SERANGOON SECONDARY SCHOOL
PRELIMINARY EXAMINATION
SECONDARY 4 EXPRESS

CANDIDATE NAME					( )	CLASS			
CENTER NUMBER	S					INDEX NUMBER			

CHEMISTRY

Paper 2

6092/02
22 Aug 2024
1 hour 45 minutes

Candidates answer on the Question Paper.

Setter(s):

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 staplers, paper clips, glue or correction fluid.

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 27.

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

For examiner's use	
Section A	/**70**
Section B	/**10**
9	
10	
Total	/**80**

This question paper consists of **26** printed pages, including this cover page.

Section A [70 marks]
Answer **all** questions.

1 Fig. 1.1 shows part of the Periodic Table.

Li													C	N	O
												Al			
	Ca						Fe			Cu	Zn				

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) forms a stable ion by losing three electrons,

……..…….. [1]

(b) exists as diatomic molecules,

……..…….. [1]

(c) forms an ion which gives a red-brown precipitate on addition of aqueous ammonia,

……..…….. [1]

(d) has chemical properties similar to those of magnesium,

……..…….. [1]

(e) has a giant covalent structure,

……..…….. [1]

(f) reacts with sodium to form an ionic compound with Mr less than 70.

……..…….. [1]

[Total: 6]

2 A laboratory technician mixes red, blue and yellow dyes to make black dye for a paper chromatography experiment. A common solvent used to separate the dyes in black ink is a mixture of ethanol and water. The coloured dyes have different R_f values in solvents with different composition of ethanol as shown in Fig. 2.1.

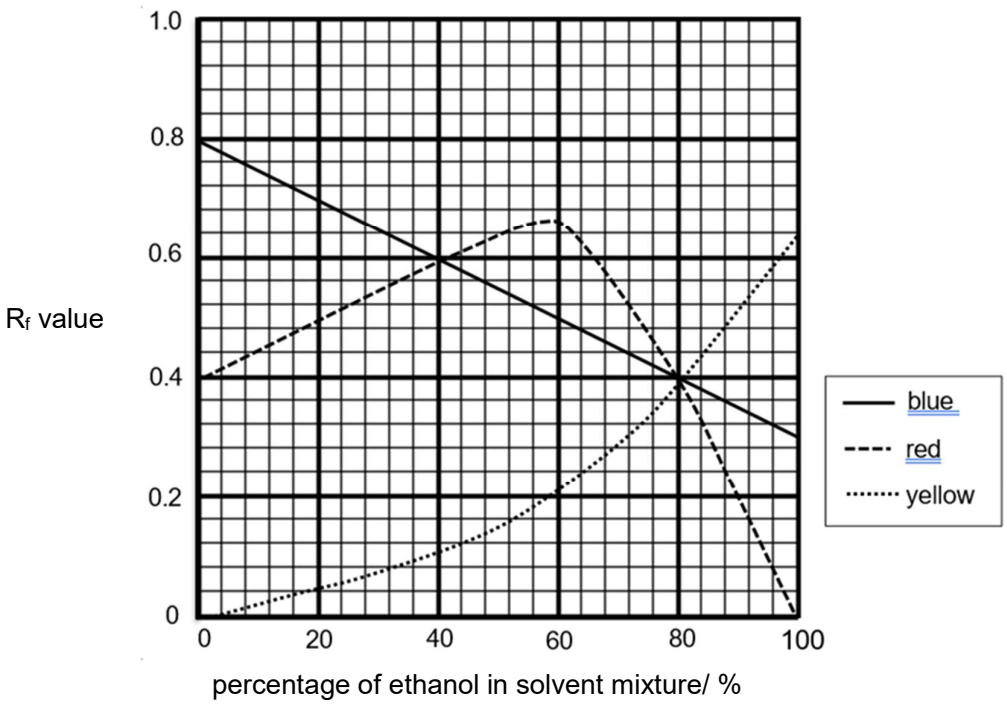


Fig. 2.1

(a) Predict the colours of the separated spots observed when the solvent used consists of 40% ethanol in the mixture.

……..…….. [1]

(b) State the R_f value of the yellow dye on the chromatogram when the solvent is a mixture of 64 cm^3 of ethanol and 136 cm^3 of water.

……..…….. [1]

(c) Explain why a pure solvent of water or ethanol is not suitable for the separation of the black ink using paper chromatography.

……..……..…..

……..……...

……..…….. [2]

(d) A student carried out chromatography on the black ink using a mixture of ethanol and water as solvent. Only one spot was observed on the resulting chromatogram.

What is the percentage of ethanol in the solvent mixture used? Explain why only one spot is observed.

……..……..…...

……..……...

……..…….. [2]

(e) Draw and label on the chromatography paper below the chromatogram obtained when a mixture containing 90% ethanol is used.

