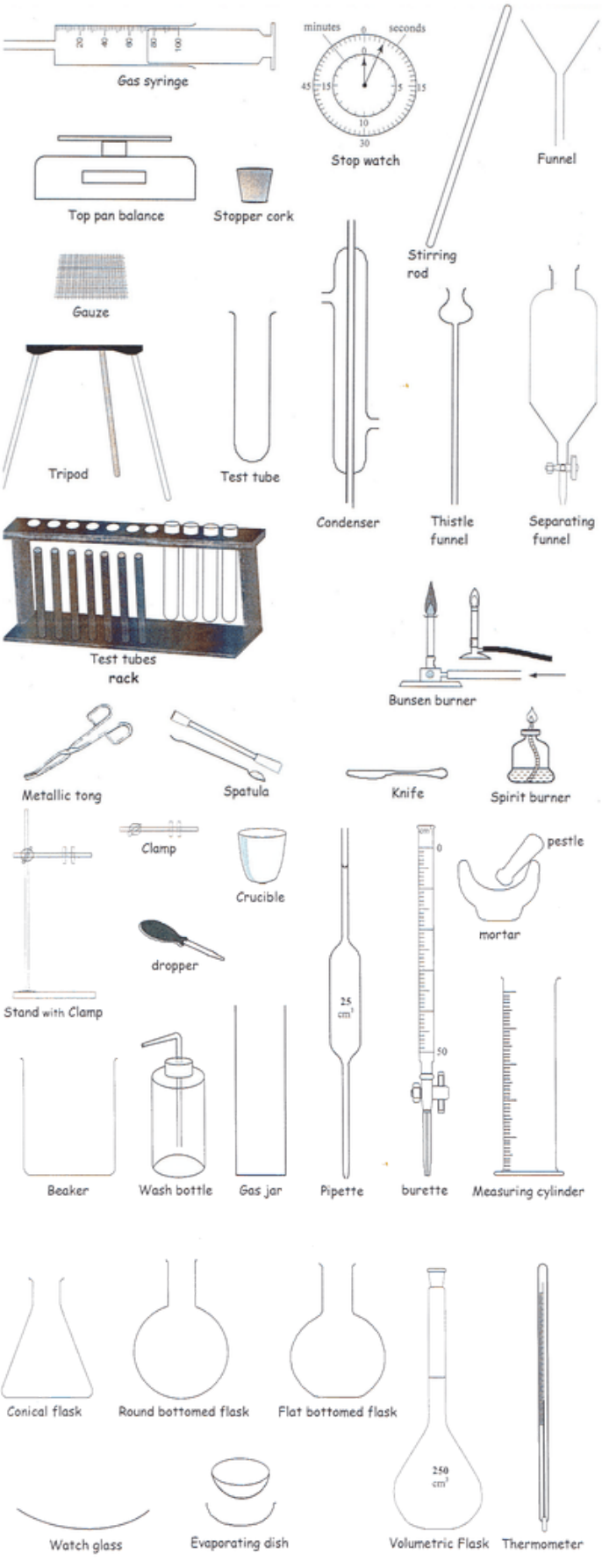
ZNOTES.ORG

UPDATED TO 2023-25 SYLLABUS

# CAIE IGCSE CHEMISTRY

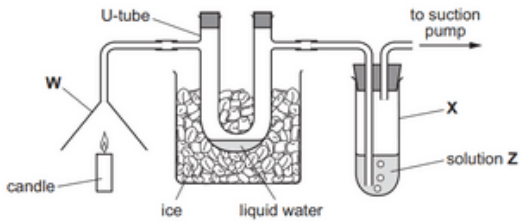
SUMMARIZED NOTES ON THE ALTERNATIVE TO PRACTICAL SYLLABUS

# 1. General Apparatus



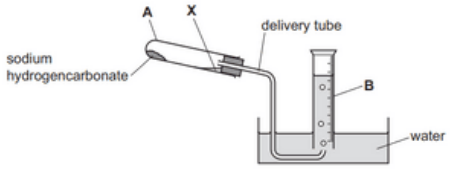

## 1.2. Apparatus in Past Paper Question

Here are samples of 2022 Questions about Labelling Apparatus

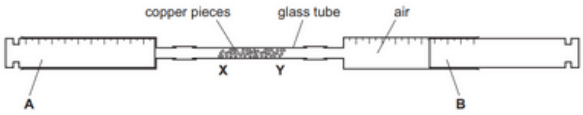



1. Apparatus W is **Filter Funnel**

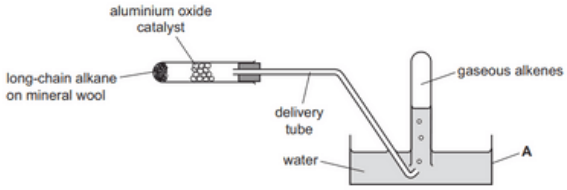
2. Apparatus X: **Boiling Tube/Test Tube**




