MINISTRY OF EDUCATION, SINGAPORE
in collaboration with
CAMBRIDGE ASSESSMENT INTERNATIONAL EDUCATION
General Certificate of Education Ordinary Level

CANDIDATE NAME	
CENTRE NUMBER	S
INDEX NUMBER	

CHEMISTRY

6092/02

Paper 2

For examination from 2024

SPECIMEN PAPER

1 hour 45 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, index number and name 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 staples, paper clips, glue or correction fluid.
DO **NOT** WRITE ON ANY BARCODES.

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

Section B
Answer **one** question.
Write your answers in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 24.

The use of an approved scientific calculator is expected, where appropriate.

This document consists of **22** printed pages and **2** blank pages.

Singapore Examinations and Assessment Board

Cambridge Assessment International Education

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Section A

Answer **all** questions.

1 Fig. 1.1 shows part of the Periodic Table.

				He
C	N	O	F	Ne
		S	C*l*	Ar
			Br	Kr

Fig. 1.1

Select elements from Fig. 1.1 to answer the following questions. You may use each element once, more than once or not at all.

Write down the symbol for an element which:

(a) has five electrons in its outer shell,

..... [1]

(b) exists as diatomic molecules,

..... [1]

(c) reacts with sodium to form an ionic compound with M_r less than 60,

..... [1]

(d) is a noble gas,

..... [1]

(e) has a giant covalent structure,

..... [1]

(f) has a smaller proton number than fluorine,

..... [1]

(g) is the most abundant gas in the air.

..... [1]

[Total: 7]

2 A new type of electroplating is known as 'brush electroplating'.
It is used to electroplate zinc onto very large iron supports to be used in buildings.
The iron supports are too big to be plated in a normal electrolysis tank.

During the process, a metal brush spreads a layer of aqueous zinc sulfate over the iron surface.
A battery gives the brush a positive charge and gives the iron support a negative charge.
A layer of zinc forms on the surface of the iron support.

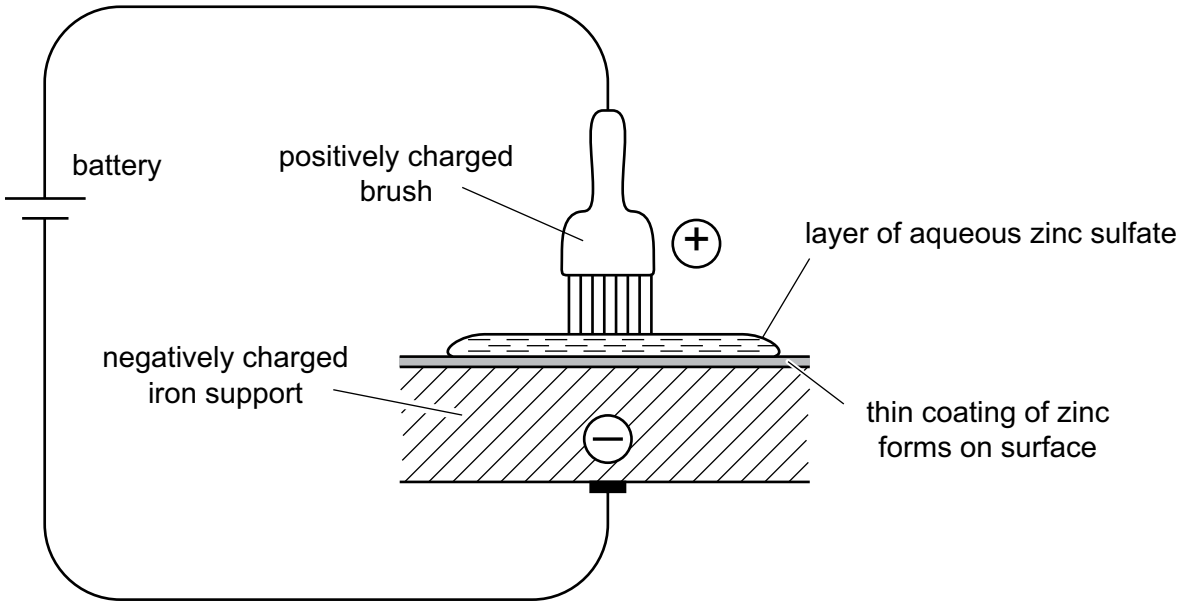

Fig. 2.1

(a) The surface of the iron acts as a cathode.
Zinc ions from the solution form zinc on the surface of the iron.

