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NEET SYLLABUS

p-Block Elements : *General Introduction to p-Block Elements. General introduction, electronic configuration, occurrence, variation of properties, oxidation states, trends in chemical reactivity, anomalous properties of first element of the Groups 13 to 18 elements.*

OBJECTIVES

After studying this unit, you will be able to :

- *appreciate general trends in the chemistry of elements of groups 13 to 18;*
- *explain anomalous behaviour of boron and carbon;*
- *describe allotropic forms of carbon;*
- *learn the preparation, properties and uses of dinitrogen and phosphorus and some of their important compounds;*
- *describe the preparation, properties and uses of dioxygen and ozone and chemistry of some simple oxides;*
- *know allotropic forms of sulphur, chemistry of its important compounds and the structures of its oxoacids;*
- *describe the preparation, properties and uses of chlorine and hydrochloric acid;*
- *know the chemistry of interhalogens and structures of oxoacids of halogens;*
- *enumerate the uses of noble gases;*
- *appreciate the importance of these elements and their compounds in our day to day life.*

p-Block elements signify common man in society on whom all socio-economic rules are applicable.

Linus Pauling

p-BLOCK ELEMENTS

IMPORTANT CONCEPTS :

- | | |
|--|--------------------------------------|
| 1. Back bonding | 2. Dimerisation |
| 3. Inert pair effect | 4. Oxyacids |
| 5. Hydrolysis | 6. Allotropes |
| 7. Silicates and Silicones | 8. Drying agent and bleaching agents |
| 9. Reactions and compounds (Group 13-18) | |

1. BACK BONDING

It is formed between two covalently bonded adjacent atoms.

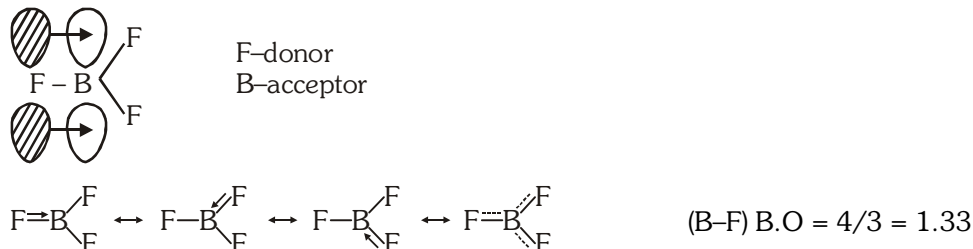
Conditions for back bonding :

- Both bonded atoms must belong to 2nd period or one bonded atom must belong to 2nd period and the other must belong to 3rd period.
- One bonded atom must possess vacant orbital and the other bonded atom must possess lone pair.

- As a result of back bonding between the bonded atoms, bond length decreases and bond energy increases.

Back bonding :

It is a partial sideways overlap in which there is a slight electron transference from electron rich atom to electron deficient atom. As a result the electron deficiency of the deficient atom gets slightly compensated.



Types of back bonding :

Based on type of orbital : (2 types)

- $p\pi-p\pi$ back bonding
- $p\pi-d\pi$ back bonding

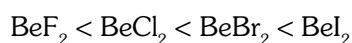
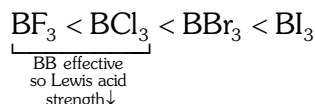
(1) $p\pi-p\pi$ back bonding :

Order of strength : $2p-2p > 2p-3p > 2p-4p \dots\dots$

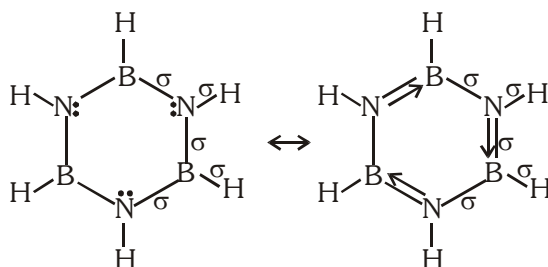
Size $\uparrow$ extent of B.B. $\downarrow$

It is used to explain following observations :-

- Abnormal bond length and bond energy of B-F bond in BF_3 .
- Lewis acidic order of **Boron** and **Beryllium** halides.

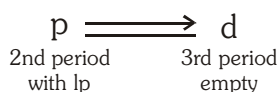


- (c) **Hybridisation** : If a lone pair participates in back bonding then it is not considered in hybridisation.
 Ex. $B_3N_3H_6$ (inorganic benzene or borazene or borazole)
- Hybridisation of B as well as N = sp^2



- Inorganic benzene is more reactive than organic benzene as in it the **bonds are polar**, although over all molecule is non polar.
- If back bonding is present then tendency to form dimer or polymer decreases.
 Ex. BF_3 , BeF_2

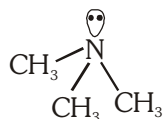
(2) $p\pi-d\pi$ back bonding :



it is used to explain following observations :

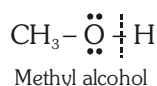
(a) Hybridisation

Ex. Trimethyl amine
 $(CH_3)_3N$



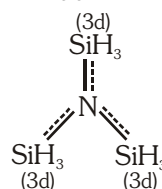
- sp^3 hybrid (N)
- trigonal pyramidal
- Lewis base (due to presence of lp)

(b) Acidic strength

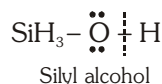


- No back bonding
- Less acidic

Trisilyl amine
 $(SiH_3)_3N$



- sp^2 hybrid (N)
- trigonal planar
- Not Lewis base
- Bond angle increases



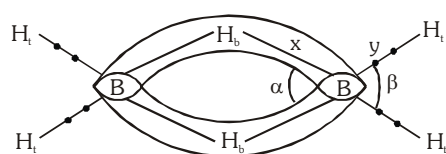
- Back bonding present in conjugate base
- More acidic

2. DIMERISATION / POLYMERISATION

Types of Dimerisation	
3C—2e	3C—4e
B ₂ H ₆	(BeCl ₂) ₂
(BeH ₂) ₂	(BeCl ₂) _n
(BeH ₂) _n	(AlCl ₃) ₂
Al ₂ (CH ₃) ₆	(ICl ₃) ₂
Ga ₂ (CH ₃) ₆	

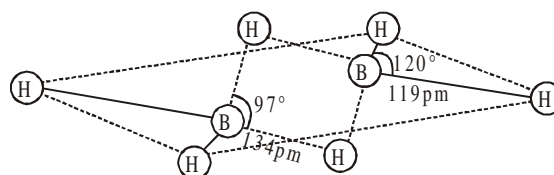
(A) By banana Bond or by 3C—2e bond or by e⁻ deficient bond

(a) B₂H₆



$$\alpha < \beta = \text{BA}$$

$$x > y = \text{BL}$$



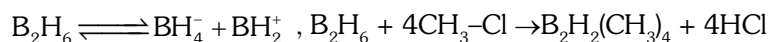
$$2\text{C} - 2e^- \text{ bonds} = 4$$

$$3\text{C} - 2e^- \text{ bonds} = 2$$

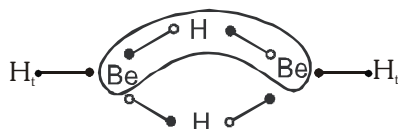
Hybridisation state = sp³

Electron deficient molecule (act as Lewis acid)

- All four terminal hydrogen and two boron atoms are present in same plane both bridging H are present in perpendicular plane.
- If substitution reaction takes place than only four terminal hydrogen atom will be substituted.



(b) (BeH₂)₂ (dimer of BeH₂ in vapour state)

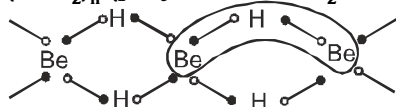


Hybridisation state = sp²

Planar

electron deficient molecule

(c) (BeH₂)_n (polymer of BeH₂ in solid state)



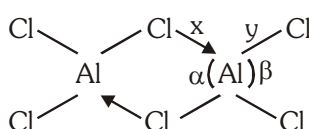
Hybridisation state = sp³

Non-planar

electron deficient molecule

(B) By-coordinate Bond / 3C—4e bond

(a) Al₂Cl₆ (dimer of AlCl₃ in liquid or solid state)



$$\text{BA} = \alpha < \beta$$

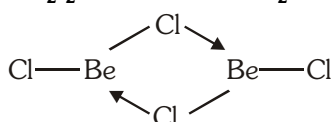
$$\text{BL} = x > y$$

Hybridisation state = sp³

Non-planar

octet complete

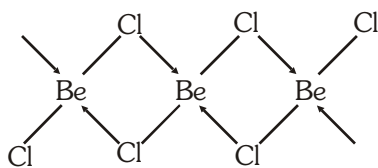
(b) (BeCl₂)₂ (dimer of BeCl₂ in vapour state)



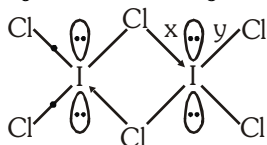
Hybridisation state = sp²

Planar

electron deficient molecule

(c) $(\text{BeCl}_2)_n$ (polymer of BeCl_2 in solid state)

Hybridisation state = sp^3
Non-planar
octet complete

(d) I_2Cl_6 (dimer of ICl_3)

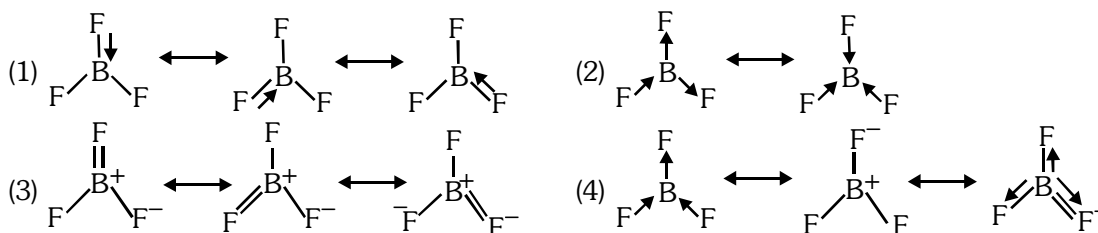
Hybridisation state = sp^3d^2
Planar
super octet complete (12 electrons)

Note :

- BCl_3 , BBr_3 & BI_3 do not form dimer due to smaller size of boron & large size of halogen (due to more steric repulsion)
- BF_3 cannot form dimer due to its back bonding.
- AlF_3 cannot form dimer due to its ionic nature.

BEGINNER'S BOX-1

- In BF_3 :
 - B-F bond has some double bond character and this bond is delocalised
 - All the B-F bonds are single covalent in nature
 - Bond energy and bond length of B-F bond indicate its single bond character
 - All the bonds are ionic
- Which of the following statements is incorrect in the context of the B-F bond in BF_3 :-
 - All the three B-F bond lengths are equal and each of them is shorter than the sum of the covalent radii of boron and fluorine.
 - The bond energy of the B-F bond is very high, higher than for any other single bond
 - The unusual shortness and strength of the B-F bond may be explained by a $\pi\text{-}\pi$ interaction between boron and fluorine atoms.
 - The unusual shortness and strength of the bonds may be explained by a $\pi\text{-}\text{d}\pi$ interaction between the atoms of boron and fluorine.
- In BF_3 , the B-F bond length is $1.30 \text{ \AA}$, when BF_3 is allowed to be treated with Me_3N , it forms an adduct, $[\text{Me}_3\text{N} \rightarrow \text{BF}_3]$. The bond length of B-F in the adduct is :
 - Greater than $1.30 \text{ \AA}$
 - Smaller than $1.30 \text{ \AA}$
 - Equal to $1.30 \text{ \AA}$
 - None of these
- Which of the following structures correctly represents the boron trifluoride molecule :



- Trisilylamine $[\ddot{\text{N}}(\text{SiH}_3)_3]$ has a
 - Planar geometry
 - Tetrahedral geometry
 - Pyramidal geometry
 - None of these

6. In which of the following molecule, vacant orbitals do not participate in bonding:-
 (1) B_2H_6 (2) Al_2Cl_6 (3) $[H_3N.BF_3]$ (4) Si_2H_6
7. Which of the following is not possible due to back bonding.
 (1) State of hybridisation may change (2) Bond order increases
 (3) Bond angle always increases (4) Lewis acidic strength decreases
8. In which of the following compounds B-F bond length is shortest?
 (1) BF_4^- (2) $BF_3 \leftarrow NH_3$ (3) BF_3 (4) $BF_3 \leftarrow N(CH_3)_3$
9. In diborane –
 (1) 2 bridged hydrogen and four terminal hydrogen are present
 (2) 3 bridged and three terminal hydrogen are present
 (3) 4 bridged hydrogen atoms are not in the same plane in diborane
 (4) 1 bridged hydrogen and 1 terminal hydrogen are present
10. Which of the following statements is correct in the context of diborane (B_2H_6)?
 (1) There are 12 valence electrons-three from each of the two boron atoms and six from the six hydrogen atoms
 (2) Two of the six hydrogen atoms form two bridges between two boron atoms
 (3) The two bridging hydrogen atoms are in a plane perpendicular to the rest of the molecule and prevent rotation between the two boron atoms
 (4) All of these

3. INERT PAIR EFFECT

	Group-13	Group-14	Group-15
(group oxidation state)	$\frac{ns^2np^1}{+3}$	$\frac{ns^2np^2}{+4}$	$\frac{ns^2np^3}{+5}$

- While moving down the group the stability of lower oxidation state (2 less than group oxidation state) progressively increases, for the last element of the group the stability of lower oxidation state becomes even greater than the group oxidation state. **This is called inert pair effect.**
- For the last element group oxidation state is highly oxidising in nature.

Group-13	Group-14	Group-15
B +3	C +4	N +5
Al +3	Si +4	P +5

Ga +3 > +1	Ge +4 > +2	As +5 > +3
In +3 > +1	Sn +4 > +2	Sb +5 > +3
Tl +3 < +1	Pb +4 < +2	Bi +5 < +3

Reason : As we move down the group there is presence of d & f-orbitals in inner shells which have poor shielding effect hence Z_{eff} increases. As a result the ns^2 electron pair becomes more and more tightly held to the nucleus and becomes reluctant to participate in bonding.

Examples :

- $PbCl_2$ is more stable than $PbCl_4$.
- $TlCl$ is more stable than $TlCl_3$
- $GaCl_3$ is more stable than $TlCl_3$
- $SnCl_4$ is more stable than $PbCl_4$
- Thallium (III) iodide does not exist.
- PbI_4 does not exist.
- Only BiF_5 exists but $BiCl_5$ does not exist ?

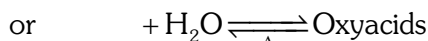


4. OXY ACID

General Formula of Oxy acid : $\text{H}_x\text{Z}_y\text{O}_z$ (Z = non metal)

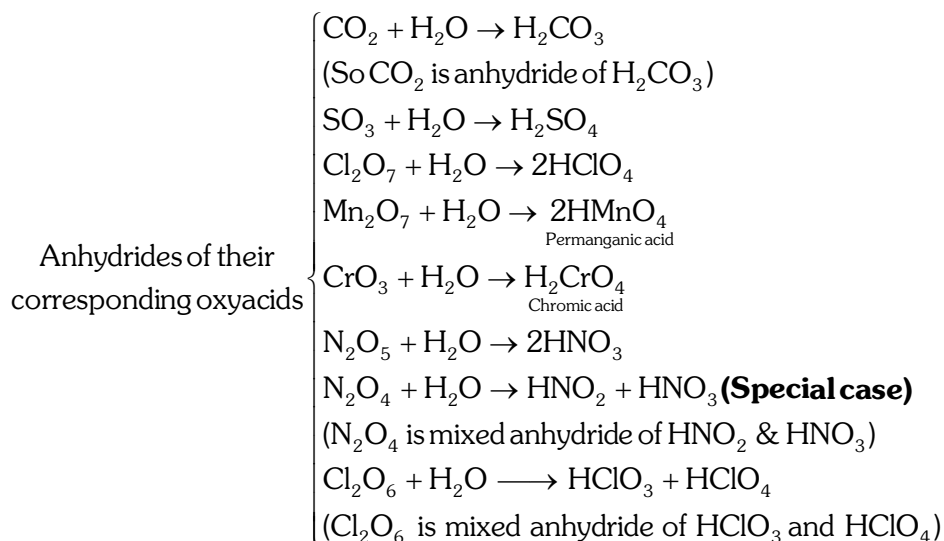
- Compounds which contain Z-OH bond are known as oxyacids.

- Acidic oxide



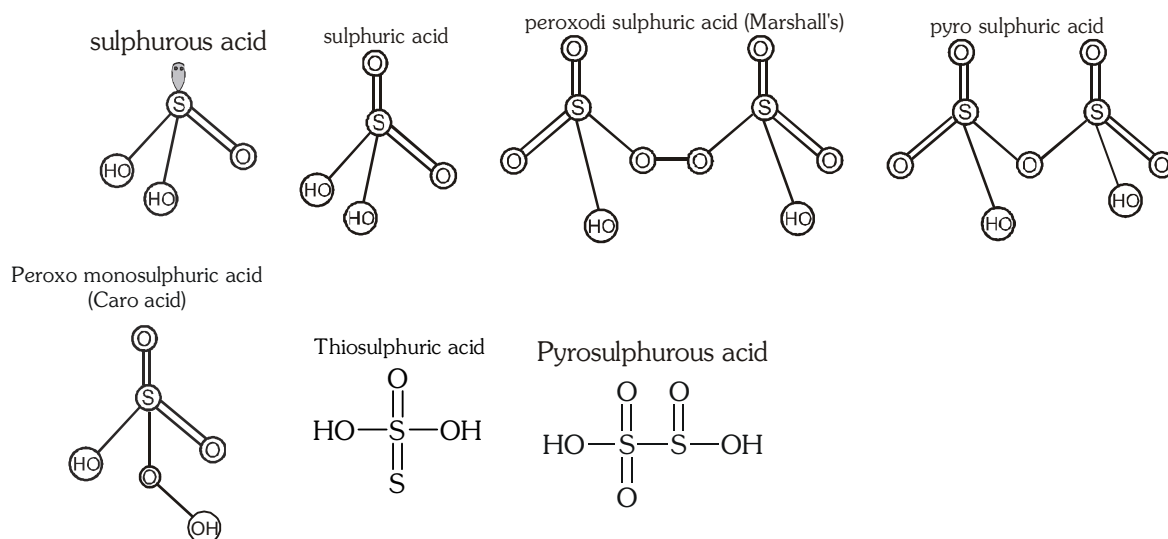
Non metallic oxide

Anhydrides of oxyacids

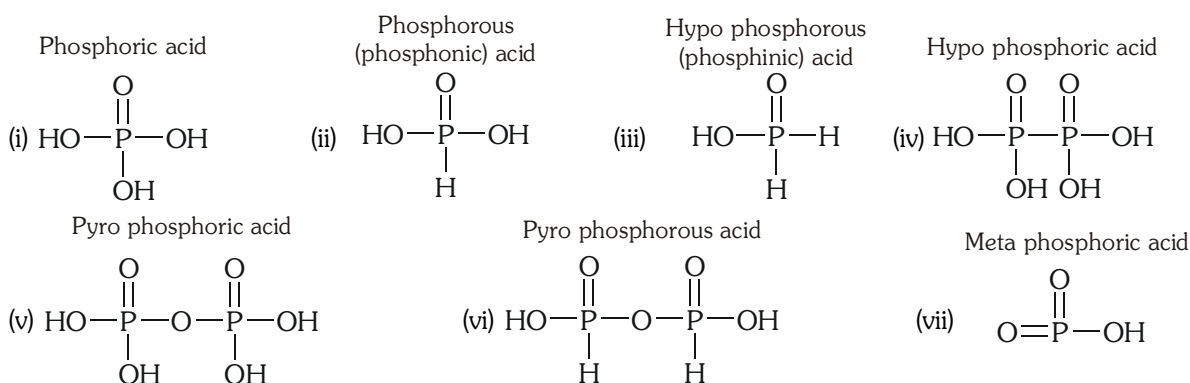


- Oxidation state of central atom does not change.

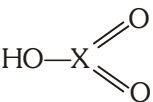
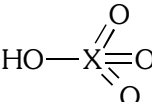
Pyro	Meta	Per oxy acid	Hypo	
↓	↓	↓	Ous acid	ic acid
2 mole oxy acid	1 mole oxy acid		↓ -O	↓ -O
↓ -H ₂ O	↓ -H ₂ O	Z—O—O—H	Hypo us acid	Hypo ic acid
pyro acid	meta acid			
Ex. $\text{H}_2\text{S}_2\text{O}_5$ $\text{H}_2\text{S}_2\text{O}_7$ $\text{H}_4\text{P}_2\text{O}_7$	Ex. HPO_3 HBO_2	Ex. H_2SO_5 $\text{H}_2\text{S}_2\text{O}_8$ HNO_4 $\text{CH}_3\text{CO}_3\text{H}$ $\text{C}_6\text{H}_5\text{CO}_3\text{H}$	Ex. HOX H_3PO_2	Ex. $\text{H}_4\text{P}_2\text{O}_6$



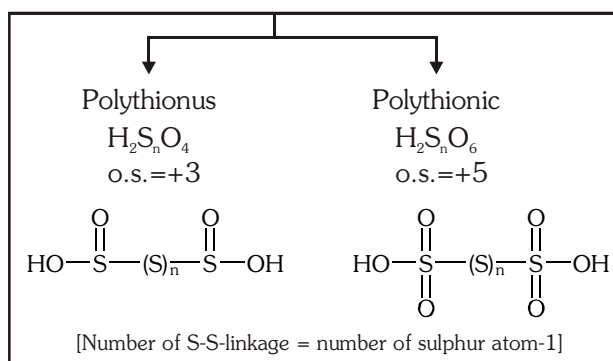
OXY ACID OF PHOSPHORUS

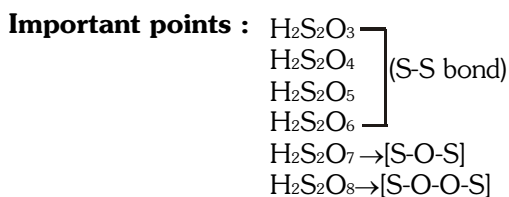


OXY ACIDS OF HALOGENS

Hypohalous	Halous	Halic	Per halic
HO—X	O=X—OH	HO—X 	HO—X 
+1 HOCl HOBr HOI	+3 HClO ₂ — —	+5 HClO ₃ HBrO ₃ HIO ₃	+7 HClO ₄ HBrO ₄ HIO ₄

OXY ACIDS CONTAINING S-S LINKAGE

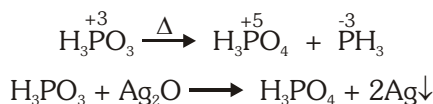
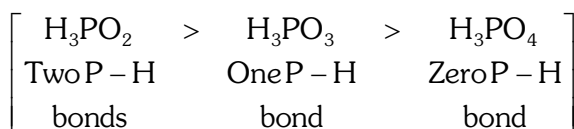


**Trick for drawing structure of oxy compound**

Oxy compounds	Group present
$\text{X}_2\text{O}_6^{-q}$	$[\text{X-X}]$
$\text{X}_2\text{O}_7^{-q}$	$[\text{X-O-X}]$
$\text{X}_2\text{O}_8^{-q}$	$[\text{X-O-O-X}]$

Some important points

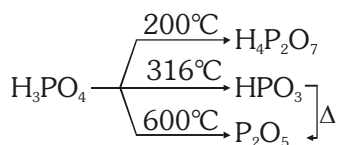
- (1) Oxy acid of phosphorus having +1 & +3 oxidation state (having P-H bond) can act as reducing agent or give disproportionation reaction on heating.

**Order of reducing nature.**

Note : Nitrogen compound having +1 & +3 oxidation state gives disproportion to reaction in acidic medium.



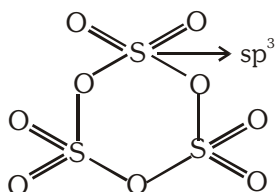
- (2) **Heating effect of phosphoric acid**



- (3) **Heating effect of boric acid**

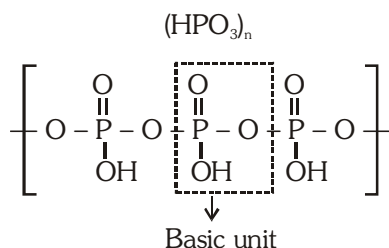
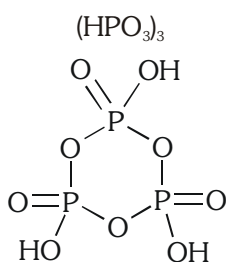


- (4) **SO_3 exists as a cyclic trimer (S_3O_9)**



6 S=O bonds
3 S-O-S bonds
 sp^3 hybrid 'S', Non planar

- (5) **Metaphosphoric acid exists as dimer, cyclic trimer or polymer**



(6) Acidic nature of oxy acids.

General concept :

$$\text{For same elements} \left(\begin{array}{l} \text{Acidic nature} \\ \text{of oxyacids} \end{array} \propto \begin{array}{l} \text{Oxidation number of} \\ \text{active element} \end{array} \right)$$

(Acidic nature of oxyacids $\propto$ EN of active element) for different elements

Exception :

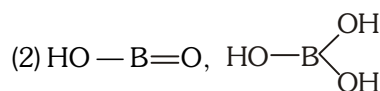
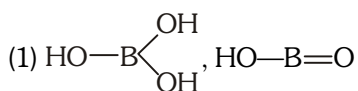
- for oxy acids of P

$$\left(\text{Acidic nature} \propto \frac{1}{\text{Oxidation number}} \right)$$

Example : $\text{H}_3\text{PO}_2 > \text{H}_3\text{PO}_3 > \text{H}_3\text{PO}_4$ (acidic order)

BEGINNER'S BOX-2

1. Structures of metaboric acid and orthoboric acid respectively are :



(3) Both the above

(4) None

2. Orthoboric acid –

(1) Donate proton to form H_2BO_3^-

(2) Accept proton of form H_4BO_3^+

(3) Donate OH^- to form H_2BO_2^+

(4) Accept OH^- to form $[\text{B}(\text{OH})_4]^-$

3. Pick out the incorrect statement :-

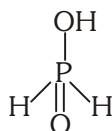
(1) Orthophosphorus acid can be obtained by reacting P_4O_6 with H_2O

(2) Orthophosphoric acid can be obtained by reacting P_4O_{10} with H_2O

(3) Pyrophosphoric acid can be obtained by heating Orthophosphorus acid

(4) Metaphosphoric acid is obtained by the dehydration of orthophosphoric acid at 316°C .

