NAME	CLASS	INDEX NO.

ST. PATRICK'S SCHOOL

MASTERY REVIEW 2026

SUBJECT : CHEMISTRY (6092) **DATE : 07 MAY 2026**

LEVEL : SECONDARY 4 EXPRESS **DURATION : 1 H 45 MINS**

INSTRUCTIONS TO CANDIDATES:

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.

1. Write down your name, class and index number on the Question Paper in the spaces provided.
2. Write in dark blue or black pen. You may use an HB pencil for any diagrams or graphs. Do not use correction fluid.
3. This paper consists of **THREE (3) Sections: Section A, B and C.**
4. Answer **ALL** questions in **Section A** on the **table** provided in **page 2**.
5. Answer **ALL** questions in **Section B and C** in the spaces provided.
6. Section C comprises of 2 questions – Question 11 and Question 12**. SELECT ONLY ONE QUESTION from this Section**.
7. The use of an approved scientific calculator is expected, where appropriate.
8. **DO NOT DETACH** any sections from this paper.

INFORMATION FOR CANDIDATES:

The number of marks is given in brackets [ ] at the end of each question.

SECTION **A** :	/10
SECTION **B** :	/60
SECTION **C**	
Question 11	/10
Question 12	/10
TOTAL	/80
GRADE	

This question paper consists of <u>26</u> printed pages, including this cover page and a copy of the Periodic Table.

Section A (10 Marks)

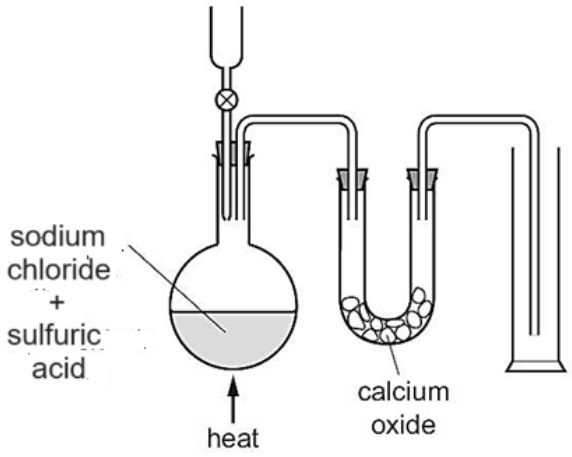
Each question is provided with **four** possible answers (**A**, **B**, **C** and **D**). Select the most appropriate answer and write it in the table provided.

1	2	3	4	5	6	7	8	9	10

1 Hydrogen chloride gas can be produced from the reaction of sodium chloride with sulfuric acid.

Which set of apparatus is suitable for preparing and collecting a dry sample of hydrogen chloride?

A



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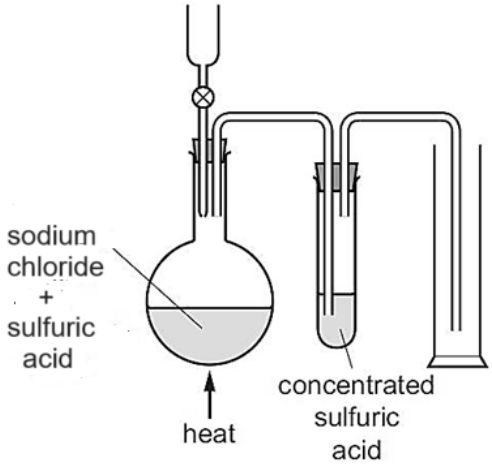
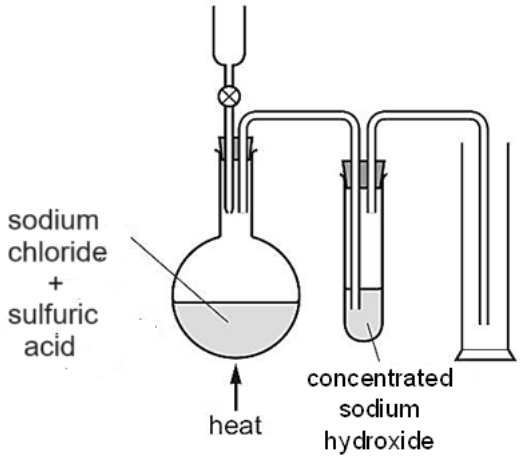


C



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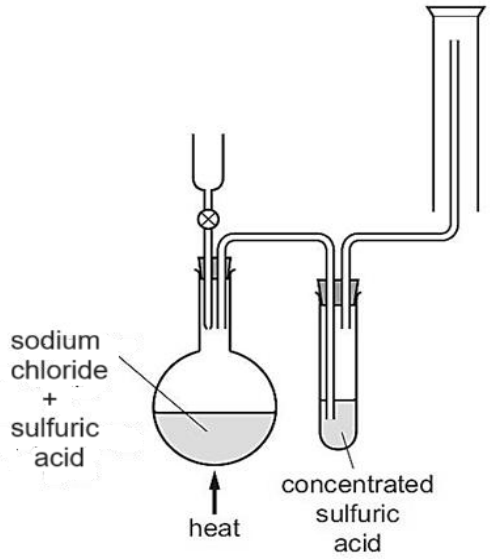
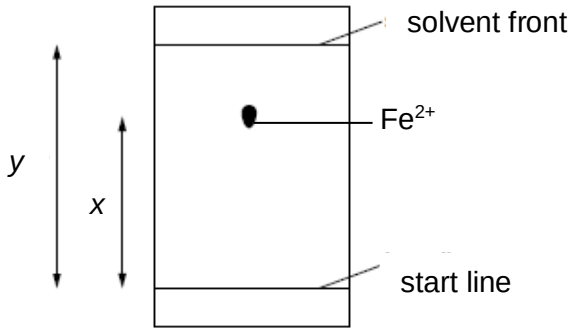


