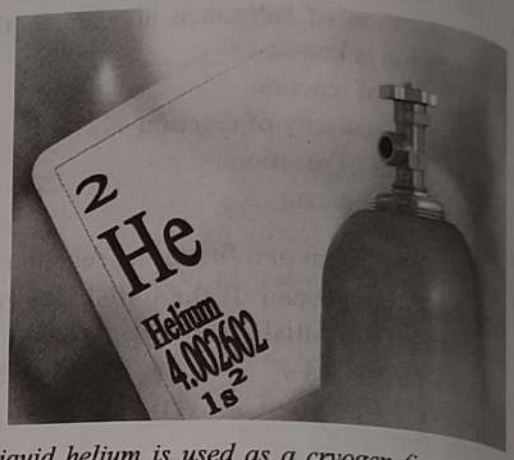
07 Elements of Groups 16, 17 and 18

Subtopics

Liquid Helium

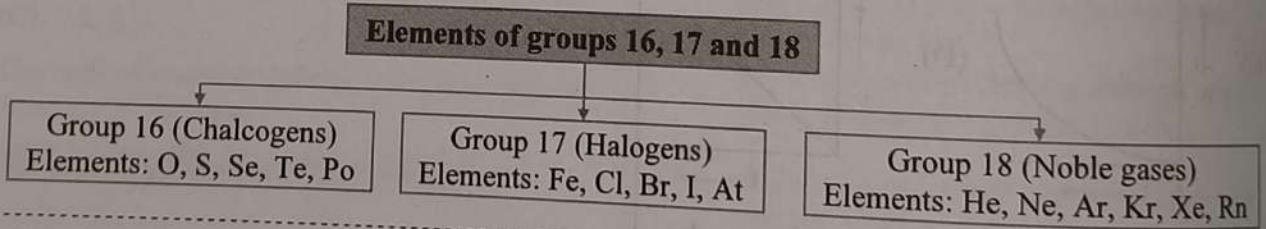


Liquid helium is used as a cryogen (i.e., used to produce very low temperatures) for various applications. One of the important application is in the medical field; MRI technology (magnetic resonance imaging). It is majorly used to detect any anomaly present in the nervous and cardiovascular system. MRI instrumentation involves the use of superconducting magnet, which is cooled using liquid helium.

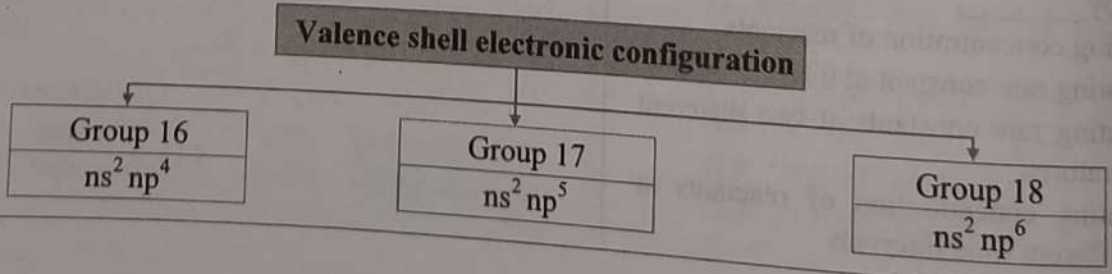
Also, liquid helium when cooled below the critical value, it becomes a quantum fluid known as helium-II. It's a superfluid, that is, a fluid with "zero viscosity and flows without any loss of kinetic energy".

Quick Review

➤ **Elements of groups 16, 17 and 18:**



➤ **Valence shell electronic configuration:**



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Group oxidation state	Group 16	Group 17	Group 18
	−2	−1	0
Common oxidation states	−2, +2, +4, +6	−1, +3, +5, +7	+4, +6 (in xenon)

Properties of hydrides:

Properties of hydrides

Group 16

Acidic character: $H_2O < H_2S < H_2Se < H_2Te$
Thermal stability: $H_2O > H_2S > H_2Se > H_2Te$
Bond energy: $H - O > H - S > H - Se > H - Te$
Reducing property: $H_2S < H_2Se < H_2Te$

