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## SERANGOON GARDEN SECONDARY SCHOOL PRELIMINARY EXAMINATION 2020

SUBJECT: CHEMISTRY; 6092/1  
 LEVEL: SECONDARY 4 EXPRESS  
 DATE: 25 AUGUST 2020 (TUESDAY)  
 TIME: 1055 - 1155 HOURS  
 DURATION: 1 HOUR

### READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

Do not use staples, paper clips, glue or correction fluid.

Write your name, class register number and class on the Answer Sheet in the spaces provided unless this has been done for you.

**DO NOT WRITE IN ANY BARCODES.**

There are **forty** questions on this paper. Answer **all** questions. For each question, there are four possible answers **A, B, C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

**Read the instructions on the Answer Sheet very carefully.**

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this paper.

A copy of the Periodic Table is printed on page 18.

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

<p>_____ Name/Signature of Parent/Guardian</p> <p>_____ Date</p>	<p><b>FOR MARKER'S USE</b></p> <hr/> <p style="font-size: 2em;"><b>40</b></p>
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This question paper consists of 17 printed pages and 1 blank page.

Setter: Mr Michael Chia

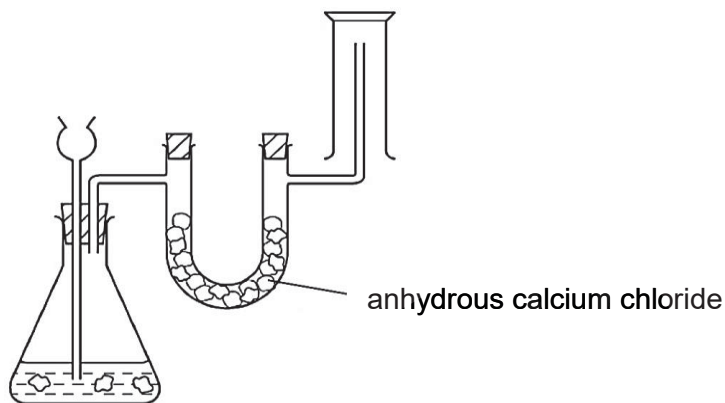
Vetter: Ms Lim Wan Qi

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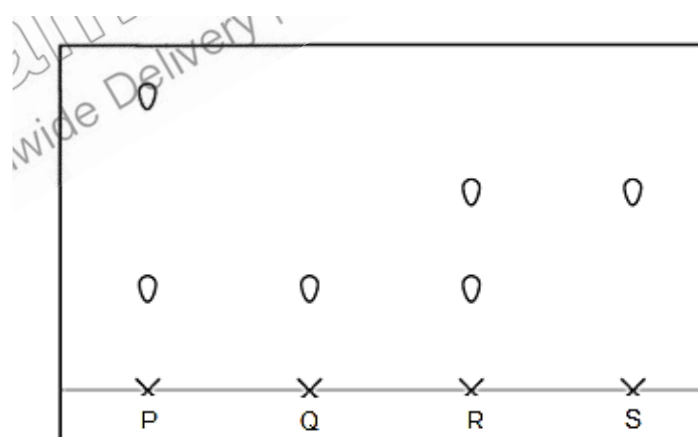
For each question, there are four possible answers **A**, **B**, **C** and **D**.  
Choose the **one** you consider correct and record your choice in **soft pencil** on the  
separate Answer Sheet.

- 1 The diagram below shows an experimental set up for the preparation and collection of a dry gas.



What could the gas be?

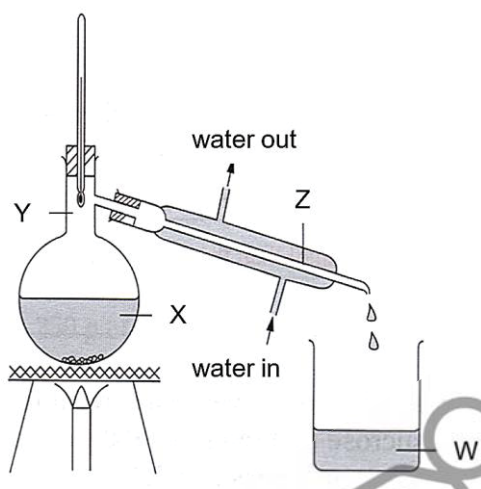
- A** carbon monoxide  
**B** carbon dioxide  
**C** hydrogen  
**D** sulfur dioxide
- 2 The diagram below shows the paper chromatogram for 4 substances, P, Q, R and S.



Based on the chromatogram, which of the above substances are pure?

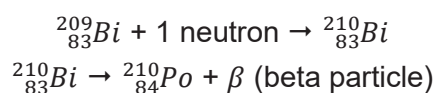
- A** P and Q  
**B** P and R  
**C** Q and R  
**D** Q and S

- 3 The diagram shows the apparatus used to obtain water from aqueous iron(II) sulfate which is pale green in colour.



Which of the following statements about the separation process is true?

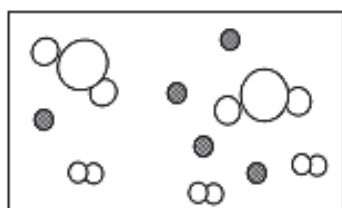
- A** Liquid X becomes darker in colour.
- B** A green precipitate is formed in liquid W.
- C** Liquid W changes from colourless to green.
- D** The temperature at Y steadily rises as liquid W is being collected.
- 4 A sample of hydrogen contains a mixture of two isotopes;  ${}^2_1\text{H}$  and  ${}^3_1\text{H}$ . Which of the following relative molecular mass is not a possible value when this sample of hydrogen reacts with sulfur to form hydrogen sulfide,  $\text{H}_2\text{S}$ ?
- A** 34
- B** 36
- C** 37
- D** 38
- 5 Polonium is an element in Group VI of the Periodic Table. One of its isotopes, Po-210, is a rare radioactive metal discovered by Marie Curie in the late 19<sup>th</sup> century. Po-210 can be produced artificially by bombarding Bismuth-209 with neutrons.



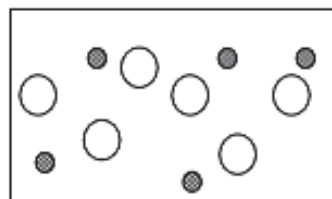
Which statement about the above reaction is correct?

- A**  ${}^{209}_{83}\text{Bi}$  atom has the same number of neutrons as  ${}^{210}_{84}\text{Po}$  atom.
- B**  ${}^{210}_{83}\text{Bi}$  atom has the same number of protons as  ${}^{210}_{84}\text{Po}$  atom.
- C**  ${}^{209}_{83}\text{Bi}$  atom has fewer electrons than  ${}^{210}_{83}\text{Bi}$  atom.
- D**  ${}^{210}_{83}\text{Bi}$  atom has fewer neutrons than  ${}^{210}_{84}\text{Po}$  atom.

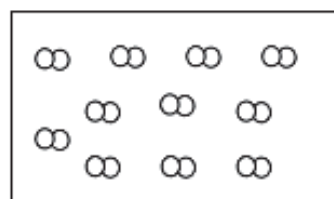
- 6 The composition of the particles in four different substances, are shown in the diagrams below.



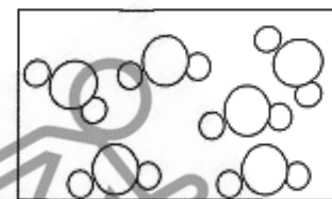
I



II



III



IV

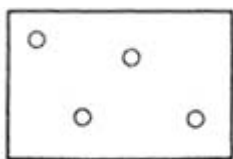
Which of the following shows the correct composition of the particles in the four substances?

	molecules of an element	molecules of a compound	mixture of elements	mixture of elements and compounds
A	I	II	III	IV
B	II	IV	III	I
C	III	IV	II	I
D	IV	III	I	II

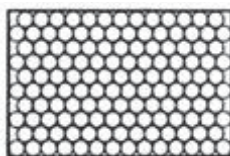
- 7 Which of the following particles contain 10 electrons, 11 protons and 12 neutrons?

- A  ${}_{12}^{24}\text{Mg}^{2+}$   
 B  ${}_{11}^{23}\text{Na}$   
 C  ${}_{11}^{23}\text{Na}^{+}$   
 D  ${}_{10}^{21}\text{Ne}$

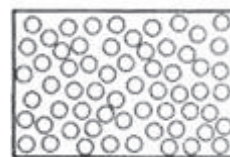
- 8 The diagrams below show how the particles of a substance are packed at different temperatures.



X

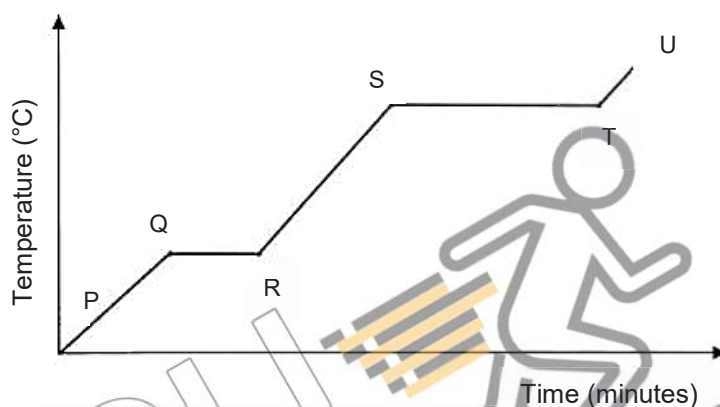


Y



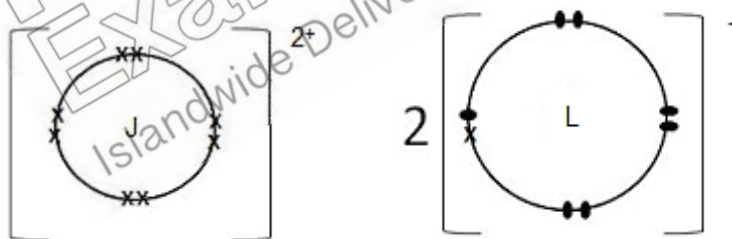
Z

Which region in the graph would contain particles with the arrangement of particles as shown in diagrams Y and Z?