3. Apparatus A: **Test Tube/Boiling Tube**
4. Apparatus B: **Measuring Cylinder**



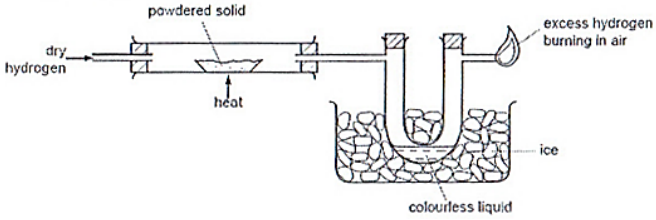

5. Apparatus B is a **Gas Syringe**



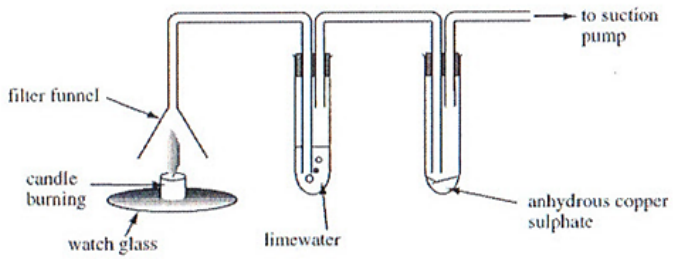

6. Apparatus A is a **water bath/trough.**

# 2. Experiments

- Reducing Copper(III) Oxide to Copper

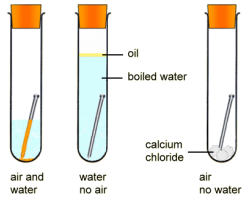



- Testing products of combustion:

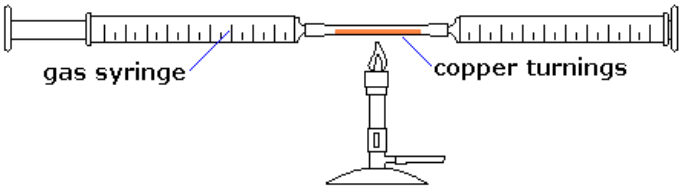


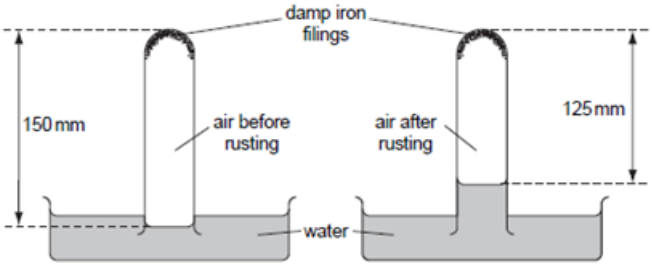

## 2.2. Experiments

- Showing that oxygen and water is needed for rusting iron




- Showing that air is 21% Oxygen

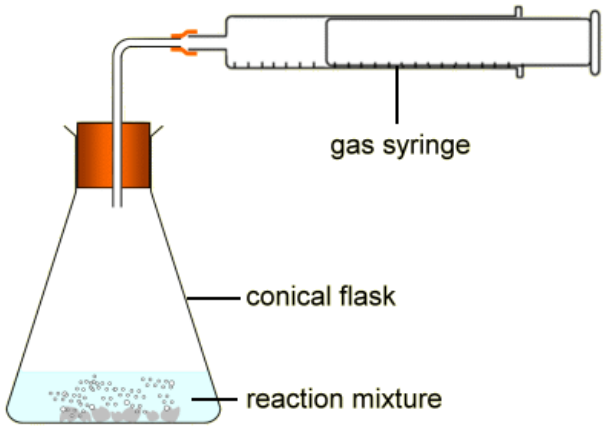


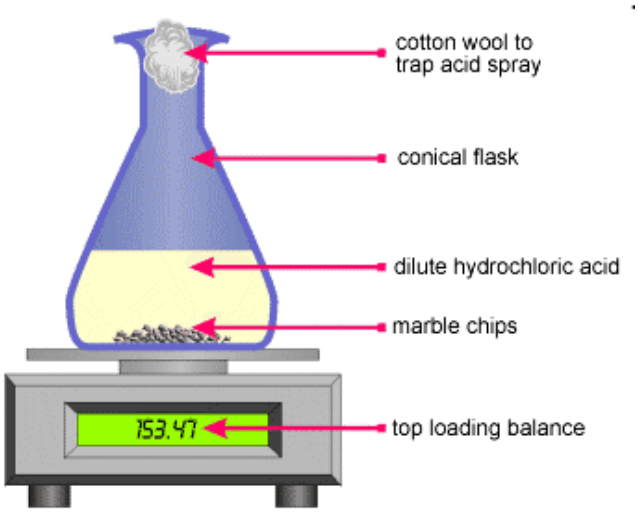




# 3. Rates of Reaction

## 3.1. Testing factors affecting rate of reaction

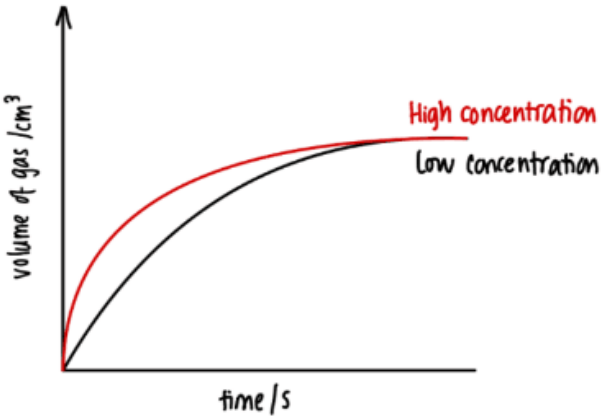
- Different temperature acid
- Different size of particle/reactant
- Concentration of acid



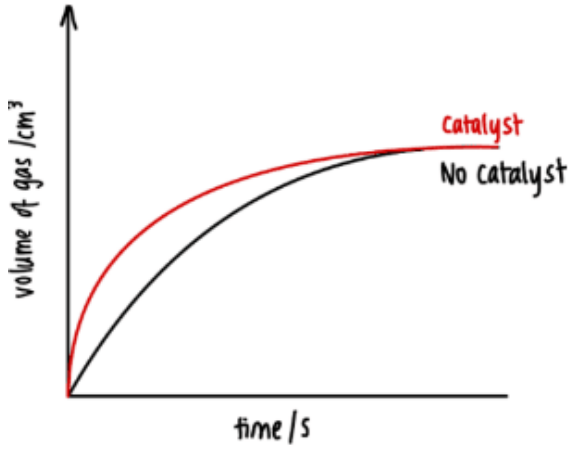




## Rate of Reaction Graphs

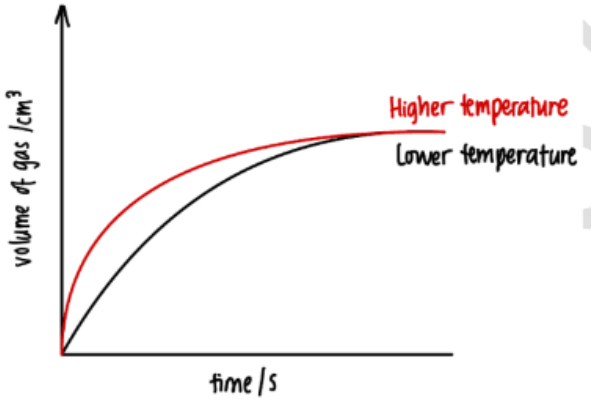
1. Concentration



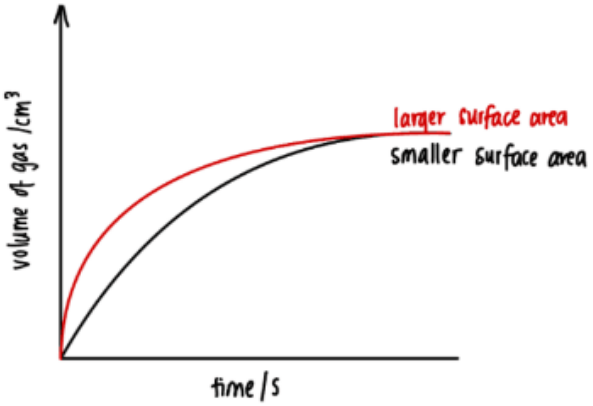
2. Catalyst




3. Temperature

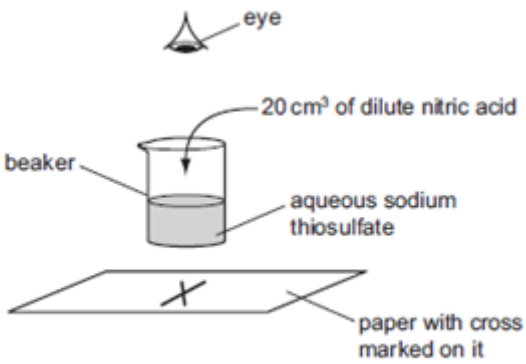



4. Surface Area



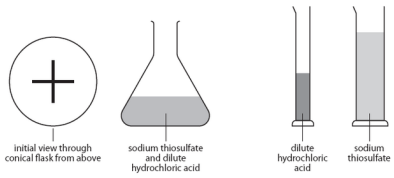

## 3.2. Timing

- Time how long it takes for the cross to disappear from view
- You can change the temperature and concentration of acid used




## 3.3. Constant Variables:

- Diameter of beaker
- The Cross
- Volume




# 4. # Planning Investigation

The Planning Investigation (6 marks) is one of the key highlights of the IGCSE Chemistry: Alternative to Practical and it is definitely possible to achieve full marks in this question. Unlike IGCSE Biology & Physics, Chemistry requires a detailed step to step process in planning your investigation.