Write an ionic half-equation, with state symbols, for this reaction.

..... [2]

(b) Two different designs of metal brush are available.

One type of brush is made from zinc, one type is made from platinum.

As the electrolysis takes place, each brush has a different effect on the concentration of zinc ions in the solution.

(i) What will happen to the concentration of the zinc ions during the electrolysis if the brush is made from platinum?

..... [1]

(ii) What will happen to the concentration of the zinc ions during the electrolysis if the brush is made from zinc?

..... [1]

(iii) Platinum brushes are much more expensive than zinc brushes.

However, zinc brushes need replacing regularly but platinum brushes do not.

Explain why.

.....

..... [2]

(c) During the process, a worker needs to hold the brush.

Which of the following materials would be a good choice for the handle of the brush?
Give a reason for your answer.

chromium copper graphite iron poly(ethene)

material .....

reason .....
[2]

(d) Explain why iron supports coated with zinc do not rust, even if the zinc coating is damaged.

.....

..... [2]

[Total: 10]

3 The space ship Curiosity landed an analytical lab on Mars in 2012. The lab contained equipment which can determine the percentages of elements in rocks.

The percentage by mass of the elements in compound **Z**, determined using this type of equipment, is given in Table 3.1.

Table 3.1

element	percentage by mass
potassium	39.4
iron	28.3
oxygen	32.3

(a) Show that the empirical formula of **Z** is K_2FeO_4.

[2]

(b) Compound **Z**, K_2FeO_4, can be prepared in the laboratory by the reaction between iron(III) oxide, Fe_2O_3, chlorine, Cl_2, and potassium hydroxide, KOH.

$$Fe_2O_3 + 3Cl_2 + 10KOH \rightarrow 2K_2FeO_4 + 6KCl + 5H_2O$$

A 2.00 g sample of Fe_2O_3 is added to 20.0 cm^3 of 4.00 mol / dm^3 KOH.

(i) Calculate the amount of Fe_2O_3 used.

amount of Fe_2O_3 used = ... mol [2]

(ii) Calculate the amount of KOH used.

amount of KOH used = ... mol [1]

(iii) Which reagent, Fe_2O_3 or KOH, is in excess in this reaction?

Explain your answer.

.....

.....

..... [1]

(c) A few drops of aqueous **Z** are added to a test-tube containing 3 cm^3 of aqueous potassium iodide. The solution in the test-tube changes from colourless to pale brown.

Given this information, what can you deduce about the chemical properties of **Z**?

..... [1]

[Total: 7]

4 This question is about hydrogen and some compounds containing hydrogen.

(a) Hydrogen is a gas at room temperature.

Describe the arrangement and motion of the molecules in hydrogen gas.

.....

..... [2]

(b) The symbols for two isotopes of hydrogen are shown below.

$^{1}_{1}H$ $^{2}_{1}H$

Complete Table 4.1 to show the number of subatomic particles in these two isotopes of hydrogen.

Table 4.1

	$^{1}_{1}H$	$^{2}_{1}H$
number of electrons		
number of neutrons		
number of protons		

[2]

(c) The isotope $^{2}_{1}H$ can be called deuterium and is given the symbol D. This isotope is present in heavy water, D_2O, which is used to absorb neutrons in nuclear reactors.

A sample of water vapour containing a small percentage of D_2O is introduced into a long, heated tube.