[1]

[Total: 7]

3 Until recently, arsenic poisoning, either deliberate or accidental, has been a frequent cause of death. The symptoms of arsenic poisoning are identical to those of a common illness, cholera. A reliable test was needed to prove the presence of arsenic in a body.

In 1840, Marsh devised a reliable test for arsenic as shown in Fig 3.1.

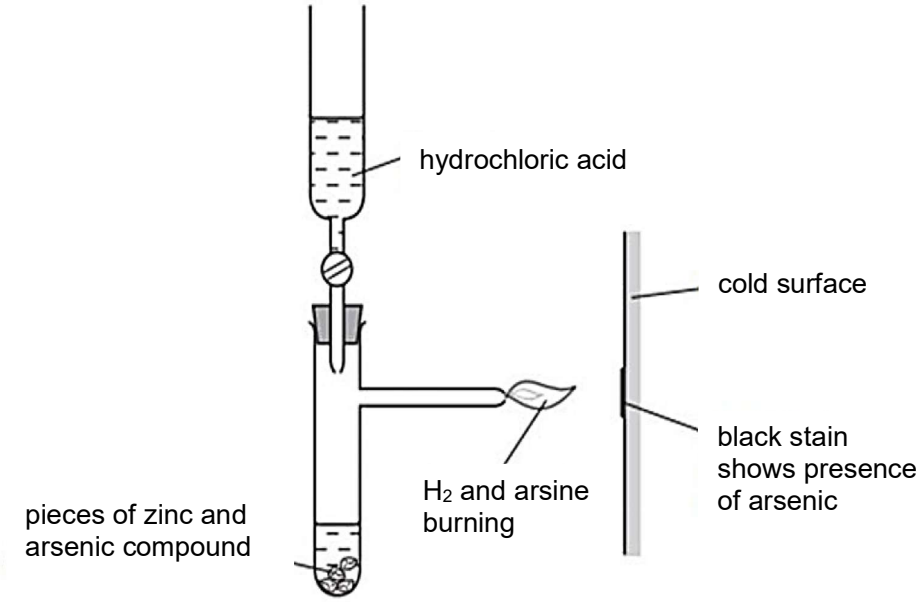


Fig 3.1

Hydrogen is formed in this reaction.

(a) Any arsenic compound reacts with this hydrogen will form arsine which is arsenic hydride, a covalent compound.

The mixture of hydrogen and arsine is burnt at the jet and arsenic forms as a black stain on the glass.

(i) Write an equation for the reaction which forms hydrogen.

……. [1]

(ii) Arsenic (As) is located in Group 15.
Suggest the formula of arsine.

……. [1]

(iii) Draw a 'dot and cross' diagram to show the bonding in the compound arsine.

Show the outer shell electrons only.

[2]

(b) Table 3.1 shows the composition of another hydride of arsenic.

Table 3.1

arsenic	hydrogen
97.4%	2.6%

(i) Determine the empirical formula of this hydride from the data above.

empirical formula: …… [2]

(ii) The mass of one mole of this hydride is 154 g.

What is its molecular formula?

molecular formula: …… [1]

(iii) Draw the full structural formula of this hydride from **(b)(ii)**.

[1]

[Total: 8]

4 This question is about halogens and their compounds.

(a) Explain in terms of electron transfer why halogens behave chemically as non-metals.

……

…… [1]

(b) Complete Table 4.1 to show the results of experiments where aqueous halogens are added to the solutions of aqueous halides.

Use the following legend:
✓ a reaction occurs
× no reaction occurs

Table 4.1

	At_2 (aq)	Br_2 (aq)	Cl_2 (aq)
At^- (aq)			
Br^- (aq)			
Cl^- (aq)			

[2]

(c) Two students commented on the use of potassium iodide.

Student 1: "Potassium iodide can be very useful because when it is oxidised, a colour change is produced."

Student 2: "Aqueous potassium iodide can be used to test for the presence of an oxidising agent."

(i) Describe the colour change when potassium iodide is oxidised.

…… [1]

(ii) Explain why the reaction between aqueous potassium iodide and oxidising agents is a redox reaction.

……

……

…… [2]

(d) Concentrated aqueous hydrochloric acid releases fumes of hydrogen chloride gas.

A long glass tube is set up as shown in Fig. 4.1.

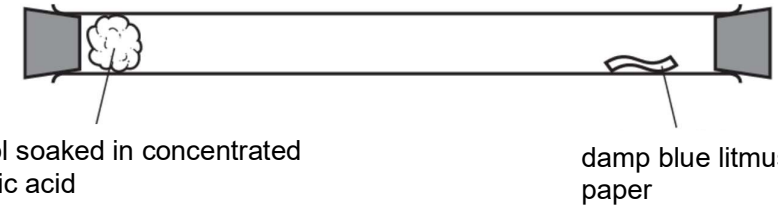


Fig. 4.1

Use the kinetic particle model to explain why the blue litmus paper turns red after a short while.