- A Region PQ  
**B Region QR**  
 C Region RS  
 D Region ST

- 9 The diagram below shows the 'dot and cross' diagram of the compound formed between elements J and L.

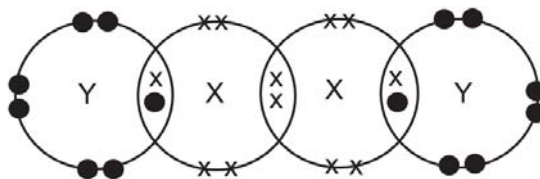


Which of the following statements is/are correct?

- I L is an element in Group I of the Periodic Table.  
 II Element J donates 2 electrons to element L.  
 III Elements L and J are bonded by ionic bonds.

- A III only  
 B I and II only  
**C II and III only**  
 D I, II and III

- 10 The diagram shows the bonding between two unknown elements **X** and **Y**.



Which of the following statements is true?

- A Element **X** is in Group IV of the Periodic Table.  
**B Element X has 6 electrons in its outermost shell.**  
 C Element **Y** has 6 electrons in its outermost shell.  
 D Element **Y** is in Group I of the Periodic Table.
- 11 A student obtained the following information about substance **W**:
- can be separated into its constituent elements through electrolysis of its molten compound
  - melting point higher than 500 °C
  - soluble in water
  - insoluble in organic solvent
- What substance is **W** likely to be?

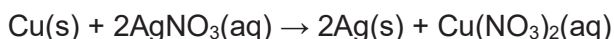
- A lithium chloride**  
 B poly(ethene)  
 C magnesium  
 D silicon dioxide
- 12 The table below gives the proton and nucleon numbers of atoms **P**, **Q**, **R** and **S**.

atom	proton number	nucleon number
<b>P</b>	6	14
<b>Q</b>	7	14
<b>R</b>	16	32
<b>S</b>	20	40

Which of the following statements is true?

- A Atom **P** and atom **Q** are isotopes of the same element.  
**B Atom P and atom R will combine to form a covalent compound.**  
 C Atom **Q** and atom **S** will form an ionic compound with the formula **S<sub>2</sub>Q<sub>3</sub>**.  
 D Atom **S** can form a diatomic molecule.

- 13 Copper powder was added to excess silver nitrate solution. The chemical equation for the reaction that occurred is shown below:



After the reaction was completed, the mixture was filtered.

Which of the following gives the correct description of the residue and the filtrate obtained?

	residue	filtrate
A	blue solid	colourless solution
B	grey solid	blue solution
C	reddish-brown solid	colourless solution
D	reddish-brown solid	blue solution

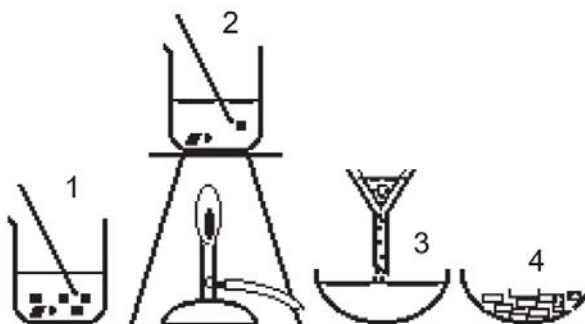
- 14 A student wanted to retain  $\text{Ba}^{2+}$  ions and remove  $\text{I}^-$  ions from a bottle containing aqueous barium iodide solution and wrote the following procedure.

Add \_\_\_\_\_ 1 \_\_\_\_\_ to aqueous barium iodide until no more \_\_\_\_\_ 2 \_\_\_\_\_ precipitate forms.

Which of the following completes the blanks in the procedure?

	1	2
A	aqueous lead(II) nitrate	white
B	aqueous lead(II) nitrate	yellow
C	dilute sulfuric acid	white
D	dilute sulfuric acid	yellow

- 15 Which of the following reagents can be used to prepare a salt that would involve the steps shown by the diagram below?



- A calcium sulfate with dilute hydrochloric acid to prepare calcium chloride  
**B lead(II) carbonate with dilute nitric acid to prepare lead(II) nitrate**  
 C potassium oxide with dilute hydrochloric acid to prepare potassium chloride  
 D sodium carbonate with dilute sulfuric acid to prepare sodium sulfate

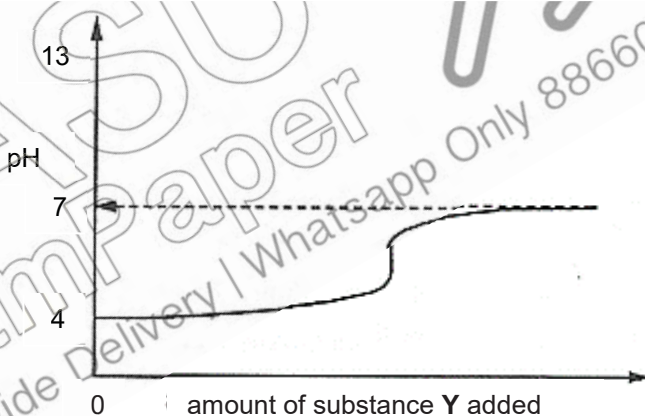
16 Which substance has the highest percentage by mass of nitrogen?

- A  $\text{CO}(\text{NH}_2)_2$
- B  $\text{KNO}_3$
- C  $\text{NH}_4\text{Cl}$
- D  $(\text{NH}_4)_3\text{PO}_4$

17 A  $25.0 \text{ cm}^3$  sample of dilute sulfuric acid contains 0.025 moles of the acid. What is the concentration of the hydrogen ions in the solution?

- A  $0.250 \text{ mol/dm}^3$
- B  $0.500 \text{ mol/dm}^3$
- C  $1.00 \text{ mol/dm}^3$
- D  $2.00 \text{ mol/dm}^3$

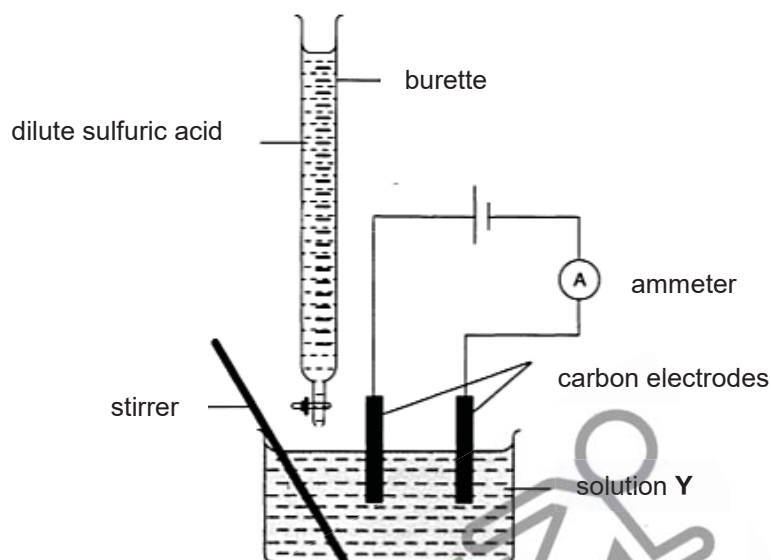
18 Substance Y was added slowly, with stirring to aqueous solution Z. The changes in pH of the mixture are shown in the graph.



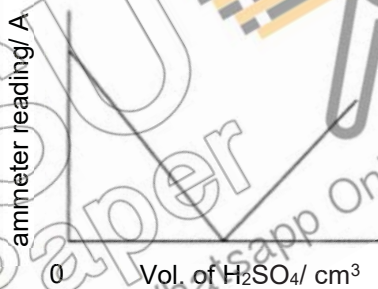
Which of the following are possible identities for substance Y and substance Z?

	substance Z	substance Y
A	ethanoic acid	calcium oxide
B	ethanoic acid	lead(II) oxide
C	hydrochloric acid	copper(II) oxide
D	hydrochloric acid	sodium oxide

- 19 Dilute sulfuric acid was added to solution Y, as shown in the diagram below. After each addition, the mixture was stirred and the ammeter reading was recorded.



The following graph was obtained based on all the readings recorded.



Which of the following is likely to be solution Y?

