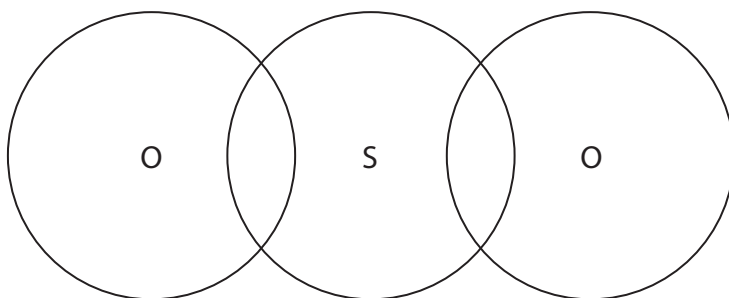
## SECTION C

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

19 Major volcanic eruptions, such as the one in Indonesia in 1815, eject large amounts of ash and gases into the atmosphere. The gases include carbon dioxide, water vapour, hydrogen chloride and sulfur dioxide.

- (a) (i) Complete the dot-and-cross diagram to show a possible arrangement of the outer shell electrons in a molecule of sulfur dioxide.  
Use dots (•) for the sulfur electrons and crosses (×) for the oxygen electrons.

(2)



- (ii) Suggest a value for the bond angle.

(1)

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P 6 1 6 5 7 A 0 2 3 2 8

(b) The levels of sulfur dioxide in the atmosphere can be measured by collection and titration with sodium hydroxide solution.

One possible method is:

- air containing sulfur dioxide is bubbled through hydrogen peroxide solution
- all the sulfur dioxide reacts to form  $40.0 \text{ cm}^3$  of dilute sulfuric acid, solution Z



- a pipette is used to remove  $10.0 \text{ cm}^3$  portions of solution Z
- each portion is titrated with  $0.00500 \text{ mol dm}^{-3}$  sodium hydroxide.

The results are shown in the table.

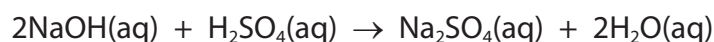
Titration	1	2	3
Final volume/ $\text{cm}^3$	21.55	42.70	21.05
Initial volume/ $\text{cm}^3$	0.00	21.55	0.00
Titre/ $\text{cm}^3$	21.55	21.15	21.05

The mean titre is  $21.10 \text{ cm}^3$

(i) Give a reason why a further titration was not attempted.

(1)

(ii) Calculate the number of moles of sulfuric acid in the  $40 \text{ cm}^3$  of solution Z.

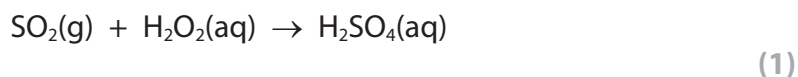


(3)





- (iii) Deduce the number of moles of sulfur dioxide bubbled through the hydrogen peroxide solution, using the answer from (b)(ii) and the equation



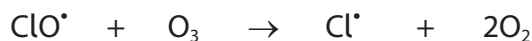
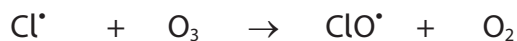
- (iv) The air containing sulfur dioxide was bubbled through the hydrogen peroxide solution at a rate of  $10 \text{ dm}^3 \text{ min}^{-1}$  for 30 minutes.

Calculate the concentration of sulfur dioxide in the air in parts per million (ppm) by volume.

The molar volume of a gas at r.t.p. is  $24 \text{ dm}^3 \text{ mol}^{-1}$ .

(3)

- (c) (i) During a volcanic eruption, hydrogen chloride gas is also released into the upper atmosphere, which in turn produces some chlorine free radicals. Chlorine free radicals react with ozone:



Derive the overall equation for this reaction of ozone.  
State symbols are not required.

(1)



- (ii) Give **two** reasons why the presence of a small number of chlorine free radicals in the upper atmosphere causes a large decrease in the amount of ozone.

(2)

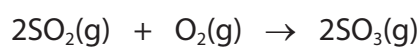
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- (d) (i) Sulfur dioxide is converted into sulfur trioxide in the upper atmosphere in the presence of ultraviolet light.



Show, by use of all the relevant oxidation numbers, that this is a redox reaction.

