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

PURE CHEMISTRY **6092/02**
PAPER 2 **September 2021**
1 hour 45 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.

You are advised to spend no longer than one hour on Section A and no longer than 45 minutes on Section B.
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. 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

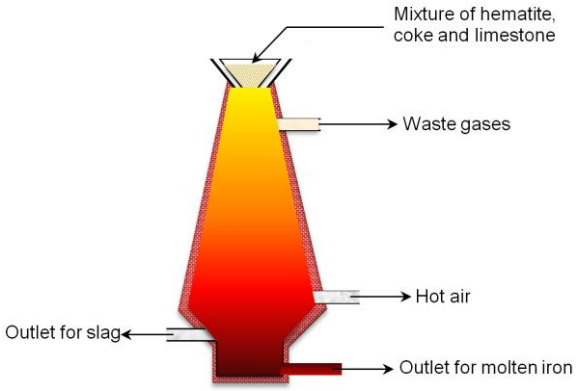
e) Reacts with calcium carbonate to form carbon dioxide gas [1]

Hydrochloric acid

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

Sodium hydroxide

2. 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) **Identify the reducing agent** in the reaction which reduced the product to become molten iron and **explain why**. [2]

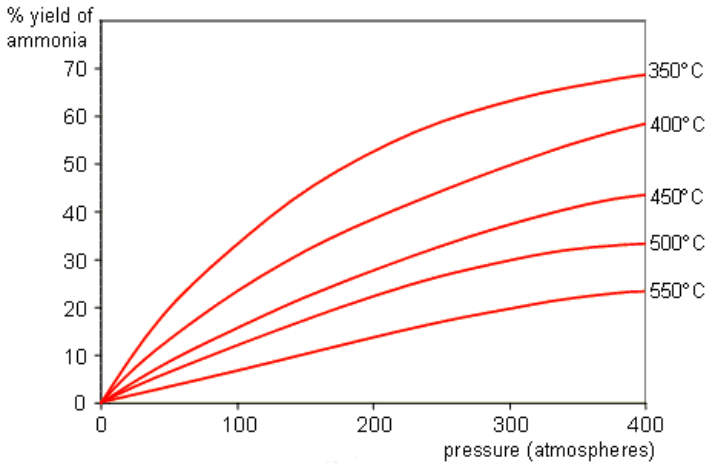
Carbon monoxide is the reducing agent as it caused **Fe_2O_3 to reduce its oxidation state from +3 to 0 in Fe.**

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

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

3. The Haber process chemical equation is as such:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$



The Haber process is carried out at a **temperature of 450°C, pressure of 200 atm** and in the presence an iron catalyst.

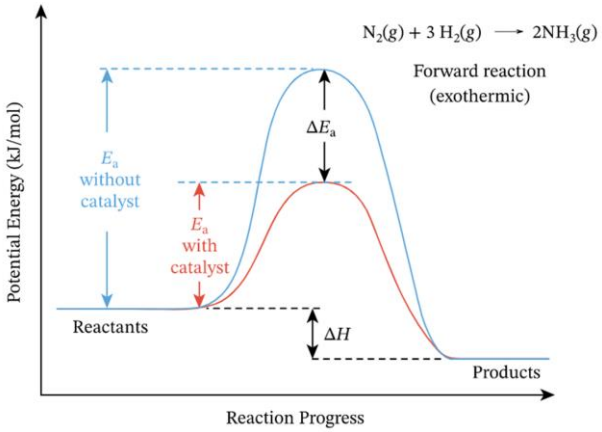
a) **Explain** in terms of **collision theory**, why using a **higher pressure** will **increase the rate of reaction.** [2]

At a higher pressure, the reactants are brought closer together.
There will be **more reactants 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** why **450°C** is used even though it **lowers the yield of the reaction**. [2]

Even though yield will decrease when temperatures falls below 450°C, **a low temperature will lead to a low rate of reaction.** Hence, it is more **cost efficient to use a higher temperature to increases the rate of reaction** despite the lower yield.

c) Draw the **energy profile diagram** for Haber process. [3]



d) Draw an **additional line** to show the effects of **having iron as a catalyst**. [1]

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.** [2]

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.

f) One way to reduce the effects of pollutant gas is to use a catalytic converter. Using **chemical equations**, show how **carbon monoxides** and **oxides of nitrogen are removed** via the catalytic converter. [2]

$$2\ CO\ (g) + O_2\ (g) \rightarrow 2\ CO_2\ (g)$$
$$2\ NO\ (g) + 2\ CO\ (g) \rightarrow N_2\ (g) + 2\ CO_2\ (g)$$

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:

