OVERMUGGED O LEVEL MOCK PAPER 2021
SECONDARY 4 EXPRESS
SECONDARY 5 NORMAL ACADEMIC

COMBINED SCIENCE (CHEMISTRY) **5076/03|5078/03**
PAPER 3 **September 2021**
1 hour 15 mins

INSTRUCTIONS TO CANDIDATES

Write in dark blue or black pen.
You may use an HB pencil for 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 on the Question Paper.

Section B
Answer **all** questions, the last question is in the form either/or.
Write your answers in the spaces provided on the Question Paper.

Electronic calculators may be used.

The number of mark is given in brackets [ ] at the end of each question or part question.

**Questions in this mock paper may contain adapted questions from the Ten Year Series and Prelim Papers from various schools in Singapore.*

Section A

1. James did a series of experiments using varying amount of zinc metal and $100cm^3$ of different concentration of sulfuric acid.

Experiment	Amount of Zn metal	Concentration of H_2SO_4	Temperature	Time taken to produce $100cm^3$ of H_2 gas
A	5g (solid form)	2.0 mol/dm^{-3}	25 °C	200s
B	5g (powder form)	2.0 mol/dm^{-3}	25 °C	133s
C	5g (powder form)	4.0 mol/dm^{-3}	25 °C	X
D	5g (powder form)	4.0 mol/dm^{-3}	45 °C	Y

a) **Predict an estimate value of X** and **explain** your answer. [2]

Any value below 100. When the concentration of reactant particles increases, there will be a higher number of reacting particles per unit volume, leading to a higher frequency of collision between reactants and thus a higher frequency of effective collisions. The rate of reaction will increase.

b) **Explain the difference in time taken between Experiment A and B. [2]**

When the size of the particles are smaller (powder form), the **greater the exposed surface area to volume ratio**, there will be a **higher number of reactants exposed to collisions with other reacting particles**, frequency of collision between reactants increases, frequency of effective collision between reactants increases, therefore the rate of reaction will increase.

c) Would the value of X be greater than or smaller than Y. **Explain** your answer. [2]

X would be greater than Y. When the temperature increases, the average kinetic energy of the particles increases and the particles will move faster. Frequency of collision between reactants increases.

Also, more particles has sufficient energy to overcome the activation energy barrier, hence, frequency of effective collision between reactants increases, rate of reaction increases.

Hence, Experiment D will take a shorter time and Y would be a smaller value.

2. Choose from the following compounds to answer the questions below.

Carbon dioxide
Calcium oxide
Sodium nitrate
Sodium hydroxide
Copper (II) sulphate
Nitrogen dioxide
Aqueous ammonia
Zinc oxide
Hydrochloric acid

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

a) Formed due to high temperature in car engines [1]

Nitrogen dioxide

b) Reacts with both acid and base to form salt and water [1]

Zinc oxide

c) Gives a white precipitate when added to acidified silver nitrate [1]

Hydrochloric acid

d) A salt that should be prepared via titration. [1]

Sodium nitrate

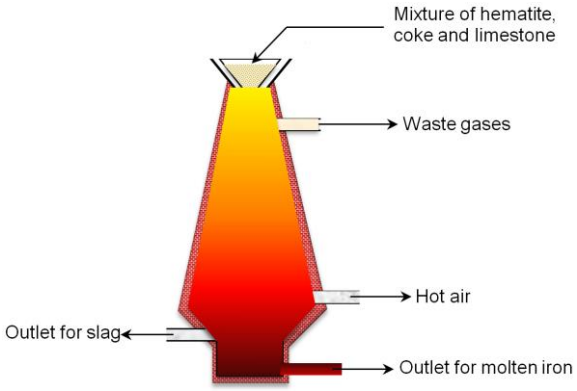
e) Reacts with calcium carbonate to form carbon dioxide gas [1]

Hydrochloric acid

f) Turn moist red litmus paper blue when added to ammonium nitrate. [1]

