IGCSE CHEMISTRY 0620 · NIGHT-BEFORE SHEET · ~13 MIN READ

# Chemistry Facts, Equations & Tests

Every test and colour, the mole calculations, key equations, industrial processes and the reactivity series on one sheet. Learn the tests word for word, because examiners mark the exact observation.

Tests | Colours | Moles | Equations | Electrolysis | Industry | Organic

RS by Riyaz Sir
mentorriyaz.in

No tag = **Core** (everyone) EXTENDED Extended only highlight = comes up again and again
HANDY worth memorising Test yourself at the end

## IN 30 SECONDS

- **Tests are worth easy marks** if you write the reagent, the observation and the colour change. "Limewater turns milky" scores. "It goes cloudy" often does not.
- **Mole calculations** all start with n = m ÷ Mr. Turn everything into moles first, use the equation ratio, then turn the answer back into grams, $dm^3$ or concentration.
- **Know the conditions** for the Haber and Contact processes, the extraction of iron and aluminium, and what is made at each electrode.

## 1 Tests to learn word for word

### Tests for gases

| Gas | Test | Positive result |
|---|---|---|
| Hydrogen, $H_2$ | lighted splint | squeaky pop |
| Oxygen, $O_2$ | glowing splint | relights |
| Carbon dioxide, $CO_2$ | bubble through limewater | turns milky |
| Ammonia, $NH_3$ | damp red litmus paper | turns blue |
| Chlorine, $Cl_2$ | damp litmus paper | bleached white |
| Sulfur dioxide, $SO_2$ | acidified aqueous potassium manganate(VII) | purple to colourless |

- **Water:** anhydrous copper(II) sulfate turns white to blue. Anhydrous cobalt(II) chloride turns blue to pink.
- **Unsaturated compound (alkene):** bromine water turns from orange to colourless.

## Tests for cations and flame colours

### Hydroxide precipitates



| | $Cu^{2+}$ | $Fe^{2+}$ | $Fe^{3+}$ | $Zn^{2+}$ | $Al^{3+}$ | $Ca^{2+}$ |
|---|---|---|---|---|---|---|
| **colour** | light blue | green | red-brown | white | white | white |
| **excess** NaOH | no change | no change | no change | **dissolves** | **dissolves** | no change |
| **excess** $NH_3(aq)$ | **dissolves** | no change | no change | **dissolves** | no change | no ppt |

### Flame tests



| $Li^+$ | $Na^+$ | $K^+$ | $Ca^{2+}$ | $Cu^{2+}$ |
|---|---|---|---|---|
| red | yellow | lilac | orange-red | blue-green |

**Silver nitrate (with nitric acid): $Cl^-$ white · $Br^-$ cream · $I^-$ yellow precipitate**

Add NaOH(aq) a drop at a time and then in excess. Note the colour of the precipitate and whether it dissolves.

- **Ammonium, $NH_4^+$:** add NaOH(aq) and warm gently. Ammonia gas is given off and turns damp red litmus blue.
- **Zinc or aluminium?** Both give a white precipitate that dissolves in excess NaOH. Use $NH_3(aq)$: the zinc precipitate dissolves in excess, but the aluminium one does not.
- **Copper(II) with excess ammonia:** the light blue precipitate dissolves to give a deep blue solution.
- **Flame tests:** use a clean nichrome wire or splint. Say the colour of the flame, not just "it burns".

## Tests for anions

| Ion | Test | Positive result |
|---|---|---|
| Carbonate, $CO_3^{2-}$ | add dilute acid | fizzing, gas turns limewater milky |
| Chloride, $Cl^-$ | dilute nitric acid, then silver nitrate | white precipitate |
| Bromide, $Br^-$ | dilute nitric acid, then silver nitrate | cream precipitate |
| Iodide, $I^-$ | dilute nitric acid, then silver nitrate | yellow precipitate |
| Sulfate, $SO_4^{2-}$ | dilute nitric acid, then barium nitrate | white precipitate |
| Nitrate, $NO_3^-$ | NaOH(aq) and aluminium foil, warm | ammonia gas (turns damp red litmus blue) |

- **Why acidify first?** Dilute nitric acid removes carbonate ions, which would give a false white precipitate with silver or barium ions.