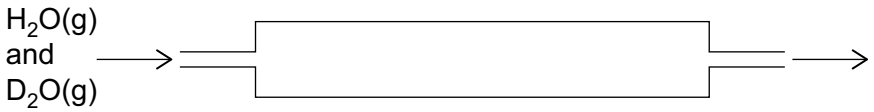

Fig. 4.1

The percentage of D_2O in the vapour that **first** comes out of the tube is less than the percentage of D_2O as it enters the tube. Explain this difference.

.....

.....

.....

..... [3]

(d) Hydrochloric acid, HC*l*, is an acid because it produces H^+ ions in aqueous solution. Hydrochloric acid reacts both with metals and with metal oxides.

(i) A student observed the reaction of hydrochloric acid with four different metals. The student used the same concentration and volume of hydrochloric acid and the same mass of metal in each experiment.

Table 4.2

metal	observations
cobalt	dissolved very slowly and very few bubbles produced
iron	dissolved slowly and a few bubbles produced slowly
magnesium	dissolved very quickly and many bubbles produced very rapidly
zinc	dissolved quickly and many bubbles produced rapidly

Use the information in Table 4.2 to suggest the order of reactivity of these metals.

most reactive .... least reactive [2]

(ii) Magnesium oxide is classified as a basic oxide but zinc oxide is classified as an amphoteric oxide.

Explain the meaning of the terms *basic* and *amphoteric* as applied to these oxides. Include one equation in your explanation.

.....

.....

.....

..... [2]

[Total: 11]

5 Some versions of the Periodic Table place hydrogen in Group 1 (Fig. 5.1). Other versions place hydrogen alone and not with any other group (Fig. 5.2).

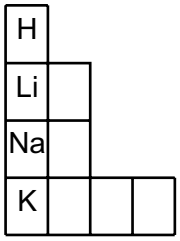

Fig. 5.1

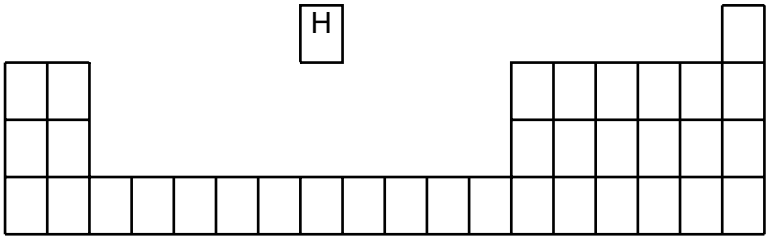

Fig. 5.2

(a) Give **two** similarities between hydrogen and the elements in Group 1.

.....

.....

.....

..... [2]

(b) Give **two** properties of hydrogen that do **not** fit with the properties of the elements in Group 1.

.....

.....

.....

..... [2]

(c) Hydrogen is in Period 1 of the Periodic Table.

Explain why Period 1 only contains 2 elements.

.....

..... [1]

(d) Hydrogen is used to make margarine from vegetable oil.

Describe, in terms of bonds, what happens when hydrogen reacts with vegetable oil.

.....

..... [2]

[Total: 7]

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6 Fig. 6.1 shows a fractionating column for separating crude oil.
The fractions produced are labelled **A**, **B**, **C**, **D** and **E**.