4. Hypophosphorus acid H_3PO_2 is –



(1) Tribasic acid

(2) Dibasic acid

(3) Monobasic acid

(4) Not acidic at all

5. The correct order of decreasing acid strength of oxy acids of group 15 elements is :

(1) $\text{HNO}_3 > \text{H}_3\text{SbO}_4 > \text{H}_3\text{AsO}_4 > \text{H}_3\text{PO}_4$

(2) $\text{H}_3\text{PO}_4 > \text{H}_3\text{AsO}_4 > \text{H}_3\text{SbO}_4 > \text{HNO}_3$

(3) $\text{HNO}_3 > \text{H}_3\text{PO}_4 > \text{H}_3\text{AsO}_4 > \text{H}_3\text{SbO}_4$

(4) $\text{HNO}_3 > \text{H}_3\text{AsO}_4 > \text{H}_3\text{PO}_4 > \text{H}_3\text{SbO}_4$

6. Which one of the following is a mixed anhydride :

(1) NO

(2) NO_2

(3) N_2O_3

(4) N_2O_5

7. Which of the following oxy acids of sulphur contains a sulphur-sulphur single bond :

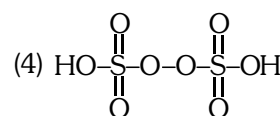
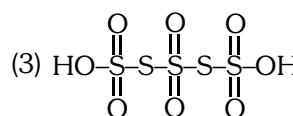
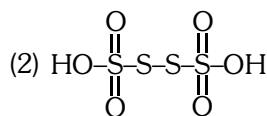
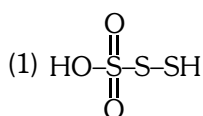
(1) $\text{H}_2\text{S}_2\text{O}_6$

(2) $\text{H}_2\text{S}_2\text{O}_7$

(3) $\text{H}_2\text{S}_2\text{O}_8$

(4) $\text{H}_2\text{S}_2\text{O}_3$

8. The structure of peroxodisulphuric acid is :



9. Number of S-S bond in $\text{H}_2\text{S}_n\text{O}_6$

(1) n

(2) (n-1)

(3) (n-2)

(4) (n+1)

10. Ga^+ acts as a reducing agent because –

(1) Ga^{3+} state is less stable than Ga^{+1}

(2) Ga^{3+} state is more stable than Ga^{+1}

(3) Ga^{3+} convert into Ga^{+1} reducing

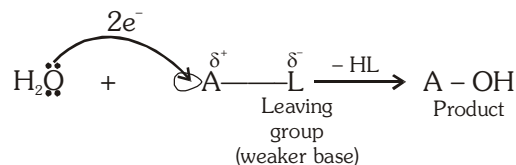
(4) None of the above

5. HYDROLYSIS

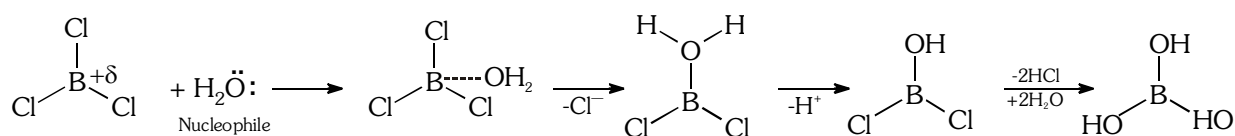
Chemical reaction of H_2O with a covalent compound.

Condition :

One atom must possess vacant orbital and positive charge.

Mechanism : (SN^2 mechanism)

- Weaker base goes out and a stronger base substitutes it.

Example

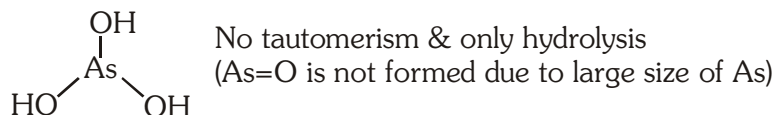
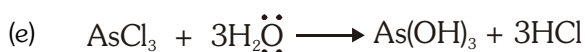
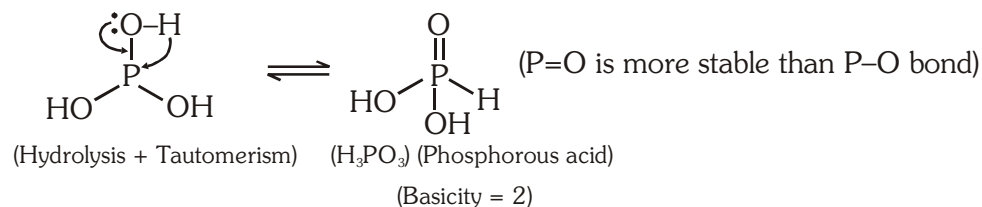
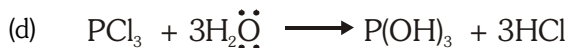
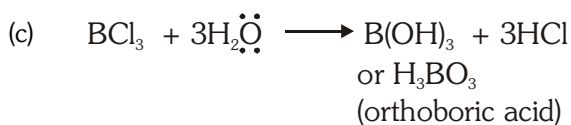
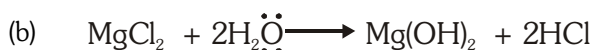
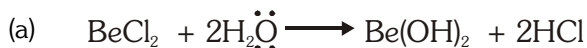
- For hybridisation of transition state

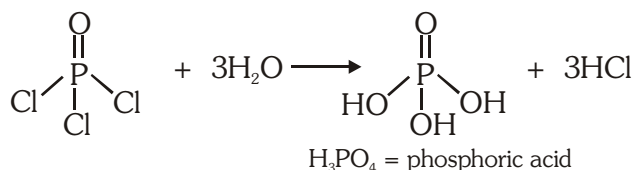
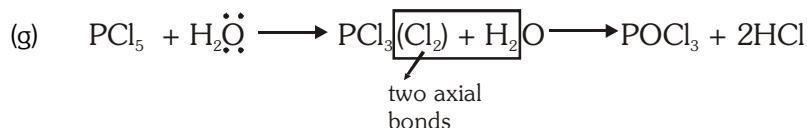
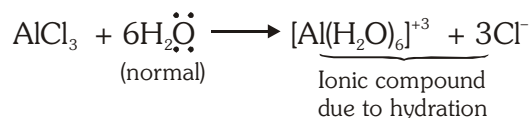
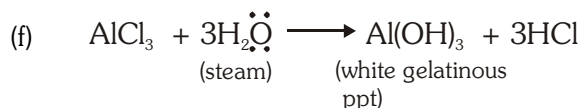
Reactant $\longrightarrow$ Transition state

Ex. : $sp \longrightarrow sp^2$

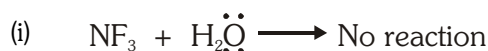
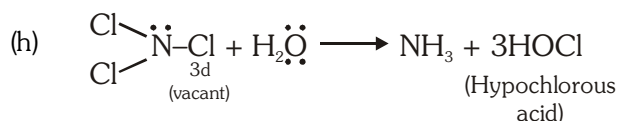
$sp^2 \longrightarrow sp^3$

$sp^3 \longrightarrow sp^3d$

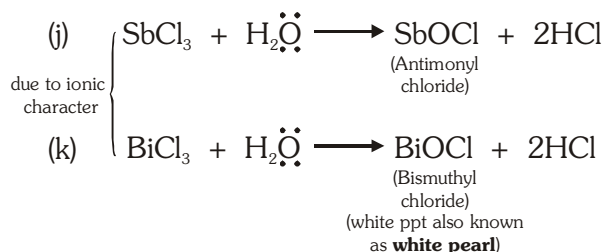
Important examples of hydrolysis**1. Hydrolysis of some important covalent molecules.**



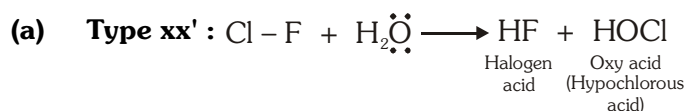
• **Hydrolysis is not a redox reaction**



• **Partial hydrolysis**

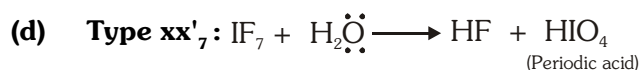
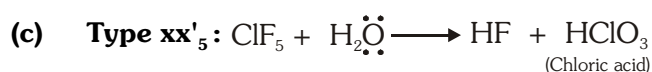
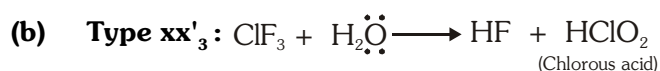


2. Hydrolysis of interhalogen compounds

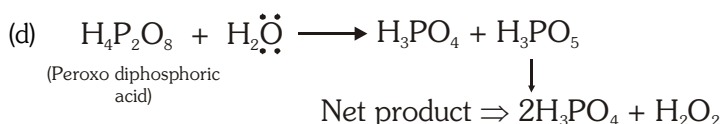
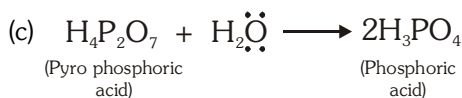
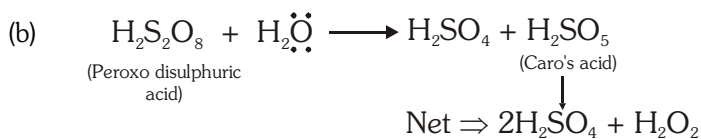
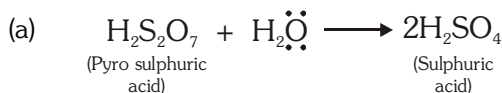


x = oxy acid (same oxidation number)

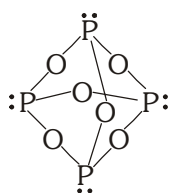
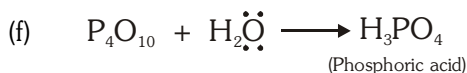
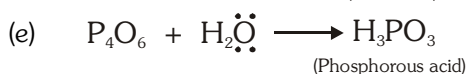
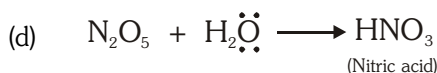
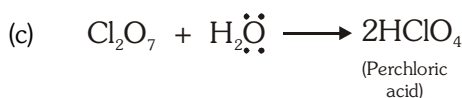
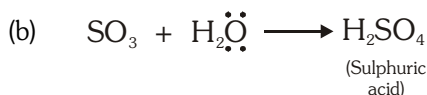
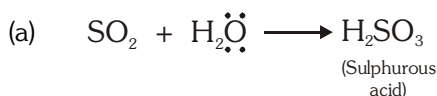
x' = Halogen acid



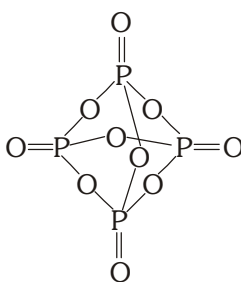
3. Hydrolysis of oxyacids



4. Hydrolysis of oxides (N, P, S, Cl)

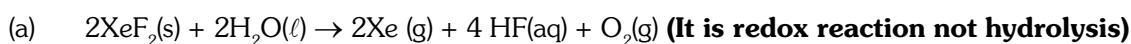


P_4O_6
 $\rightarrow \text{sp}^3$ hybrid 'P'
 $\rightarrow 6 \text{ P-O-P bonds}$
 $\rightarrow \text{lp on 'P'} = 4$

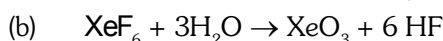


P_4O_{10}
 $\rightarrow \text{sp}^3$ hybrid 'P'
 $\rightarrow 6 \text{ P-O-P bonds}$
 $\rightarrow 4 \text{ P=O bonds}$

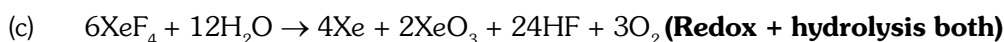
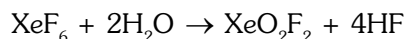
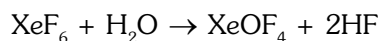
5. Hydrolysis of Xe-fluoride



Hydrolysis of XeF_4 and XeF_6 with water gives XeO_3



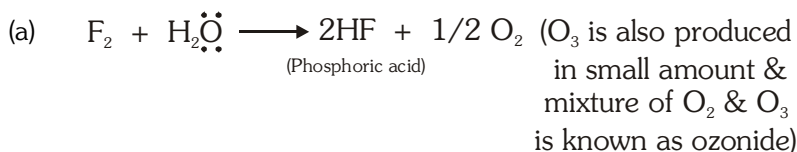
Partial hydrolysis of XeF_6 gives oxyfluorides, XeOF_4 and XeO_2F_2 .



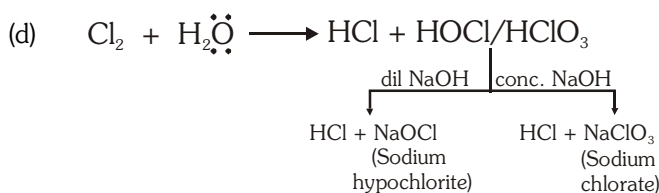
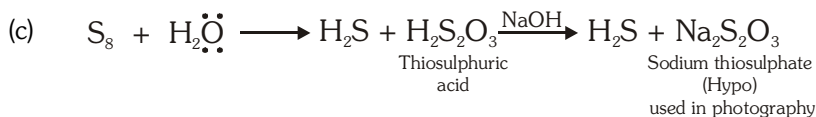
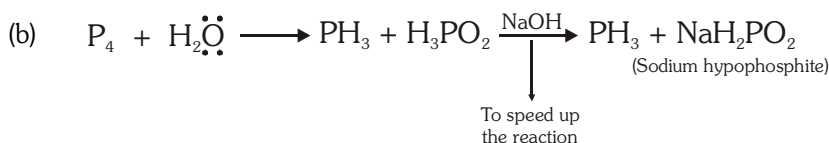
6. Hydrolysis of ionic compounds

- (a) Carbides (b) Nitrides (c) Phosphides

7. Hydrolysis of non-metals and halogen



- 'F₂' is the only non-metal that can oxidise H₂O as it is a powerful oxidising agent. Other halogens & non-metals undergo disproportionation with water in basic medium. (Redox reaction)



BEGINNER'S BOX-3

1. Which of the following statements is correct :

- (1) Aluminium carbide as well as beryllium carbide produce methane gas on treatment with water
- (2) On reacting with water, calcium carbide (CaC₂) produces acetylene while magnesium carbide (Mg₂C₃) gives propyne
- (3) Both of these
- (4) None of these

2. (a) $Al \xrightarrow{N_2} A$ (b) $Al \xrightarrow{C} B$
- High temp. High temp.

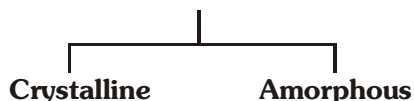
Product A and B on hydrolysis yields respectively.

- (1) Ammonia and acetylene
- (2) Ammonia and methane
- (3) Nitric oxide and acetylene
- (4) None

3. SbCl_3 and BiCl_3 on hydrolysis gives :
- (1) Sb^{+3} and Bi^{+3} (2) Sb(OH)_3 and Bi(OH)_3
(3) SbOCl and BiOCl (4) None
4. The hydrolysis of PCl_3 , produces :
- (1) $\text{H}_3\text{PO}_3 + \text{HClO}$ (2) $\text{H}_3\text{PO}_3 + \text{HCl}$
(3) $\text{H}_3\text{PO}_4 + \text{HCl}$ (4) $\text{PH}_3 + \text{HClO}$
5. The number of molecules of water needed to convert one molecule of P_2O_5 into orthophosphoric acid is :
- (1) 2 (2) 3 (3) 4 (4) 5
6. XeF_6 on partial hydrolysis produces :-
- (1) XeF_2 (2) XeOF_4 (3) XeF_4 (4) XeO_3
7. Which of the following halides does not hydrolysed?
- (1) PbCl_4 (2) SiCl_4 (3) CCl_4 (4) SnCl_4
8. which of the following is an uncommon hydrolysis product of XeF_2 and XeF_4 ?
- (1) Xe (2) XeO_3 (3) HF (4) O_2
9. Consider the following reactions :
- (i) $\text{PCl}_3 + 3\text{H}_2\text{O} \rightarrow \text{H}_3\text{PO}_3 + 3\text{HCl}$
(ii) $\text{SF}_4 + 3\text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_3 + 4\text{HF}$
(iii) $\text{BCl}_3 + 3\text{H}_2\text{O} \rightarrow \text{H}_3\text{BO}_3 + 3\text{HCl}$
(iv) $\text{XeF}_6 + 3\text{H}_2\text{O} \rightarrow \text{XeO}_3 + 6\text{HF}$
- Then according to given information the incorrect statement is
- (1) During the (i) reaction the hybridisation of 15th group element does not change
(2) During the (ii) reaction the hybridisation of 16th group element has been change
(3) During the (iii) reaction the hybridisation of 13th group element does not change
(4) During the (iv) reaction the hybridisation of 18th group element does not change
10. Select correct statement about hydrolysis of BCl_3 and NCl_3
- (1) NCl_3 is hydrolysed and gives HOCl but BCl_3 is not hydrolysed
(2) Both NCl_3 and BCl_3 on hydrolysis gives HCl
(3) NCl_3 on hydrolysis gives HOCl but BCl_3 gives HCl
(4) Both NCl_3 and BCl_3 on hydrolysis gives HOCl

6. ALLOTROPES

(A) Allotropes of Carbon



Ex. Diamond

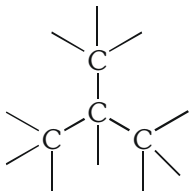
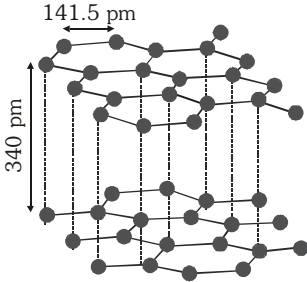
Graphite

Fullerene

Ex. Coke

Charcoal

Coal, C-lamp black

DIAMOND	GRAPHITE
	
Each carbon bonded with four other carbon atom sp^3 hybridisation	Each carbon bonded with three other carbon atom sp^2 hybridisation
tetrahedral structure	hexagonal layer structure
Insulator due to absence of free electrons	Conductor due to presence of delocalised electrons
Hard due to presence of strong sigma bond and 3D structure	Soft due to presence of weak van der Waals forces between two layers
Density = 3.35 gm/cm^3	Density = 2.22 gm/cm^3
High melting point (giant molecule)	Low melting point
Bond length (C—C) = $1.54 \text{ \AA}$	Bond length (C—C) = $1.41 \text{ \AA}$

Special Point :

- Thermodynamically graphite is more stable than diamond.
- Aqueous solution of graphite is known as **aquadag**.
- Graphite is also known as **plumbago (used in lead pencil)**
- Graphite use as a dry lubricants.
- Hardest allotrope** of carbon is diamond, **softest allotrope** is lamp black, **purest allotrope** is fullerene

Fullerene

- C-60 & C-70 are common fullerene.
- C-60 is also known as Buckminster fullerene (Bucky ball)

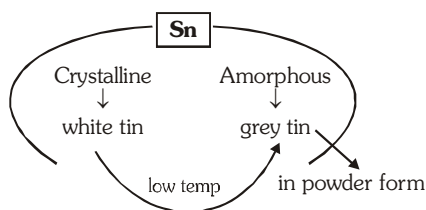
- There are 32 rings $\begin{matrix} 32 < \begin{matrix} 12 \text{ pentagonal} \\ 20 \text{ hexagonal} \end{matrix} \end{matrix}$

- Each carbon atom bonded with 3 other carbon by sigma & double bond (resonance)
- sp^2 hybridisation & aromatic in nature

⚡ Dangling Bond

In diamond or graphite some surface carbon atom have free valency. These carbon atoms form new bonds with impurities. These new bonds are known as dangling bond.

(B) ALLOTROPE OF TIN



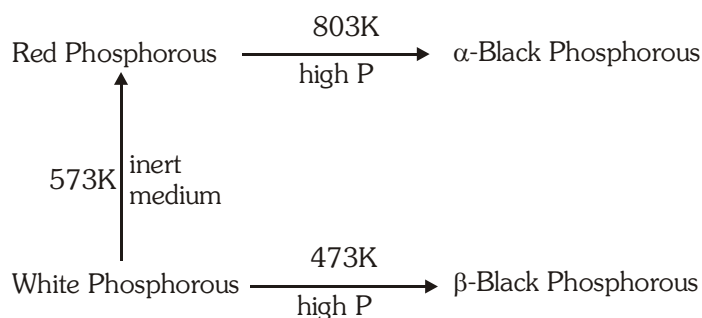
(C) ALLOTROPE OF PHOSPHOROUS

(a) white/yellow phosphorous

(b) Red phosphorous

(c) Black phosphorous

White phosphorous	Red Phosphorous
Waxy solid	Brittle powder
Poisonous	Non poisonous
Soluble in CS_2 , Insoluble in water	Insoluble in water & CS_2
Monomer of P_4	Polymer of P_4
Highly reactive due to bond angle strain	More stable than white phosphorous
It glows in dark due to slow oxidation (phosphorescence)	It does not glow in dark
It gives phosphene (PH_3) on reaction with NaOH	It give hypo phosphoric acid when on reaction with NaOH

Order of stability or MP or density $\rightarrow$ white < red < black

(D) ALLOTROPE OF SULPHUR

S	
Crystalline	Amorphous
Rhombic sulphur ($\alpha\text{-S}$) most stable form	Milk of sulphur Plastic sulphur ($\gamma\text{-S}$)
Monoclinic sulphur ($\beta\text{-S}$)	Colloidal sulphur
$\alpha\text{-S} \xrightleftharpoons[<95.6^\circ\text{C}]{>95.6^\circ\text{C}} \beta\text{-S}$	$\text{H}_2\text{S} + 2\text{HNO}_3 \xrightarrow{\text{Redox}} \text{S} + 2\text{NO}_2 + 2\text{H}_2\text{O}$ RA OA
95.6°C = transition Temp. both are soluble in CS_2 but insoluble in water	

- II. (a) density of $\alpha S > \beta S$
 (b) Both are puckered crown shape having S_8 units
 (c) S_2 is paramagnetic sulphur which exist in vapour form at high temperature.
 (d) S_6 is chair form of S

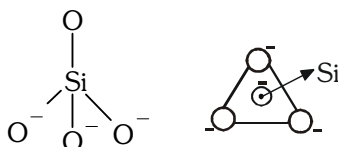
III. Effect of temperature :



7. (A) SILICATES

Basic / structural unit : SiO_4^{-4}

SiO_4^{-4} have a tendency of polymerisation



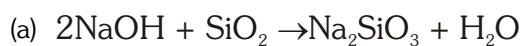
Silicate	No. of shared oxygen per unit	General formula	Structure	Example
Ortho silicate	0	SiO_4^{-4}		Zircon $ZrSiO_4$
Pyro silicate	1	$Si_2O_7^{-6}$		Hemi morphite $Zn_3Si_2O_7 \cdot Zn(OH)_2 \cdot 2H_2O$
Single chain silicate	2	$(SiO_3^{-2})_n$		$LiAlSi_2O_6$ Spodumene
Cyclic silicate	2	$(SiO_3^{-2})_n$		Beryl ($Be_3Al_2Si_6O_{18}$)
Sheet silicate	3	$(Si_2O_5^{-2})_n$		Talc $Mg_3(OH)_2(Si_2O_5)_2$
3-D silicate	4	$(SiO_2)_n$		Silica (SiO_2)

(B) Sodium Zeolite $[Na_2Al_2Si_2O_8]/[Na_2O \cdot Al_2O_3 \cdot 2SiO_2 \cdot xH_2O]$

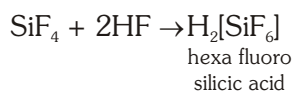
- (i) It is a 3-D silicate
 (ii) It is used in
 (a) For softening of hard water
 (b) For cracking of hydrocarbon & isomerisation

Ex. ZSM-5 (Zeolite) is used to convert ethyl alcohol into petrol.

(C) **SILICA** : Generally silica is inert but it can react with NaOH & HF.



[Na₂SiO₃ known as water glass or water soluble]



- This process is also known as **Etching of glass**.

(D) SILICONES

Silicones are organometallic polymer which contain R₂SiO as a basic unit.

Properties :

- Silicones are chemically inert due to presence of strong sigma bond.
- Silicones have water repelling nature due to presence of alkyl group.
- Silicones are insulator due to absence of free electrons.

