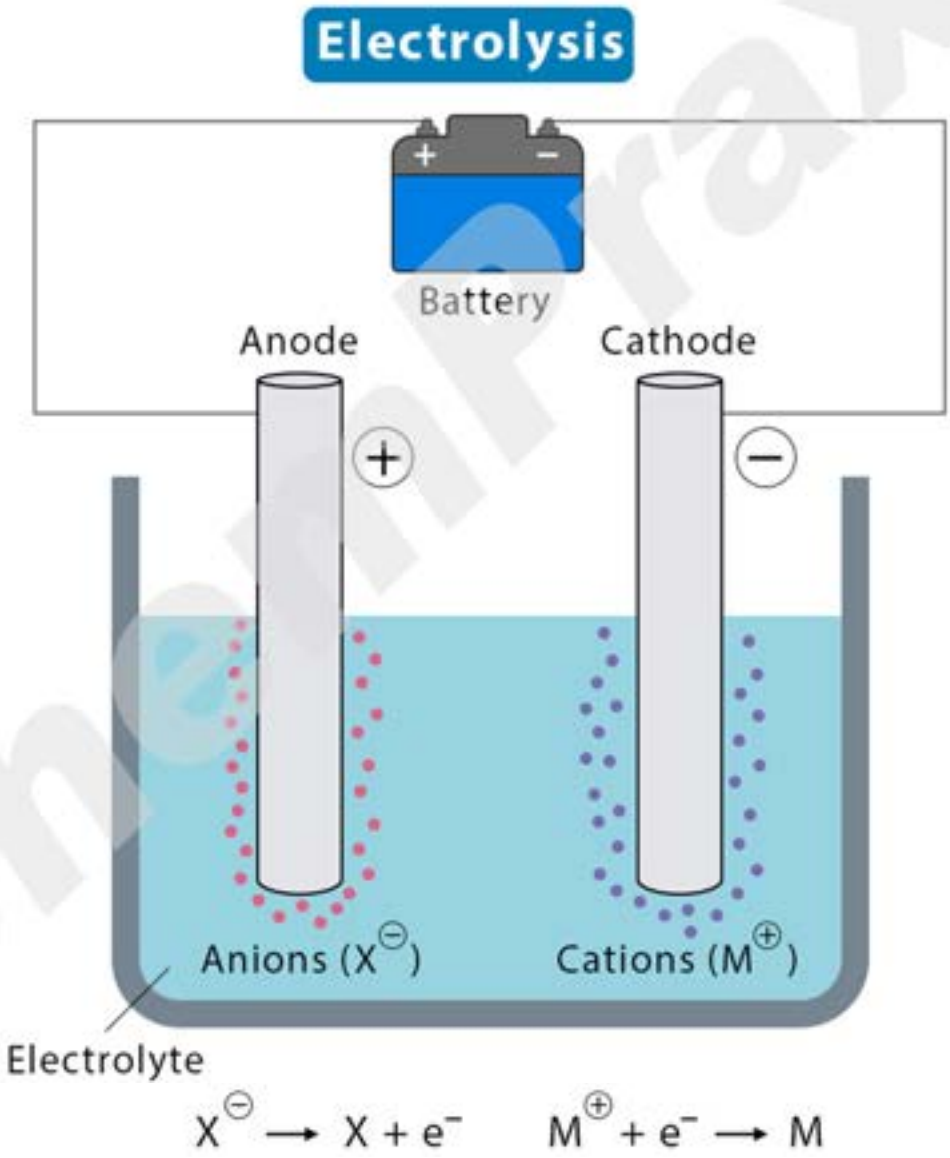
4.Electrochemistry

(IGCSE Chemistry Syllabus 2023-2025)

