聖 嬰 中 學
HOLY INNOCENTS' HIGH SCHOOL

Established in 1892

Name of Student

Class | Index Number

/ 80

PRELIMINARY EXAMINATION 2020
SECONDARY 4 EXPRESS
CHEMISTRY Paper 2 6092/02

Date: 27 Aug 2020
Duration: 1 HR 45 MIN
Time: 0800 – 0945

Additional Materials: *Nil*

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use paper clips, glue or correction tape/fluid.

Section A
Answer **all** questions.
Write your answers in the spaces provided on the question paper.

Section B
Answer **all three** questions, the last question is in the form either/or.
Write your answers in the spaces provided.

Information for Candidates
A copy of the Periodic Table is printed on page 2.

You are advised to spend no longer than 65 minutes on Section **A** and no longer than 40 minutes on Section **B**.
For Sections **A** and **B**, the number of marks is given in brackets [ ] at the end of each question or part question.

	For Examiner's use
Sect A	
Sect B	
Total	

Set by: Mr Daniel Lau
Vetted by: Mrs Sheryl Mok

The Periodic Table of the Elements

Group																	
I	**II**											**III**	**IV**	**V**	**VI**	**VII**	**0**
							1 **H** hydrogen 1										2 **He** helium 4
			key														
3 **Li** lithium 7	4 **Be** beryllium 9		proton (atomic) number atomic symbol name relative atomic mass									5 **B** boron 11	6 **C** carbon 12	7 **N** nitrogen 14	8 **O** oxygen 16	9 **F** fluorine 19	10 **Ne** neon 20
11 **Na** sodium 23	12 **Mg** magnesium 24											13 **Al** aluminium 27	14 **Si** silicon 28	15 **P** phosphorus 31	16 **S** sulfur 32	17 **Cl** chlorine 35.5	18 **Ar** argon 40
19 **K** potassium 39	20 **Ca** calcium 40	21 **Sc** scandium 45	22 **Ti** titanium 48	23 **V** vanadium 51	24 **Cr** chromium 52	25 **Mn** manganese 55	26 **Fe** iron 56	27 **Co** cobalt 59	28 **Ni** nickel 59	29 **Cu** copper 64	30 **Zn** zinc 65	31 **Ga** gallium 70	32 **Ge** germanium 73	33 **As** arsenic 75	34 **Se** selenium 79	35 **Br** bromine 80	36 **Kr** krypton 84
37 **Rb** rubidium 85	38 **Sr** strontium 88	39 **Y** yitrium 89	40 **Zr** zirconium 91	41 **Nb** niobium 93	42 **Mo** molybdenum 96	43 **Tc** technetium -	44 **Ru** ruthenium 101	45 **Rh** rhodium 103	46 **Pd** palladium 106	47 **Ag** silver 108	48 **Cd** cadmium 112	49 **In** indium 115	50 **Sn** tin 119	51 **Sb** antimony 122	52 **Te** tellurium 128	53 **I** iodine 127	54 **Xe** xenon 131
55 **Cs** caesium 133	56 **Ba** barium 137	57 – 71 lanthanoids	72 **Hf** hafnium 178	73 **Ta** tantalum 181	74 **W** tungsten 184	75 **Re** rhenium 186	76 **Os** osmium 190	77 **Ir** iridium 192	78 **Pt** platinum 195	79 **Au** gold 197	80 **Hg** mercury 201	81 **Tl** thallium 204	82 **Pb** lead 207	83 **Bi** bismuth 209	84 **Po** polonium -	85 **At** astatine -	86 **Rn** radon -
87 **Fr** francium -	88 **Ra** radium -	89 - 103 actinoids	104 **Rf** Rutherfordium -	105 **Db** dubnium -	106 **Sg** seaborgium -	107 **Bh** bohrium -	108 **Hs** hassium -	109 **Mt** meitnerium -	110 **Ds** darmstadtium -	111 **Rg** roentgenium -	112 **Cn** copernicium -		114 **Fl** flerovium -		116 **Lv** livermorium -		

lanthanoids	57 **La** lanthanum 139	58 **Ce** cerium 140	59 **Pr** praseodymium 141	60 **Nd** neodymium 144	61 **Pm** promethium -	62 **Sm** samarium 150	63 **Eu** europium 152	64 **Gd** gadolinium 157	65 **Tb** terbium 159	66 **Dy** dysprosium 163	67 **Ho** holmium 165	68 **Er** erbium 167	69 **Tm** thulium 169	70 **Yb** ytterbium 173	71 **Lu** lutetium 175
actinoids	89 **Ac** actinium -	90 **Th** thorium 232	91 **Pa** protactinium 231	92 **U** uranium 238	93 **Np** neptunium -	94 **Pu** plutonium -	95 **Am** americium -	96 **Cm** curium -	97 **Bk** berkelium -	98 **Cf** californium -	99 **Es** einsteinium -	100 **Fm** fermium -	101 **Md** mendelevium -	102 **No** nobelium -	103 **Lr** lawrencium -

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.)

