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Chemistry P3 Notes

9701

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CONTENTS

Titration

Tip: read the question very carefully and do it step by step.

- ➔ For accuracy burette and pipette can be rinsed with the chemical that would go into them.
- ➔ It is preferable that the burette is filled till 0 cm^3 using a funnel for every titration, so that you can easily fill the initial readings of titrations in the table.
- ➔ The other chemical(as per the question) is added into the conical flask with the help of pipette.
- ➔ 2-3 drops of the indicator mentioned in the question are added, make sure not to add excess.
- ➔ Begin the titration, allow a few drops of chemicals from the burette at a time, meanwhile shake the conical flask continuously.
- ➔ Whenever you think that the end point is near, add the solution in burette drop by drop.
- ➔ Immediately, tighten the knob of the burette when you see a colour change.
- ➔ Note down the reading of the burette, this would be the rough titration

	Rough titration
Final Volume/cm^3	
Initial Volume/cm^3	
Titre/cm^3	

- ➔ Now carry out the rest of the titrations, if the first two titres are within 0.1 cm^3 then there is no need for the third titration.
- ➔ If not,again take the reading on the same table but on a new row.

	1	**2**
Final Volume/cm^3		
Initial Volume/cm^3		
Titre/cm^3		
Best Titre (✓)		

- ➔ For best titre E.g: if one of the titre is 22.4 cm^3 and the second titre is 22.8 cm^3 and the third tire is 22.7 cm^3, the best titre will be second and third titre.
- ➔ In the table, the headings and their units have separate marks.
- ➔ Give your answers to 3s.f. (unless otherwise indicated)
- ➔ Make sure to put the mole ratio in mind when doing titration questions

Rate of Reaction

- ➔ In such questions all the instructions are provided in the question and the student is asked to perform it step by step and record the readings.
- ➔ E.g of rate of question is below

Quantitative analysis

Read through the whole method before starting any practical work. Where appropriate, prepare a table for your results in the space provided.

Show your working and appropriate significant figures in the final answer to **each** step of your calculations.

1 The thiosulfate ion, $S_2O_3^{2-}$, is unstable in the presence of acid. The following reaction occurs.

$$S_2O_3^{2-}(aq) + 2H^+(aq) \rightarrow S(s) + SO_2(aq) + H_2O(l)$$

The rate of this reaction can be measured by timing how long it takes for the solid sulfur that is formed to make the mixture too cloudy to see through.

You will investigate how the concentration of the thiosulfate ions affects the rate of this reaction.

Throughout these experiments care must be taken to avoid inhaling any SO_2 that is produced. It is very important that as soon as each experiment is complete, the contents of the beaker are emptied into the quenching bath and the beaker is rinsed thoroughly.

FB 1 is 0.100 mol dm^{-3} sodium thiosulfate, $Na_2S_2O_3$.
FB 2 is 2.00 mol dm^{-3} hydrochloric acid, HC*l*.
distilled water

(a) Method

Experiment 1

- Label one burette **FB 1** and fill it with **FB 1**.
- Run 45.00 cm^3 of **FB 1** from the burette into the 100 cm^3 beaker.
- Use the 25 cm^3 measuring cylinder to measure 10.0 cm^3 of **FB 2**.
- Add **FB 2** to **FB 1** and start timing **immediately**.
- Stir the mixture once and place the beaker on the printed insert.
- View the print on the insert from above the mixture.
- Stop timing when the print on the insert is no longer visible.
- Record this reaction time to the nearest second.
- Empty the contents of the beaker into the quenching bath.
- Rinse and dry the beaker so it is ready for use in **Experiment 2**.

Experiment 2

- Fill the second burette with distilled water.
- Refill the burette labelled **FB 1** with **FB 1**.
- Run 20.00 cm^3 of **FB 1** into the 100 cm^3 beaker.
- Run 25.00 cm^3 of distilled water into the same beaker.
- Use the 25 cm^3 measuring cylinder to measure 10.0 cm^3 of **FB 2**.
- Add **FB 2** to the beaker and start timing **immediately**.
- Stir the mixture once and place the beaker on the printed insert.
- View the print on the insert from above the mixture.
- Stop timing when the print on the insert is no longer visible.
- Record this reaction time to the nearest second.
- Empty the contents of the beaker into the quenching bath.
- Rinse and dry the beaker so it is ready for use in the next experiment.