Group 17

Acidic strength: $HF < HCl < HBr < HI$
Thermal stability: $HF > HCl > HBr > HI$
Bond energy: $HF > HCl > HBr > HI$

Dioxygen:

Preparations:

- $KClO_3$ (Potassium chlorate) —
- HgO (Mercuric oxide) — Δ
- Ag_2O (Silver oxide) — Δ
- PbO_2 (Lead dioxide) — Δ
- H_2O_2 (Hydrogen peroxide) — Δ, MnO_2
- H_2O (Water) — Electrolysis
- Liquid air — Fractional distillation

→ **O_2 Dioxygen**

Reactions:

- Ca → CaO Calcium oxide
- Al, Δ → Al_2O_3 Aluminium oxide
- P_4 → P_4O_{10} Phosphorus (V) oxide
- C → CO_2 Carbon dioxide (excess O_2)
- HCl, $CuCl_2$, Δ → $H_2O_{(g)}$ Water + $Cl_{2(g)}$ Chlorine
- SO_2, V_2O_5 → $2SO_{3(g)}$ Sulfur trioxide
- ZnS → ZnO Zinc oxide + SO_2 Sulfur dioxide
- CH_4, Δ → CO_2 Carbon dioxide + H_2O Water

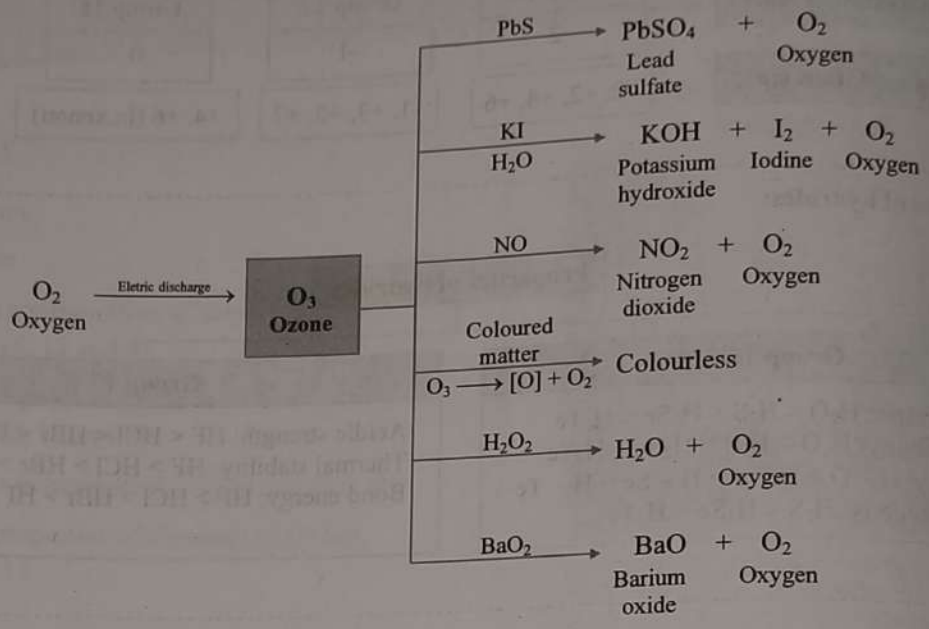
Types of oxides:

Types of oxides

Acidic	Basic	Amphoteric	Neutral
$SO_2, SO_3, CO_2, N_2O_5, Cl_2O_7$	Na_2O, CaO, BaO	Al_2O_3	CO, NO, N_2O

➢ Ozone:

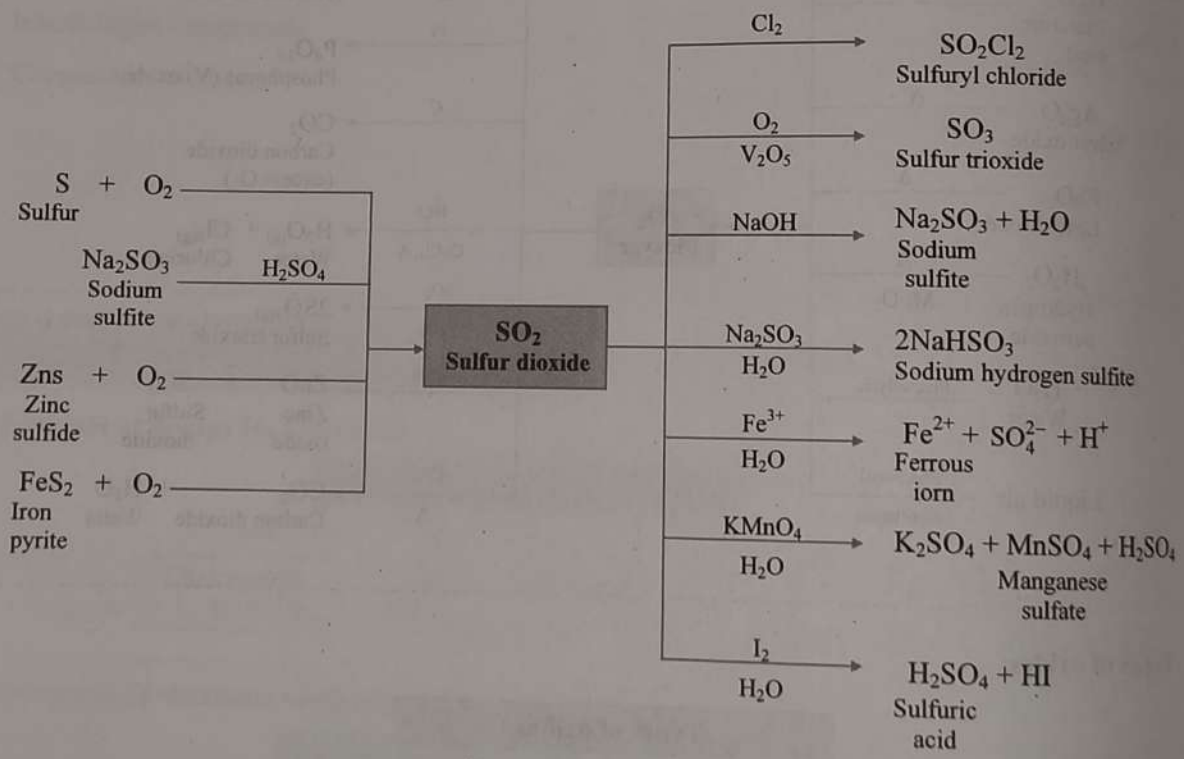
Reactions:



➢ Sulfur dioxide:

Preparations:

Reactions:



Sulfuric acid:

Preparation:

Contact process

Stage – 1

$S + O_2 \longrightarrow SO_2$

$FeS_2 + 11O_2 \longrightarrow 2Fe_2O_3 + 8SO_2$

Stage – 2

$2SO_2 + O_2 \longrightarrow 2SO_3$

Stage – 3

$SO_3 + H_2SO_4 \longrightarrow H_2S_2O_7$

$H_2S_2O_7 + H_2O \longrightarrow$ **H_2SO_4 Sulfuric acid**

Reactions:

H_2SO_4 (Sulfuric acid) →

- H_2O → $HSO_4^- + H_3O^+$ ↓ H_2O → $SO_4^{2-} + H_3O^+$
- Cu → $CuSO_4 + SO_2 + H_2O$
- S → $SO_2 + H_2O$
- C → $CO_2 + SO_2 + H_2O$
- $C_{11}H_{22}O_{11}$ → $C + H_2O$
- NaCl → $NaHSO_4 + HCl$
- KNO_3 → $KHSO_4 + HNO_3$
- CaF_2 → $CaSO_4 + HF$

Chlorine:

Preparations:

- MnO_2 (Manganese dioxide) + HCl (Hydrochloric acid) — Δ
- $KMnO_4$ (Potassium permanganate) + HCl (Hydrochloric acid)
- NaCl (Sodium chloride) — MnO_2, H_2SO_4
- O_2 (Oxygen) + HCl (Hydrochloric acid) — $CuCl_2$, 723 K
- NaCl (Sodium chloride) — electrolysis