2 A student uses paper chromatography to find an R_f value for $Fe^{2+}(aq)$. The result is shown.

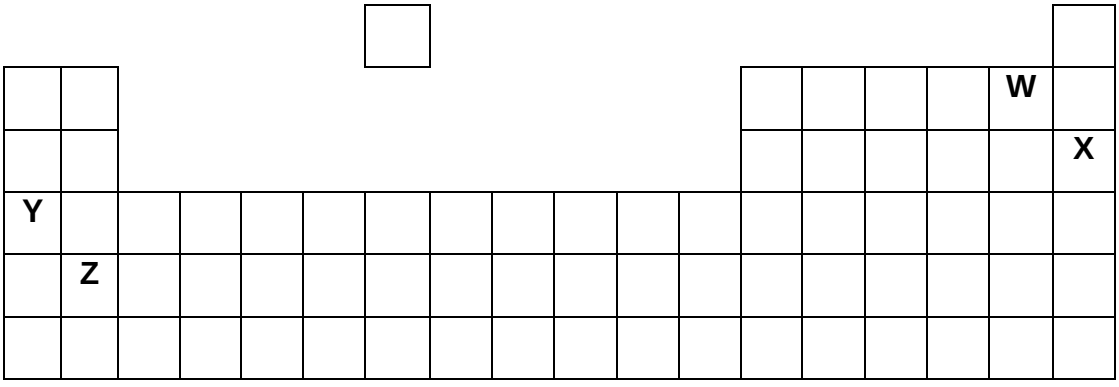


To make the component containing $Fe^{2+}(aq)$ more visible, the paper is sprayed with a solution, V so that a coloured spot, W forms.

Which row gives the correct identity of solution V, colour of spot, W and R_f value of $Fe^{2+}(aq)$?

	solution V	colour of spot, W	R_f value
A	aqueous ammonia	green	x/y
B	aqueous ammonia	reddish-brown	y/x
C	aqueous sodium hydroxide	green	y/x
D	hydrochloric acid	reddish-brown	x/y

3 Some elements on the Periodic Table are shown below.

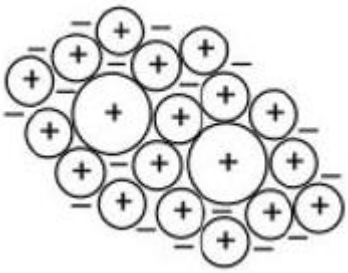


Which row correctly describes **W**, **X**, **Y** and **Z**?

	most number of protons	least reactive	gains electrons most easily
A	W	X	Z
B	W	Y	Z
C	Z	X	W
D	Z	Y	W

4 The structures of four substances are shown.

1



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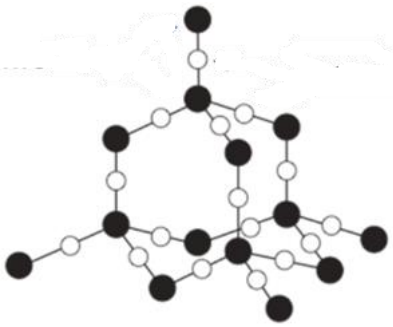

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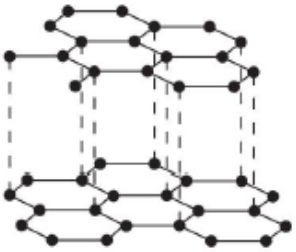

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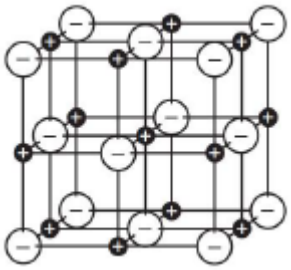


Which statement about the structures is correct?

A Structures 3 and 4 are hard and crystalline.
B Structures 1 and 3 can conduct electricity in solid state.
C Structures 1 and 2 are compounds with high melting points.
D Structures 2 and 4 are compounds with giant molecular structures.

5 Alkali metals and halogens react readily to form salts.

Which alkali metal and halogen will react most vigorously?

	alkali metal	halogen
A	lithium	fluorine
B	lithium	iodine
C	potassium	fluorine
D	potassium	iodine

6 Zinc thiocyanate has the chemical formula $Zn(SCN)_2$.

Bismuth oxide has the chemical formula Bi_2O_3.

What is the chemical formula of bismuth thiocyanate?

A Bi_2SCN
B Bi_3SCN
C $Bi(SCN)_2$
D $Bi(SCN)_3$

7 Which two substances when mixed, will result in an increase of lead(II) ions in solution?

A lead and dilute nitric acid
B lead(II) oxide and sulfuric acid
C aqueous lead(II) nitrate and zinc
D lead(II) nitrate and potassium hydroxide

8 A sample of carbonic acid was contaminated with a substance that does not decompose upon heating. Carbonic acid decomposes upon heating to form carbon dioxide and water vapour as the only products.

