QUICK RECAP

- Elements in which the last electron enters any one of the three *p*-orbitals of their respective outermost shell are called *p-block elements.*

GROUP 15 ELEMENTS (NITROGEN FAMILY)

- Group 15 elements are collectively called *pnictogens.*

- **General characteristics :**

Electronic configuration	$ns^2\ np^3$
Elements	$_7N$, $_{15}P$, $_{33}As$, $_{51}Sb$, $_{83}Bi$
Physical state and metallic character	N_2 (unreactive gas), P_4 (solid non-metal), As_4 and Sb_4 (Solid metalloids), Bi (metal)
Atomic radii	Increase down the group, smaller than that of group 14 elements due to increased nuclear charge.
Melting and boiling points	M.pt. increases from N to As and then decreases whereas b. pt. increases from N to Sb and decreases very slightly.
Ionisation enthalpy	Decreases regularly down the group due to increase in size.
Electronegativity	Decreases down the group.
Allotropy	Nitrogen (α and β-Nitrogen), phosphorus (white, red, scarlet, violet, α- black, β-black), arsenic (grey, yellow, black), antimony (metallic, yellow, explosive)

- **Chemical properties :**
  - Stability of +3 oxidation state increases and that of +5 decreases down the group due to *inert pair effect.*
  - **Halides :** All the elements form trihalides of the type MX_3 and except nitrogen, all form pentahalides of the type MX_5.
    - **Stability :** $NF_3 > NCl_3 > NBr_3$
    - **Lewis acid strength :** $PCl_3 > AsCl_3 > SbCl_3$ and $PF_3 > PBr_3 > PI_3$
    - **Lewis base strength :** $NI_3 > NBr_3 > NCl_3 > NF_3$
    - **Bond angle :** $PF_3 < PCl_3 < PBr_3 < PI_3$ (increasing *b.p.* – *b.p.* repulsions)
  - **Hydrides :** All the elements form hydrides of the type MH_3 which are covalent and pyramidal in shape. Their general trends are :

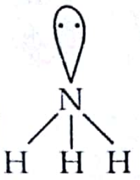
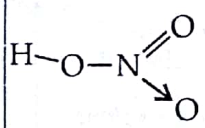
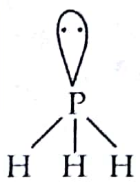
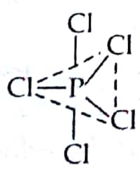
Increase upward (Max at NH_3)	Hydride	Increase downward (Max at BiH_3)
• Ease of formation • Stability • Basic character • Solubility • Bond angle • Strength of M-H bond • Dipole moment • Decomposition temperature	NH_3 PH_3 AsH_3 SbH_3 BiH_3	• Reducing character • Covalent character • Poisonous nature • Rate of combustion

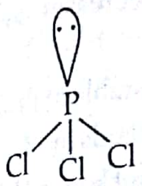
  - **Oxides :** All these elements form oxides of the type X_2O_3, X_2O_4 and X_2O_5.

N_2O_3	P_2O_3	As_2O_3	Sb_2O_3	Bi_2O_3	Acidic
N_2O_4	P_2O_4	As_2O_4	Sb_2O_4	Bi_2O_4	nature
N_2O_5	P_2O_5	As_2O_5	Sb_2O_5	Bi_2O_5	increases ↓
Acidic nature decreases →					

- **Preparation, properties and uses of some important compounds :**

Compound	Preparation	Properties	Uses
N_2 $N\equiv N$	$NH_4Cl + NaNO_2 \longrightarrow N_2\uparrow + 2H_2O + NaCl$ $(NH_4)_2Cr_2O_7 \xrightarrow{\Delta} N_2\uparrow + 4H_2O + Cr_2O_3$ $Ba(N_3)_2 \xrightarrow{\Delta} Ba + 3N_2\uparrow$	$6Li + N_2 \xrightarrow{Heat} 2Li_3N$ $3Mg + N_2 \xrightarrow{Heat} Mg_3N_2$ $N_{2(g)} + 3H_{2(g)} \xrightleftharpoons{773\ K} 2NH_{3(g)}$ $N_{2(g)} + O_{2(g)} \xrightleftharpoons{Heat} 2NO_{(g)}$	Used in manufacture of nitric acid, ammonia, calcium cyanamide and other nitrogen compounds. Liquid dinitrogen is used as a refrigerant to preserve biological materials, food items and in cryosurgery.