Preparation :

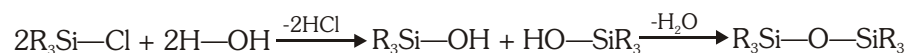
Alkyl chloro silane $\xrightarrow{\text{hydrolysis}}$ product $\xrightarrow{\text{condensation}}$ silicones

R₃SiCl : dimer (used to stop chain formation)

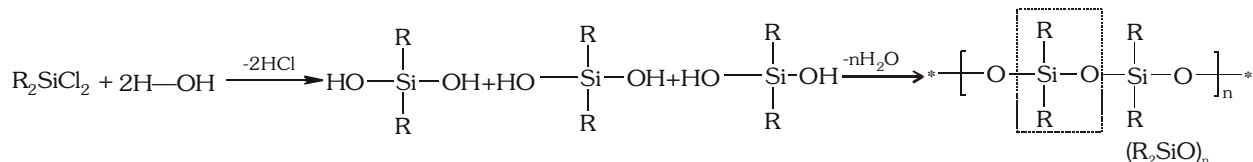
R₂SiCl₂ : linear polymer

RSiCl₃ : cross link polymer

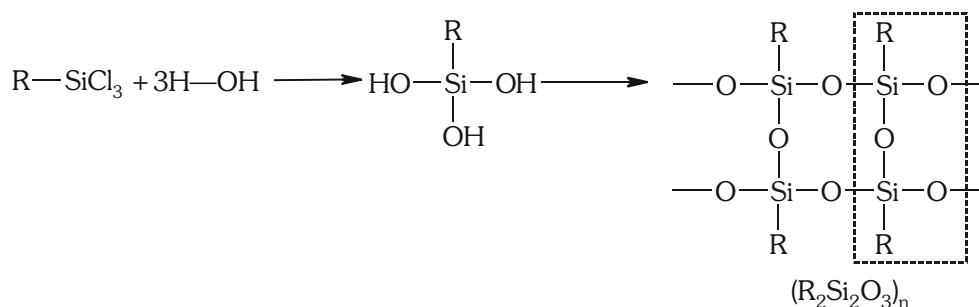
(a) Dimer silicone:



(b) Linear chain silicone



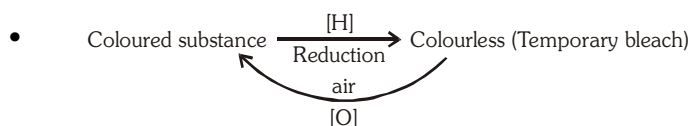
(c) Cross linked silicone



8. BLEACHING AGENTS AND DEHYDRATING AGENTS

(A) BLEACHING AGENTS

- Bleaching can be done by oxidation or reduction.
- Coloured substance $\xrightarrow[\text{Oxidation}]{[\text{O}]}$ Colourless (Permanent bleach)



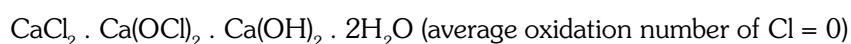
Examples :

By oxidation

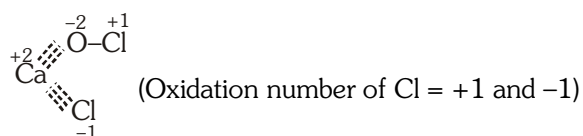
By Reduction

- | | | |
|-----|---|---------------------------------|
| (1) | O ₃ (Dry bleach) | SO ₂ (with moisture) |
| (2) | H ₂ O ₂ (with moisture) | |
| (3) | Cl ₂ (with moisture) | |

- **Bleaching powder** : Used in textile industries. Bleaches by oxidation.

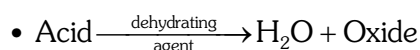


or

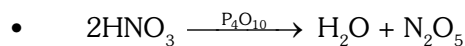
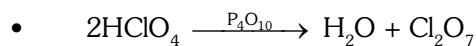
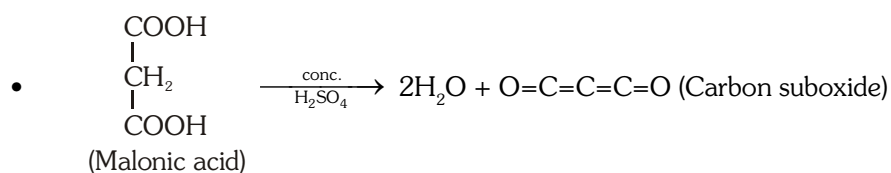
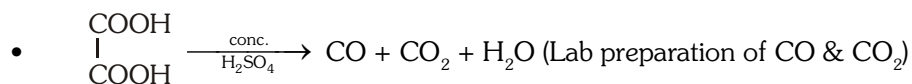
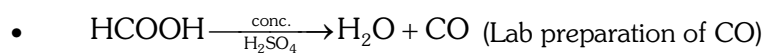


(B) DEHYDRATING AGENTS

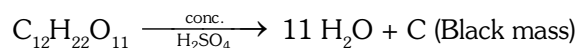
Example : P_4O_{10} , (Conc.) H_2SO_4 , CaO (Quick lime), CaCl_2 (Anhydrous)]



Example :



- Charring of sugar (dehydration) :



Some extra points :

- (i) NH_3 can not be dried by conc. H_2SO_4 , P_4O_{10} and CaCl_2
- (ii) Alcohols, phenols can not be dried by metal hydrides.
- (iii) $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$ and $\text{AlCl}_3 \cdot 6\text{H}_2\text{O}$ can not be dried by heating alone.

BEGINNER'S BOX-4

- Silicones have the general formula
 (1) SiO_4^{4-} (2) $\text{Si}_2\text{O}_7^{6-}$ (3) $(\text{R}_2\text{SiO})_n$ (4) $(\text{SiO}_3)_n^{2-}$
- Glass or silica soluble in :
 (1) HClO_4 (2) HF (3) Aqua-regia (4) H_2SO_4
- $\text{Si}_2\text{O}_7^{6-}$ anion is obtained when
 (1) no oxygen of a SiO_4^{4-} tetrahedron is shared with another SiO_4^{4-} tetrahedron
 (2) one oxygen of a SiO_4^{4-} tetrahedron is shared with another SiO_4^{4-} tetrahedron
 (3) two oxygen of a SiO_4^{4-} tetrahedron is shared with another SiO_4^{4-} tetrahedron
 (4) three or all four oxygen of a SiO_4^{4-} tetrahedron is shared with another SiO_4^{4-} tetrahedron
- Consider the following route of reactions
 $\text{R}_2\text{SiCl}_2 + \text{Water} \rightarrow (\text{A}) \xrightarrow{\text{polymerisation}} (\text{B})$
 Compound(B) in above reaction is
 (1) Dimer silicone (2) Linear silicone
 (3) cross linked silicone (4) polymerisation of (A) does not occur
- $(\text{Si}_2\text{O}_5)^{2n-}$ anion is obtained when
 (1) no oxygen of a SiO_4^{4-} tetrahedron is shared with another SiO_4^{4-} tetrahedron
 (2) one oxygen of a SiO_4^{4-} tetrahedron is shared with another SiO_4^{4-} tetrahedron
 (3) two oxygen of a SiO_4^{4-} tetrahedron is shared with another SiO_4^{4-} tetrahedron
 (4) three oxygen of a SiO_4^{4-} tetrahedron is shared with another SiO_4^{4-} tetrahedron
- What is true about various allotropes of carbon ?
 (1) Diamond is the hardest and graphite is the softest
 (2) Diamond is the hardest and coke is the softest
 (3) Diamond is the hardest and lamp black is the softest
 (4) Coke is the hardest and diamond is the softest
- Different layers in graphite are held together by :
 (1) Ionic bonding (2) Metallic bonding
 (3) Covalent bonding (4) Vander Waals forces
- Bucky ball or buckminster fullerene is :
 (1) An allotrope of carbon
 (2) It is referred as C-60
 (3) It has sp^2 -hybridised nature and resembles with soccer ball
 (4) all of these
- Which of the following statement is correct for allotrops of P :-
 (1) White P is soluble in CS_2 but red P is insoluble in CS_2
 (2) P-P-P bond angle is 60° in red P
 (3) On heating in air, white P change into red P
 (4) White P change in black P at ordinary temp.
- Which of the following structural features of graphite best accounts for its use as a lubricant?
 (1) delocalized electrons
 (2) strong covalent bonds between carbon atoms
 (3) van der Waal's forces between layers
 (4) limited three covalency of carbon

BORON FAMILY (GROUP 13)

INTRODUCTION

The p-block elements are those elements of the periodic table in which the differentiating electron (or the last electron) enters the p-subshell of the last (outermost) shell. Since the maximum capacity of any atomic orbital is of two electrons with opposite spins (Pauli's principle), the maximum number of electrons that can be accommodated in any p-subshell is six. As a result, the p-block of the periodic table consists of six groups: 13 (III A), 14 (IV A), 15 (V A), 16 (VI A), 17 (VIIA) and 18 (zero group). On the basis of electronic configuration, the element He is to be excluded from the p-block as its last electron enters the s-subshell of the last shell.

BORON FAMILY

Boron is a typical non-metal, aluminium is a metal but shows many chemical similarities to boron, and gallium, indium and thallium are almost exclusively metallic in character,

GENERAL CHARACTERISTICS

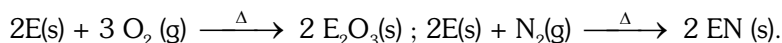
Physical properties :

- Boron is non-metallic in nature.
- It is extremely hard and black coloured solid. It exists in many allotropic forms.
- Due to very strong crystalline lattice, boron has unusually high melting point.
- Rest of the members are soft metals with low melting point and high electrical conductivity. Gallium with low melting point (303 K), could exist in liquid state during summer. Its **high boiling point (2676 K)** makes it a useful material for measuring high temperatures.

Chemical properties

Reactivity towards air

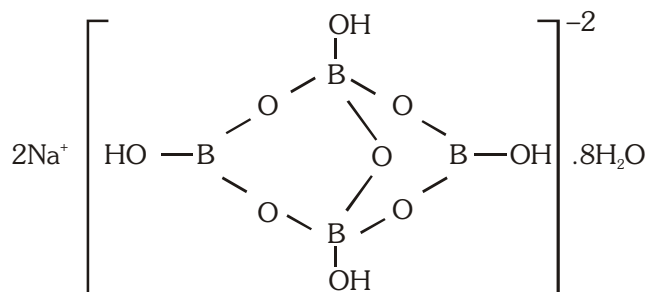
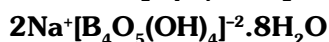
- Boron is unreactive in crystalline form.
- Aluminium forms a very thin oxide layer on the surface which protects the metal from further attack.
- Amorphous boron and aluminium metal on heating in air form B_2O_3 and Al_2O_3 respectively. With dinitrogen at high temperature they form nitrides.



The nature of these oxides varies down the group. Boron trioxide is acidic and reacts with basic (metallic) oxides forming metal borates. Aluminium and gallium oxides are amphoteric and those of indium and thallium are basic in their properties.

COMPOUNDS OF BORON

(I) Borax ($Na_2B_4O_7 \cdot 10H_2O$)

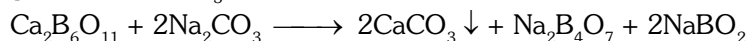


Important points :

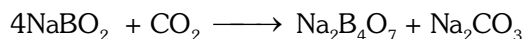
- B-O-B linkage = 5
- Total B-O bonds = 14
- Two Boron- sp^2 hybridised
- Two Boron- sp^3 hybridised

(i) From Colemanite.

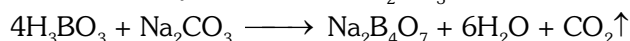
When colemanite powder is heated with Na_2CO_3 solution, the following reaction occurs with the precipitation of CaCO_3 .



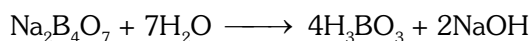
The filtrate is cooled when white crystals of borax are precipitated. The mother liquor on treatment with CO_2 converts NaBO_2 to $\text{Na}_2\text{B}_4\text{O}_7$ which precipitates out on crystallization.

**(ii) From orthoboric acid.**

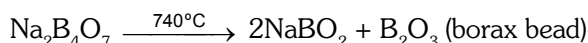
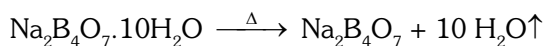
Borax is obtained by the action of Na_2CO_3 on orthoboric acid.

**Properties :**

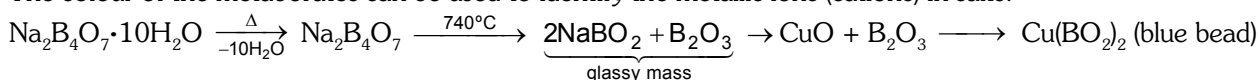
- (i) Borax is a white powder, less soluble in cold water, more soluble in hot water.
- (ii) Its aqueous solution is alkaline because of its hydrolysis to weak acid H_3BO_3 and strong alkali NaOH .

**(iii) Action of heat.**

When borax powder is heated, it first swells due to loss of water in the form of steam but at 740°C it becomes converted into colourless transparent borax bead.

**Borax-bead test :**

Borax reacts with certain metal salts such as, Ni^{2+} , Co^{2+} , Cr^{3+} , Cu^{2+} , Mn^{2+} etc. to form coloured metaborates. The colour of the metaborates can be used to identify the metallic ions (cations) in salts.

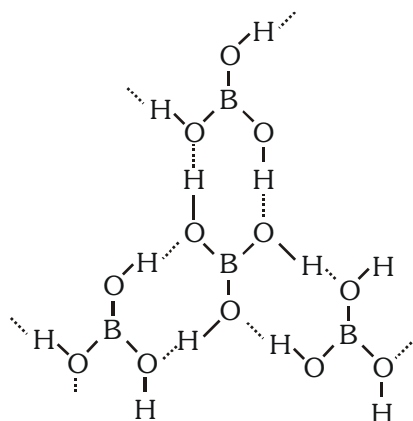


Uses : Borax is used

1. in borax bead test
2. in purifying gold
3. as flux during welding of metals and
4. in production of glass.

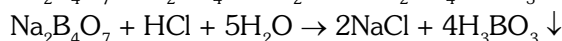
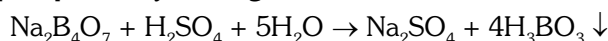
(II) ORTHO BORIC ACID [$\text{H}_3\text{BO}_3/\text{B}(\text{OH})_3$]

Orthoboric acid is greasy to touch less soluble in cold water but more soluble in hot water. In the solid state, the $\text{B}(\text{OH})_3$ units are hydrogen bonded together into two dimensional sheets with almost hexagonal symmetry.

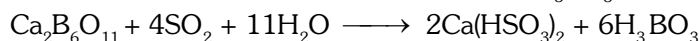


(A) Preparation :

- (i) It is precipitated by treating a concentrated solution of borax with mineral acid.

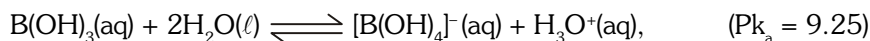


- (ii) From Colemanite: Powdered colemanite is suspended in water and excess SO_2 is passed through it. On filtering and cooling the filtrate, white crystals of H_3BO_3 are obtained.



(B) Properties:

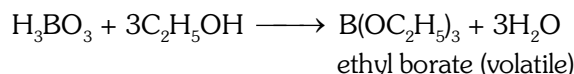
It is a weak monobasic acid soluble in water and in aqueous solution the boron atom completes its octet by accepting OH^- from water molecules:



It, therefore, functions as a Lewis acid and not as a proton donor like most acids.

(C) Test for Borate radical :

When boric acid is heated with ethyl alcohol, the evolved gas is burned forming a green edged flame.



Uses :

1. It is an antiseptic and its water solution is used as an eyewash.
2. It is also used in glass, enamel and pottery industry.

(III) DIBORANE (B_2H_6)

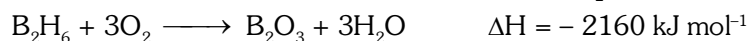
Binary compounds of boron with hydrogen are called boron hydrides or boranes.

Preparation :

- (i) $4\text{BF}_3 + 3\text{LiAlH}_4 \xrightarrow{\text{ether}} 2\text{B}_2\text{H}_6 + 3\text{LiF} + 3\text{AlF}_3$
- (ii) $2\text{NaBH}_4 + \text{I}_2 \xrightarrow{\text{ether}} \text{B}_2\text{H}_6 + 2\text{NaI} + \text{H}_2$
- (iii) $2\text{BF}_3 + 6\text{NaH} \xrightarrow{453\text{ K}} \text{B}_2\text{H}_6 + 6\text{NaF}$ (Industrial method)

Properties :

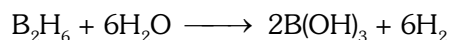
- (i) B_2H_6 is colourless gas and highly reactive (boiling point 183 K).
- (ii) It catches fire spontaneously in air and explodes with O_2 . Reaction with oxygen is extremely exothermic.



Mixtures of diborane with air or oxygen in flame spontaneously producing large amount of heat. Diborane has a higher heat of combustion per unit weight of fuel than most other fuels. It is therefore used as a rocket fuel.

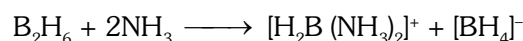
At red-heat the boranes decomposes to boron and hydrogen.

- (iii) Reaction with water is instantaneous.

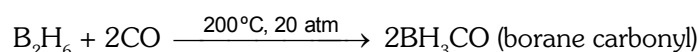
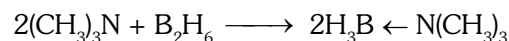


- (iv) The electron deficient 3c-2e B-H-B bridges are sites of nucleophilic attack.

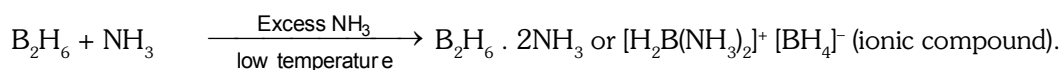
Small amines such as NH_3 , CH_3NH_2 and $(\text{CH}_3)_2\text{NH}$ give unsymmetrical cleavage of diborane.



Large amines such as $(\text{CH}_3)_3\text{N}$ and pyridine give symmetrical cleavage of diborane.



- (v) The reaction with ammonia depends on conditions.

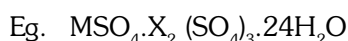


Borazole is much more reactive than benzene.

COMPOUNDS OF ALUMINIUM :

ALUM

- (a) Alums are double sulphates with their general formula $\text{M}_2\text{SO}_4 \cdot \text{M}'_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$
where M = monovalent radical like Na^+ , K^+ , NH_4^+ and M' = Trivalent radical like Al^{+3} , Cr^{+3} , Fe^{+3} .
- (b) The different alums are -
- (i) Potash alum - $\text{K}_2\text{SO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$
 - (ii) Chrome alum - $\text{K}_2\text{SO}_4 \cdot \text{Cr}_2(\text{SO}_4)_3 \cdot 24 \text{H}_2\text{O}$
 - (iii) Iron alum - $(\text{NH}_4)_2\text{SO}_4 \cdot \text{Fe}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$
 - (iv) Ammonium alum - $(\text{NH}_4)_2\text{SO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$
- (c) In alums each metal ion is surrounded by six water molecules.
- (d) Lithium does not form alum because Li ion is too small to have a coordination number of six.
- (e) **Pseudo alums** : Double sulphates of divalent ions and trivalent ions with 24 water molecules in their crystals are known as **pseudo alums**.



M = divalent or Bivalent ion

X = Trivalent metal ion

Properties :

- (a) It is a white crystalline solid highly soluble in water.
- (b) On heating it undergoes dehydration and swells up.
- (c) It is highly acidic in aqueous solution due to the hydrolysis of aluminium sulphate to sulphuric acid
- (d) It is a double salt and its aqueous solution gives reaction of all the constituents ions K^+ , Al^{+3} , SO_4^{-2} .

Uses :

- (i) Alum is used to stop bleeding.
- (ii) It is used for purification of water.
- (iii) It is used as a mordant in dyeing industry.
- (iv) Alum is used for tanning of leather.

BEGINNER'S BOX-5

- On the addition of mineral acid to an aqueous solution of borax, the compound formed is –
 - (1) Orthoboric acid
 - (2) Boron hydride
 - (3) Metaboric acid
 - (4) Pyroboric acid
- Which of the following can be detected by the borax-bead test ?
 - (1) Ni^{2+}
 - (2) Co^{2+}
 - (3) Pb^{+2}
 - (4) Both (1) & (2)
- A mixture of boric acid with ethyl alcohol burns with green edged flame due to the formation of –
 - (1) Ethyl borax
 - (2) Ethyl borate
 - (3) Methyl borax
 - (4) Methyl borate
- The hydrolysis of borax produces –
 - (1) An acidic medium
 - (2) A basic medium
 - (3) A neutral medium
 - (4) An acidic or an neutral medium
- In alums, each metal ion is surrounded by–
 - (1) Two water molecules
 - (2) Four water molecules
 - (3) Six water molecules
 - (4) Eight water molecules
- Which of the following is false statements :-
 - (1) Boranes are easily hydrolysed
 - (2) LiAlH_4 reduces BCl_3 to borane
 - (3) BH_3 is a Lewis acid
 - (4) All the B–H distances in diborane (B_2H_6) are equal
- Inorganic graphite is :-
 - (1) $\text{B}_3\text{N}_3\text{H}_6$
 - (2) B_2H_6
 - (3) BN
 - (4) BF_3
- By which of the following reactions is borazine prepared ?
 - (1) $\text{B}_2\text{H}_6 + \text{NH}_3 \text{ (excess)} \xrightarrow{\text{low temperature}}$
 - (2) $\text{B}_2\text{H}_6 + \text{NH}_3 \text{ (excess)} \xrightarrow{\text{high temperature}}$
 - (3) $\text{B}_2\text{H}_6 + \text{NH}_3 \xrightarrow[\text{high temperature}]{\text{(ratio } 2\text{NH}_3 : 1\text{B}_2\text{H}_6)}$
 - (4) None of the above
- When an inorganic compound (X) having 3c–2e as well as 2c–2e bonds reacts with ammonia gas at a certain temperature, gives a compound (Y), isostructural with benzene. Compound (X) with ammonia at a high temperature produces a substance (Z) :
 - (1) (X) is B_2H_6
 - (2) (Z) is known as inorganic graphite
 - (3) (Y) is $\text{B}_3\text{N}_3\text{H}_6$
 - (4) All of these
- Which one of the following has the lowest m.p.?
 - (1) B
 - (2) Al
 - (3) Ga
 - (4) Tl

CARBON FAMILY (GROUP 14)

PHYSICAL PROPERTIES

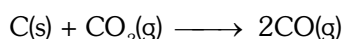
- All group 14 members are solids.
- Carbon and silicon are non-metals, germanium is metalloid whereas tin and lead are soft metals with low melting points.
- Melting points and boiling points of group 14 elements are much higher than those of corresponding elements of group 13 due to stronger metallic bonding.

COMPOUNDS OF CARBON

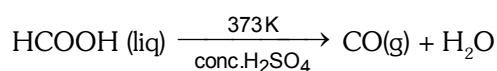
(A) Carbon Monoxide (CO)

(I) Preparation

- (i) It is formed together with CO_2 , when carbon or carbonaceous matter is oxidized by air or oxygen. It is also produced when CO_2 is reduced by red-hot carbon; this reaction is of importance in metal extractions.



- (ii) In the laboratory it can be prepared by dehydrating methanoic acid with concentrated sulphuric acid.



(II) Physical Properties

- Carbon monoxide is a colourless, odourless gas which burns in air with a blue flame, forming CO_2 .
- It is sparingly soluble in water and is a neutral oxide.
- CO is toxic, because it forms a complex with haemoglobin in the blood and this complex is more stable than oxy-haemoglobin. This prevents the haemoglobin in the red blood corpuscles from carrying oxygen round the body. This causes oxygen deficiency, leading to unconsciousness and then death.
- It acts as good reducing agents for all metal oxide.

(B) CARBON DIOXIDE (CO_2)

Preparation :

- Complete combustion of carbon containing compounds.

$$\text{CH}_4 + \text{O}_2 \longrightarrow \text{CO}_2 + \text{H}_2\text{O}$$
- In the laboratory it can be conveniently made by the action of dilute hydrochloric acid on marble chips :

$$\text{CaCO}_3(\text{aq}) + 2\text{H}^+(\text{aq}) \longrightarrow \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\ell)$$
- Industrially it is produced as a by-product during the manufacture of quicklime and in fermentation processes:

$$\text{CaCO}_3(\text{s}) \longrightarrow \text{CaO}(\text{s}) + \text{CO}_2(\text{g}) ; \quad \text{C}_6\text{H}_{12}\text{O}_6(\text{aq})\{\text{glucose}\} \longrightarrow 2\text{C}_2\text{H}_5\text{OH}(\text{aq}) + 2\text{CO}_2(\text{g})$$

Properties :

- It is a colourless, odourless and heavy gas.
- Carbon dioxide is the acid anhydride of carbonic acid, which is a weak dibasic acid and ionises in two steps as follows :

$$\text{H}_2\text{CO}_3(\text{aq}) + \text{H}_2\text{O}(\ell) \rightleftharpoons \text{HCO}_3^-(\text{aq}) + \text{H}_3\text{O}^+(\text{aq})$$

$$\text{HCO}_3^-(\text{aq}) + \text{H}_2\text{O}(\ell) \rightleftharpoons \text{CO}_3^{2-}(\text{aq}) + \text{H}_3\text{O}^+(\text{aq})$$

$$\text{H}_2\text{CO}_3 / \text{HCO}_3^- \text{ buffer system helps to maintain pH of blood between 7.26 to 7.42.}$$

A solution of carbonic acid in water will slowly turn blue litmus red and when the solution is boiled, all the CO_2 is evolved.
- Carbon dioxide readily reacts with alkalis forming the carbonate and, if CO_2 is in excess, the hydrogen carbonate. This is the basis of the lime-water test for CO_2 gas.

$$\text{Ca(OH)}_2(\text{aq}) + \text{CO}_2(\text{g}) \rightarrow \text{CaCO}_3(\text{s}) + \text{H}_2\text{O}(\text{liq}) ; \quad \text{CaCO}_3(\text{s}) + \text{H}_2\text{O}(\text{liq}) + \text{CO}_2(\text{g}) \rightarrow \text{Ca(HCO}_3)_2(\text{aq})$$

The above reaction accounts for the formation of temporarily hard water.
- Gaseous CO_2 is extensively used to carbonate soft drinks. Being heavy and non-supporter of combustion it is used as fire extinguisher. A substantial amount of CO_2 is used to manufacture urea.