1.5 g of this mixture was heated in a test-tube until no further change was observed. The final mass of the substance in the test-tube was 0.15 g.

What is the percentage purity of the carbonic acid in the sample?

A 10 % **B** 11 % **C** 45 % **D** 90 %

9 A solution containing copper ions is electrolysed using inert electrodes.

During electrolysis:

- 0.24 dm^3 of oxygen gas is produced at the anode (measured at room conditions)
- 0.040 mol of copper metal is deposited at the cathode

What is the charge on the copper ion in the solution?

A +1 **B** +2 **C** +3 **D** +4

10 Dilute aqueous sodium chloride is electrolysed using graphite electrodes.

Which row gives the correct results of the electrolysis?

	gases released		pH of electrolyte
	cathode	anode	
A	hydrogen	chlorine	increase
B	hydrogen	oxygen	decrease
C	hydrogen	oxygen	no change
D	oxygen	hydrogen	no change

Section B (60 marks)

Answer **all** the questions in this section in the spaces provided.

1 The list below shows the chemical formulae of some compounds.

$(NH_4)_2SO_4$	Ag_2CO_3	NaBr
$ZnCl_2$	$CaCl_2$	$FeSO_4$
Al_2O_3	KNO_3	SiO_2

Use the substances in the list to answer the questions below. Each compound can be used once, more than once, or not at all.

Identify the compound which:

(a) is coloured

…… **[1]**

(b) can be prepared by precipitation

…… **[1]**

(c) reacts with both an acid and an alkali

…… **[1]**

(d) dissolves in water and produces a white precipitate that is insoluble in excess aqueous sodium hydroxide

…… **[1]**

(e) has an extended network of giant tetrahedral structure.

…… **[1]**

2 Chemists sometimes use a quantity, pK_a, to describe the strength of acids. A pK_a value of less than zero denotes a strong acid.

During the titration of a weak acid with sodium hydroxide, the pH of the solution when half of the acid has been neutralised is equal to the pK_a value of the acid. The pK_a value of the acid can be used to confirm the identity of the acid.

The chemist transferred 25.0 cm³ of acid Y into a beaker using a pipette and measured the pH using a pH meter that can be read to one decimal place.

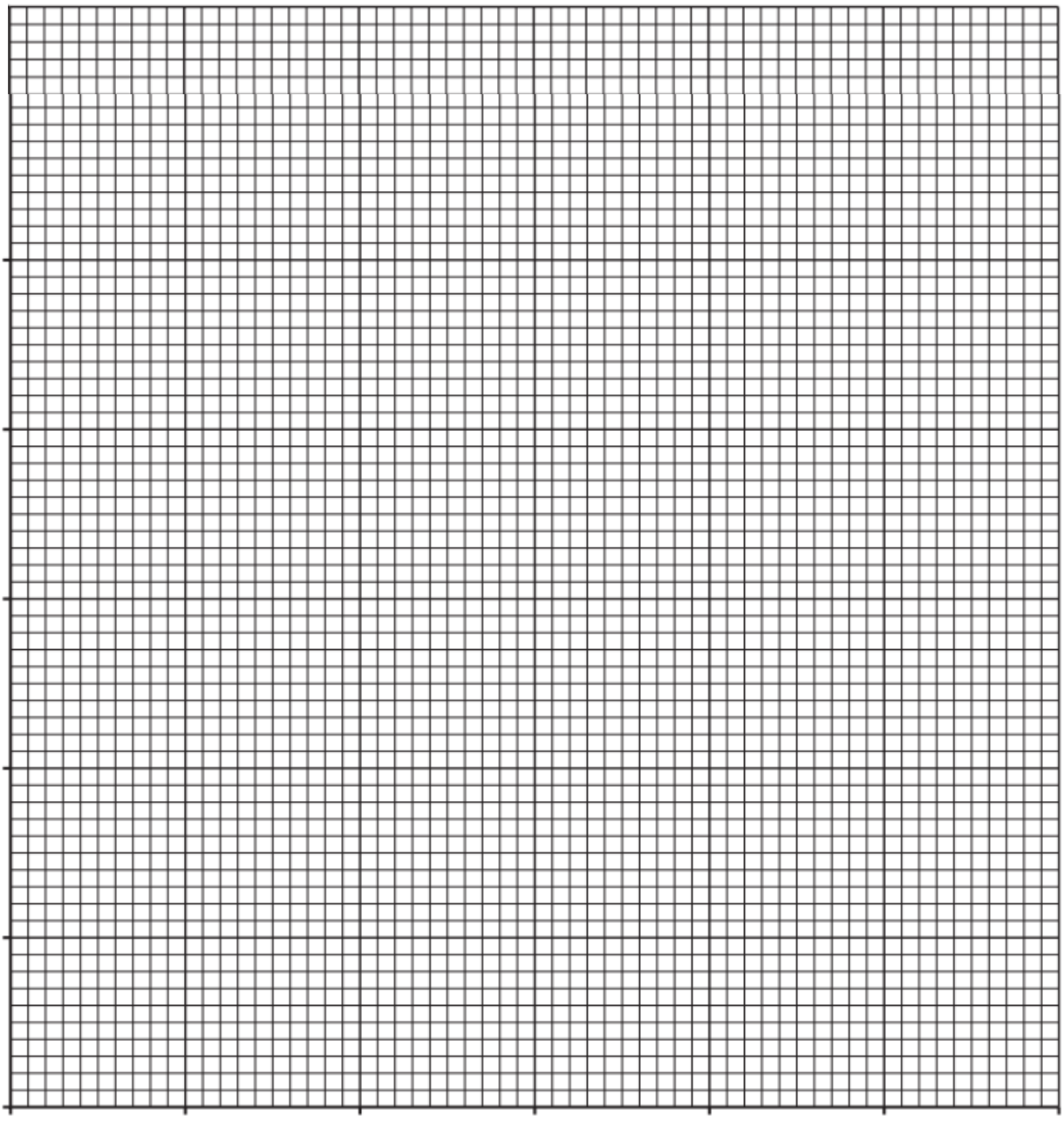
A solution of 0.100 mol/dm^3 sodium hydroxide was added from a burette in small portions. After each addition, the pH of the mixture was recorded.
The results are shown in Table 2.1 below.

