

Please check the examination details below before entering your candidate information			
Candidate surname		Other names	
<b>Pearson Edexcel</b> <b>International</b> <b>Advanced Level</b>		Centre Number	Candidate Number
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<b>Friday 11 October 2019</b>			
Morning (Time: 1 hour 30 minutes)		Paper Reference <b>WCH12/01</b>	
<b>Chemistry</b> <b>International Advanced Subsidiary Level</b> <b>Unit 2: Energetics, Group Chemistry, Halogenoalkanes and Alcohols</b>			
<b>Candidates must have: Scientific calculator</b> <b>Data Booklet</b> <b>Ruler</b>			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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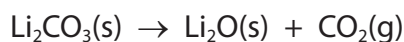
## SECTION A

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?

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

- ☐ 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)

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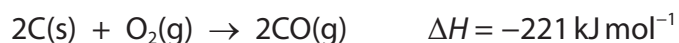
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- 3 Under certain conditions, graphite burns to form carbon monoxide.



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?

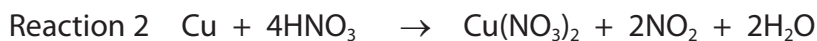
- ☐ A covalent bonds
- ☐ B hydrogen bonds
- ☐ C ionic bonds
- ☐ D London forces

(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)

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**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"/> <b>A</b>	increase	decrease
<input type="checkbox"/> <b>B</b>	decrease	decrease
<input type="checkbox"/> <b>C</b>	increase	increase
<input type="checkbox"/> <b>D</b>	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"/> <b>A</b>	increase	decrease
<input type="checkbox"/> <b>B</b>	decrease	decrease
<input type="checkbox"/> <b>C</b>	increase	increase
<input type="checkbox"/> <b>D</b>	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

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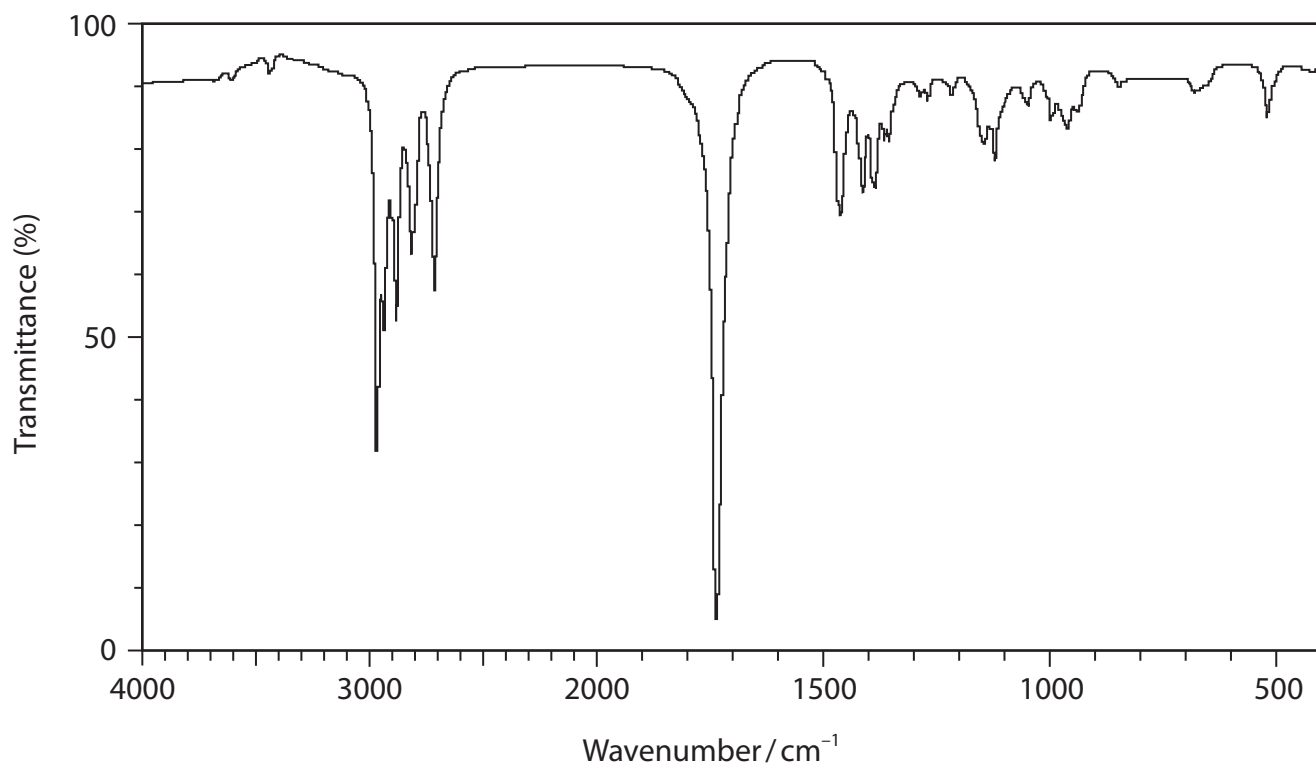
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(c) The infrared spectrum of one of the four compounds is shown.