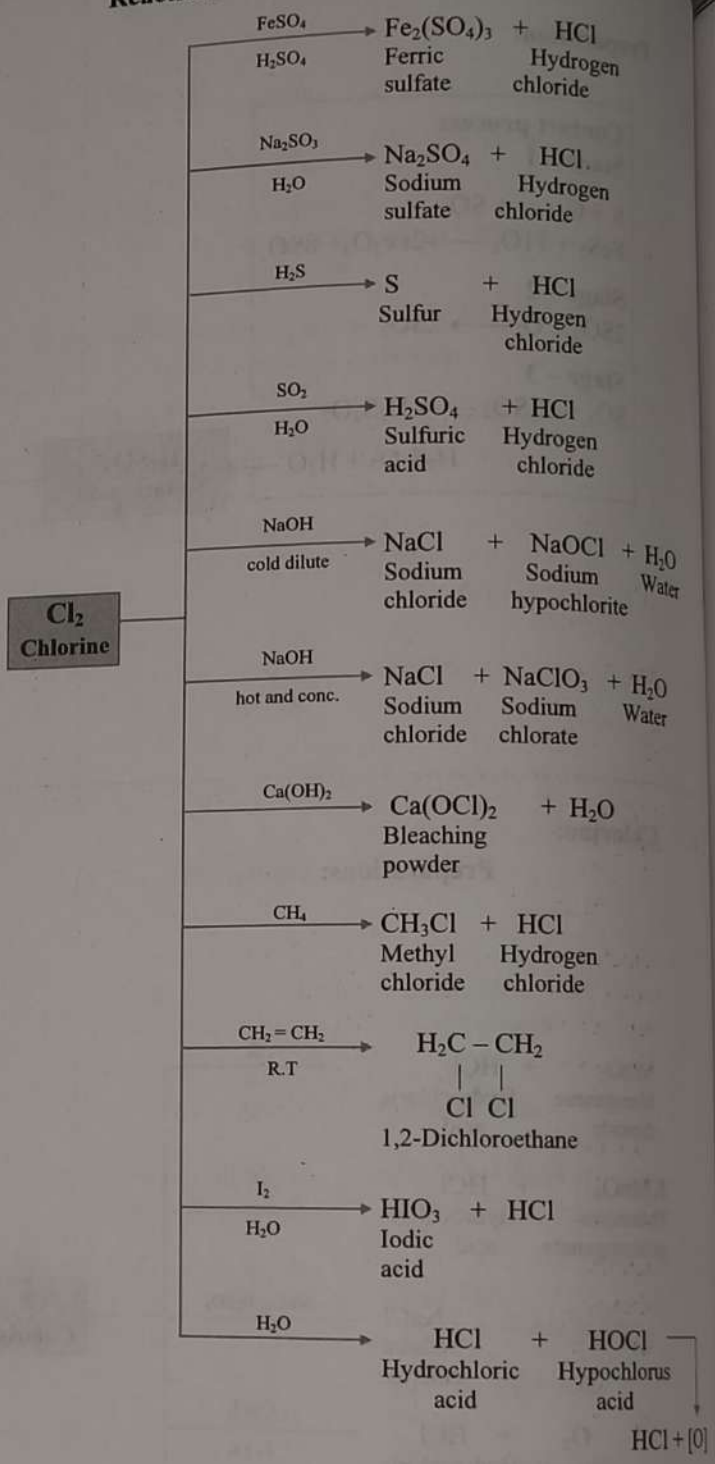
→ **Cl_2 Chlorine**

Reactions:

Cl_2 Chlorine →

- Na → NaCl, Sodium chloride
- Fe → $FeCl_3$, Ferric chloride
- Al → $AlCl_3$, Aluminium chloride
- S_8 → S_2Cl_2, Sulfur monochloride
- P_4 → PCl_3, Phosphorus trichloride
- H_2 (diffused sunlight) → HCl, Hydrogen chloride
- NH_3 → HCl (Hydrogen chloride) + NCl_3 (Nitrogen trichloride)
- excess NH_3 → NH_4Cl (Ammonium chloride) + N_2 (Nitrogen)

Reactions of chlorine:



➢ **Xenon fluorides and oxyfluorides:**