Table 2.1

volume of sodium hydroxide solution added / cm³	pH	volume of sodium hydroxide solution added / cm³	pH
0.0	3.0	23.5	5.1
2.0	3.4	24.0	5.5
4.0	3.5	24.5	11.8
8.0	3.7	25.0	12.1
12.0	4.3	26.0	12.3
16.0	4.1	27.0	12.4
20.0	4.3	28.0	12.5
22.0	4.7	30.0	12.5

(a) Plot a graph of the results in Table 2.1, marking each point with a cross (x). Draw a best-fit line, taking into account all the plotted points, ignoring any inconsistent results.

pH



volume of sodium hydroxide in cm^3

[3]

(b) Use your graph from **(a)** to determine the

(i) volume of sodium hydroxide solution at the end-point of the titration (*end point of titration is **halfway** up the steep curve, where the H^+ ions are completely neutralized by OH^- ions*)

…….. **[1]**

(ii) volume of sodium hydroxide solution needed to neutralise half the acid

…….. **[1]**

(iii) pH of the half-neutralised mixture. Give your answer to one decimal place.

…….. **[1]**

(c) Explain how the pH value you obtained in **(b)(iii)** shows that acid Y is a weak acid.

……

…… **[2]**

(d) Table 2.2 shows the pK_a values for some organic acids.

Table 2.2

acid	pK_a
methanoic	3.8
ethanoic	4.8
iodoethanoic	2.2
propanoic	4.9

Use your answer from **(c)** to identify acid Y from Table 2.2.

…… **[1]**

3 The ionic equation for the reaction of chlorine with dilute aqueous sodium hydroxide is shown.

$$Cl_2 + 2OH^- \rightarrow ClO^- + Cl^- + H_2O$$

State the roles of chlorine in the reaction. Explain your answer using ideas of oxidation state.

……..

……..

……..

……..

…….. **[3]**

4 Older cars are tested each year to measure the amount of pollutants contained in exhaust fumes. Table 4.1 shows the maximum allowed percentages of exhaust pollutants for petrol cars.

Table 4.1

age of cars in years	maximum allowed percentage (%) of exhaust pollutant	
	carbon monoxide	unburned hydrocarbons
16-24	0.30	0.02
3-16	0.20	0.02

(a) Suggest **one** reason why the maximum allowed percentage of carbon monoxide has been decreased for newer cars.

……

……

…… **[1]**

(b) Give **one** reason for limiting emissions of unburned hydrocarbons in exhaust fumes.

……

…… **[1]**

(c) Explain why oxides of nitrogen are formed in an internal combustion engine but not when a small sample of petrol is burnt in an evaporating dish.

……

…… **[2]**

(d) The engines of modern motor cars have exhaust systems which are fitted with catalytic converters to reduce atmospheric pollution from substances such as NO and NO_2.

(i) Write a balanced chemical equation to show how oxides of nitrogen are removed from the exhaust gases of a car engine by a catalytic converter.

…….. **[1]**

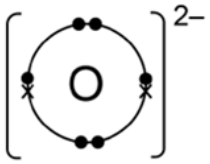
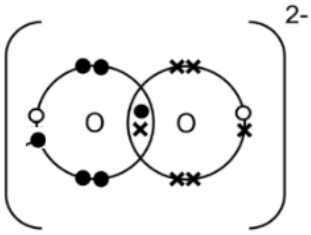
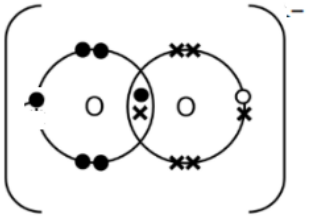
(ii) Briefly describe one feature of the catalytic converter that allows the fast, high-efficiency conversion of toxic fumes into less harmful emissions.

……..

…….. **[1]**

5 Table 5.1 shows three anions formed by oxygen.

Table 5.1

name	oxide	peroxide	superoxide
chemical formula	O^{2-}	O_2^{2-}	O_2^-
dot-and-cross (outer shell electrons only)			

(a) Which anion has an unusual electronic structure? Explain your answer.

……

…… **[1]**

(b) Deduce the formula for

(i) sodium peroxide ……...

(ii) magnesium superoxide ……... **[1]**

(c) **(i)** Draw the dot-cross diagram for oxygen O_2, showing only valence electrons.