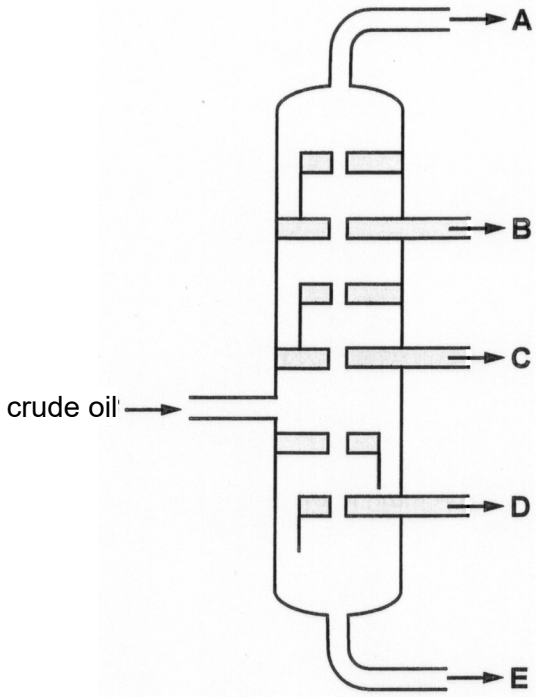

Fig. 6.1

(a) **(i)** Which fraction, **A**, **B**, **C**, **D** or **E**, is most likely to be a solid at room temperature?

..... [1]

(ii) Which fraction, **A**, **B**, **C**, **D** or **E**, has the smallest molecules?

..... [1]

(b) Fraction **C** is a liquid.

Explain how **C** is produced from crude oil.

.....

..... [2]

(c) Long chain alkanes can be cracked to produce shorter chain alkanes and alkenes.

(i) What is the molecular formula of an alkane with 12 carbon atoms in each molecule?

..... [1]

(ii) The alkane in **(c)(i)** can be cracked to produce butene and one other product. Write the equation to show this reaction.

..... [1]

(iii) Explain why cracking makes the oil industry more profitable.

.....

..... [1]

(d) Ethene is also produced by cracking.

Ethene is used in a further process to make ethanol. Ethanol can also be made from sugarcane.

Explain why burning ethanol made from sugarcane causes less harm to the environment than burning ethanol made from ethene.

.....

..... [1]

[Total: 8]

7 Car engines produce carbon monoxide and nitrogen monoxide as waste gases.

(a) Describe how carbon monoxide and nitrogen monoxide form in the car engine and identify a health problem caused by each gas.

.....

.....

.....

.....

.....

.....

..... [4]

(b) Carbon monoxide reacts with nitrogen monoxide in a catalytic converter.

$$2CO + 2NO \rightarrow 2CO_2 + N_2$$

State and explain, with reference to oxidation states, which element is oxidised and which element is reduced in this reaction.

.....

.....

.....

..... [2]

(c) Explain why the reaction in the catalytic converter does **not** solve all of the environmental problems caused by the waste gases.

.....

.....

..... [2]

[Total: 8]

8 Instrumental techniques in analysis

Flame tests for Group 1 elements

Flame tests were used in the 1850s. Robert Bunsen developed the Bunsen burner and used it to show that many metals give characteristic colours when they are heated in the flame. The colour comes from light emitted by individual atoms when they become very hot. For example, sodium gives a very intense yellow-orange colour. The table shows the flame colours of Group 1 elements.

Table 8.1

element	flame colour
lithium	red
sodium	yellow-orange
potassium	pale violet
rubidium	red-violet
caesium	blue-violet

Group 1 element emission spectra

Bunsen realised that, in practice, it was difficult to use flame tests to identify elements in mixtures. In the 1860s, Bunsen worked with fellow scientist, Gustav Kirchhoff. They used a spectroscope to split the colours of the flames into individual lines. They found that atoms of an element each give a characteristic pattern of lines which is known as an emission spectrum. Fig. 8.1 shows the emission spectra of some Group 1 elements.

Emission spectra from elements can be used as a reference. They can be compared with the emission spectrum of a mixture so that individual elements in the mixture can be identified. This technique is used today to analyse light from stars to work out which elements are present in the star.