Section A [50 marks]
Answer **all** questions in this section. Write your answer in the spaces provided.

A1 Fig. A1.1 below shows part of the Periodic Table.

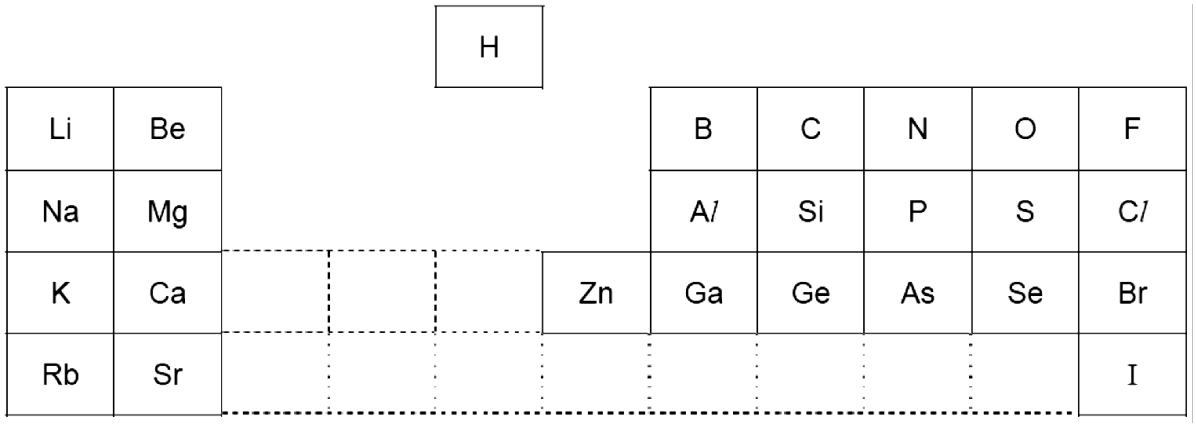


Fig. A1.1

Answer these questions using only the elements shown in the diagram. Each element can be used once, more than once or not at all.

(a) Which element has an atom with only seven protons in its nucleus?

…….. [1]

(b) Which element forms an ion with a charge of +2 and has only one completely filled shell of electrons?

…….. [1]

(c) Which element combines with oxygen to form a giant molecular structure?

…….. [1]

(d) Which element exists as a diatomic molecule with 4 shared electrons?

…….. [1]

(e) Which two elements in Period 3 form a covalent compound with the formula of the type $\mathbf{YZ_3}$?

…….. [1]

[Total: 5]

A2 A sample of black ink contains a mixture of red, blue and yellow dyes. A mixture of ethanol and water is usually used as the solvent for paper chromatography to separate the dyes in black ink. The coloured dyes have different R_f values in solvents with different compositions of ethanol as shown in Fig. A2.1.

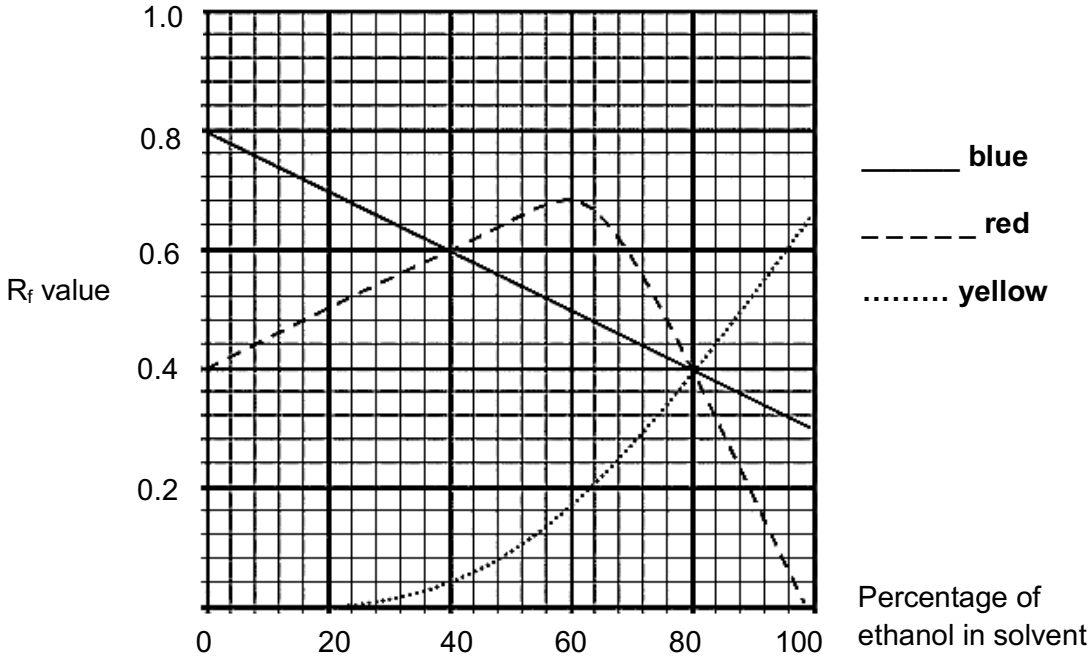


Fig. A2.1

(a) State the R_f value of blue dye on the chromatogram when the solvent is a mixture of 200 cm^3 of ethanol and 300 cm^3 of water.