[2]

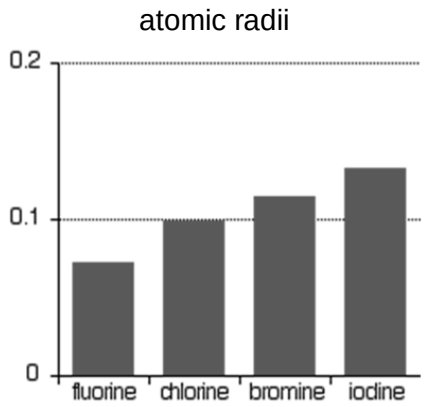
(ii) Explain why the bonding between oxygen atoms in O_2 is different from that in peroxide ion O_2^{2-}.

……..

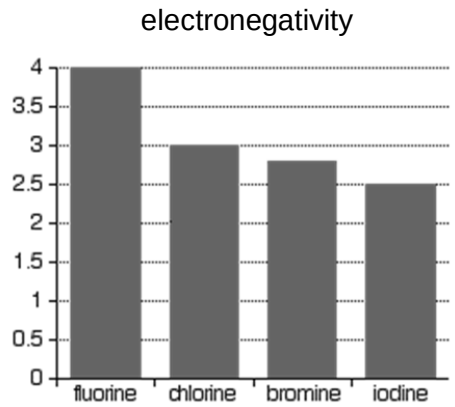
……..

…….. **[2]**

6 The graphs below show some properties of Group 17 elements, the halogens. Graph 1 shows the atomic radii and Graph 2 shows the electronegativity of the Group 17 elements. Electronegativity is a measure of the tendency of an atom to attract a bonding pair of electrons. It is usually measured on the Pauling scale, on which the most electronegative element (fluorine) is given an electronegativity of 4.0.



Graph 1



Graph 2

(a) Using Graph 1, describe and explain the trend of the atomic radii of the halogens down the group.

……

……

……

…… **[2]**

(b) Using Graph 2, predict and explain the reactivity of the halogens down the group.

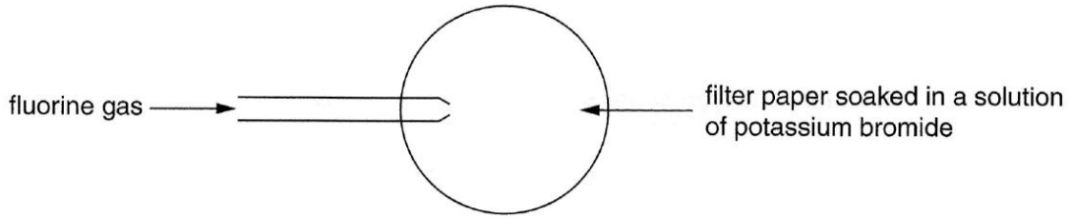
……

……

……

…… **[3]**

(c) Fluorine is the first element in Group 17.
A jet of fluorine gas is aimed at a filter paper soaked in a solution of potassium bromide.



The solution on the filter paper quickly turns brown.

Explain why the solution turns brown. Include a chemical equation with state symbols to support your answer.

……

……

……

…… **[3]**

7 A student titrates 20.0 cm^3 of metal hydroxide $M(OH)_2$, of concentration 0.060 mol/dm^3 with a strong acid of concentration 0.050 mol/dm^3.
It requires 24.0 cm^3 of acid to neutralise the metal hydroxide completely.

Deduce whether the acid used is more likely to be hydrochloric acid or sulfuric acid.
Explain your answer with appropriate calculations.

……

……

…… **[3]**

8 A student investigated the reaction when dilute sulfuric acid reacts with zinc in the presence of varying amounts of copper(II) sulfate solution. He found that when copper(II) sulfate solution is added, it increases the rate of reaction between zinc and sulfuric acid.

(a) Write an ionic equation for the reaction between zinc and sulfuric acid.

…… **[1]**

(b) State the role of copper(II) sulfate in the reaction.

…… **[1]**

The student added different volume of copper(II) sulfate solution to the same amount of sulfuric acid. He measured the total volume of gas at the end of each experiment and found that the reaction also produced copper metal.

Fig. 8.1 shows his results.