(C) Carbides :

On the basis of type of bonding carbides are of three types :-

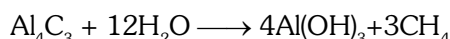
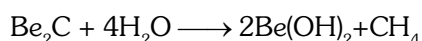
- (I) Salt like carbides (ionic carbides)
- (II) Covalent carbides (giant molecular carbides)
- (III) Interstitial carbides.

(I) Salt like carbides (ionic carbides) :

- (a) These are formed by strong electropositive elements of groups 1, 2 and 13
- (b) These are transparent crystalline substances and do not conduct electric current in the solid state.
- (c) These are easily hydrolysed by water or dilute acids to give aliphatic hydrocarbons,

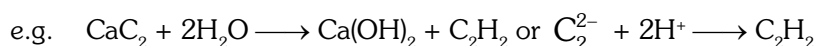
(i) **Methanides (Methides)** – Methanides are the carbides which give methane on hydrolysis.

They contain C^{4-} ions.



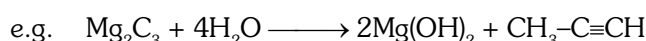
(ii) **Acetylides** – These are the carbides which yield acetylene on hydrolysis.

They contain the ion C_2^{2-} .



(iii) **Allylides** – These carbides give methylacetylene or allylene ($CH_3-C\equiv CH$) on hydrolysis.

They contain C_3^{4-} ions.



(II) Covalent carbides (giant molecular carbides)

- (a) Covalent carbides are the compounds of carbon with elements having similar electronegativity.
- (b) These are covalent, polymeric, thermally stable, extremely hard, high melting and technically inert solid.
- (c) B_4C and SiC are two main covalent carbides.

(III) Interstitial carbides.

Transition metals like Ti, Zr, Hf, V, Nb, Ta and Mo form these carbides. The metals retain their **close packed lattice** and carbons are incorporated in their interstitial spaces. These carbides are extremely hard and have very high melting points. The carbides of V and Ta are very hard hence they are used for manufacture of high speed cutting tools.

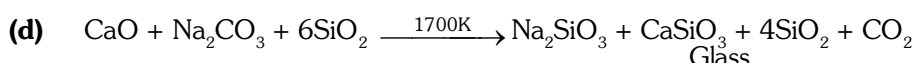
GLASS

- (a) Glass is a hard, brittle transparent, amorphous solid or supercooled liquid made up of silicates of Na, Ca and other metals like Pb, Zn etc.
- (b) Being amorphous solid (not a true solid) it has no sharp melting and melts at high temperature.
- (c) Glass has no definite chemical formula, however it may be represented as :



where M = monovalent metals (eg : Na, K)

M' = bivalent metals Ca, Pb, Zn etc. x and y are integers.



Different Types of Glass

- (i) **Soda or Soft glass or Sodaline glass** : It is common glass. Contains Na & Ca metal carbonate. Used for formation of tube, window.
- (ii) **Potash or Hard glass** : It is a mixture of potassium and calcium silicates. It fuses with difficulty. It is used for making hard glass apparatus.

- (iii) **Flint glass** : It is mixture of potassium and lead silicates. It has a very high refractive index and is used for making electric bulbs and optical instruments.
- (iv) **Crooke's glass** : It is a optical glass containing CeO_2 which prevents the entry of UV rays.
- (v) **Pyrex glass or borasil or borosilicate glass** : It is used to make lab appliances as it is resistant to heat, shock and common reagents. It is a mixture of zinc and barium boro silicates and alumina silicate.

Small part of SiO_2 is replaced by boric oxide/borax.

Low coefficient and thermal expansion, can with stand sudden change in temperature so used for making lab glass wares.

SOME GASEOUS FUELS

- | | |
|---|---|
| (a) Water gas or syn gas = $\text{CO} + \text{H}_2$ | (b) Producer gas = $\text{CO} + \text{N}_2$ |
| (c) Semi water gas = $\text{CO} + \text{N}_2 + \text{H}_2$ | (d) Natural gas = CH_4 |
| (e) Coal gas = $[\text{CO}_2 + \text{CO} + \text{H}_2 + \text{CH}_4]$ | |

BEGINNER'S BOX-6

- Carbon has no tendency to form complex compounds because of :

(1) Its small size	(2) The availability of vacant d-orbitals
(3) Non availability of vacant d-orbitals	(4) No tendency to form covalent bonds
- Which of the following statement is false :

(1) Dry ice is solid CO_2	(2) CO_2 is weakly acidic
(3) CO_2 and SiO_2 are linear molecules	(4) CO_2 is a gas while SiO_2 is solid
- CO is :

(1) Reductant	(2) Poisonous gas
(3) Neutral to litmus	(4) all
- Which is/are true statements :
 - (1) Diamond is unaffected by conc. acids but graphite reacts with hot conc. HNO_3 forming mellitic acid, $\text{C}_6(\text{COOH})_6$
 - (2) CO is toxic because it forms a complex with haemoglobin in the blood
 - (3) In C_3O_2 , all carbons are sp hybridised
 - (4) All are true statements

NITROGEN FAMILY (GROUP 15)

Group 15 includes nitrogen phosphorus, arsenic, antimony and bismuth.

PHYSICAL PROPERTIES:

- Dinitrogen is a diatomic gas while all others are solids.
- Except nitrogen, all the elements show allotropy.
- As we go down the group, there is a shift from non-metallic to metallic through metalloidic character. Nitrogen and phosphorus are non-metal, arsenic and antimony are metalloid and bismuth is a typical metal.

CHEMICAL PROPERTIES

Oxidation States and trends in a chemical reactivity :

- The common oxidation states of these elements are -3 , $+3$ and $+5$. The tendency to exhibit -3 oxidation state decreases down the group, bismuth hardly forms any compound in -3 oxidation state.
- Nitrogen also exhibits $+1$, $+2$, $+4$ oxidation states when it reacts with oxygen. Phosphorus also shows $+1$ and $+4$ oxidation states in some oxyacids.
- In the case of nitrogen, all oxidation states from $+1$ to $+4$ tend to disproportionate in acid solution.
For example, $3 \text{HNO}_2 \longrightarrow \text{HNO}_3 + \text{H}_2\text{O} + 2 \text{NO}$
- Similarly, in case of phosphorus nearly all intermediate oxidation states disproportionate into $+5$ and -3 both in alkali and acid. However $+3$ oxidation state in case of arsenic, antimony and bismuth become increasingly stable with respect to disproportionation.

Reactivity towards hydrogen :

- All the elements of Group 15 form hydrides of the type EH_3 where $\text{E} = \text{N}, \text{P}, \text{As}, \text{Sb}$ or Bi .
- The stability of hydrides decreases from NH_3 to BiH_3 . Consequently the reducing character of the hydrides increases. Ammonia is only a mild reducing agent while BiH_3 is the strongest reducing agent amongst all the hydrides. Due to weaker Bi-H bond.

Reactivity towards oxygen :

- All these elements form two types of oxides : E_2O_3 and E_2O_5 . The oxides of the type E_2O_3 of nitrogen and phosphorus are purely acidic, that of arsenic and antimony amphoteric and those of bismuth is predominantly basic.

Reactivity towards halogens :

- These elements react to form two series of halides : EX_3 and EX_5 .
- All the trihalides of these elements except those of nitrogen are stable. In case of nitrogen, only NF_3 is known to be stable. Trihalides except BiF_3 are predominantly covalent in nature.

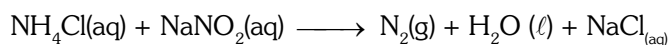
COMPOUND OF NITROGEN

1. NITROGEN GAS (N_2) :

Nitrogen is an important and essential constituent of proteins and amino acids. Nitrates and other nitrogen compounds are extensively used in fertilizers and explosive.

(a) Preparation :

(i) Laboratory method of preparation :

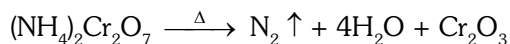


N_2 is collected by the downward displacement of water.

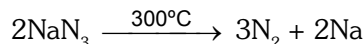
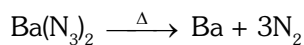
This reaction takes place in two steps as given below :



- (ii)
- By heating ammonium dichromate :**



- (iii)
- Very pure nitrogen can be obtained by heating sodium or barium azide.**



- (iv)
- Industrial methods of preparation :**

From liquified air by fractional distillation : The boiling point of N_2 is -196°C and that of oxygen is -183°C and hence they can be separated by fractional distillation of air.

(b) Properties :

- (i) N_2 is a colourless, odourless gas very less soluble in water. It is neither combustible nor a supporter of combustion.
- (ii) **Reaction with oxygen:** Dinitrogen combines with dioxygen only at very high temperature (at about 2000K) to form nitric oxide.

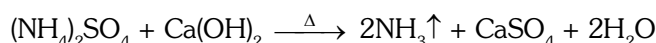
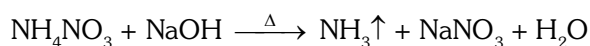
This reaction is endothermic. $\text{N}_2 + \text{O}_2 \longrightarrow 2\text{NO}$

(c) Uses :

- (i) For providing an inert atmosphere during many industrial processes where presence of air or O_2 is to be avoided.
- (ii) For manufacture of NH_3 by the Haber's process.
- (iii) Liquid dinitrogen is used as a refrigerant to preserve biological materials, food items & cryosurgery.

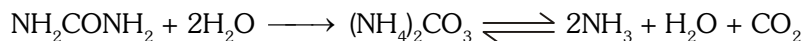
2. AMMONIA (NH_3)**(a) Preparation :**

- (i) By the action of any base or alkali on any ammonium salt :

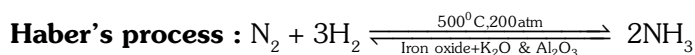


This is a general method and is used as a test for ammonium salts.

Ammonia is present in small quantities in air and soil where it is formed by the decay of nitrogenous organic matter e.g., urea.



- (ii)
- Industrial methods of preparation :**

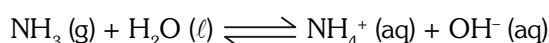


In accordance with Le Chatelier's principle, high pressure would favour the formation of ammonia. The optimum conditions for the production of ammonia are a pressure of 200×10^5 Pa (about 200 atm), a temperature of ~ 700 K and the use of a catalyst such as iron oxide with small amounts of K_2O and Al_2O_3 to increase the rate of attainment of equilibrium.

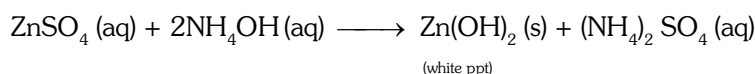
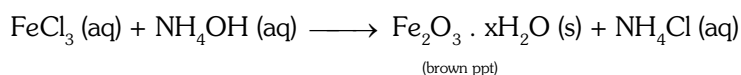
- (b) Physical properties :**
- Ammonia is a colourless gas with a pungent odour.

(c) Chemical properties :

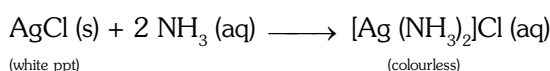
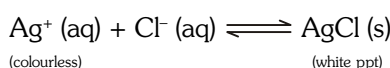
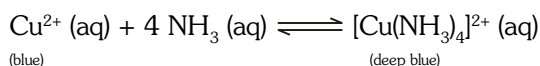
- (i) Its aqueous solution is weakly basic due to the formation of
- OH^-
- ions.



- (ii) It forms ammonium salts with acids, e.g., NH_4Cl , $(\text{NH}_4)_2\text{SO}_4$ etc. As a weak base, it precipitates the hydroxides of many metals from their salt solutions. For example,



- (iii) The presence of lone pair of electrons on the nitrogen atoms of the ammonia molecule makes it a Lewis base. It donates the electrons pair and forms linkage with metal ions and the formation of such complex compounds finds applications in detection of metal ions such as Cu^{2+} , Ag^+

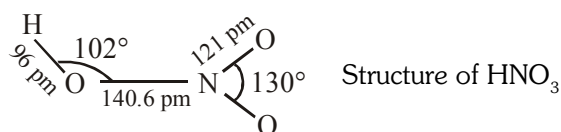


3. OXIDES OF NITROGEN :

Nitrogen forms a number of oxides, N_2O , NO , N_2O_3 , NO_2 or N_2O_4 and N_2O_5 . All these oxides of nitrogen exhibit $p\pi-p\pi$ multiple bonding between nitrogen and oxygen.

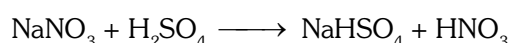
Name	Formula	Oxidation state of nitrogen	Common methods of preparation	Physical appearance and chemical nature
Dinitrogen oxide [Nitrogen(I) oxide]	N_2O	+ 1	$\text{NH}_4\text{NO}_3 \xrightarrow{\text{Heat}} \text{N}_2\text{O} + 2\text{H}_2\text{O}$	colourless gas, neutral
Nitrogen monoxide [Nitrogen(II) oxide]	NO	+ 2	$2\text{NaNO}_2 + 2\text{FeSO}_4 + 3\text{H}_2\text{SO}_4 \longrightarrow \text{Fe}_2(\text{SO}_4)_3 + 2\text{NaHSO}_4 + 2\text{H}_2\text{O} + 2\text{NO}$	colourless gas, neutral
Dinitrogen trioxide [Nitrogen(III) oxide]	N_2O_3	+ 3	$2\text{NO} + \text{N}_2\text{O}_4 \xrightarrow{250\text{ K}} 2\text{N}_2\text{O}_3$	blue solid, acidic
Nitrogen dioxide [Nitrogen(IV) oxide]	NO_2	+ 4	$2\text{Pb}(\text{NO}_3)_2 \xrightarrow{673\text{ K}} 4\text{NO}_2 + 2\text{PbO} + \text{O}_2$	brown gas, acidic
Dinitrogen tetroxide [Nitrogen(IV) oxide]	N_2O_4	+ 4	$2\text{NO}_2 \xrightleftharpoons[\text{Heat}]{\text{cool}} \text{N}_2\text{O}_4$	colourless solid / liquid, acidic
Dinitrogen pentoxide [Nitrogen(V) oxide]	N_2O_5	+ 5	$4\text{HNO}_3 + \text{P}_4\text{O}_{10} \longrightarrow 4\text{HPO}_3 + 2\text{N}_2\text{O}_5$	colourless solid, acidic

4. NITRIC ACID (HNO_3)



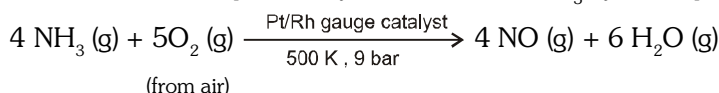
(a) Preparation :

In the laboratory, nitric acid is prepared by heating KNO_3 or NaNO_3 and concentrated H_2SO_4 in a glass retort.

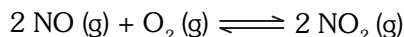


On a large scale it is prepared mainly by **Ostwald's process**.

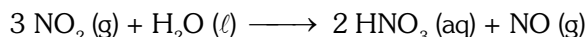
This method is based upon catalytic oxidation of NH_3 by atmospheric oxygen.



Nitric oxide thus formed combines with oxygen giving NO_2 .



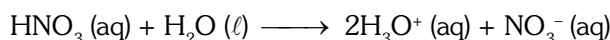
Nitrogen dioxide so formed, dissolves in water to give HNO_3 .



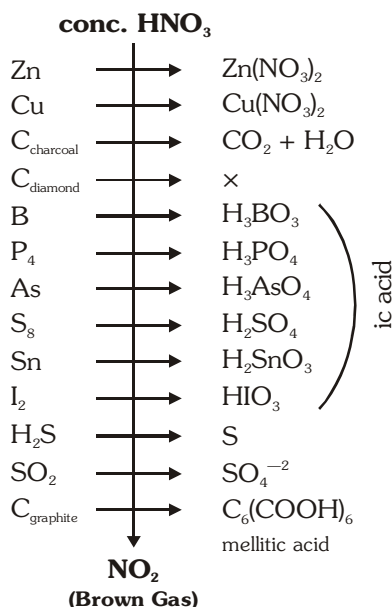
NO thus formed is recycled and the aqueous HNO_3 can be concentrated by distillation upto ~ 68% by mass. Further concentration to 98% can be achieved by dehydration with concentrated H_2SO_4 .

(b) Physical properties :

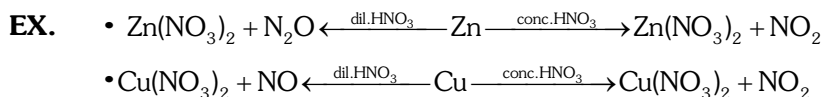
- (i) It is a colourless liquid. Freezing point is 231.4 K and boiling point is 355.6 K. Laboratory grade nitric acid contains ~ 68% of the HNO_3 by mass and has a specific gravity of 1.504.
- (ii) In the gaseous state, HNO_3 exists as a planar molecule.
- (iii) In aqueous solution, nitric acid behaves as a strong acid giving hydronium and nitrate ions.



- (iv) Concentrate nitric acid is a strong oxidising agent and attacks most metals except Au & Pt. The product of oxidation depend upon the concentration of the acid, temperature and nature of metal.
- (v) Concentrate HNO_3 also oxidises non-metals and their compounds.

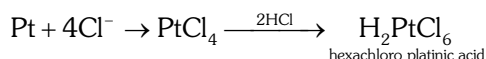
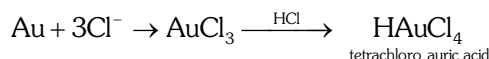


Types of Metal	conc. HNO_3	dil. HNO_3	very dil. HNO_3
negative SRP metal	Metal nitrate + NO_2	Metal nitrate + N_2O	Metal nitrate + $\text{NH}_4\text{NO}_3/(\text{NH}_3)$
positive SRP metal & Pb	Metal nitrate + NO_2	Metal nitrate + NO	×
Metalloids, Non-metals & Sn	ic-acid + NO_2	×	×



SOME EXCEPTIONAL POINTS

- **Mg and Mn form H_2 gas on reaction with very dilute HNO_3**
- **Be, Al, Fe, Cr do not react with conc. HNO_3 due to formation of protective oxide layer.**
- **Au and Pt (Noble metals) do not react with conc. HNO_3**
- **Sn reacts with conc. HNO_3 and forms H_2SnO_3 (metastannic acid)**
- **Au and Pt react only with aqua regia (3 part of conc. HCl and 1 part of conc. HNO_3)**



conc. HNO_3 + skin $\rightarrow$ yellow spot (protein $\rightarrow$ xanthoprotein)

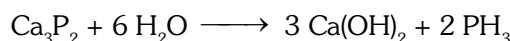
- **The major use of nitric acid is in the manufacture of ammonium nitrate for fertilizers and other nitrates for use in explosives and pyrotechnics. It is also used for the preparation of nitroglycerin, trinitrotoluene and other organic nitro compounds. Other major uses are in the pickling of stainless steel, etching of metals and as an oxidiser in rocket fuels.**

COMPOUNDS OF PHOSPHORUS :

1. Phosphine (PH_3) :

(a) Preparation :

- (i) Phosphine is prepared by the reaction of calcium phosphide with water.

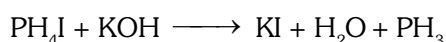


- (ii) In the laboratory, it is prepared by heating white phosphorus with concentrated NaOH solution in an inert atmosphere of CO_2 .



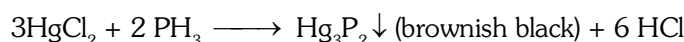
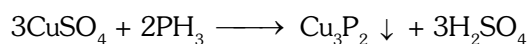
(sodium hypophosphite)

- (iii) When pure, it is non inflammable but becomes inflammable owing to the presence of P_2H_4 or P_4 vapours. To purify it from the impurities, it is absorbed in HI to form phosphonium iodide (PH_4I) which on treating with KOH gives off phosphine.



(b) Properties :

- (i) It is a colourless gas with rotten fish smell and is highly poisonous. It is slightly soluble in water. The solution of PH_3 in water decomposes in presence of light giving red phosphorus and H_2 .
- (ii) When absorbed in copper sulphate or mercuric chloride, the corresponding phosphides are obtained.



- (iii) Phosphine is weakly basic and like ammonia, gives phosphonium compounds with acids



- **Uses :** The spontaneous combustion of phosphine is technically used in **Holme's signals**. Containers containing calcium carbide and calcium phosphide are pierced and thrown in the sea when the gases evolved burn and serve as a signal.
- It is also used in the production of smoke screens. Calcium phosphide reacts with water producing phosphine which burns in air to give clouds of phosphorus pentaoxide and that acts as smoke screens.

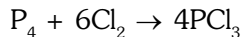
2. PHOSPHOROUS HALIDES

Phosphorous forms two types of halides, PX_3 ($X = F, Cl, Br, I$) and PX_5 ($X = F, Cl, Br$).

Phosphorous Trichloride (PCl_3)

(a) Method of preparation

(i) It is obtained by passing dry chlorine over heated white phosphorus.

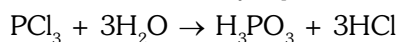


(ii) It is also obtained by the action of thionyl chloride with white phosphorus.

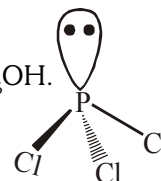
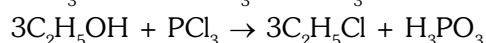
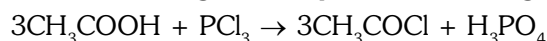


(b) Properties

(i) It is a colourless oily liquid and hydrolyses in the presence of moisture.

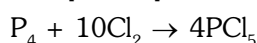


(ii) It reacts with organic compounds containing $-OH$ group such as CH_3COOH , C_2H_5OH .

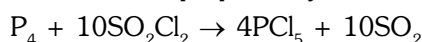
PHOSPHORUS PENTACHLORIDE (PCl_5)

(a) Method of preparation

(i) Phosphorus pentachloride is prepared by the reaction of white phosphorus with excess of dry chlorine.

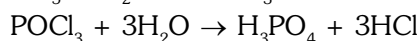
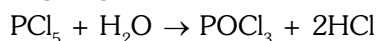


(ii) It can also be prepared by the action of SO_2Cl_2 on phosphorus.

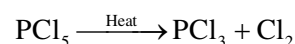


(b) Properties

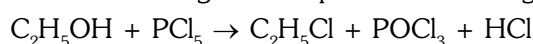
(i) PCl_5 is a yellowish white powder and in moist air, it hydrolyses to $POCl_3$ and finally gets converted to phosphoric acid.



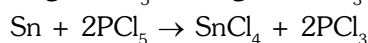
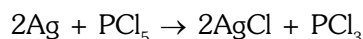
(ii) When heated, it sublimes but decomposes on stronger heating.



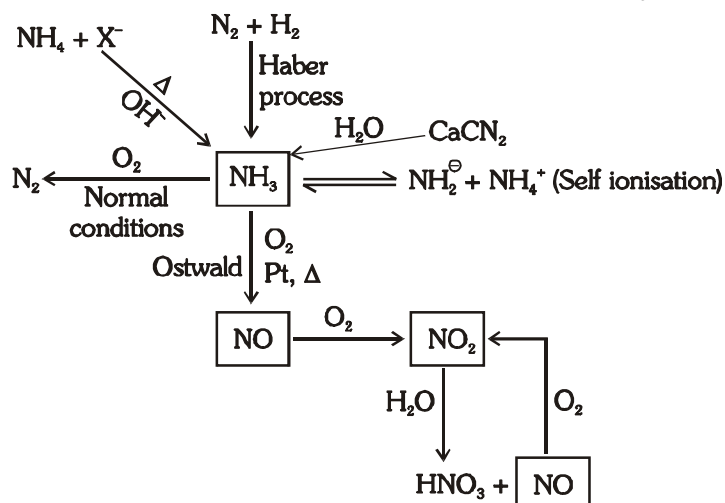
(iii) It reacts with organic compounds containing $-OH$ group converting them to chloro derivatives.



(iv) Finally divided metals on heating with PCl_5 give corresponding chlorides.



(v) It is used in the synthesis of some organic compounds, e.g., C_2H_5Cl , CH_3COCl .



NCERT QUESTIONS (REASONING)

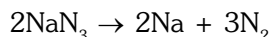
Q.1 Why BiH_3 is the strongest reducing agent amongst all the hydrides of Group 15 elements ?

Ans. In hydrides of nitrogen family on moving down the group M-H bond length increases so bond strength decreases hence tendency to release hydrogen increases and reducing nature increases.

Increasing order of reducing nature is $\text{NH}_3 < \text{PH}_3 < \text{AsH}_3 < \text{SbH}_3 < \text{BiH}_3$

Q.2 Write the reaction of thermal decomposition of sodium azide.

Ans. Thermal decomposition of sodium azide gives dinitrogen gas.



Q.3 Why N_2 is less reactive at room temperature?

Ans. N_2 is less reactive at room temperature because of the high bond enthalpy of $\text{N}\equiv\text{N}$ bond.

Q.4 Why does $\text{R}_3\text{P}=\text{O}$ exist but $\text{R}_3\text{N}=\text{O}$ does not (R = alkyl group)?

Ans. Due to presence of vacant d orbital phosphorous can form five covalent bond, while nitrogen restricts its covalency to four due to absence of vacant d orbitals.

Q.5 Why does nitrogen show catenation properties less than phosphorus?

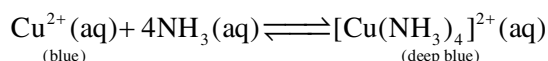
Ans. N-N bond is weaker than the single P-P bond due to high interelectronic repulsion of non-bonding electrons as a result the catenation tendency is weaker in nitrogen.