Riyaz Sir

### Indicators and pH

| pH | Universal indicator colour | Type |
|---|---|---|
| 0 to 2 | red | strong acid |
| 3 to 6 | orange to yellow | weak acid |
| 7 | green | neutral |
| 8 to 11 | blue | weak alkali |
| 12 to 14 | purple | strong alkali |

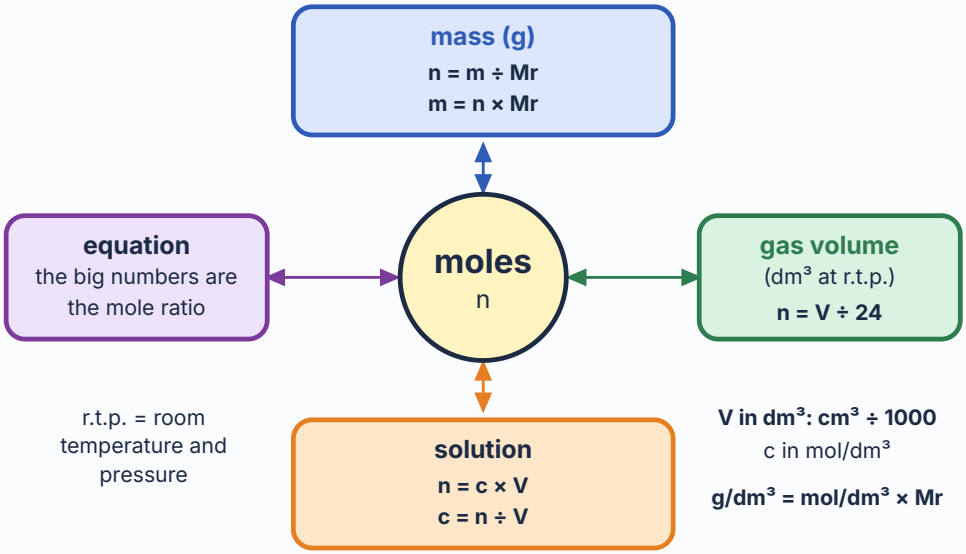
- **Litmus:** red in acid, blue in alkali. **Methyl orange:** red in acid, yellow in alkali. **Phenolphthalein:** colourless in acid, pink in alkali.

EXAM TIP

**Write the reagent AND the observation AND the colour change.** "Limewater turns milky" scores, but "it goes cloudy" often does not.

## 2 Moles and calculations

### Mole map




Moles are the bridge. Mass, gas volume and concentration all convert to moles, and the equation gives the ratio between substances.

$$n = \frac{m}{Mr}$$

m in grams, Mr = relative formula mass

$$n = \frac{V}{24}$$

V in dm³ for a gas at room temperature and pressure

$$n = c \times V$$

c in mol/dm³ and V in dm³. Divide cm³ by 1000

$$\text{percentage yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

always less than 100%

$$\text{percentage purity} = \frac{\text{mass of pure substance}}{\text{total mass of sample}} \times 100$$

- **Empirical formula** EXT : divide each mass (or percentage) by its Ar, divide by the smallest answer, then make whole numbers.
- **Limiting reactant:** the substance that runs out first decides how much product forms.

