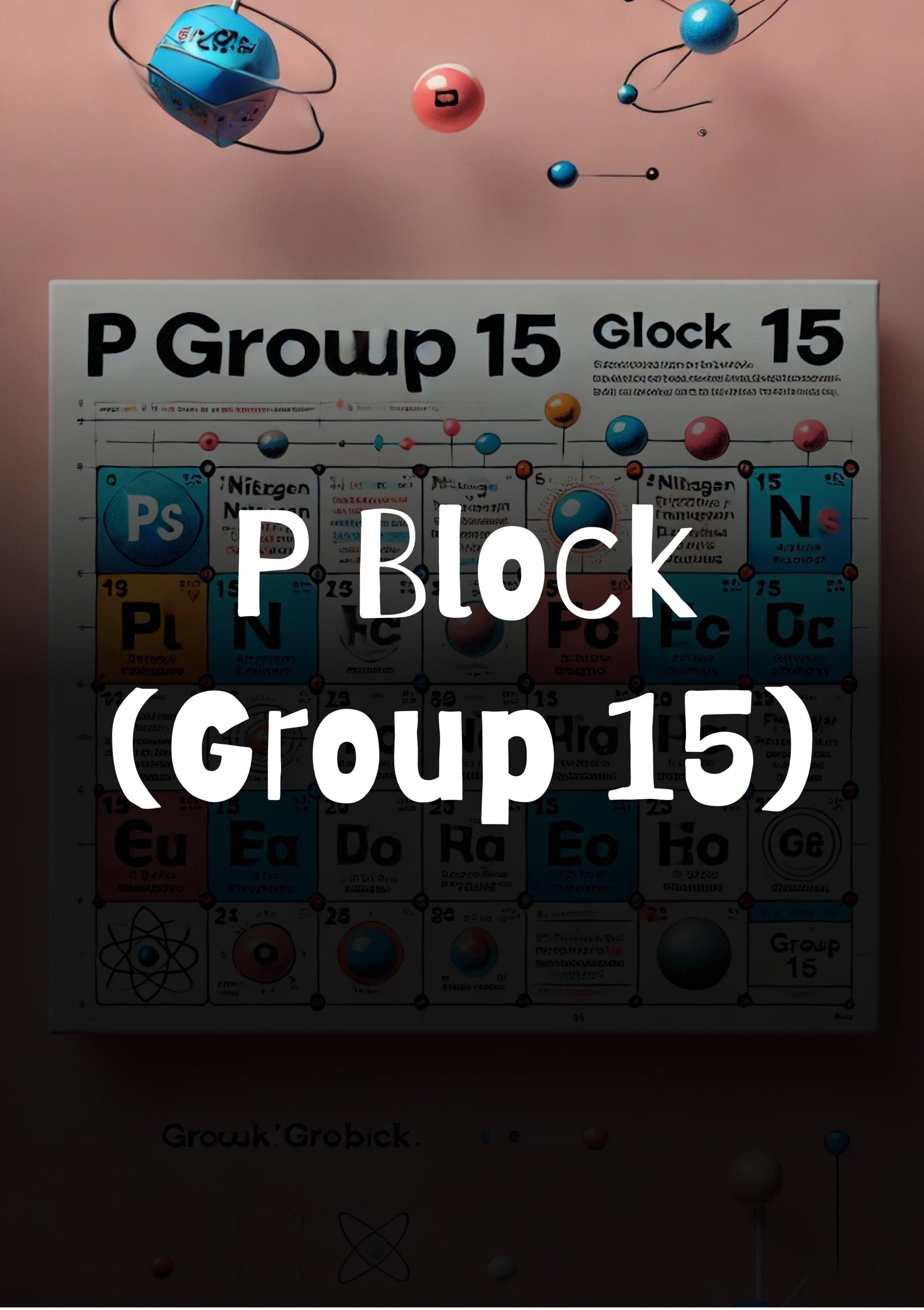


P Block
(Group 15)

* P- Block *

Group - 15

* Nitrogen Family *

N] → Found as $NaNO_3$ (chile Salt Peter) & KNO_3 (Indian salt peter)

non metal

P] → Found as apetatite family $Ca_9(PO_4)_6 \cdot CaX_2$ X = F, Cl, Br, OH

$Ca_9 \cdot (PO_4)_6 \cdot CaF_2$

Fluxapatite

As]
metalloids
Sb]

Bi] metal

* Electronic configuration.

Nitrogen Family → [IG] $ns^2 np^3$ (Half filled configuration) extrastable configuratio

2nd Period	N →	$[He]\ 2s^2\ 2p^3$
3rd	"	P →	$[Ne]\ 3s^2\ 3p^3$
4th	"	As →	$[Ar]\ 3d^{10}\ 4s^2\ 4p^3$
5th	"	Sb →	$[Kr]\ 4d^{10}\ 5s^2\ 5p^3$
6th	"	Bi →	$[Xe]\ 4f^{14}\ 5d^{10}\ 6s^2\ 6p^3$

* Atomic Radius

N
$\wedge$] considerable ↑
P
$\wedge$
As
$\wedge$]
Sb] Small ↑ due to poor shielding of d & f orbital
$\wedge$]
Bi

* Ionization Energy

N
$\vee$
P
$\vee$
As
$\vee$
Sb
$\vee$
Bi

G14 G15
↓
Half filled configuration

$\boxed{G15 > G14}$

* Electronegativity

N

v $\boxed{EN \propto Size}$

P

v

As

v

Sb

||

Bi

* Physical properties

→ all members are polyatomic solid but Nitrogen is diatomic gas

→ B.P → ↑ from top to bottom - N < P < As < Sb > Bi

→ M.P → ↑ upto Arsenic & ↓ upto Bismuth N < P < As > Sb > Bi

→ Allotropy - Except nitrogen all show allotropy because nitrogen do not catenation because $\ddot{N} - \ddot{N}$ is weak

* General oxidation state

−3	+3	+5
↓	↓	↓
Tendency to show −3 oxidation state ↓ down the Group # Bi never forms −3 oxidation state	due to inert pair effect stability of +3 oxidation state ↑ down the group	due to inert pair effect stability of +5 oxidation state ↓ down the group only BiF_5 is form

$$N \rightarrow \boxed{-3}\quad \underbrace{+1\quad +2\quad \boxed{+3}\quad +4}_{\text{when reacts with oxygen}}\quad \boxed{+5}$$

$$P \rightarrow \boxed{-3}\quad \underbrace{+1\quad \boxed{+3}\quad +4}_{\text{In Oxoacids}}\quad \boxed{+5}$$

In Nitrogen, all oxidation state from +1 to +4 tend to disproportional in acid solution

$H\overset{+3}{N}O_2 \longrightarrow H\overset{+5}{N}O_3 + \overset{+2}{N}O + H_2O$

In phosphorous all intermediate oxidation state disproportionate into +5 and -3 in acid / base rxn

* Covalency

$_7N \rightarrow 1s^2\ 2s^2\ 2p^3$

$\underbrace{\boxed{\uparrow\downarrow}}_{\text{1 coordinate bond (lone pair)}} \quad \underbrace{\boxed{\uparrow|\uparrow|\uparrow}}_{\text{3 covalent bond}}$

→ max covalency of Nitrogen is 4

→ But other members of Nitrogen family forms more than 4 bond because of vacant d orbital eg- PF_6^-

* Anomalous Property of Nitrogen.

→ Small size

→ High electronegativity

→ High Ionization potential

→ no vacant d orbital

→ Nitrogen forms pπ - pπ multiple bond N≡N, C≡N, C≡O but other members can form dπ - pπ or dπ-dπ

→ N	P	As	Sb	Bi
N≡N	P-P	As-As	Sb-Sb	× metal

→

→ $\ddot{N}-\ddot{N} < P-P$ (so catenation is weak in nitrogen)

lone pair repulsion

* Chemical Reaction.

1) Reaction with Hydrogen → EH_3 Hydride

$$\begin{array}{cc} E & H \\ 3 & 1 \end{array}$$

$\ddot{N}H_3$ $\ddot{P}H_3$ $\ddot{As}H_3$ $\ddot{Sb}H_3$ $\dot{Bi}H_3$

Stability $1 > 2 > 3 > 4 > 5$

Reducing Nature - $5 > 4 > 3 > 2 > 1$

Basic order - $1 > 2 > 3 > 4 > 5$

2) Reaction with Oxygen - E_2O_5 is more acidic than E_2O_3

$$\begin{array}{cc} E & O \\ 3 & 2 \end{array} \quad \overset{(+3)}{\boxed{E_2O_3}} \qquad \overset{(+5)}{\boxed{E_2O_5}} \quad \begin{array}{cc} E & O \\ 5 & 2 \end{array}$$

as we go down acidic character decreases ↓

N_2O_3, P_2O_3] Acidic.