Sodium hydroxide

3. Haematite and coke are used in the extraction of iron in the blast furnace.



a) Give the **chemical formula of haematite**. [1]

Fe_2O_3

b) With the **aid of chemical equations, explain** the importance of adding **coke** for the extraction of iron. [3]

Carbon present in coke burns in hot air to produce carbon dioxide.

$$C\ (s) + O_2\ (g) \rightarrow CO_2\ (g)$$

The carbon dioxide reacts further with coke to form carbon monoxide.

$$CO_2\ (g) + C\ (s) \rightarrow 2\ CO\ (g)$$

Carbon monoxide reduces iron (III) oxide in haematite to iron.

$$Fe_2O_3\ (s) + 3CO\ (g) \rightarrow 2Fe\ (l) + 3CO_2\ (g)$$

c) Using oxidation states, **state and explain whether haematite that got oxidised or reduced** in the blast furnace reaction. [2]

Haematite is reduced as **Fe_2O_3 reduced its oxidation state from +3 to 0 in Fe.**

d) Write out the **full balanced equation** which shows a reaction between an acidic oxide and a base. [1]

$$CaO\ (s) + SiO_2\ (l) \rightarrow CaSiO_3\ (l)$$

4. Acid rain is formed when atmospheric **acidic oxides** such as **sulfur dioxide and nitrogen dioxide** react with oxygen and water in the atmosphere.

a) Using **balanced chemical equations** show how **acid rain is formed**. [2]

$$2SO_2\ (g) + O_2\ (g) + 2H_2O\ (l) \rightarrow 2H_2SO_4\ (aq)$$
$$4NO_2\ (g) + O_2\ (g) + 2H_2O\ (l) \rightarrow 4HNO_3\ (aq)$$

b) **State 2 negative effect of acid rain** on the **environment.** [1]

Acid rain makes the **soil acidic, affecting plants and trees**. Acid rain **reduces the pH of lake water, making it unsuitable for aquatic organisms.**

c) **Suggest** how farmers can **reduce the acidity of the soil** such that their crops can grow better. Name **2 methods**. [2]

Neutralise the acid in soils using **slaked lime (calcium hydroxide) or limestone (calcium carbonate).**

d) Assuming that the crops **grow best at pH 7**, **state** and **explain which method** mentioned in part c) will be a **better choice**. [2]

Calcium carbonate, $CaCO_3$ will be a better choice. Calcium carbonate will react with acid to produce salt, water and carbon dioxide.

Excess calcium carbonate will not cause the pH of the soil to increase further. Meanwhile, excess calcium hydroxide will increase the pH of the soil to the alkaline range and may cause the soil to be too alkaline for the crops.

e) Some fertilisers contain **ammonium chloride NH_4Cl** which are help crops grow better. Some crops also grow better in a more alkaline soil at higher pH.

Using a **balanced chemical equation, explain why the fertilisers** and the **alkaline solution should not be added together**. [2]

$$NH_4Cl\ (aq) + NaOH\ (aq) \rightarrow NaCl\ (aq) + H_2O\ (l) + NH_3\ (g)$$

When an alkaline like NaOH is mixed with fertilisers containing NH_4Cl, a **chemical reaction occurs** and ammonia gas is released.

The crops will not get to absorb the NH_4Cl as it is **released in the form of NH_3 gas** and the **alkaline will be reacted away** and will not be able to increase the pH of the soil to make it more alkaline and suitable for the crop.

5. The table below shows the various ionic versions of manganese.

Substance
MnO_4^-
MnO_4^{2-}
Mn^{2+}
MnO_2

a) Arrange the substances **increasing order of oxidation state** of Mn. [2]

Mn^{2+} → +2, MnO_2 → +4, MnO_4^{2-} → +6, MnO_4^- → +7

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b) When solid manganese (II) nitrate is heated, solid manganese (IV) oxide and nitrogen dioxide will be produced. The chemical equation is listed below.

