Candidate Name: ______________________________ Index No: _____ Class: _________

ZHENGHUA SECONDARY SCHOOL
PRELIMINARY EXAMINATION 2024
SECONDARY FOUR EXPRESS
CHEMISTRY

6092/02

Paper 2

22 Aug 2024

1 hour 45 minutes

Students answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, index number and class on all the work you hand in.
Write in dark blue or black ink.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, 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 25.

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

Name of Setter: Ms Nur Elfianie

Section A

Answer **all** questions.

1 Different types of reactions are listed below.

combustion	**precipitation**
displacement	**polymerisation**
electrolysis	**rusting**

Use the list to answer the questions.

Name the process of,

(a) burning petrol in unlimited supply of air

……………………………………………………………………………………………………….. [1]

(b) making barium sulfate from two soluble compounds

……………………………………………………………………………………………………….. [1]

(c) extracting sodium metal from its ore

……………………………………………………………………………………………………….. [1]

(d) oxidising iron metal in the presence of moisture

……………………………………………………………………………………………………….. [1]

[Total: 4]

2 Fig. 2.1 shows the apparatus for measuring the rate of diffusion of gases.

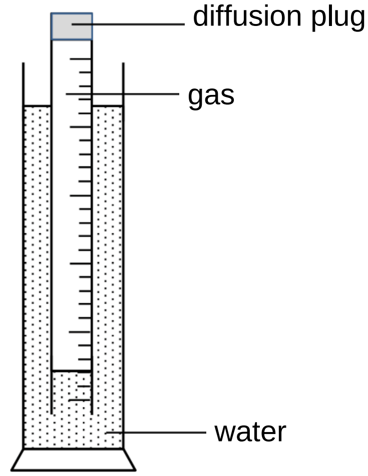

Fig. 2.1

The time taken for 100 cm^3 of argon, methane, nitrogen and oxygen gases at room temperature and pressure, to reach the diffusion plug were recorded.

(a) **(i)** Deduce the order at which the four gases reach the diffusion plug from the first to the last.

first ……………………………………..………

……………………………………..………

……………………………………..………

last ……………………………………..………

[1]

(ii) Explain your answer in **(a)(i)**.

…………………………………………………………………..……………………………..

…………………………………………………………………..……………………………….

…………………………………………………………………..……………………………..

…………………………………………………………………..………………………….. [2]

(b) Explain, in terms of kinetic particle theory, why the temperature of the gases has to be kept constant in this experiment.

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………………………………………………………………………………………………… [2]

(c) Suggest the name of another gas that will diffuse faster than the four gases stated.

………………………………………………………………………………………………… [1]

(d) Suggest why the apparatus is unsuitable for finding the rate of diffusion of ammonia.

………………………………………………………………………………………………… [1]

[Total: 7]

3 Some cars have components made from an alloy of aluminium and silicon.

Silicon is extracted from silicon dioxide in sand by heating the sand to 2000 °C in a furnace with carbon. The reaction is shown below.

$$SiO_2 + 2C \rightarrow Si + 2CO$$

Sand also contains small amounts of aluminium oxide. However, aluminium oxide remains in the silicon after the extraction and further processes are needed to remove it.

(a) Using ideas about reduction, deduce the relative reactivity of silicon and aluminium.

Explain your answer.

……

……

……

………………………………………………………………………………………………… [2]

(b) Table 3.1 shows information about the oxides of carbon, silicon and aluminium.

Table 3.1

oxide	melting point /°C	electrical conductivity
carbon monoxide	-205	does not conduct in any state
silicon dioxide	1600	does not conduct in any state
aluminium oxide	2000	conduct in molten

Using ideas about bonding and structure, explain the differences in the properties of the three oxides.

………

………

………

………

………

………

……… [4]

[Total: 6]

4 A sample of copper(II) chloride is dissolved in concentrated aqueous potassium chloride and the resulting solution is evaporated. Crystals of the salt produced was found to have the following composition by mass: 31.5% K, 25.6% Cu and the remaining C*l*.

(a) Calculate the empirical formula of the salt crystal formed.

Show all your workings.

