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Candidate surname	Other names

Pearson Edexcel
International Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

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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P 6 1 6 5 7 A 0 1 2 8

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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.

$$Li_2CO_3(s) \rightarrow Li_2O(s) + CO_2(g)$$

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

[M_r Li_2CO_3 = 73.8 Molar volume of a gas at r.t.p. = 24.0 $dm^3\,mol^{-1}$]

☒ **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, CH_2ClCH_2Cl, contains only the isotopes ^{1}H, ^{12}C, ^{35}Cl and ^{37}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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3 Under certain conditions, graphite burns to form carbon monoxide.

$$2C(s) + O_2(g) \rightarrow 2CO(g) \qquad \Delta H = -221\ kJ\,mol^{-1}$$

Which of these is correct?

☒ **A** $\Delta_c H$ (carbon) $= -221\ kJ\,mol^{-1}$

☒ **B** $\Delta_f H$ (carbon monoxide) $= -221\ kJ\,mol^{-1}$

☒ **C** $\Delta_c H$ (carbon) $= -110.5\ kJ\,mol^{-1}$

☒ **D** $\Delta_f H$ (carbon monoxide) $= -110.5\ kJ\,mol^{-1}$

(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.

Reaction 1 $2Cu^{2+} + 4I^- \rightarrow 2CuI + I_2$

Reaction 2 $Cu + 4HNO_3 \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$

Reaction 3 $2Cu^+ \rightarrow Cu + Cu^{2+}$

Reaction 4 $CuO + H_2SO_4 \rightarrow CuSO_4 + H_2O$

(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)

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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** $SrBr_2$
- ☒ **B** NaBr
- ☒ **C** LiCl
- ☒ **D** BaI_2

(Total for Question 8 = 1 mark)

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

(a) What is the concentration, in 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 ± 0.05 cm^3.

What is the percentage uncertainty in measuring 50.00 cm^3 of the nitric acid?

(1)

- ☒ **A** ± 0.40%
- ☒ **B** ± 0.20%
- ☒ **C** ± 0.10%
- ☒ **D** ± 0.05%

(Total for Question 9 = 2 marks)

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

- ☒ **A** NaCl and NaClO
- ☒ **B** NaClO and $NaClO_3$
- ☒ **C** NaCl and $NaClO_3$
- ☒ **D** NaClO and $NaClO_4$

(Total for Question 10 = 1 mark)

11 Potassium iodide reacts with concentrated sulfuric acid.

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

- ☒ **A** H_2S
- ☒ **B** I_2
- ☒ **C** S
- ☒ **D** SO_3

(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.

$$PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g) \qquad \Delta H = -88\,kJ\,mol^{-1}$$

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 $PCl_5(g)$
☒ **A**	increase	decrease
☒ **B**	decrease	decrease
☒ **C**	increase	increase
☒ **D**	decrease	increase

(b) Increasing the pressure at constant temperature.

(1)

	Effect on rate of reaction	Effect on yield of $PCl_5(g)$
☒ **A**	increase	decrease
☒ **B**	decrease	decrease
☒ **C**	increase	increase
☒ **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)

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

propan-1-ol, $CH_3CH_2CH_2OH$ and propan-2-ol, $CH_3CH(OH)CH_3$

propanal, CH_3CH_2CHO and propanone, CH_3COCH_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