……

……

……

…… [3]

[Total: 9]

5 Ozone does not come directly from factories and vehicles. Ozone is formed when heat and sunlight cause chemical reactions between oxides of nitrogen (NOX) and Volatile Organic Compounds (VOC). This reaction can occur both near the ground and high in the atmosphere.

(a) **(i)** Predict the effect of each factor on the ozone level by completing Table 5.1.

Table 5.1

Factor	**Ozone levels (Increase or Decrease)**
Smaller population density	
More electrical cars	
Sunny skies	

[1]

(ii) Ozone levels in a city are usually at their peak in mid-afternoon. Suggest two reasons for this.

……

……

…… [2]

(b) In Singapore, a small fraction of our electricity is generated by burning petroleum. Most power stations have switched to the use of natural gas.

(i) Name one air pollutant produced by burning petroleum in a power station.

…… [1]

(ii) How can power stations reduce the amount of this pollutant from **(b)(i)** that is released into the atmosphere?

……..

…… [1]

[Total: 5]

6 A group of students were investigating the effects of 'acid rain'. They decided to look at the effect of acid on metals used as building materials. Lead and copper are used as materials for roofing and iron and aluminum can be used for window frames.

They learnt that the order of the reactivity of the metals as:

aluminium > iron > lead > copper

The students went on to test on the metals by adding dilute sulfuric acid to pieces of each metal to simulate the effects of 'acid rain' on the metals. It is found that only the iron seemed to give a reaction.

(a) Explain why the students deduce that aluminium did not react with the acid, even when aluminum is known to be more reactive than iron.

……

…… [1]

(b) As the reaction is carried out with sulfuric acid, there were no reactions for both lead and copper. It did not prove that lead was more reactive than copper.

(i) Explain why the copper show no reactions with sulfuric acid.

……..

…… [1]

(ii) Describe an experiment the students can carry out to show that lead is more reactive than copper.

……..

……..

……..

…… [3]

(c) Iron, when exposed to environmental factors can undergo rusting. Hence, sacrificial protection can be used to prevent rusting. State an example of sacrificial protection and explain how it prevents rusting.

……

……

…… [2]

[Total: 8]

7 Lead(II) carbonate reacts with dilute nitric acid as shown by the equation below:

$$PbCO_3(s) + 2\,HNO_3(aq) \rightarrow CO_2(g) + Pb(NO_3)_2(aq) + H_2O(l)$$

Two experiments are carried out using lumps or powder of lead(II) carbonate of the same mass, with other conditions kept the same.

The results are shown in Fig. 7.1.

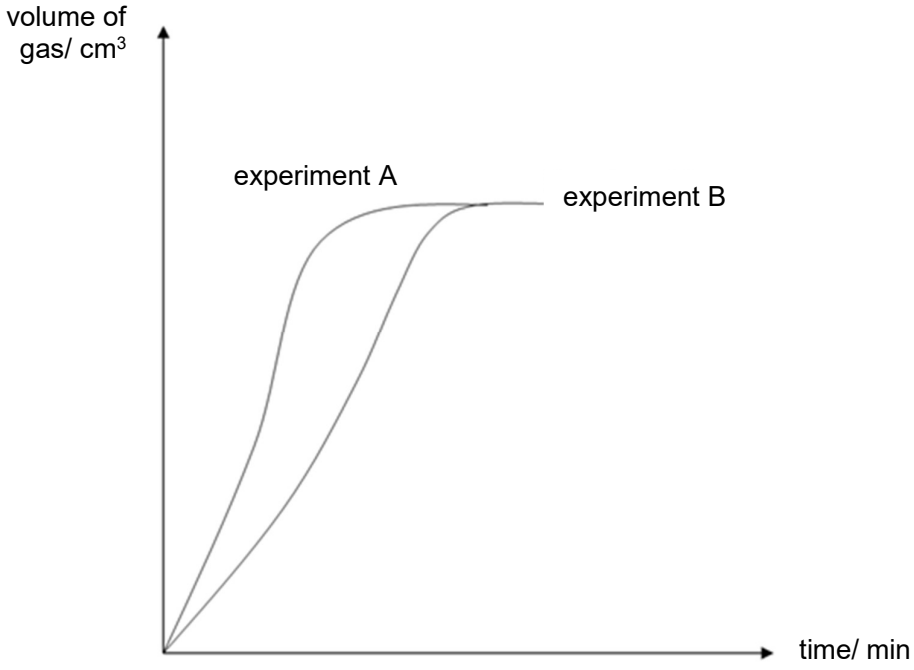


Fig. 7.1

(a) With reference to the graph, which experiment, **A** or **B**, was carried out using lumps of lead(II) carbonate?