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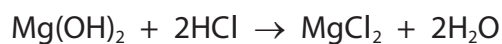
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- (ii) Write the equation for the formation of the precipitate.  
Include state symbols.

(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)

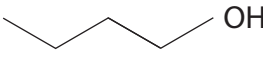
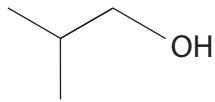
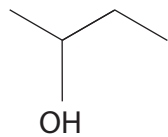
(Total for Question 16 = 9 marks)



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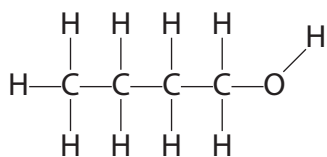
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(iii) The displayed formula of butan-1-ol is shown.

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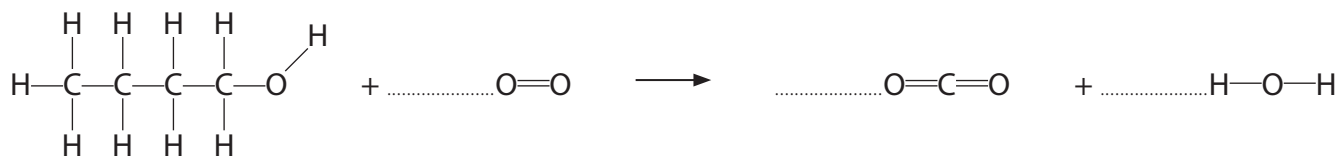
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- (b) (i) Complete the equation for the combustion of butan-1-ol.  
State symbols are not required.

(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)



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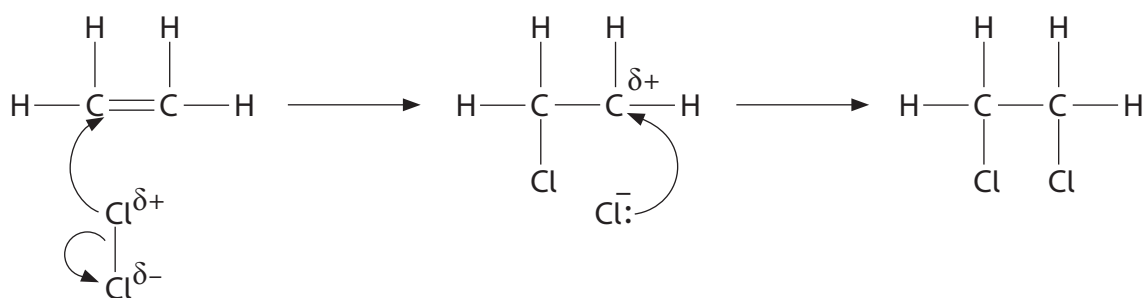
**18** Two different processes can be used for the production of chloroethene ( $\text{CH}_2=\text{CHCl}$ ), which is the monomer for the manufacture of poly(chloroethene).

(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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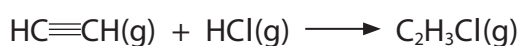


- (ii) Write the overall equation for Process **A** and use it to calculate the percentage atom economy by mass for the production of chloroethene.