As_2O_3, Sb_2O_3] Amphoteric

Bi_2O_3] Basic

3) Reaction with Halogen

$\overset{+3}{EX_3}$ $\overset{+5}{EX_5}$ (NX_5 is never formed because max. covalency of Nitrogen is 4)

→ EX_5 is more covalent than EX_3. (Fajan's Rule)

→ Nitrogen trihalides are unstable, but only NF_3 is found to be stable.

→ NCl_3 is explosive.

BiF_3 → ionic

Rest trihalides are covalent

4) Reaction with metal· reacts with metal in -3 oxdn state

Ca^{+2} N^{-3} →

Ca_3N_2	calcium nitride
Ca_3P_2	calcium phosphide
Na_3As	sodium Arsenide
Zn_3Sb_2	zinc Antimonide
Mg_3Bi_2	Magnetium Bismuthide

* Compounds of Nitrogen

1) Dinitrogen (N_2 gas)

Preparation → liquification & fractional distillation of air
commercially

(liq N_2 + liq O_2) → mixture

$$\underset{\text{B·P } 77.2\text{k}}{\downarrow} \qquad \underset{90\text{k}}{\downarrow}$$

distills out first & liquid O_2 is obtained

(ammonium NH_4^+)

Laboratory → अम्मी अजान करती है
Preparation

nitrite	dichromate	azide → very pure
NH_4NO_2	$(NH_4)_2Cr_2O_7$	(Na, Ba) Nitrogen

$NH_4Cl + NaNO_2$
↓

$$NH_4NO_2 \xrightarrow{\Delta} N_2\uparrow + NaCl + H_2O$$

(NO and HNO_3 is also formed here.
and removed by pairing gas through
aq· H_2SO_4 containing $K_2Cr_2O_7$.

$$(NH_4)_2Cr_2O_7 \xrightarrow{\Delta} N_2\uparrow + \underset{\text{(Green)}}{\overset{+3}{Cr_2O_3}} + H_2O$$

$NaN_3 \xrightarrow{\Delta} Na + N_2\uparrow$ (pure) } very pure N_2 } ultra pure N_2.

$Ba(N_3)_2 \xrightarrow{\Delta} Ba + N_2\uparrow$ (pure)

Properties of N_2:

→ colourless, odourless, tasteless, non toxic acid.
→ Two stable isotope N^{14} & N^{15}
→ N_2 is usually inert (non reactive) at room temp because of high bond energy ($N \equiv N$)
→ when T ↑ reactivity ↑
→ N_2 + metal → ionic nitride
$Li + N_2 \rightarrow Li_3N$; $Mg + N_2 \rightarrow Mg_3N_2$
→ N_2 + nonmetal → covalent nitride

N_2 reacts with Hydrogen → Ammonia (Haber's process)

$$N_2(g) + 3H_2(g) \xrightleftharpoons{773K} 2NH_3(g)$$
$\Delta H = -46.1$ kJ/mol (exothermic Reaction)

N_2 reacts with oxygen → nitric oxide (NO)

$$N_2(g) + O_2(g) \longrightarrow 2NO(g)$$

→ Fertilizer
Uses - manufacture of NH_3, calcium cyanamide ($CaCN_2$
Ca^{+2} CN_2^{-2}
Ca^{+2} [$\bar{N} = C = \bar{N}$]

2) NH_3 Ammonia
Preparation - decay of nitrogenous organic matter eg-Urea
$$\underset{\text{Urea}}{NH_2CONH_2} + H_2O \longrightarrow (NH_4)_2CO_3 \xrightarrow{\Delta} NH_3 + H_2O + CO_2$$

on small scale

$NH_4Cl + Ca(OH)_2 \longrightarrow NH_4OH + CaCl_2 \rightarrow NH_3 + H_2O + CaCl_2$

$(NH_4)_2SO_4 + NaOH \rightarrow NH_4OH + Na_2SO_4 \rightarrow NH_3 + H_2O + Na_2SO_4$

on large scale $\boxed{\text{Haber's Process}}$

$N_2(g) + 3H_2(g) \xrightleftharpoons{773K/500°C = 700K} 2NH_3(g)$ Exothermic

200 atm or $\Delta H = -46.1$ kJ/mol

200×10^5 pascal

Catalyst → Iron oxide + K_2O + Al_2O_3

earlier → Iron (Fe) + MO (promoter)

According to Lechatalier's principle → $\boxed{\text{High Pressure \& low Temp}}$

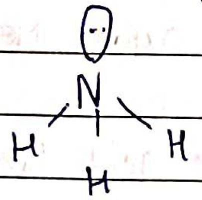
Favors NH_3 Formation

* Properties

→ colorless, Pungent color.

→ Solid / liquid state → it shows Hydrogen bonding

→



→ 3 σ bond. + 1 lone pair

→ sp^3 ; tetrahedral

→ Highly soluble in H_2O. it aqueous is weakly base

$NH_3(g) + H_2O \rightleftharpoons NH_4OH \rightleftharpoons NH_4^+(aq) + OH^-(aq)$

weak base

- Reaction with acid

$NH_3 + HCl \rightarrow NH_4Cl$

$NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$

→ Reaction of aq. ammonia NH_4OH with metal salt. metal forms precipitate.

$$ZnSO_4 + NH_4OH \longrightarrow \underset{\text{White ppt}}{Zn(OH)_2} \downarrow + (NH_4)_2SO_4$$

$$FeCl_3 + NH_4OH \longrightarrow \underset{\text{Brown ppt}}{\underset{Fe_2O_3 \cdot xH_2O}{\underset{\text{or}}{Fe(OH)_3}}} \downarrow + \cancel{+} NH_4Cl$$

→ NH_3 is a lewis base → donates lone pair to metal ion
↳ complex compound

$$\underset{\text{blue}}{Cu^{+2}} + \ddot{N}H_3 \quad \underset{\text{deep blue}}{[Cu(NH_3)_4]^{+2}}$$

$$\underset{\text{White ppt}}{\overset{+}{Ag}Cl} + \ddot{N}H_3 \longrightarrow \underset{\text{colourless}}{[Ag(NH_3)_2]}$$

→ Liq. NH_3 → Refrigrant

* Oxides of Nitrogen

+1	$\overset{+1}{N}_2O$	dinitrogen oxide or nitrous oxide	Neutral	colorless
+2	NO	nitrogen monoxide or nitric acid	Neutral	Colorless
+3	N_2O_3	dinitrogen trioxide	Acidic	blue
+4	NO_2	nitrogen dioxide	Acidic	brown
+4	N_2O_4	dinitrogen tetraoxide	Acidic	Colorless
+5	N_2O_5	dinitrogen Pentaoxide	Acidic	Colorless

N_2O $NH_4NO_2 \xrightarrow{\Delta} N_2 + H_2O$ $:N \equiv N \rightarrow O$

$NH_4NO_3 \xrightarrow{\Delta} N_2O + H_2O$ $N \equiv \underset{\oplus}{N} - \underset{\ominus}{O}$ $N=N=O$

Linear

NO $N_2 + O_2 \xrightarrow{200K} 2NO$

$NH_4NO_2 + FeSO_4 \rightarrow Fe_2(SO_4)_3 + NO + NaHSO_4 + H_2O$ $:\dot{N} = \ddot{O}:$ Odd electron molecule

N_2O_3 $NO + N_2O_4 \rightarrow N_2O_3$

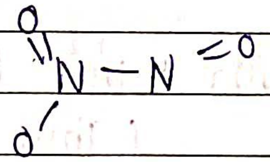
NO_2 $Pb(NO_3)_2 \xrightarrow{\Delta} PbO + NO_2 + O_2$

N_2O_4 $2NO_2 \underset{heat}{\overset{cool}{\rightleftharpoons}} N_2O_4$

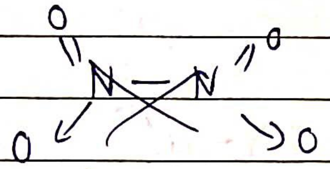
N_2O_5 $2HNO_3 + P_4O_{10} \xrightarrow{-H_2O} N_2O_5 + HPO_3$

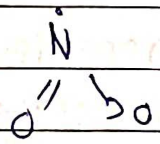
dehydrating agent

N_2O_3

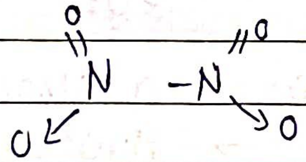


NO_2

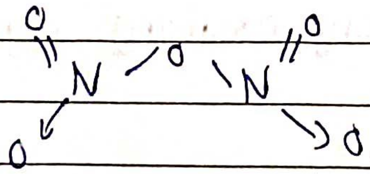




N_2O_4



N_2O_5



* Nitric Acid

$H\overset{+5}{N}O_3$ (nitric acid) $HO-\overset{\overset{O}{\uparrow}}{N}=O$

$H\overset{+3}{N}O_2$ (nitrous acid) $HO-N=O$

$H_2\overset{+1}{N}_2O_2$ (hyponitrous acid) $H-\ddot{\underset{..}{O}}-\ddot{N}=\ddot{N}-\ddot{\underset{..}{O}}-H$

Preparation (Laboratory)

Indian salt peter $KNO_3 + H_2SO_4 \rightarrow HNO_3 + K_2SO_4$.