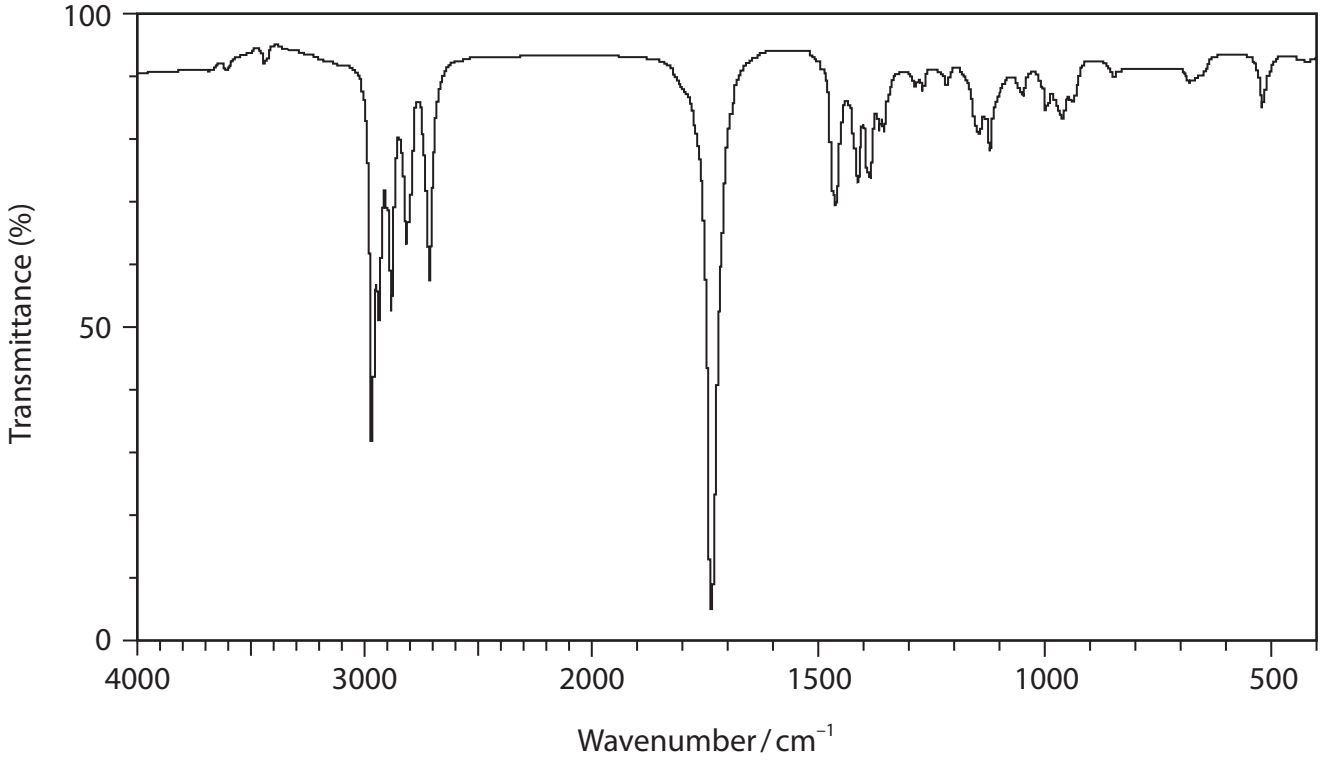
☒ **D** propanone

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(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

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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)

(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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(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.

$$Mg(OH)_2 + 2HCl \rightarrow MgCl_2 + 2H_2O$$

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)

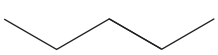
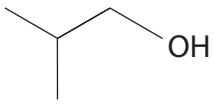
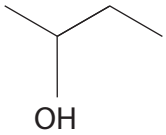
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17 Biobutanol is a possible alternative to bioethanol as an additive to petrol.

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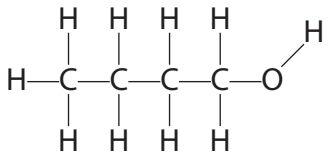
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(iii) The displayed formula of butan-1-ol is shown.

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

(2)

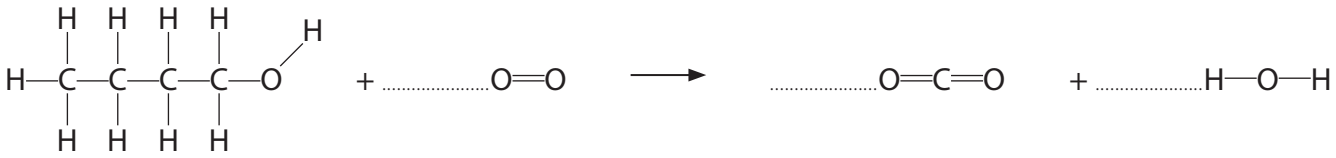


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(b) (i) Complete the equation for the combustion of butan-1-ol.
State symbols are not required.

(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^{-1}	347	358	805	413	464	498

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

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 $23\,MJ\,dm^{-3}$ compared to petrol which releases $32\,MJ\,dm^{-3}$.

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

Biofuel	Formula	$\Delta_c H$ / kJ mol^{-1}	Density / g cm^{-3}
biobutanol	C_4H_9OH	−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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18 Two different processes can be used for the production of chloroethene ($CH_2{=}CHCl$), which is the monomer for the manufacture of poly(chloroethene).

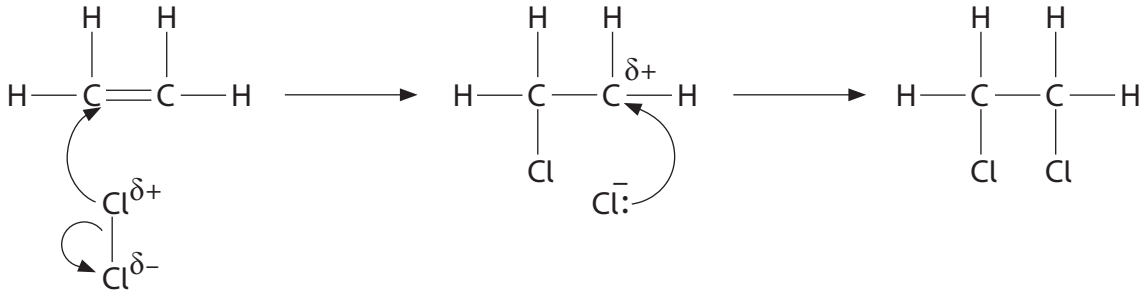
(a) Process **A**

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.

$$C_2H_4(g) + Cl_2(g) \xrightarrow{\text{Reaction } \mathbf{1}} C_2H_4Cl_2(g)$$

$$C_2H_4Cl_2(g) \xrightarrow{\text{Reaction } \mathbf{2}} C_2H_3Cl(g) + HCl(g)$$

(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 .....