- A** barium hydroxide  
**B** potassium oxide  
**C** iron(II) chloride  
**D** zinc nitrate
- 20 Solid X is a good conductor of electricity. It also reacts with oxygen to form compound Y that turns moist red litmus paper blue. Which of the following is likely to be solid X?
- A** graphite  
**B** calcium  
**C** chlorine  
**D** sulfur

21 Which of the following equations suggests that the metal oxide, MO, has amphoteric properties?

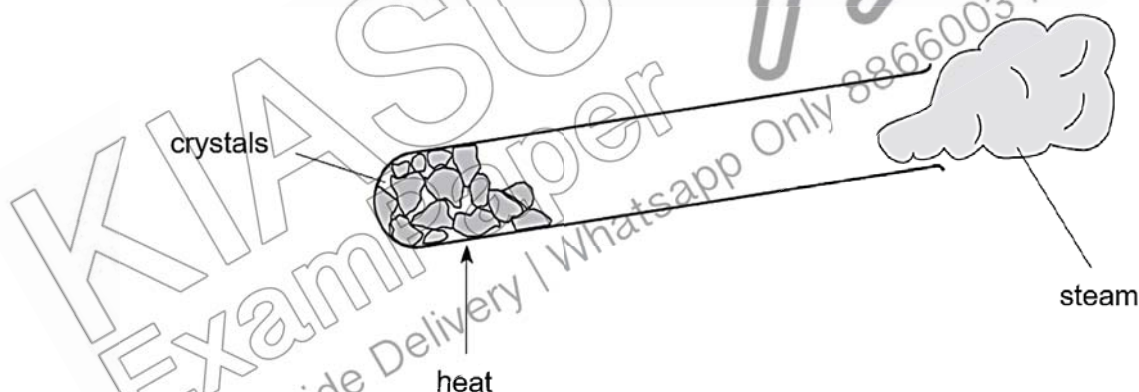
- A  $\text{MO(s)} + \text{C(s)} \rightarrow \text{M(s)} + \text{CO(g)}$   
 B  $\text{MO(s)} + \text{H}_2\text{O(l)} \rightarrow \text{M}^{2+}(\text{aq}) + 2\text{OH}^{-}(\text{aq})$   
 C  $\text{MO(s)} + 2\text{OH}^{-}(\text{aq}) \rightarrow \text{MO}_2^{2-}(\text{aq}) + \text{H}_2\text{O(l)}$   
 D  $\text{MO(s)} + 2\text{NH}_4\text{Cl(s)} \rightarrow \text{MCl}_2(\text{s}) + \text{H}_2\text{O(l)} + 2\text{NH}_3(\text{g})$

22 A student recorded that pale green iron(II) sulfate solution turned brown when reacted with hydrogen peroxide solution.

Which of the following best explains the observation recorded by the student?

- A Hydrogen peroxide was the reducing agent in the reaction.  
 B Iron(II) sulfate reacted to form iron(III) hydroxide, a brown precipitate.  
 C The brown solution was due to the oxidation of  $\text{Fe}^{2+}$  ions to  $\text{Fe}^{3+}$  ions.  
 D The  $\text{Fe}^{2+}$  ions reacted with oxygen and underwent rusting.

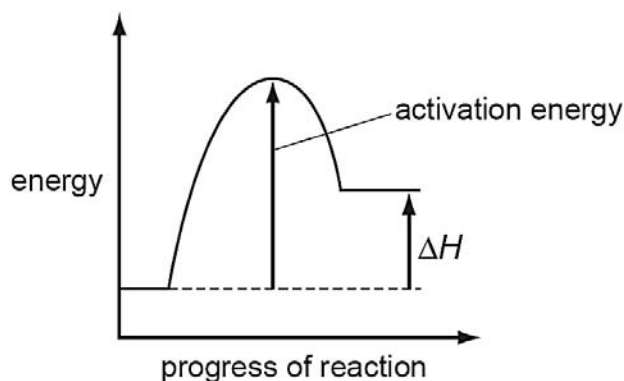
23 The diagram below shows crystal of copper(II) sulfate,  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ , being heated.



The copper(II) sulfate crystals were noted to have changed colour during the heating. Which two terms best describe the changes observed in the above diagram?

- A endothermic and dehydration  
 B endothermic and hydration  
 C exothermic and dehydration  
 D exothermic and hydration

- 24 The energy profile diagram for the forward reaction of a chemical reaction is shown below.

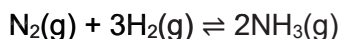


Which row correctly shows the enthalpy change, the activation energy and the type of enthalpy change for the reverse reaction?

	sign of enthalpy change	sign of activation energy	type of enthalpy change
A	negative	negative	exothermic
B	negative	positive	exothermic
C	positive	negative	endothermic
D	positive	positive	endothermic

For questions 25 and 26, refer to the information below.

Ammonia has many important uses and is manufactured industrially by the Haber process. The equation for the reaction is shown below:



- 25 Which statements correctly describe the Haber process?

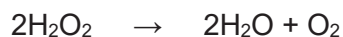
- I It is a direct combination of elements.
- II It is a reversible reaction.
- III It is a redox reaction

- A I and II only
- B I and III only
- C II and III only
- D I, II and III

- 26 Ammonia gas is produced industrially by the Haber process. Which of the following statements is **not true** with regard to the Haber process?

- A A catalyst is added to increase the rate of reaction.
- B High pressure is applied to increase the yield of ammonia.
- C High temperature is applied to increase the yield of ammonia.
- D Nitrogen is obtained from the air.

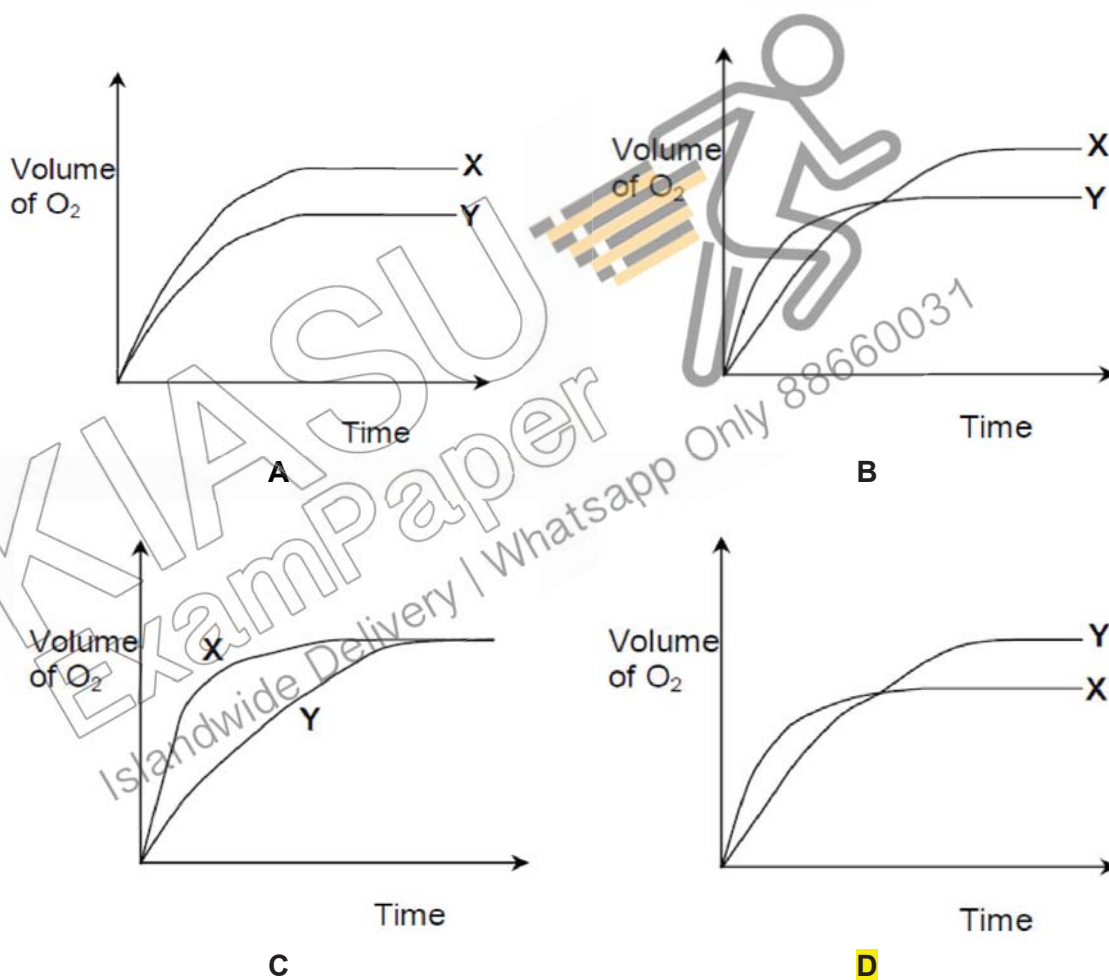
- 27 Aqueous hydrogen peroxide decomposes according to the following equation.



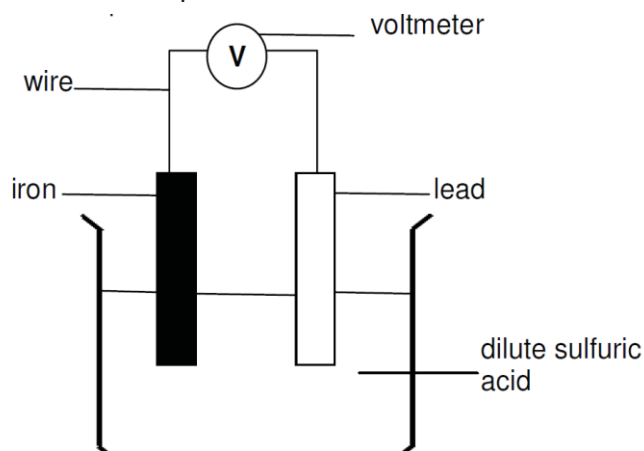
Two experiments were carried out to measure the rate of production of oxygen from aqueous hydrogen peroxide. The results are given below.

Experiment	Solution used
X	100 cm <sup>3</sup> of 2 mol/dm <sup>3</sup> H <sub>2</sub> O <sub>2</sub>
Y	mixture of 100 cm <sup>3</sup> of 2 mol/dm <sup>3</sup> H <sub>2</sub> O <sub>2</sub> and 50 cm <sup>3</sup> of 1 mol/dm <sup>3</sup> H <sub>2</sub> O <sub>2</sub>

Which graph best shows the results of the two experiments?