[3]

(b) The ion of an isotope of copper has the formula $^{66}_{29}Cu^{2+}$.

Complete the table with information about this ion.

sub-atomic particles	number in $^{66}_{29}Cu^{2+}$
electron	
proton	
neutron	

[2]

(c) Fluorine gas was bubbled into a separate solution of copper(II) chloride, forming a solution of copper(II) fluoride.

With the aid of a chemical equation, explain the chemistry behind this reaction.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

[Total: 7]

5 Both zinc and iron react with dilute hydrochloric acid.

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

$$Fe + 2HCl \rightarrow FeCl_2 + H_2$$

(a) **(i)** 1.65 g sample of zinc is reacted with excess hydrochloric acid.

Calculate the volume of hydrogen, measured at room temperature and pressure, formed in this reaction.

volume of hydrogen = …………………………………. dm^3 [2]

(ii) Explain why a different volume of hydrogen, measured at room temperature and pressure, is formed when 1.65 g of iron is reacted with excess hydrochloric acid.

……………………………………………………………………………………………………..

……………………………………………………………………………………………………… [1]

(b) A mixture of iron powder and zinc powder is added to excess sulfuric acid.

Describe a chemical test to be carried out on the reacting mixture to show that only zinc has reacted.

……

……

……………………………………………………………………………………………………… [2]

[Total: 5]

6 Ozone molecules are continually being broken down and formed in the upper atmosphere of the earth.

(a) The equation shows the formation of ozone, O_3 in the upper atmosphere.

$$O_2 + O \rightarrow O_3 \qquad \Delta H = -392 \text{ kJ/mol}$$

(i) Explain, in terms of bond breaking and bond forming, why this reaction is exothermic.

……..

……….. [1]

(ii) When one mole of oxygen molecules reacts, 392 kJ of energy is released.

Calculate the amount of energy released when 48.0 g of oxygen molecules react.

energy released = ……………………………. kJ [2]

(iii) Complete the energy profile diagram for formation of ozone, O_3 in the upper atmosphere of the earth.

Your diagram should include:

- products of the reaction;
- labels to show the enthalpy change, ΔH and activation energy, E_a of the reaction.

[3]

[Total: 6]

7 Sodium burns in air to form sodium oxide as shown in **Fig 7.1**.

At the end of the reaction, the product dissolves in a solution of universal indicator.

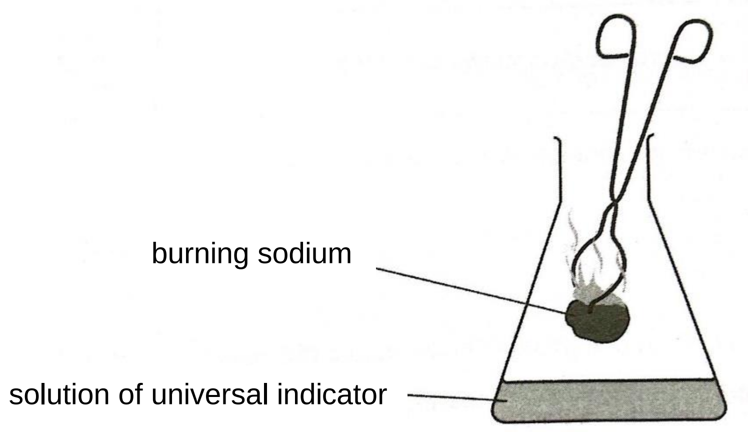

Fig. 7.1

(a) Draw a 'dot-and-cross' diagram to show the arrangement of outer shell electrons in the ions in sodium oxide, Na_2O.

[2]

(b) Suggest and explain any observations seen in the indicator at the end of the reaction.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

(c) Write a balanced chemical equation for the reaction.

…………………………………………………………………………………………………… [1]

(d) The mass of the sodium at the start was 0.80 g.

(i) Calculate the theoretical yield of sodium oxide formed from burning sodium in air.

[2]

(ii) **Table 7.2** shows the mass of the flask and its content before and after the reaction.

Table 7.2

mass of flask and its content at the start / g	10.20
mask of flask and its content at the end / g	10.55

Calculate the percentage yield of sodium oxide.