Q.6 Mention the conditions required to maximise the yield of ammonia.

Ans. In accordance with Le Chatelier's principle, high pressure would favour the formation of ammonia. The optimum conditions for the production of ammonia are a pressure of 200×10^5 Pa (about 200 atm), a temperature of ~ 700 K and the use of a catalyst such as iron oxide with small amounts of K_2O and Al_2O_3 to increase the rate of attainment of equilibrium.

Q.7 How does ammonia react with a solution of Cu^{2+} ?

Ans. The presence of a lone pair of electrons on the nitrogen atom of the ammonia molecule makes it a Lewis base. It donates the electron pair and forms linkage with metal ions and the formation of such complex compounds finds applications in detection of Cu^{2+} .



Q.8 Illustrate how copper metal can give different products on reaction with HNO_3 .

Ans. $3\text{Cu} + 8\text{HNO}_3(\text{dilute}) \rightarrow 3\text{Cu}(\text{NO}_3)_2 + 2\text{NO} + 4\text{H}_2\text{O}$

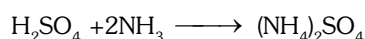
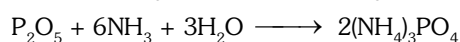


Q.9 Why is nitrogen di-oxide paramagnetic in gaseous state but the solid obtained on cooling it is diamagnetic.

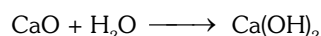
Ans. NO_2 contains odd number of electrons in its valence shell. On cooling it forms dimer and converted to stable N_2O_4 which is a colourless solid and diamagnetic in nature.

Q.10 Why NH_3 gas cannot be dried by passing over P_2O_5 , CaCl_2 and H_2SO_4 ?

Ans. $\text{CaCl}_2 + 8\text{NH}_3 \longrightarrow \text{CaCl}_2 \cdot 8\text{NH}_3$



So it is dried by passing over quick lime (CaO).

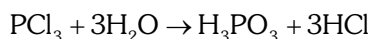


Q.11 Why inert atmosphere of CO_2 is taken in the formation of PH_3 by the reaction of white phosphorous with conc. NaOH solution.

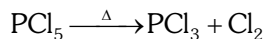
Ans. To decrease the partial pressure of O_2 in atmosphere.

Q.12 Why does PCl_3 fumes in moisture?

Ans. PCl_3 hydrolyses in the presence of moisture giving fumes of HCl

**Q.13 What happens when PCl_5 is heated?**

Ans. When heated, it sublimes but decomposes on stronger heating

**Q.14 Can PCl_5 act as an oxidising as well as reducing agent? Justify.**

Ans. It can act as an oxidising as well as reducing agent due to oxidising nature of P(V) and reducing nature of Cl⁻

BEGINNER'S BOX-7

- Which of the following halide of nitrogen is stable?
 (1) NF_3 (2) NCl_3 (3) NBr_3 (4) NI_3
- The nitrogen oxide(s) that does not contain N-N bond(s) is
 (1) N_2O (2) N_2O_3 (3) N_2O_4 (4) N_2O_5
- What is false about N_2O_5 ?
 (1) It is anhydride of HNO_3 (2) It is a powerful oxidizing agent
 (3) Solid N_2O_5 is called nitronium nitrate (4) Structure of N_2O_5 contains no $[\text{N} \rightarrow \text{O}]$ bond
- Conc. HNO_3 is yellow coloured liquid due to –
 (1) Dissolution of NO in conc. HNO_3 (2) Dissolution of NO_2 in conc. HNO_3
 (3) Dissolution of N_2O in conc. HNO_3 (4) Dissolution of N_2O_3 in conc. HNO_3
- Which of the following process is not involved in Ostwald's process for the manufacture of HNO_3 ?
 (1) $4\text{NH}_3(\text{g}) + 5\text{O}_2(\text{g}) \xrightarrow[500\text{K}, 9\text{bar}]{\text{Pt}} 4\text{NO}(\text{g}) + 6\text{H}_2\text{O}(\text{g})$
 (2) $2\text{NO}(\text{g}) + \text{O}_2 \rightleftharpoons 2\text{NO}_2(\text{g})$
 (3) $3\text{NO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightarrow 2\text{HNO}_3(\text{aq}) + \text{NO}(\text{g})$
 (4) None
- Which of the following salts give NH_3 in alkaline medium?
 (1) $(\text{NH}_4)_2\text{CO}_3$ (2) $(\text{NH}_4)_2\text{SO}_4$ (3) NH_4Cl (4) All of the above
- Which of the following reaction is suitable for obtaining very pure nitrogen?
 (1) $\text{NH}_4\text{Cl}(\text{aq}) + \text{NaNO}_2(\text{aq}) \longrightarrow \text{N}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}) + \text{NaCl}(\text{aq})$
 (2) $(\text{NH}_4)_2\text{Cr}_2\text{O}_7 \xrightarrow{\Delta} \text{N}_2 + 4\text{H}_2\text{O} + \text{Cr}_2\text{O}_3$
 (3) $\text{Ba}(\text{N}_3)_2 \xrightarrow{\Delta} \text{Ba} + 3\text{N}_2$
 (4) All of the above
- In warfare smoke screens are prepared from
 (1) CaC_2 (2) PH_3 (3) P_2O_5 (4) COCl_2
- White phosphorous on reaction with NaOH gives PH_3 as one of the products. This is a
 (1) dimerisation reaction (2) disproportionation reaction
 (3) condensation reaction (4) precipitation reaction
- Which of the following is not correctly matched?
 (1) $\text{P}_4\text{O}_{10} + \text{H}_2\text{O} \longrightarrow$ reactants involved in formation of H_3PO_4
 (2) $\text{CaC}_2 + \text{H}_2\text{O} \longrightarrow \text{C}_2\text{H}_2 + \text{Ca}(\text{OH})_2$;
 $\text{Ca}_3\text{P}_2 + \text{H}_2\text{O} \longrightarrow \text{PH}_3 + \text{Ca}(\text{OH})_2$ reactions involved in Holmes signal
 (3) $\text{PH}_3 + \text{HI} \longrightarrow \text{PH}_4\text{I} \xrightarrow{\text{KOH}} \text{KI} + \text{H}_2\text{O} + \text{PH}_3$; purification of PH_3
 (4) $\text{PH}_3 + \text{HI} \longrightarrow \text{PH}_4\text{I}$; shows Lewis acidic nature of PH_3

OXYGEN FAMILY (GROUP 16)

INTRODUCTION

Oxygen, sulphur, selenium, tellurium and polonium constitute group 16 of the periodic table. This is sometimes known as group of chalcogens (ore forming elements) because a large number of metals ores are oxides or sulphides.

Physical Properties :

- Oxygen and sulphur are non-metal, selenium and tellurium metalloids, whereas polonium is a metal. Polonium is radioactive and is short lived (Half-life 13.8 days).
- The melting and boiling points increase with an increase in atomic number down the group. The larger difference between the melting and boiling points of oxygen and sulphur may be explained on the basis of their atomicity; oxygen exist as diatomic molecules (O_2) whereas sulphur exists as polyatomic molecule (S_8).

CATENATION

Tendency for catenation decreases down the group. This property is prominently displayed by sulphur (S_8). The S—S bond is important in biological system and is found in some proteins and enzymes such as cysteine.

Chemical Properties

Oxidation states and trends in chemical reactivity :

The elements of group 16 exhibit a number of oxidation states. The stability of -2 oxidation state decreases down the group. Except oxygen other elements of the group exhibit + 2, + 4, + 6 oxidation states but + 4 and + 6 are more common. Sulphur, selenium and tellurium usually show + 4 oxidation in their compounds with oxygen and +6 oxidation state with fluorine. The stability of +6 oxidation state decreases down the group and stability of + 4 oxidation state increases (inert pair effect). Bonding in + 4 and + 6 oxidation states are primarily covalent.

(i) Reactivity with hydrogen :

All the elements of group 16 form hydrides of the type H_2E ($E = O, S, Se, Te, Po$).

(ii) Reactivity with oxygen :

All these elements form oxides of the EO_2 and EO_3 types where $E = S, Se, Te$ or Po . Ozone (O_3) and sulphur dioxide (SO_2) are gases while selenium dioxide (SeO_2) is solid. Reducing property of dioxide decreases from SO_2 to TeO_2 ; SO_2 is reducing while TeO_2 is an oxidising agent. Besides EO_2 type sulphur, selenium and tellurium also form EO_3 type oxides (SO_3, SeO_3, TeO_3). Both types of oxides are acidic in nature.

(iii) Reactivity toward the halogens :

Elements of group 16 form a larger number of halides of the type EX_6 , EX_4 and EX_2 where E is an element of the group -16 and X is an halogen. The stabilities of the halides decrease in the order $F > Cl > Br > I$. Amongst hexahalides, hexafluorides are the only stable halides. All hexafluorides are gaseous in nature. They have octahedral structure. Sulphur hexafluoride SF_6 is exceptionally stable for steric reasons.

Amongst tetrafluorides, SF_4 is a gas, SeF_4 liquid and TeF_4 a solid

All elements except selenium form dichlorides and dibromides. The well known monohalides are dimeric in nature, Examples are $S_2F_2, S_2Cl_2, S_2Br_2, Se_2Cl_2$ and Se_2Br_2 . These dimeric halides undergo disproportionation

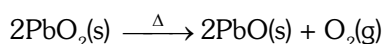
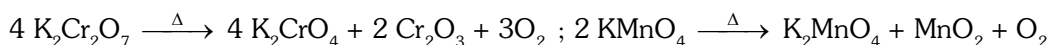
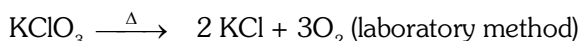
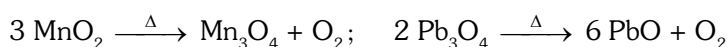
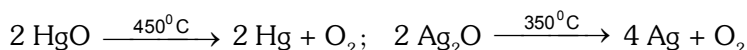
as given $2Se_2Cl_2 \longrightarrow SeCl_4 + 3Se$.

COMPOUNDS OF OXYGEN

1. DIOXYGEN (O_2)

(a) Preparation of DiOxygen (O_2) :

By thermal decomposition of oxides of metals.

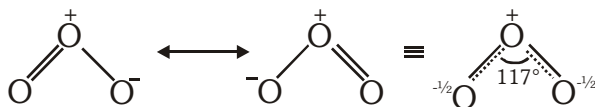


Properties:

- Dioxygen is a colourless and odourless gas.
- Oxygen atom has three stable isotopes: ^{16}O , ^{17}O and ^{18}O . Molecular oxygen.
- O_2 is paramagnetic (by MOT)
- Dioxygen directly reacts with nearly all metals and non-metals except some metals (e.g., Au, Pt) and some noble gases.

2. OZONE (O_3) :

Preparation : It is prepared by passing silent electric discharge through pure and dry oxygen.



Mixture obtained contains 5-10% ozone by volume and this mixture is called ozonised oxygen.

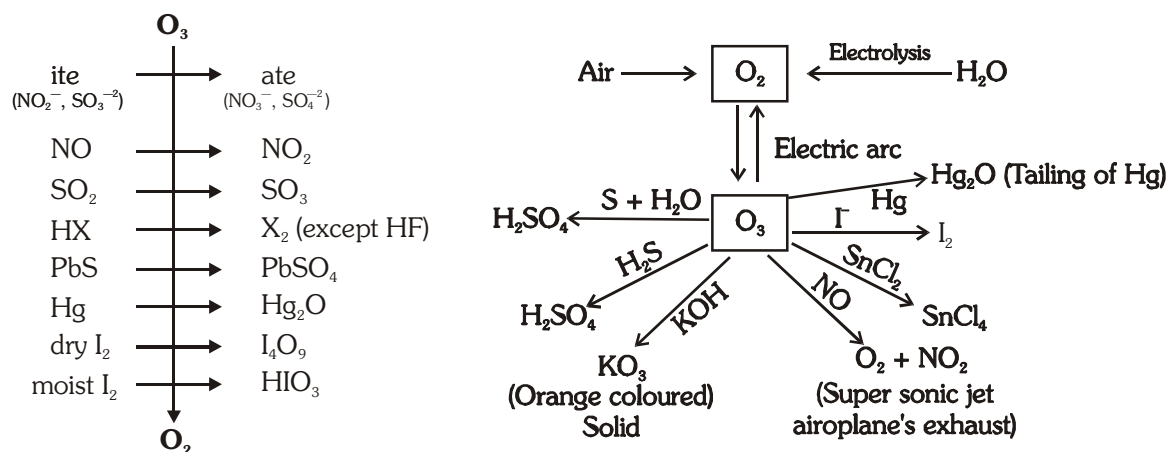
Since the formation of ozone from oxygen is an endothermic process, it is necessary to use a silent electrical discharge in its preparation to prevent its decomposition. If concentrations of ozone greater than 10 per cent are required, a battery of ozonisers can be used, and pure ozone (b.p. 385 K) can be condensed in a vessel surrounded by liquid oxygen.

Properties :

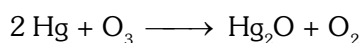
- Pure ozone is a pale blue gas, dark blue liquid and violet-black solid.
- Ozone is thermodynamically unstable with respect to oxygen since its decomposition into oxygen results in the liberation of heat (ΔH is negative) and an increase in entropy (ΔS is positive). These two effects reinforce each other, resulting in large negative Gibbs energy change (ΔG) for its conversion into oxygen. Therefore, high concentrations of ozone can be dangerously explosive.

Oxidising behaviour of ozone :

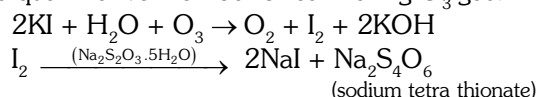
Due to the ease with which it liberates atoms of nascent oxygen ($\text{O}_3 \rightarrow \text{O}_2 + \text{O}$), it acts as a powerful oxidising agent. For example, it oxidises lead sulphide to lead sulphate and iodide ions to iodine.

**Tests for Ozone**

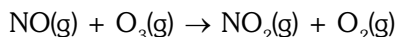
Tailing of mercury : Pure mercury is a mobile liquid but when brought in contact with O_3 its mobility decreases and it starts sticking to glass surface forming a type of tail due to the dissolution of Hg_2O (mercury sub-oxide) in Hg.



Estimation of Ozone : When ozone reacts with an excess of potassium iodide solution buffered with a borate buffer (pH 9.2), iodine is liberated which can be titrated against a standard solution of sodium thiosulphate. This is a quantitative method for estimating O_3 gas.



Depletion of ozone layer : Experiments have shown that nitrogen oxides (particularly nitric oxide) combine very rapidly with ozone and there is, thus, the possibility that nitrogen oxides emitted from the exhaust systems of supersonic jet aeroplanes might be slowly depleting the concentration of the ozone layer in the upper atmosphere.

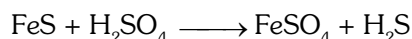


Another threat to this ozone layer is probably posed by the use of freons which are used in aerosol sprays and as refrigerants.

COMPOUNDS OF SULPHUR :

1. Hydrogen Sulphide (H_2S)

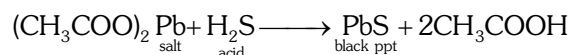
Preparation :



It is prepared in kipp's apparatus

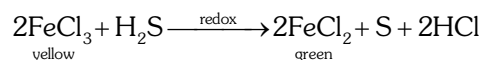
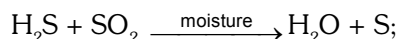
Properties :

- (i) Colourless gas with rotten egg smell .
- (ii) Moderately soluble in water but solubility decreases with increasing temperature.
- (iii) It gives black ppt with lead acetate



Reducing behaviour :

Acts as a strong reducing agent as it decomposes evolving hydrogen.



2. SO_2 (Sulphur Dioxide)

Preparation :

- (i) $S + O_2$ or air $\xrightarrow{\text{Burn}} SO_2$
- (ii) By reaction of metal sulphites with dilute HCl (Laboratory method)

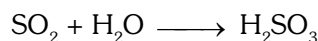
$$Na_2SO_3 + 2HCl \longrightarrow 2NaCl + SO_2 + H_2O$$
 Similarly bisulphites also give SO_2 with dilute HCl

$$NaHSO_3 + HCl \longrightarrow NaCl + SO_2 + H_2O$$
- (iii) By heating sulphides (metal sulphide ores) in excess of air.

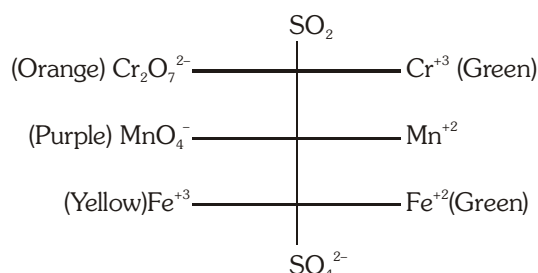
$$2ZnS + 3O_2 \longrightarrow 2ZnO + 2SO_2$$
 By this method SO_2 is obtained in large scale

Properties :

- (i) Colourless gas with pungent smell.
- (ii) It is heavier than air and is highly soluble in water.
- (iii) Acidic Nature : Acidic oxide and thus dissolve in water forming sulphurous acid.

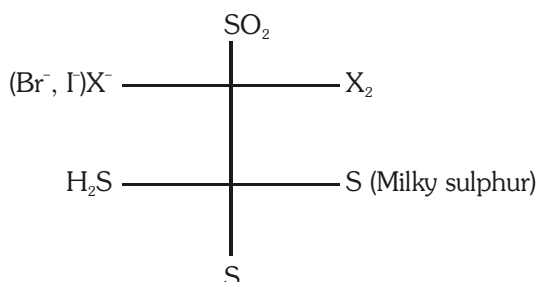


Reducing nature :



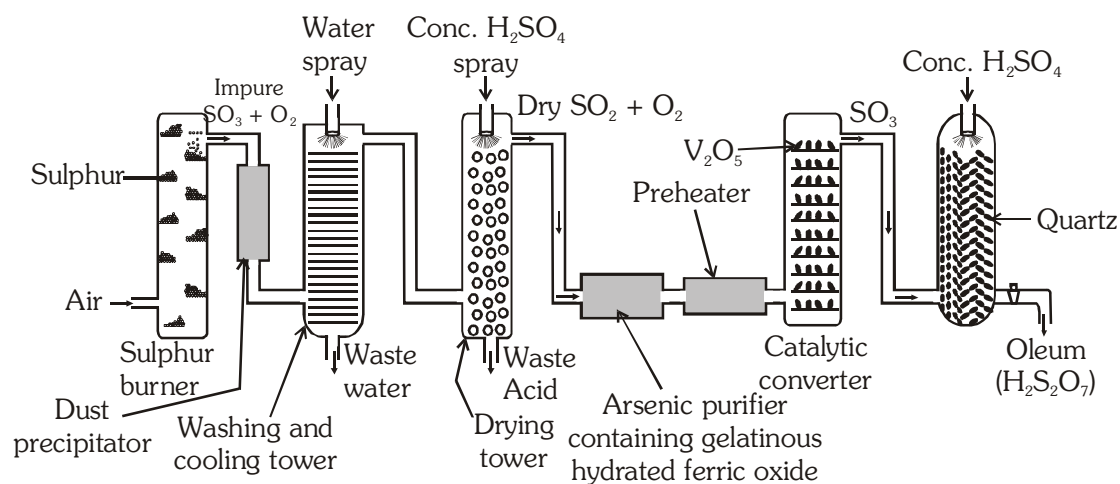
The above reactions are not given by CO_2 , so they are used to distinguish between SO_2 and CO_2

Oxidising nature : Acts as oxidising agent with strong reducing agent



3. SULPHURIC ACID (H_2SO_4) :

Manufacture by contacts process :



Flow diagram for the manufacture of sulphuric acid

Sulphuric acid is one of the most important industrial chemicals worldwide.

Sulphuric acid is manufactured by the contact process which involves three steps :

- burning of sulphur or sulphide ores in air to generate SO_2
- Conversion of SO_2 to SO_3 by the reaction with oxygen in the presence of a catalyst (V_2O_5), and
- Absorption of SO_3 in H_2SO_4 to give Oleum ($\text{H}_2\text{S}_2\text{O}_7$)

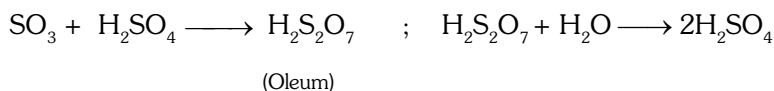
The SO_2 produced is purified by removing dust and other impurities such as arsenic compounds.

The key step in the manufacture of H_2SO_4 is the catalytic oxidation of SO_2 with O_2 to give SO_3 in the presence of V_2O_5 (catalyst).



The reaction is exothermic reversible and the forward reaction leads to a decrease in volume. Therefore, low temperature and high pressure are the favourable conditions for maximum yield. But the temperature should not be very low otherwise rate of reaction will become slow.

Dilution of oleum with water gives H_2SO_4 of the desired concentration. In the industry two steps are carried out simultaneously to make the process a continuous one and also to reduce the cost.

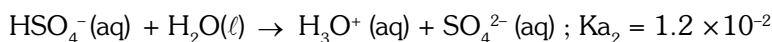
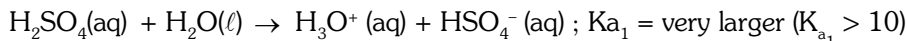


The sulphuric acid obtained by Contact process is 96-98% pure.

Properties : Sulphuric acid is a colourless, dense, oily liquid with a specific gravity of 1.84 at 298 K. The acid freezes at 283 K and boils at 611 K. It dissolves in water with the evolution of a larger quantity of heat.

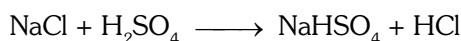
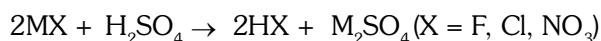
The chemical reaction of sulphuric acid are as a result of the following characteristics : (a) low volatility (b) strong acidic character (c) strong affinity for water and (d) ability to act as an oxidising agent in aqueous solution,

- (i) Sulphuric acid ionises in two steps.

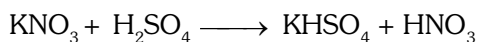


The larger value of K_{a1} ($K_{a1} > 10$) means that H_2SO_4 is largely dissociated into H^+ and HSO_4^- . Greater the value of dissociation constant (K_a) the stronger is the acid.

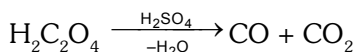
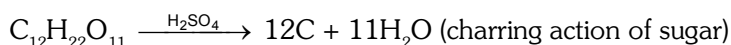
- (ii) **The acid forms two series of salts :** Normal sulphates (such as sodium sulphate and copper sulphate and acid sulphate (e.g., sodium hydrogen sulphate)
- (iii) Sulphuric acid, because of its low volatility can be used to manufacture more volatile acid from their corresponding salts.



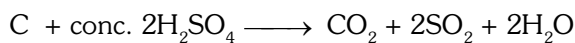
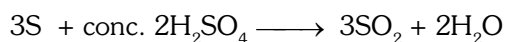
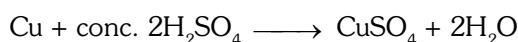
(M = Metal)



- (iv) Concentrated sulphuric acid is a strong dehydrating agent. Many wet gases can be dried by passing them through sulphuric acid, provided the gases do not react with the acid. Sulphuric acid removes water from organic compound; it is evident by its charring action on carbohydrates.



- (v) Hot concentrated sulphuric acid is moderately strong oxidising agent. In this respect it is intermediate between phosphoric and nitric acids. Both metals and non-metals are oxidised by concentrated sulphuric acid, which is reduced to SO_2 .



NCERT QUESTIONS (REASONING)

Q.1 H_2S is less acidic than H_2Te . Why?

Ans. Due to the decrease in bond (E–H) dissociation enthalpy down the group, acidic character increases.

Q.2 Why is H_2O a liquid and H_2S a gas?

Ans. Hydrogen bonds are present between H_2O molecules while between H_2S molecules, vander Waal's forces are present.

Q.3 Why is dioxygen a gas but sulphur a solid?

Ans. Oxygen exist as a O_2 molecule while sulphur exist as a S_8 molecule due to more molecular mass sulphur is solid.

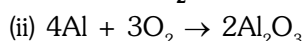
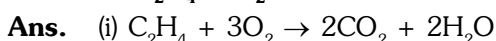
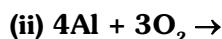
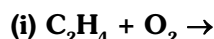
Q.4 Knowing the electron gain enthalpy values for $\text{O} \rightarrow \text{O}^-$ and $\text{O} \rightarrow \text{O}^{2-}$ as -141 and 702 kJ mol^{-1} respectively, how can you account for the formation of a large number of oxides having O^{2-} species and not O^- ?

Ans. Consider lattice energy factor in the formation of compounds.

Q.5 Which of the following does not react with oxygen directly? Zn, Ti, Pt, Fe

Ans. Pt is a noble metal which does not react directly with oxygen.

Q.6 Complete the following reactions:



Q.7 How is O_3 estimated quantitatively?

Ans. When ozone reacts with an excess of potassium iodide solution buffered with a borate buffer (pH 9.2), iodine is liberated which can be titrated against a standard solution of sodium thiosulphate. This is a quantitative method for estimating O_3 gas.

Q.8 What happens when sulphur dioxide is passed through an aqueous solution of Fe(III) salt?



Q.9 How is the presence of SO_2 detected?

Ans. It has colourless gas with pungent smell and decolourise acidified KMnO_4 solution.

Q.10 Write the conditions to maximise the yield of H_2SO_4 by Contact process.

Ans. The reaction is exothermic, reversible and the forward reaction leads to a decrease in volume. Therefore, low temperature and high pressure are the favourable conditions for maximum yield. But the temperature should not be very low otherwise rate of reaction will become slow.