$$Mn(NO_3)_2\ (s) \rightarrow MnO_2\ (s) + 2\ NO_2\ (g)$$

Based on the change in oxidation state of manganese, explain whether manganese (II) nitrate has undergone **oxidation or reduction**. [2]

Manganese (II) nitrate underwent oxidation as the oxidation state of manganese increased from +2 in manganese (II) nitrate to +4 in manganese (IV) oxide.

c) Chlorine is often used as a disinfectant in swimming pools. The chemical equation is as follows:

$$\mathbf{S_2O_3^{2-} + 4Cl_2 + 5\ H_2O \rightarrow 2SO_4^{2-} + 8Cl^- + 10H^+}$$

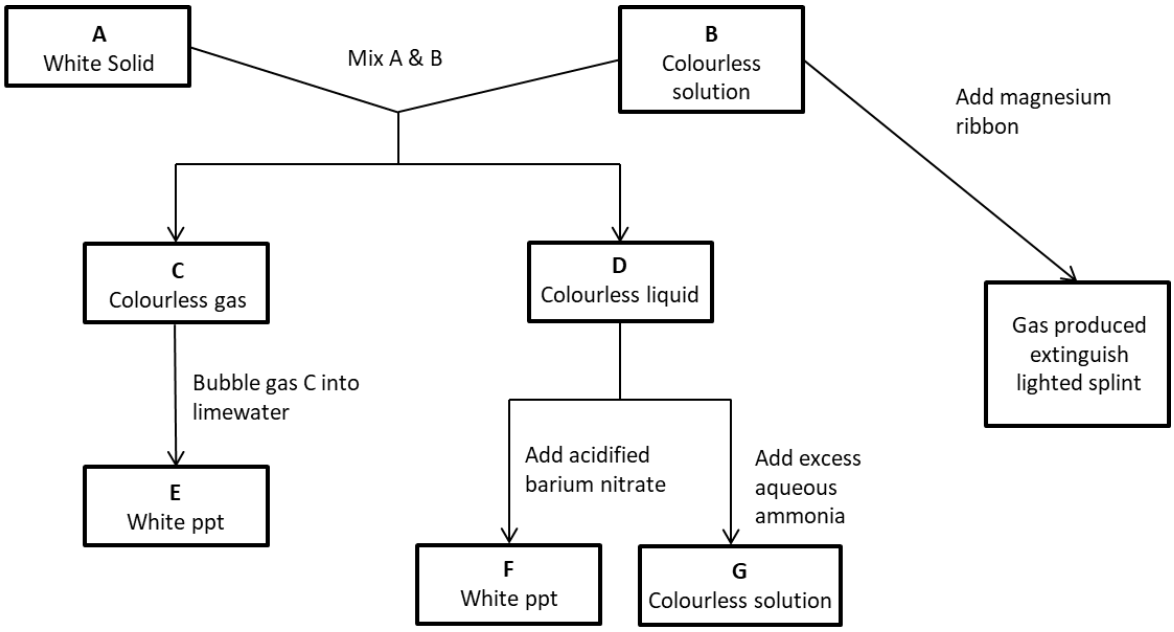
i) Deduce **the oxidation states** of sulfur in each substance. [2]

Substance	Oxidation state of sulfur
$S_2O_3^{2-}$	+2
SO_4^{2-}	+6

ii) Identify the **substance that got reduced** in this reaction. **Explain** your answer. [2]

Chlorine. Chlorine underwent reduction as its oxidation state decreased from 0 in Cl_2 to -1 in Cl^-.