[2]

[Total: 9]

8 A student investigated the rate of reaction when dilute acid reacts with a piece of marble, $CaCO_3$.

In each experiment, 10.0 cm^3 of different solutions of acids were used. The student measured the time taken to collect 10 cm^3 of gas at room temperature and pressure.

In all five experiments, the dilute acid was in excess.

Table 8.1 shows the experimental results.

Table 8.1

experiment	temperature / °C	acid solution	time / min
1	25	1.0 mol / dm^3 nitric acid	3
2	25	0.5 mol / dm^3 nitric acid	5
3	25	1.0 mol / dm^3 ethanoic acid	18
4	40	1.0 mol / dm^3 nitric acid	?
5	40	1.0 mol / dm^3 ethanoic acid	12

(a) Explain in terms of collisions between reacting particles, the results of experiment 1 and experiment 3.

………

………

………

………

…………………………………………………………………………………………………… [3]

(b) There is a missing data in the results table.

Identify which experiment can be used as a reference to predict the result for experiment 4 to investigate the effect of temperature on the rate of reaction.

Predict and explain the results of experiment 4 as compared to the experiment you have identified above.

experiment number ………………….

……………..………………………………………………………………………..……………..

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……………..………………………………………………………………………..……………..

……………..………………………………………………………………………..………….. [3]

[Total: 6]

9 Silicon is used to make condensation polymers, which are generally known as siloxanes. Siloxanes contain the –O–Si–O– functional group, also known as the *siloxy* group, where *sil* refers to silicon and *oxy* refers to oxygen.

The partial structure of a siloxane can be represented in Fig. 9.1.

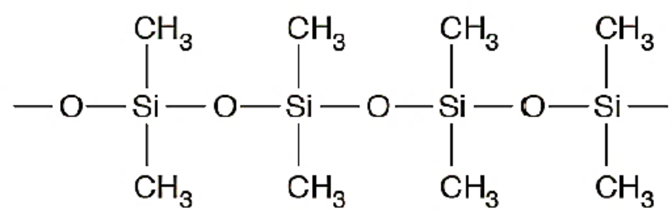


Fig. 9.1

(a) Explain the term condensation polymerisation.

……

…… [1]

(b) Siloxanes are formed from monomers that contain two hydroxyl groups.

Deduce the structural formula of the monomer used to form the siloxane represented above.

[1]

(c) Based on the information above, explain if siloxanes are saturated or unsaturated.

Describe a test to confirm your answer.

……

……

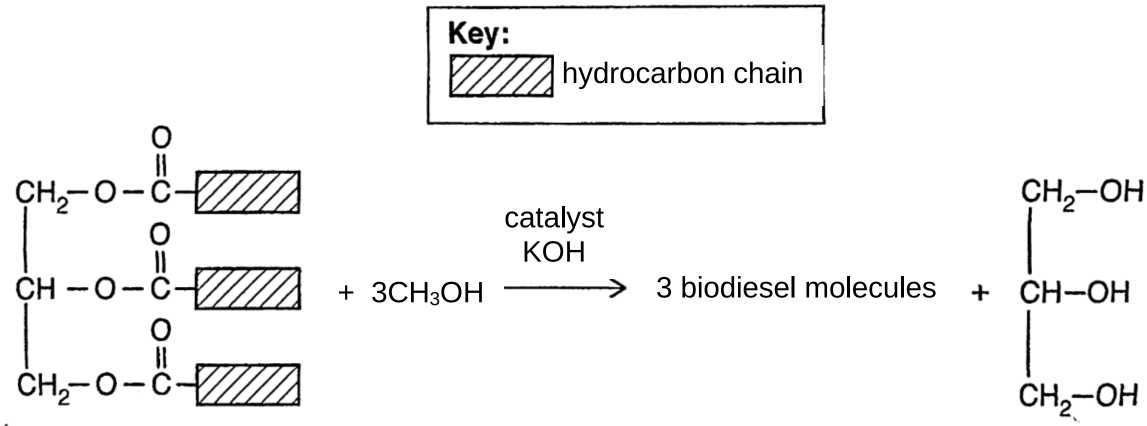
…… [2]

[Total: 4]

10 Vegetable oils from used cooking oil is often recycled to make biodiesel for fuel.

Vegetable oil are *tri-esters* with long hydrocarbon chains. It reacts with methanol in the presence of potassium hydroxide catalysts.