Experiments 3–5

- Carry out three further experiments to investigate how the reaction time changes with different volumes of **FB 1**.

The combined volume of **FB 1** and distilled water must always be 45.00 cm^3.
Do not use a volume of **FB 1** that is less than 20.00 cm^3.

Record all your results in a table.
You should include the volume of **FB 1**, the volume of distilled water, the reaction time and the reaction rate for each of your five experiments.
Calculate the rate of reaction using the following formula.

$$\text{rate} = \frac{1000}{\text{reaction time}}$$

Now a table shall be drawn, and readings would be noted in it.

	Volume of FB1/cm^3	Volume of distilled water/cm^3	Time/s	Rate t/s^{-1}
1	45.00	0.00		
2	35.00	10.00		
3	30.00	15.00		
4	25.00	20.00		
5	20.00	25.00		

- ➔ Sum of both volumes shall be 45 cm^3, as stated in the question.
- ➔ Time will be noted using a stopwatch
- ➔ Make sure to note down the time accurately so that you can find the rate, by the help of the formula given in question.
- ➔ Rest of the parts could be graphs, calculations or improvements which will be covered later on.
- ➔ There are only a few tips regarding the rate of reaction questions. Many of the questions include measurement of temperature for that first, always stir the mixture before recording the temperature. Secondly, when measuring temperature, make sure that the thermometer is not taken out from the solution.

Gravimetric Experiments

- ➔ Again, make sure to read the question VERY carefully.
- ➔ Heating is mostly done using a bunsen burner (for which a pipe clay triangle is used)/ bathtub/hot plate (and if you are using a hot plate make sure to heat it properly, before you start to heat the reactants).
- ➔ Wear a mask while heating, as gases can be released.
- ➔ A specific distance must be maintained to avoid any contact with the hot instrument/reactants.
- ➔ To measure the mass, electronic balance is to be used.
- ➔ Make sure that the initial reading of the electronic balance is zero.
- ➔ It measures in grams, so always write units **("g")**.
- ➔ A table like this shall be neatly drawn.

	Experiment 1	**Experiment 2**
Mass of empty test tube/g		
Mass of empty test tube + Sample X/g		
Mass of test tube + residual sample X/g		
Mass of sample X used/g		

Thermometric Experiments

There are a few important points to keep in mind when starting with this type of questions:

- ➔ Firsty, always stir the mixture before recording the temperature. This will ensure that the temperature is evenly distributed throughout the mixture.
- ➔ Second, when measuring the temperature, make sure that the thermometer is not taken out of the solution. This will prevent the temperature of the thermometer from being affected by the air.

This part of the paper involves graph plotting and calculations of moles and enthalpy change. The concept of plotting graphs is discussed further in the pdf.

2 You are to determine the enthalpy change for the neutralisation reaction given below.

$$HA(aq) + NaOH(aq) \rightarrow NaA(aq) + H_2O(l)$$

You will be using solutions of different concentrations from those in **Question 1**.

FA 3 is 1.80 mol dm^{-3} HA.
FA 4 is aqueous sodium hydroxide, NaOH.

(a) Method

Read through the instructions carefully and prepare a table below for your results before starting any practical work.

- Support the plastic cup in the 250 cm^3 beaker.
- Rinse and fill the burette with **FA 3**.
- Use the measuring cylinder to transfer 25 cm^3 of **FA 4** into the plastic cup.
- Place the thermometer in the plastic cup and record the temperature of the solution. Tilt the cup if necessary to ensure the thermometer bulb is fully immersed.
- Run 5.00 cm^3 of **FA 3** into the cup. Stir, and record the new temperature of the solution and the volume of **FA 3** added.
- Run a second 5.00 cm^3 of **FA 3** into the cup. Stir and record the new temperature and the total volume of **FA 3** added.
- Continue adding **FA 3** in 5.00 cm^3 portions. Stir and record each new temperature and total volume of **FA 3** until a total of 45.00 cm^3 has been added.

Results

In order to answer a question like this, it is necessary to draw a table to record your observations.