NH_3 	$NH_2CONH_2 + 2H_2O \longrightarrow$ $(NH_4)_2CO_3 \rightleftharpoons 2NH_3 + H_2O + CO_2$ $2NH_4Cl + Ca(OH)_2 \longrightarrow 2NH_3 + 2H_2O + CaCl_2$ $(NH_4)_2SO_4 + 2NaOH \longrightarrow 2NH_3 + 2H_2O + Na_2SO_4$ *Haber's process :* $N_{2(g)} + 3H_{2(g)} \xrightleftharpoons{773\ K} 2NH_{3(g)};$ $\Delta H_f^\circ = -46.1$ kJ/mol	$NH_{3(g)} + H_2O_{(l)} \rightleftharpoons NH^+_{4(aq)} + OH^-_{(aq)}$ $ZnSO_{4(aq)} + 2NH_4OH_{(aq)} \longrightarrow$ $Zn(OH)_{2(s)} + (NH_4)_2SO_{4(aq)}$ (white ppt.) $FeCl_{3(aq)} + NH_4OH_{(aq)} \longrightarrow$ $Fe_2O_3 . xH_2O_{(s)} + NH_4Cl_{(aq)}$ (brown ppt.) $Cu^{2+}_{(aq)} + 4NH_{3(aq)} \rightleftharpoons [Cu(NH_3)_4]^{2+}_{(aq)}$ (blue) (deep blue) $Ag^+_{(aq)} + Cl^-_{(aq)} \longrightarrow AgCl_{(s)}$ (colourless) (white ppt.) $AgCl_{(s)} + 2NH_{3(aq)} \longrightarrow [Ag(NH_3)_2]Cl_{(aq)}$ (white ppt.) (colourless)	Used in refrigerators, manufacturing of rayon, HNO_3, $NaHCO_3$, nitrogenous fertilizers.
HNO_3 	$NaNO_3 + H_2SO_4 \longrightarrow NaHSO_4 + HNO_3$ *Ostwald's Process :* $4NH_3 + 5O_2 \xrightarrow[500\ K,\ 9\ bar]{Pt/Rh\ gauge\ catalyst} 4NO + 6H_2O$ $2NO + O_2 \rightleftharpoons 2NO_2$ $3NO_2 + H_2O \longrightarrow 2HNO_3 + NO$	$HNO_{3(aq)} + H_2O_{(l)} \longrightarrow H_3O^+_{(aq)} + NO^-_{3(aq)}$ $3Cu + 8HNO_3(dilute) \longrightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$ $Cu + 4HNO_3(conc.) \longrightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$ $4Zn + 10HNO_3(dilute) \longrightarrow 4Zn(NO_3)_2 + 5H_2O + N_2O$ $Zn + 4HNO_3(conc.) \longrightarrow Zn(NO_3)_2 + 2H_2O + 2NO_2$ $I_2 + 10HNO_3 \longrightarrow 2HIO_3 + 10NO_2 + 4H_2O$ $C + 4HNO_3 \longrightarrow CO_2 + 2H_2O + 4NO_2$ $S_8 + 48HNO_3 \longrightarrow 8H_2SO_4 + 48NO_2 + 16H_2O$ $P_4 + 20HNO_3 \longrightarrow 4H_3PO_4 + 20NO_2 + 4H_2O$ $NO_3^- + 3Fe^{2+} + 4H^+ \longrightarrow NO + 3Fe^{3+} + 2H_2O$ $[Fe(H_2O)_6]^{2+} + NO \longrightarrow [Fe(H_2O)_5(NO)]^{2+} + H_2O$ (brown)	Used as fertilizers, explosives, perfumes and dyes.
PH_3 	$Ca_3P_2 + 6H_2O \longrightarrow 3Ca(OH)_2 + 2PH_3$ $Ca_3P_2 + 6HCl \longrightarrow 3CaCl_2 + 2PH_3$ $P_4 + 3NaOH + 3H_2O \longrightarrow PH_3 + 3NaH_2PO_2$ (sodium hypophosphite) $PH_4I + KOH \longrightarrow KI + H_2O + PH_3$	$3CuSO_4 + 2PH_3 \longrightarrow Cu_3P_2 + 3H_2SO_4$ $3HgCl_2 + 2PH_3 \longrightarrow Hg_3P_2 + 6HCl$ $PH_3 + HBr \longrightarrow PH_4Br$	The spontaneous combustion of phosphine is technically used in *Holme's signals*. It is also used in *smoke screens*.
PCl_5 	$P_4 + 10Cl_2 \longrightarrow 4PCl_5$ (white or red)	$PCl_5 \xrightarrow[(in\ excess)]{H_2O} H_3PO_4 + HCl$ $PCl_5 \xrightarrow{P_4S_{10}} PSCl_3$ $PCl_5 \xrightarrow{SO_2} SOCl_2 + POCl_3$ $PCl_5 \xrightarrow{P_4O_{10}} POCl_3$	Used as chlorinating and dehydrating agent.