(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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- \*(c) Process **B** involves gas molecules reacting at high temperature in the presence of a catalyst.

Explain the effects on the rate of reaction of increasing the temperature and using a catalyst in Process **B**, referring to a labelled diagram of the Maxwell-Boltzmann distribution.

(6)

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(Total for Question 18 = 13 marks)

**TOTAL FOR SECTION B = 39 MARKS**



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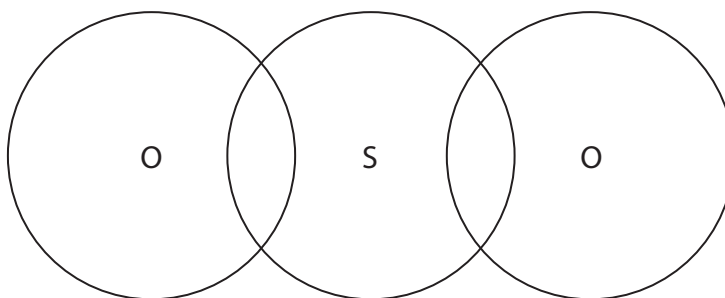
## SECTION C

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)



- (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 cm<sup>3</sup> of dilute sulfuric acid, solution Z



- a pipette is used to remove 10.0 cm<sup>3</sup> portions of solution Z
- each portion is titrated with 0.00500 mol dm<sup>-3</sup> sodium hydroxide.

The results are shown in the table.

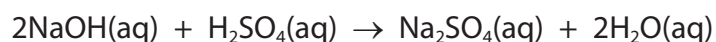
Titration	1	2	3
Final volume / cm <sup>3</sup>	21.55	42.70	21.05
Initial volume / cm <sup>3</sup>	0.00	21.55	0.00
Titre / cm <sup>3</sup>	21.55	21.15	21.05

The mean titre is 21.10 cm<sup>3</sup>

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

(1)

- (ii) Calculate the number of moles of sulfuric acid in the 40 cm<sup>3</sup> of solution Z.

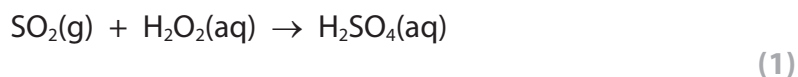


(3)





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



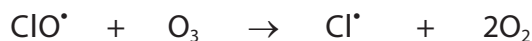
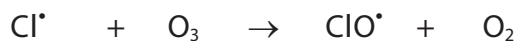
- (iv) The air containing sulfur dioxide was bubbled through the hydrogen peroxide solution at a rate of  $10 \text{ dm}^3 \text{ min}^{-1}$  for 30 minutes.

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)

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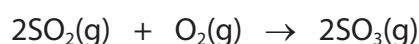
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- (d) (i) Sulfur dioxide is converted into sulfur trioxide in the upper atmosphere in the presence of ultraviolet light.



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

(2)

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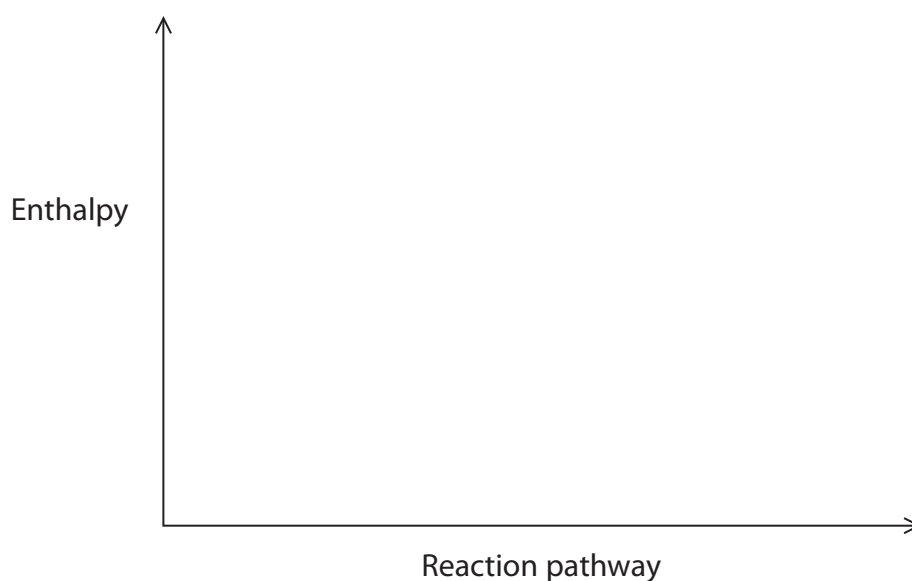
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- (ii) Sulfur trioxide reacts with water to produce sulfuric acid.