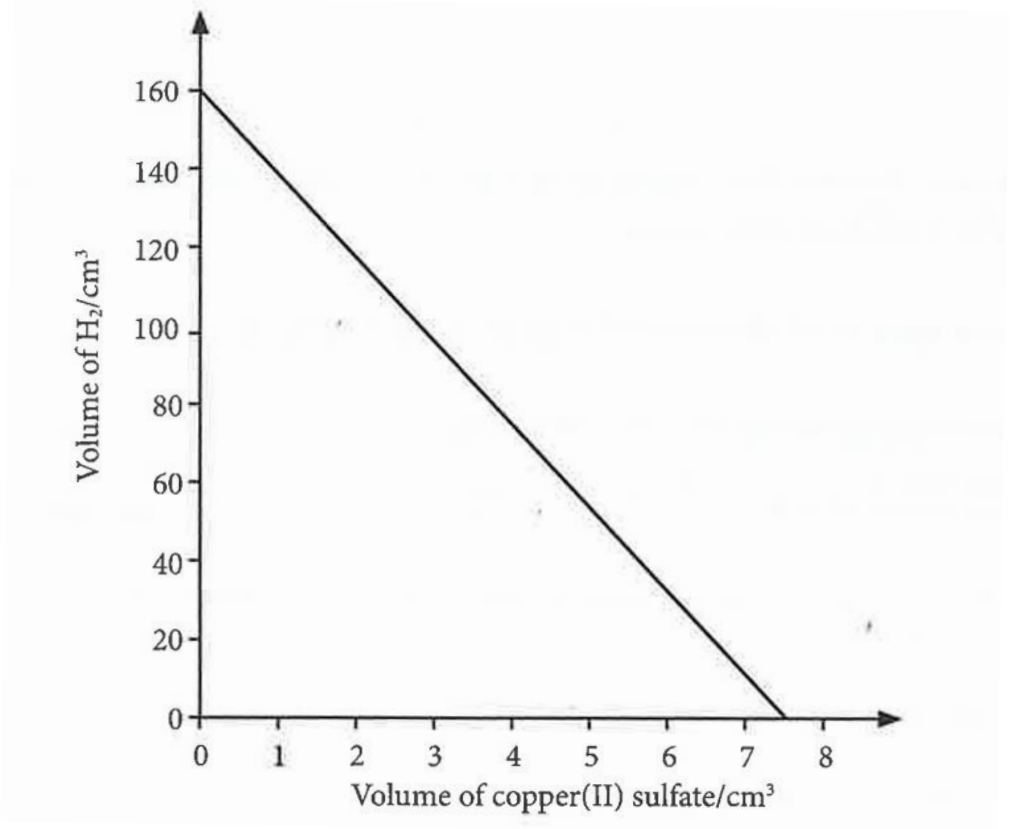


Fig. 8.1

(c) When the volume of copper(II) sulfate solution used increases, the volume of hydrogen gas collected decreases. Explain why.

……

……

……

…… **[2]**

The student repeats the experiment to produce hydrogen gas by using different metals (zinc, iron and magnesium) but this time **without** copper(II) sulfate.
He claimed that '10g of a different metal will produce an equal volume of hydrogen gas when reacted with sulfuric acid'.

(d) Do you agree with the student? Explain your reasoning.

……

……

……

…… **[2]**

9 The enthalpy change for the reaction between methane and steam to produce carbon monoxide and hydrogen is +206 kJ/mol.
Fig. 9.1 shows the relative concentrations of methane and carbon monoxide in a closed container as the reaction progresses.

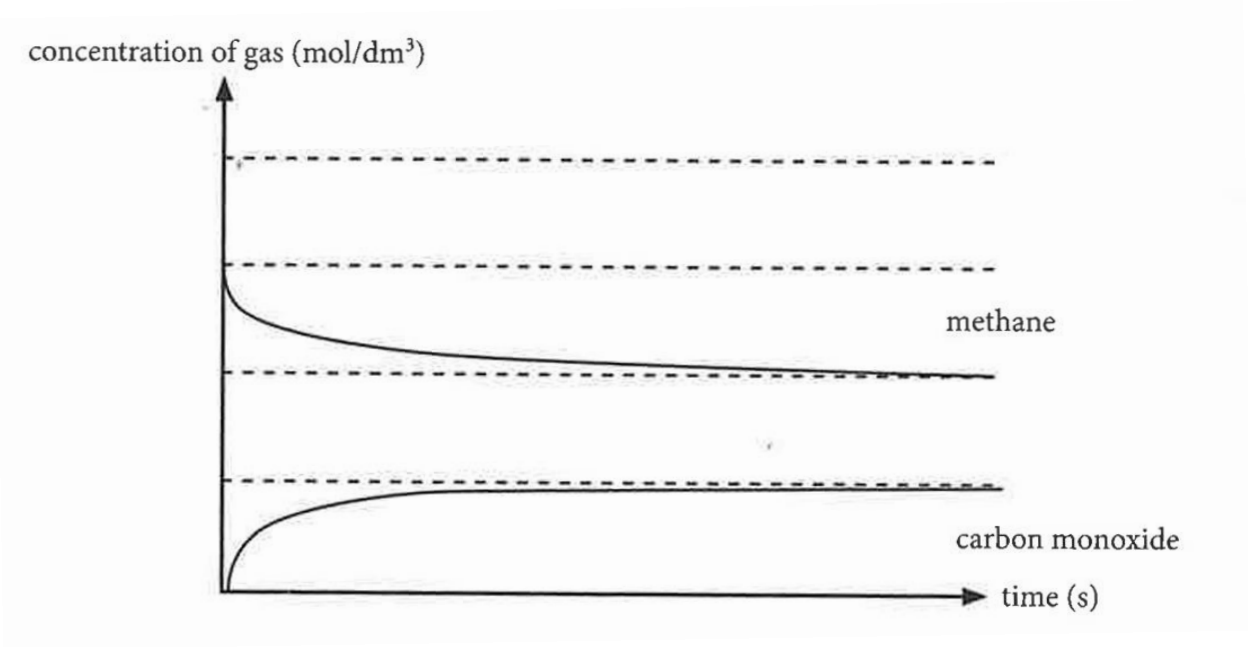


Fig. 9.1

(a) On Fig. 9.1, draw a line to show the change in concentration of

(i) hydrogen gas as the reaction progresses – label this line '**J**' **[1]**

(ii) carbon monoxide when the experiment is conducted in the presence of a catalyst – label this line '**K**' **[1]**

(b) In the space below, draw the energy profile diagram for the reaction between methane and steam.
Your diagram should include

- the chemical formulae of the reactions and products,
- labels for the enthalpy change of reaction and activation energy

[2]

10 Hydrogen bromide HBr can be produced by different methods.

Method 1: Reaction between amine, $C_6H_5NH_2$, and bromine

$$C_6H_5NH_2 + 3Br_2 \rightarrow C_6H_2NH_2Br_3 + 3HBr$$

The initial rate of this reaction was determined using different concentrations of the reactants, as shown in Table 10.1.