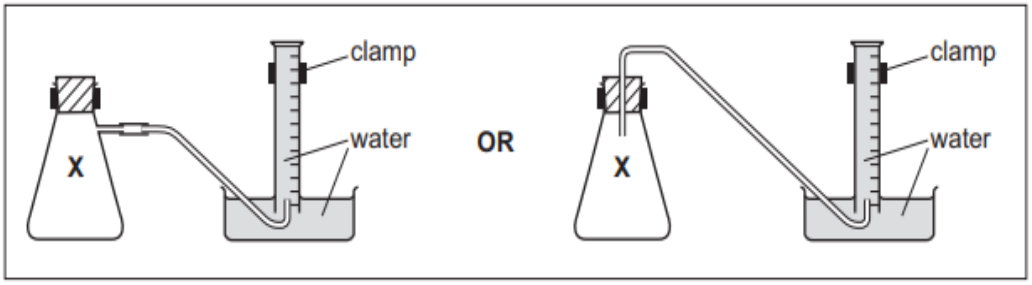
Volume of FA3 added/cm^3	Temperature/°C	ΔT/°C
0.0	26.0	0.0
5.0	29	3.0
10.0	32.0	6.0
15.0	34.0	8.0
20.0	34.0	8.0
25.0	34.0	8.0
30.0	32.0	6.0
35.0	31.0	5.0
40.0	31.0	5.0
45.0	30.0	4.0

For calculations keep the following points in mind:

- ➔ **3 significant figures:** Calculations should be rounded to three significant figures. This means that any digits after the third significant figure should be ignored. For example, the number 25.6 is written with three significant figures, while the number 25.60 is written with four significant figures. The number 25.659 would be rounded to 25.7 when read to three significant figures.
- ➔ **Show your working in calculations:** All of your calculations should be shown in your answers. This will help the examiner to understand how you arrived at your final answer.
- ➔ **Calculations involving enthalpy:** In calculations involving enthalpy, it is important to use the following convention:
    - Exothermic reactions have a negative enthalpy change ($\Delta H < 0$).
    - Endothermic reactions have a positive enthalpy change ($\Delta H > 0$).

Gas Volume Experiments

- ➔ In the paper you might be given an image like this with a set of instructions telling you how to set the apparatus.
- ➔ You have to follow the instruction exactly with a few exceptions and a few tips that are mentioned below:
  - I. You will have to fill a measuring cylinder and invert it in a tub. The instruction will tell you to use a paper towel while inverting but it is not advisable. Instead, roll your sleeves up and use your hands to cover the top of the measuring cylinder and then quickly invert it in the tub of water.



  - II. Then you will set the conical flask accordingly, so that the pipe connected to it is at the entrance of the measuring cylinder (refer to the image above).
  - III. You will then add the given substances to the conical flask and immediately close the bung to prevent the gas from escaping.
  - IV. Since the purpose of the experiment is to find the unknown carbonate/compound, you should measure the volume of gas very carefully. (Measure the volume of water before the addition of substances to the flask and then after)

MOST IMPORTANTLY, read all the instructions carefully before starting and do not miss any measurements as they will be essential for calculations later on.

Salt Analysis

Before starting with this part of the exam keep the following points in mind:

- ➔ **Always write observations by looking at the salt analysis data given at the back of the question paper.** This is important because it ensures that your observations are accurate and consistent with the expected results. The salt analysis data sheet will list the possible observations for each test, along with the cations and anions that would produce those observations. By matching your observations to the data sheet, you can be confident that you are identifying the correct cations and anions in your salt sample.
- ➔ **Find a close match to your observations from the sheet and copy the same wordings of the observations given in the data sheet.** This is important because it ensures that your observations are clear and concise. The data sheet will use specific terminology to describe the different observations, so by copying the same terminology, you can be sure that your observations are easy to understand.
- ➔ **There will be rare cases when you will be unable to find a match.** In that case, write down whatever you see. This is important because it is better to record an accurate observation than to make something up. If you are unable to find a match for your observation, be sure to note that in your lab report.
- ➔ **When you are asked to state certain reagents, always write their proper bench names.** Do not write them as ions, such as H^+ or $Cr_2O_7^{2-}$. Instead, write them as the full chemical names of the bench reagents, such as HCl(aq) or HNO_3(aq) or $K_2Cr_2O_7$.