WORKED EXAMPLE

**Calculate the mass of 0.25 mol of calcium carbonate, $CaCO_3$ (Ar: Ca 40, C 12, O 16).**

1. Mr = 40 + 12 + (3 × 16) = 100
2. **mass = n × Mr = 0.25 × 100 = 25 g**

WORKED EXAMPLE

**What volume of carbon dioxide at room temperature and pressure forms when 5.0 g of calcium carbonate reacts with excess acid? $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$**

1. $n(CaCO_3) = 5.0 \div 100 = 0.05$ mol
2. ratio 1 : 1 so $n(CO_2) = 0.05$ mol
3. **$V = 0.05 \times 24 = 1.2$ dm³**

WORKED EXAMPLE

**4.0 g of sodium hydroxide is dissolved to make 500 cm³ of solution. Find the concentration in mol/dm³.**

1. Mr(NaOH) = 23 + 16 + 1 = 40
2. n = 4.0 ÷ 40 = 0.10 mol
3. V = 500 ÷ 1000 = 0.50 dm³
4. **c = 0.10 ÷ 0.50 = 0.20 mol/dm³**

WORKED EXAMPLE

**25.0 cm³ of 0.100 mol/dm³ NaOH is neutralised by 20.0 cm³ of hydrochloric acid, HCl. Find the concentration of the acid.**

1. n(NaOH) = 0.100 × 0.0250 = 0.00250 mol
2. $NaOH + HCl \rightarrow NaCl + H_2O$, ratio 1 : 1, so n(HCl) = 0.00250 mol
3. **c(HCl) = 0.00250 ÷ 0.0200 = 0.125 mol/dm³**

WORKED EXAMPLE

**Find the mass of magnesium needed to make 10 g of magnesium oxide. $2Mg + O_2 \rightarrow 2MgO$ (Ar: Mg 24, O 16)**

1. Mr(MgO) = 24 + 16 = 40
2. n(MgO) = 10 ÷ 40 = 0.25 mol
3. ratio 2 : 2 so n(Mg) = 0.25 mol
4. **mass = 0.25 × 24 = 6.0 g**

WORKED EXAMPLE

**The theoretical yield of a product is 10.0 g but only 8.0 g is collected. Find the percentage yield.**

1. **percentage yield = 8.0 ÷ 10.0 × 100 = 80%**

COMMON MISTAKE

Using **cm³ instead of dm³** in n = c × V. Divide the volume in cm³ by 1000 first.

COMMON MISTAKE

Using the **mass ratio** from the equation. The numbers in an equation are **mole** ratios.