Chile salt peter $NaNO_3 + H_2SO_4 \rightarrow HNO_3 + Na_2SO_4$

This is prepared in glass retort.

Large Scale preparation (ostwald process)

→ catalytic oxidation of NH_3 by atmospheric oxygen

$$\underset{}{NH_3\,(g)} + \underset{\text{from air}}{O_2\,(g)} \xrightarrow[\text{500k 9atm}]{\text{Pt/Rh guage}} \underset{\boxed{\text{nitric oxide}}}{NO\,(g)} + H_2O$$

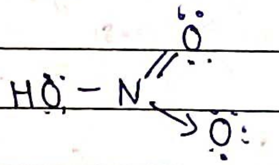
$$NO\,(g) + \underset{\text{From air}}{O_2} \longrightarrow NO_2\,(g)$$

$$\overset{+4}{N}O_2 + H_2O \longrightarrow H\overset{+5}{N}O_3 + \overset{+2}{NO} \quad (\text{disprop})$$

(This is NO is recycled)

HNO3 Properties

→ gaseous state



(Planar) (Resonance)

→ In aq. soln of HNO_3 is a strong acid.

$$HNO_3\,(aq) + H_2O\,(l) \longrightarrow H_3O^+(aq) + NO_3^-\,(aq)$$

→ conc. HNO_3 → Strong oxidising agent (reacts with all me
except noble metal Au,

Reaction with HNO_3

Conc. HNO_3 Any metal $\overset{+4}{N}O_2 + H_2O$ + metal nitrate.

dil HNO_3	Pb, Cu, Ag, Hg	$\overset{+2}{N}O + H_2O$ + metal nitrate
	Fe, Zn	$\overset{+1}{N}_2O + H_2O$ + metal nitrate
	Sn	NH_4NO_3 + metal nitrate.

very dil. HNO_3	Mn Mg	H_2 + metal nitrate
	Fe, Zn, Sn	NH_4NO_3 + metal nitrate

$Cu + HNO_3\ (dil) \rightarrow NO + H_2O + Cu(NO_3)_2$

$Cu + HNO_3\ (conc.) \rightarrow NO_2 + H_2O + Cu(NO_3)_2$

$Zn + HNO_3\ (dil.) \rightarrow N_2O + H_2O + Zn(NO_3)_2$

$Zn + HNO_3\ (conc.) \rightarrow NO_2 + H_2O + Zn(NO_3)_2$

$\boxed{Cr/Al + conc.\ HNO_3 \rightarrow \text{No Reaction}}$

metal becomes Passive ← { oxide layer formation on metal surface

conc. HNO_3 → Strong Oxidising Agent

$HNO_3 \rightarrow NO_2 + [O]$

Non metal + conc. HNO_3 → oxo acid

I_2 + " $\rightarrow HIO_3 + NO_2 + H_2O$

C + " $\rightarrow H_2CO_3 + NO_2 + H_2O$

S_8 + " $\rightarrow H_2SO_4 + NO_2 + H_2O$

P_4 + " $\rightarrow H_3PO_4 + NO_2 + H_2O$

* Brown Ring Test.

→ Test for nitrate (NO_3^-)

→ NO_3^- reacts with Fe^{+2} and $\overset{\text{oxidation}}{\text{converts}}$ into Fe^{+3}

→ dil. Ferrous Sulphate is added to aq. soln containing nitrate ion & carefully conc. H_2SO_4 is added to side walls of test tube.

→ NO reacts with Fe^{+2} and forms Brown ring complex

$[Fe(H_2O)_6]^{+2} + NO \longrightarrow [\overset{+1}{Fe}(H_2O)_5\overset{+1}{NO}]$

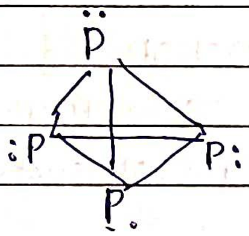
Brown Ring Complex

* Phosphorous - 3 allotrope

1) white phosphorous
2) Red ''
3) Black ''

1) white phosphorous

→ P_4 molecule



→ Tetrahedral (sp^3 hybridization)

→ less stable (angle strain)

→ most reactive betn white, Red, & Black

→ catches fire in air to give dense fumes of P_4O_{10}

$P_4 + 5O_2 \longrightarrow P_4O_{10}$ (white dense fumes)

→ Translucent white waxy solid

→ Poisonous, insoluble in H_2O, soluble in CS_2

→ Glows in dark

→ dissolves in boiling NaOH

$P_4^{0} + NaOH + H_2O \longrightarrow \overset{-3}{P}H_3 + NaH_2\overset{+1}{P}O_2$ (dispron

Sodium Hypophosphite

2) Red phosphorous

→ Heating of white phosphorous at 573 K in inert atmosph

→ Iron grey lustre

→ odourless, non poisonous

→ insoluble in H_2O and CS_2

→ more stable than white phosphorous

→ less reactive than white phosphorous

→ do not glow in dark

→ Polymer of P_4

3) Black phosphorous

Red phosphorous is heated under high pressure → Black phosphoro

α- Black	β- Black
→ Red phosphorous is heated in a sealed tube at 803 K	→ White phosphorous is heated at 473 K under high pressure
→ do not oxidise in air	→ doesn't burn in air upto 673 K

→ Black phosphorous has layered str. like graphite.

* PH_3 Phosphine

→ Calcium phosphide + H_2O / dil HCl → phosphine

$$Ca_3P_2 + H_2O / \text{dil } HCl \longrightarrow \underset{CaCl_2}{Ca(OH)_2} + PH_3$$

Laboratory preparation

$$\text{white } \underset{(P_4)}{P} + NaOH \longrightarrow \overset{-3}{P}H_3 + NaH_2\overset{+1}{P}O_2$$

↓ In pure form - non inflammable becomes inflammable in presence of P_2H_4 or P_4 vapours

To purify PH_3

$PH_3 + HI \rightarrow PH_4I$

$PH_4I + KOH \rightarrow PH_3 + H_2O + KI$

→ colourless, rotten fish smell, highly poisonous

→ explodes in presence of oxidizing agent (HNO_3 or Cl_2 / Br_2 vapour)

→ $CuSO_4 + PH_3 \rightarrow Cu_3P$

→ $HgCl_2 + PH_3 \rightarrow Hg_3P_2$

NH_3 → weak base $PH_3 + HCl \rightarrow \overset{+}{P}H_4 Cl^-$

PH_3 → weak base $PH_3 + HBr \rightarrow PH_4Br$

Phosphorous Halide

PX_3

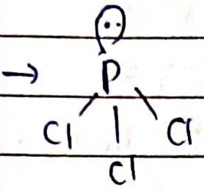
$X = F, Cl, Br, I$

① White P + Cl_2 →

$P_4 + Cl_2 \rightarrow PCl_3$

② White P + thionyl chloride

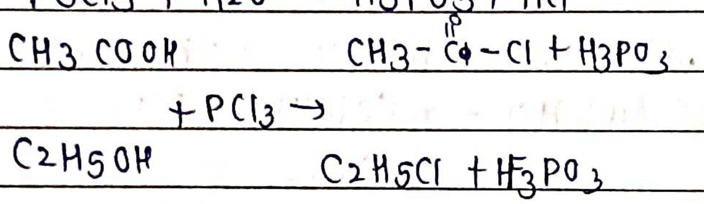
$P_4 + SOCl_2 \rightarrow PCl_3 + SO_2 + S_2Cl_2$

→ 

Pyramidal sp^3

colorless oily liq

· $POCl_3 + H_2O \rightarrow H_3PO_3 + HCl$



$CH_3COOH \quad + PCl_3 \rightarrow \quad CH_3-\overset{O}{\overset{\|}{C}}-Cl + H_3PO_3$

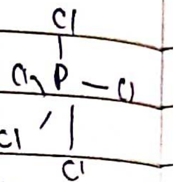
$C_2H_5OH \quad + PCl_3 \rightarrow \quad C_2H_5Cl + H_3PO_3$

PX_5

$X = F, Cl, Br$

$P_4 + \underset{\text{excess}}{Cl_2} \rightarrow PCl_5$

$P_4 + SO_2Cl_2 \rightarrow PCl_5 + SO_2$

→ gas / liq → TBP 

2 axial bonds are longer (weak) than equatorial (Strong)