(2)

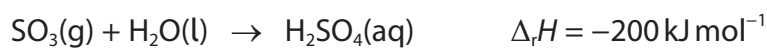
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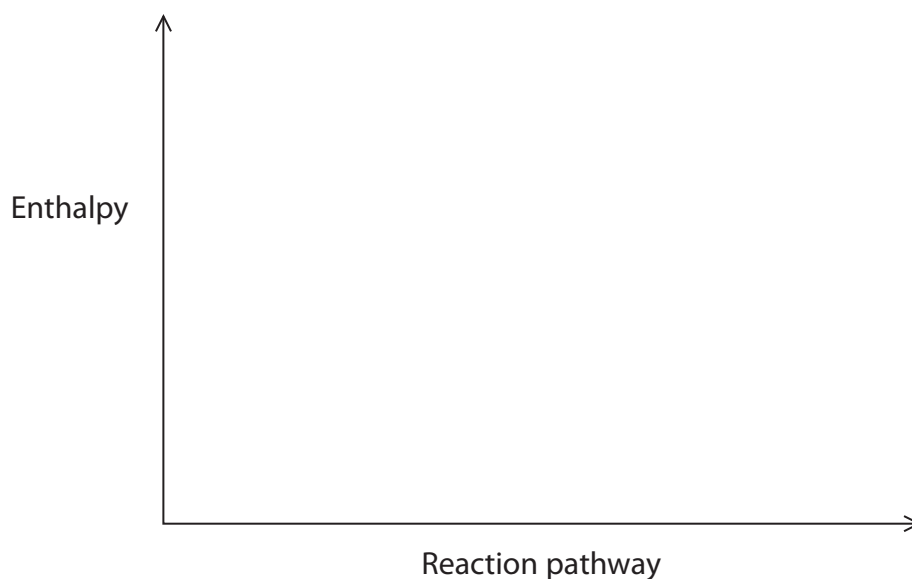
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- (ii) Sulfur trioxide reacts with water to produce sulfuric acid.



Draw an enthalpy level diagram to show the enthalpy change for this reaction.

(2)



(iii) Droplets of sulfuric acid are formed when sulfur trioxide reacts with water in the upper atmosphere. These droplets reflect ultraviolet radiation from the Sun back into space.

In the volcanic eruption in Indonesia in 1815, large amounts of both carbon dioxide and sulfur dioxide were released.  
During the following year, there were global low temperatures.

Assess the effect of **both** gases on global temperatures after the volcanic eruption.  
(3)

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**(Total for Question 19 = 21 marks)**

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

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# The Periodic Table of Elements

1      2      3      4      5      6      7      0 (8)

1.0	<b>H</b>							4.0
hydrogen	1							<b>He</b> helium 2

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)				
	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	54.9	<b>Mn</b> manganese 25	58.9	<b>Co</b> cobalt 27	63.5	<b>Zn</b> zinc 30	69.7	<b>Ga</b> gallium 31	72.6	<b>Ge</b> germanium 32	79.9	<b>Kr</b> krypton 36			
	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	[98]	<b>Tc</b> technetium 43	101.1	<b>Ru</b> ruthenium 44	106.4	<b>Cd</b> cadmium 48	114.8	<b>In</b> indium 49	118.7	<b>Sn</b> tin 50	127.6	<b>Te</b> tellurium 52	131.3	<b>Xe</b> xenon 54	
	39.1	<b>K</b> potassium 19	40.1	<b>Ca</b> calcium 20	180.9	<b>Ta</b> tantalum 73	178.5	<b>Hf</b> hafnium 72	186.2	<b>Re</b> rhenium 75	190.2	<b>Os</b> osmium 76	195.1	<b>Pt</b> platinum 78	204.4	<b>Pb</b> lead 82	207.2	<b>Po</b> polonium 84	[210]	<b>At</b> astatine 85	[222]	<b>Rn</b> radon 86	
	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	186.2	<b>Re</b> rhenium 75	190.2	<b>Os</b> osmium 76	195.1	<b>Pt</b> platinum 78	204.4	<b>Pb</b> lead 82	207.2	<b>Po</b> polonium 84	[210]	<b>At</b> astatine 85	[222]	<b>Rn</b> radon 86	
	132.9	<b>Cs</b> caesium 55	137.3	<b>Ba</b> barium 56	227	<b>Ac*</b> actinium 89	227	<b>Rf</b> rutherfordium 104	[261]	<b>Bh</b> bohrium 107	[277]	<b>Hs</b> hassium 108	[271]	<b>Ds</b> darmstadtium 110	272	<b>Rg</b> roentgenium 111							
	[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	[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

140	<b>Ce</b> cerium 58	141	<b>Pr</b> praseodymium 59	144	<b>Nd</b> neodymium 60	147	<b>Pm</b> promethium 61	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	[237]	<b>Np</b> neptunium 93	[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

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