.....

Correction .....

.....

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 (HC≡CH), with hydrogen chloride. Ethyne is produced from coal. This reaction uses a catalyst of mercury(II) chloride which is highly toxic.

$$HC{\equiv}CH(g) + HCl(g) \longrightarrow C_2H_3Cl(g)$$

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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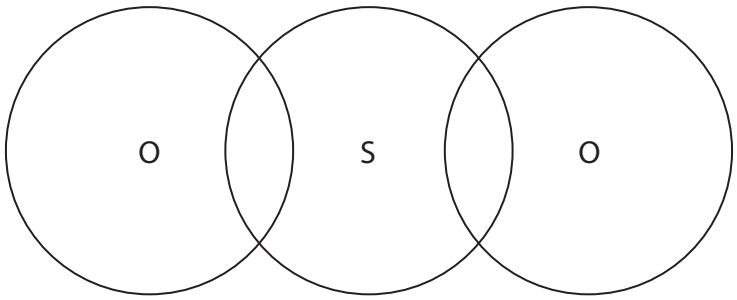
SECTION C

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)

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(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^3 of dilute sulfuric acid, solution Z

$$SO_2(g) + H_2O_2(aq) \rightarrow H_2SO_4(aq)$$

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

The results are shown in the table.

Titration	1	2	3
Final volume / cm^3	21.55	42.70	21.05
Initial volume / cm^3	0.00	21.55	0.00
Titre / cm^3	21.55	21.15	21.05

The mean titre is 21.10 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 cm^3 of solution Z.

$$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(aq)$$

(3)

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

$$SO_2(g) + H_2O_2(aq) \rightarrow H_2SO_4(aq)$$

(1)

(iv) The air containing sulfur dioxide was bubbled through the hydrogen peroxide solution at a rate of $10\,dm^3\,min^{-1}$ 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 $24\,dm^3\,mol^{-1}$.

(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:

$$Cl^{\bullet} + O_3 \rightarrow ClO^{\bullet} + O_2$$

$$ClO^{\bullet} + O_3 \rightarrow Cl^{\bullet} + 2O_2$$

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)

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

$$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$$

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

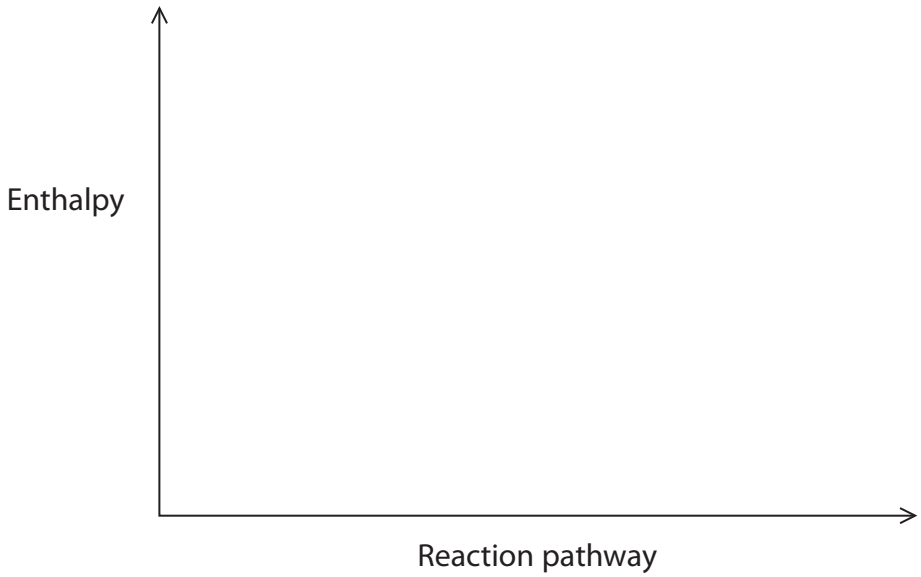
(2)

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

$$SO_3(g) + H_2O(l) \rightarrow H_2SO_4(aq) \qquad \Delta_r H = -200\,kJ\,mol^{-1}$$

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)
																	(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)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

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
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

* Lanthanide series

* Actinide series

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