$PCl_5 \xrightarrow{\Delta} PCl_3 + Cl_2$ (20Fj QUP)

→ Solid $[PCl_6^-]$ $[PCl_4^+]$

$[PCl_6^-]$ ↓ sp^3d^2 Octahedral

$[PCl_4^+]$ ↓ sp^3 tetrahedra

→ Yellowish white powder

$PCl_5 + H_2O \rightarrow POCl_3 + HCl$

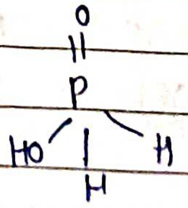
$POCl_3 + H_2O \rightarrow H_3PO_3 + HCl$

$C_2H_5OH + PCl_5 \rightarrow C_2H_5-Cl + POCl_3 + HCl$

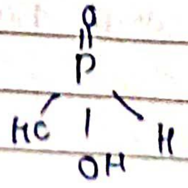
$CH_3COOH + PCl_5 \rightarrow CH_3COCl + POCl_3 + HCl$

✱ Oxoacid of phosphorous

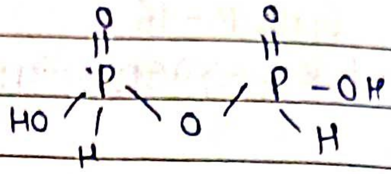
+1 H_3PO_2 Hypophosphorous acid (Phosphinic)



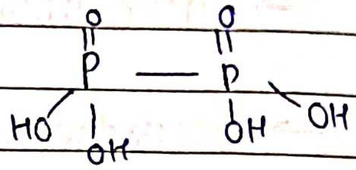
+3 H_3PO_3 Orthophosphorous (Phosphonic)



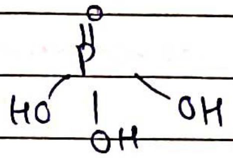
+3 $H_4P_2O_5$ pyrophosphorous



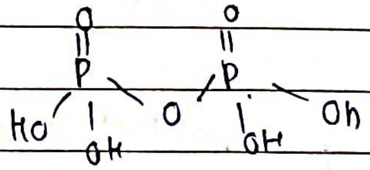
+4 $H_4P_2O_6$ Hypophosphorous



+5 H_3PO_4 Orthophosphorous

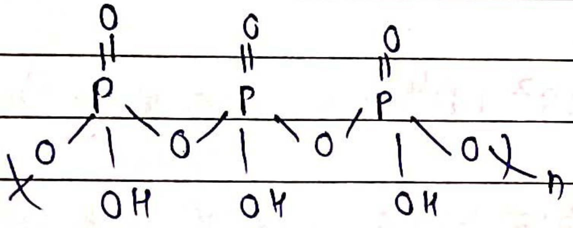


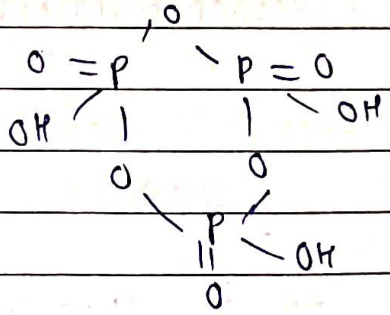
+5 $H_4P_2O_7$ pyrophosphorous



+5 $(HPO_3)_n$ metaphosphoric — cyclic meta → $(HPO_3)_n$ ↓ n=3

— poly meta





Group - 16

* Oxygen Family *

O → most abundat on Earth

S → Occurence → sulphates → gypsum ($CaSO_4 \cdot 2H_2O$)
Epsom salt ($MgSO_4 \cdot 7H_2O$)
Baryte ($BaSO_4$)
→ sulphide - Galena - PbS
zinc blende - ZnS
copper pyrites - $CuFeS_2$

Se } → metal selenides
Te } metal Tellurides.

Po → decay product of Thorium & Uranium

* Electronic configⁿ - $ns^2\ np^4$

* Atomic & Ionic Radius - G15 > G16
$O < S < Se < Te < Po$ (size)

* IE - G15 > G16
Half filled configⁿ
$O > S > Se > Te > Po$ (I.E)

* Electron gain enthalpy -
$Al > Ga > In > Tl > \textcircled{B}$
$S > Se > Te > \textcircled{O}$
$\boxed{Si > C} > Ge > Sn > Pb$
$\boxed{P > N} > As > Sb > Bi$
$\boxed{Cl > F} > Br > I$

Electronegativity: O > S > Se > Te > PO

metallic character O < S < Se < Te < PO

* Physical property

O } non metal
S }
Se } metalloid
Te }
] all show allotropy

PO → metal (Radioactive)

* M.P & B.P – $\underbrace{O < S}$ < Se < Te

large diff betn MP & B.P

O_2 S_8

* Chemical property

Oxidation State

O	-2	+2	X	X
S	-2	+2	+4	+6
Se	-2	+2	+4	+6
Te	-2	+2	+4	+6
PO	X	+2	+4	X

→ Stability of -2 oxidation ↓ down the group (PO → -2 ✗)

→ Oxygen - generally shows -2 but $\underset{+2}{OF_2}$ & $\underset{+1}{O_2F_2}$

→ due to inert pair effect - stability of lower oxidation state (+4) ↑ and stability of high oxidation state (+6) ↓

* Anomalous Behaviour of oxygen

→ small size and high I.E & high EN.

→ H_2O → shows Hydrogen bond

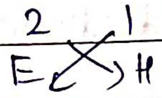
H_2S
H_2Se } Do not show H bond.
H_2Te

S, Se, Te - covalence more than 4
↑

→ max. covalency is 4 (absence of d orbital) → generally 2 bond

* Reactivity with H - Hydride

$H_2E \rightarrow$ O, S, Se, Te



H_2E

H_2O H_2S H_2Se H_2Te

① acidic character - $H_2O < H_2S < H_2Se < H_2Te$

② Thermal stability $H_2O > H_2S > H_2Se > H_2Te$

③ Reducing property - $H_2O < H_2S < H_2Se > H_2Te$
↓
do not show Reducing property

MP & BP - $H_2O > H_2Te > H_2Se > H_2S$
↑
H-Bond

Reaction with oxygen - oxide (both EO_2 & EO_3 are acidic oxides)

EO_2	EO_3
O_3 } gas	SO_3
SO_2 } gas	SeO_3
SeO_2 → solid	TeO_3
TeO_2	

Reducing nature of dioxide

$SO_2 > SeO_2 > TeO_2$

Reducing Agent   oxidising agent

* Reaction with Halogen → Halide

EX_2 | EX_4 | EX_6

Stability of halide $F^- \ngtr Cl^- > Br^- > I^-$

EX_4 ↓ Tetrahalide ↓ Tetraflorides

$SF_4 \rightarrow$ gas

$SeF_4 \rightarrow$ liq.

$TeF_4 \rightarrow$ Solid

EX_6 ↓ Hexahalide ↓ Only hexa floride is stable ⇓ all hexa floride are gases ⇓

$SF_6 \rightarrow$ exceptionally stable (steric reason

→ monohalides exists as dimer

eg- S_2F_2, S_2Cl_2, S_2Br_2, Se_2Cl_2, Se_2Br_2

These dimer → disproportionate

$$\overset{+1}{Se_2}Cl_2 \longrightarrow \overset{+4}{Se}Cl_4 + \overset{0}{Se}$$

* Dioxygen (O_2)

Lab prepn:- ① Heating oxygen containing salt (chlorate, nitrate, permagnate)

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

② Thermal decomposition of less reactive metal oxide
↳ down in reactivity series

$$Ag_2O \xrightarrow{\Delta} Ag + O_2$$

$$HgO \xrightarrow{\Delta} Hg + O_2$$

$$Pb_3O_4 \xrightarrow{\Delta} PbO + O_2$$

$$PbO_2 \xrightarrow{\Delta} PbO + O_2$$

③ decomposition of H_2O by catalyst ↗ Finely divided metal & MnO_2

$$2H_2O_2(aq) \longrightarrow 2H_2O(l) + O_2(g)$$

Large scale prepn electrolysis of H_2O [↱ H_2 gas → cathode
↳ O_2 gas → anode

industrial → air
Prepn ↓ remove CO_2 & water vapour
↳ remaining gas are liquified & upon Fractional distillation gives N_2 & O_2