…….. [1]

(b) Using evidence from Fig. A2.1, explain why a pure solvent of either water or ethanol is **not** suitable for the separation of the black ink.

…….....

…….....

…….....

…….. [2]

(c) A student carried out paper chromatography on the black ink using a mixture of ethanol and water as the solvent. He concluded that the black ink was a pure substance as there was only one spot forming on his resulting chromatogram. Using information from Fig. A2.1, state the percentage of ethanol where only one spot was formed and explain what caused him to draw the wrong conclusion.

……

……

…… [2]

[Total: 5]

A3 Aqueous sodium hydroxide is gradually added to dilute sulfuric acid until it is in excess. The temperature of the mixture rises initially as sodium hydroxide is added to the sulfuric acid. It then reaches a maximum and eventually falls as more sodium hydroxide is added. The graph in Fig. A3.1 shows how the temperature of the mixture varies with the volume of aqueous sodium hydroxide added.

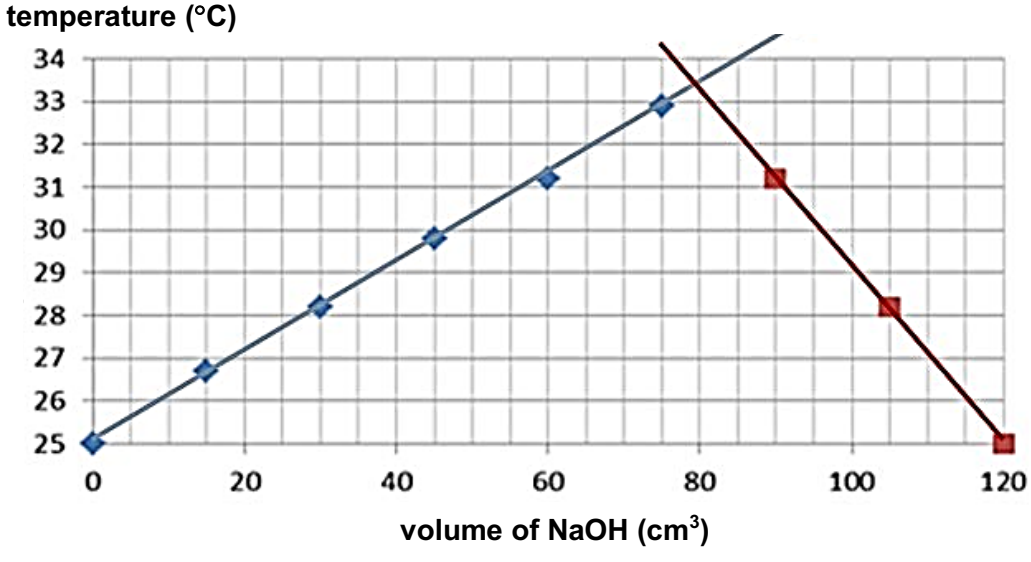


Fig. A3.1

(a) Why does the temperature rise initially and fall subsequently?

……

……

…… [2]

(b) What is the volume of aqueous sodium hydroxide that gives the highest temperature reading?

…… [1]

(c) Suggest whether the value in **(b)** will be higher/remains the same/be lower if the same reaction is carried out with the same concentration of hydrochloric acid instead. Briefly explain your answer.

……

……

……

…….. [2]

(d) When the reaction is repeated with lead(II) hydroxide, the temperature of the mixture rises initially as well but stopped after a minute. Suggest why this is the case.

……

……

……

…….. [2]

[Total: 7]

A4 The labels of three bottles each containing a colourless solution fell off. These three solutions are known to be solutions of sulfuric acid, silver nitrate and sodium carbonate. Table A4.1 shows the observations when the solutions were mixed.

Table A4.1

solutions mixed together	observation
solution **1** + solution **2**	Effervescence is observed.
solution **1** + solution **3**	No visible reaction.
solution **2** + solution **3**	White precipitate is formed.

Identify the three solutions.

solution **1**: ……

solution **2**: ……

solution **3**: …… [3]

[Total: 3]

A5 Calcium oxide, commonly known as quicklime, dissolves in water to produce calcium hydroxide, which is a strong alkali. The equation is shown below.

$$CaO\ (s) + H_2O\ (l) \rightarrow Ca(OH)_2\ (aq)$$

(a) Define the term "strong alkali".