Explain your answer in terms of collisions between particles.

……

……

……

…… [2]

(b) Experiment **A** is repeated using the same mass of calcium carbonate in place of lead(II) carbonate. All other conditions are kept constant.

Will the total volume of gas produced be more, less, or the same, as compared to Experiment **A**?

Explain your answer.

……

……

…… [2]

(c) Experiment **A** is repeated using excess sulfuric acid in place of nitric acid. All other conditions are kept constant.

(i) Sketch in Fig. 7.1 the result you would expect to obtain. [1]

(ii) Explain the shape of your graph.

……

……

……

……

…… [2]

[Total: 7]

8 This question is about the electrolysis of aqueous copper(II) nitrate.
Some students investigated the electrolysis of copper(II) nitrate solution using inert electrodes.

Fig. 8.1 shows the apparatus.

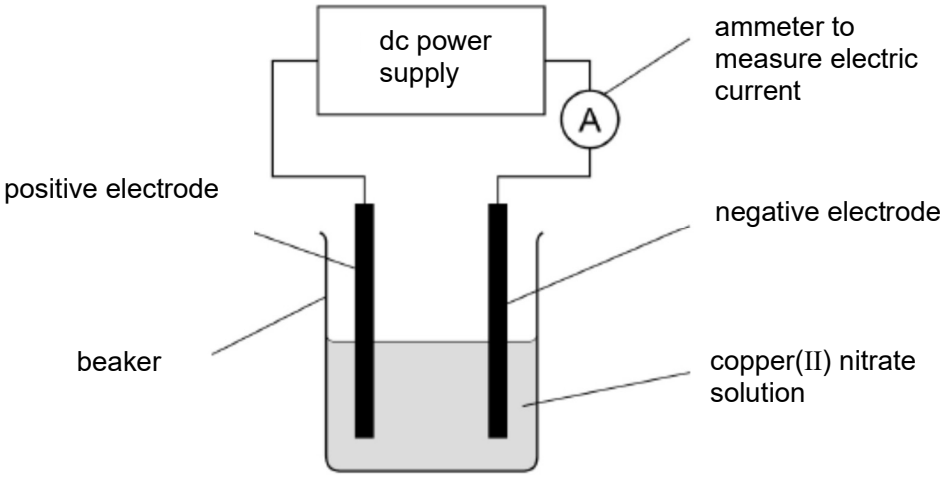


Fig. 8.1

The students investigated how the mass of copper produced at the negative electrode varies with time and current.

This is the method used.
1. Weigh the negative electrode.
2. Set up the apparatus shown.
3. Adjust the power supply until the ammeter shows a current of 0.3A.
4. Switch off the power supply after 5 minutes.
5. Rinse the negative electrode with water and allow to dry.
6. Reweigh the negative electrode.
7. Repeat steps 1 to 6 for different times.

Repeat steps 1 to 7 at different currents.

(a) Write the ionic equation for the reaction at the negative electrode.

…….. [1]

(b) Some of the copper produced did not stick to the negative electrode but fell to the bottom of the beaker.
Suggest how the students could find the total mass of the copper produced.

……..

……..

……..

…….. [3]

(c) The student plotted their results on a graph.
Figure 8.2 shows the graph.