Q.11 Why is $K_{a2} \ll K_{a1}$ for H_2SO_4 in water?

Ans. It is difficult to remove H^+ ion from HSO_4^- ion.

BEGINNER'S BOX-8

- Which of the following is not oxidised by O_3 ?
 (1) KI (2) FeSO_4 (3) KMnO_4 (4) K_2MnO_4
- In which of the following reaction conc. H_2SO_4 is not used as an oxidising agent?
 (1) $\text{Cu} + 2\text{H}_2\text{SO}_4 \longrightarrow \text{CuSO}_4 + \text{SO}_2 + 2\text{H}_2\text{O}$ (2) $2\text{HI} + \text{H}_2\text{SO}_4 \longrightarrow \text{I}_2 + \text{SO}_2 + 2\text{H}_2\text{O}$
 (3) $\text{CaF}_2 + \text{H}_2\text{SO}_4 \longrightarrow \text{CaSO}_4 + 2\text{HF}$ (4) None
- Hot conc. H_2SO_4 acts as strong oxidising agent which of the following element is oxidised by conc. H_2SO_4 into two gaseous products?
 (1) Cu (2) S (3) C (4) Zn
- HCOOH reacts with conc. H_2SO_4 to produce
 (1) CO (2) CO_2 (3) NO (4) NO_2

HALOGEN FAMILY (GROUP-17)

(A) PHYSICAL PROPERTIES

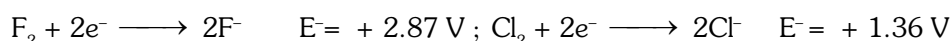
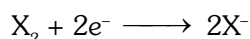
- (i) Fluorine and chlorine are gases, bromine is a liquid whereas iodine is a solid.
- (ii) Their melting and boiling points steadily increase with atomic number.
- (iii) All halogens are coloured. This is due to absorption of radiations in visible region which results in the excitation of outer electrons to higher energy level. By absorbing different quanta of radiation, they display different colours.
For example, F_2 , has yellow, Cl_2 , greenish yellow, Br_2 , red and I_2 , violet colour.
- (iv) Fluorine and chlorine react with water. Bromine and iodine are only sparingly soluble in water. But are soluble in organic solvents such as chloroform, carbon tetrachloride, carbon disulphide and hydrocarbons to give coloured solutions.
- (v) Except the smaller enthalpy of dissociation of F_2 compared to that of Cl_2 . **The X-X bond disassociation enthalpies from chlorine onwards show the expected trend : $Cl - Cl > Br - Br > F - F > I - I$. The reason for the smaller enthalpy of dissociation of F_2 is the relatively larger electrons-electrons repulsion among the lone pairs in F_2 molecule where they are much closer to each other than in case of Cl_2 .**

(B) CHEMICAL PROPERTIES

(i) Oxidation states and trends in chemical reactivity

- All the halogens exhibit -1 oxidation state. However, chlorine, bromine and iodine exhibit $+1$, $+3$, $+5$ and $+7$ oxidation states also. The higher oxidation states of chlorine, bromine and iodine are realised mainly when the halogens are in combination with the small and highly electronegative fluorine and oxygen atoms e.g., in interhalogens, oxides and oxoacids.
- The fluorine atom has no d orbitals in its valence shell and therefore cannot expand its octet. Being the most electronegative, it exhibits only -1 oxidation state.
- All the halogens are highly reactive. They react with metals and non-metals to form halides. The reactivity of the halogens decreases down the group.

Standard Reduction Potential (SRP)



More the value of the SRP, more powerful is the oxidising agent.

Hence the order of oxidising power is $F_2 > Cl_2 > Br_2 > I_2$

Order of reducing behaviour is $I^- > Br^- > Cl^- > F^-$

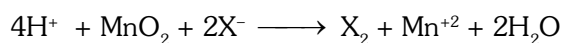
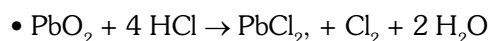
(ii) Halogen oxides :

- Fluorine forms two oxides OF_2 and O_2F_2 . However, only OF_2 is the thermally stable at 298 K. These oxides are essentially oxygen fluorides because of the higher electronegativity of fluorine than oxygen. Both are strong fluorinating agents.
- O_2F_2 oxidises plutonium to PuF_6 and the reaction is used in removing plutonium as PuF_6 from spent nuclear fuel.
- Chlorine, bromine and iodine form oxides in which the oxidation states of these halogens vary from $+1$ to $+7$. A combination of kinetic and thermodynamic factors lead to the generally decreasing order of stability of oxides formed by halogens, $I > Cl > Br$. The higher oxides of halogens tend to be more stable than the lower ones. This is called middle row anomaly.
- Chlorine oxides, Cl_2O , ClO_2 , Cl_2O_6 and Cl_2O_7 are highly reactive oxidising agents and tend to explode. ClO_2 is used as a bleaching agent for paper pulp and textiles and in water treatment.
- The bromine oxides, Br_2O , BrO_2 , BrO_3 are the least stable halogen oxides and exist only at low temperature. They are very powerful oxidising agents.
- The iodine oxides, I_2O_4 , I_2O_5 , I_2O_7 are insoluble solids and decompose on heating. I_2O_5 is very good oxidising agent and is used in the estimation of carbon monoxide.

COMPOUNDS OF HALOGEN

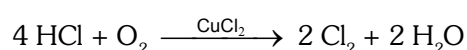
1. CHLORINE GAS (Cl_2)

(a) Preparation :

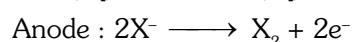
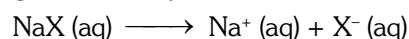
(i) By heating chloride with concentrated H_2SO_4 in presence of MnO_2 .Bromides and iodides also liberate Br_2 and I_2 respectively with concentrated H_2SO_4 and MnO_2 .(ii) • $\text{CaOCl}_2 + 2\text{HCl} \longrightarrow \text{CaCl}_2 + \text{Cl}_2 + \text{H}_2\text{O}$ 

(iii) Manufacture of chlorine :

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



- **Electrolytic process** : Chlorine is obtained by the electrolysis of brine (concentrated NaCl solution). Chlorine is liberated at anode. It is obtained as a by-product in many chemical industries e.g.; in manufacturing of sodium hydroxide.

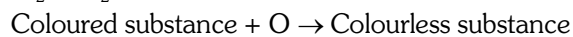
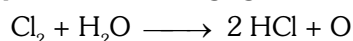


(b) Properties :

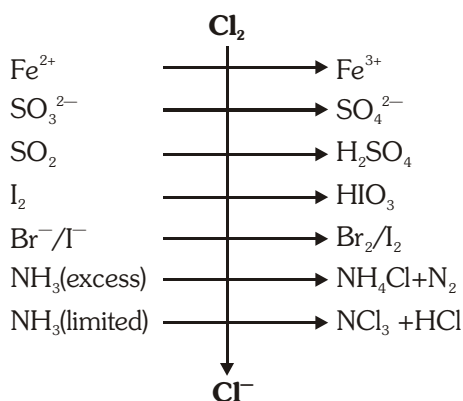
(i) It is a greenish-yellow gas with pungent and suffocating odour. It is about 2–5 times heavier than air. It can be liquefied into greenish-yellow liquid which boils at 239 K. It is soluble in water.

(ii) **Oxidising & bleaching properties** : Chlorine dissolves in water giving HCl and HOCl . Hypochlorous acid (HOCl) so formed, gives nascent oxygen which is responsible for oxidising and bleaching properties of chlorine.

It is a powerful bleaching agent ; bleaching action is due to oxidation.

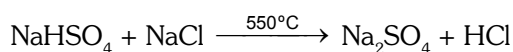
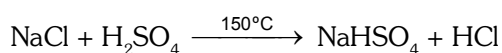


It bleaches vegetable or organic matter in the presence of moisture. Bleaching effect of chlorine is permanent.

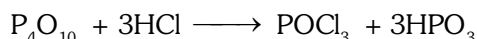
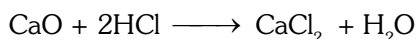
2. HALOGEN ACIDS (HCl)

(a) Preparation :

(i) By heating a halide with concentrated acid :



- Above method is called as salt cake method as it involves the formation of NaHSO_4 (salt cake).
- HCl cannot be dried over P_2O_5 (P_4O_{10}) or quick lime since they react with gas chemically.



- HCl is, hence dried by passing through concentrated H_2SO_4 .

(b) Properties :

- This is colourless, pungent smelling gas with acidic taste.
- This is neither combustible nor supporter of combustion.
- When perfectly dry, HX have no action on litmus, but in presence of moisture, they turn blue litmus red, showing acidic nature. Among HX , HI is the strongest and HF is the weakest acid.

3. Pseudo halogens and pseudo halides : Some inorganic compounds consisting of two or more atoms of which at least one is N have been found to behave like halogens & they are known as pseudo halogen solids,

Pseudo halogens	Pseudo halides
(i) $(\text{CN})_2$ cyanogen	(i) $(\text{CN})^-$ cyanide ion
(ii) $(\text{SCN})_2$ thiocyanogen	(ii) $(\text{SCN})^-$ thiocyanate ion
(iii) $(\text{SeCN})_2$ selenocyanogen	(iii) $(\text{SeCN})^-$ selenocyanate ion
(iv) $(\text{SCSN}_3)_2$ azidocarbonyl disulphide	(iv) $(\text{OCN})^-$ cyanate ion
	(v) $(\text{NCN})^{2-}$ cyanamide ion
	(vi) $(\text{N}_3)^-$ azide ion etc.

4. INTERHALOGEN COMPOUNDS :

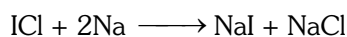
We know that halogen atoms have different electronegativity. Due to this difference in electronegativity the halogen atoms combine with each other and give rise to the formation of binary covalent compounds, which are called interhalogen compounds. These are of four types.

AB	AB_3	AB_5	AB_7^*
ClF	ClF_3	ClF_5	IF_7
BrF	BrF_3	BrF_5	
ICl	ICl_3	IF_5	
IF	IF_3		

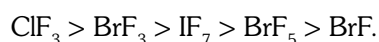
* Where A - halogen of smaller size and A is more electro positive than B.

(a) Properties :

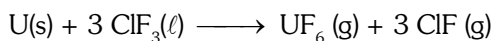
- These compounds may be gases, liquids or solids.
Gases : ClF , BrF , ClF_3 , IF_7 ; Liquids : BrF_3 , BrF_5 ; Solids : ICl , IBr , IF_3 , ICl_3 .
- Interhalogens containing fluorine are generally colourless but inter halogens consisting of heavier halogens are coloured. The intensity of colour increases with increase in the molecular weight of the compounds.
- All interhalogens are covalent molecules and are diamagnetic in nature since all the valence electrons present as bonding or non-bonding electrons are paired.
- Interhalogen compounds are more reactive than the parent halogens but less reactive than F_2 .



The order of reactivity of some interhalogens is as follows :



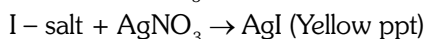
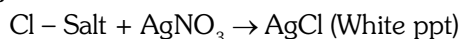
- (v) These compounds can be used as non aqueous solvents. Interhalogen compounds are very useful fluorinating agents. ClF_3 and BrF_3 are used for the production of UF_6 in the enrichment of ^{235}U .



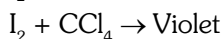
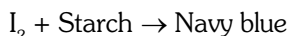
TEST OF HALOGENS

1. F^- = **Itching of glass**

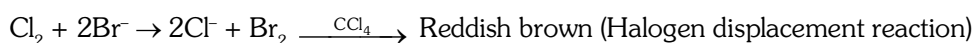
2. **AgNO_3 test** (Cl^- , Br^- , I^-)



3. **Test of I_2**



4. **Layer test (Br^- , I^-)**



(Note : In case of I^- violet colour is obtained.)

5. **Chromyl chloride test** (Test of Cl^-) : see d-block

NCERT QUESTIONS (REASONING)

Q.1 Covalent radius of fluorine is 64 pm but the bond length is not equal to 128 pm and that is 143 pm and bond energy is found to be comparable to I_2 .

Ans. This may be attributed to $\ell.p - \ell.p$ repulsions due to small size of F atom.

Q.2 Electron affinity of chlorine is more than F. In spite of this F_2 is the better oxidising agent. Why?

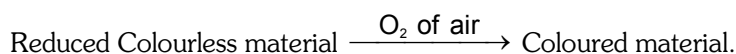
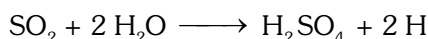
Ans. SRP of F_2 is much higher than that of Cl_2 on account of smaller bond dissociation energy and high hydration energy of F^- ion.

Q.3 Layer test of Br^- is successful with Cl_2 but not with I_2 . Explain?

Ans. Br^- is oxidised by Cl_2 but not by I_2

Q.4 What is the difference between bleaching action of SO_2 and Cl_2

Ans. The bleaching action of SO_2 is temporary because it takes place through reduction.



The bleaching action of Cl_2 is permanent because it takes place through oxidation

Q.5 (a) When HCl reacts with finely powdered iron, it forms ferrous chloride and not ferric chloride. why?

(b) Chlorine water turns blue litmus red but solution becomes colourless after sometime.

Ans. (a) It forms H_2 gas. $\text{Fe} + 2 \text{HCl} \longrightarrow \text{FeCl}_2 + \text{H}_2$.

Liberation of hydrogen prevents the formation of ferric chloride.

(b) Blue litmus change into red due to acidic nature ($\text{Cl}_2 + \text{H}_2\text{O} \rightarrow \text{HOCl} + \text{HCl}$) but it is bleaching agent, therefore, it decolourises the red litmus.

ZERO GROUP (GROUP-18)

INTRODUCTION

Group 18 consists of six elements: helium, neon, argon, krypton, xenon and radon. All these are gases and chemically unreactive. They form very few compounds. Because of this they are termed noble gases.

(A) PHYSICAL PROPERTIES

- (i) All the noble gases are mono-atomic.
- (ii) They are colourless, and tasteless. They are sparingly soluble in water.
- (iii) They have very low melting and boiling points because the only type of interatomic interaction in these elements is weak dispersion forces.
- (iv) Helium has the lowest boiling point (4.2K) of any known substance. It has a unusual property of diffusing through most commonly used laboratory materials such as rubber, glass or plastics.

(B) CHEMICAL PROPERTIES

In general, noble gases are least reactive. Their inertness to chemical reactivity is attributed to the following reasons:

- (i) The noble gases except helium ($1s^2$) have completely filled $ns^2 np^6$ electronic configuration in their valence shell.
- (ii) They have high ionisation enthalpy and more positive electron gain enthalpy.

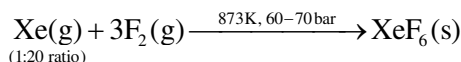
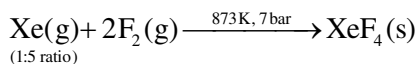
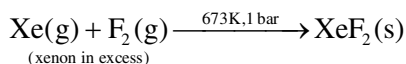
Neil Bartlett, observed the reaction of a noble gas. First, he prepared a red compound which is formulated as $O_2^+ [PtF_6]^-$. He, then realised that the first ionisation enthalpy of molecular oxygen (1175 kJ mol^{-1}) was almost identical with that xenon (1170 kJ mol^{-1}). He made efforts to prepare same type of compound with $Xe^+ [PtF_6]^-$ by mixing PtF_6 and Xenon. After this discovery, a number of xenon compounds mainly with most electronegative elements like fluorine and oxygen, have been synthesised.

The compounds of krypton are fewer. Only the difluoride (KrF_2) has been studied in detail. Compounds of radon have not been isolated but only identified (e.g., RnF_2) by radiotracer technique. No true compounds of Ar, Ne or He are yet known.

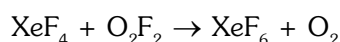
COMPOUNDS OF XENON

Xenon-fluorine compounds

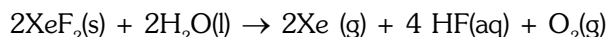
Xenon forms three binary fluorides, XeF_2 , XeF_4 and XeF_6 by the direct reaction of elements under appropriate experimental conditions.



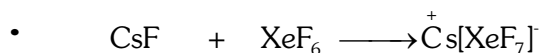
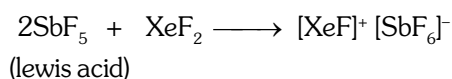
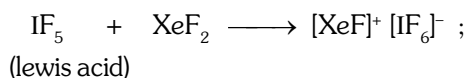
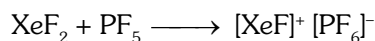
XeF_6 can also be prepared by the interaction of XeF_4 and O_2F_2 at 143K.



XeF_2 , XeF_4 and XeF_6 are colourless crystalline solids and sublime readily at 298 K. They are powerful fluorinating agents. They are readily hydrolysed even by traces of water. For example, XeF_2 is hydrolysed to give Xe, HF and O_2 .



Formation of addition compounds : XeF_2 reacts with fluoride ion acceptors to form cationic species and fluoride ion donors to form fluoroanions.



[With s-block fluorides and alkyl fluorides it is F^- acceptor with others it is F^- donor]

USES OF INERT GASES :

- (1) He is non-inflammable and light gas, so it is used in filling balloons for meteorological observations.
- (2) He is used in gas cooled nuclear reactors.
- (3) Liquid He is used as cryogenic agent.
- (4) He is used to produce powerful superconducting magnets.
- (5) Ne is used in discharge tubes.
- (6) Ar is used as inert atmosphere in metallurgical process.
- (7) Xenon and Krypton are used in light bulbs designed for special purposes.

IMPORTANT ORDER :

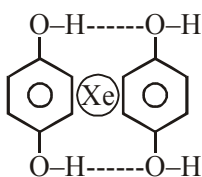
- | | |
|---|--------------------------|
| (1) $\text{He} < \text{Ne} < \text{Ar} < \text{Kr} < \text{Xe}$ | Atomic radius |
| (2) $\text{He} > \text{Ne} > \text{Ar} > \text{Kr} > \text{Xe}$ | Ionisation energy |
| (3) $\text{He} < \text{Ne} < \text{Ar} < \text{Kr} < \text{Xe} < \text{Rn}$ | Density |
| (4) $\text{He} < \text{Ne} < \text{Ar} < \text{Kr} < \text{Xe} < \text{Rn}$ | mpt. bpt |

[Atomic mass / size / polarisability / London force] $\uparrow$

- (5) $\text{He} < \text{Ne} < \text{Ar} < \text{Xe} < \text{Rn}$ **[solubility in water because of dipole-induced dipole attraction]**

Clathrate Compounds : Larger inert gas atoms are trapped into cavity or crystal structure of some organic compounds and form clathrate compounds. For eg xenon diquinoxaline.

- Force of attraction between noble gas and organic compound is **dipole-induced dipole** attraction.



He, Ne do not form clathrate compounds due to smaller size

BEGINNER'S BOX-9

- Which is correct
 - (1) $\text{NaCl} \xrightarrow{\text{conc. H}_2\text{SO}_4} \text{yellow green gas}$
 - (2) $\text{NaBr} \xrightarrow{\text{conc. H}_2\text{SO}_4} \text{red brown vapour}$
 - (3) $\text{NaF} + \text{Cl}_2 \longrightarrow \text{NaCl} + \text{F}_2$
 - (4) All
- "Middle row anomaly" is related with
 - (1) stability of transition metal oxides
 - (2) stability of alkali metal oxides
 - (3) stability of halogen oxides
 - (4) stability of alkaline earth metal oxides
- True statement about I^- will be
 - (1) weak base
 - (2) strong nucleophile
 - (3) strong reducing agent
 - (4) all

4. Of the following statements :
 (a) Cl_2 gas is dried by using conc. H_2SO_4
 (b) Fluorine have highest oxidising power
 (c) Oxidising power of halogens follow the order $\text{I}_2 > \text{Br}_2 > \text{Cl}_2$
 (d) HI is the strongest acid among HI, HBr, HCl
 (1) a, b and d are correct (2) a, c are correct (3) b, c are correct (4) c, d are correct
5. Chromyl chloride test is performed for the confirmation of the presence of the following in mixture:
 (1) SO_4^{2-} (2) Cr^{+++} (3) Cl^- (4) Cr^{+++} and Cl^-
6. The ion that cannot undergo disproportionation is
 (1) ClO_4^- (2) ClO_3^- (3) ClO_2^- (4) ClO^-
7. A greenish yellow gas reacts with an alkali metal hydroxide to form a halate which can be used in fire works and safety matches. The gas and halate respectively are :
 (1) Br_2 , KBrO_3 (2) Cl_2 , KClO_3 (3) I_2 , NaIO_3 (4) Cl_2 , NaClO
8. In the clathrates of xenon with water, the nature of bonding between xenon and water molecule is :
 (1) covalent (2) hydrogen bonding (3) co-ordinate (4) dipole-induced dipole interaction
9. XeF_2 reacts with PF_5 to give :
 (1) XeF_6 (2) $[\text{XeF}]^+ [\text{PF}_6]^-$ (3) XeF_4 (4) $[\text{PF}_4]^+ [\text{XeF}_3]^-$
10. The first compound of noble gases prepared by Neil-Bartlett was :-
 (1) $\text{Xe}^+ [\text{PtF}_6]^-$ (2) XeF_4 (3) XeF_6 (4) XeOF_4

ANSWER KEY

BEGINNER'S BOX-1	Que.	1	2	3	4	5	6	7	8	9	10
	Ans.	1	4	1	1	1	4	3	3	1	4
BEGINNER'S BOX-2	Que.	1	2	3	4	5	6	7	8	9	10
	Ans.	2	4	3	3	3	2	1	4	2	2
BEGINNER'S BOX-3	Que.	1	2	3	4	5	6	7	8	9	10
	Ans.	3	2	3	2	2	2	3	2	4	3
BEGINNER'S BOX-4	Que.	1	2	3	4	5	6	7	8	9	10
	Ans.	3	2	2	2	4	3	4	4	1	3
BEGINNER'S BOX-5	Que.	1	2	3	4	5	6	7	8	9	10
	Ans.	1	4	2	2	3	4	3	3	4	3
BEGINNER'S BOX-6	Que.	1	2	3	4						
	Ans.	3	3	4	4						
BEGINNER'S BOX-7	Que.	1	2	3	4	5	6	7	8	9	10
	Ans.	1	4	4	2	4	4	3	2	2	4
BEGINNER'S BOX-8	Que.	1	2	3	4						
	Ans.	3	3	3	1						
BEGINNER'S BOX-9	Que.	1	2	3	4	5	6	7	8	9	10
	Ans.	2	3	4	1	3	1	2	4	2	1

EXERCISE-I (Conceptual Questions)

Build Up Your Understanding

IMPORTANT CONCEPTS

- "Hybridisation of central atom does not always change due to back bonding". This statement is valid for which of the following compounds?
 (i) CCl_3^- (ii) CCl_2
 (iii) CF_2 (iv) $\text{N}(\text{SiH}_3)_3$
 (1) (i), (ii) (2) (i), (iii)
 (3) (ii), (iii) (4) All
- The geometry with respect to the central atom of the following molecules are $\text{N}(\text{SiH}_3)_3$, Me_3N , $(\text{SiH}_3)_3\text{P}$
 (1) planar, pyramidal, planar
 (2) planar, pyramidal, pyramidal
 (3) pyramidal, pyramidal, pyramidal
 (4) pyramidal, planar, pyramidal
- In which of the following compounds, observed bond angle is found to be greater than expected, but not due to back bonding
 (1) $\text{N}(\text{SiH}_3)_3$ (2) $\text{O}(\text{CH}_3)_2$
 (3) $\text{O}(\text{SiH}_3)_2$ (4) All of these
- According to following reactions,

$$\text{CHF}_3 \xrightarrow{K\alpha} \text{CF}_3^- + \text{H}^+$$

$$\text{CHCl}_3 \xrightarrow{K'\alpha} \text{CCl}_3^- + \text{H}^+$$
 correct statement(s) is :
 (1) $K_\alpha > K'_\alpha$
 (2) CHF_3 act as a stronger bronsted acid than CHCl_3
 (3) CCl_3^- is more stable than CF_3^-
 (4) None of these
- The product formed in the reaction,
 $\text{BCl}_3 + \text{H}_2\text{O} \longrightarrow \text{Product is -}$
 (1) $\text{H}_3\text{BO}_3 + \text{HCl}$ (2) $\text{B}_2\text{O}_3 + \text{HOCl}$
 (3) $\text{B}_2\text{H}_6 + \text{HCl}$ (4) No reaction
- Which of the following statements is incorrect in relation to the structure of diborane
 (1) All the terminal B-H bond length are equal
 (2) The terminal B-H bond is a 2-centre 3-electron bond
 (3) The terminal B-H bond is a 2-centre 2-electron bond
 (4) The bridge  is a 3-centre 2-electron bond
- The type of hybridization of boron in diborane is -
 (1) sp (2) sp^2
 (3) sp^3 (4) sp^3d^2