Table 10.1

experiment	concentration of $C_6H_5NH_2$ (mol/dm^3)	concentration of Br_2 (mol/dm^3)	initial rate of reaction (mol/dm^3s^{-1})
1	0.001	0.001	0.007
2	0.001	0.002	0.014
3	0.001	0.003	0.021
4	0.002	0.003	0.084
5	0.003	0.003	0.189

Varying the concentration of each reactant affects the rate of reaction to different extents. Knowing how the rate is affected by the concentration of each reactant would allow the rate of the reaction to be predicted.

Reactions can be classified into two categories, depending on how the rate is affected by concentrations of each reactant. Table 10.2 shows the description of each type of reaction.

Table 10.2

type of reaction	characteristic	example
first order reaction with respect to reactant A	the rate of reaction is proportional to the concentration of A	If the concentration of A is doubled, the rate of reaction is doubled. If the concentration of A is tripled, the rate of reaction is tripled.
second order reaction with respect to reactant A	the rate of reaction is proportional to the square of the concentration of A	If the concentration of A is doubled, the rate of reaction increases by 4 times (2^2). If the concentration of A is tripled, the rate of reaction increases by 9 (3^2).

Method 2: Reaction between solid bromide and concentrated sulfuric acid

The primary reaction between solid bromide and concentrated sulfuric acid produces misty fumes of HBr.

$$\text{Primary reaction: } Br^- + H_2SO_4 \rightarrow HBr + HSO_4^-$$

However, the reaction is often contaminated when HBr continues to react with concentrated sulfuric acid. This secondary reaction lowers the yield of HBr and causes the products to be contaminated by Br_2.

Secondary reaction: $2HBr + H_2SO_4 \rightarrow Br_2 + 2H_2O + SO_2$

Method 1

(a) Using information in Tables 10.1 and 10.2, determine the order of reaction with respect to $C_6H_5NH_2$ and Br_2.

$C_6H_5NH_2$……

Br_2…….. **[2]**

(b) Determine the rate of reaction when concentration of $C_6H_5NH_2$ is 0.002 mol/dm^3 and concentration of Br_2 is 0.001 mol/dm^3.

…… **[1]**

(c) Use ideas about collisions between particles to describe and explain the effect of concentration on the speed of reaction.

……

……

……

…… **[2]**

Method 2

(d) A student claimed that concentrated sulfuric acid functions as an oxidizing agent in both primary and secondary reactions.

Do you agree with the student? Explain your answer in terms of oxidation states.

……

……

……

…… **[2]**

(e) Briefly describe the environmental problems that can arise from the production of HBr using method 2. Where possible, include a chemical equation in your answer.

.....

.....

.....

..... **[3]**

Section C (10 marks)

Answer any **ONE** out of **TWO** full questions in this section. Show your working and answers in the space provided.

11 A microbial fuel cell (MFC) is a bio-electrochemical system that makes use of respiring bacteria to convert organic molecules available in biodegradable compounds (in sewage, agricultural or food waste) into electrical energy using oxidation and reduction processes. Carbon dioxide and water are also produced in the process. MFCs harvest a part of this bacterial energy in the form of electricity and at the same time, act as a biological filter, removing organic pollutants from wastewater.

The infrastructure is simple – MFCs can operate at room temperature and normal pressure, making them safer and easier to deploy in remote or developing areas. A MFC consists of an anode and a cathode separated by an ion-exchange membrane, as shown in Fig. 11.1.