Fig. 10.1 shows the structures of some of the molecules involved in the reaction.



vegetable oil **methanol**

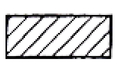
Fig. 10.1

(a) Suggest why vegetable oils are called *tri-esters.*

.... [1]

(b) One molecule of vegetable oil reacts to form three molecules of biodiesel. Biodiesel is an ester.

(i) Suggest the structure of one molecule of biodiesel.

Use  to represent the hydrocarbon chain.

[1]

(ii) Biodiesel, a type of biofuel, is a cleaner alternative to crude oil.

Using ideas about carbon dioxide emission, suggest why biodiesel is more environmentally sustainable than crude oil.

………………………………………………………………………………………………………..

……………………………………………………………………………………………………. [1]

(c) Vegetable oils that have been used for cooking contain acids. The oils must be treated to neutralise the acids before they can be used in the reaction to make biodiesel.

A titration was carried out to find out how much potassium hydroxide is needed to be added to each kilogram of oil to neutralise the acids.

10.0 g of oil was titrated with aqueous potassium hydroxide with a concentration of 1.00 g/dm^3.

Results

	rough	titration 1	titration 2
final burette reading / cm^3	22.00	43.50	21.60
initial burette reading / cm^3	0.00	22.00	0.00
volume of KOH used / cm^3	22.00	21.50	21.60

Use the average titration results to calculate the mass (in grams) of potassium hydroxide that needs to be added to neutralise the acid found in 1 kg of oil.

[3]

[Total: 6]

11 Gas Chromatography as a Separating Technique

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.

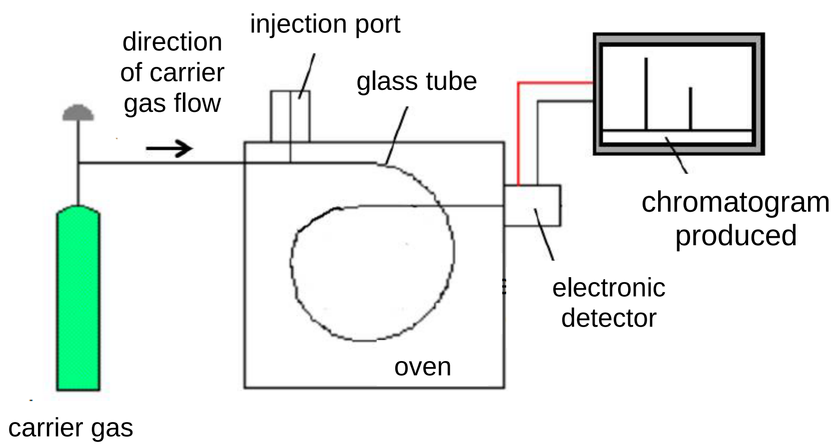


Fig. 11.1

Fig. 11.1 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 gas carrier in gas chromatography as it will not react with the mixture of substances to be analysed.

Explain why helium is unreactive.

……………………………………………………………………………..…………………………..

……………………………………………………………………………..…………………… [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 substance is provided in the table below.

substance	boiling point / °C
mesitylene	165
toluene	111

Fig. 11.2 shows the chromatogram obtained from the separation.