- Which is less hydrolysed :
 (1) PCl_3 (2) NCl_3
 (3) AsCl_3 (4) SbCl_3
- Which of the following halides cannot be hydrolysed?
 (i) TeF_6 (ii) SF_6 (iii) NCl_3 (iv) NF_3
 Choose the correct code
 (1) iii and iv (2) i, ii and iii
 (3) i, ii and iv (4) ii and iv
- Which of the following is an uncommon hydrolysis product of XeF_2 and XeF_4 ?
 (1) Xe (2) XeO_3 (3) HF (4) O_2
- In which of the following dimer empty atomic orbital of central atom of monomer does not involve in hybridisation?
 (1) Ga_2H_6 (2) Al_2Br_6 (3) Be_2H_4 (4) Cl_2O_6
- Which of the following molecule is having complete octet
 (1) $\text{BeCl}_2(\text{dimer})$ (2) $\text{BeH}_2(\text{dimer})$
 (3) $\text{BeH}_2(\text{s})$ (4) $\text{BeCl}_2(\text{s})$
- Which one of the following oxy acid of fluorine exists ?
 (1) HOF (2) HFO_3
 (3) HFO_4 (4) HFO_2
- Which of the following statements is correct
 (1) All form HOXO_3 type oxy acid
 (2) Only chlorine and bromine form oxyacids
 (3) All halogens form oxyacids
 (4) Only iodine forms oxyacid
- Consider the oxy acids HClO_n series, here value of n is 1 to 4. Then incorrect statement regarding these oxy acids is
 (1) acidic character of oxy acids increases with increasing value of n .
 (2) oxidising power of oxy acids increases with decreasing value of n .
 (3) thermal stability of oxy acids decreases with increasing value of n .
 (4) Cl-O bond order decreases with decreasing value of n .
- $2\text{P} \xrightarrow{-\text{H}_2\text{O}} \text{Q} \xrightarrow{-[\text{O}]} \text{R}$
 If P is parent phosphoric acid then according to given information the incorrect statement is
 (1) Q is pyro form and R is hypo form of given present oxy acid P
 (2) Number of H-atoms present in each given oxy acid is equal to its basicity
 (3) In P, Q, R oxy acids, oxidation state of central atom remains same
 (4) All given oxy acids have $p\pi-d\pi$ bond(s) in their structure

17. Silicate having one monovalent corner oxygen atom in each tetrahedron unit is
 (1) sheet silicate (2) cyclic silicate
 (3) single chain silicate (4) double chain silicate
18. The silicate anion in the mineral kinoite is a chain of three SiO_4^{4-} tetrahedra, that share corners with adjacent tetrahedra. The charge of the silicate anion is
 (1) -4 (2) -8
 (3) -6 (4) -2
19. Which of the following is an organo silicon polymer?
 (1) silica (2) silicon
 (3) silicon carbide (4) silicic acid
20. Which reacts rapidly with oxygen in the air at ordinary temperature :
 (1) White P (2) Red P
 (3) N_2 (4) C
21. Red and yellow phosphorus are :
 (1) Allotropes (2) Isobars
 (3) Isomers (4) Isotopes
22. Phosphorus is kept in :
 (1) Kerosene oil (2) Alcohol
 (3) Water (4) Ammonia
23. Graphite conducts electricity because of the –
 (1) Highly polarized nature of π -electrons.
 (2) Highly delocalized nature of π -electrons
 (3) Highly localized nature of π -electrons
 (4) None of these

BORON AND CARBON FAMILY

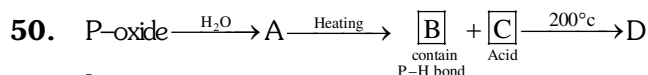
24. Melting point is higher for –
 (1) B (2) Al (3) Ga (4) In
25. Alane is chemically –
 (1) AlH_3 (2) $(\text{AlH}_3)_n$ (3) LiAlH_4 (4) None
26. Aluminium is not acted upon by pure water as –
 (1) Impurities in water are essential for the reaction to occur
 (2) It is light metal
 (3) It is protected by a film of aluminium oxide
 (4) It is not a reactive metal
27. The borax bead test is based upon the formation of
 (1) Boron oxide (2) Boric acid
 (3) Meta borates (4) Elemental boron
28. Boric acid polymerizes due to –
 (1) The presence of hydrogen bonds
 (2) Its acidic nature
 (3) Its geometry
 (4) Its monobasic nature

29. Alum is found to contain hydrated monovalent cation $[\text{M}(\text{H}_2\text{O})_6]^+$, trivalent cation $[\text{M}'(\text{H}_2\text{O})_6]^{+3}$ and SO_4^{2-} in the ratio of :
 (1) 1 : 1 : 1 (2) 1 : 1 : 2
 (3) 1 : 2 : 2 (4) 1 : 2 : 3
30. Borax $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$ is actually :-
 (1) $\text{Na}_2[\text{B}_4\text{O}_5(\text{OH})_4] \cdot 8\text{H}_2\text{O}$
 (2) $\text{Na}_2[\text{B}_4\text{O}_4(\text{OH})_6] \cdot 7\text{H}_2\text{O}$
 (3) $\text{Na}_2[\text{B}_4\text{O}_3(\text{OH})_8] \cdot 6\text{H}_2\text{O}$
 (4) $\text{Na}_2[\text{B}_4\text{O}_2(\text{OH})_{10}] \cdot 5\text{H}_2\text{O}$
31. Diborane is a Lewis acid forming addition compound $\text{B}_2\text{H}_6 \cdot 2\text{NH}_3$ with NH_3 , a Lewis base. This
 (1) Is ionic and exists as $[\text{BH}_2(\text{NH}_3)_2]^+$ and $[\text{BH}_4]^-$ ions
 (2) On heating, is converted into borazine, $\text{B}_3\text{N}_3\text{H}_6$
 (3) Both are correct
 (4) None is correct
32. Which alum is a double salt made up of two salts :
 (1) Salt of a (SA + WB) + Salt of a (WA + WB)
 (2) Salt of a (SA + SB) + Salt of a (SA + WB)
 (3) Salt of a (SA + SB) + Salt of a (WA + WB)
 (4) Salt of a (SA + WB) + Salt of a (WA + WB)
33. From B_2H_6 all the following can be prepared except :
 (1) H_3BO_3 (2) $\text{B}_2(\text{CH}_3)_4\text{H}_2$
 (3) $\text{B}_2(\text{CH}_3)_6$ (4) NaBH_4
34. Borax on heating with cobalt oxide forms a blue bead of
 (1) $\text{Co}(\text{BO}_2)_2$ (2) CoBO_2
 (3) $\text{Co}_3(\text{BO}_3)_2$ (4) $\text{Na}_3\text{Co}(\text{BO}_3)_2$
35. The hydrides of group 14 elements are :
 (1) Ionic (2) Oxidising
 (3) Covalent (4) None of these
36. Which gas is responsible for green house effect :
 (1) CO_2 (2) SO_2 (3) CO (4) SO_3
37. Artificial gem used for cutting glass is :
 (1) Graphite (2) Diamond
 (3) SiC (4) CaCN_2

NITROGEN FAMILY

38. Nitrogen reacts with calcium carbide to give –
 (1) Calcium nitride (2) Calcium cyanide
 (3) Calcium cyanamide (4) Calcium nitrate
39. P_2O_5 is used extensively as a :
 (1) Dehydrating agent (2) Catalytic agent
 (3) Reducing agent (4) Preservative
40. PH_3 produces smoky rings when it comes in contact with air. This is because :
 (1) It is inflammable
 (2) It combines with water vapours
 (3) It combines with nitrogen
 (4) It contains impurity of P_2H_4

41. Which of the following is the correct statement for PH_3
- (1) It is less basic than NH_3
 - (2) It is less poisonous than NH_3
 - (3) Bond angle of $\text{PH}_3 > \text{NH}_3$
 - (4) It does not show reducing properties
42. Ammonia reacts with excess of chlorine to form:
- (1) N_2 and NH_4Cl
 - (2) NCl_3 and HCl
 - (3) NH_4Cl and NCl_3
 - (4) N_2 and HCl
43. Concentrated nitric acid reacts with iodine to give:-
- (1) HI
 - (2) HOI
 - (3) HOIO_2
 - (4) HOIO_3
44. Each of the following is true of white and red phosphorus except that they
- (1) Are both soluble in CS_2
 - (2) Can be oxidised by heating in air
 - (3) Consist of the same kind of atoms
 - (4) Can be converted into one another
45. A gas which is used as anaesthetic in dental surgery is :
- (1) N_2
 - (2) CO
 - (3) N_2O
 - (4) NH_3
46. The wrong statement about NH_3 is :
- (1) It is oxidised with oxygen at 700°C in the presence of platinum
 - (2) It gives reddish brown ppt with nessler's reagent
 - (3) It can be dried by P_2O_5 , H_2SO_4 and CaCl_2
 - (4) It gives white fumes with HCl
47. On heating, ammonium dichromate and barium azide separately, we get :-
- (1) N_2 with ammonium dichromate and NO with barium azide
 - (2) N_2O with ammonium dichromate and NO_2 with barium azide
 - (3) N_2O with ammonium dichromate and NO with barium azide
 - (4) N_2 in both cases
48. Which one of the following acid possesses oxidising, reducing and complex forming properties?
- (1) HNO_3
 - (2) HCl
 - (3) H_2SO_4
 - (4) HNO_2
49. NO_2 is formed when
- (1) Cu reacts with conc. HNO_3
 - (2) Zn reacts with conc. HNO_3
 - (3) $\text{Pb}(\text{NO}_3)_2$ is heated
 - (4) All



Incorrect statement is :-

- (1) Gas B is PH_3
 - (2) D is pyrophosphoric acid
 - (3) A is H_3PO_3
 - (4) D on strong heating gives P_2O_3
51. Which of the following does not produce NO_2 gas with conc. HNO_3 ?
- (1) Cu
 - (2) I_2
 - (3) Ag
 - (4) Au

OXYGEN FAMILY

52. SO_2 can acts as -
- (1) Reducing agent
 - (2) Oxidising agent
 - (3) Bleaching agent
 - (4) All
53. Which reaction cannot be used for the preparation of the halogen acid-
- (1) $2\text{KBr} + \text{H}_2\text{SO}_4 \xrightarrow{\text{Conc.}} \text{K}_2\text{SO}_4 + 2\text{HBr}$
 - (2) $\text{NaCl} + \text{H}_2\text{SO}_4 \xrightarrow{\text{conc.}} \text{NaHSO}_4 + \text{HCl}$
 - (3) $\text{NaHSO}_4 + \text{NaCl} \xrightarrow{\text{conc.}} \text{Na}_2\text{SO}_4 + \text{HCl}$
 - (4) $\text{CaF}_2 + \text{H}_2\text{SO}_4 \xrightarrow{\text{conc.}} \text{CaSO}_4 + 2\text{HF}$
54. Ozone acts as
- (1) Oxidising agent
 - (2) reducing agent
 - (3) bleaching agent
 - (4) all
55. A black sulphide when treated with ozone becomes white. The white compound is :
- (1) ZnSO_4
 - (2) CaSO_4
 - (3) BaSO_4
 - (4) PbSO_4
56. H_2S gas changes a filter paper dipped in lead acetate solution into :
- (1) Black
 - (2) Red
 - (3) Green
 - (4) Yellow
57. The number of S-S bonds in sulphur trioxide trimer (S_3O_9) is :
- (1) Three
 - (2) Two
 - (3) One
 - (4) Zero
58. Dry bleaching is done by :
- (1) Cl_2
 - (2) SO_2
 - (3) O_3
 - (4) None
59. Compounds A and B are treated with dilute HCl separately. The gases liberated are Y and Z respectively Y turns acidified dichromate paper green while Z turns lead acetate paper black. So A and B compounds are respectively :-
- (1) Na_2SO_3 , Na_2S
 - (2) NaCl , Na_2CO_3
 - (3) Na_2S , Na_2SO_3
 - (4) Na_2SO_3 , K_2SO_4

60. When KBr is treated with conc. H_2SO_4 reddish brown gas is evolved. The gas is :
 (1) Br_2 (2) HOBr (3) NO_2 (4) H_2O_2
61. One gas bleaches the colour of the flowers by reduction while the other by oxidation. The gases are :
 (1) CO and CO_2 (2) H_2S and Br_2
 (3) SO_2 and Cl_2 (4) NH_3 and SO_3
62. On addition of conc. H_2SO_4 to a chloride salt, colourless fumes are evolved but in case of iodide salt, violet fumes come out. This is because:-
 (1) H_2SO_4 reduces HI to I_2
 (2) HI is of violet colour
 (3) HI gets oxidised to I_2
 (4) HI changes to HIO_3
63. Which of the following is responsible for turning starch-iodide paper blue when it is brought in contact with O_3 ?
 (1) Liberation of iodine
 (2) Liberation of oxygen
 (3) Formation of alkali
 (4) Reaction of ozone with litmus paper.
64. Which one of the following property is not correct for ozone ?
 (1) It oxidises lead sulphide
 (2) It oxidises potassium iodide
 (3) It oxidises mercury
 (4) It cannot act as bleaching agent in dry state.
65. By which of the following SO_2 is formed ?
 (1) Reaction of dilute H_2SO_4 with O_2 .
 (2) Heating $\text{Fe}_2(\text{SO}_4)_3$.
 (3) Reaction of concentrated H_2SO_4 with Cu .
 (4) None.
66. Pick out the statement/s that is/are wrong :-
 (1) Oxygen is paramagnetic in all the three states of matter
 (2) Ozone is diamagnetic
 (3) Ozone is a linear molecule
 (4) The O-O bonds in ozone have considerable double bond character
67. **Column-I** **Column-II**
 (A) Caro's acid (p) - S - S - bond
 (B) Polythionic acid (q) - S = S bond
 (C) Pyrosulphuric acid (r) - S - O - S - bond
 (D) Thiosulphuric acid (s) - S - O - O - bond
 (1) A-p, B-q, C-r, D-s (2) A-p, B-q, C-s, D-r
 (3) A-s, B-p, C-r, D-q (4) A-q, B-s, C-r, D-p

HALOGEN FAMILY AND INERT GASES

68. Select the correct statement (s) from the following-
 (1) Fluorine displaces other halogens from the corresponding halides
 (2) Fluorine reacts slowly with halogens
 (3) Fluorine does not decompose water
 (4) Except fluorine, other halogens directly combine with carbon
69. Which of the following is a false statement
 (1) Halogens are oxidizing agent
 (2) Halogens show only (-1) oxidation state
 (3) HF molecules form intermolecular H-bonds
 (4) Fluorine is highly reactive
70. The halide which does not give a precipitate with AgNO_3 is-
 (1) F^- (2) Cl^- (3) Br^- (4) I^-
71. Volatile nature of halogen is because :
 (1) Halogen molecules are bonded by strong forces
 (2) Halogen molecules are bonded by electrostatic forces
 (3) The forces existing between the discrete molecule are only weak vander Waals force.
 (4) Halogen molecules are more reactive
72. Iodine gas turns starch iodide paper :
 (1) Blue (2) Red
 (3) Colourless (4) Yellow
73. BrF_5 is a :
 (1) Interhalogen compound
 (2) Pseudohalogen compound
 (3) Both the above
 (4) None of the above
74. Which of the following statements is not correct when a mixture of NaCl and $\text{K}_2\text{Cr}_2\text{O}_7$ is gently warmed with conc. H_2SO_4 :
 (1) A deep red vapour is evolved
 (2) The vapour when passed into NaOH solution gives a yellow solution of Na_2CrO_4
 (3) Chlorine gas is evolved
 (4) Chromyl chloride is formed
75. Which of the following does not decolourise iodine?
 (1) Na_2SO_3 (2) $\text{Na}_2\text{S}_2\text{O}_3$
 (3) NaCl (4) NaOH
76. Which one of the following halogen liberates oxygen on reacting with H_2O
 (1) I_2 (2) Cl_2 (3) Br_2 (4) F_2
77. Which of the following gases can be dried by concentrated H_2SO_4 ?
 (1) HCl (2) HBr
 (3) HI (4) H_2S

- 78.** Helium is added to oxygen used by deep sea divers because :
 (1) It is less soluble in blood than nitrogen under high pressure
 (2) It is lighter than nitrogen
 (3) It is readily miscible with oxygen
 (4) It is less poisonous than nitrogen
- 79.** Which of the following is not correct :
 (1) XeO_3 has four σ and four π bonds
 (2) The hybridization of Xe in XeF_4 is sp^3d^2
 (3) Among noble gases, the occurrence of argon is highest in air
 (4) Liquid helium is used as cryogenic liquid
- 80.** XeF_2 reacts with SbF_5 to form :
 (1) $[\text{XeF}]^+ [\text{SbF}_6]^-$ (2) $[\text{XeF}_3]^+ [\text{SbF}_4]^-$
 (3) $\text{Xe}^- [\text{PtF}_6]^+$ (4) XeF_4
- 81.** Which factor is most responsible for the increase in boiling points of noble gases from He to Xe?
 (1) decrease in I.E.
 (2) Monoatomic nature
 (3) decrease in polarisability
 (4) increase in polarisability
- 82.** The compound that cannot be formed by xenon is
 (1) XeO_3 (2) XeF_4
 (3) XeCl_4 (4) XeO_2F_2
- 83.** XeF_6 dissolves in anhydrous HF to give a good conducting solution which contains
 (1) H^+ and XeF_7^- ion
 (2) HF_2^- and XeF_5^+ ions
 (3) HXeF_6^+ and F^- ions
 (4) none of these
- 84.** SbF_5 reacts with XeF_4 to form an adduct. The shapes of cation and anion in the adduct are respectively
 (1) square planar, trigonal bipyramidal
 (2) T-shaped, octahedral
 (3) square pyramidal, octahedral
 (4) square planar, octahedral
- 85.** Which of the following noble gas does not form clathrate compound?
 (1) Kr (2) Ne (3) Xe (4) Ar
- 86.** An inorganic salt when heated with concentrated H_2SO_4 evolves a colourless pungent smelling gas but with concentrated H_2SO_4 and MnO_2 evolves a coloured pungent smelling gas which bleaches moist litmus paper. The coloured gas is :-
 (1) NO_2 (2) Cl_2 (3) Br_2 (4) I_2
- 87.** Identify the incorrect statement (Structure is including the location of lone pair of electrons) :-
 (1) XeO_2F_2 has 7 bonded electron pairs and one valence shell lone pair of electron. Its structure is square pyramidal with one pi bond.
 (2) XeO_2F_2 has 6 bonded electron pairs and one valence shell lone pair of electrons. Its structure is trigonal bipyramidal with two pi bonds.
 (3) XeF_6 has 6 bonded electron pairs and one valence shell lone pair of electrons. Its structure is pentagonal bipyramidal.
 (4) XeF_2 has 5 electron pairs (bonded and valence shell lone pairs both) and its structure is trigonal bipyramidal.

EXERCISE-I (Conceptual Questions)

ANSWER KEY

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	3	2	2	3	1	2	3	4	4	2	4	4	1	3	3
Que.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ans.	3	1	2	2	1	1	3	2	1	2	3	3	1	2	1
Que.	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Ans.	3	2	3	1	3	1	3	3	1	4	1	2	3	1	3
Que.	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	3	4	4	4	4	4	4	1	4	4	1	4	3	1	1
Que.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
Ans.	3	3	1	4	3	3	3	1	2	1	3	1	1	3	3
Que.	76	77	78	79	80	81	82	83	84	85	86	87			
Ans.	4	1	1	1	1	4	3	2	2	2	2	1			

EXERCISE-II (Previous Year Questions)

AIPMT/NEET & AIIMS (2006-2018)

AIPMT 2006

1. Which of the following is **not** a correct statement?
 (1) Multiple bonds are always shorter than corresponding single bonds
 (2) The electron-deficient molecules can act as Lewis acids
 (3) The canonical structures have no real existence
 (4) Every AB_5 molecule does in fact have square pyramid structure.

AIIMS 2006

2. The colour imparted by Co(II) compounds to glass is –
 (1) Green (2) Deep-Blue
 (3) Yellow (4) Red
3. Tincture of iodine is –
 (1) Aqueous solution of I_2
 (2) Solution of I_2 in aqueous KI
 (3) Alcoholic solution of KI with I_2
 (4) Aqueous solution of KI
4. Which two of the following salts are used for preparing iodized salt–
 (i) KIO_3 (ii) KI
 (iii) I_2 (iv) HI
 (1) (i) and (ii) (2) (i) and (iii)
 (3) (ii) and (iv) (4) (iii) and (iv)
5. Borax is used as cleansing agent because on dissolving in water it gives.
 (1) Alkaline solution (2) Acidic solution
 (3) Bleaching solution (4) Colloidal solution

AIPMT 2007

6. Which one of the following anions is present in the chain structure of silicates :
 (1) SiO_4^{4-} (2) $Si_2O_7^{6-}$
 (3) $(Si_2O_5^{2-})_n$ (4) $(SiO_3^{2-})_n$

AIPMT 2009

7. The straight chain polymer is formed by :-
 (1) Hydrolysis of $(CH_3)_2SiCl_2$ followed by condensation polymerisation
 (2) Hydrolysis of $(CH_3)_3SiCl$ followed by condensation polymerisation
 (3) Hydrolysis of CH_3SiCl_3 followed by condensation polymerisation
 (4) Hydrolysis of $(CH_3)_4Si$ by addition polymerisation

AIPMT Pre. 2010

8. Which one of the following molecular hydrides acts as a Lewis acid ?
 (1) CH_4 (2) NH_3
 (3) H_2O (4) B_2H_6

9. Oxidation states of P in $H_4P_2O_5$, $H_4P_2O_6$, $H_4P_2O_7$, are respectively :-
 (1) +3, +4, +5 (2) +3, +5, +4
 (3) +5, +3, +4 (4) +5, +4, +3
10. How many bridging oxygen atoms are present in P_4O_{10} :-
 (1) 4 (2) 2
 (3) 5 (4) 6

AIIMS 2010

11. The product obtained when one mole of diborane reacts with two mole of NH_3 at high temperature
 (1) $B_2H_6 \cdot 2NH_3$ (2) $B_3N_3H_6$
 (3) $(BN)_x$ (4) $[BH_2(NH_3)_2]^+ [BH_4]^-$

AIPMT Pre. 2011

12. Name the type of the structure of silicate in which one oxygen atom of $[SiO_4]^{4-}$ is shared ?
 (1) Linear chain silicate
 (2) Sheet silicate
 (3) Pyrosilicate
 (4) Three dimensional

AIPMT Mains 2010

13. Which of the following oxide is amphoteric :-
 (1) CO_2 (2) SnO_2 (3) CaO (4) SiO_2

AIIMS 2011

14. The wrong statement about fullerene is–
 (1) It has 5-membered carbon ring
 (2) It has 6-membered carbon ring
 (3) It has sp^2 hybridization
 (4) It has no. of 5-membered ring more than 6-membered ring

15. First compound for Xe synthesized was–
 (1) $[XeF^+][XePtF_5^-]$ (2) $[XeO_2]$
 (3) $Xe[PtF_6]$ (4) $O_2[XeF_6]$

16. Iodine oxidises sodium borohydride to gives:
 (1) B_2H_6 (2) Sodium hydride
 (3) HI (4) I_3^-

AIPMT Pre. 2012

17. Which of the following statements is not valid for oxyacids of phosphorus?
 (1) All oxyacids contain tetrahedral four coordinated phosphorus
 (2) All oxyacids contain atleast one $P=O$ unit and one $P-OH$ group
 (3) Orthophosphoric acid is used in the manufacture of triple superphosphate
 (4) Hypophosphorous acid is a diprotic acid

18. Sulphur trioxide can be obtained by which of the following reaction:

- (1) $S + H_2SO_4 \xrightarrow{\Delta}$
 (2) $H_2SO_4 + PCl_5 \xrightarrow{\Delta}$
 (3) $CaSO_4 + C \xrightarrow{\Delta}$
 (4) $Fe_2(SO_4)_3 \xrightarrow{\Delta}$

AIIMS 2012

19. How many P = O bond present in $(HPO_3)_3$?
 (1) 0 (2) 3 (3) 6 (4) 9

20. N-N bond length minimum in :-
 (1) N_2O (2) N_2O_3 (3) N_2O_4 (4) N_2O_5

21. $S_2O_8^{2-}$ have :-
 (1) S-S bond
 (2) S-O bridge
 (3) O-O bridge
 (4) All S-O bond length same

NEET-UG 2013

22. The basic structural unit of silicates is :-
 (1) SiO_4^{2-} (2) SiO^- (3) SiO_4^{4-} (4) SiO_3^{2-}

23. Which of these is not a monomer for a high molecular mass silicone polymer ?
 (1) $PhSiCl_3$ (2) $MeSiCl_3$
 (3) Me_2SiCl_2 (4) Me_3SiCl

24. Which of the following does not give oxygen on heating ?
 (1) $(NH_4)_2Cr_2O_7$ (2) $KClO_3$
 (3) $Zn(ClO_3)_2$ (4) $K_2Cr_2O_7$

25. Roasting of sulphides gives the gas X as a by product. This is colourless gas with choking smell of burnt sulphur and causes great damage to respiratory organs as a result of acid rain. Its aqueous solution is acidic, acts as reducing agent and its acid has never been isolated. The gas X is :-
 (1) SO_3 (2) H_2S (3) SO_2 (4) CO_2

AIIMS 2013

26. Bleaching powder does not contain :-
 (1) $CaCl_2$ (2) $Ca(OH)_2$
 (3) $Ca(OC)_2$ (4) $Ca(ClO)_2$

AIIMS 2014

27. sp^2 carbon is not present in :-
 (1) Fullerene (2) Graphite
 (3) Carbonic acid (4) Dry ice

28. Which of the following halogen form only one oxyacids (HOX)

- (1) F (2) Br (3) I (4) Cl

29. Rhombic sulphur is not soluble in :-
 (1) CS_2 (2) Benzene (3) Water (4) Ether

30. Which compound is used for enrichment of U_{235} concentration in nuclear reactions ?
 (1) ClF_3 (2) IF_7
 (3) U_3O_8 (4) $XePtO_4$

AIPMT 2015

31. Nitrogen dioxide and sulphur dioxide have some properties in common. Which property is shown by one of these compounds, but not by the other?
 (1) is a reducing agent
 (2) is soluble in water
 (3) is used as a food-preservative
 (4) forms 'acid-rain'

Re-AIPMT 2015

32. Strong reducing behaviour of H_3PO_2 is due to :
 (1) High oxidation state of phosphorus
 (2) Presence of two -OH groups and one P-H bond
 (3) Presence of one -OH group and two P-H bonds
 (4) High electron gain enthalpy of phosphorus