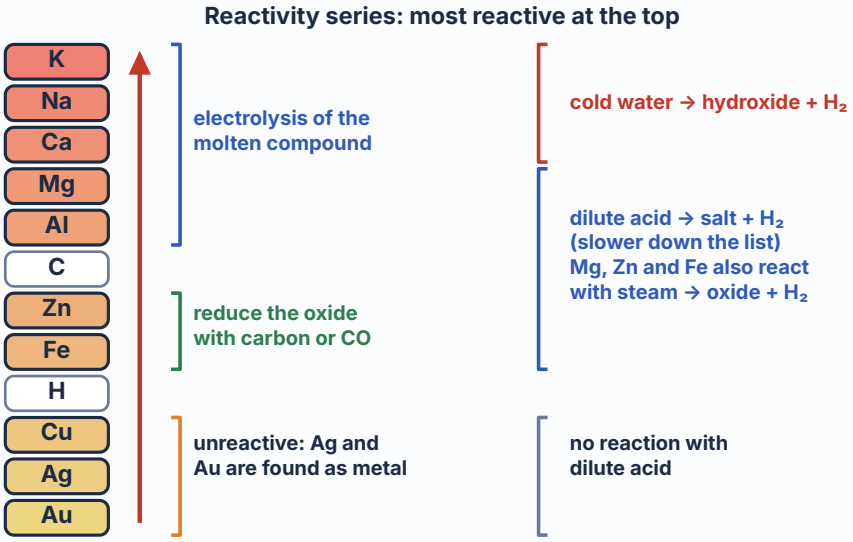
## 3 Equations to know

### Reactions and half-equations

- **Acid + metal** → salt + hydrogen. **Acid + base** → salt + water. **Acid + carbonate** → salt + water + carbon dioxide.
- **Combustion of methane:** $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$. **Photosynthesis:** $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$.
- **Thermal decomposition of limestone:** $CaCO_3 \rightarrow CaO + CO_2$. **Displacement:** $Mg + CuSO_4 \rightarrow MgSO_4 + Cu$.
- **Iron extraction:** $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$. **Fermentation:** $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$.
- **Haber process** EXT : $N_2 + 3H_2 \rightleftharpoons 2NH_3$. **Contact process** EXT : $2SO_2 + O_2 \rightleftharpoons 2SO_3$.
- **At the cathode:** $Cu^{2+} + 2e^- \rightarrow Cu$, $2H^+ + 2e^- \rightarrow H_2$ and $Al^{3+} + 3e^- \rightarrow Al$. **At the anode:** $2Cl^- \rightarrow Cl_2 + 2e^-$ and $4OH^- \rightarrow 2H_2O + O_2 + 4e^-$. EXT
- **Balance** by changing the big numbers in front of formulas only, never the small numbers inside a formula.

## 4 Industry and the reactivity series

### Reactivity and extraction




The more reactive a metal, the harder it is to extract from its ore, so the method depends on the position in the series.

- **A more reactive metal displaces a less reactive one** from its compound. Magnesium displaces copper from copper(II) sulfate, but copper cannot displace magnesium.
- **Rusting** needs both water and oxygen. Prevent it with paint, oil, plastic coating, galvanising (zinc) or sacrificial protection with a more reactive metal.
- **Aluminium** is protected by a thin layer of aluminium oxide, so it seems unreactive.

Riyaz Sir

## Industrial processes

| Process | Raw materials | Conditions | Product |
|---|---|---|---|
| Haber | nitrogen from air and hydrogen from natural gas | iron catalyst, 450 °C, 200 atm | ammonia |
| Contact | sulfur (burned to $SO_2$) and air | vanadium(V) oxide catalyst, 450 °C, 2 atm | sulfuric acid |
| Blast furnace | haematite, coke, limestone and hot air | carbon monoxide reduces iron(III) oxide | molten iron and slag |
| Aluminium | aluminium oxide dissolved in molten cryolite | electrolysis with carbon electrodes | aluminium at the cathode |
| Brine electrolysis | concentrated sodium chloride solution | electrolysis | hydrogen, chlorine and sodium hydroxide |
| Cracking | long-chain alkanes | high temperature and a catalyst | shorter alkanes and alkenes |
| Fermentation | glucose and yeast | about 30 °C, no oxygen | ethanol and carbon dioxide |
| Hydration of ethene | ethene and steam | phosphoric acid catalyst, 300 °C, 60 atm | ethanol |

- **Slag** in the blast furnace is calcium silicate. Limestone decomposes to CaO, which reacts with silicon dioxide impurities.
- **The carbon anodes burn away** in aluminium extraction, because oxygen reacts with them to make carbon dioxide, so they must be replaced.

### Electrolysis rules

- **PANIC:** Positive Anode, Negative Is Cathode. **OIL RIG:** Oxidation Is Loss, Reduction Is Gain (of electrons).
- **Cathode (negative):** a metal, or hydrogen if the metal is more reactive than hydrogen. **Anode (positive):** a halogen if a halide ion is present, otherwise oxygen.
- **Molten ionic compound:** the metal forms at the cathode and the non-metal forms at the anode.
- **Copper electrodes in copper(II) sulfate solution:** the anode dissolves and copper is deposited on the cathode. This purifies copper.

## 5 Structure, bonding and organic facts

### Structure and properties

| Structure | Examples | Melting point | Conducts electricity |
|---|---|---|---|
| Ionic lattice | sodium chloride | high | only when molten or dissolved |
| Simple molecular | water, carbon dioxide | low | never |
| Giant covalent | diamond, graphite, silicon dioxide | very high | graphite only, because of free electrons |
| Metallic | copper, iron | high | yes, in solid and liquid state |

- **Group I metals** become more reactive going down. **Group VII elements** become less reactive going down. **Noble gases** are unreactive because their outer shells are full.
- **Air** is about 78% nitrogen, 21% oxygen, 1% argon and 0.04% carbon dioxide.