1. Independent Variable: The variable you will change
2. Dependent Variable: The variable you will measure.
3. Control Variable: Variables that you will keep the same.

**Key things which helps to guide your response:**

- If large lumps, you must state "use a pestle and mortar to crush". This will get you 2 marks.
- Stating the apparatus + exact volume/mass + name of chemical/substance, always!
  - E.g. Use a measuring cylinder to measure 50cm3 of hydrochloric acid
- Draw a labelled diagram (even if it doesn't directly tell you to do this)
  - You may also get some marks from labels
- State the type of experiment you will carry out (e.g. chromatography/crystallisation)

**Example Question:**

Cadmium, cobalt and vanadium are all metals. They react with dilute hydrochloric acid to form hydrogen gas. These reactions are exothermic.

Plan an investigation to find the order of reactivity of the three metals.

Your plan must make it clear how your investigation will be a fair test and how you will use your results to place the metals in order of reactivity.

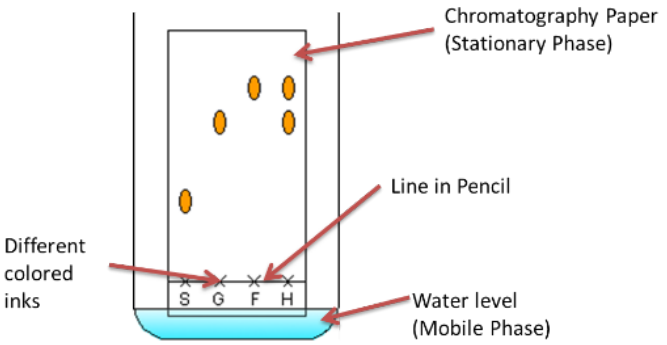
You are provided with powdered samples of each metal, dilute hydrochloric acid and common laboratory apparatus.

**Full 6 marks response:**

Prepare all the apparatus needed for this investigation. Weigh the same mass of the Cadmium metal and placed it in a beaker. Add 30cm^3 of dilute hydrochloric acid in to the beaker, where its concentration remains the same. Observe the reaction in a set time of 2 minutes and record the gas produced using a gas syringe connected. Repeat the investigation using Cobalt and Vanadium. An a conclusion can be made by comparing the which metal produces the largest gas volume produced and placed it accordingly from least reactive to most reactive.

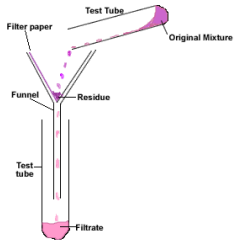
# 5. Chromatography

- **Principle: Difference in solubility separates different pigments**
  - Drop substance to center of filter paper and allow it to dry
  - Drop water on substance, one drop at a time
  - Paper + rings = chromatogram.
- **Stationary phase:** material on which the separation takes place
- **Mobile phase:** mixture you want to separate, dissolved in a solvent (water or ethanol)
- **Interpreting simple chromatograms:**
  - Number of rings/dots = number of substances
  - If two dots travel the same distance up the paper they are the same substance.
  - Pure substance only shows one dot on the chromatogram.
- You can calculate the Rf value to identify a substance, given by the formula:
- $Rf\ Value = \frac{\text{Distance moved by solute}}{\text{Distance moved by solvent}}$
- To make colorless substances visible
  - Dry chromatogram in an oven
  - Spray it with a locating agent
  - Heat it for 10 minutes in the oven

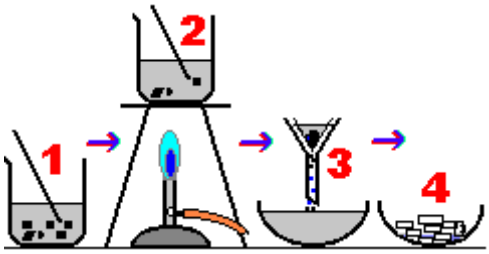



# 6. Separation Techniques

- **Filtration**
  - Mixture goes in a funnel with filter paper, into a flask.
  - Residue is insoluble and filtrate goes through




- **Crystallization**
  - Some water in the solution is evaporated so solution becomes more concentrated.
  - Solution is left to cool and crystallise (**solubility decreases as temperature decreases**)
  - Crystals are filtered to remove solvent.