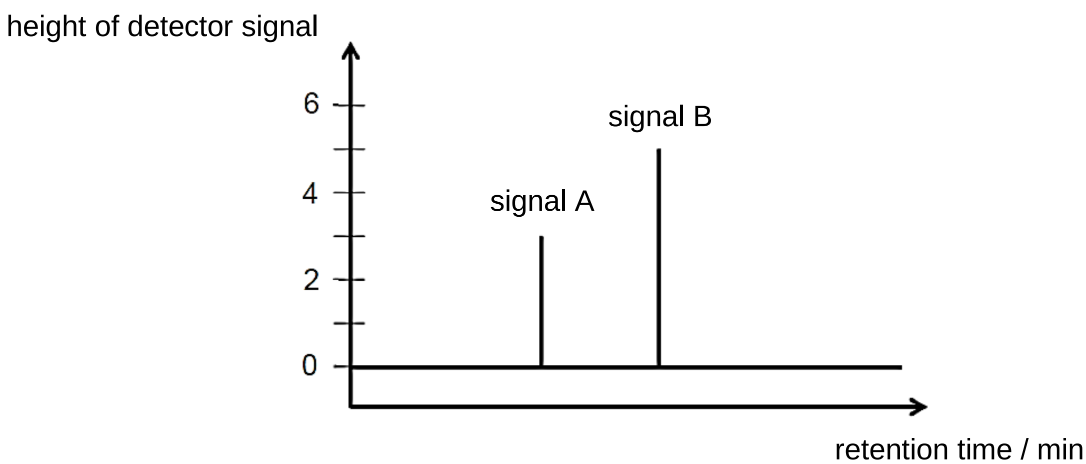


Fig. 11.2

(i) Identify the substance in the mixture that produced each signal.

signal A ....

signal 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.

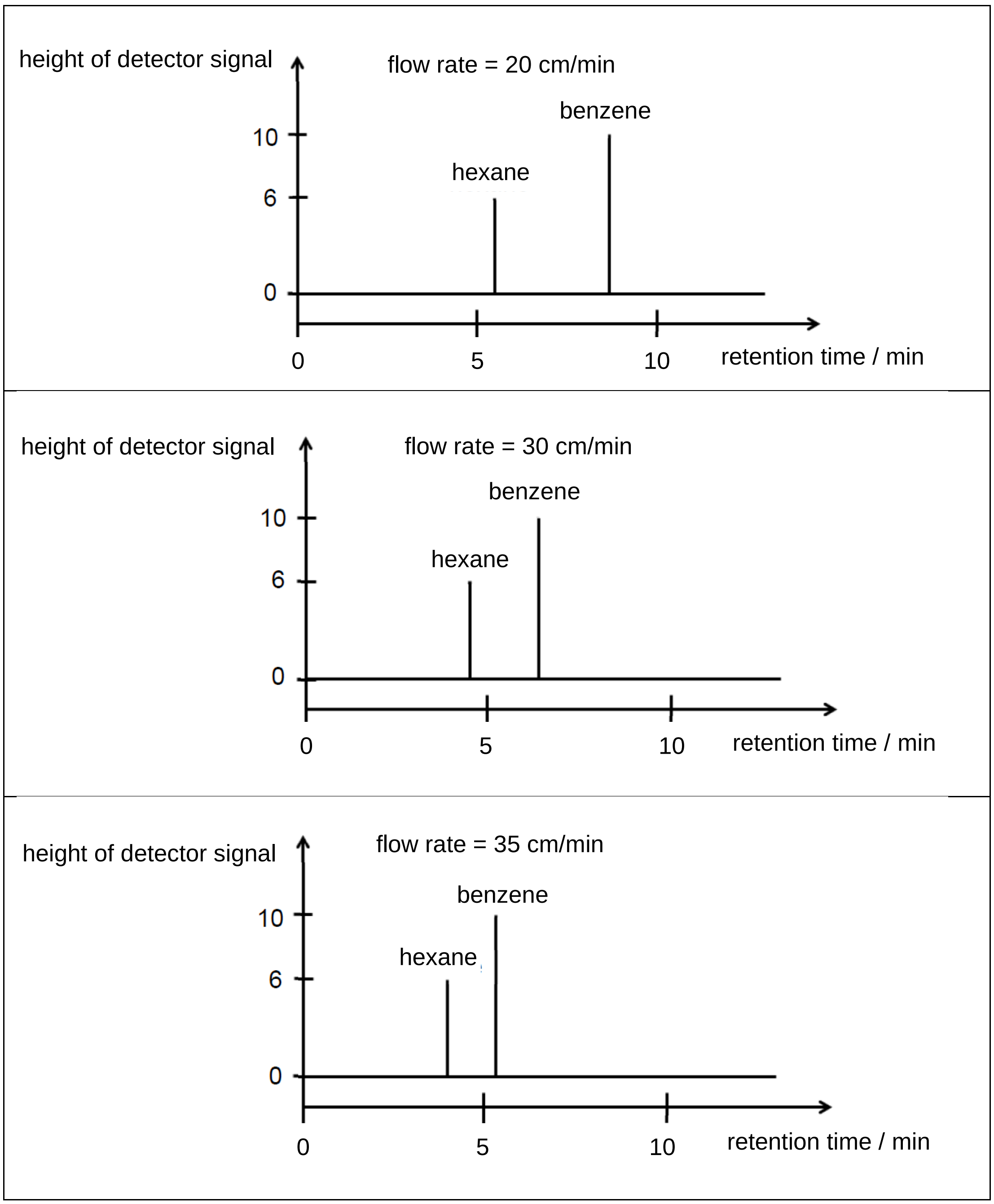
[2]