### Organic chemistry

| Family | General formula | Key feature |
|---|---|---|
| Alkanes | $C_nH_{2n+2}$ | single bonds only (saturated) |
| Alkenes | $C_nH_{2n}$ | a C=C double bond (unsaturated) |
| Alcohols | contain the OH group | made by fermentation or hydration of ethene |
| Carboxylic acids | contain the COOH group | weak acids, react with carbonates |

- **First four alkanes:** methane $CH_4$, ethane $C_2H_6$, propane $C_3H_8$ and butane $C_4H_{10}$. **Alkenes:** ethene $C_2H_4$ and propene $C_3H_6$.
- **Complete combustion** gives carbon dioxide and water. **Incomplete combustion** gives carbon monoxide (toxic) or carbon.
- **Addition polymerisation:** many alkene molecules join to form one long polymer. Poly(ethene) is made from ethene.

## Test yourself — cover the answers first

### QUICK CHECK

1. What is the test for hydrogen gas?
2. What is the test for carbon dioxide?
3. What colour is the precipitate of copper(II) ions with sodium hydroxide?
4. A white precipitate forms with silver nitrate and dilute nitric acid. Which ion is present?
5. What colour flame does a sodium compound give?
6. Which gas is released at the anode in concentrated sodium chloride solution?
7. Work out the number of moles in 4.4 g of $CO_2$ (Mr = 44).
8. What volume does 0.5 mol of any gas occupy at room temperature and pressure?
9. EXT What are the conditions of the Haber process?
10. EXT Which catalyst is used in the Contact process?
11. Why is aluminium extracted using electrolysis and not carbon?
12. Which general formula do alkenes have?

### EXAM-STYLE

13. Calculate the volume of hydrogen at room temperature and pressure made when 2.4 g of magnesium reacts with excess dilute hydrochloric acid. $Mg + 2HCl \rightarrow MgCl_2 + H_2$ (Ar: Mg 24) [3]
14. 25.0 $cm^3$ of 0.200 $mol/dm^3$ sodium hydroxide is neutralised by 20.0 $cm^3$ of sulfuric acid. $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$. Find the concentration of the acid. [3]
15. Heating 12.5 g of zinc carbonate, $ZnCO_3$, gives zinc oxide, ZnO. The yield is 6.48 g. Find the percentage yield. (Ar: Zn 65, C 12, O 16) [4]
16. A solution gives a white precipitate with NaOH that dissolves in excess. With $NH_3(aq)$ the white precipitate also dissolves in excess. Name the metal ion and explain. [2]

Show answers

1. lighted splint gives a squeaky pop
2. it turns limewater milky
3. light blue
4. chloride, $Cl^-$
5. yellow
6. chlorine
7. 0.1 mol
8. 12 $dm^3$
9. iron catalyst, 450 °C, 200 atm
10. vanadium(V) oxide
11. aluminium is more reactive than carbon
12. $C_nH_{2n}$
13. n(Mg) = 2.4 ÷ 24 = 0.10 mol
    ratio 1 : 1 so $n(H_2)$ = 0.10 mol
    V = 0.10 × 24 = 2.4 $dm^3$
14. n(NaOH) = 0.200 × 0.0250 = 0.00500 mol
    ratio 2 : 1 so $n(H_2SO_4)$ = 0.00250 mol
    c = 0.00250 ÷ 0.0200 = 0.125 mol/$dm^3$
15. $Mr(ZnCO_3)$ = 125 and Mr(ZnO) = 81
    $n(ZnCO_3)$ = 12.5 ÷ 125 = 0.100 mol
    theoretical mass of ZnO = 0.100 × 81 = 8.10 g
    percentage yield = 6.48 ÷ 8.10 × 100 = 80.0%
16. the ion is zinc, $Zn^{2+}$
    aluminium, $Al^{3+}$ also dissolves in excess NaOH but its precipitate does not dissolve in excess ammonia

**Stuck on a question?**

Send it to me on WhatsApp. I read every message.

Share with a friend

Ask Riyaz Sir

Want regular help? Send this to your parent →