Properties. colorless, odorless ; liquifying temp → 90k
freezing temp → 55k ; 3 stable isotope O^{16} O^{17} O^{18}
O_2 → paramagnetic (MOT)

metal / non-metal + O_2 → Oxide except Au, Pt

$Ca + O_2 \rightarrow CaO$

$Al + O_2 \rightarrow Al_2O_3$

$P_4 + O_2 \rightarrow P_4O_{10}$

$C + O_2 \rightarrow CO_2$

$ZnS + O_2 \rightarrow ZnO + SO_2$

$CH_4 + O_2 \rightarrow CO_2 + H_2O$

$SO_2 + O_2 \xrightarrow{V_2O_5} SO_3$

$HCl + O_2 \xrightarrow{CuCl_2} Cl_2 + H_2O$

Oxide

Simple oxide
MgO, Al_2O_3

Mixed Oxide
Pb_3O_4, Fe_3O_4
↓
PbO FeO
PbO_2 Fe_2O_3

Types of simple oxide

1) Acidic Oxide
Oxide + H_2O → Acid

$\overset{+4}{SO_2}$, $\overset{+7}{Cl_2O_7}$, $\overset{+4}{CO_2}$, N_2O_5

SO_2 ↓ H_2O ↓ $H_2\overset{+4}{S}O_3$

Cl_2O_7 ↓ $H\overset{+7}{Cl}O_4$

CO_2 ↓ $H_2\overset{+4}{C}O_3$

N_2O_5 ↓ $H\overset{+5}{N}O_3$

2) Basic Oxide
Oxide + H_2O → Base

$Na_2O \rightarrow NaOH$

$CaO \rightarrow Ca(OH)_2$

$BaO \rightarrow Ba(OH)_2$

3) Ampholeric oxide

Oxide — Acidic
　　　 — Basic

Al_2O_3

$Al_2O_3 + 6HCl \xrightarrow{H_2O} [Al(H_2O)_6]^{+3} + 6Cl^-$

$Al_2O_3 + 6NaOH \xrightarrow{H_2O} Na_3[Al(OH)_6]$

4) Neutral oxide

neither Acidic nor basic

→ NO, CO, N_2O, H_2O

Generally, metal oxide → basic
non metal oxide → acidic.

But some metal oxides in high oxidation state - acidic

$\overset{+7}{Mn}_2O_7$　$\overset{+6}{Cr}\cancel{2}O_3$　$\overset{+5}{V}_2O_5$

* Ozone

→ allotrope of oxygen

Preph - steam of oxygen is passed through silent electric discharge

conversion of O_2 to O_3 → is only 10%.

$3O_2 \longrightarrow 2O_3$　$\boxed{\Delta H = +ve}$

Ozonised oxygen

→ since rxn → endothermic, so silent electric discharge is used to prevent decomposition of ozone

→ if more than 10% ozone is required, a battery of ozonizer used. pure ozone is condensed in vessel surrounded by liq O_2.

Properties → Pure O_3 → Pale blue gas, dark blue liq, violet black soln

→ O_3 - Thermodynamically unstable.

$\# \; O_3 \rightarrow O_2$ — $\Delta H = -ve$, $\Delta S = +ve$ } $\Delta G = -ve$ spontaneous rxn

$\# \; O_3 \rightarrow O_2 + [O]$ → Powerful oxidizing agent

$\# \; SO, \; S^{-2} \rightarrow \overset{+6}{S}O_4^{-2}$

$I^- \rightarrow I_2^0$

$PbS + O_3 \longrightarrow PbSO_4 + O_2$

$I^- + O_3 \longrightarrow I_2 + O_2$

Depletion of ozone layer

→ NO gas emmited from supersonic jet aeroplane deplete ozone layer.

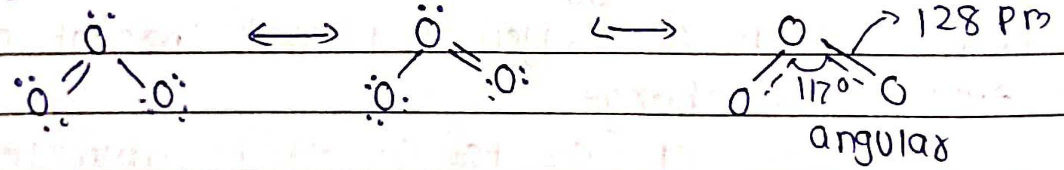
$NO(g) + O_3 \longrightarrow NO_2(g) + O_2(g)$

→ Use of freons deplete ozone layer

aerosol spray

& refrigrant

→ Structure



Sulphur allotrope

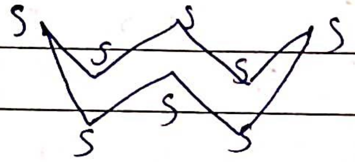
Rhombic sulphur	Monoclinic sulphur
(yellow)	β-sulphur
α-sulphur	stable above 369 k
Stable at room temp (below 369 k)	

α sulphur $\xrightleftharpoons{369 k}$ β sulphur

below 369 k	after 369 k	at 369 k both α & β
α sulphor stable	β sulphur stable	sulphur stable

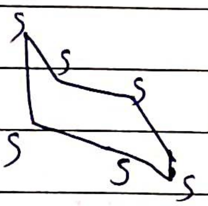
α - Sulphur	β - Sulphur
Prepⁿ roll sulphur + CS_2 $\xrightarrow{evaporate}$ α-sulphur	→ Soluble in CS_2 → melting α sulphur in a dish & cooling till crust is formed
→ Insoluble in H_2O → partly dissolve in Benzene Alcohol, ether. → soluble in CS_2	→ Two holes are made in crust and remaining liq is poured out → on removing crust needle shape β sulphur is formed

→ Both α and β sulphur → S_8 molecule



crown shape·

→ S_6 form
Chair form



T ≥ 1000 k
S_2 - Paramagnetic
like O_2

SO_2 prepⁿ

$S + O_2 \longrightarrow SO_2$ (6-8% SO_3 is also formed)

lab prepⁿ - $SO_3^{-2}(aq) + H^+(aq) \rightarrow H_2O(l) + SO_2(g)$
sulphite acidic solⁿ

industrial biproduct of roasting of sulphide ore
Prepⁿ $FeS_2 + O_2(g) \rightarrow Fe_2O_3(s) + SO_2(g)$

Properties

$\overset{+4}{SO_2} + H_2O \longrightarrow \overset{+4}{H_2SO_3}$

$SO_2 + NaOH \longrightarrow Na_2SO_3 + H_2O$ } lime water turns milky

$Na_2SO_3 + SO_2 \longrightarrow NaHSO_3$

$SO_2 + Cl_2 \xrightarrow[\text{catalyst}]{\text{charcoal}} SO_2Cl_2$ Sulphuryl chloride

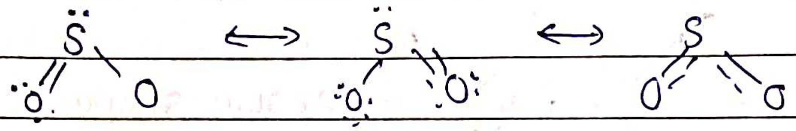
$SO_2 + O_2 \xrightarrow[\text{catalyst}]{V_2O_5} SO_3$

Moist SO_2 → behave - Reducing Agent → Fe^{+3} → Fe^{+2}

Permagnate decolori

$Fe^{+3} + SO_2 + H_2O \longrightarrow Fe^{+2} + SO_4^{-2} + H^+$

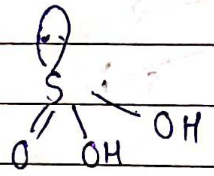
$\overset{+7}{Mn}O_4 + SO_2 + H_2O \longrightarrow Mn^{+2} + SO_4^{-2} + H^+$



Oxoacids of sulphur

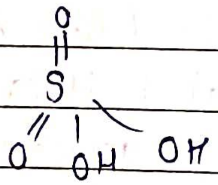
$\overset{+4}{H_2SO_3}$

sulphurous acid



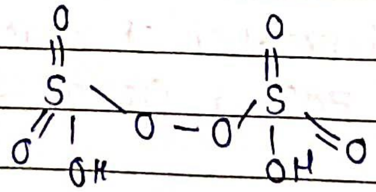
$\overset{+6}{H_2SO_4}$

Sulphuric acid



$H_2S_2O_8$

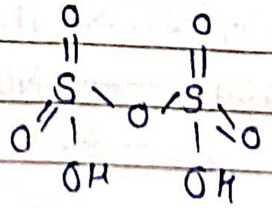
Peroxodisulphuric acid



$H_2S_2O_7$

Pyrosulphuric acid

Coleum



Sulphuric acid

Prepn contact process → 3 step process

① Burning of sulphur or sulphide ore → SO_2 produce

② $SO_2 + O_2 \xrightarrow{V_2O_5} SO_3$

③ $\overset{+6}{S}O_3 + H_2SO_4 \longrightarrow H_2S_2O_7$ $\boxed{\text{oleum}}$

dilution of oleum ($H_2S_2O_7$) with H_2O → H_2SO_4 of desired concn.