How to distinguish between Pb2+/Al3+ ions:

- ➔ **NaOH and NH_3** can be used to identify Pb^{2+} and Al^{3+} ions, but they give the same results (observations).
- ➔ **$PbCl_2$, PbI_2, $PbSO_4$, $PbCr_2O_7$, and $PbCrO_4$ are insoluble compounds.** To distinguish between Pb^{2+} and Al^{3+} ions, you can use reagents that contain these compounds, such as HCl, KI, $K_2Cr_2O_7$, etc. The insolubility of these compounds will help you identify the presence of Pb^{2+} ions.
- ➔ Be careful of other precipitates that may interfere with your results. For example, $BaCl_2$ (aq) contains Cl^- ions, which can be used to test for Pb^{2+} ions. However, Ba^{2+} ions can also form precipitates, so it is important to use reagents that contain Na^+, K^+, or H^+ ions. These ions will always form soluble compounds, which will reduce the possibility of other precipitates forming, except for those formed by Pb^{2+} ions.

How to distinguish between Ba^{2+}/NH_4^+:

- ➔ **Ba^{2+} and NH^{4+} ions do not produce a precipitate when treated with NaOH or NH_3.** However, NH_3 gas is produced when NH^{4+} ions are warmed with NaOH. Ba^{2+} ions can be identified by adding H_2SO_4, which will produce a white precipitate.

Tests for Cations:

- ➔ **Mn^{2+}:** Manganese (II) ions can be identified with ammonia or sodium hydroxide. These reagents will produce a white or pale brown precipitate, which will turn brown when exposed to air. The precipitate is insoluble in the reagent, and will form a brown residue on the top and sides of the test tube. A white or light brown precipitate will also form at the bottom of the test tube.

- ➔ **Cu^{2+}: Reaction with NaOH:** A pale blue precipitate forms when copper(II) ions are reacted with sodium hydroxide. The precipitate is insoluble in excess sodium hydroxide. **Reaction with NH_3:** A blue precipitate forms when copper(II) ions are reacted with ammonia. The precipitate dissolves in excess ammonia, forming a dark blue solution. If too much copper(II) ions are present in the test tube, it may be difficult to dissolve the precipitate. In this case, you can either use a small quantity of copper(II) ions or use a lot of ammonia (fill the entire test tube) and shake vigorously to dissolve the precipitate.

Problems with Al^{3+} test with NaOH:

- ➔ The precipitate formed when Al^{3+} ions react with NaOH is very soluble and disappears very quickly. Students may easily miss this precipitate and mistakenly record that no reaction occurred. To avoid this, add a very small amount of NaOH to the test tube at first, just a few drops at a time. Shake the test tube gently after each addition. A small white precipitate will form on the surface of the solution. If you add too much NaOH, the precipitate will dissolve very quickly.

The identification of the other cations and anions can be easily accomplished by referring to the salt analysis notes provided at the end of the paper.

Identification of Anions

Whenever a gas evolves, it will cause bubbles to form in the solution. If you see this happening, place your thumb over the top of the test tube to build up pressure. If there is indeed a gas evolving, the pressure will increase and you will be able to feel it.

- ➔ **CO_3^{2-}:** If you see vigorous effervescence in a test tube that contains an acid or has acid added to it, it is likely that carbon dioxide (CO_2) is evolving. To confirm, you can test the gas with **lime water**, which will turn milky if **CO_2** is present.
- ➔ **SO_3^{2-}**: When a dilute acid is added to SO_3^{2-}, **SO_2** is liberated, which indicates the presence of SO_3^{2-} ions. The test for SO_2 is that it will turn **damp blue litmus paper red**. SO_2 gas also smells like rotten eggs or burnt matches. It can also be distinguished by dipping a paper in $K_2Cr_2O_7$ and then placing it at the mouth of the test tube. The paper will turn from orange to green.
- ➔ **NO_3^-,NO_2^-**: To test for these ions, NaOH is added followed by the addition of Al foil and heat. Now place a damp red litmus paper to the mouth of the test-tube, **NH_3** gas will turn the **damp red litmus paper blue** when it is liberated.

Test for Hydrogen Gas

There are three ways to test for the presence of hydrogen gas.

- ➔ One way is to use a **lighted splint.** If hydrogen gas is present, the splint will ignite with a popping sound.
- ➔ Another way is to use **moistened red litmus paper.** If hydrogen gas is present, the litmus paper will turn blue.
- ➔ And at last, hydrogen gas can also be detected by its **characteristic smell**, which is similar to that of rotten eggs.