PCl_3 	$P_4 + 6Cl_2 \longrightarrow 4PCl_3$ $P_4 + 8SOCl_2 \longrightarrow 4PCl_3 + 4SO_2 + 2S_2Cl_2$	$PCl_3 + 3H_2O \longrightarrow H_3PO_3 + 3HCl$ $3CH_3COOH + PCl_3 \longrightarrow 3CH_3COCl + H_3PO_3$ $3C_2H_5OH + PCl_3 \longrightarrow 3C_2H_5Cl + H_3PO_3$	Used as reagent in organic synthesis and as a precursor of PCl_5, $POCl_3$ and $PSCl_3$. It is used in the synthesis of some organic compounds, *e.g.*, C_2H_5Cl, CH_3COCl.

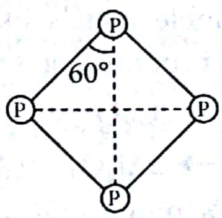
Preparation and properties of oxides of nitrogen :

Formula	O.S.	Preparation	Properties
N_2O	+1	$NH_4NO_3 \xrightarrow{\Delta} N_2O + 2H_2O$	colourless gas, neutral
NO	+2	$2NaNO_2 + 2FeSO_4 + 3H_2SO_4 \longrightarrow Fe_2(SO_4)_3 + 2NaHSO_4 + 2H_2O + 2NO$	colourless gas, neutral
N_2O_3	+3	$2NO + N_2O_4 \xrightarrow{250\text{ K}} 2N_2O_3$	blue solid, acidic
NO_2	+4	$2Pb(NO_3)_2 \xrightarrow{673\text{ K}} 2PbO + 4NO_2 + O_2$	brown gas, acidic
N_2O_4	+4	$2NO_2 \underset{\text{heat}}{\overset{\text{cool}}{\rightleftharpoons}} N_2O_4$	colourless solid/liquid, acidic
N_2O_5	+5	$4HNO_3 + P_4O_{10} \longrightarrow 4HPO_3 + 2N_2O_5$	colourless solid, acidic

Allotropes of phosphorus :

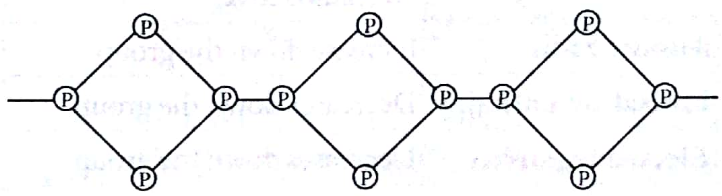
Property	White phosphorus	Red Phosphorus	Black phosphorus
Colour	White, but turns yellow on exposure	Dark red	Black
State	Waxy solid, can be cut with knife	Brittle powder	Crystalline with greasy touch
Smell	Garlic smell	Odourless	—
Density	1.84	2.1	2.69
Ignition temperature	307 K	543 K	673 K
Melting point	317 K	Sublimes in absence of air at 560 K	860 K

- White phosphorus consists of discrete tetrahedral P_4 molecule.



Structure of white phosphorus

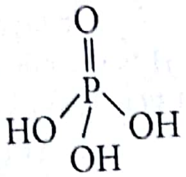
- Red phosphorus is polymeric and consists of inter linked P_4 tetrahedra.



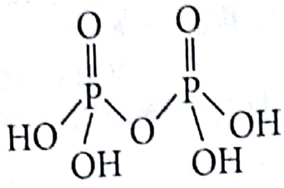
Structure of red phosphorus

- Black phosphorus is thermodynamically most stable at room temperature and has two forms : α-black phosphorus and β-black phosphorus.

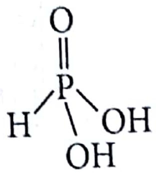
Oxoacids of phosphorus :



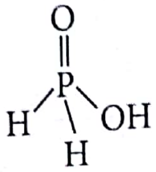
H_3PO_4
Orthophosphoric acid



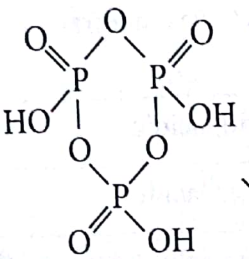
$H_4P_2O_7$
Pyrophosphoric acid



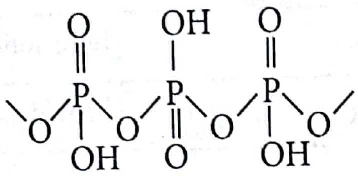
H_3PO_3
Orthophosphorous acid



H_3PO_2
Hypophosphorous acid



$(HPO_3)_3$
Cyclotrimetaphosphoric acid



$(HPO_3)_n$
Polymetaphosphoric acid

GROUP 16 ELEMENTS (OXYGEN FAMILY)