- 28 The diagram below shows a simple cell.



Which half-equations best represent the reactions occurring at the positive and the negative electrode?

	negative electrode	positive electrode
A	$\text{Fe} \rightarrow \text{Fe}^{2+} + 2\text{e}^-$	$\text{Pb}^{2+} + 2\text{e}^- \rightarrow \text{Pb}$
B	$\text{Fe} \rightarrow \text{Fe}^{2+} + 2\text{e}^-$	$2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$
C	$2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$	$\text{Fe} \rightarrow \text{Fe}^{2+} + 2\text{e}^-$
D	$\text{Pb}^{2+} + 2\text{e}^- \rightarrow \text{Pb}$	$2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$

- 29 Which of the following is expected of a metal that is positioned between aluminium and lead in the reactivity series?
- A It forms a hydroxide that dissolves in water.
  - B It forms an oxide that decomposes to form the metal on heating.
  - C It liberates hydrogen from dilute hydrochloric acid.
  - D It reacts with aluminium oxide when heated.
- 30 Which of the following has no change in the concentration of the solution during electrolysis?
- A copper(II) sulfate solution between copper electrodes
  - B copper(II) sulfate solution between platinum electrodes
  - C dilute sodium chloride solution between platinum electrodes
  - D concentrated sodium chloride solution between carbon electrodes

- 31 The table shows the properties of some metal oxides, W, X, Y and Z.

oxide	colour of oxide	change on heating
W	black	remains black
X	red	oxygen gas evolved and silvery liquid remains
Y	white	solid turns yellow when hot by turns white again when cold
Z	brown	oxygen evolves and solid turns yellow

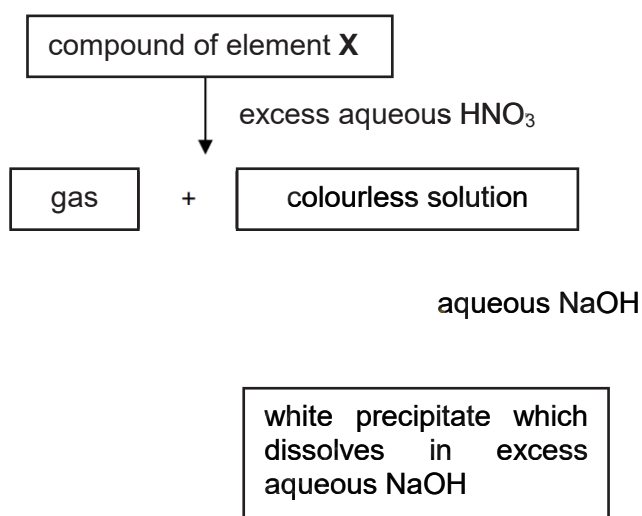
Which of the oxides in the table above remain(s) chemically unchanged when heated?

- A W only  
 B Y only  
 C X and Z only  
 D W and Y only
- 32 The table below shows some properties of four elements. Which element is likely to be copper?

	element	density (g/cm <sup>3</sup> )	melting point (°C)	electrical conductivity
A	P	0.97	97.8	poor
B	Q	2.34	2300	poor
C	R	13.6	-38.9	good
D	S	8.96	1083	good

- 33 Which statement about the four gases carbon dioxide (CO<sub>2</sub>), hydrogen (H<sub>2</sub>), oxygen (O<sub>2</sub>) and ozone (O<sub>3</sub>) is correct?
- A One mole of each gas has the same volume at room temperature and pressure.  
 B Ozone has the fastest rate of diffusion at room temperature and pressure.  
 C They are all denser than air.  
 D They are all elements.
- 34 It was found that cars which were parked near a coal-fired power station often corroded more quickly. Which gas, when present in above average levels in the air, is a possible explanation for this?
- A carbon dioxide  
 B nitrogen monoxide  
 C sulfur dioxide  
 D water vapour

- 35 Which of the following statements best explains why the elements sodium and chlorine are in the same period in the Periodic Table?
- A Sodium and chlorine are both reactive elements.  
 B The atomic numbers of sodium and chlorine differ by less than eight.  
 C The atoms of both elements have eight electrons in their second shell.  
 D The atoms of both elements have only three shells containing electrons.
- 36 The scheme below shows some reactions of a compound of element X.



Which of the following substances is likely to be a compound of element X?

- A aluminium carbonate  
 B calcium(II) carbonate  
 C copper(II) sulfate  
 D lead(II) sulfate
- 37 An aqueous sample of T shows these observations with the following reagents.

Reagent	Observation
Aqueous ammonia	Reddish brown precipitate
Lead(II) nitrate	White precipitate
Barium nitrate	White precipitate

Which of the following is likely to be compound T?

- A iron(II) sulfate  
 B iron(III) sulfate  
 C iron(III) chloride  
 D potassium chloride

38 Which statement about alkali metals is true?

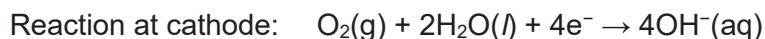
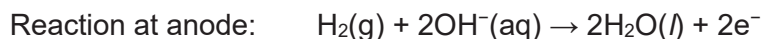
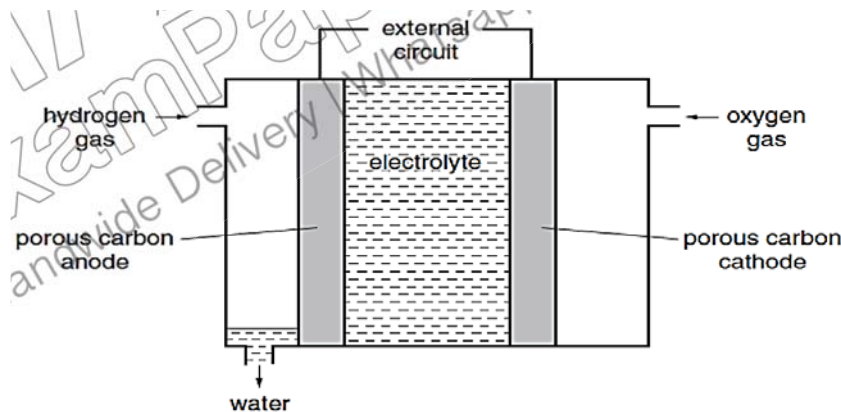
- A** Their melting points decrease on going down Group I.  
**B** Their reactivity decrease on descending Group I.  
**C** They form covalent bonds with Group VII.  
**D** They form oxides on reacting with water.

39 Elements **X** and **Y** are in Group VII of the Periodic Table. **X** is a liquid at room temperature. **Y** is a solid at room temperature. Which statement(s) is/are correct?

- 1 Atoms of **Y** have more protons than atoms of **X**.  
 2 Molecules of **Y** have more atoms than molecules of **X**.  
 3 **Y** displaces **X** from aqueous solutions of **X**<sup>-</sup> ions.

- A** 1 only  
**B** 2 only  
**C** 3 only  
**D** 1, 2 and 3

40 A hydrogen-oxygen fuel cell is built using sodium hydroxide solution as the electrolyte. What would be the change in pH of the solution around each electrode when current flows?



	anode	cathode
<b>A</b>	increase	decrease
<b>B</b>	increase	increase
<b>C</b>	decrease	increase
<b>D</b>	decrease	decrease

END OF PAPER

## The Periodic Table of Elements

I		II		Group																III		IV	V	VI	VII	0																																																																																																				
3 Li lithium 7		4 Be beryllium 9		<div style="display: flex; justify-content: space-between;"> <div style="border: 1px solid black; padding: 2px;"> <b>Key</b>                      proton (atomic) number                      atomic symbol                      name                      relative atomic mass                 </div> <div style="border: 1px solid black; padding: 2px;">                     hydrogen                      1                 </div> </div>																5 B boron 11		6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20		<div style="display: flex; justify-content: space-between;"> <div style="border: 1px solid black; padding: 2px;">                     sodium                      23                 </div> <div style="border: 1px solid black; padding: 2px;">                     magnesium                      24                 </div> </div>																11 Na sodium 23		12 Mg magnesium 24	13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5		18 Ar argon 40		19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84		37 Rb rubidium 85	38 Sr strontium 88	39 Y 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 -	118 Og oganeson -
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		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<sup>3</sup> at room temperature and pressure (r.t.p.).

NAME		REG. NO.		CLASS	
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## SERANGOON GARDEN SECONDARY SCHOOL PRELIMINARY EXAMINATION 2020

SUBJECT: CHEMISTRY; 6092/2  
 LEVEL: SECONDARY 4 EXPRESS  
 DATE: 21 AUGUST 2020 (FRIDAY)  
 TIME: 1045 – 1230 HOURS  
 DURATION: 1 HOUR 45 MINUTES

### READ THESE INSTRUCTIONS FIRST

Write your name, class register number and class 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.

### Section A [50 marks]

Answer all questions in the spaces provided.

### Section B [30 marks]

Answer all **three** questions, the last question is in the form either/or.  
 Answer all questions in the spaces provided.

At the end of the examination, fasten all your work securely together.  
 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 22.

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

<p>_____</p> <p>Name/Signature of Parent/Guardian                      Date</p>	<p><b>FOR MARKER'S USE</b></p> <hr/> <p style="font-size: 2em; font-weight: bold;">80</p>
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This question paper consists of 21 printed pages and 1 blank page.

Setter: Mr Michael Chia

Vetter: Ms Lim Wan Qi

[Turn Over

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### Section A

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

**A1** Choose from the following elements to answer the questions below.

hydrogen	sodium	zinc
chlorine	iodine	calcium
magnesium	nickel	platinum

Each element can be used once, more than once or not at all.