Tests for organic compounds

Following reagents are used for testing organic compounds:

- ➔ **Tollens reagent** is made by mixing silver nitrate ($AgNO_3$) and ammonia (NH_3). It reacts with **aldehydes** to form a silver mirror. In some cases, the silver mirror may not be visible, but a black precipitate will still form. This black precipitate is sufficient to test for the presence of an aldehyde.
- ➔ **Fehling solution** is a mixture of copper(II) sulphate ($CuSO_4$), potassium hydroxide (KOH), and sodium hydroxide (NaOH). It is used to test for the presence of **aldehydes**. When an aldehyde is added to the Fehling solution and heated lightly, a red/brown precipitate of copper(I) oxide (Cu_2O) is formed. This precipitate is a positive indication of the presence of an aldehyde.
- ➔ **2,4-Dinitrophenylhydrazine (2,4-DNPH):** The colour of the precipitate formed when (2,4-DNPH) is added to a **carbonyl compound** can be used to determine the type of carbonyl compound. **Ketones** form orange precipitates, while aldehydes form yellow precipitates.
- ➔ **Sodium Carbonate (Na_2CO_3):** If you add sodium carbonate (Na_2CO_3) to a substance and observe vigorous effervescence, then the substance is likely a **carboxylic acid**.
- ➔ **Potassium DiChromate:** When potassium dichromate ($K_2Cr_2O_7$) is added to **alcohols or aldehydes**, it will turn from orange to green. However, the colour change is only visible when the mixture is gently heated. If the mixture is heated too strongly, the alcohols or aldehydes will evaporate and the test will not be valid. Additionally, do not add too much potassium dichromate, as this will also result in a mixture of green and orange colours that may be difficult to distinguish.
- ➔ **Potassium Manganate (VII) ($KMnO_4$)** is added to a solution and then warmed in a water bath, the purple colour of the solution will disappear if it contains an **aldehyde or alcohol.**

Recording Data and Observations

- ➔ Present data/observations neatly in a table with proper headings and units.
- ➔ Record raw readings of a quantity to the same degree of precision. For example if raw reading is given as 0.08g you will collect the mass in nearest 0.01g.
- ➔ Record observations with a lot of detail. For example colours should be described as dark blue or pale yellow. You can also draw comparisons such as 'the brown fumes were darker after 2 minutes'
- ➔ You may use abbreviations such as ΔH (enthalpy change) or ppt(precipitate).
- ➔ Have a consistent number of significant figures and decimal places when recording data. For instance temperature will always be measured in 2 decimal places (So every temperature reading must have 2 decimal places).

Graphs

- ➔ First of all read the question carefully, this is very important.
- ➔ Draw your axis and label them (question mentions the x axis and y axis labelling) and also Mention the units of quantity.
- ➔ Decide a suitable scale for your graph and it would be better if it's a factor of 2.5 and 10.
- ➔ Also it's not important to start a graph with zero,it can start with another number too.
- ➔ Be careful while plotting,keep in mind that the plotted point should be smaller than the small box.
- ➔ Cover more than 50 percent of the graph paper.
- ➔ For line of best fit;keep in mind that it should be average of all values
- ➔ Scattering of point must be even
- ➔ Number of points above and below the line of best fit must be the same
- ➔ All the points must be plotted and if there's any anomalous point,encircle it and mention that it is an anomaly.
- ➔ When calculating gradient,keep in mind to draw a triangle for the points you're considering to take gradient of.

Errors and Improvements

- Error in mass and volume reading:

- ➔ Use larger mass
- ➔ Use balance with more decimal places
- ➔ Use a precisely calibrated burette

-Error when gas escape before bung can be inserted:

- ➔ Use syringe/dropping funnel for the chemicals and subtract initial volume from final volume
- ➔ Arrange marble chip in flask so mixing is carried out after bung is replaced
- ➔ Use larger lump of solid

-Error when heating is not complete:

- ➔ Repeat heating until constant mass obtained

-Error when carbon dioxide is dissolved in water:

- ➔ Use a substance in which carbon dioxide is insoluble (oil)

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A Note from Mojza

This resource for Chemistry (9701) has been prepared by Team Mojza, covering the content for AS Level 2022-24 syllabus. The content of this resource has been prepared with utmost care. We apologise for any issues overlooked; factual, grammatical or otherwise. We hope that you benefit from these and find them useful towards achieving your goals for your Cambridge examinations.

If you find any issues within these notes or have any feedback, please contact us at support@mojza.org.

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