- Group 16 elements are collectively called *chalcogens.*

General characteristics :

Electronic configuration	ns^2np^4
Elements	${}_8O$, ${}_{16}S$, ${}_{34}Se$, ${}_{52}Te$, ${}_{84}Po$
Physical state and metallic characters	O_2 (gas), S_8 (solid non-metal), Se and Te (solid metalloid), Po (radioactive)
Atomic radii	Increase down the group
Ionisation enthalpy	Decreases down the group
Electronegativity	Decreases down the group
Electron gain enthalpy	Increases from oxygen to sulphur and then decreases.
Melting and boiling points	Increase down the group upto Te and then decreases.
Allotropy	All elements show allotropy

Chemical properties :

- Stability of −2 oxidation state decreases down the group, stability of +4 oxidation state increases and that of +6 oxidation state decreases down the group due to *inert pair effect.*
- **Hydrides :** All the elements form stable hydrides of the type H_2M. Their general trends are :
  - **Boiling point :** $H_2O > H_2Te > H_2Se > H_2S$
  - ***Volatility :*** $H_2S > H_2Se > H_2Te > H_2O$
  - **Bond angle :** $H_2O > H_2S > H_2Se > H_2Te$
  - **Acidic character :** $H_2O < H_2S < H_2Se < H_2Te$
  - **Reducing power :** $H_2Te > H_2Se > H_2S > H_2O$
- **Halides :** All elements form halides of the type EX_6, EX_4 and EX_2.
- **Oxides :**

Simple oxides	MgO, Al_2O_3
Mixed oxides	Pb_3O_4, Fe_3O_4
Acidic oxides	SO_2, Cl_2O_7, CO_2, N_2O_5
Basic oxides	Na_2O, CaO, BaO
Amphoteric oxides	Al_2O_3
Neutral oxides	CO, NO, N_2O

Dioxygen (O_2) :

- **Preparation :**

$$2KClO_3 \xrightarrow[MnO_2]{\Delta} 2KCl + 3O_2$$

$$2Ag_2O_{(s)} \xrightarrow{\Delta} 4Ag_{(s)} + O_{2(g)}$$

$$2Pb_3O_{4(s)} \xrightarrow{\Delta} 6PbO_{(s)} + O_{2(g)}$$

$$2HgO_{(s)} \longrightarrow 2Hg_{(l)} + O_{2(g)}$$

$$2PbO_{2(s)} \longrightarrow 2PbO_{(s)} + O_{2(g)}$$

$$2H_2O_{2(aq)} \longrightarrow 2H_2O_{(l)} + O_{2(g)}$$

- **Properties :**
  - Dioxygen is colourless and odourless gas, soluble in water and paramagnetic in nature.
  - Dioxygen directly reacts with all metals (except noble metals like Au, Pt), non-metals (except noble gases).

$2Ca + O_2 \longrightarrow 2CaO$ (Basic oxide)

$4Al + 3O_2 \longrightarrow 2Al_2O_3$ (Amphoteric oxide)

$P_4 + 5O_2 \longrightarrow P_4O_{10}$ (Acidic oxide)

$C + O_2 \longrightarrow CO_2$ (Acidic oxide)

$2ZnS + 3O_2 \longrightarrow 2ZnO + 2SO_2$ (Roasting)

$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$ (Combustion)

$2SO_2 + O_2 \xrightarrow{V_2O_5} 2SO_3$ (Catalytic oxidation)

$4HCl + O_2 \xrightarrow{CuCl_2} 2Cl_2 + 2H_2O$ (Catalytic oxidation)

- **Uses :**
  - For artificial respiration in hospitals and by mountaineers, pilots and divers.
  - In oxy-hydrogen and oxy-acetylene torches which are used for cutting and welding of metals.
  - Liquid dioxygen is used as a rocket fuel.

Ozone (O_3) :

- **Preparation :** $3O_2 \xrightarrow{\text{electric discharge}} 2O_3$
- **Properties :** It is a pale blue gas, dark blue liquid and violet black solid.
- **Oxidising action :**

$O_3 \longrightarrow O_2 + O$

$PbS + 4O_3 \longrightarrow PbSO_4 + 4O_2$

$2I^-_{(aq)} + H_2O_{(l)} + O_{3(g)} \longrightarrow 2OH^-_{(aq)} + I_{2(g)} + O_{2(g)}$

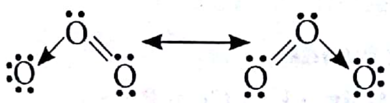
(used for estimation of O_3 by reacting I_2 with hypo.)