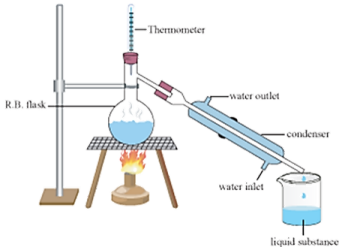



**Question: How can we obtain pure dry crystals from the filtrate?**

1. Pour the filtrate in the evaporating basin and heat
2. Leave to evaporate and let it cool to crystallisation point
3. Wash the crystals with distilled water
4. Dry it between the filter paper.

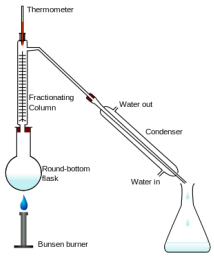
## 6.2. Simple distillation:

- Impure liquid is heated
- It boils, and steam rises into the condenser
- Impurities are left behind
- Condenser is cold so steam condenses to the pure liquid and it drops into the beaker



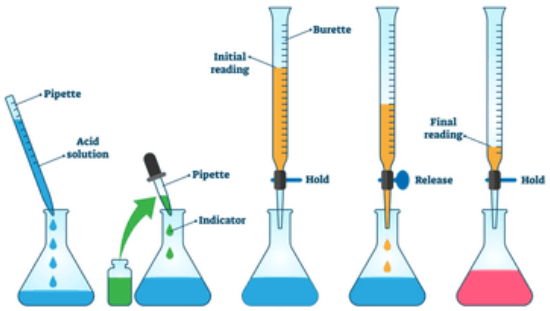

## 6.3. Fractional distillation:

- Removes a liquid from a mixture of liquids, because liquids have different b.p.s
- Mixture is heated to evaporate substance with lowest b.p.
- some of the other liquid(s) will evaporate too.
- Beads are heated to boiling point of lowest substance, so that substance being removed cannot condense on beads.
- Other substances continue to condense and will drip back into the flask
- The beaker can be changed after every fraction.
- The thermometer is placed on the top to **measure the temperature of the vapour instead of the liquid**




## 6.4. Acid-Base Titration

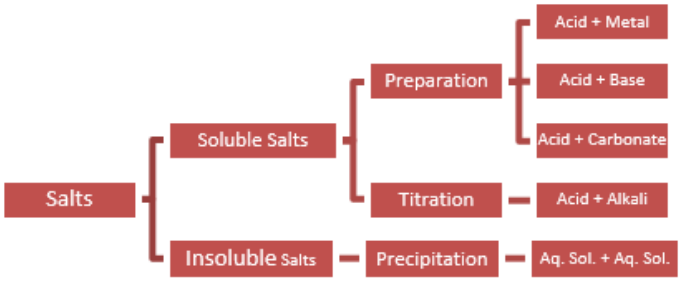
1. Place known volume of alkali using volumetric pipette into a conical flask
2. Add indicator (e.g. thymolphthalein)
3. Titration: add acid using burette until end point has reached
4. Record volume of acid added
5. Repeat without indicator
6. Transfer to evaporating basin
7. Heat with bunsen burner
8. Leave to cool to crystallisation point
9. Wash crystals with distilled water
10. Dry crystals on filter paper




## 6.5. Choosing a suitable method:

| Method of separation | Used to separate |
|---|---|
| Filtration | A solid from a liquid |
| Evaporation | A solid from a solution |
| Crystallization | A solid from a solution |
| Simple Distillation | A solvent from a solution |
| Fractional Distillation | Liquids from each other |
| Chromatography | Different substances from a solution |

# 7. Making Salts




## 7.1. Starting with a metal:

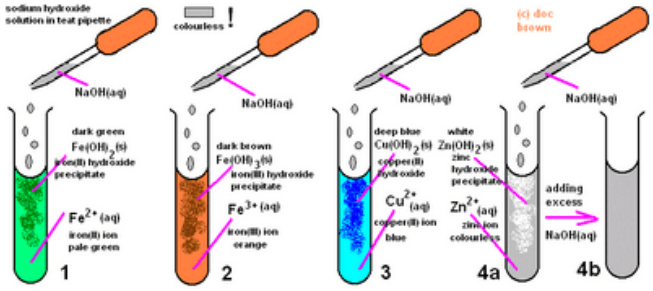
1. Warm acid (increases speed of reaction)
2. Add excess of reactant + stir
3. Filter mixture
4. Transfer to evaporating basin
5. Heat using bunsen burner
6. Leave to cool to crystallisation point
7. Wash crystals with distilled water
8. Dry crystals on filter paper

## Starting with an insoluble base:

- Add insoluble base to acid and heat gently, it will dissolve
- Keep adding until no more dissolves (reaction is done)
- Filter out the insoluble (excess) base