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

(2)



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- (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)

(Total for Question 19 = 21 marks)

**TOTAL FOR SECTION C = 21 MARKS**

**TOTAL FOR PAPER = 80 MARKS**



# The Periodic Table of Elements

1	2	3	4	5	6	7	0 (8)
1.0 H hydrogen 1							(18)
6.9 Li lithium 3	9.0 Be beryllium 4	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	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	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	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	204.4 Tl thallium 81	200.6 Hg mercury 80	207.2 Pb lead 82	209.0 Bi bismuth 83	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[227] La* lanthanum 57	[227] Pr praseodymium 59	[227] Nd neodymium 60	[227] Pm promethium 61	[227] Sm samarium 62
[227] Ce cerium 58	[227] Pr praseodymium 59	[227] Nd neodymium 60	[227] Pm promethium 61	[227] Sm samarium 62	[227] Eu europium 63	[227] Gd gadolinium 64	[227] Tb terbium 65
[227] Dy dysprosium 66	[227] Ho holmium 67	[227] Er erbium 68	[227] Tm thulium 69	[227] Yb ytterbium 70	[227] Lu lutetium 71	[227] Hf hafnium 72	[227] Ta tantalum 73
[227] W tungsten 74	[227] Re rhenium 75	[227] Os osmium 76	[227] Ir iridium 77	[227] Pt platinum 78	[227] Au gold 79	[227] Ag silver 80	[227] Cd cadmium 81
[227] Zn zinc 82	[227] Ga gallium 83	[227] Ge germanium 84	[227] As arsenic 85	[227] Se selenium 86	[227] Br bromine 87	[227] Kr krypton 88	[227] Xe xenon 89
[227] I iodine 90	[227] Te tellurium 91	[227] Sb antimony 92	[227] Sn tin 93	[227] Pb lead 94	[227] Bi bismuth 95	[227] Po polonium 96	[227] At astatine 97
[227] Rn radon 98	[227] Fr francium 99	[227] Ra radium 100	[227] Ac* actinium 101	[227] La* lanthanum 102	[227] Pr praseodymium 103	[227] Nd neodymium 104	[227] Pm promethium 105
[227] Ce cerium 106	[227] Pr praseodymium 107	[227] Nd neodymium 108	[227] Pm promethium 109	[227] Sm samarium 110	[227] Eu europium 111	[227] Gd gadolinium 112	[227] Tb terbium 113
[227] Dy dysprosium 114	[227] Ho holmium 115	[227] Er erbium 116	[227] Tm thulium 117	[227] Yb ytterbium 118	[227] Lu lutetium 119	[227] Hf hafnium 120	[227] Ta tantalum 121
[227] W tungsten 122	[227] Re rhenium 123	[227] Os osmium 124	[227] Ir iridium 125	[227] Pt platinum 126	[227] Au gold 127	[227] Ag silver 128	[227] Cd cadmium 129
[227] Zn zinc 130	[227] Ga gallium 131	[227] Ge germanium 132	[227] As arsenic 133	[227] Se selenium 134	[227] Br bromine 135	[227] Kr krypton 136	[227] Xe xenon 137
[227] I iodine 138	[227] Te tellurium 139	[227] Sb antimony 140	[227] Sn tin 141	[227] Pb lead 142	[227] Bi bismuth 143	[227] Po polonium 144	[227] At astatine 145
[227] Rn radon 146	[227] Fr francium 147	[227] Ra radium 148	[227] Ac* actinium 149	[227] La* lanthanum 150	[227] Pr praseodymium 151	[227] Nd neodymium 152	[227] Pm promethium 153