- **Reducing action :**

$H_2O_2 + O_3 \longrightarrow H_2O + 2O_2$

$BaO_2 + O_3 \longrightarrow BaO + 2O_2$

- **Structure :**



Oxidation state of O is +1 and −1.

- **Uses :**
  - Used for bleaching ivory, flour, delicate fabrics, etc.
  - As germicide and disinfectant for sterilising water.
  - Manufacture of $KMnO_4$ and artificial silk.

Allotropes of sulphur :

- **Rhombic sulphur (α-sulphur) :** Has S_8 molecules, yellow in colour, m.pt. 385.8 K, specific gravity 2.06 g cm^{-3}, insoluble in water, soluble in CS_2.
- **Monoclinic sulphur (β-sulphur) :** Has S_8 molecules, colourless, needle-shaped crystals, m.pt. 393 K, specific gravity 1.98 g cm^{-3}, soluble in CS_2.

Sulphur dioxide (SO_2) :

- **Preparation :**
  - **By heating sulphur in air :**

    $S + O_2 \xrightarrow{\Delta} SO_2$
  - **Lab method :** By heating Cu with conc. H_2SO_4.

    $Cu + 2H_2SO_4 \longrightarrow CuSO_4 + SO_2 + 2H_2O$

It is also prepared by treating a sulphite with dilute H_2SO_4.

$SO_3{}^{2-}{}_{(aq)} + 2H^+_{(aq)} \longrightarrow H_2O_{(l)} + SO_{2(g)}$

- **Properties :**
  - **As reducing agent :**

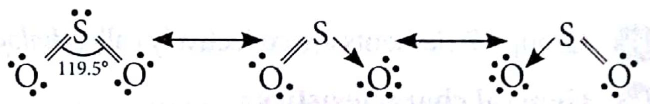
    $SO_2 + Cl_2 + 2H_2O \longrightarrow H_2SO_4 + 2HCl$

    $2KMnO_4 + 5SO_2 + 2H_2O \longrightarrow K_2SO_4 + 2MnSO_4 + 2H_2SO_4$
  - **As oxidising agent :**

    $2H_2S + SO_2 \longrightarrow 2H_2O + 3S\downarrow$
  - **Bleaching action :** Its bleaching action is due to reduction and is temporary.

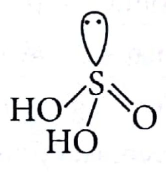
    $SO_2 + 2H_2O \longrightarrow H_2SO_4 + 2[H]$

    Coloured matter + [H] $\longrightarrow$ Colourless matter.
- **Structure :** SO_2 is a gas having sp^2 hybridisation and V-shape.



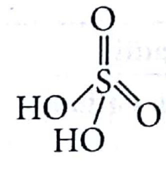
- **Uses :**
  - In the manufacture of sulphuric acid, sulphites and hydrogen sulphide.
  - As a disinfectant, fumigant and preservative.
  - For bleaching delicate articles.

Oxoacids of sulphur :