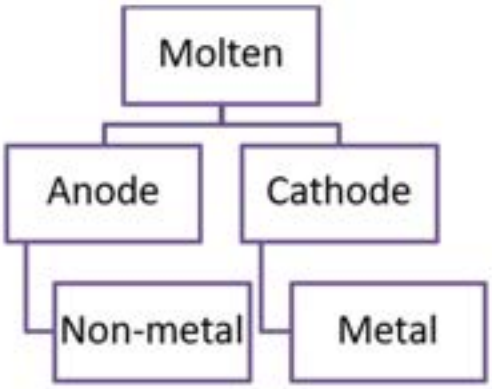
4.1 Electrolysis

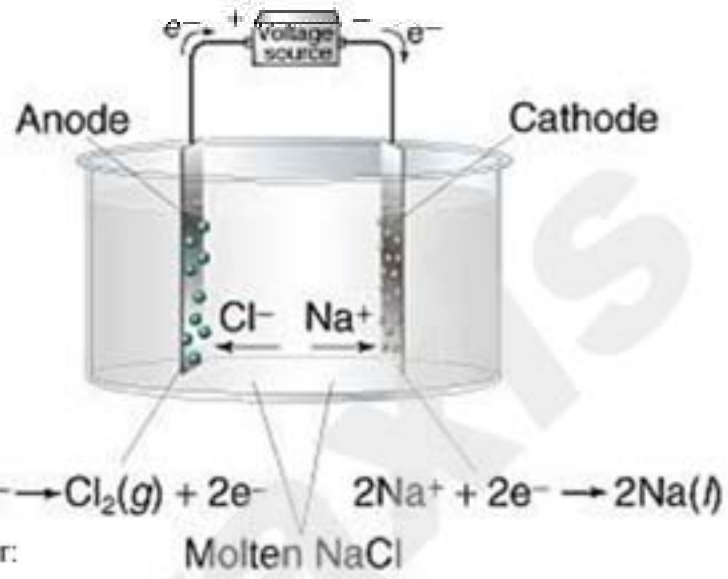
- **Electrolysis**: decomposition of ionic compound in molten/aq by the passage of an electric current
- Electrolyte: Ionic compound that able to produce free moving ions in **molten or aqueous state**
- Anode (**Add**: "+"): terminal positive → attract **negative ion (anion)**
- Cathode (**Cut**: "-"): **terminal** negative → attract **positive ion (cation)**
- **Oxidation** (loses electron) happens at **Anode**
- **Reduction** (gains electron) happens at **Cathode**

  Add: circuit : electrons: electrolyte: ions



Molten Electrolyte





Exercise

Write the ionic equations for both anode and cathode for:

(a) Molten potassium chloride

Anode		Cathode	
Observation		Observation	

(b) Molten magnesium oxide

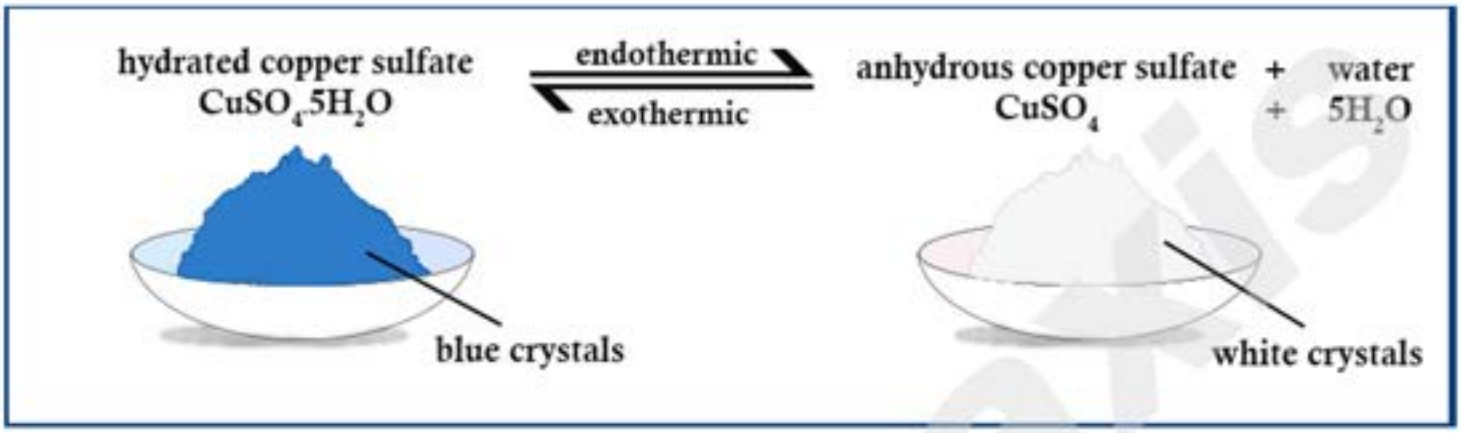
Anode		Cathode	
Observation		Observation	

(c) Molten aluminium chloride

Anode		Cathode	
Observation		Observation	

6.3 Reversible Reactions and Equilibrium

- Reversible reaction: a reaction in which reactants form products and the products can then react or decompose to form the reactants



Dynamic equilibrium:

- Rate of forward reaction = rate of backward reaction
- Concentration of reactants and products remain constant
- Close system