……

…… [1]

(b) Name the white precipitate formed when carbon dioxide gas is bubbled through the product of the reaction above.

…… [1]

(c) Predict if there will be a similar reaction when sulfur dioxide gas is bubbled through the product of the reaction above, and explain your prediction.

……

……

…… [2]

[Total: 4]

A6 Elements, with atomic numbers from 87 to 118, are found in Period 7 of the Periodic table.

(a) One of the elements, with atomic number 87, is Francium. Francium is used for diagnostics for curing cancers.

(i) State the appearance of Francium.

…… [1]

(ii) The most common isotope of Francium is ^{223}Fr. State what is meant by the term "isotope".

……

…… [1]

(iii) Write a chemical equation to show what would happen if francium is not stored in a moisture-free environment.

…… [1]

(b) Another element, with atomic number 117, was named Tennessine, Ts.

(i) With reference to the Periodic Table, state the group you would expect Tennessine to be found.

…….. [1]

(ii) A student predicted that Tennessine would have similar chemical properties as chlorine. Explain if you would agree with the prediction.
Hence, or otherwise, write down the formula of the Tennessine ion.

……

……

…….. [2]
[Total: 6]

A7 Ammonia is produced industrially by reacting nitrogen, extracted from liquified air, with hydrogen, obtained by cracking petroleum.

(a) Iron is also used in the production process of ammonia. State the role of iron in the industrial production of ammonia and explain how it affects the product yield.

……

……

…….. [2]

(b) Ammonia is used to manufacture nitric acid by a two-stage process.
Stage 1: $4\ NH_3\ (g) + 5\ O_2\ (g) \rightarrow 4\ NO\ (g) + 6\ H_2O\ (g)$
Stage 2: $4\ NO\ (g) + 2\ H_2O\ (g) + 3\ O_2\ (g) \rightarrow 4\ HNO_3\ (aq)$

(i) Explain why the reaction in stage 1 is a redox reaction, in terms of oxidation state.

……

……

……

……

…….. [3]

(ii) Calculate the maximum mass of nitric acid which can be made from 600 dm^3 of ammonia at room temperature and pressure. [2]

[Total: 7]

A8 In Fig. A8.1, Graph **A** shows the volume of carbon dioxide given off when 1.00 g of powdered calcium carbonate were reacted with excess hydrochloric acid at room temperature.

This experiment was repeated four times with one experimental condition modified from the initial experiment each time. Graphs **B** to **E** show the volumes of carbon dioxide given off for the repeat experiments.