Which element

(a) is used as a catalyst in the catalytic converter of cars?

**platinum**

..... [1]

(b) reacts with dilute acids readily but not cold water?

**zinc**

..... [1]

(c) forms an ion, that in solution, reacts with aqueous sodium hydroxide to give a white precipitate that remains insoluble in excess sodium hydroxide?

**calcium/magnesium**

..... [1]

(d) is **most** suitable as a sacrificial material used to prevent the rusting of underground water pipes made of iron?

**magnesium**

..... [1]

(e) is able to decolourise aqueous iron(III) chloride when added in excess?

**magnesium/zinc/calcium**

..... [1]

(f) reacts with water to form an acidic solution?

**chlorine/iodine**

..... [1]

(g) forms a hydroxide that reacts with sodium hydroxide to form a colourless solution?

**zinc**

..... [1]

[Total marks: 7]

**A2** Carbon is a group IV element and it forms many inorganic and organic compounds. In these compounds, carbon shows a range of oxidation numbers.

Name	Formulae	Oxidation number of carbon
methane	CH <sub>4</sub>	-4
ethane	C <sub>2</sub> H <sub>6</sub>	-3
methanol	CH <sub>3</sub> OH	<b>-2</b>
ethanol	C <sub>2</sub> H <sub>5</sub> OH	-2
glucose	C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>	<b>0</b>
carbon dioxide	CO <sub>2</sub>	+4

(a) Complete the table above by filling in the oxidation numbers of carbon in the respective compounds. [1]

(b) Suggest the formula of a compound in which carbon has an oxidation number of +2.

**CO or any correct formula**

..... [1]

(c) Plants undergo a process known as photosynthesis. Choose from the table above, two substances that are involved in photosynthesis, and write the balanced chemical equation.

**6CO<sub>2</sub> + 6H<sub>2</sub>O → C<sub>6</sub>H<sub>12</sub>O<sub>6</sub> + 6O<sub>2</sub>**

..... [2]

(d) Explain if carbon is likely to exhibit an oxidation number of +5 in its compounds.

**No, as it has only 4 valence electrons**

..... [1]

(e) Using your knowledge on oxidation states, explain if the change of ethanol to form ethanoic acid (CH<sub>3</sub>COOH) is an oxidation reaction.

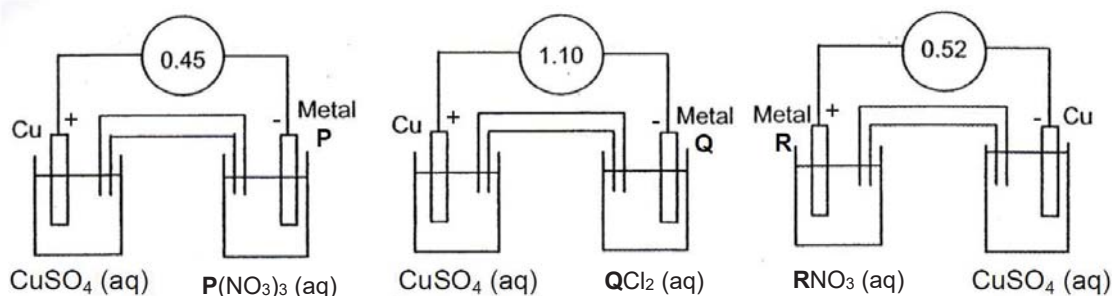
**Oxidation state of carbon increases from -2 in ethanol [1]**

**to 0 in ethanoic acid [1]. Hence it is an oxidation reaction.**

..... [2]

[Total marks: 7]

- A3** Three electrochemical cells are set up as shown below. The electromotive force (e.m.f.) in volts is shown on each voltmeter.



- (a) Arrange the four metals (Cu, P, Q and R) in order of decreasing reactivity.

**Q, P, Cu, R**

[1]

- (b) A piece of magnesium ribbon is added separately to each of the salt solutions of metals P, Q and R. The observations made are as shown in the table below.

Test	Observations
Magnesium ribbon in $\text{P}(\text{NO}_3)_3(\text{aq})$	A silver solid is formed. The green solution is decolourised.
Magnesium ribbon in $\text{QCl}_2(\text{aq})$	A silver-grey solid is formed. The solution remained colourless.
Magnesium ribbon in $\text{RNO}_3(\text{aq})$	A silver solid is formed. The solution remained colourless.

- (i) Write an ionic equation for the reaction between magnesium and  $\text{P}(\text{NO}_3)_3$ .



[1]

- (ii) Give two observations that can be made if metal P is placed in aqueous copper (II) sulfate.

**Blue solution turned green. [1]**

**Brown/reddish-brown solid formed. [1]**

[2]

- (iii) Suggest the most economical method to extract metal P from its ore.

**Heating with carbon/carbon monoxide**

[1]

- (iv) In the industry, metal **P** is mixed with carbon and iron to form steel alloys. Suggest why the use of alloys of iron is preferred over pure iron.

Atoms of P and iron have different atomic size [1] and this disrupts the  
.....  
orderly arrangement of atoms in iron. [1] This makes it harder for the layers  
.....  
to slide past one another, making it stronger.[1]

[3]

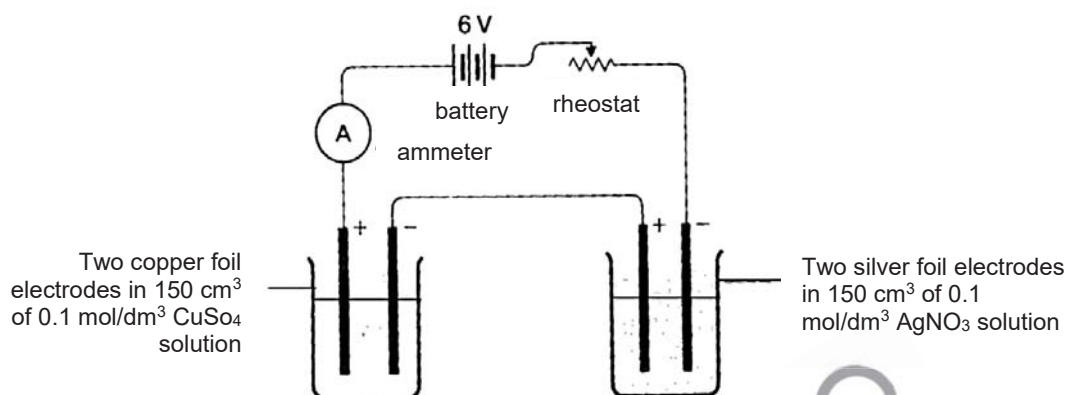
- (v) Metal **Q** can be used to protect iron or steel objects from rusting through a process known as galvanising. Explain why metal **Q** is a more suitable choice than copper to prevent iron from rusting.

Metal Q is more reactive than iron and will corrode in place of iron by  
.....  
losing electrons. [1] Copper is less reactive than iron and iron will  
.....  
corrode instead. [1]

[2]

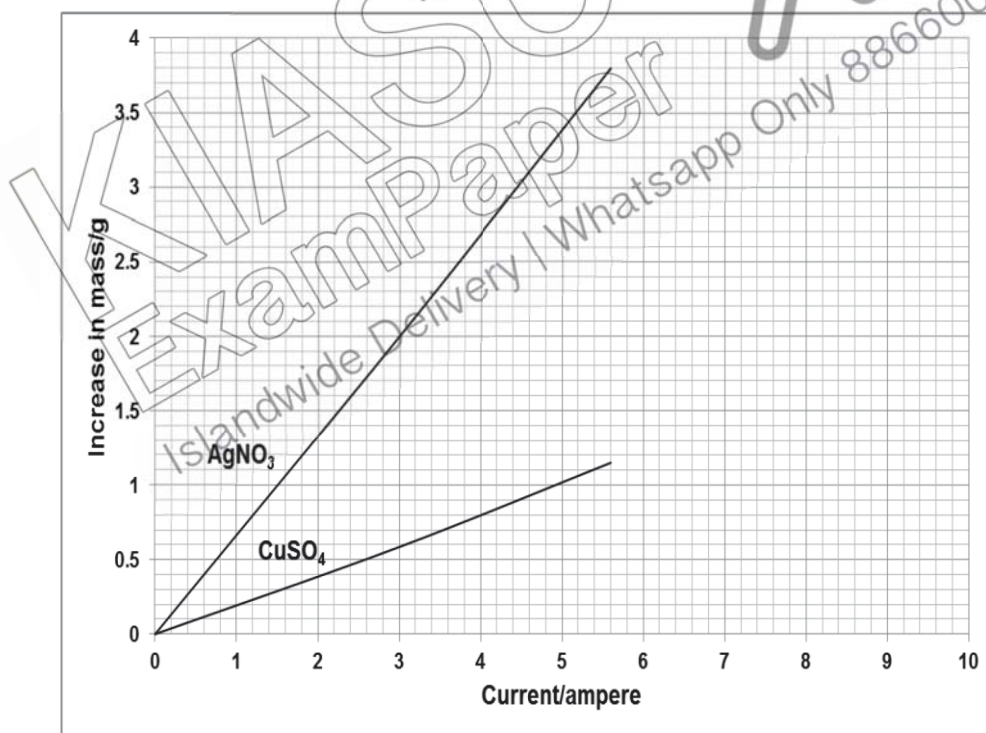
[Total marks: 10]

- A4** A student carries out a series of experiments. He electrolyzes aqueous copper(II) sulfate and aqueous silver nitrate using the apparatus shown.



He repeats the experiment a few times using the same concentration of copper(II) sulfate and silver nitrate, but changes the current that passes through the solution. He runs each experiment for 10 min. At the end of 10 min, the student weighs the mass of the negative electrodes and works out the increase in mass of the electrodes.