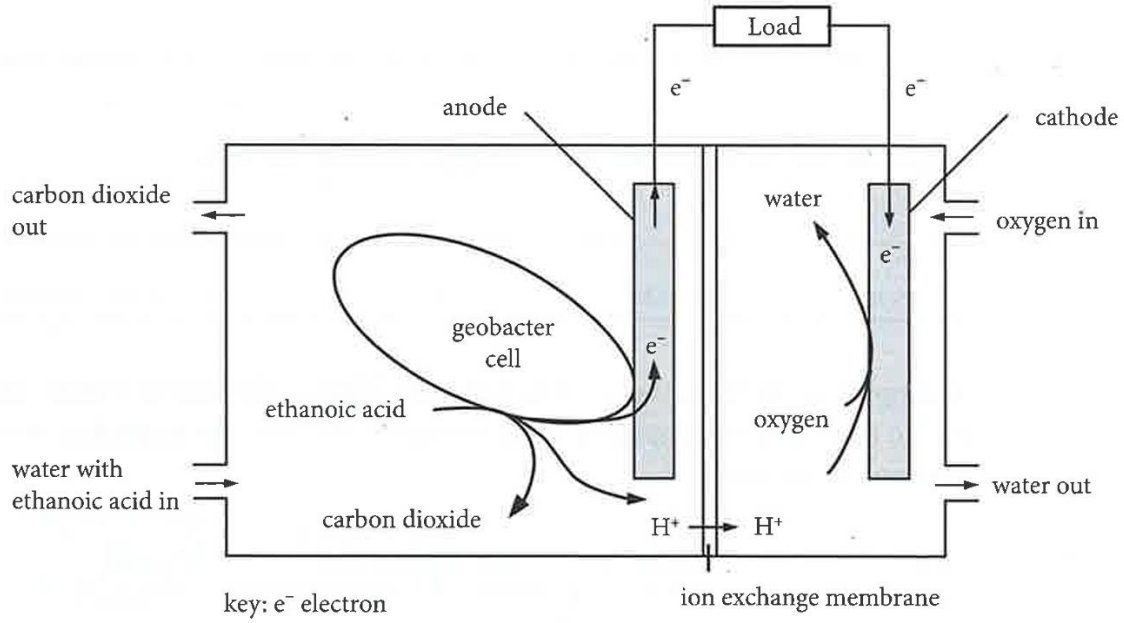


Fig. 11.1

The bacteria live in the anode where oxygen is absent, and it converts ethanoic acid, $C_2H_4O_2$ and water into carbon dioxide, hydrogen ions and electrons. The electrons then flow through the external circuit to the cathode. The hydrogen ions migrate through the ion-exchange membrane to the cathode. At the cathode, the oxygen gas reacts with the hydrogen ions to form water which is then drained out of the cell.

(a) Write the half-equations for the reactions that occur at both the electrodes.

cathode: ……..

anode: …….. **[2]**

(b) State the function of the ion-exchange membrane.

.....

.....

[1]

(c) MFCs are widely considered a carbon-neutral or low-carbon technology. Explain what *carbon-neutral* means.

.....

.....

.....

[1]

(d) Suggest one advantage of MFCs over hydrogen-oxygen fuel cells.

.....

.....

.....

.....

[2]

(e) When the temperature of the MFC is raised from 20°C to 35°C, the reaction rates double. However, at 60°C, rate of reaction falls to zero.
Explain the observations using your knowledge of enzymes and collision theory.

.....

.....

.....

.....

.....

.....

.....

.....

[3]

(f) Engineers often use a carbon brush anode, instead of a flat carbon plate. Suggest a reason for this.

.....

.....

.....

[1]

12 Blood glucose meters are medical devices that measure the concentration of glucose in a blood sample by detecting an electrical signal generated through a chemical reaction.

The electrochemical monitoring system typically consists of two main parts:

- handheld meter: a battery-powered read that applies a precise voltage to the test trip and measures the resulting electrical current
- disposable test strips: plastic strips containing electrodes and chemical reagents (enzymes and mediators) that react with a small drop of blood

First-generation blood glucose meters

The enzyme consumes oxygen present in the user's blood to break down glucose into gluconic acid and hydrogen peroxide H_2O_2. A small voltage is applied causing hydrogen peroxide to oxidise.

$$\text{glucose} + O_2 \text{ in blood} \rightarrow \text{gluconic acid} + H_2O_2$$
$$H_2O_2 \rightarrow O_2 + 2H^+ + 2e$$

While the oxygen-based glucose monitoring was highly effective, a major limitation was that these sensors rely on the dissolved oxygen in the user's body, leading to inaccurate glucose readings.

Second-generation blood glucose meters

To solve the "oxygen-dependence" issue, second-generation glucose meters replaced oxygen with a chemical messager called a redox mediator. Ferricyanide is the most common mediator – acting as an artificial electron shuttle, moving electrons from the enzyme directly to the electrode without needing oxygen or producing the corrosive hydrogen peroxide. The enzyme oxidises glucose $C_6H_{12}O_6$ and water into gluconic acid $C_6H_{12}O_7$, hydrogen ions and electrons. During this process, the mediator ferricyanide $[Fe(CN)_6]^{3-}$ is reduced to ferrocyanide $[Fe(CN)_6]^{4-}$

However, second-generation meters are susceptible to the Vitamin C glitch. As Vitamin C, $C_6H_8O_6$ is a strong reducing agent, it can be oxidized at the electrode and can lead to inaccurate results.

$$C_6H_8O_6 \rightarrow C_6H_6O_6 + 2H^+ + 2e$$

First-generation blood glucose meters

(a) Explain how the concentration of glucose affects the current measured by the meter.

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..... **[2]**

(b) At high altitudes or in users with medical conditions like hypoxia or anemia, the low oxygen concentration can lead inaccurate readings. Predict if the glucose reading will be higher or lower than actual. Explain your answer.

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…… **[2]**

Second-generation blood glucose meters

(c) Given that cyanide ion is CN^-, calculate the oxidation number of iron in

ferricyanide $[Fe(CN)_6]^{3-}$ ……

ferrocyanide $[Fe(CN)_6]^{4-}$ …… **[2]**

(d) Write the half-equations for the reactions that occur at both the electrodes.

cathode: ……..

anode: …….. **[2]**

(e) A user has a true blood glucose level of 100 mg/dL. However, he just took a high-dose Vitamin C supplement. Will the meter display a reading higher or lower than 100 mg/dL? Explain your answer using the flow of electrons.

……

……

…… **[2]**

END OF PAPER

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 –		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.).
The Avogadro constant, L = 6.02×10^{23} mol^{-1}.