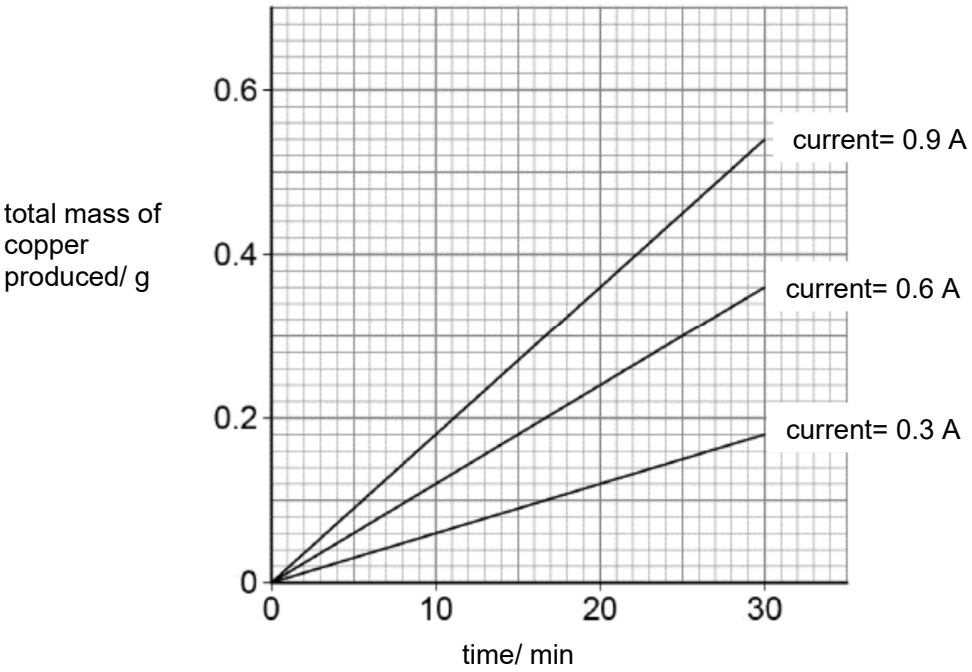


Fig. 8.2

A student concludes that the total mass of copper produced is directly proportional to the time taken and the current.

Do you agree? Justify your answer using the information given.

……

……

……

…….…..... [2]

(d) Describe and explain what happens to the copper(II) nitrate solution during electrolysis.

……

……

……

……

…….…..... [3]

(e) Calculate the number of atoms of copper produced when copper(II) nitrate solution is electrolysed for 20 minutes at a current of 0.6A.

number of Cu atoms: …….. [2]

[Total: 10]

9 Gas Chromatography

Gas chromatography is a commonly used separation technique in many environmental and forensic laboratories for quality control as well as identification and quantitation of compounds in a miscible mixture. Gas chromatography allows for the separation and detection of compounds even in very small quantities. A broad variety of samples can be analysed as long as the compounds are sufficiently stable to heat and reasonably volatile.

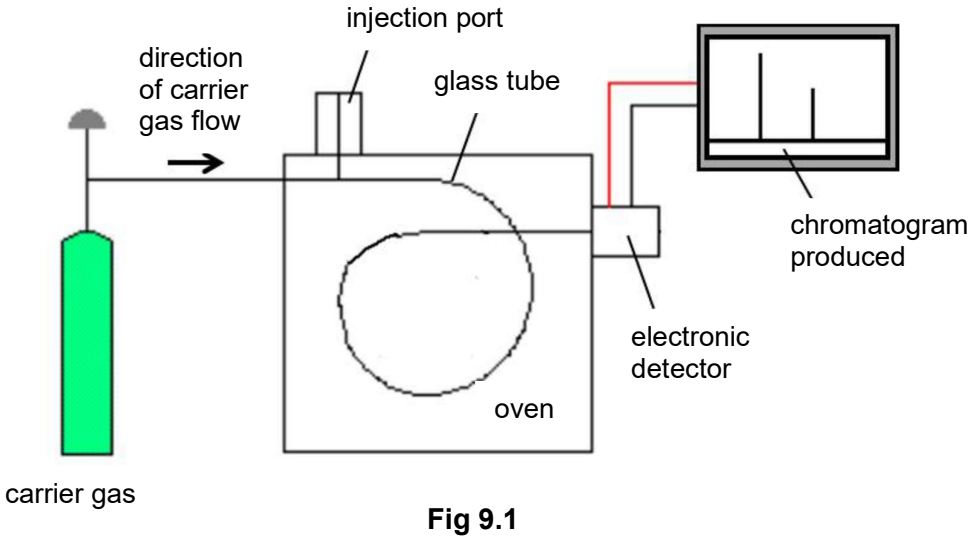


Fig 9.1

Fig. 9.1 shows a schematic diagram of the gas chromatography machine. The gas chromatography machine consists of a thin glass tube placed inside an oven, where the temperature can be adjusted. A carrier gas, such as helium, is allowed to flow through the glass tube.

Next, a small sample of a mixture is injected into the glass tube and heated at a fixed temperature. The substance (in the mixture) with lower boiling point evaporates more easily and moves through the glass tube due to the flow of the carrier gas. The mixture separates into its constituent substances as it passes through the glass tube.

The time taken by each substance to reach the end of the glass tube is known as the retention time. Different substances have different retention times as they move through the glass tube at different rates.

A signal is recorded by the electronic detector when each substance reaches the end of the glass tube.

(a) Helium is often used as a carrier gas in gas chromatography because it will not react with the mixture of substances analysed.

Explain why helium will not react with other substances.

……

……

…… [2]

(b) Gas chromatography is often compared to fractional distillation due to their similarities.

State two similarities between gas chromatography and fractional distillation.

similarity 1 ……...

……..……..

similarity 2 ……...

……..…….. [2]

(c) A mixture of mesitylene and toluene is separated using gas chromatography. The boiling point of each compound is provided in the table below.

compound	boiling point / °C
mesitylene	165
toluene	111

Fig 9.2 shows the chromatogram obtained.