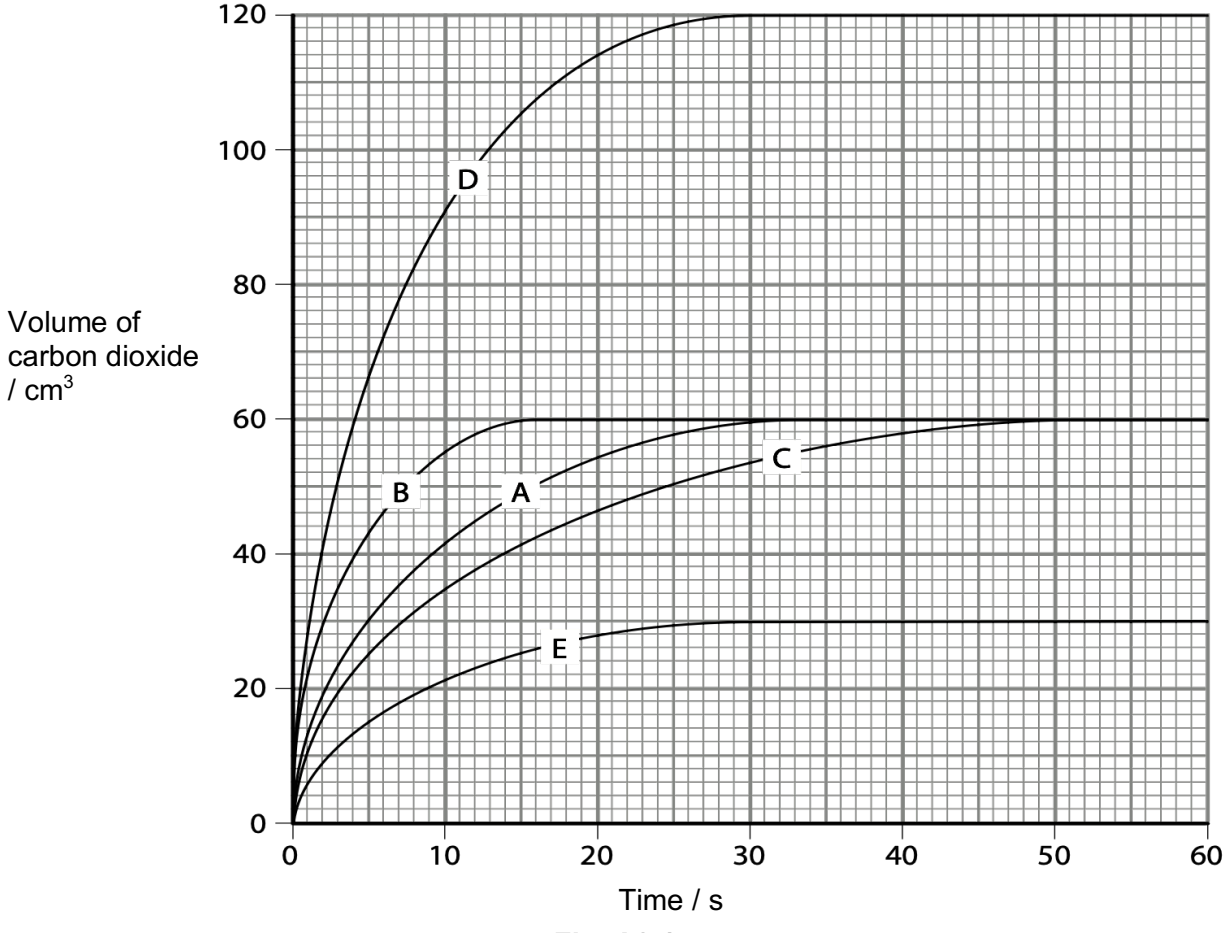


Fig. A8.1

Complete the table below to identify the graph that corresponds to each modified experimental condition. Use your knowledge of collision theory to explain your answer.

modified experimental condition	graph	explanation
Used 1.00 g of calcium carbonate lumps	graph …….	…… …… …… …… …… ……
Used 0.50 g of powdered calcium carbonate	graph …….	…… …… …… …… …… ……

[6]

[Total: 6]

A9 Fig. A9.1 below shows the set-up of an electrolysis experiment. **W** and **X** are silver electrodes while **Y** and **Z** are copper electrodes.

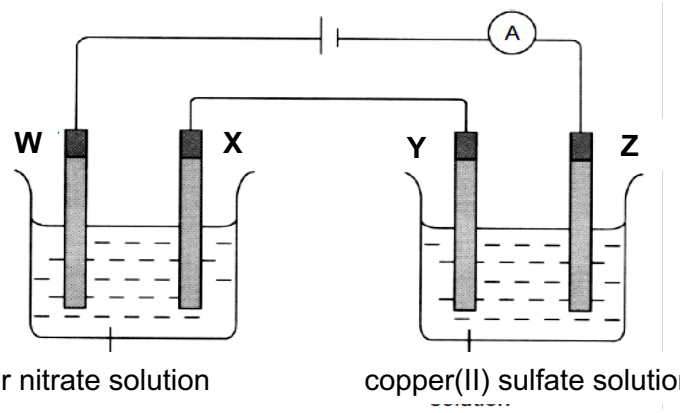


Fig. A9.1

(a) List the formulae of all the ions present in the two electrolytes.

cations: ……

anions: …… [2]

(b) Explain why electrodes **X** and **Z** will increase in mass after some time. Use half-equations to support your answer.

……

……

……

……

……

…… [3]

(c) Predict whether electrode **X** or **Z** will increase in mass at a faster rate. Explain why this is so.

……

……

……

…… [2]

[Total: 7]

Section B [30 marks]
Answer all **three** questions in this section. Write your answers in the spaces provided.
The last question is in the form of **Either/Or** question. Only one part should be answered.

B10 Ozone, is a triatomic molecule consisting of three oxygen atoms. It is an allotrope of oxygen that is much less stable than the diatomic allotrope, O_2.

In Fig. B10.1 below, we see a standard profile of ozone gas concentration through the Earth's atmosphere, extending from ground level up to 35 kilometres in altitude. Ozone plays a different role in atmospheric chemistry at different heights in the Earth's atmosphere. We can differentiate this profile into two key zones: tropospheric zone and stratospheric zone.