(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.

Table 11.3 shows the chromatograms obtained for the different flow rate of carrier gas.

Table 11.3



(i) 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 remained the same, flowing at a rate of 30 cm / min but the temperature of the oven was set higher at 210 °C.

Only one signal is obtained in the chromatogram shown in Fig. 11.4.

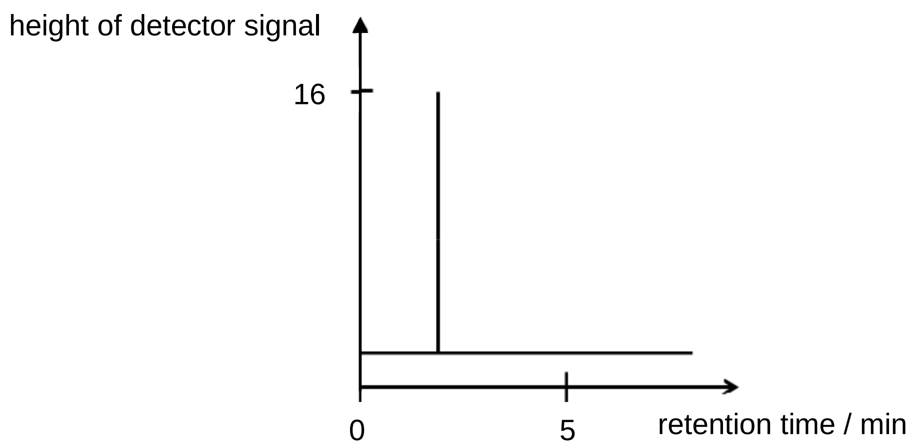


Fig. 11.4

Suggest why only one signal was observed.

…………………………………………………………………………………………………..

…………………………………………………………………………………………… [1]

[Total: 10]

Section B

Answer **one** question from this section.

12 An electrolysis experiment was carried out using inert electrodes as shown in Fig. 12.1.

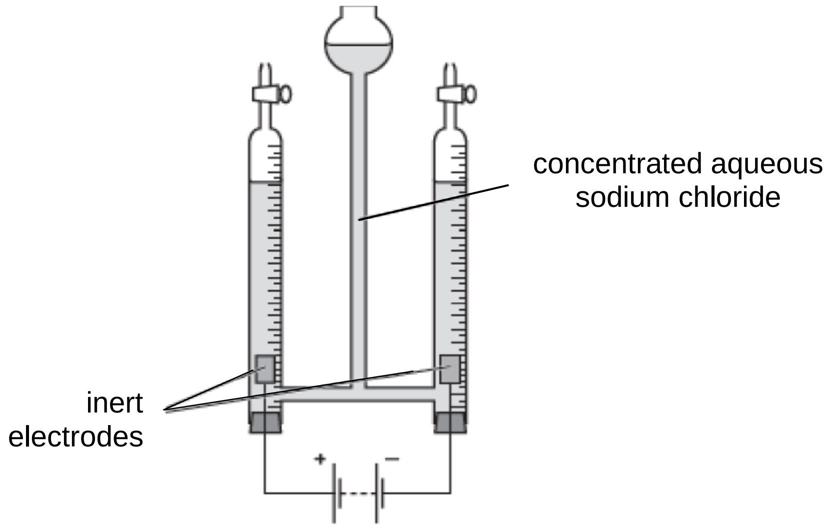


Fig. 12.1

(a) Explain the observations for the experiment.