Equilibrium

- Le Chatelier's Principle: if conditions of an equilibrium are changed, the position of equilibrium moves to oppose change
- Equilibrium is affected by:

Temperature

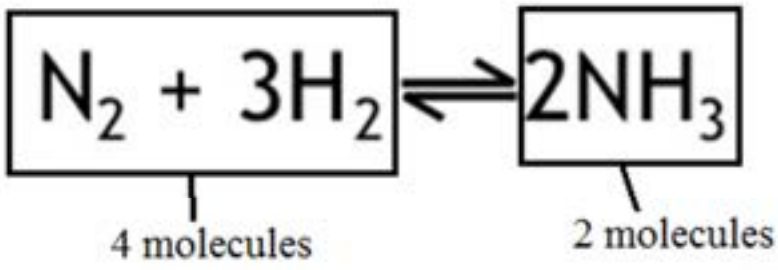
- High temperature favours endothermic reaction
- Low temperature favours exothermic reaction

hydrated copper sulfate $CuSO_4.5H_2O$ $\rightleftharpoons$ (endothermic / exothermic) anhydrous copper sulfate + water, $CuSO_4$ + $5H_2O$

- High temperature favours forward reaction
- Low temperature favours backward reaction

Pressure

- High pressure favours side with less number of molecules
- Low pressure favours side with more number of molecules



- High pressure favor forward reaction
- Low pressure favor backward reaction

Concentration

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

- High concentration of hydrogen will shift the equilibrium to the right, increase the yield of ammonia, to oppose the change
- Removing ammonia (low concentration of ammonia) will shift the equilibrium to the right, to increase the yield of ammonia, to oppose the change

- Symbol Equation for Production of Ammonia in the Haber Process: $N_{2(g)} + 3H_2 \rightleftharpoons 2NH_{3\,(g)}$
- The source of the hydrogen used in Haber Process is methane and the source of the nitrogen is from the air
- Conditions for Haber Process: 450°C, 20000kPa /200atm and an iron catalyst
- Symbol equation for conversion of sulfur dioxide to sulfur trioxide in Contact Process: $2SO_{2(g)} + O_2 \rightleftharpoons 2SO_{3(g)}$
- The sources of sulfur dioxide and oxygen in the Contact Process is burning/roasting sulfur ores and air respectively.
- Conditions for Conversion of Sulfur Dioxide to Sulfur Trioxide in the Contact Process: 450°C, 200kPa /2atm and a vanadium(V) oxide catalyst
- If temperature is changed the equilibrium position will move hence changing the yield.
- Rate of reaction is slow at low temperatures hence 450°C is chosen as this is low enough to achieve an acceptable yield and high enough to complete in an acceptable time.
- If pressure is increased, the equilibrium position moves in the direction of the fewest molecules of gas
- It is very expensive to achieve very high pressures hence a pressure of 200 atmospheres is used as it is low enough to keep costs down and high enough to achieve an acceptable yield.
- Catalysts do not change the equilibrium concentrations of the reactants in reversible reactions but instead reduces the time required to reach an equilibrium. Iron and vanadium (v) oxide are cheap catalysts and hence used in both the processes.

Past Year Topical Questions

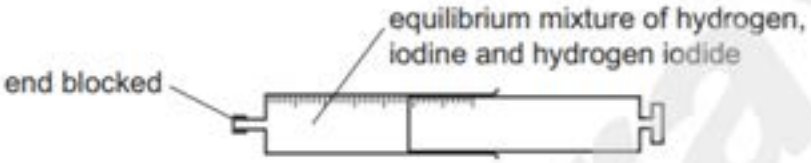
May/June 2018 (42)

5 Hydrogen and iodine react together in a reversible reaction. Hydrogen iodide is formed.

$$\underset{\text{colourless gas}}{H_2(g)} + \underset{\text{purple gas}}{I_2(g)} \rightleftharpoons \underset{\text{colourless gas}}{2HI(g)}$$

The forward reaction is exothermic.

A gas syringe containing an equilibrium mixture of hydrogen, iodine and hydrogen iodide gases was sealed and heated to 250 °C. The equilibrium mixture was a pale purple colour.



(a) What is meant by the term *equilibrium*?

.....

.....

..... [2]

(b) The plunger of the gas syringe was pressed in while the end of the gas syringe was blocked. This increased the pressure. The position of the equilibrium did **not** change. The colour of the gaseous mixture turned darker purple.

(i) Give a reason why the position of the equilibrium did **not** change.

..... [1]

(ii) Suggest why the gaseous mixture turned darker purple, even though the position of the equilibrium did **not** change.