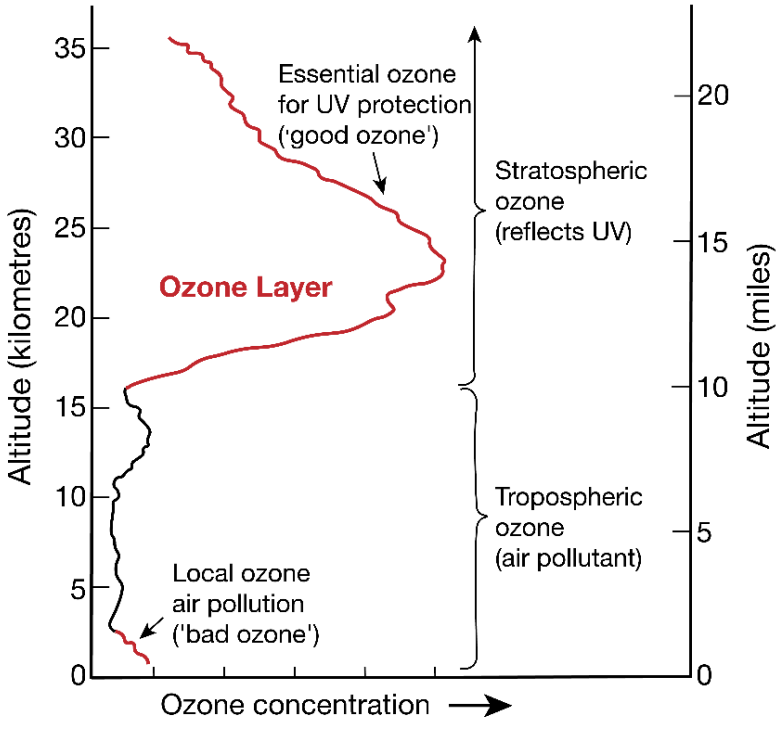
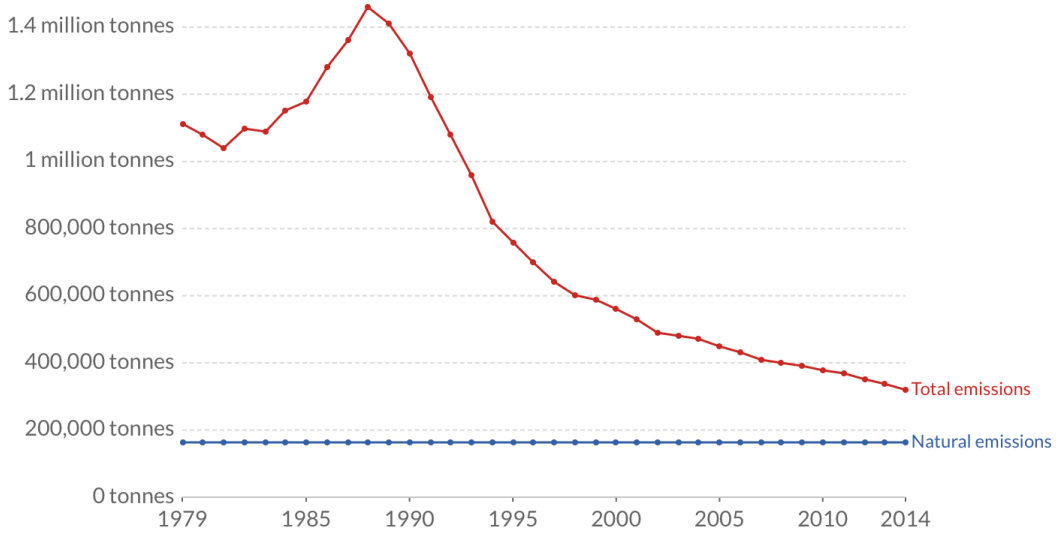


Fig. B10.1 Earth's atmospheric ozone

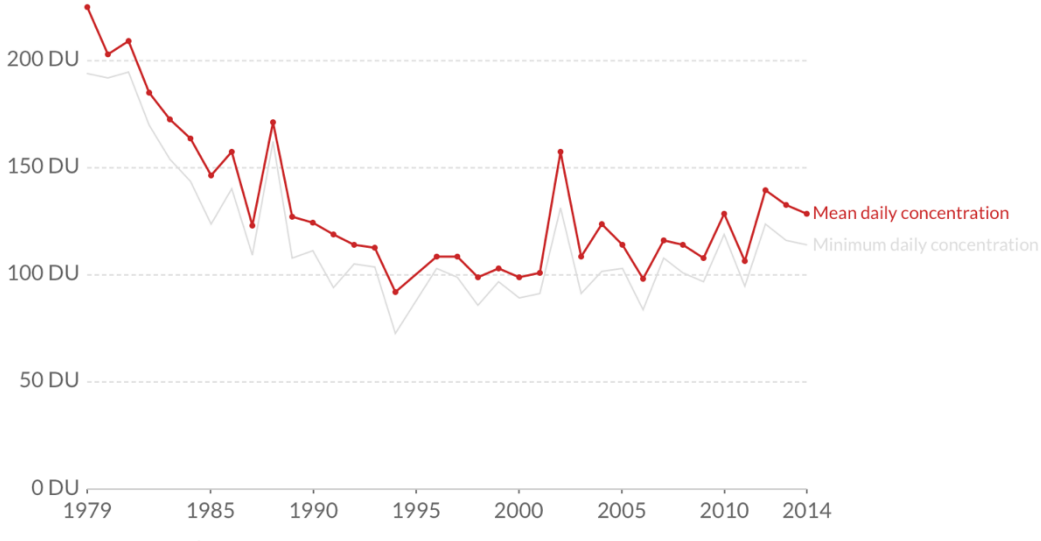
Ozone-depleting substances (ODS) are halogen gases containing chlorine and/or bromine which have the potential to break down ozone in the stratosphere. Fig. B10.2 shows how the world's ODS emission, in terms of chlorofluorocarbon-11-equivalents (CFC_{11} equivalents) has changed over 35 years (from 1979 to 2014).