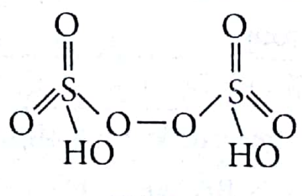
H_2SO_3

Sulphurous acid



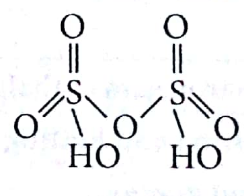
H_2SO_4

Sulphuric acid



$H_2S_2O_8$

Peroxodisulphuric acid

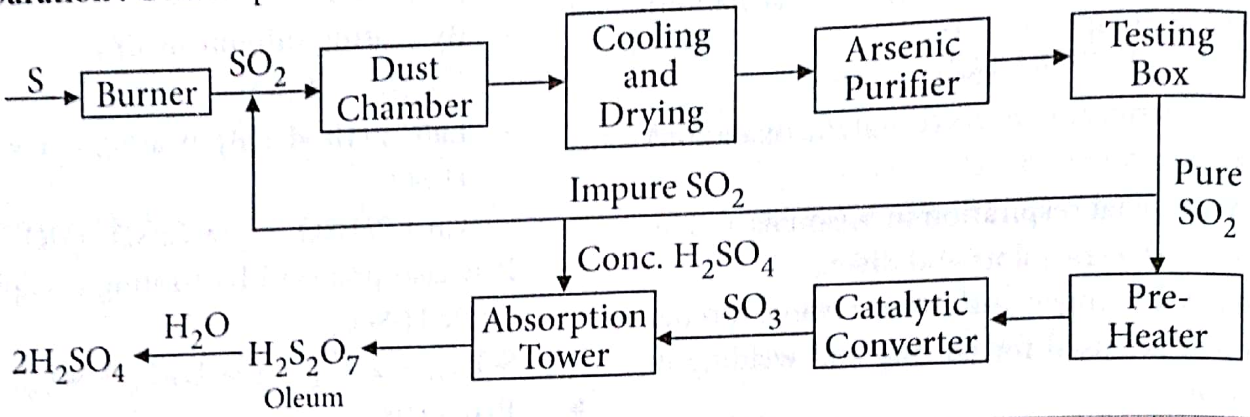


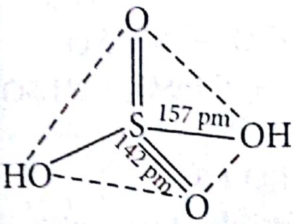
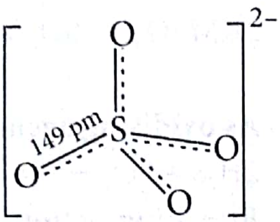
$H_2S_2O_7$

Pyrosulphuric acid (Oleum)

Sulphuric Acid (H_2SO_4) :

- **Preparation :** Contact process :



Structure	Properties	Uses
 Sulphuric acid  Sulphate ion	$H_2SO_4 \xrightarrow{NaOH} NaHSO_4 + H_2O$ $H_2SO_4 \xrightarrow{2NaOH} Na_2SO_4 + 2H_2O$ $H_2SO_4 \xrightarrow{Zn} ZnSO_4 + H_2$ $H_2SO_4 \xrightarrow{C_{12}H_{22}O_{11}} 12C + 11H_2O$ $H_2SO_4 \xrightarrow{S_8} SO_2 + H_2O$ $H_2SO_4 \xrightarrow{Na_2S} Na_2SO_4 + H_2S$ $H_2SO_4 \xrightarrow{BaCl_2} BaSO_4 + 2HCl$ $H_2SO_4 \xrightarrow{K_4[Fe(CN)_6]} K_2SO_4 + FeSO_4 + (NH_4)_2SO_4 + CO\uparrow$	It is used as oxidising agent, dehydrating agent and for the preparation of dyes, drugs, explosives, volatile acids, etc.

GROUP 17 ELEMENTS (HALOGEN FAMILY)

- Group 17 elements are collectively called *halogens.*
- **General characteristics :**

Electronic configuration	ns^2np^5
Elements	$_9F$, $_{17}Cl$, $_{35}Br$, $_{85}At$
Colour and physical state	F_2 (pale yellow gas), Cl_2 (greenish yellow gas), Br_2 (reddish brown liquid), I_2 (purple solid)
Atomic radii	Increase down the group
Ionisation enthalpy	Very high and decreases down the group.
Electronegativity	Decreases down the group.
Electron gain enthalpy	Cl > F > Br > I
Melting and boiling points	Increase down the group
Bond energy	$Cl_2 > Br_2 > F_2 > I_2$
Heat of hydration	$F^- > Cl^- > Br^- > I^-$

- **Chemical properties :**
  - F shows only – 1 oxidation state while other elements show –1, +1, +3, +5 and +7 oxidation states also.
  - **General trends :**
    - **Reactivity :** $F_2 > Cl_2 > Br_2 > I_2$
    - **Boiling points :** HF > HI > HBr > HCl
    - **Melting points :** HI > HF > HBr > HCl
    - **Bond lengths :** HI > HBr > HCl > HF
    - **Bond dissociation enthalpy :** HF > HCl > HBr > HI
    - **Acidic strength :** HI > HBr > HCl > HF
    - **Thermal stability :** HF > HCl > HBr > HI
    - **Reducing power :** HI > HBr > HCl > HF
  - **Oxides :**
    - Fluorine forms two oxides OF_2 and O_2F_2 called *oxygen fluorides*, other halogens form oxides in which oxidation states of these halogens range from +1 to +7.
    - The higher oxides of halogens are more stable than the lower ones.

Metal halides :

- **Ionic character :** $MF > MCl > MBr > MI$
- For metals exhibiting more than one oxidation states, the halides in higher oxidation states will be more covalent than the one in lower oxidation states.