## 7.2. Precipitation:

- Mix the two soluble salts, so they react together
- Filter the mixture to separate the products produced (soluble and insoluble salt produced)
- Wash the insoluble salt on the filter paper
- Dry the insoluble salt between the filter paper




# 8. Salts and Indicators

## 8.1. Solubility of salts

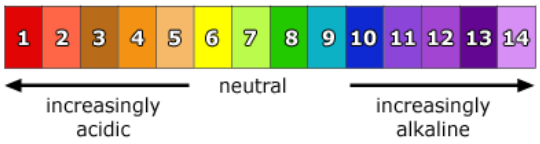
| Soluble Salts | Insoluble Salts |
|---|---|
| All sodium, potassium and ammonium salts | None |
| All nitrates | None |
| Chlorides | Except silver and lead |

| Soluble Salts | Insoluble Salts |
|---|---|
| Sulphates | Except barium, lead and calcium |
| Potassium, sodium and ammonium carbonates | All other carbonates |
| Sodium, potassium and ammonium hydroxides | Nearly all hydroxides |

## 8.2. Indicators:

| Indicators | Color in acid | Color in alkaline |
|---|---|---|
| Thymolphthalein | Colorless | Blue |
| Methyl orange | Red | Yellow |
| Litmus Paper | Red | Blue |
| Universal Indicator | Red | Blue |

## 8.3. pH Scale:




## 8.4. Colours of Transition Metal Compound

| Metal Compounds | Colour |
|---|---|
| Copper (II) Sulfate | Blue |
| Copper (II) Oxide | Black |
| Copper (II) Carbonate | Green |
| Manganese (IV) Oxide | Black |
| Iron (II) Salts | Pale Green |
| Iron (III) Salts | Brown or Orange |

# 9. Test for Anions and Cations

In the 2023-2025 syllabus, the Cation and Anion Test are ONLY given in Paper 5 & 6!

## 9.1. Cations Test

| Cation | Sodium Hydroxide | Ammonia |
|---|---|---|
| Aluminum ($Al^{3+}$) | Soluble white ppt, gives colourless solution | White ppt, insoluble in excess |
| Ammonium ($NH_4^+$) | Ammonia gas - damp red litmus turns blue | N/A |
| Calcium ($Ca^{2+}$) | White ppt, Insoluble in excess | No ppt. |
| Chromium ($Cr^{3+}$) | Green ppt, soluble in excess | Green ppt, insoluble in excess |
| Copper ($Cu^{2+}$) | Light blue ppt, Insoluble in excess | Light blue, soluble ppt, giving dark blue |
| Iron(II) ($Fe^{2+}$) | Green ppt, Insoluble in excess, turns brown near surface | Green ppt, Insoluble in excess, turns brown near surface |
| Iron(III) ($Fe^{3+}$) | Red-brown ppt, insoluble | Red-brown ppt, insoluble |
| Zinc ($Zn^{2+}$) | White soluble ppt, giving colourless solution | White soluble ppt, giving colourless solution |

## Anions Test

| Anion | Test | Test result |
|---|---|---|
| Carbonate ($CO_3^{2-}$) | Add dilute nitric acid | Limewater goes cloudy |
| Chloride ($Cl^-$) | Add nitric acid, then aqueous silver nitrate | White ppt. |
| Bromide ($Br^-$) | | Cream ppt. |
| Iodide ($I^-$) | | Yellow ppt. |
| Nitrate ($NO_3^-$) | Add aqueous sodium hydroxide then add aluminum | Ammonia gas produced turns damp red litmus paper blue |
| Sulfate ($SO_4^{2-}$) | Add nitric acid, then add aqueous barium nitrate | White ppt. |
| Sulfite ($SO_3^{2-}$) | Add acidified aqueous potassium manganate (VII) | Purple to colourless. |

# 10. Harder Ion Testing Question

In this question, even though the Cation and Anion Tests are given at the back of the paper. Some questions maybe unfamiliar to you. If you have cross checked multiple times, and still it doesn't show, it might be a "no reaction" answer.

3 A student tests two solutions: solution **C** and solution **D**.

**Tests on solution C**

Solution **C** is aqueous calcium nitrate.

Complete the expected observations.

The student divides solution **C** into three portions.

**(a)** The student carries out a flame test on the first portion of solution **C**.

observations ..... [1]

**(b)** To the second portion of solution **C**, the student adds aqueous sodium hydroxide dropwise until it is in excess.

observations adding dropwise .....

observations in excess .....

[2]

**(c)** To the product from **(b)**, the student adds a piece of aluminium foil and warms the mixture gently. Any gas produced is tested.

observations .....

..... [1]

**(d)** To the third portion of solution **C**, the student adds about 1 cm depth of dilute nitric acid followed by a few drops of aqueous silver nitrate.

observations .....