Your answer should:

- describe the reactions taking place at each electrode using half-equations to represent the reactions
- explain how the pH of the solution changed during electrolysis
- explain why the initial volume of gas collected at the anode is lower than the volume of gas collected at the cathode but this difference reduced over time

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…… [6]

(b) A student used the following electrochemical cell as shown in Fig. 12.2.

The reading on the voltmeter was +1.10 V.

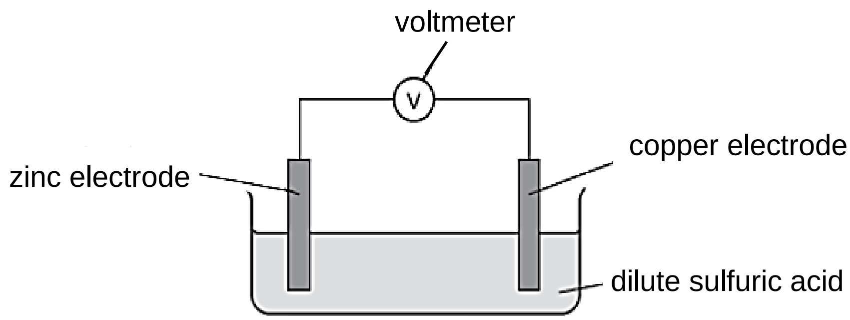

Fig. 12.2

(i) Suggest the change, if any, in the voltmeter reading if the zinc electrode was replaced with an iron electrode.

Explain your answer.

……

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…… [2]

(ii) The zinc electrode was replaced with a silver electrode. The reading on the voltmeter was – 0.46 V.

Suggest why the sign of the voltmeter reading became negative.

……

…… [2]

[Total: 10]

13 An experiment was conducted to coat a metal spoon with gold as shown in Fig. 13.1. Aqueous sodium dicyanoaurate, $NaAu(CN)_2$, was used as the electrolyte. The spoon is placed at the cathode and a piece of gold is used as the anode.

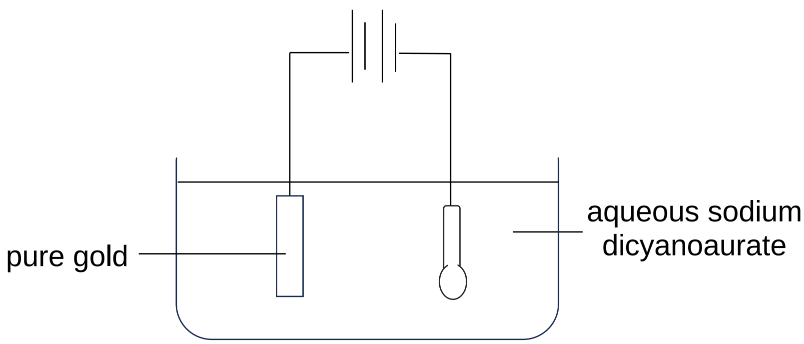

Fig. 13.1

(a) Explain the observations for the experiment.

Your answer should:

- describe any physical changes that occurred to each electrode
- explain, with the use of half-equations, why the changes at each electrode occurred
- explain how the concentration of the solution changed during electrolysis

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……… [6]

(b) Describe and explain the products formed at the cathode initially and after a period of time, when gold electrode was replaced by graphite.

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………………………………………………………………………………………………………

……………………………………………………………………………………………… [2]

(c) The cyanide ion has the formula CN^-. Given that sodium dicyanoaurate ionises in water to form sodium ions, gold ions and cyanide ions, CN^-, deduce the oxidation state of the elements in the electrolyte.

element	oxidation state in $NaAu(CN)_2$
carbon	
gold	
nitrogen	-3
sodium	

[2]

[Total: 10]

END OF PAPER

The Periodic Table of Elements

Group																	
1	2											13	14	15	16	17	18
				Key			1 H hydrogen 1										2 He helium 4
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	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, $L = 6.02 \times 10^{23}$