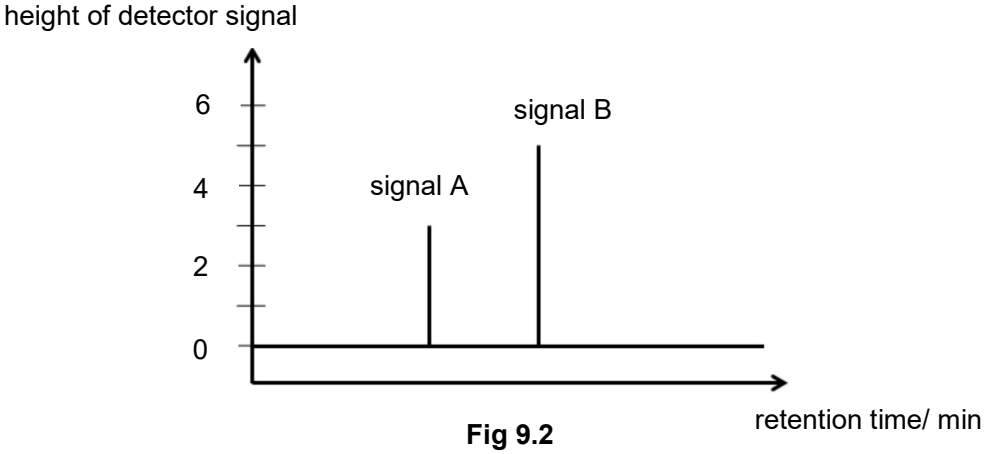


Fig 9.2

(i) Identify the compound that produced each signal.

signal	compound
A	
B	

[1]

(ii) The ratio of the heights of the signals gives the ratio of the amounts of the compounds present in the mixture.

Use the chromatogram above to find the percentage of each compound present.

Show your working in the space below.

[2]

(d) The flow rate of the carrier gas can affect the retention times of the substances separated by gas chromatography.

Three identical mixtures of benzene and hexane are separated using gas chromatography with different flow rates of the carrier gas. The type of carrier gas used, and the temperature of the oven are kept constant for the three separations.

Fig. 9.3 shows the chromatograms obtained for the different flow rate of carrier gas.