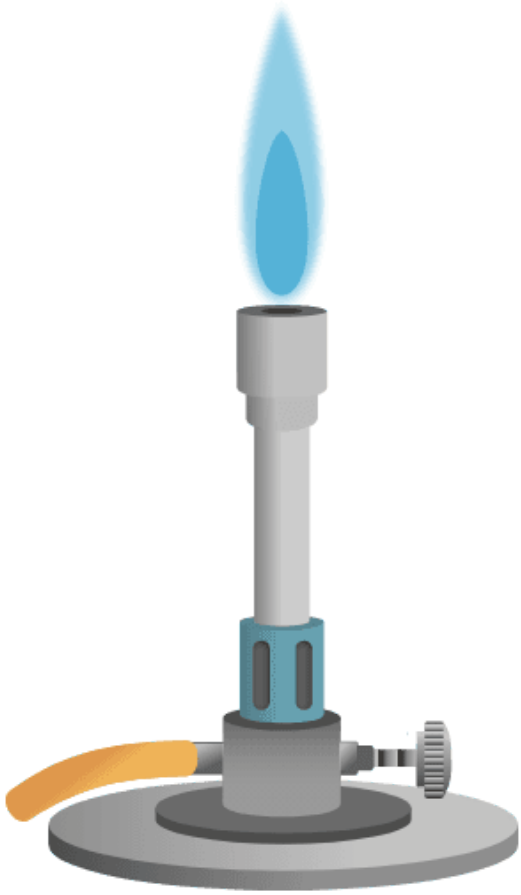
..... [1]

1. If nothing happens (i.e. there is no reaction), put "No Change"
2. If it says "condensation forms on the side of the test tube", it is hydrated
3. If a solid is coloured, it is a transition metal
4. If it is non-transition metal, it is a white solid OR colourless solution
5. When the liquid was touched with a lighted splint, it burns with a blue flame, it is an organic fuel (flammable)

# 11. Flame Tests For Metal Ions

- **Lithium** = Red
- **Sodium** = Yellow
- **Potassium** = Lilac
- **Calcium =** Orange-Red
- **Barium** = Light Green
- **Copper (II)** = Blue Green

## 11.2. Process of Flame Testing



- Dip the **unreactive** metal wire into concentrated acid, and then hold it in the blue flame of a Bunsen burner until there is no colour change
- Dip the loop into the solid sample and place it in the edge of the **blue** Bunsen flame
- Observe the flame colour and record it down.

1. **How is the Bunsen burner adjusted to give a very hot flame?**

By opening the air hole to increase air supply.

# 12. Gas & Other Tests

In the 2023-2025 syllabus, the Gas Test is **ONLY** given in Paper 5 & 6.

| Gas | Test and test result |
|---|---|
| Ammonia ($NH_3$) | Damp red litmus paper turns blue |
| Carbon dioxide ($CO_2$) | Bubble gas through limewater - from colourless to cloudy |
| Chlorine ($Cl_2$) | Bleaches red/blue litmus paper |
| Hydrogen ($H_2$) | Place lighted splint, squeaky pop |
| Oxygen ($O_2$) | Place glowing splint, splint relights |

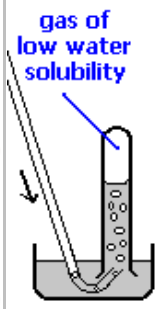
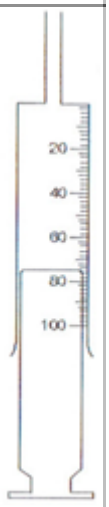
| Gas | Test and test result |
|---|---|
| Sulfur Dioxide ($SO_2$) | Turns Acidified Aqueous Potassium Manganate (VII) from purple to colourless |

| Substance | Test and test result |
|---|---|
| Water | White anhydrous copper (II) sulphate turns blue |
| | Anhydrous cobalt (II) chloride turns pink |
| Alkene | Add to bromine water; from orange to colourless |
| Alkane | Add to bromine water; remains orange |
| Acid | Blue litmus paper turns red |
| | Add a metal carbonate; bubbles of $CO_2$ |
| Base | Red litmus paper turns blue |

# 13. # Common Errors and Improvements

| Errors | Improvements |
|---|---|
| No Repeats | Repeat Three Times |
| Different Colour Changes | Use a colorimeter |
| The measuring cylinder is inaccurate | Use a burette because it is more accurate |
| Adding past endpoint | Add volume in smaller quantities |
| Temperature/Heat Loss | Use a thermostatically controlled water bath |
| Same measuring cylinder used in multiple investigations | Use different measuring cylinders |