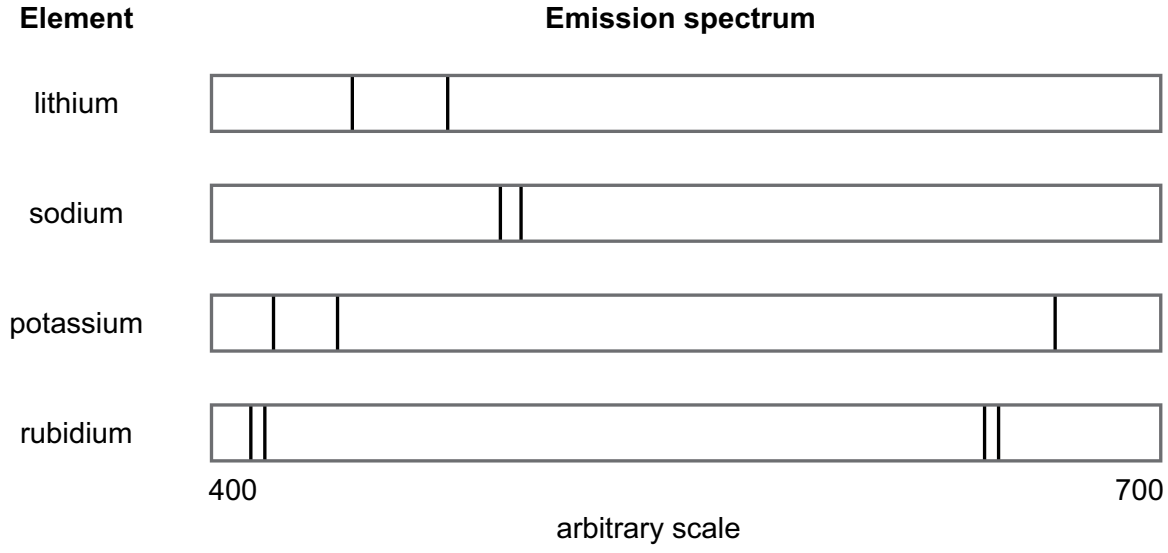

Fig. 8.1

Ion chromatography of a sample of water

In the 1950s, ion chromatography was developed. This technique involves passing a sample through a chromatography column. Different ions travel through the column at different speeds. A detector is attached to the end of the column. The results are printed out as a graph.

The **retention time** is the time it takes each ion to travel through the column. Ions can be identified by their retention times. The position of the peaks show the retention time of each ion.

The **height** of each peak (relative intensity) is proportional to the **relative amount** of each ion in the sample.

Ion chromatography can be used to identify any ion, even those which contain multiple atoms, such as the sulfate ion.

The ion chromatography analyses of a sample of water from a natural source are shown in Fig. 8.2 and Fig. 8.3.

Fig. 8.2 shows the ion chromatogram of positive ions in a sample of water.

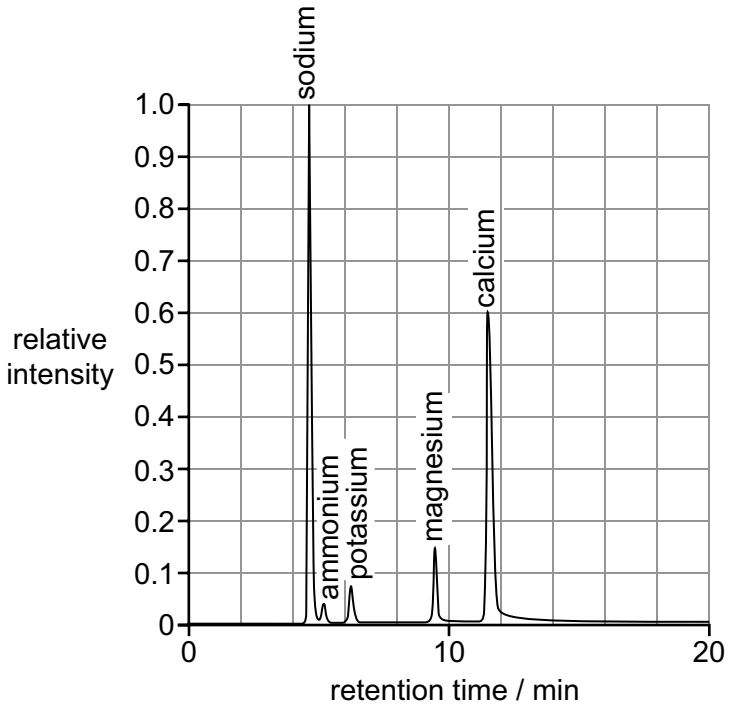

Fig. 8.2

Fig. 8.3 shows the ion chromatogram of negative ions in a sample of water.