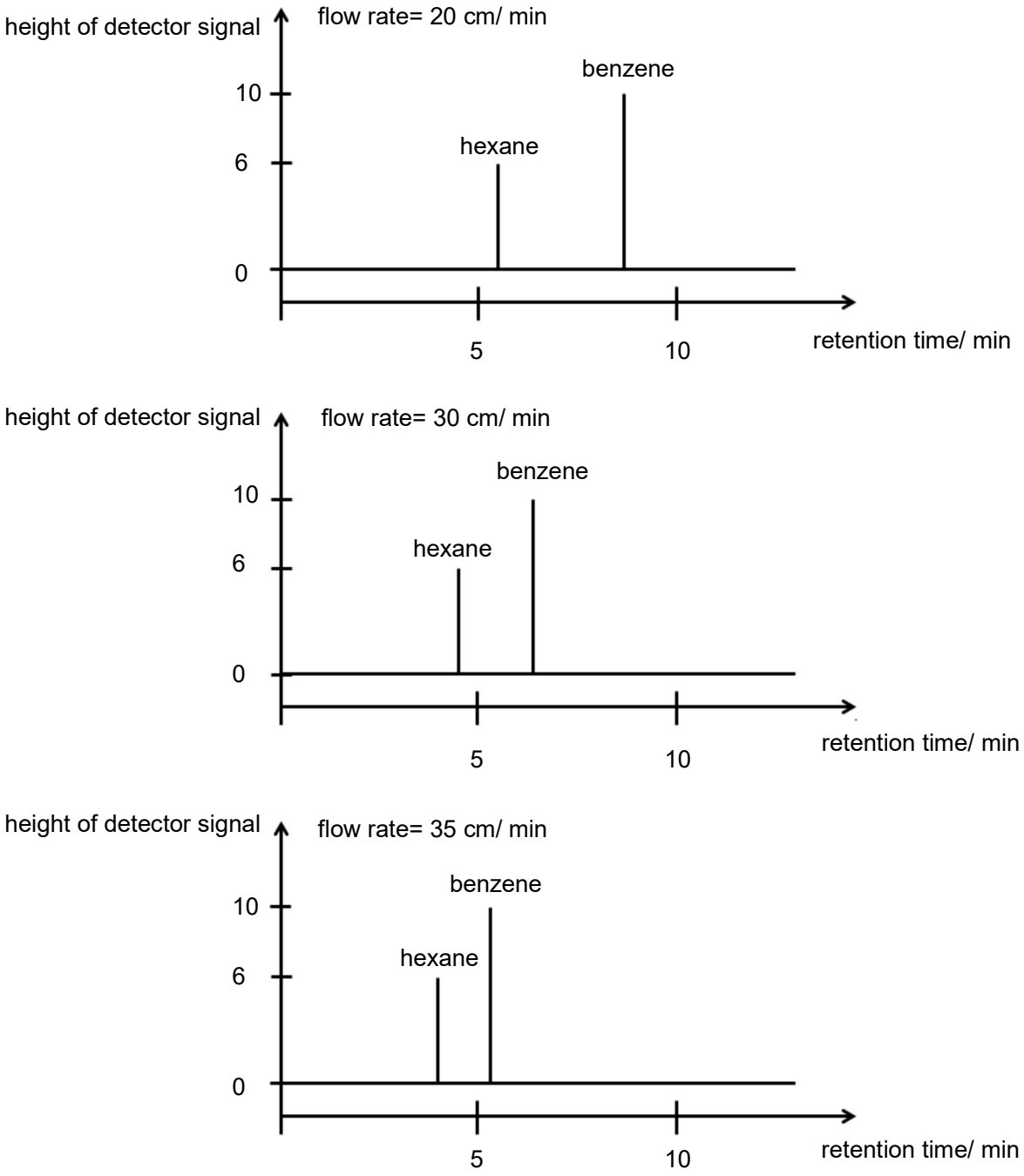


Fig. 9.3

(i) Use the information provided in Fig 9.3, describe how the flow rate of the carrier gas affects the retention time of the compounds.

……

……

…… [2]

(ii) Another identical mixture of benzene and hexane is separated with gas chromatography. The type of carrier gas and temperature used are kept constant, but the flow rate of the carrier gas is increased to higher than 35 cm/min.

Only one signal is obtained in the chromatogram shown in Fig. 9.4.

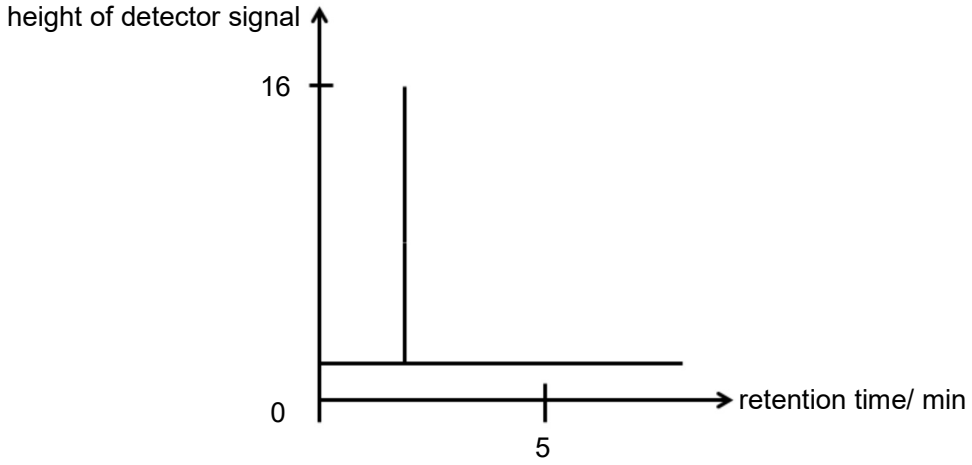


Fig. 9.4

Suggest why only one signal is obtained.

……

…… [1]

[Total: 10]

Section B [10 marks]

Answer **one** question from this section.

10 Vinegar, also known as 'sour wine', is a type of carboxylic acid industrially made by the oxidation of an aqueous solution of ethanol in air and catalysed by bacteria which provide enzymes that speed up the oxidation process.

(a) Give the chemical name and draw the full structural formula of vinegar.

chemical name ……

full structural formula

[1]

(b) Apple cider vinegar is industrially made from oxidation of ethanol obtained from apple juice.

Briefly describe the process of how ethanol is obtained from apple juice. Include a balanced equation in your answer, stating the conditions required clearly.

……

……

……

……

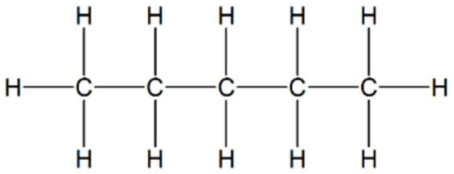
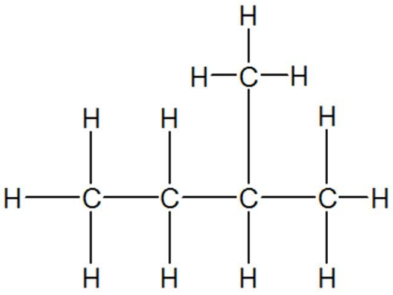
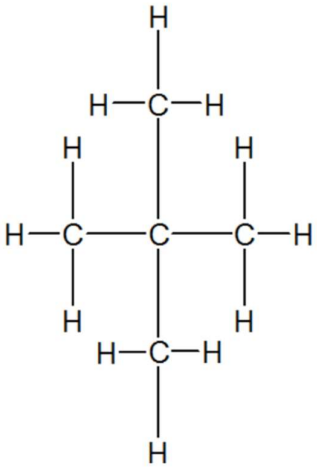
……

…… [3]

(c) The extent to which a particular type of gasoline will burn smoothly in an engine is indicated by the octane rating. Brands of petrol are typically available with octane ratings in the range of 83 to 98.