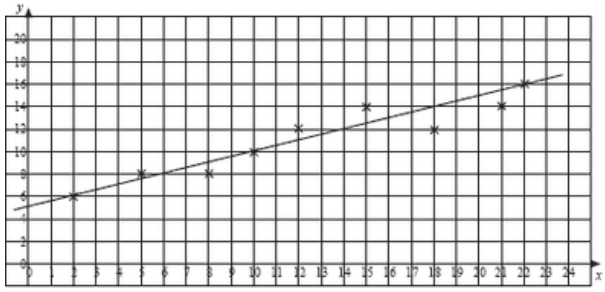
# 14. Collecting Gases

| Method | Downward Delivery | Upward Delivery | Collection Over water | Gas syringe |
|---|---|---|---|---|
| Use when... | Gas more dense than air | Gas less dense than air | Gas is sparingly soluble in water | To measure the volume |
| Apparatus |  |  |   |   |
| Examples | Carbon-dioxide, chlorine, sulfur dioxide, hydrogen chloride | Ammonia, hydrogen | Carbon dioxide, hydrogen, oxygen | Any gas |

# 15. # Drawing Graphs

Drawing Graphs in IGCSE Sciences is such an important skill as it is worth full of free marks up for grabs in these questions. Here are the rules and requirements to earn the full mark.

1. Use a sharp pencil
2. Label both axes with units (IV on x-axis, DV on y-axis)
3. Labels should be in the form "quantity/units"
4. Choose appropriate scale
5. Use crosses "x" to mark the data points (for scatter graphs)
6. Graph should cover at least half the grid
7. Include an appropriate title
8. Include a line of best fit
9. Circle anomalous results



**Common Question: Why does the graph level off?**
The reaction is finished and ALL of the [named reactant] has reacted
**Common Question: Why must the graph line past through (0,0)?**

It is because when no [named reactant] is added, there is no reaction

# 16. # General Information on Tables and Graphs

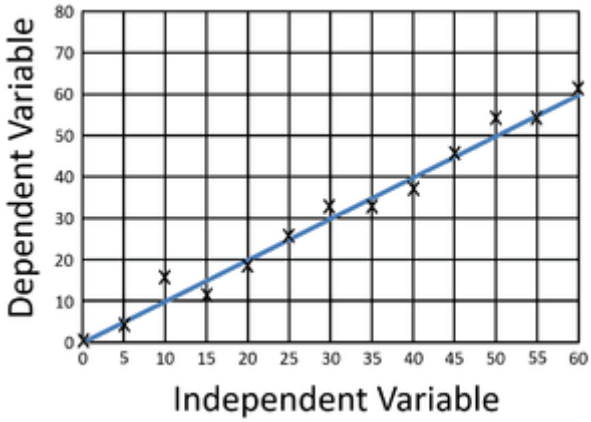
This applies to the **Biology, Chemistry and Physics: Practical/Alternative to Practical (Paper 5 & 6)**. Scheme through the requirements CIE wants from candidates in tabulating data.

## 16.1. Tables

• Each column of a table should be headed with the physical quantity and the appropriate units.
• The column headings of the table can be directly transferred to the axes of a constructed graph.

## 16.2. Graphs

• Unless instructed otherwise, the independent variable **should be plotted on the x-axis** (horizontal axis) and the dependent variable **plotted on the y-axis** (vertical axis).
• Each axis should be labelled with the physical quantity and the appropriate unit, e.g. time / s.
• Unless otherwise instructed the scales for the axes should allow more than half of the graph grid to be used in both directions, and be based on sensible ratios, e.g. 2 cm on the graph grid representing 1, 2 or 5 units of the variable.
• The graph is the whole diagrammatic presentation, including the best-fit line when appropriate. It may have one or more sets of data plotted on it.
• Points on the graph should be clearly marked as **crosses (×)** or **encircled dots (⊙)**.
• Large 'dots' are **penalised**. Each data point should be plotted to an **accuracy of better than one half** of each of the smallest squares on the grid.
• A best-fit line (trend line) should be a **single, thin, smooth straight line or curve**. The line does not need to coincide exactly with any of the points; where there is scatter evident in the data, Examiners would expect a roughly even distribution of points either side of the line over its entire length. Points that are clearly anomalous should be ignored when drawing the best-fit line.




## 16.3. Numerical Results

• Data should be recorded so as to reflect the precision of the measuring instrument.
• The number of significant figures given for calculated quantities should be appropriate to the least number of significant figures in the raw data used.

Table 2.1

| experiment | mass of ammonium chloride / g | total volume of water / cm³ | thermometer diagram when a solid starts to form | temperature when a solid starts to form / °C |
|---|---|---|---|---|
| 1 | | 8.0 |  | |
| 2 | | |  | |
| 3 | | |  | |
| 4 | | |  | |
| 5 | | |  | |

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## Chemistry