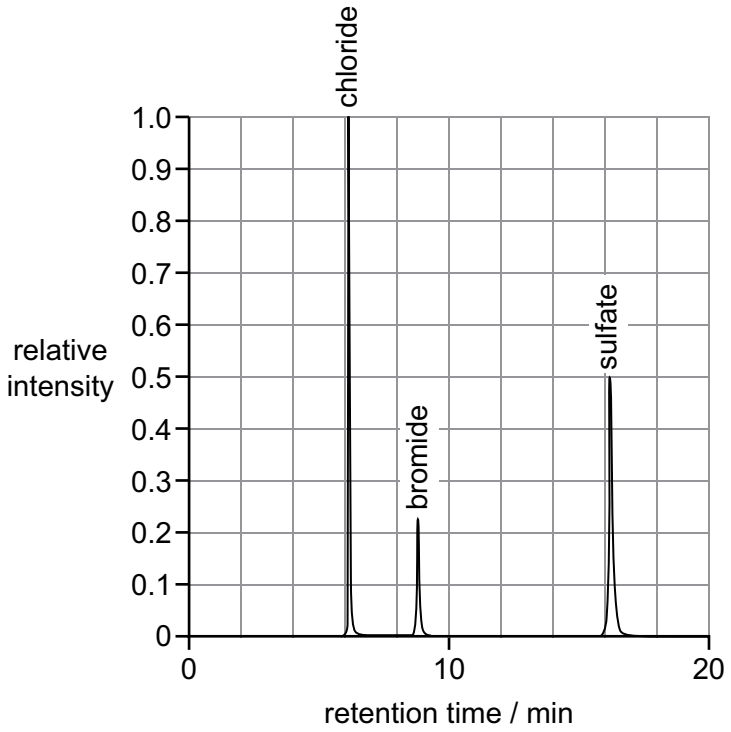

Fig. 8.3

(a) Bunsen said that it is difficult to use flame tests to identify elements in mixtures.

Explain why it is difficult to use flame tests to identify which Group 1 elements are in a mixture.

.....

.....

..... [2]

(b) This is the emission spectrum from a mixture.

Fig. 8.4

(i) What conclusions can you make about which Group 1 elements this mixture does and does not contain?

Explain your reasoning.

.....

.....

.....

.....

.....

.....

..... [3]

(ii) What additional information would you need so that you could use the spectrum to identify **all** of the elements in the mixture?

.....

..... [1]

(c) Further analysis of the same sample of water that was tested by **ion chromatography** was done.

(i) The sample was analysed to find out the concentration of sodium ions.

The first stage was to crystallise solid salts from the water.

Give the formulae of **three** different sodium salts which could crystallise from the water sample.

salt 1 .....

salt 2 .....

salt 3 .....

[2]

(ii) The concentration of calcium ions in the water is 0.00420 mol / dm^3.

Calculate the concentration of magnesium ions and the concentration of sodium ions in the water.

[2]

(d) A student comments that the ion chromatograms give more information about mixtures than the emission spectrum.

Give reasons to support his idea.

.....

.....

.....

..... [2]

[Total: 12]

Section B

Answer **one** question from this section.

9 Liquefied Petroleum Gas (LPG) and ethanol can be used as fuels for cars instead of petrol.

LPG contains mainly propane.

This table shows some information about propane and ethanol.

Table 9.1

name	formula	boiling point / °C	physical state at room temperature and pressure	enthalpy change of combustion / kJ per mol
ethanol	C_2H_5OH	78		–1371
propane	C_3H_8	–42		–2220

(a) Complete Table 9.1 by filling in the boxes. [1]

(b) Give **one** similarity and **one** difference between the **structures** of ethanol and propane.

similarity .....

difference .....