Chlorine (Cl_2) :

Preparation :

$PbO_2 + 4HCl \longrightarrow PbCl_2 + 2H_2O + Cl_2$

$2KMnO_4 + 16HCl \longrightarrow 2KCl + 2MnCl_2 + 8H_2O + 5Cl_2$

$MnO_2 + 4HCl \longrightarrow MnCl_2 + 2H_2O + Cl_2$

Manufacture :

- **Deacon's process :** By oxidation of hydrogen chloride gas by atmospheric oxygen in the presence of $CuCl_2$ at 723 K.

  $4HCl + O_2 \xrightarrow{CuCl_2} 2Cl_2 + 2H_2O$
- **Electrolytic process :** By the electrolysis of brine solution.
- **Down's process :** Obtained as by-product during manufacture of sodium by electrolysis of fused NaCl.

Properties : It is a yellowish green gas, poisonous in nature, soluble in water. Its aqueous solution is known as *chlorine water*.

- **Bleaching action and oxidising property :**

  $Cl_2 + H_2O \longrightarrow HOCl + HCl$

  $HOCl \longrightarrow HCl + [O]$

  Coloured matter + [O] $\longrightarrow$ Colourless matter

The bleaching action of chlorine is permanent and is due to its oxidising nature.

- **Action of hydrogen :**

  $H_2 + Cl_2 \xrightarrow[\text{Charcoal catalyst}]{\text{U.V. light}} 2HCl$
- **Displacement reactions :**

  $2KBr + Cl_2 \longrightarrow 2KCl + Br_2$

  $2KI + Cl_2 \longrightarrow 2KCl + I_2$
- **Action of NaOH :**

  $\underset{\text{(cold)}}{2NaOH} + Cl_2 \longrightarrow NaCl + NaOCl + H_2O$

  $\underset{\text{(hot and conc.)}}{6NaOH} + 3Cl_2 \longrightarrow 5NaCl + NaClO_3 + 3H_2O$
- **Addition reactions :**

  $SO_2 + Cl_2 \longrightarrow SO_2Cl_2$;

  $CO + Cl_2 \longrightarrow COCl_2$

Uses : It is used as a bleaching agent, disinfectant and in the manufacture of $CHCl_3$, CCl_4, DDT, bleaching powder, poisonous gas phosgene ($COCl_2$), tear gas (CCl_3NO_2) and mustard gas ($ClC_2H_4SC_2H_4Cl$).

Hydrochloric acid (HCl) :

Preparation	Properties	Uses
$NaCl + H_2SO_4 \xrightarrow{420\ K} NaHSO_4 + HCl$ $NaHSO_4 + NaCl \xrightarrow{823\ K} Na_2SO_4 + HCl$	Colourless and pungent smelling gas, easily liquifiable, extremely soluble in water. $NH_3 + HCl \longrightarrow NH_4Cl$ $Na_2CO_3 + 2HCl \longrightarrow 2NaCl + H_2O + CO_2$; $Na_2SO_3 + 2HCl \longrightarrow 2NaCl + H_2O + SO_2$ 3 parts of conc. HCl and 1 part of conc. HNO_3 is used for dissolving noble metals *e.g.*, gold, platinum $Au + 4H^+ + NO_3^- + 4Cl^- \longrightarrow AuCl_4^- + NO + 2H_2O$; $3Pt + 16H^+ + 4NO_3^- + 18Cl^- \longrightarrow 3PtCl_6^{2-} + 4NO + 8H_2O$	In manufacture of Cl_2, NH_4Cl and glucose in medicine and as a laboratory reagent. For extracting glue from bones and purifying bone black.

Oxyacids of halogens :

Variation of the general properties of oxyacids of halogens

Halogen	Hypohalous acids (O.S. of halogen = +1)	Halous acids (O.S. of halogen = +3)	Halic acids (O.S. of halogen = +5)	Perhalic acid (O.S. of halogen = +7)
F	HOF	—	—	—
Cl	HClO	$HClO_2$	$HClO_3$	$HClO_4$
Br	HBrO	—	$HBrO_3$	$HBrO_4$
I	HIO	—	HIO_3	HIO_4

– Oxidation number of the central atom increases (+1, +3, +5, +7) →
– Thermal stability increases →
– Covalent character of X—O bond increases →
– Oxidising power decreases →
– Acidity increases →
– Electronegativity of the central atoms remains the same —

↓ Electronegativity decreases —
↓ Thermal stability decreases —
↓ Oxidising power decreases —
↓ Acidic strength decreases —

Interhalogens compounds : Halogens combine amongst themselves to form a number of interhalogens of the type XX', XX'_3, XX'_5 and XX'_7, where X is a larger size halogen (more electropositive) and X' is smaller size halogen.