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

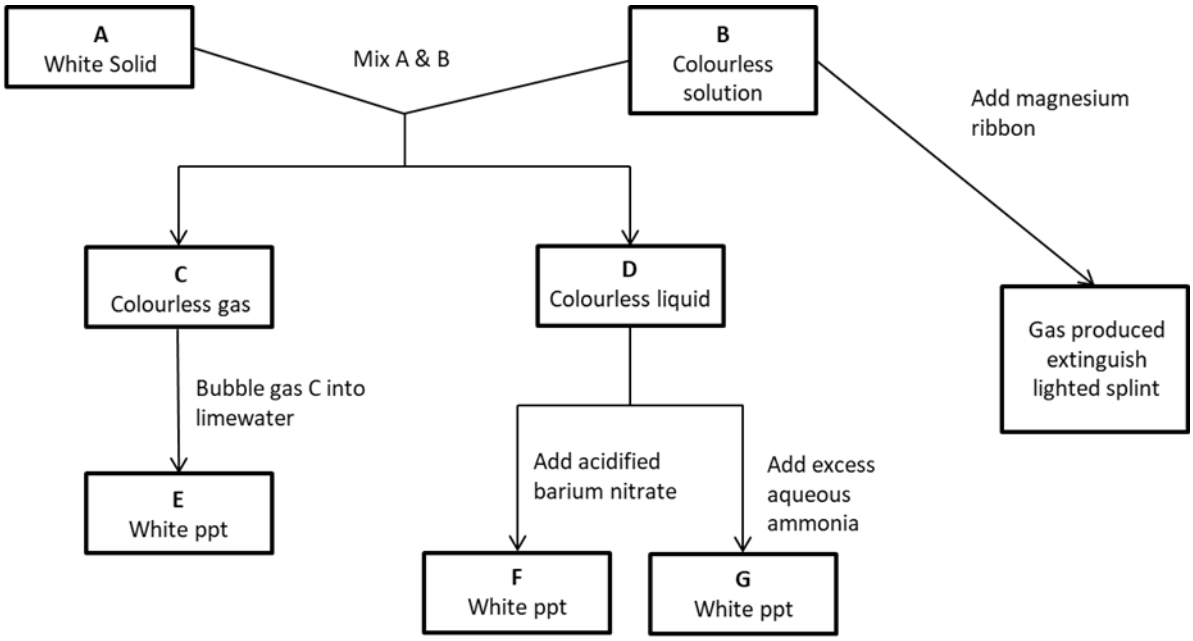
i) Deduce **the oxidation states** of sulfur in each substance. [2]

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

ii) Identify the **oxidising agent** in this reaction. **Explain** your answer. [2]

Chlorine. Chlorine oxidise $S_2O_3^{2-}$ by increasing its oxidation state from +2 in $S_2O_3^{2-}$ to +6 in SO_4^2. Meanwhile, chlorine itself underwent reduction. Therefore, chlorine is the oxidising agent in this reaction.

6. Refer to the flowchart below.



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

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

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

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

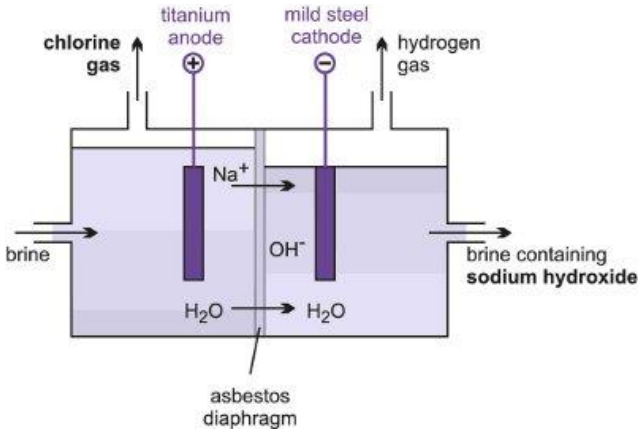
c) **Identify** the chemical reaction and write the **balanced ionic equation** when colourless liquid D reacts with acidified barium nitrate. [1]

Precipitation.

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

Section B

7. The electrolysis of brine in a diaphragm cell is as shown below.



Brine is made with **concentrated sodium chloride solution**. The diaphragm allows for particles like Na^+ and H_2O molecules to pass through but does not allow negatively charged ions like OH^- and Cl^- to pass through.

This allows for **sodium hydroxide and chlorine gas** to be produced in the same set-up.

a) **Identify** the **respective ions present** in each side of the cell. [2]

Titanium anode: Na^+, Cl^-, H^+, OH^-
Mild steel cathode: Na^+, H^+, OH^-

b) **State** and **explain** the reaction occurring at each electrode, with the **aid of ionic-half equations.** [4]

Titanium anode: $2\,Cl^- \rightarrow Cl_2 + 2e^-$

Chlorine ions are oxidised to chlorine gas. Chlorine gas is discharged preferentially over OH^- ions due to concentration effect.

Mild steel cathode: $2H^+ + 2e^- \rightarrow H_2$

H+ ions are selectively discharged over Na+ ions and hydrogen gas is produced.

c) **Explain** why it is important that the negatively charged ions like OH^- and Cl^- are **not allowed to pass** through the membrane. [2]

If OH^- was allowed to pass through to the left side of the cell, it will be discharged at the anode and oxygen gas will be produced instead.