The graph below shows the results of his investigations.



- (a) Describe the relationship between the current and the increase in mass of the negative electrode as shown by the graph.

**Increase in mass** of the **electrodes** is **proportional** to the **increase in current**. [1]

.....  
 .....

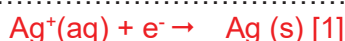
[1]

- (b) Use the graph to predict the increase in mass of the negative electrode in copper(II) sulfate solution if the experiment is carried out using an electric current of 9.0 A for 5 min.

10 mins – increase in mass of 1.7 – 2.0 g, 5 mins – increase in mass of 0.85 – 1 g

[1]

- (c) During the electrolysis, copper and silver are deposited at the negative electrodes. Write equations to show the deposition of copper and silver at the electrodes.



[2]

- (d) Determine the number of moles of copper and the number of moles of silver that are formed when a current of 4.0 A is used for 10 minutes.

Mass of copper = 0.8 g

$$\text{No. of moles of copper} = \frac{0.8}{64} = 0.0125 \quad [1]$$

Mass of silver = 2.7 g OR 2.65g

$$\text{No. of moles of silver} = \frac{2.7}{108} = 0.0250 \quad [1]$$

[2]

- (e) Comment on the difference between the masses of copper and silver formed when the same conditions are used for the electrolysis. Explain the difference.

**No. of moles of silver formed is twice the no. of moles of copper formed./ The**

**equations show that 1 mol of electrons discharge 1 mol of silver but 0.5 mol**

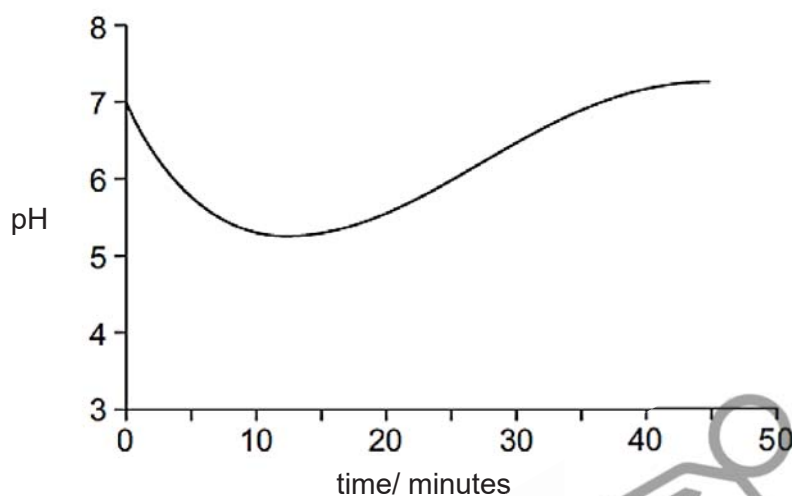
**of copper; [1] Ar of Cu is 64 and Ar of Ag is 108 / Ar of Cu and Ag are different**

**[1]**

[2]

[Total marks: 8]

**A5** The diagram shows the changes in pH in a student's mouth after she has eaten a sweet.



- (a) Chewing an acidic sweet stimulates the formation of saliva. Saliva is slightly alkaline. Use this information to describe and explain the shape of the graph.  
Initially **pH decreases** from **7 to 5.1/5.2/5.3** then **increases to 7.2/7.3** [1];

**pH decreases** at first due to **increasing concentration of hydrogen ions** [1]

**pH subsequently increases** due to **decreasing concentration of hydrogen ions/ saliva** which is

**alkaline** is only **gradually produced** which **neutralises** the **acid/sweet** [1]

[3]

- (b) Many sweets contain citric acid. Citric acid can be extracted from lemon juice using the following steps:

stage 1: add calcium carbonate to excess hot lemon juice

stage 2: filter off the precipitate which is formed (calcium citrate)

stage 3: wash the calcium citrate precipitate with water

stage 4: add sulfuric acid to the calcium citrate to make a solution of citric acid

stage 5: crystallise the citric acid and obtain the pure and dry sample

- (i) When calcium carbonate is added to lemon juice, fizzing is observed. Explain why there is fizzing.

**Carbon dioxide gas is produced** [1]

[1]

- (ii) Suggest why the calcium citrate precipitate is washed with water.

**To remove the (excess) lemon juice** [1]

[1]

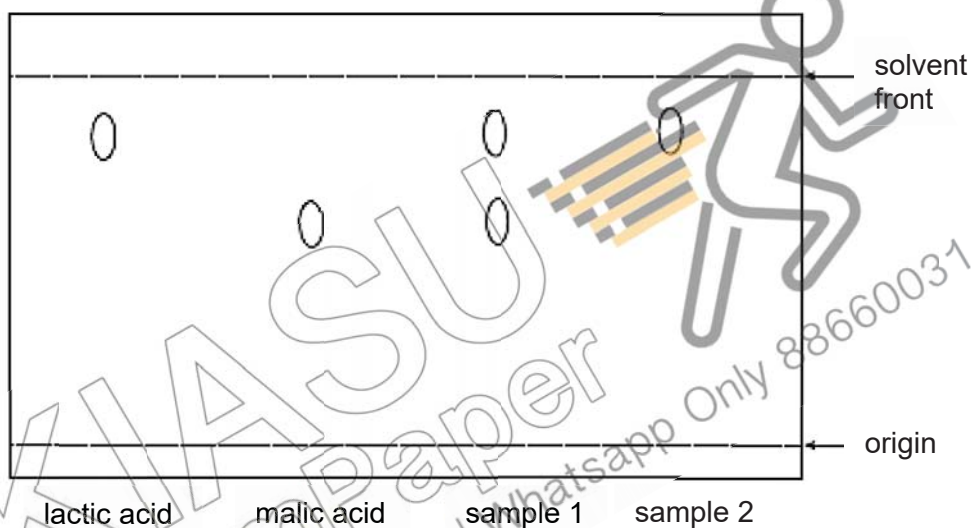
**Reject 'to remove impurities'.**

- (iii) Describe how 'stage 5' should be carried out.

Heat the solution until saturated/concentrated and allow the solution to cool for crystals to form. [1] Filter to obtain the crystals, wash with little cold distilled water & dry between pieces of filter paper [1]

[2]

- (c) Wines contain malic and lactic acids. This is because of a process known as malo-lactic fermentation. During this process, malic acid is converted into lactic acid. The extent of malo-lactic fermentation in 2 samples of wine was analysed using thin layer chromatography. A sample of each wine was spotted onto the chromatography plate. Reference samples of lactic acid and malic acid were also spotted onto the plate. The chromatogram obtained is shown below:



- (i) Explain why malic acid moved a shorter distance than lactic acid.

Malic acid is less soluble in the solvent than lactic acid [1]

[1]

- (ii) Which sample of wine is older? Explain your answer.

Sample 2 [1]

All malic acid has been converted to lactic acid/ Sample 2 shows that malo-lactic fermentation is complete while sample 1 is not. [1]

[2]

[Total marks: 10]

- A6** Singapore is a densely populated city with strict standards on air quality as well as preventive air pollution control measures. The following table shows the ambient air quality targets set by the National Environment Agency (NEA). ( $1 \mu\text{g} = 10^{-6}\text{g}$ )

pollutant	sulfur dioxide	nitrogen dioxide	ozone	carbon monoxide
target ( $\mu\text{g}/\text{m}^3$ )	15	40	100	30000

- (a) Explain why carbon monoxide is considered as an air pollutant.

Carbon monoxide **binds to haemoglobin** which **reduces the ability of haemoglobin to transport oxygen** [1]

[1]

- (b) State a source of nitrogen dioxide.

Oxides of nitrogen are produced in **internal combustion engines of cars** [1]

Or formed during lightning activity.

[1]

- (c) A researcher working with the NEA takes a  $200 \text{ dm}^3$  sample of gaseous emissions from a factory. The composition of this sample of air is shown in the table below.

gas	sulfur dioxide	nitrogen dioxide	nitrogen	oxygen	carbon dioxide
volume ( $\text{cm}^3$ )	0.0022	0.0031	157000	42900	99.9

Explain, with calculations, whether the emissions of sulfur dioxide and nitrogen dioxide meet the targets set by NEA. [ $1\text{m}^3 = 1000 \text{ dm}^3$ ]

moles of  $\text{SO}_2$  from emissions in  $200 \text{ dm}^3$ :  $0.0022/1000 \div 24 = 9.166 \times 10^{-8} \text{ mol}$

moles of  $\text{SO}_2$  from emissions in  $1\text{m}^3$ :  $9.166 \times 10^{-8} \times 5 = 4.583 \times 10^{-7} \text{ mol}$  [1]

mass of  $\text{SO}_2$ :  $4.583 \times 10^{-7} \times [32 + 2(16)] \approx 2.93 \times 10^{-5} = 29.3\mu\text{g}$  [1]

Did not meet NEA target

moles of  $\text{NO}_2$  from emissions in  $200 \text{ dm}^3$ :  $0.0031/1000 \div 24 = 1.291 \times 10^{-7} \text{ mol}$

moles of  $\text{NO}_2$  from emissions in  $1 \text{ m}^3$ :  $1.291 \times 10^{-7} \times 5 = 6.458 \times 10^{-7} \text{ mol}$  [1]

mass of  $\text{NO}_2$ :  $6.458 \times 10^{-7} \times [14 + 2(16)] \approx 2.97 \times 10^{-5} = 29.7\mu\text{g}$  [1]

Met NEA target

1 mark for both statements to conclude whether the gases meet target.