H_2SO_4 obtained by contact process → 96·98% pure

Property.

→ dissolves in H_2O → releases high amount of energy

→ conc. H_2SO_4 is added in H_2O slowly by const stirring

→ In aq. soln $K_a > 10$

$H_2SO_4(aq) + H_2O(l) \longrightarrow H_3O^+(aq) + HSO_4^-(aq)$ K_a - very large

$HSO_4^-(aq) + H_2O(l) \longrightarrow H_3O^+(aq) + SO_4^{2-}(aq)$ $K_a \rightarrow 1.2\times10^{-2}$

conc. H_2SO_4 → dehydrating agent

$$C_{12}H_{22}O_{11} \xrightarrow[\text{conc. } H_2SO_4]{} 12C + 11H_2O$$

Hot conc. H_2SO_4 → moderate oxidizing Agent

↳ Reduce → SO_2

Cu + conc H_2SO_4 → $CuSO_4 + SO_2$

S + " → $SO_2 + H_2O$

C + " → $CO_2 + SO_2 + H_2O$

Group-17

Halogen Family

Greek halo means salt and genes means born i.e salt producers.

Fluorine	F	9	$[He]\ 2s^2\ 2p^5$	फिर
Chlorine	Cl	17	$[Ne]\ 3s^2\ 3p^5$	कल
Bromine	Br	35	$[Ar]\ 3d^{10}\ 4s^2\ 4p^5$	बाहर
Iodine	I	53	$[Kr]\ 4d^{10}\ 5s^2\ 5p^5$	आई
Astatine	At	85	$[Xe]\ 4f^{14}\ 5d^{10}\ 6s^2\ 6p^5$	आंटी
Tennessine	Ts	117	$[Rn]\ 5f^{14}\ 6d^{10}\ 7s^2\ 7p^5$	रिस्ता

Note- Astatine and Tennesine are radioactive Elements.

Tennessine- It is a synthetic radioactive element. Atomic mass is 294, only very small amount of element could be prepared. Also its half life is in miliseconds only, so its chemistry could not be established.

Occurence

F → F is present as insoluble flourides like fluorspar(CaF_2) Cryolite (Na_3AlF_6) & in small quantities in soil, river water, plants, bone as well as teeth of animals

→ Cl, Br, I are present as chlorides, Bromide, iodide of sodium, potassium, calcium, Magnesium etc

→ The dried up seas contain sodium chloride and Cornalite ($KCl.MgCl_2.6H_2O$)

→ Iodine is also present in sea weeds (0.5% iodine) and chile salt petre contains upto 0.2% of sodium iodide

* Electronic configuration. Outermost shell electronic configuration is $ns^2 np^5$

* Atomic and ionic radii
Size increases down the group due to increase in no. of shells, Halogens have smallest size in their respective periods due to high Zeff.

* Ionization enthalpy.
Due to low tendency to lose electron, they have high IE
Down the group I.E ↓ due to ↑ in size.

* Electron gain Enthalpy. $Cl > F > Br > I$
F has less electron gain enthalpy than Cl because of its small size and incoming e^- feels repulsive force from valence e^- So some energy is absorbed to overcome the repulsive force and net energy released is decreases

* Electronegativity. They have very high E.N Down the Group EN ↓. F is most EN element in periodic table

* Physical properties

Physical state- F, Cl → Gases, Br - liquid, I - solid.
MP & B.P. ↑ down the Group with ↑ in atomic ~~size~~ no.
Colour - F_2 (yellow), Cl_2 (Greenish Yellow), Br_2 (Red)
I_2 (violet)
Bond dissociation Enthalpy - $Cl-Cl > Br-Br > F-F > I-I$
Reason for this is large electron-electron repulsion among the lone pairs in F_2 molecule due to which than Cl, Br they require less bond dissociation enthalpy

Solubility. F & Cl react with water, Br and I sparingly soluble in water but soluble in various organic solvents such as chloroform, CCl_4, CS_2, etc.

Q Why Fluorine is stronger oxidizing agent than Chlorine?
i) low enthalpy of dissociation of F-F bond.
ii) High Hydration enthalpy of F^-

Oxidation state - All halogen exhibit -1 oxidation state Cl, Br and I exhibit +1, +3, +5 and +7 O.S also O.S of +4 and +6 occur in Oxides and oxoacids of Cl and Br

The F atom has no d orbital in its valence shell and therefore cannot expand its octet. Being the most EN it shows only -1 O.S

Note- A halogen oxidise halide ions of higher atomic number Ex- $F_2 + 2X^- \longrightarrow 2F^- + X_2$ ($X = Cl, Br,$ or I)

Note - Fluorine oxidies water in oxygen

$$2F_2 + 2H_2O \longrightarrow 4H^+ + 4F^- + O_2$$

Cl and Br react with water to form corresponding hydrohalic & hyphalous acids Ex- $X_2 + H_2O \longrightarrow HX + HOX$

Reaction of I with water is non spontaneous. I^- can be oxidised by oxygen in acidic medium.

$$4I^- + 4H^+ + O_2 \longrightarrow 2I_2 + 2H_2O$$

* Anamalous behaviour of Fluorine

→ IE, EN, electrode potential are higher for F than expected from the bends set by halogens

→ covalent & ionic radii, MP & BP, bond dissociation enthalpy and electron gain enthalpy is quite lower than expected.

→ Most of F reactions are exothermic.

→ only shows -1 O.S.

→ It forms only one oxoacid i.e HOF

→ Hydrogen Fluoride (HF) is a liquid due to strong H- bonding

→ Act as strong oxidizing agent.

Reason - Due to smaller size, higher EN and non ovaibality of d orbital.

* Chemical properties

Reaction with Hydrogen

$X + H_2 \longrightarrow XH$ (Hydrogen halide)

$F_2 + H_2 \longrightarrow HF$ $\quad$ $Br_2 + H_2 \longrightarrow HBr$

$Cl_2 + H_2 \longrightarrow HCl$ $\quad$ $I_2 + H_2 \longrightarrow HI$

Bond / Strength / Stability - Stability of these halides ↓ down the group due to ↓ in bond (H-X) dissociatio

$HF > HCl > HBr > HI$

Acidic character - ↑ down the grp due to ↓ in H-X bond dissociation energy $HF < HCl < HBr < HI$

Reducing nature - Releases H easily

$HF < HCl < HBr < HI$

Note - Hydrogen halides dissolve in water to form hydrohalic aci
HF act as a very strong reducing agent.

Physical State - Except HF all others are gases at room temp. but HF is liquid.

Reaction with oxygen. Most of halogen oxides are unstable
F forms only 2 oxides i.e
OF_2 - Thermally stable at 298 K
O_2F_2 - It oxidise plutonium as PuF_6 from spent nuclear Fue

Cl, Br, & I form oxides in which O.S of these halogen Range from +1 to +7

Chlorine oxides - Cl_2O, ClO_4, Cl_2O_6, Cl_2O_2
Highly reactive oxidizing agent & tend to explode
Note - ClO_2 is used in bleaching agent

Bromine oxides - Br_2O, BrO_2, BrO_3 these are least stable exist only at low temp & powerful oxidising agent

Iodine oxides, I_2O_5, I_2O_4, I_2O_7 these are insoluble solids & decomposes on heating.
Note - I_2O_5 is a very good oxidising agent and its is used in the estimation of CO.

Stability of oxides - I > Cl > Br (Due to combination of kinetic and thermodynamic factor)

Reaction towards metals · $M + X \rightarrow MX$ (metal halides)
Ex - $Mg + Cl_2 \rightarrow MgCl_2$
If M is a monovalent Metal then
Ionic character $MF > MCl > MBr > MI$

Note - Halide in Higher O.S will be more covalent than the one in lower O.S Ex $SnCl_4$ is more covalent than $SnCl_2$.