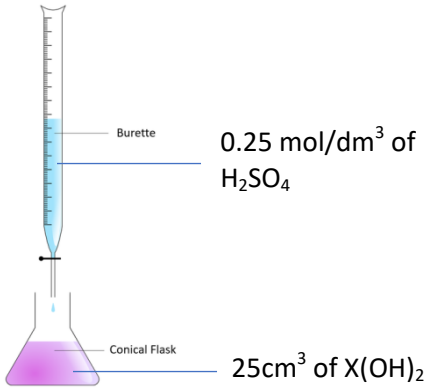
This will reduce the amount of chlorine gas produced. Similarly, if Cl^- was allowed to pass through, it will react with Na^+ and result in an impure mixture of sodium chloride and sodium hydroxide.

d) Construct the **balanced ionic equation & chemical equation** for the whole process. [2]

Ionic equation: $2H_2O\,(l) + 2Cl^-\,(aq) \rightarrow H_2\,(g) + Cl_2\,(g) + 2OH^-\,(aq)$
Chemical equation: $2H_2O\,(l) + 2NaCl\,(aq) \rightarrow H_2\,(g) + Cl_2\,(g) + 2NaOH\,(aq)$

8. 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/dm^3) = 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.

9 EITHER)

A compound contains **38.6% potassium, 13.9% nitrogen and the rest is made of oxygen.** 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 oxidation. The oxidation process is represented using **two ionic half-equations** below.

$$Fe\ (s) \rightarrow Fe^{2+}\ (aq) + 2e^-\ (1)$$
$$O_2\ (g) + 2H_2O\ (l) + 4e^- \rightarrow 4OH^-\ (aq)\ (2)$$

b) Combine the **two half-equations** to form the **chemical equation** for the reaction. [2]

Balance the electrons.

2 x Equation (1): $2Fe\ (s) \rightarrow 2Fe^{2+}\ (aq) + 4e^-$
Equation (2): $O_2\ (g) + 2H_2O\ (l) + 4e^- \rightarrow 4OH^-\ (aq)$

Combing both half equations:

$2Fe\ (s) + O_2\ (g) + 2H_2O\ (l) \rightarrow 2Fe(OH)_2\ (s)$

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

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

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

Displacement/redox reaction.

d) In terms of **gain or loss of oxygen**, **identify** and **explain** which compound has been reduced. [2]

Fe_2O_3 has been reduced as it has loss oxygen to form Fe. A compound that loses of oxygen atoms undergoes reduction.

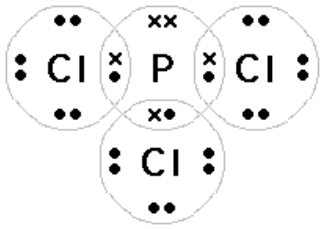
e) Aluminium oxide can only be extracted from its ore via electrolysis while iron (III) oxide can be extracted via heating with carbon. Referencing the reactivity series, **explain.** [2]

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.**

9 OR)

Phosphorus trichloride is a colorless, clear, fuming liquid with a strong odor. It is used in gasoline additives, textile finishing and to make other chemicals like pesticides.

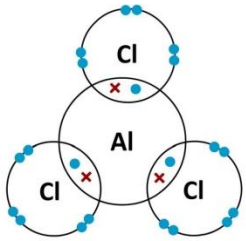
a) **Draw a 'dot-and-cross' diagram to show the bonding in** Phosphorus trichloride. Show only the valence electrons only. [2]



b) **State** whether the **melting and boiling point of phosphorus trichloride is high or low** and **explain** why. [2]

Phosphorus trichloride molecules have low MP/BP as they have a **simple molecular structure** where the small discrete molecules are held together by **weak intermolecular forces of attractions**. Hence, **little heat energy is needed to overcome the weak intermolecular forces**, resulting in low melting and boiling points.

The diagram below shows the bonding for aluminium chloride.

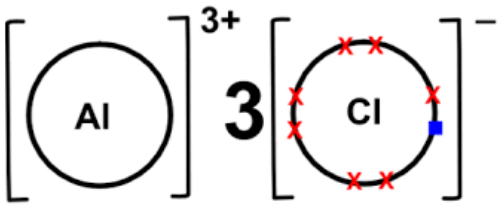


Aluminium chloride $AlCl_3$

c) **Explain** why this bond is **unconventional**. [2]

For bonding between metal and non-metals, ionic bonds are usually formed via the transfer of electrons. However, for aluminium chloride, it is covalently bonded through the sharing of electrons instead.

d) **Draw the bonding** that should **exist for aluminium chloride** in normal conditions. [1]



e) State, with clearly outline steps, the steps to prepare **a sample of aluminium chloride salt.** [3]

1) Add excess of your aluminium in a beaker containing the hydrochloric acid and stir until no further reaction is observed.

2) Pour the mixture into a filter funnel with a filter paper. Keep the **filtrate** (soluble salt).

3) Pour your filtrate into an evaporating dish and **heat till saturation**. Allow the solution to cool and crystals will form.

4) Wash the crystals with cold distilled water and dry between sheets of filter paper/ place in a crucible and dry in an oven.