..... [1]

(c) The temperature of the gas syringe was increased to 300 °C.

(i) What happened to the **position** of the equilibrium when the temperature of the gas syringe was increased from 250 °C to 300 °C?

..... [1]

(ii) What happened to the **rate** of the forward reaction and the **rate** of the backward reaction when the temperature of the gas syringe was increased from 250 °C to 300 °C?

rate of the forward reaction .....

rate of the backward reaction .....

[2]

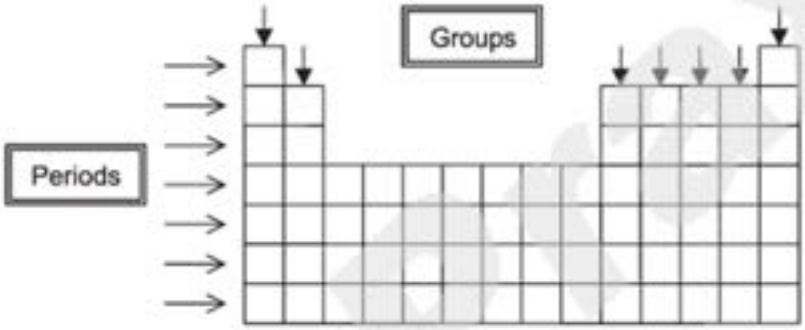
[Total: 7]

8.The Periodic Table

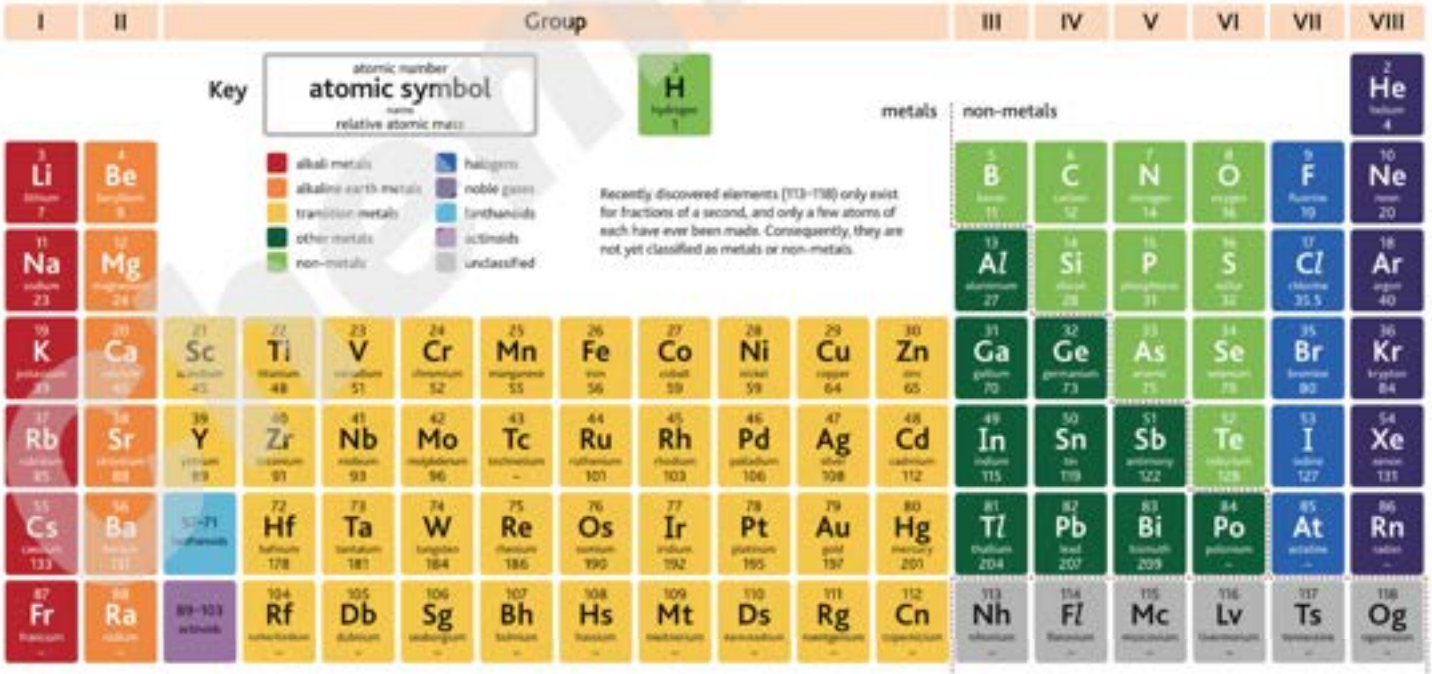
(IGCSE Chemistry Syllabus 2023-2025)