[2]

(c) When 1 kg of propane burns, 50 450 kJ of energy is given out.

(i) Show by calculation, using data from Table 9.1, that ethanol gives out less energy per kg than propane.

[3]

(ii) Suggest a reason why the combustion of 1 kg of ethanol gives out less energy than the combustion of 1 kg of propane.

.....

..... [1]

(d) In an ethanol-powered car engine, a spark plug ignites a mixture of air and ethanol. The spark is needed because the combustion of ethanol needs activation energy.

Complete the energy profile diagram in Fig. 9.1 for the complete combustion of ethanol.

Show the names of the products and label the activation energy for the reaction.

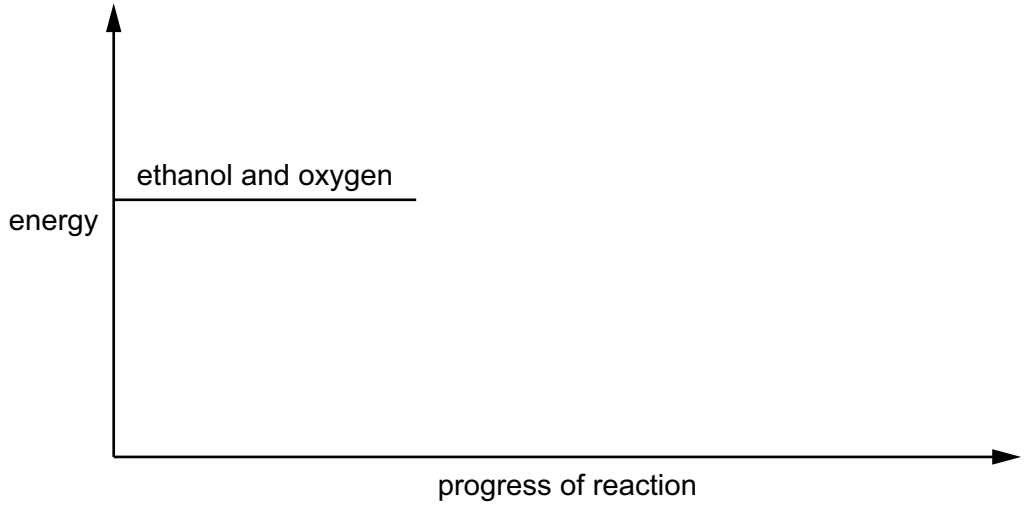

Fig. 9.1

[3]

[Total: 10]

10 Table 10.1 shows the formulae of the first three members of the alcohol homologous series.

Table 10.1

alcohol	formula
methanol	CH_3OH
ethanol	C_2H_5OH
propanol	C_3H_7OH

(a) Deduce the general formula for the alcohol homologous series.

..... [1]

(b) Ethanol can be manufactured from either ethene or glucose.

(i) Write an equation for the production of ethanol from ethene and state the conditions under which the reaction takes place.

.....

.....

..... [2]

(ii) The fermentation of glucose can be represented by the following equation.

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$$

Calculate the maximum mass of ethanol that could be made from 36 tonnes of glucose.

1 tonne = 1×10^6 g

[3]

(iii) Explain why ethanol made from ethene is a non-renewable fuel but that made from glucose is a renewable fuel.

.....

.....

..... [2]

(c) Propanol reacts in a similar way to ethanol.

(i) Name the organic product of the reaction between propanol and warm, acidified potassium manganate(VII).

..... [1]

(ii) Name the type of product formed when the organic product in **(c)(i)** reacts with an alcohol.

..... [1]

[Total: 10]

The Periodic Table of Elements

Group																	
1	2											13	14	15	16	17	18
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											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	3	4	5	6	7	8	9	10	11	12	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 yttrium 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 –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

Key

proton (atomic) number
atomic symbol
name
relative atomic mass

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.).
The Avogadro constant, $L = 6.02 \times 10^{23}\ mol^{-1}$.