▶ **Preparation :**

$Cl_2 + F_2 \xrightarrow{437\text{ K}} 2ClF$; (equal volume)

$I_2 + 3Cl_2 \longrightarrow 2ICl_3$ (excess)

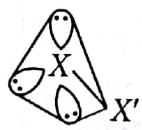
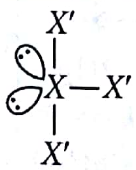
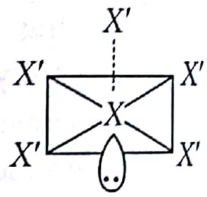
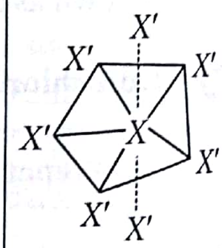
$Cl_2 + 3F_2 \xrightarrow{573\text{ K}} 2ClF_3$; (excess)

$Br_2 + 3F_2 \longrightarrow 2BrF_3$ (diluted with water)

$I_2 + Cl_2 \longrightarrow 2ICl$; (equimolar)

$Br_2 + 5F_2 \longrightarrow 2BrF_5$ (excess)

▶ **Structures :**

Type	Hybridisation	Shape	Structure
XX^1	sp^3	Linear	
XX'_3	sp^3d	T-shaped	
XX'_5	sp^3d^2	Square pyramidal	
XX'_7	sp^3d^3	Pentagonal bipyramidal	

GROUP 18 ELEMENTS (NOBLE GASES)

These are monoatomic gases and are also known as *rare gases* or *aerogens*.

General characteristics :

Electronic configuration	ns^2np^6
Elements	$_2He$, $_{10}Ne$, $_{18}Ar$, $_{36}Kr$, $_{54}Xe$, $_{86}Rn$
Physical state	Gases
Atomic radii	Increase down the group.
Electron gain enthalpy	Positive
Melting and boiling points	Very low due to weak dispersion forces

- **Chemical properties :** Noble gases are least reactive due to high ionization enthalpy and more positive electron gain enthalpy.

Xenon-fluorine compounds :

$$\underset{\text{(excess)}}{Xe} + F_2 \xrightarrow{673\text{ K}, 1\text{ bar}} XeF_2$$

$$\underset{(1:5\text{ ratio})}{Xe} + 2F_2 \xrightarrow{873\text{ K}, 7\text{ bar}} XeF_4$$

$$\underset{(1:20\text{ ratio})}{Xe} + 3F_2 \xrightarrow{573\text{ K}, 60-70\text{ bar}} XeF_6$$

Xenon-oxygen compounds :

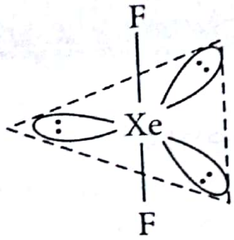
$$6XeF_4 + 12H_2O \longrightarrow 4Xe + 2XeO_3 + 24HF + 3O_2$$

$$XeF_6 + 3H_2O \longrightarrow XeO_3 + 6HF$$

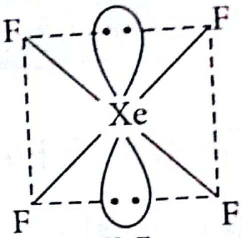
$$XeF_6 + H_2O \longrightarrow XeOF_4 + 2HF$$

$$XeF_6 + 2H_2O \longrightarrow XeO_2F_2 + 4HF$$

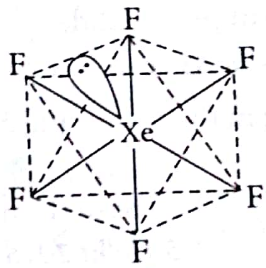
- **Structures of some compounds of xenon :**



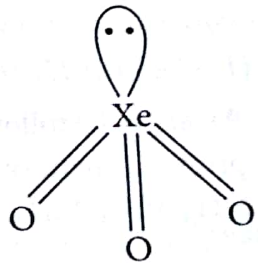
XeF_2
Linear, sp^3d



XeF_4
Square planar, sp^3d^2



XeF_6
Distorted octahedral, sp^3d^3



XeO_3
Pyramidal, sp^3

- **Uses :**

Helium	Neon	Argon	Krypton	Xenon
- To lift weather balloons and air ships. - As breathing mixture. - For inflating the tyres of aeroplanes	- For advertising. - For filling sodium vapour lamps. - In becon light	- To create an inert atmosphere. - In geiger counters. - To date the age of rocks	- For runway and approach lights in airports. - In high efficiency miners' cap lamps.	- In electric flash bulbs for high speed photography. - Krypton and xenon are more efficient than argon in gas filled lamps.