8.1 Arrangement of Elements

- Elements are arranged in order of **increasing atomic/proton number**
- Rows: Periods
- Columns: Groups
- **Group**: number of valence electrons
- **Period**: number of electron shells
- Left: Metals
- Right: Non-metals



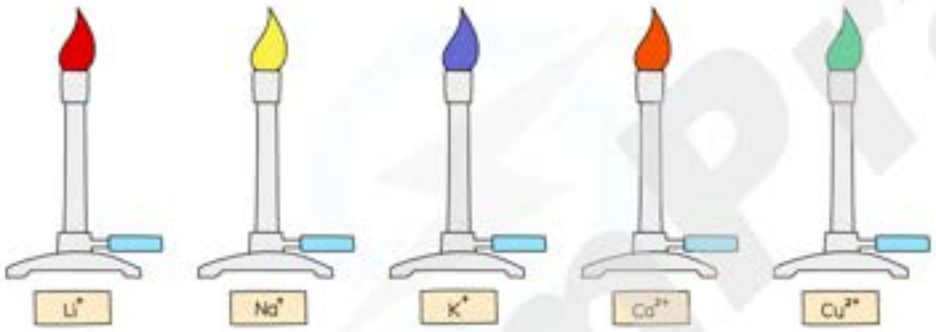
Periodic Trends



- Going down a group: metal becomes more reactive; non-metal becomes less reactive

8.2 Group 1 Properties

- **Physical properties**:
  i. Good conductors of heat and electricity
  ii. Soft (compared to other metals)
  iii. Low densities (compared to other metals)
  iv. Low melting points and boiling points (compared to other metals)
- **Chemical properties**:
  i. Form ionic compounds with non-metal (e.g. sodium chloride)
  ii. React violently with chlorine
  iii. Burst into flames when heated with oxygen - produces soluble white compound
    - A red flame for lithium
    - A yellow flame for sodium
    - A lilac flame for potassium



Cation	Colour of Flame
Li^+	Red
Na^+	Yellow
K^+	Lilac
Ca^{2+}	Orange-red
Cu^{2+}	Blue-green

iv. React with cold water to form alkaline solution

$2Li(s) + 2H_2O(l) \longrightarrow 2LiOH(aq) + H_2(g)$
Lithium + Water → Lithium hydroxide + Hydrogen

$2Na(s) + 2H_2O(l) \longrightarrow 2NaOH(aq) + H_2(g)$
Sodium + Water → Sodium hydroxide + Hydrogen

$2K(s) + 2H_2O(l) \longrightarrow 2KOH(aq) + H_2(g)$
Potassium + Water → Potassium hydroxide + Hydrogen

Reactivity increases

- **Patterns**:
  i. **Reactivity, density and softness increase** further down the group
  ii. **Melting point and boiling points decrease** down the group – metallic bond becomes weaker
  iii. **Reactivity increases** – more electron shells → attraction between the nucleus and the valence electron becomes weaker → the electron loses more easily

Past Year Topical Questions

Oct/Nov 2021 (42)

5 Iron is a transition element. Potassium is a Group I element.

(a) Iron and potassium have the same type of bonding.

Name and describe the type of bonding in these two elements.

name .....

description .....

.....

.....

.....

[4]

(d) Chemical properties of some Group I elements are shown in the table.

element	reaction with cold water	reaction with oxygen	flame test colour
lithium	• steadily effervesces • forms a colourless solution	very slowly forms an oxide layer	red
sodium	• strongly effervesces • forms a colourless solution	slowly forms an oxide layer	
potassium	• very strongly effervesces • forms a colourless solution	quickly forms an oxide layer	
rubidium			ruby red

(i) Add to the table:

- the flame test colours for sodium and potassium
- the predicted reactions of rubidium with water and with oxygen.

[4]

(ii) Name the gas produced when Group I elements react with water.

..... [1]

(iii) Name the solution formed when potassium reacts with water.

..... [1]

(iv) Predict the pH of the colourless solution formed when potassium reacts with water.

..... [1]

(v) Write the chemical equation for the reaction of sodium with oxygen.

..... [2]

Oct/Nov 2020 (23)

26 Elements in Group II of the Periodic Table show the same trends in their reaction with water and their density as Group I.

Which row shows how the properties of barium compare with calcium?

	reaction with water	density
A	faster	higher
B	faster	lower
C	slower	higher
D	slower	lower