Fig. B10.3 shows how the concentration of the stratospheric ozone has changed over 35 years (from 1979 to 2014).



Source: Hegglin et al. (2014). Twenty questions and answers about the ozone layer: 2014 update.

Fig. B10.2 Ozone-depleting substances emission



Source: NASA Ozone Watch

Fig. B10.3 Stratospheric ozone concentration (in Dobson Units)

(a) Name **two** allotropes of another element.

…… [1]

(b) "Ozone can be considered to be both beneficial and damaging."
Suggest how the information in Fig. B10.1 supports the above statement.

……

……

……

…… [2]

(c) By referring to Fig. B10.2, describe how the world's emission of ODS has changed over 35 years.

……

……

……

…….. [2]

(d) What evidence, if any, is there to indicate a link between the world's ODS emission and the concentration of stratospheric ozone in the atmosphere?

……

……

……

…….. [2]

(e) In 1989, 80% of the ODS emission is made up of trichlorofluorocarbon, $CFCl_3$. $CFCl_3$ will decompose in the atmosphere according to the equation below:

$$CFCl_3 \rightarrow CFCl_2 + Cl$$

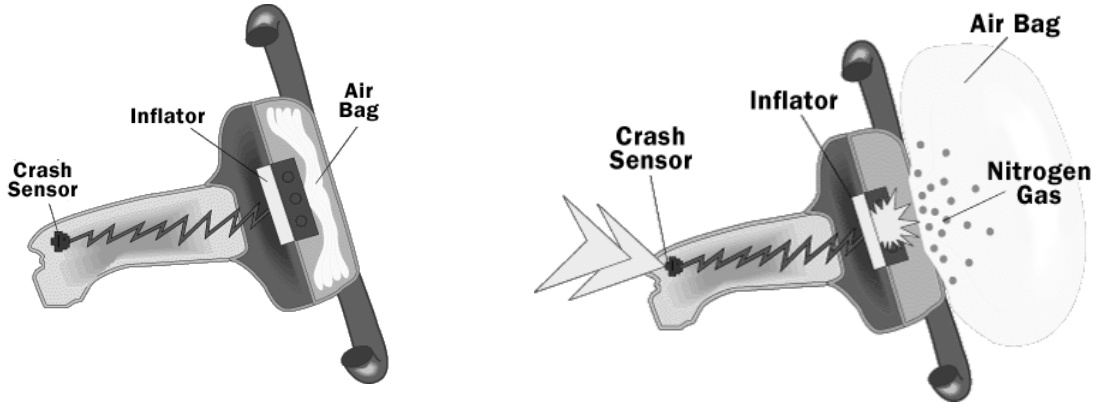
These *Cl* atoms will then destroy the ozone molecules. Use the data from Fig. B10.2 to determine the mass of *Cl* atoms present in 1989. [3]

(f) State **two** other air pollutants.

…….. [1]

[Total: 11]

B11 Airbags are used to protect passengers in a car during an accident. When the crash sensor detects an impact, the airbag's inflation system ignites the gas-generator mixture of sodium azide (NaN_3), potassium nitrate (KNO_3) and silicon dioxide (SiO_2) by an electrical impulse, creating the high-temperature condition necessary for sodium azide to decompose to form sodium and nitrogen.



(a) An airbag contains 130 g of sodium azide. On impact, the sodium azide decomposes to give 67.0 dm^3 of nitrogen at room temperature and pressure within 40 milliseconds.

(i) Write the balanced chemical equation for decomposition of sodium azide into its elements.

…….. [1]

(ii) Calculate the percentage yield of nitrogen from the decomposition of sodium azide in an airbag. [2]

(iii) Using Kinetic Particle Theory, explain how the decomposition of sodium azide inflates the airbag.

…….....

…….....

…….....

…….. [2]

(b) The sodium produced when the sodium azide decomposes is dangerous. The potassium nitrate present in the airbag is meant to make the sodium *safe*. Sodium reacts with potassium nitrate to produce sodium oxide, potassium oxide and nitrogen. The nitrogen generated in this second reaction also fills the airbag, and the metal oxides react with silicon dioxide in a final reaction to produce silicate glass, which is harmless and stable.