[227] Ce cerium 154	[227] Pr praseodymium 155	[227] Nd neodymium 156	[227] Pm promethium 157	[227] Sm samarium 158	[227] Eu europium 159	[227] Gd gadolinium 160	[227] Tb terbium 161
[227] Dy dysprosium 162	[227] Ho holmium 163	[227] Er erbium 164	[227] Tm thulium 165	[227] Yb ytterbium 166	[227] Lu lutetium 167	[227] Hf hafnium 168	[227] Ta tantalum 169
[227] W tungsten 170	[227] Re rhenium 171	[227] Os osmium 172	[227] Ir iridium 173	[227] Pt platinum 174	[227] Au gold 175	[227] Ag silver 176	[227] Cd cadmium 177
[227] Zn zinc 178	[227] Ga gallium 179	[227] Ge germanium 180	[227] As arsenic 181	[227] Se selenium 182	[227] Br bromine 183	[227] Kr krypton 184	[227] Xe xenon 185
[227] I iodine 186	[227] Te tellurium 187	[227] Sb antimony 188	[227] Sn tin 189	[227] Pb lead 190	[227] Bi bismuth 191	[227] Po polonium 192	[227] At astatine 193
[227] Rn radon 194	[227] Fr francium 195	[227] Ra radium 196	[227] Ac* actinium 197	[227] La* lanthanum 198	[227] Pr praseodymium 199	[227] Nd neodymium 200	[227] Pm promethium 201
[227] Ce cerium 202	[227] Pr praseodymium 203	[227] Nd neodymium 204	[227] Pm promethium 205	[227] Sm samarium 206	[227] Eu europium 207	[227] Gd gadolinium 208	[227] Tb terbium 209
[227] Dy dysprosium 210	[227] Ho holmium 211	[227] Er erbium 212	[227] Tm thulium 213	[227] Yb ytterbium 214	[227] Lu lutetium 215	[227] Hf hafnium 216	[227] Ta tantalum 217
[227] W tungsten 218	[227] Re rhenium 219	[227] Os osmium 220	[227] Ir iridium 221	[227] Pt platinum 222	[227] Au gold 223	[227] Ag silver 224	[227] Cd cadmium 225
[227] Zn zinc 226	[227] Ga gallium 227	[227] Ge germanium 228	[227] As arsenic 229	[227] Se selenium 230	[227] Br bromine 231	[227] Kr krypton 232	[227] Xe xenon 233
[227] I iodine 234	[227] Te tellurium 235	[227] Sb antimony 236	[227] Sn tin 237	[227] Pb lead 238	[227] Bi bismuth 239	[227] Po polonium 240	[227] At astatine 241
[227] Rn radon 242	[227] Fr francium 243	[227] Ra radium 244	[227] Ac* actinium 245	[227] La* lanthanum 246	[227] Pr praseodymium 247	[227] Nd neodymium 248	[227] Pm promethium 249
[227] Ce cerium 250	[227] Pr praseodymium 251	[227] Nd neodymium 252	[227] Pm promethium 253	[227] Sm samarium 254	[227] Eu europium 255	[227] Gd gadolinium 256	[227] Tb terbium 257
[227] Dy dysprosium 258	[227] Ho holmium 259	[227] Er erbium 260	[227] Tm thulium 261	[227] Yb ytterbium 262	[227] Lu lutetium 263	[227] Hf hafnium 264	[227] Ta tantalum 265
[227] W tungsten 266	[227] Re rhenium 267	[227] Os osmium 268	[227] Ir iridium 269	[227] Pt platinum 270	[227] Au gold 271	[227] Ag silver 272	[227] Cd cadmium 273
[227] Zn zinc 274	[227] Ga gallium 275	[227] Ge germanium 276	[227] As arsenic 277	[227] Se selenium 278	[227] Br bromine 279	[227] Kr krypton 280	[227] Xe xenon 281
[227] I iodine 282	[227] Te tellurium 283	[227] Sb antimony 284	[227] Sn tin 285	[227] Pb lead 286	[227] Bi bismuth 287	[227] Po polonium 288	[227] At astatine 289