Reactivity of halogen towards other halogen.
Halogen combine amongst themselves to form a no. of compounds called interhalogens

Chlorine
i) Preparation - Using Manganese dioxide.

$$MnO_2 + HCl_{(conc.)} \xrightarrow{\Delta} MnCl_2 + Cl_2 + H_2O$$

$$MnO_2 + NaCl + H_2SO_4 \xrightarrow{\Delta} MnCl_2 + Cl_2 + H_2O + NaHSO_4$$

ii) By action of HCl on potassium permanganate

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

Manufacture
i) Decon's process - Oxd^n of HCl

$$HCl + O_2 \xrightarrow[CuCl_2]{723K} Cl_2 + H_2O$$

ii) Electrolytic process - Electrolysis of brine (conc. NaCl soln)

$$NaCl + H_2O \longrightarrow NaOH + H_2 + Cl_2 \quad \text{(at anode)}$$

Properties. Greenish yellow gas, pungent odour & suffocating odour, easily liquified, soluble in water. 2-5 times heavier than air

Reaction with metal

Ex- $Al + Cl_2 \rightarrow AlCl_3$

$Na + Cl_2 \rightarrow NaCl$

$Fe + Cl_2 \rightarrow FeCl_3$

Reaction with nonmetal

Ex- $P_4 + Cl_2 \rightarrow PCl_3$

$S_8 + Cl_2 \rightarrow S_2Cl_2$

Reaction with H containing compounds

Ex. $H_2 + Cl_2 \rightarrow HCl$

$H_2S + Cl_2 \rightarrow HCl + S$

$C_{10}H_{16} + Cl_2 \rightarrow HCl + C$

Rxn with cold & dilute alkali to produce chloride & hypochlorite

$NaOH + Cl_2 \rightarrow NaCl + NaOCl + H_2O$

Rxn with hot & conc. alkali to give chloride & chlorate

$NaOH + Cl_2 \rightarrow NaCl + NaClO_3 + H_2O$

Rxn with dry slaked lime to give bleaching powder

$Ca(OH)_2 + Cl_2 \rightarrow Ca(OCl)_2 + CaCl_2 + H_2O$

Rxn with hydrocarbon Ex-

$CH_4 + Cl_2 \xrightarrow{UV} CH_3Cl + HCl$ (Metal chloride)

$C_2H_4 + Cl_2 \xrightarrow{Room\ t.} C_2H_4Cl_2$ (1,2 Dichloroethane)

Rxn with ammonia ex-

$NH_3\ (excess) + Cl_2 \rightarrow NH_4Cl + N_2$

$NH_3 + Cl_{2\,(excess)} \rightarrow NCl_3 + HCl$

Oxidation by Cl_2 Ex

$FeSO_4 + H_2SO_4 + Cl_2 \rightarrow Fe_2(SO_4)_3 + HCl$

$Na_2SO_3 + Cl_2 + H_2O \rightarrow Na_2SO_4 + HCl$

$SO_2 + Cl_2 + H_2O \rightarrow H_2SO_4 + HCl$

$I_2 + Cl_2 + H_2O \rightarrow HIO_3 + HCl$

Bleaching effect of Cl_2 - Chlorine is a powerful bleaching agent, bleaching action is due to oxidation, which is permanent i.e.

$Cl_2 + H_2O \longrightarrow 2HCl + [O]$ (nascent oxygen)

coloured substance + [O] → colourless substance

Uses. For bleaching wood pulp, cotton and textiles, extraction of gold and platinum, manufacture of dyes drugs, organic compounds such as CCl_4, $CHCl_3$, DDT, refrigrant, used in sterilising drinking water

Q.) Name two poisonous which can be prepared from Cl_2?

Phosgene ($COCl_2$), tear gas (CCl_3NO_2) Mustard gas ($CCKH_2CH_2SCH_2CH_2Cl$).

Q) $Cl_2 + NaOH \longrightarrow NaCl + NaClO_3 + H_2O$. Is this reaction a disproportionate reaction

Yes chlorine forms a oxidation state is changed to -1 an +5 oxidation states

Note- Chlorine was discovered by Scheele in 1774 by action of HCl on MnO_2. In 1810 Davy established its elimentary nature & suggested name chlorine on account of its colour (Greek chloros - greenish yellow)

* Hydrogen Chloride (HCl)

Glauber prepared this acid in 1648 & Davy in 1810 showed that it is compound of H and Cl.

Preparation (lab) - $NaCl + H_2SO_4 \xrightarrow{420K} NaHSO_4 + HCl$

$NaHSO_4 + NaCl \xrightarrow{823K} Na_2SO_4 + HCl$

HCl can be dried by passing through concentrated H_2SO_4

Properties · Colourless, pungent smelling gas, easily liquified extremely soluble in water, freezes to a white crystalline solid.

It aqueous soln in water is called hydrochloric acid

$HCl(g) + H_2O(l) \longrightarrow H_3O^+(aq) + Cl^-(aq)$ · $ka = 10^7$

High value of dissociation constant (ka) indicates that it is a strong acid in water

Rxn with ammonia – $NH_3 + HCl \rightarrow NH_4Cl$

Hydrochloric acid decomposes salts of weaker acid

$Na_2CO_3 + HCl \rightarrow NaCl + H_2O + CO_2$

$NaHCO_3 + HCl \longrightarrow NaCl + H_2O + CO_2$

$Na_2SO_3 + HCl \longrightarrow NaCl + H_2O + CO_2$

Uses.- Used in manufacture of chlorine, NH4Cl, glucose, extracting glue from bones & purifying bone black In medicine and as a laboratory reagent

Aqua regia.

when 3 parts of conc. HCl and 1 part of conc. HNO_3 are mixed, aqua regia is formed which is used for dissolving noble metals eg - gold, platinum

$Au + 4H^+ + NO_3^- + 4Cl^- \longrightarrow AuCl_4^- + NO + 2H_2O$

$3Pt + 16H^+ + 4NO_3^- + 18Cl^- \longrightarrow 3PtCl_6^{2-} + 4NO + 8H_2O$

Q.' when HCl reacts with finely powdered iron, it forms ferrous chloride and not ferric chloride why?

The rxn with iron produces H_2 which prevents formn of ferric chloride · i.e $Fe + 2HCl \rightarrow FeCl_2 + H_2$

* Oxaacids of Halogens

Halic (I) acid (Hypohalous acid)

HOF - Hypofluorous acid HOBr - Hypobromous acid

HOCl - Hypochlorous acid HOI - Hypoiodous acid

Note- Due to high EN and small size F forms only one oxoacid

Halic (III) acid (Halous acid)

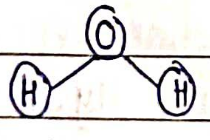
HOClO - Chlorous acid

Halic (V) acid (Halic acid)

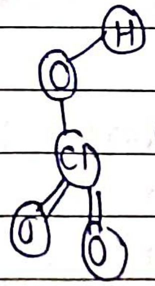
$HOClO_2$	$HOBrO_2$	$HOIO_2$
Chloric acid	Bromic acid	Iodic acid

Halic (VII) acid (Perhalic acid)

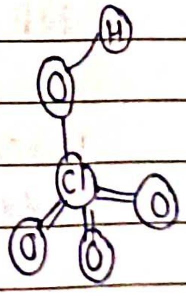
$HOClO_3$	$HOBrO_3$	$HOIO_3$
perChloric acid	Perbromic acid	Iodic acid



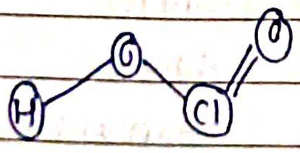
Hypochlorous acid



chloric acid



Perchloric acid



Interhalogen compounds

When two diff halogens reacts with each other inter halogen compounds are formed. They can be assigned general composition as XX', XX'_3, XX'_5 and XX'_7

where X → less EN, large size, central atom
X' → More EN, small size. Bonded atom

Note- As ratio betn X and X' increase the no. of atom per molecule increases

Ex- Radius ratio of iodine to fluorine is maximum so it forms IF_2

Preparation

$Cl_2 + F_2 \xrightarrow{473K} ClF$ (equal volm)

$Cl_2 + F_2 \xrightarrow{573K} ClF_3$ (excess)

$I_2 + Cl_2 \longrightarrow ICl$ (equal molar)

$I_2 + Cl_2 \longrightarrow ICl_3$ (excess)

$Br + F_2 \longrightarrow BrF_3$ (Diluted with water)

$Br_2 + F_2 \longrightarrow BrF_5$ (excess)

Properties · All these molecules are covalent and diamagnetic volatile solids or liquid except ClF which is a gas
MP and BP are little higher than the halogen

Interhalogen undergo hydrolysis give Hydrogen Halide

$XX' + H_2O \longrightarrow HX' + HOX$ (hypohalite)

$XX'_3 + H_2O \longrightarrow HX' + HOXO$ (Halite)

$XX'_5 + H_2O \longrightarrow HX' + HOXO_2$ (Halate)

$XX'_7 + H_2O \longrightarrow HX' + HOXO_3$ (Perhalate)

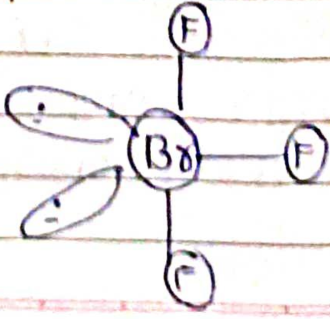
Structure of interhalogen compound

BrF_3 (yellow green liquid)

ClF_3 (colourless gas)

XX'_3 type

Bent T-shaped

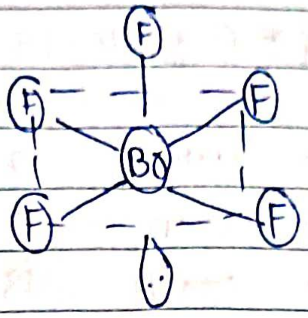


XX'_5 type

Ex IF_5 (colourless gas)

BrF_5 (" liquid)

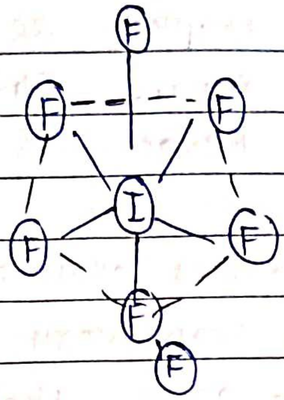
Square pyramidal shape.