[5]

- (d) Another factory was found to emit  $60 \mu\text{g}/\text{m}^3$  of sulfur dioxide. Suggest a reason why the factory produces such a high amount of sulfur dioxide.

Combustion of fossil fuels / No flue gas desulfurisation process [1]

.....

..... [1]

[Total marks: 8]

### Section B

Answer all **three** questions, the last question is in the form either/or.  
Answer all questions in the spaces provided.

- B7** Ionization energy (IE) is the energy required to remove an electron from a gaseous atom or ion.



It is possible to remove more electrons from most elements, so this quantity is more precisely known as the first ionization energy, the energy to go from neutral atoms to cations with a 1+ charge. The second ionization energy is the energy that is required to remove a second electron from the cation with a 1+ charge, to form cations with a 2+ charge.



The third ionization energy is the energy required to form cations with a 3+ charge:



A graph of the logarithm of the ionisation energy of a sodium atom against the number of electrons removed is shown in Fig. 7.1 below.

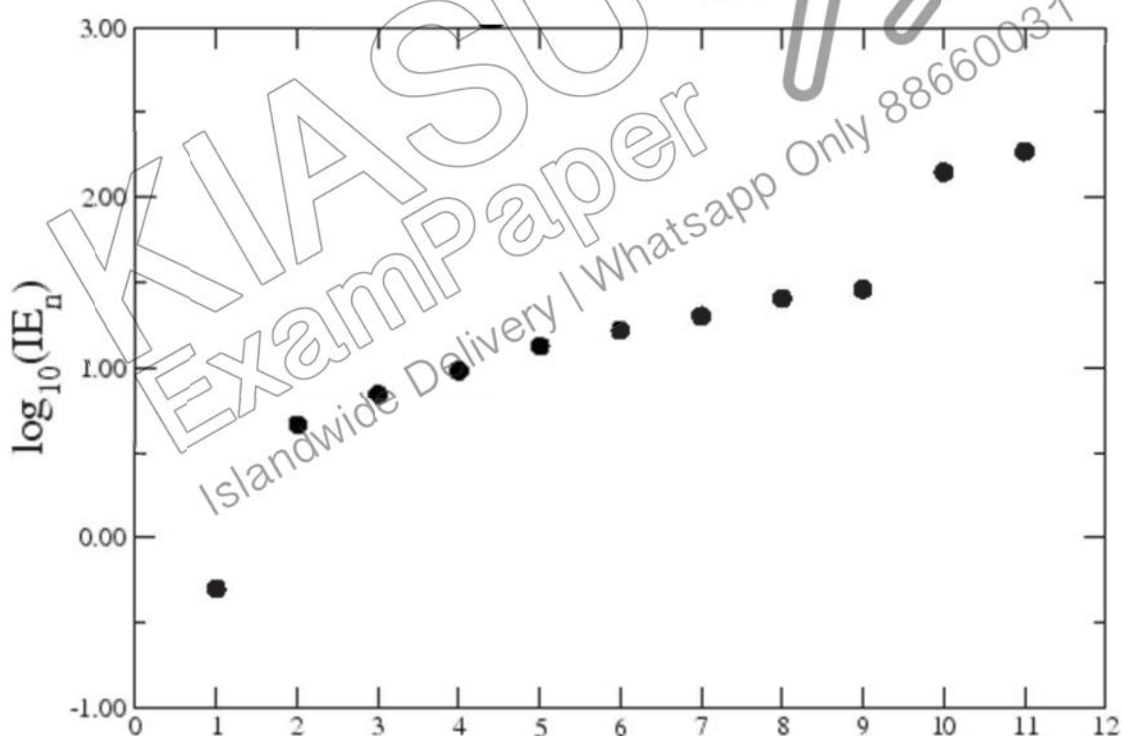


Fig. 7.1

The ionization energy may be an indicator of the reactivity of an element. Table 7.1 shows the ionization energies of the elements across Period 3 of the Periodic Table.

**Table 7.1**

element	Na	Mg	Al	Si	P	S	Cl	Ar
first ionisation energy	496	738	578	789	1012	1000	1251	1521

- (a) With reference to the electronic structure of sodium, explain the trend in the ionization energy shown in Fig. 7.1.

The first ionisation energy is removing one electron from the third shell which is furthest away from the nucleus hence lowest energy required. [1] There is only a slight increase from the 2<sup>nd</sup> to 9<sup>th</sup> ionisation energy as this involves the removal of 8 electrons from the same second shell. [1] 10<sup>th</sup> and 11<sup>th</sup> ionisation energy are the highest as it involves removal from the first shell closest to the nucleus.

[3]

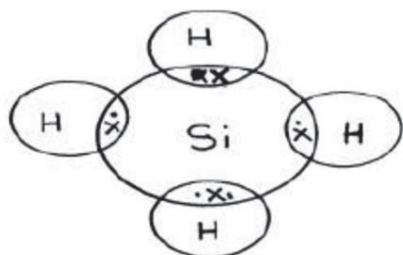
- (b) Explain the difference in first ionization energies for sodium and argon.

First ionisation energy of Na and Ar both involves removal of one electron from the third shell. [1] However the completely-filled shell of Ar has extra stability. It is more difficult to remove electron from this stable configuration and hence the ionisation energy is very high. [1]

[2]

The term hydride is commonly named after binary compounds that hydrogen forms with other elements of the Periodic Table. Hydrides can be classified as covalent or ionic hydrides, depending on which element hydrogen bonds to.

- (c) Draw a 'dot and cross' diagram to show the bonding in silane, the hydride formed by the reaction between silicon and hydrogen. Show only the outermost electrons.



Correct number of shared electrons [1]  
Correct ratio of atoms [1]

- (d) Suggest one similarity and one difference in physical properties between sodium hydride and hydrogen chloride.

similarity **NaH and HCl are both soluble in water [1]**

.....  
.....

difference **NaH has high melting point and boiling point but HCl has**

**low melting and boiling point. [1]**

..... [2]

- (e) The hydride formed by phosphorus is phosphine. Suggest with reasons, whether phosphine will have a higher or lower melting point than hydrogen chloride.

**Phosphine is a larger molecule than HCl and will have stronger**

**intermolecular attraction than HCl. Hence it will have a higher**

**melting and boiling point. [1]**

..... [1]

...

[Total marks: 10]

- B8** A student carries out some tests on an unknown solution **P** which is known to contain 2 metallic cations and 1 anion. She recorded her observations and deductions in the table shown below.

Expt no	Procedure	Observations	Deductions
1a	To a solution of <b>P</b> , add sodium hydroxide solution.	White ppt formed.	$\text{Pb}^{2+}$ , $\text{Zn}^{2+}$ , $\text{Ca}^{2+}$ or $\text{Fe}^{2+}$ could be present.
1b	Add excess sodium hydroxide solution into the test-tube in expt 1a.	Ppt decreased by approximately half. The remaining ppt is insoluble in excess sodium hydroxide.	$\text{Ca}^{2+}$ is present.
2	Add aluminium foil to the mixture in expt 1b. Warm the mixture.	Gas evolved turns moist red litmus paper blue.	$\text{Cl}^-$ is present.
3a	To new sample of solution <b>P</b> , add aqueous ammonia.	White ppt formed.	$\text{Al}^{3+}$ , $\text{Pb}^{2+}$ or $\text{Zn}^{2+}$ could be present.
3b	Add excess aqueous ammonia solution into the test-tube.	White ppt insoluble in excess aqueous ammonia.	$\text{Al}^{3+}$ or $\text{Pb}^{2+}$ could be present.

- (a) The student made 3 mistakes in her deductions. In Table 8.1, state the experiment number in which the mistakes were made. **Briefly** explain your answer.

	Expt no	Explanation
Mistake 1	1a	$\text{Fe}^{2+}$ ions cannot be present as it forms green ppt, [1]
Mistake 2	1a	Aluminium ion ( $\text{Al}^{3+}$ ) should also be a possible ion present as it forms white ppt with aqueous sodium hydroxide [1]
Mistake 3	2	Nitrate ion ( $\text{NO}_3^-$ ) should be present as ammonia gas ( $\text{NH}_3$ ) was evolved, not chloride [1]

- (b) Describe a simple test to differentiate between aluminium ions ( $\text{Al}^{3+}$ ) and lead(II) ions ( $\text{Pb}^{2+}$ ).

Add aqueous potassium iodide; [1] only lead(II) ions will give

.....  
 ...

yellow ppt [1] **OR**

.....  
 ...

Add any solution containing chloride or sulfate ions (except of barium);[1]

.....

only lead(II) ions will give white ppt [1]

.....  
 ...

[2]

- (c) Chlorine undergoes a reaction when it dissolves in water. The equation for the reaction is:



The bond energies of the reaction are given in the table below

Bond	Bond Energy (kJ/mol)	Bond	Bond Energy (kJ/mol)
Cl – Cl	239	H – Cl	427
Cl – O	203	H – O	467

- (i) Calculate the enthalpy change of the reaction.