[227] Rn radon 290	[227] Fr francium 291	[227] Ra radium 292	[227] Ac* actinium 293	[227] La* lanthanum 294	[227] Pr praseodymium 295	[227] Nd neodymium 296	[227] Pm promethium 297
[227] Ce cerium 298	[227] Pr praseodymium 299	[227] Nd neodymium 300	[227] Pm promethium 301	[227] Sm samarium 302	[227] Eu europium 303	[227] Gd gadolinium 304	[227] Tb terbium 305
[227] Dy dysprosium 306	[227] Ho holmium 307	[227] Er erbium 308	[227] Tm thulium 309	[227] Yb ytterbium 310	[227] Lu lutetium 311	[227] Hf hafnium 312	[227] Ta tantalum 313
[227] W tungsten 314	[227] Re rhenium 315	[227] Os osmium 316	[227] Ir iridium 317	[227] Pt platinum 318	[227] Au gold 319	[227] Ag silver 320	[227] Cd cadmium 321
[227] Zn zinc 322	[227] Ga gallium 323	[227] Ge germanium 324	[227] As arsenic 325	[227] Se selenium 326	[227] Br bromine 327	[227] Kr krypton 328	[227] Xe xenon 329
[227] I iodine 330	[227] Te tellurium 331	[227] Sb antimony 332	[227] Sn tin 333	[227] Pb lead 334	[227] Bi bismuth 335	[227] Po polonium 336	[227] At astatine 337
[227] Rn radon 338	[227] Fr francium 339	[227] Ra radium 340	[227] Ac* actinium 341	[227] La* lanthanum 342	[227] Pr praseodymium 343	[227] Nd neodymium 344	[227] Pm promethium 345
[227] Ce cerium 346	[227] Pr praseodymium 347	[227] Nd neodymium 348	[227] Pm promethium 349	[227] Sm samarium 350	[227] Eu europium 351	[227] Gd gadolinium 352	[227] Tb terbium 353
[227] Dy dysprosium 354	[227] Ho holmium 355	[227] Er erbium 356	[227] Tm thulium 357	[227] Yb ytterbium 358	[227] Lu lutetium 359	[227] Hf hafnium 360	[227] Ta tantalum 361
[227] W tungsten 362	[227] Re rhenium 363	[227] Os osmium 364	[227] Ir iridium 365	[227] Pt platinum 366	[227] Au gold 367	[227] Ag silver 368	[227] Cd cadmium 369
[227] Zn zinc 370	[227] Ga gallium 371	[227] Ge germanium 372	[227] As arsenic 373	[227] Se selenium 374	[227] Br bromine 375	[227] Kr krypton 376	[227] Xe xenon 377
[227] I iodine 378	[227] Te tellurium 379	[227] Sb antimony 380	[227] Sn tin 381	[227] Pb lead 382	[227] Bi bismuth 383	[227] Po polonium 384	[227] At astatine 385
[227] Rn radon 386	[227] Fr francium 387	[227] Ra radium 388	[227] Ac* actinium 389	[227] La* lanthanum 390	[227] Pr praseodymium 391	[227] Nd neodymium 392	[227] Pm promethium 393
[227] Ce cerium 394	[227] Pr praseodymium 395	[227] Nd neodymium 396	[227] Pm promethium 397	[227] Sm samarium 398	[227] Eu europium 399	[227] Gd gadolinium 400	[227] Tb terbium 401
[227] Dy dysprosium 402	[227] Ho holmium 403	[227] Er erbium 404	[227] Tm thulium 405	[227] Yb ytterbium 406	[227] Lu lutetium 407	[227] Hf hafnium 408	[227] Ta tantalum 409
[227] W tungsten 410	[227] Re rhenium 411	[227] Os osmium 412	[227] Ir iridium 413	[227] Pt platinum 414	[227] Au gold 415	[227] Ag silver 416	[227] Cd cadmium 417