XX'_7 type

Ex IF_7 (Colorless gas)

. Pentagonal bipyramidal



XX' type

Ex- ClF (colourless gas)

ICl (ruby red solid α-form) Cl – F

(Brown red solid β-form) linear

Uses · Used as non-aq. solvents, fluorinating agents

ClF_3 and BrF_3 are used in production of UF_6 in excitement of ^{235}U. i.e $U + 3ClF_3 \rightarrow UF_6 + 3ClF$

* Group-18 (Noble gases)

He	Helium	2	$1s^2$	हे
Ne	Neon	10	$[He]\ 2s^2\ 2p^6$	नानी
Ar	Argon	18	$[Ne]\ 3s^2\ 3p^6$	आराम
Kr	Krypton	36	$[Ar]\ 4s^2\ 3d^{10}\ 4p^6$	कर
Xe	Xenon	54	$[Kr]\ 5s^2\ 4d^{10}\ 5p^6$	जिंदा
Rn	Radon	86	$[Xe]\ 6s^2\ 4f^{14}\ 5d^{10}\ 6p^6$	रहेगी

Noble gases or inert gases. All gases are chemically un reactive

Outermost shell Electronic configuration - $ns^2\ np^6$
They form very few compounds so they are called Noble gases. they react only under certain condition

Occurence- Except Rn and Oganesson all are present in atmosphere i.e 1% by volume in dry air, in which Argon is main constituent
He and Ne - found in minerals of radioactive origin
Natural gas is commercial source of Helium
Xe and Rn - rarest elements of group
Radon is obtained by decay product of 226 Ra

$$^{226}_{88}Ra \longrightarrow {}^{222}_{86}Rn + {}^{4}_{2}He$$

Oganesson is synthetically produced by collision of $^{249}_{98}Cl$ atoms and $^{48}_{20}Ca$ ions i.e.

Oganesson - symbol Og, atomic no 118, atomic mass 294 electronic configuration $[Rn]\ 5f^{14}\ 6d^{10}\ 7s^2\ 7p^6$ only its small amount has been produced. Its half life is 0.7 milliseconds

Electronic configuration. general E.C · $ns^2 np^6$ except
He which has $1s^2$

Atomic radii - ↑ down the group with ↑ in atomic no.
However it is higher than corresponding halogens.

Ionisation Enthalpy - Due to stable Electronic configuratn they have very high I.E However it ↓ down the group with ↑ in atomic size.

Electron gain Enthalpy - Since they have stable configuration they have no tendency to accept the electron & therefore have large +ve values of electron gain enthalpy.

MP and B.P - They have low MP and BP because weak vander waal forces are present betn their atoms. Down the grp MP & BP ↑ due to ↑ in atomic size leads to increase in vanderwaal forces.

Some physical properties :- Monoatomic gases, colourless, odourless, tasteless, sparingly soluble in water.

Note - He has the lowest B.P (4.2K) of any known substance. It has an unusual property of diffusing through most commonly used laboratory materials such as rubber, glass or plastic.

* Chemical properties

They are least reactive, their inertness due to

i) completely filled $ns^2 np^6$ electronic configuration except He

ii) High IE and more +ve electron gain enthalpy.

Discovery. Neil Bartlett, 1962 prepared $O_2^+PtF_6^-$ (red compound) & then prepared $Xe^+PtF_6^-$ (Red colour comp) by mixing PtF_6 and xenon.

After this discovery a no. of Xe compounds mainly with most EN elements like F and O, have synthesized

Compounds of Kr are fewer, only difluoride (KrF_2) has been studied in detail.

Compounds of radon have not been isolated but only identified (Ex. RnF_2) by radiotraces technique.

No blue compounds of Ar, Ne, or He are yet known

Xenon- fluorine compounds

Xe form 3 binary fluorides XeF_2, XeF_4, XeF_6

$$Xe(g) + F_2(g) \xrightarrow{673K\ \ 1bar} XeF_2(s) \quad \text{- Xe in excess}$$
$$Xe(g) + 2F_2(g) \xrightarrow{873K\ \ 7bar} XeF_4(s) \quad \text{- 1:5 ratio}$$
$$Xe(g) + 3F_2(g) \xrightarrow{573K\ \ 60\text{-}70bar} XeF_8(s) \quad \text{- 1:20 ratio}$$

or

$$XeF_4 + O_2F_2 \xrightarrow{143K} XeF_6 + O_2$$

Properties. Colourless, crystalline solids, sublime readily at 298 K, powerful fluorinating agents, readily hydrolysed even by traces of water.

Ex. $2XeF_2(s) + 2H_2O(l) \longrightarrow 2Xe(g) + 4HF(aq) + O_2(g)$

Xenon fluoride ion acceptors to form cationic species and fluoride ion donors in form fluoroanions

Ex. $XeF_2 + PF_5 \longrightarrow [XeF]^+[PF_6]^-$

$XeF_4 + SbF_5 \longrightarrow [XeF_3]^+[SbF_6]^-$

$XeF_6 + MF \longrightarrow M^+[XeF_7]^-$

where (M = Na, K, Rb, or Cs

Xenon - Oxygen compounds - XeO_3 & $XeOF_4$, XeO_2F_2

i) Hydrolysis of XeF_4 and XeF_6

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

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

ii) Partial hydrolysis of XeF_6 gives oxyfluorides

$XeF_6 + H_2O \longrightarrow XeOF_4 + 2HF$

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

Properties - XeO_3 - colourless explosive solid

$XeOF_4$ - colourless volatile liquid

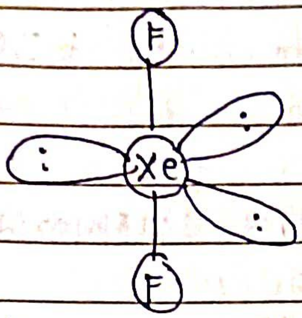
Uses -

Helium - It is a non-inflammable & light gas. It is used in filling balloons, gas-cooled nuclear reactors. Liquid He is used as cryogenic agent for, used to produce and sustain powerful superconducting ~~mag~~ magnets which is essential part of modern NMR Spectrometers & Magnetic Resonance Imaging (MRI) System. It is used as diluent for oxygen in modern diving apparatus because of its very low solubility in blood

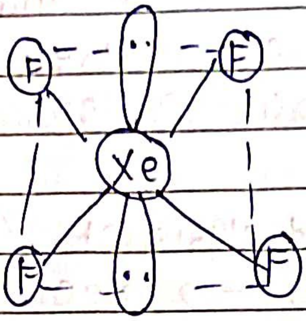
Neon - Used in discharge tubes & Fluorescent bulbs for advertisement display purposes. Neon bulbs are used in botanical gardens and in green houses

Argon - It is used to provide inert atomosphere in high temp & for filling electric bulbs. used in laboratory for handling air sensitive

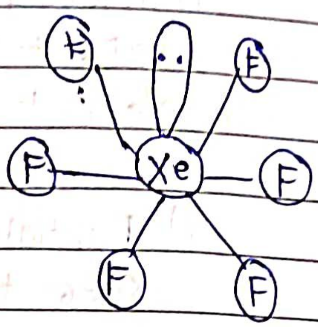
Xe & krpton - No significant uses. They are used in light bulbs ~~synthesized~~ designed for special purposes



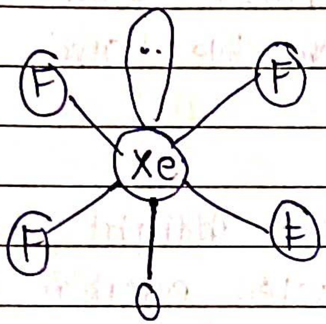
linear XeF_2



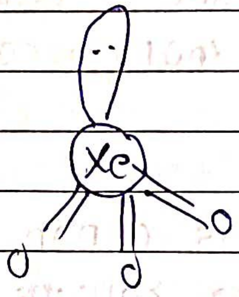
sq. planar
XeF_4



Distarted octahedral
XeF_6



sq. pyramidal
$XeOF_4$



Pyramidal
XeO_3