Total energy absorbed during bond breaking:  $239 + 2(467) = 1173\text{kJ}$  [1]

Total energy released during bond forming:  $427 + 467 + 203 = 1097\text{kJ}$  [1]

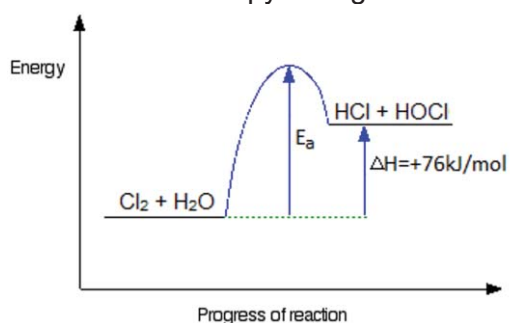
Enthalpy change:  $1173 - 1097 = +76\text{kJ}$  [1] or  $+76\text{kJ}$

*Deduct 1 mark if no proper working/heading shown to explain the string of numbers.*

[3]

- (ii) Draw the energy profile diagram for the reaction. Label:

- the reactants and products
- the activation energy
- the enthalpy change of the reaction



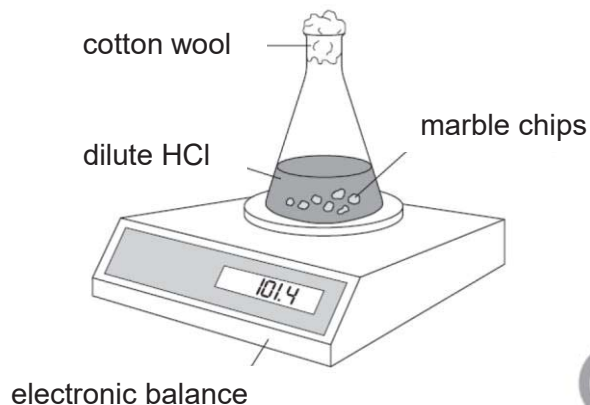
*1 mark for correct labelling of products and reactants and axes; 1 mark for correct labelling of activation energy and enthalpy change (single-arrow head);*

[2]

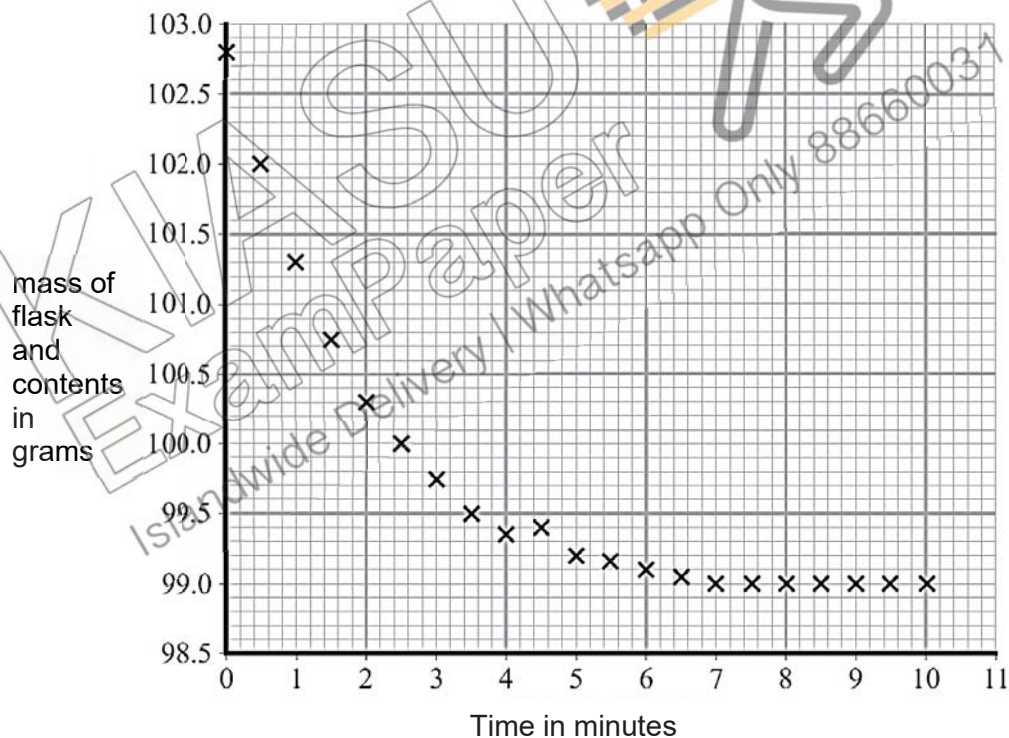
[Total marks: 10]

**B9 EITHER**

The rate of reaction between hydrochloric acid and excess marble chips (calcium carbonate) was investigated at a temperature of 40 °C using the apparatus shown in the diagram below.



The mass of the flask and contents was measured every half minute for ten minutes. The data obtained was plotted on a graph shown in the grid below.



- (a) State the time taken for the reaction to complete.

7 min [1]

[1]

- (b) Explain why the mass of the flask and contents decreased with time.

Carbon dioxide gas produced during the reaction escapes. [1]

Explanation must convey loss of carbon dioxide gas from flask to the surroundings

[1]

- (c) A student repeated the experiment but forgot to place the cotton wool at the neck of the conical flask. State how his results would be different and explain your answer.

Mass readings will be lower than the actual mass. [1]

Without the cotton wool, some acid will be lost as acid spray. [1]

[2]

- (d) Given that 40 cm<sup>3</sup> of hydrochloric acid were used in the reaction, calculate the concentration of this acid in mol/dm<sup>3</sup>.



Mass of carbon dioxide produced = 102.8 g – 99.0 g = 3.8 g

No of moles of carbon dioxide produced =  $\frac{3.8}{44}$  moles = 0.086364 mole [1]

2 moles of hydrochloric acid produces 1 mole of carbon dioxide

Hence, no of moles of hydrochloric acid present = 2 x 0.086364 moles  
= 0.17273 moles [1]

Hence, concentration of hydrochloric acid =  $\frac{0.17273}{0.04}$  = 4.32 mol/dm<sup>3</sup> [1]

[3]

- (e) Another student repeated the first experiment at a temperature of 50 °C. All other variables were kept the same.

- (i) On the same grid on page 18, draw the graph she can expect to obtain for this experiment. Label this graph T. [1]

- (ii) Explain, in terms of the collision theory, how an increase in temperature affects the rate of reaction.

Particles gain kinetic energy and move faster and frequency of collisions

increases, number of effective collisions increases per unit time. [1]

More particles possess energy equal or greater than the activation energy

rate of reaction increases. [1]

[2]

[Total marks: 10]

B9 OR

A student carried out three experiments to investigate the rate of reaction of excess magnesium carbonate with dilute acids.

Experiment	Acid
1	100 cm <sup>3</sup> of 0.10 mol/dm <sup>3</sup> sulfuric acid
2	50 cm <sup>3</sup> of 0.20 mol/dm <sup>3</sup> sulfuric acid
3	100 cm <sup>3</sup> of 0.10 mol/dm <sup>3</sup> ethanoic acid

(a) Suggest a method the student could use to follow the progress of the reaction.

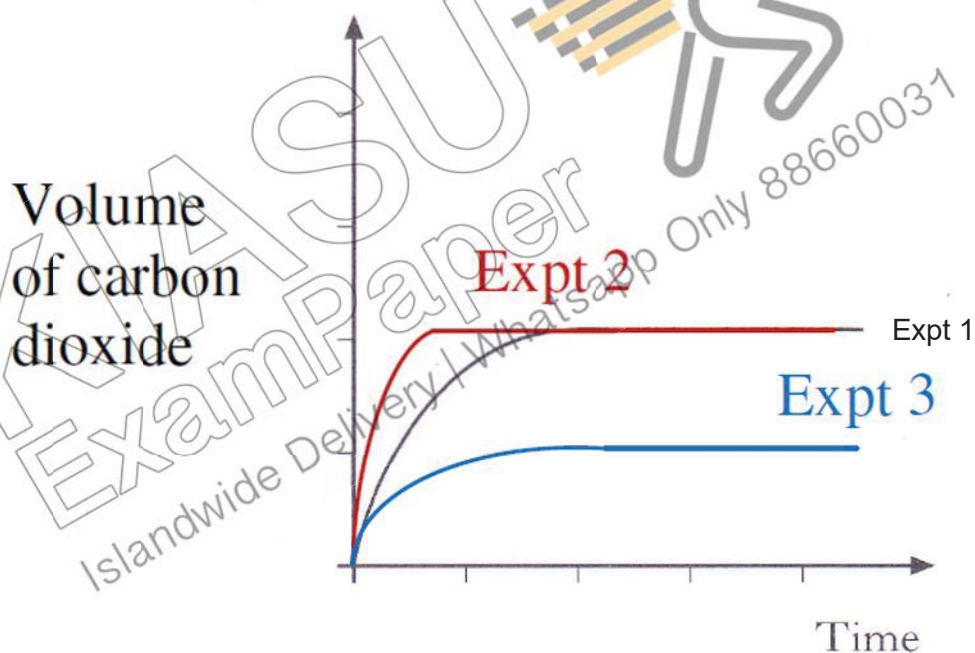
Carbon dioxide gas can be collected in a gas syringe [1]

its volume is measured at regular intervals from the start of the reaction

until there is no change in the volume observed. [1]

[2]

The curve obtained for Experiment 1 is shown on the graph below.



(b) Draw curves on the graph to show the results obtained for Experiment 2 and Experiment 3. Label each curve clearly.

[2]

- (c) Explain the shape of the curve in Experiment 3.

The gradient of the experiment 3 is gentler than that of experiment 1. [1]

Ethanoic acid is a weak acid that dissociates partially, hence

initial concentration of the hydrogen ions in experiment 3 is less than that

of sulfuric acid in experiment 1 [1]  $\text{H}_2\text{SO}_4$  also has a greater no. of  $\text{H}^+$  [1].

[3]

- (d) Another student repeated Experiment 1 at a temperature of 50 °C. All other variables were kept the same. State the effect of this temperature increase. Explain your answer using collision theory.

Particles gain kinetic energy and move faster and frequency of collisions

increases, number of effective collisions increases per unit time. [1]

More particles possess energy equal or greater than the activation energy [1]

rate of reaction increases. [1]

[2]

[Total marks: 10]

**END OF PAPER**