33. Which of the statements given below is incorrect?
 (1) ONF is isoelectronic with O_2N^-
 (2) OF_2 is an oxide of fluorine
 (3) Cl_2O_7 is an anhydride of perchloric acid
 (4) O_3 molecule is bent

34. The stability of +1 oxidation state among Al, Ga, In and Tl increases in the sequence :
 (1) $Tl < In < Ga < Al$
 (2) $In < Tl < Ga < Al$
 (3) $Ga < In < Al < Tl$
 (4) $Al < Ga < In < Tl$

AIIMS 2015

35. Which of the following statement is correct about solid state of boric acid.
 (1) H-bond is present
 (2) dissolves in water to yield H^+
 (3) shape of B is tetrahedral
 (4) None of these

36. Which of the following allotrope of phosphorous has tetrahedral discrete unit?

- (1) Red black P
- (2) White P
- (3) Red P
- (4) Red, black & white P

37. Chain growth can be controlled by

- (1) R_2SiCl_2
- (2) R_3SiCl
- (3) $RSiCl_3$
- (4) $R_4Si/SiCl_4$

38. Lowest oxidation state of phosphorous is in

- (1) H_3PO_2
- (2) H_3PO_4
- (3) $H_4P_2O_7$
- (4) H_3PO_3

39. Which one of the following element can shown +7 oxidation state with fluorine

- (1) I
- (2) Mn
- (3) F
- (4) Br

40. S-S linkage absent in

- (1) $H_2S_2O_7$
- (2) $H_2S_2O_3$
- (3) $H_2S_2O_5$
- (4) $H_2S_2O_6$

41. Which of the following gives B_2H_6 on reaction with $NaBH_4$

- (1) $LiAlH_4$
- (2) $NaOH$
- (3) I_2
- (4) None

NEET-I 2016

42. Among the following, the correct order of acidity is

- (1) $HClO_3 < HClO_4 < HClO_2 < HClO$
- (2) $HClO < HClO_2 < HClO_3 < HClO_4$
- (3) $HClO_2 < HClO < HClO_3 < HClO_4$
- (4) $HClO_4 < HClO_2 < HClO < HClO_3$

43. When copper is heated with conc. HNO_3 it produces

- (1) $Cu(NO_3)_2$ and NO_2
- (2) $Cu(NO_3)_2$ and NO
- (3) $Cu(NO_3)_2$, NO and NO_2
- (4) $Cu(NO_3)_2$ and N_2O

44. Which is the **correct** statement for the given acids?

- (1) Phosphinic acid is a diprotic acid while phosphonic acid is a monoprotic acid
- (2) Phosphinic acid is a monoprotic acid while phosphonic acid is a diprotic acid
- (3) Both are triprotic acids
- (4) Both are diprotic acids

NEET-II 2016

45. Boric acid is an acid because its molecule

- (1) accepts OH^- from water releasing proton
- (2) combines with proton from water molecule
- (3) contains replaceable H^+ ion
- (4) gives up a proton

46. AlF_3 is soluble in HF only in presence of KF . It is due to the formation of

- (1) AlH_3
- (2) $K[AlF_3H]$
- (3) $K_3[AlF_3H_3]$
- (4) $K_3[AlF_6]$

AIIMS 2016

47. At $1000^\circ C$ air is passed on coal then which product will be form :-

- (1) producer gas
- (2) water gas
- (3) CH_4
- (4) none of these

48. Which one of the following statement is not true regarding B_2H_6 :-

- (1) It react with NaH to form $NaBH_4$
- (2) It is non inflammable gas
- (3) It contain four equal B-H bonds
- (4) It react with lewis base to form always adduct

49. Which of the following is correct :-

- (1) N_2O is a coloured gas
- (2) CO is an acidic oxide
- (3) CO_2 is not absorbed in $CsOH$
- (4) N_2O is a neutral oxide

50. Which of the following has least tendency in +3 oxidation state to show disproportionation reaction.

- (1) N
- (2) P
- (3) Bi
- (4) Sb

NEET(UG) 2017

51. In which pair of ions both the species contain S-S bond?

- (1) $S_4O_6^{2-}$, $S_2O_3^{2-}$
- (2) $S_2O_7^{2-}$, $S_2O_8^{2-}$
- (3) $S_4O_6^{2-}$, $S_2O_7^{2-}$
- (4) $S_2O_7^{2-}$, $S_2O_3^{2-}$

52. It is because of inability of ns^2 electrons of the valence shell to participate in bonding that:-

- (1) Sn^{2+} is oxidising while Pb^{4+} is reducing
- (2) Sn^{2+} and Pb^{2+} are both oxidising and reducing
- (3) Sn^{4+} is reducing while Pb^{4+} is oxidising
- (4) Sn^{2+} is reducing while Pb^{4+} is oxidising

AIIMS 2017

53. Which of the following statement is incorrect about silicones ?
 (1) R_2SiCl_2 & $RSiCl_3$ are monomers of silicones
 (2) Silicones are hydrophobic
 (3) R_3SiCl is used to close polymeric chain
 (4) Polymers of $(R_3SiO)_2$
54. Boric acid in water produces ?
 (1) $H_2BO_3^-$ (2) BO_3^{3-}
 (3) $(H_4BO_4)^-$ (4) $[B(OH)]^-$
55. Which of the following is not completely soluble in conc. HNO_3 .
 (1) S_8 (2) I_2
 (3) Al (4) Zn
56. Which of the following pair of compounds gives white fumes, on exposing to moist air
 (1) $AlCl_3$ & $NiCl_2$ (2) $AlCl_3$ & $CrCl_3$
 (3) $TiCl_4$ & $SiCl_4$ (4) $SiCl_4$ & $SnCl_4$
57. Which of the following covalent hydride having highest lewis acidic character ?
 (1) $Al(CH_3)_3$ (2) $NaBH_4$
 (3) B_2H_6 (4) AsH_3
58. The structure of graphite belongs to :-
 (1) Monoclinic (2) Triclinic
 (3) Hexagonal (4) Rhombohedral

NEET(UG) 2018

59. Which of the following statements is **not** true for halogens ?
 (1) All form monobasic oxyacids.
 (2) All are oxidizing agents.
 (3) All but fluorine show positive oxidation states.
 (4) Chlorine has the highest electron-gain enthalpy.
60. The correct order of N-compounds in its decreasing order of oxidation states is
 (1) HNO_3 , NO, N_2 , NH_4Cl
 (2) HNO_3 , NO, NH_4Cl , N_2
 (3) HNO_3 , NH_4Cl , NO, N_2
 (4) NH_4Cl , N_2 , NO, HNO_3

AIIMS 2018

61. Halides of which of the following element always have only one lone pair on central atom :-
 (1) Xe (2) Cl
 (3) Se (4) N
62. Which of the following statement is not correct :-
 (1) Black phosphorus is more stable than white & red phosphorus
 (2) Red phosphorus is highly toxic
 (3) White phosphorus is highly soluble in CS_2
 (4) Red phosphorus converts in black on heating
63. The best compound which convert nitrite in N_2 is:-
 (1) Urea
 (2) Thiourea
 (3) Sulphamic acid
 (4) Ammonium chloride
64. Which pair not shows same shape :-
 (1) I_3^- , $BeCl_2$ (2) BF_3 , ClO_3^-
 (3) SO_2 , H_2O (4) XeF_4 , BrF_4^-
65. Which one is wrong :-
 (1) Pyroxene is a linear silicate
 (2) Zeolite is a 2 dimensional double strand silicate
 (3) Beryl is a cyclic silicate
 (4) Pyrex is a man-made silicate
66. When cyanogen gas is passed through strong alkali then product formed is ?
 (1) OCN^- (2) N_2
 (3) NCN^- (4) NH_2CH
67. Which of the following insoluble in dil HCl :-
 (1) $SnCl_2$ (2) $PbCl_2$
 (3) $CdCl_2$ (4) $BiOCl$
68. Which gas will diffuse fastest in Rubber
 (1) Xenon (2) Fluorine
 (3) Oxygen (4) Helium
69. Which will give Blue colour with SO_2
 (1) I_2 + Cellulose (2) Iodate + Starch
 (3) $CuSO_4$ + KI (4) I_2 solution
70. Which of the following will not convert N_2H_4 into N_2
 (1) Oxygen (2) $CuSO_4$
 (3) Ozone (4) Zn + HCl

- 71.** Which change will not take place when NaCl and MnO_2 is placed in conc. H_2SO_4
- (1) Oxidation state of sulphur will change
 - (2) Cl^- will be oxidised to Cl_2
 - (3) Greenish-yellow coloured vapour will be of Cl_2
 - (4) Oxidation state of Mn^{+4} is change to Mn^{+2}

- 72.** Which is incorrect?
- (1) ΔG_f of Br_2 is maximum in halogen.
 - (2) Bond dissociation energy of Br_2 is more than F_2 .
 - (3) Hydration energy of F^- is more than I^-
 - (4) I_2 is more soluble in water than Br_2

EXERCISE-II (Previous Year Questions)

ANSWER KEY

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	4	2	3	1	1	4	1	4	1	4	2	3	2	4	3
Que.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ans.	1	4	4	2	1	3	3	4	1	3	4	4	1	3	1
Que.	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Ans.	3	3	2	4	1	2	2	1	1	1	3	2	1	2	1
Que.	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	4	1	2	4	3	1	4	4	3	3	4	3	3	1	1
Que.	61	62	63	64	65	66	67	68	69	70	71	72			
Ans.	4	2	3	2	2	1	2	4	2	4	1	1			

EXERCISE-III (Analytical Questions)**Check Your Understanding**

- One mole of magnesium nitride on the reaction with an excess of water gives
(1) Two moles of ammonia (2) One mole of nitric acid
(3) One mole of ammonia (4) Two moles of nitric acid
- Which of the following oxides of nitrogen is solid :-
(1) NO_2 (2) N_2O
(3) NO (4) N_2O_5
- Which has no S-S-bond.
(1) $\text{S}_2\text{O}_4^{-2}$ (2) $\text{S}_2\text{O}_5^{-2}$
(3) $\text{S}_2\text{O}_3^{-2}$ (4) $\text{S}_2\text{O}_7^{-2}$
- The products obtained on heating LiNO_3 will be:-
(1) $\text{LiNO}_2 + \text{O}_2$
(2) $\text{Li}_2\text{O} + \text{NO}_2 + \text{O}_2$
(3) $\text{Li}_3\text{N} + \text{O}_2$
(4) $\text{Li}_2\text{O} + \text{NO} + \text{O}_2$
- Which of the following on thermal-decomposition yields a basic as well as an acidic oxide ?
(1) NH_4NO_3 (2) NaNO_3
(3) KClO_3 (4) CaCO_3
- An example of a cyclic silicate is :-
(1) Beryl (2) Zeolite
(3) Talc (4) Zircon
- Which one of the following reacts with glass ?
(1) H_2SO_4 (2) HF
(3) HNO_3 (4) $\text{K}_2\text{Cr}_2\text{O}_7$
- When I_2 is passed through KCl , KF , KBr solutions :
(1) Cl_2 and Br_2 are evolved
(2) Cl_2 is evolved
(3) Cl_2 , Br_2 , F_2 are evolved
(4) None of these
- Ammonia can be dried by
(1) Conc. H_2SO_4 (2) P_4O_{10}
(3) CaO (4) Anhydrous CaCl_2
- Which of the following product is not formed by the reaction of PH_4I and KOH :-
(1) KI (2) PH_3
(3) H_2O (4) P_2O_3
- Out of the following which does not liberate N_2 gas on heating :-
(1) $\text{NaNO}_2 + \text{NH}_4\text{Cl}$ (2) $\text{Ba}(\text{N}_3)_2$
(3) $\text{O}_3 + \text{NO}$ (4) $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$
- Which of the following is incorrect ?
(1) O_2 is weaker oxidant than O_3
(2) O_2 has small bond length than O_3
(3) Both O_2 and O_3 are paramagnetic
(4) O_3 is angular in shape
- Which of the following statements regarding sulphur is incorrect ?
(1) At 600°C the gas mainly consists of S_2 molecules
(2) The oxidation state of sulphur is never less than +4 in its compounds
(3) S_2 molecule is paramagnetic
(4) The vapour at 200°C consists mostly of S_8 rings
- The correct order of acidic strength is :
(1) $\text{Cl}_2\text{O}_7 > \text{SO}_3 > \text{P}_4\text{O}_{10}$
(2) $\text{CO}_2 > \text{N}_2\text{O}_5 > \text{SO}_3$
(3) $\text{Na}_2\text{O} > \text{MgO} > \text{Al}_2\text{O}_3$
(4) $\text{K}_2\text{O} > \text{CaO} > \text{MgO}$
- Which of the following statements is correct ?
(1) BCl_3 and AlCl_3 are both Lewis acids and BCl_3 is stronger than AlCl_3
(2) BCl_3 and AlCl_3 both Lewis acids and AlCl_3 is stronger than BCl_3
(3) BCl_3 and AlCl_3 are both equally strong Lewis acids
(4) Both BCl_3 and AlCl_3 are not Lewis acids.
- Which of the following statements about H_3BO_3 is not correct
(1) It is a strong tribasic acid
(2) It is prepared by acidifying an aqueous solution of borax
(3) It has a layer structure in which planar H_3BO_3 units are joined by hydrogen bonds
(4) It does not act as proton donor but acts as a Lewis acid by accepting hydroxyl ion
- Which of the following property is not related with PH_3
(1) It is a colorless gas having rotten fish smell
(2) it is non poisonous
(3) it is slightly soluble in water
(4) it is a weak Lewis base

- 18.** Which of the following is a mixed anhydride
 (1) P_4O_{10} (2) SO_3
 (3) Cl_2O_6 (4) SO_2
- 19.** In which of the following phosphorous atoms are at the corner of tetrahedron.
 (1) P_4 (2) P_4O_6
 (3) P_4O_{10} (4) All of these
- 20.** In which of the following option product gas X and Y (other than water vapour) are same ?
 (1) $Mg_2C_3 + H_2O \rightarrow X$; $Al_4C_3 + H_2O \rightarrow Y$
 (2) $NH_4NO_3 \xrightarrow{\Delta} X$; $(NH_4)_2Cr_2O_7 \xrightarrow{\Delta} Y$
 (3) $NH_4Cl \xrightarrow{\Delta} X$; $UREA \xrightarrow{H_2O} Y$
 (4) $Zn + \text{dil. } HNO_3 \rightarrow X$; $Ag + \text{dil. } HNO_3 \rightarrow Y$
- 21.** When con. H_2SO_4 is added to charcoal :
 (1) There is no reaction
 (2) Water gas is formed
 (3) SO_2 and CO_2 are evolved
 (4) CO and SO_2 are evolved
- 22.** Which of the following statements are correct for SO_2 gas?
 (1) It acts as bleaching agent in moist conditions.
 (2) It's molecule has linear geometry.
 (3) It's dilute solution is used as lubricant
 (4) It can be prepared by the reaction of dilute H_2SO_4 with metal sulphide
- 23.** Iodine is placed between two liquids C_6H_6 and water then :
 (1) It dissolves more in C_6H_6
 (2) It dissolves more in water
 (3) It dissolves equally in both
 (4) Does not dissolve in both

- 24.** Chromyl chloride vapours are dissolved in water and acetic acid and barium acetate solution is added, then :-
 (1) The solution will remain colourless
 (2) The solution will become dark green
 (3) A yellow solution will be obtained
 (4) A yellow precipitate will be obtained
- 25.** The correct order of sulphur-oxygen bond length is :-
 (1) $SOF_2 > SOCl_2 > SOBr_2$
 (2) $SOCl_2 > SOBr_2 > SOF_2$
 (3) $SOF_2 = SOCl_2 = SOBr_2$
 (4) $SOBr_2 > SOCl_2 > SOF_2$
- 26.** Which is/are wrong about P_4O_{10} molecule :-
 (1) Each 'P' atom can be considered to be sp^3 hybridised
 (2) There are six P-O-P bonds in the molecule
 (3) There are two types of P-O bond lengths
 (4) P-O-P angle is 180°
- 27.** Which of the following order(s) is/are incorrect ?
 (1) $H_3PO_4 > H_3PO_3 > H_3PO_2$ (reducing character)
 (2) $N_2O < NO < N_2O_3 < N_2O_5$ (oxidation state on nitrogen atom)
 (3) $NH_3 > PH_3 > AsH_3 > SbH_3$ (basicity)
 (4) $HClO < HClO_2 < HClO_3 < HClO_4$ (Acidic nature)
- 28.** Which of the following is correct :-
 (1) H_3BO_3 can be considered to be a lewis acid
 (2) The correct order of lewis acid strength order is $BF_3 > BCl_3 > BBr_3$
 (3) One mole borax in aqueous solution will require one mole HCl for titration
 (4) B_2H_6 can be methylated completely to give $B_2(CH_3)_6$

EXERCISE-III (Analytical Questions)

ANSWER KEY

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	1	4	4	2	4	1	2	4	3	4	3	3	2	1	1
Que.	16	17	18	19	20	21	22	23	24	25	26	27	28		
Ans.	1	2	3	4	3	3	1	1	4	4	4	1	1		

EXERCISE-IV (Assertion & Reason)

Target AIIMS

Directions for Assertion & Reason questions

These questions consist of two statements each, printed as Assertion and Reason. While answering these Questions you are required to choose any one of the following four responses.

- (A) If both Assertion & Reason are True & the Reason is a correct explanation of the Assertion.
 (B) If both Assertion & Reason are True but Reason is not a correct explanation of the Assertion.
 (C) If Assertion is True but the Reason is False.
 (D) If both Assertion & Reason are false.

- Assertion** : CCl_4 is not hydrolysed by water
Reason : Carbon in CCl_4 is sp^3 hybridised
 (1) A (2) B (3) C (4) D
- Assertion** : Between SiCl_4 and CCl_4 only SiCl_4 reacts with water.
Reason : SiCl_4 is ionic and CCl_4 is covalent.
 (1) A (2) B (3) C (4) D
- Assertion** : PbI_4 is a stable compound.
Reason : Iodine stabilizes higher oxidation state.
 (1) A (2) B (3) C (4) D
- Assertion** : The atoms in a covalent molecule are said to share electrons, yet some covalent molecules are polar.
Reason : In polar covalent molecules, the shared electrons spend more time on the average near one of the atoms due to high EN.
 (1) A (2) B (3) C (4) D
- Assertion** : Nitrogen is unreactive at room temperature but becomes reactive at elevated temperature (on heating or in the presence of catalysts).
Reason : In nitrogen molecule, there is extensive delocalization of electrons.
 (1) A (2) B (3) C (4) D
- Assertion** :- H_3PO_2 can act as strong reducing agent and gives disproportionation reaction on heating.
Reason :- Due to presence of one $-\text{OH}$ group and two $\text{P}-\text{H}$ group, H_3PO_2 is a monobasic bronsted acid.
 (1) A (2) B (3) C (4) D
- Assertion** :- NO_2 is paramagnetic in gaseous state but become diamagnetic solid on cooling.
Reason :- In gaseous state, NO_2 exists as monomer odd electron species but on cooling it dimerise to N_2O_4 .
 (1) A (2) B (3) C (4) D
- Assertion** :- For drying H_2 , conc. H_2SO_4 cannot be used.
Reason :- conc. H_2SO_4 on absorbing H_2O form moist H_2 along with large amount of heat which burn H_2 .
 (1) A (2) B (3) C (4) D
- Assertion** :- NH_3 can be dried by quick lime.
Reason :- Quick lime is also basic in nature and no reaction take place with NH_3 .
 (1) A (2) B (3) C (4) D
- Assertion** :- $\text{Cl}_2 + \text{H}_2\text{O}$ reaction is a disproportionation reaction and HOCl is formed.
Reason :- Increase in pH will increase the yield of HOCl .
 (1) A (2) B (3) C (4) D
- Assertion** :- NO_2 and ClO_2 both being odd electron molecule dimerise.
Reason :- On dimerisation, NO_2 is converted to stable N_2O_4 molecule with even number of electrons.
 (1) A (2) B (3) C (4) D
- Assertion** :- All inter halogens are diamagnetic.
Reason :- AB type of interhalogen undergoes hydrolysis giving a halide ion derived from the smaller halogen and a hypohalite ion derived from the larger halogen.
 (1) A (2) B (3) C (4) D

- 13. Assertion :-** Anhyd. calcium chloride cannot be used to dry NH_3 .
Reason :- Anhyd. CaCl_2 forms an adduct $\text{CaCl}_2 \cdot 8\text{NH}_3$ with NH_3 .
 (1) A (2) B (3) C (4) D
- 14. Assertion :-** Surface of diamond is generally impure.
Reason :- It has dangling bonds.
 (1) A (2) B (3) C (4) D
- 15. Assertion :-** SiCl_4 is more hydrolysed than SiF_4 .
Reason :- $-\text{I}$ effect of $\text{F} > \text{Cl}$.
 (1) A (2) B (3) C (4) D
- 16. Assertion :-** The solubility of I_2 increases in water in presence of KI .
Reason :- I_2 forms ionic polyhalide with KI .
 (1) A (2) B (3) C (4) D
- 17. Assertion :-** H_3PO_2 is monoprotic acid.
Reason :- It has H-bonding in solid state.
 (1) A (2) B (3) C (4) D
- 18. Assertion :-** O_3 is a good oxidising agent.
Reason :- O_3 very rapidly gives dioxygen.
 (1) A (2) B (3) C (4) D
- 19. Assertion :-** Sulphur is soluble in CS_2 .
Reason :- Sulphur exists in S_8 form.
 (1) A (2) B (3) C (4) D
- 20. Assertion :-** P_4O_{10} dehydrates HNO_3 .
Reason :- In P_4O_{10} oxidation state of P is +5.
 (1) A (2) B (3) C (4) D
- 21. Assertion :-** Peroxy disulphuric acid & oleum have same oxidation state.
Reason :- In oleum oxygen bridges two sulphur atoms.
 (1) A (2) B (3) C (4) D
- 22. Assertion :-** $3\text{O}_{2(g)} \longrightarrow 2\text{O}_{3(g)}$ the reaction occurs in presence of silent electric discharge.
Reason :- because at 298 K, $\Delta S = +ve$.
 (1) A (2) B (3) C (4) D
- 23. Assertion :-** Conc. H_2SO_4 on addition to HCOOH liberates CO .
Reason :- Hot conc. H_2SO_4 is a moderate oxidising agent.
 (1) A (2) B (3) C (4) D
- 24. Assertion :-** Salts of H_3PO_3 and H_3PO_4 used as fertilizers.
Reason :- Formed H_3PO_3 increases solubility of water in soil on addition of phosphate fertilizers.
 (1) A (2) B (3) C (4) D
- 25. Assertion :-** Pb_3O_4 reacts with HNO_3 forms PbO_2 .
Reason :- Pb^{+4} is most stable.
 (1) A (2) B (3) C (4) D
- 26. Assertion :-** SO_2 mixed with H_2SO_4 to make oleum.
Reason :- SO_2 in presence of water forms H_2SO_4 in air.
 (1) A (2) B (3) C (4) D
- 27. Assertion :-** Cl_2 is oxidised by hot & conc. NaOH .
Reason :- It is favoured by formation of NaClO_3 .
 (1) A (2) B (3) C (4) D
- 28. Assertion :-** XeF_4 is a good fluorinating agent.
Reason :- XeF_4 sublimes at 298 K.
 (1) A (2) B (3) C (4) D
- 29. Assertion :-** $\text{Ba}(\text{N}_3)_2$ give highly pure N_2 .
Reason :- Atomic weight of Ba is very high.
 (1) A (2) B (3) C (4) D
- 30. Assertion :-** As temp. increases intensity of brown colour of NO_2 decreases.
Reason :- Formation of NO_2 is an endothermic process.
 (1) A (2) B (3) C (4) D
- 31. Assertion :-** Black phosphorus is oxidised easily in air.
Reason :- Black phosphorus consists of polymer tetrahedral units of P_4 .
 (1) A (2) B (3) C (4) D
- 32. Assertion :-** Fluorine oxidises H_2O to O_2 but Cl_2 does not.
Reason :- Electronegativity of fluorine is greater than oxygen but EN of chlorine is lesser than oxygen.
 (1) A (2) B (3) C (4) D
- 33. Assertion :-** SO_2 (at room temp.) and SeO_2 (at higher temp. vapour condition) have same shape.
Reason :- Covalent radius of Se is somewhat larger than sulphur.
 (1) A (2) B (3) C (4) D

34. **Assertion :-** I_2O_5 oxidises CO

Reason :- Oxidation Number of Iodine is +5 in I_2O_5 .

- (1) A (2) B (3) C (4) D

35. **Assertion :-** O_2F_2 is used for the purification of Plutonium from spent nuclear fuel.

Reason :- O_2F_2 convert Plutonium to PuF_6 .

- (1) A (2) B (3) C (4) D

36. **Assertion :-** NH_3 is easily desolved in alkaline HgI_4^{-2}

Reason :- Compound of Hg and I^- is used in detection of NH_3 .

- (1) A (2) B (3) C (4) D

37. **Assertion :-** Liquid N_2 is used as refrigerant.

Reason :- Because Liquid N_2 is not Harmful for environment and its is non reactive.

- (1) A (2) B (3) C (4) D

38. **Assertion :-** 1ppm of NaF is compulsory in drinking water.

Reason :- It helps in maintaining blood pressure.

- (1) A (2) B (3) C (4) D

39. **Assertion :-** Graphene is obtained from graphite

Reason :- Graphene and graphite both have layered structure.

- (1) A (2) B (3) C (4) D

EXERCISE-IV (Assertion & Reason)

ANSWER KEY

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Ans.	1	2	2	2	2	2	3	2	1	3	4	2	2	2	4
Que.	31	32	33	34	35	36	37	38	39						
Ans.	4	2	2	2	1	1	1	1	3						