6. Refer to the flowchart below.



a) Suggest the identity of substances A to G. [7]

A	**Zinc carbonate**
B	**Sulfuric acid**
C	**Carbon dioxide**
D	**Zinc sulfate**
E	**Calcium carbonate**
F	**Barium sulfate**
G	**Zinc hydroxide**

b) Write the **balanced equation** when colourless **gas C** forms **substance E** when bubbled into **limewater**. [1]

$$CO_2\ (g) + Ca(OH)_2\ (aq) \rightarrow CaCO_3\ (s) + H_2O\ (l)$$

c) **Identify** the chemical reaction and write the **balanced ionic equation** when colourless liquid D reacts with acidified barium nitrate. [1]

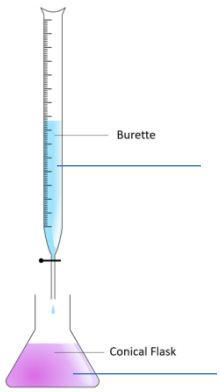
Precipitation.

$$SO_4^{2-}\ (aq) + Ba^{2+}\ (aq) \rightarrow BaSO_4\ (s)$$

Section B

7. Titration is a salt preparation method whereby an alkaline and an acid undergo neutralisation. The neutralisation reaction between an alkali $X(OH)_2$ and sulfuric acid can be represented by the following equation:

$$X(OH)_2 + H_2SO_4 \rightarrow XSO_4 + 2H_2O$$



The results of a titration experiment are as such:

Experiment	1	2	3	4
Initial volume of H_2SO_4 / cm^3	0.0	18.1	0.4	18.3
Final volume of H_2SO_4 / cm^3	18.1	35.9	18.3	36.2
Volume of H_2SO_4 used / cm^3	18.1	17.8	17.9	17.9

a) **Complete the table above**. [2]

b) Determine the **average volume** of H_2SO_4 used. [1]

$17.9cm^3$ (Use average of 2 best value)

c) Determine the **concentration of $X(OH)_2$ in mol/dm^3.** [3]

Mole of H_2SO_4 = (17.9/1000) dm^3 x 0.25mol/dm^3 = 0.004475mol

Mole ratio H_2SO_4 : $X(OH)_2$ is 1:1, there mole of $X(OH)_2$ is also 0.004475mol.

Concentration of $X(OH)_2$ = mol / vol = 0.004475mol / (25/1000) = 0.179mol/ dm^3

d) The concentration of $X(OH)_2$ is $13.26g/dm^3$. **Identify X.** [2]

Mr = mass / mol = 13.26 / 0.179 = 74. Since $X(OH)_2$ = Mr 74, X is calcium.

e) Suggest **why titration is not the most ideal method** to prepare salt **XSO_4. [2]**

$CaSO_4$ is an **insoluble salt** and should be prepared using **precipitation** instead.

8. A compound contains **38.6% potassium, 13.9% nitrogen and the rest is made of oxygen.**

a) Determine the **empirical formula** of this compound. [3]

	Potassium (K)	Nitrogen (N)	Oxygen (O)
Mass in 100 g sample/g	38.6	13.9	100 – 38.6 – 13.9 =47.5
Molar mass/g mol^{-1}	39	14	16
Number of moles	38.6 / 39 = 0.99	13.9 / 14 = 0.99	47.5 / 16 = 2.97
Simplest ratio	1	1	3

Therefore, empirical formula is KNO_3.

When iron metal is exposed to air and moisture, it will undergo rusting to form iron (III) oxide.

b) Construct a balanced chemical equation for rusting. [2]

$$4Fe\ (s) + 3O_2\ (g) + 6H_2O\ (l) \rightarrow 4Fe(OH)_3\ (s)$$

c) State one method for preventing rusting and explain how it works. [2]

Surface protection prevents rusting by protecting the iron/steel from coming in contact with air and water.

Paint, oil, plastic and metal plating are used as surface protection for iron and steel objects.

Aluminium and iron (III) oxide reacts in the chemical equation as shown below.

$$2\ Al(s) + Fe_2O_3\ (s) \rightarrow Al_2O_3\ (s) + 2\ Fe\ (l)$$

d) **Identify** the name of this **chemical reaction**. [1]

Displacement/redox reaction.

e) Aluminium oxide can only be extracted from its ore via electrolysis while iron (III) oxide can be extracted via heating with carbon. Referencing the reactivity series, **explain**. [2]

Carbon is above iron in the reactivity series and is more reactive than iron but less reactive than aluminium. Hence, carbon is able to **displace iron from its metal oxides**.