Table 10.1 lists the octane ratings of three organic compounds which can be used as fuels.

Table 10.1

compound	octane rating
	62
	92
	116

(i) Explain why the above compounds are classified as isomers.

……..

……..

……..

…….. [2]

(ii) Suggest a relationship between the structure of the compound and the octane rating.

……..

……... [1]

(iii) Heptane, an alkane with 7 carbon atoms, is a particularly bad fuel and has been assigned an octane rating of zero. It can be cracked into smaller molecules under high temperatures and a catalyst.

A large volume of heptane was subjected to cracking and the main product was methane. The other only product gas **B**, which has a relative molecular mass of 28, was also isolated in the product mixture and was found to be unsaturated.

Write a balanced equation to show the cracking process. Describe a chemical test that can be used to distinguish between methane and gas **B**.

……..

……..

……..

……..

…… [3]

[Total: 10]

11 The structure of compound **A** is shown in Fig. 11.1.

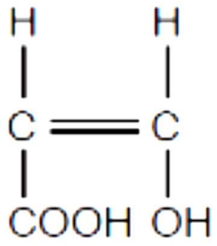


Fig. 11.1

Compound **A** can undergo two types of polymerisation.

(a) State the type of polymerisation and draw a section (showing two repeat units) of the polymer produced by each type of polymerisation.

first type of
polymerisation: .....

second type of
polymerisation: .....

[2]

(b) The structure of compound **B**, a diester, is shown in Fig. 11.2.

$H_7C_3OOC–CH(OH)–CH_2–COOC_3H_7$

Fig. 11.2

B was made from malic acid and two molecules of an alcohol with three carbon atoms.

A student tried to describe the full structural formula of malic acid.

- Malic acid is a carboxylic acid because it contains the carboxyl group.
- Malic acid is also an alcohol as it contains the hydroxyl group.

Using the information above, draw out the full structural formula of malic acid.

[2]

(c) Succinic acid is a colourless organic acid.
The structure of this acid is shown in Fig. 11.3.

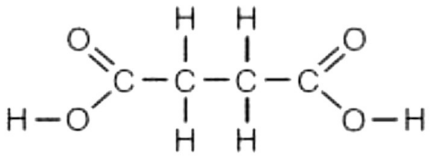


Fig. 11.3

In a titration carried out, succinic acid is neutralised by aqueous sodium hydroxide.

The chemical equation for the reaction is as shown below.

$$C_2H_4(COOH)_2 + 2NaOH \rightarrow C_2H_4(COONa)_2 + 2H_2O$$

Calculate the minimum volume of 0.0200 mol/dm^3 sodium hydroxide required to neutralize 25.0 cm^3 of 0.0500 mol/dm^3 succinic acid.

volume of sodium hydroxide: ……cm^3 [2]

(d) There are several types of nylon. One type of nylon is nylon-6,6.
Fig. 11.4 shows the repeating unit of nylon-6,6.

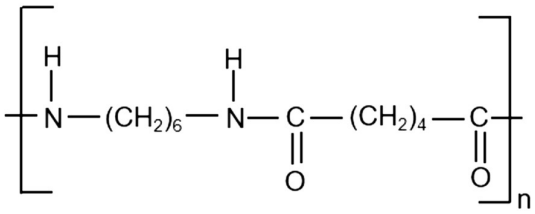


Fig. 11.4

(i) During the manufacturing process, the chain length of the nylon is controlled so that the nylon polymer molecules have an average relative molecular mass in the range of 12000 to 20000.

What is the range of the average number of repeating units in the nylon-6,6 molecules? Show your working.
[M*r* of the repeating unit: 226]

[2]

(ii) Nylon-5,10 is made by reacting the two monomers shown in Fig. 11.5.

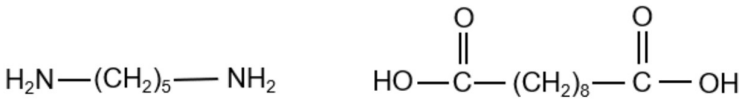


Fig. 11.5

Give one similarity and one difference between the structures of the repeating units of nylon-6,6 and nylon-5-10.

……

……

……

…… [2]

[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		Key: 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	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 –

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