(i) Write the balanced chemical equation for the reaction between sodium and potassium nitrate.

…….. [1]

(ii) Suggest why there is a need to make the sodium *safe*.

……..

…….. [1]

(iii) Propose the method to prepare the salt potassium nitrate in the laboratory and write down the formulae of the proposed reagents.

proposed method: ……..……..……..

formulae of proposed reagents: ……..……..… [2]

[Total: 9]

B12 Either

The enthalpy change of combustion is defined as the energy released per mole of a fuel, when it is burnt completely in oxygen. The combustion of ethanol proceeds as follows:

$$C_2H_5OH\ (l) + 3\ O_2\ (g) \rightarrow 2\ CO_2\ (g) + 3\ H_2O\ (g)$$

(a) In order to measure the enthalpy change of combustion of ethanol (C_2H_5OH), the following set-up in Fig. B12.1 was used. The energy released by the reaction is measured by the increase in temperature of the water in the metal can.

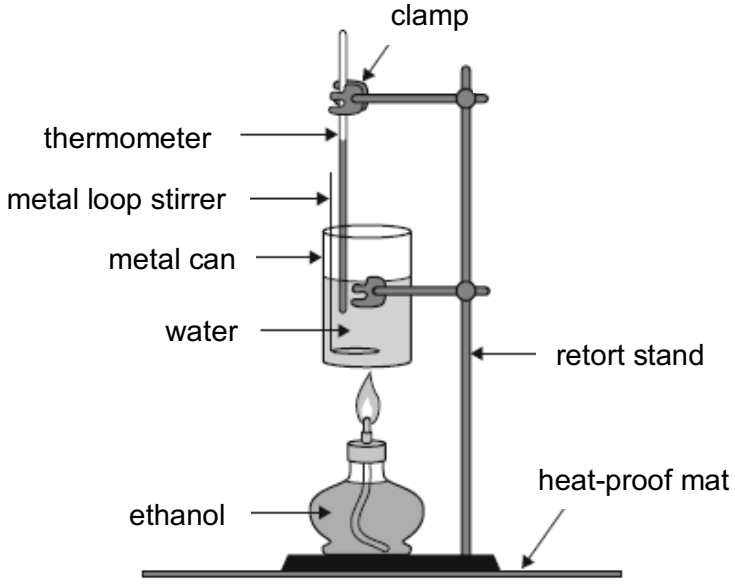


Fig. B12.1

200 g of liquid ethanol was placed in the spirit burner and burnt in air. According to the subsequent increase in temperature measured by the thermometer, it was calculated that the energy that went into heating up the water was 696 kJ.

(i) Calculate the enthalpy change of combustion of ethanol. [2]

(ii) Hence, sketch the energy profile diagram of the reaction. [2]

(iii) State an assumption made in this experiment and hence suggest how the calculated value of enthalpy change would be different from the actual value.

……

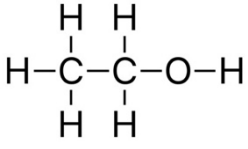
…… [2]

(b) Another way to determine the enthalpy change of combustion is to use bond energy calculations. The bond energies of some covalent bonds are given below in Table B12.2.

Table B12.2

bond	Bond energy (kJ/mol)	bond	Bond energy (kJ/mol)
C–C	348	C–O	358
C=C	614	C=O	799
C–H	413	O–O	146
O–H	463	O=O	495

The structural formula of ethanol is



(i) Draw the structural formulae of oxygen and carbon dioxide.

oxygen	carbon dioxide

[1]

(ii) Hence, calculate the enthalpy change of combustion of ethanol, using the data given in Table B12.2. [3]

[Total: 10]

B12 Or

Displacement reactions are used to extract elements from their compounds.

(a) Bacteria can dissolve copper from mining waste to make a solution of aqueous copper(II) sulfate. Subsequently, copper can be extracted from the solution by adding scrap iron. The ionic equation for the reaction is as follows:

$$Fe\ (s) + Cu^{2+}\ (aq) \rightarrow Cu\ (s) + Fe^{2+}\ (aq)$$

(i) What would be observed when iron is added to aqueous copper(II) sulfate?

……

……

……

…….. [2]

(ii) Suggest why this process has economic and environmental advantages.

……

……

……

…….. [2]

(iii) Explain why potassium **cannot** be extracted from potassium sulfate in the same way using scrap iron and state how potassium can be extracted.

……

……

…….. [2]

(b) Bromine is extracted from seawater. Bromide compounds, such as sodium bromide, in the seawater react with chlorine gas to form an orange solution of aqueous bromine.

(i) Construct a balanced ionic equation for the reaction between bromide ions and chlorine gas.

…….. [2]

(ii) By means of a dot-and-cross-diagram, draw the electronic structure of sodium bromide. Show the valence electrons only. [2]

[Total: 10]

- End of paper -