[227] Zn zinc 418	[227] Ga gallium 419	[227] Ge germanium 420	[227] As arsenic 421	[227] Se selenium 422	[227] Br bromine 423	[227] Kr krypton 424	[227] Xe xenon 425
[227] I iodine 426	[227] Te tellurium 427	[227] Sb antimony 428	[227] Sn tin 429	[227] Pb lead 430	[227] Bi bismuth 431	[227] Po polonium 432	[227] At astatine 433
[227] Rn radon 434	[227] Fr francium 435	[227] Ra radium 436	[227] Ac* actinium 437	[227] La* lanthanum 438	[227] Pr praseodymium 439	[227] Nd neodymium 440	[227] Pm promethium 441
[227] Ce cerium 442	[227] Pr praseodymium 443	[227] Nd neodymium 444	[227] Pm promethium 445	[227] Sm samarium 446	[227] Eu europium 447	[227] Gd gadolinium 448	[227] Tb terbium 449
[227] Dy dysprosium 450	[227] Ho holmium 451	[227] Er erbium 452	[227] Tm thulium 453	[227] Yb ytterbium 454	[227] Lu lutetium 455	[227] Hf hafnium 456	[227] Ta tantalum 457
[227] W tungsten 458	[227] Re rhenium 459	[227] Os osmium 460	[227] Ir iridium 461	[227] Pt platinum 462	[227] Au gold 463	[227] Ag silver 464	[227] Cd cadmium 465
[227] Zn zinc 466	[227] Ga gallium 467	[227] Ge germanium 468	[227] As arsenic 469	[227] Se selenium 470	[227] Br bromine 471	[227] Kr krypton 472	[227] Xe xenon 473
[227] I iodine 474	[227] Te tellurium 475	[227] Sb antimony 476	[227] Sn tin 477	[227] Pb lead 478	[227] Bi bismuth 479	[227] Po polonium 480	[227] At astatine 481
[227] Rn radon 482	[227] Fr francium 483	[227] Ra radium 484	[227] Ac* actinium 485	[227] La* lanthanum 486	[227] Pr praseodymium 487	[227] Nd neodymium 488	[227] Pm promethium 489
[227] Ce cerium 490	[227] Pr praseodymium 491	[227] Nd neodymium 492	[227] Pm promethium 493	[227] Sm samarium 494	[227] Eu europium 495	[227] Gd gadolinium 496	[227] Tb terbium 497
[227] Dy dysprosium 498	[227] Ho holmium 499	[227] Er erbium 500	[227] Tm thulium 501	[227] Yb ytterbium 502	[227] Lu lutetium 503	[227] Hf hafnium 504	[227] Ta tantalum 505
[227] W tungsten 506	[227] Re rhenium 507	[227] Os osmium 508	[227] Ir iridium 509	[227] Pt platinum 510	[227] Au gold 511	[227] Ag silver 512	[227] Cd cadmium 513
[227] Zn zinc 514	[227] Ga gallium 515	[227] Ge germanium 516	[227] As arsenic 517	[227] Se selenium 518	[227] Br bromine 519	[227] Kr krypton 520	[227] Xe xenon 521
[227] I iodine 522	[227] Te tellurium 523	[227] Sb antimony 524	[227] Sn tin 525	[227] Pb lead 526	[227] Bi bismuth 527	[227] Po polonium 528	[227] At astatine 529
[227] Rn radon 530	[227] Fr francium 531	[227] Ra radium 532	[227] Ac* actinium 533	[227] La* lanthanum 534	[227] Pr praseodymium 535	[227] Nd neodymium 536	[227] Pm promethium 537
[227] Ce cerium 538	[227] Pr praseodymium 539	[227] Nd neodymium 540	[227] Pm promethium 541	[227] Sm samarium 542	[227] Eu europium 543	[227] Gd gadolinium 544	[227] Tb terbium 545
[227] Dy dysprosium 546	[227] Ho holmium 547	[227] Er erbium 548	[227] Tm thulium 549	[227] Yb ytterbium 550	[227] Lu lutetium 551	[227] Hf hafnium 552	[227] Ta tantalum 553