

## P Blocks Elements

### Group – 13 (Boron family)

Boron is the first member of group 13 or IIIA of the periodic table. It consists of five elements Boron (*B*), Aluminium (*Al*), Gallium (*Ga*), Indium (*In*) and Thallium (*Tl*). Boron is the only non-metal of this group.

#### General characteristics.

##### (1) Electronic configuration

Element	Electronic configuration ( $ns^2 np^1$ )
${}_5B$	$1s^2, 2s^2 2p^1$ or $[He]2s^2 2p^1$
${}_{13}Al$	$1s^2, 2s^2 2p^6, 3s^2 3p^1$ or $[Ne]3s^2 3p^1$
${}_{31}Ga$	$1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}, 4s^2 4p^1$ or $[Ar]3d^{10} 4s^2 4p^1$
${}_{49}In$	$1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}, 4s^2 4p^6 4d^{10}, 5s^2 5p^1$ or $[Kr]4d^{10} 5s^2 5p^1$
${}_{81}Tl$	$1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}, 4s^2 4p^6 4d^{10} 4f^{14}, 5s^2 5p^6 5d^{10}, 6s^2 6p^1$ or $[Xe]4f^{14} 5d^{10} 6s^2 6p^1$

##### (2) Physical properties

(i) **Atomic radii and ionic radii** : Atoms of group 13 elements and their ions have smaller size than the corresponding atom of group 2. Both atomic and ionic radii increase on going down the group with an anomaly at gallium. The ionic radii regularly increases from  $B^{3+}$  to  $Tl^{3+}$

(ii) **Melting and boiling points** : Melting points decreases from *B* to *Ga* and then increase from *Ga* to *Tl*. Boron has a very high m. pt. because it exists as a giant covalent polymer in both solid and liquid states.

**Note** : □ The low m pt. of *Ga* is due to the fact that it consists of only  $Ga_2$  molecules. Gallium remains liquid upto 2273 K and hence it is used in high temperature **thermometry**.

(iii) **Density** : Density increases regularly as we go down the group from *B* to *Tl*.

(iv) **Ionisation energy** : Ionisation energies group 13 elements follows the order,  $B > Al < Ga > In < Tl$

(v) **Electropositive character** : These elements are less electropositive than the elements of group 1 and 2 due to their higher ionisation energies.

(vi) **Oxidation state** : Group 13 elements have three electrons in the valence shell so they can show +3 oxidation state. Boron shows oxidation state of +3 in compounds like  $BCl_3$  etc. Except boron other members also show +1 oxidation state. This is due to **inert pair effect** *i.e.*, reluctance of s-electron pair to take part in chemical combinations. The inert pair effect is due to the fact that s-orbital is more penetrating than p-orbital and hence the s-electrons are strongly held by the nucleus.

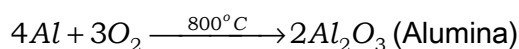
(vii) **Nature of compounds** : The tendency of formation of ionic compounds increases from B to Tl. Boron forms only covalent compounds. Aluminium can form both covalent (e.g., anhydrous  $AlCl_3$ ) and ionic compounds. Gallium forms mainly ionic compounds although anhydrous  $GaCl_2$  is covalent. Thallium compounds are only ionic.

(viii) **Complex formation** : On account of their smaller size and greater charge, these elements have a much greater tendency to form complexes than the s-block elements.

### (3) Chemical properties

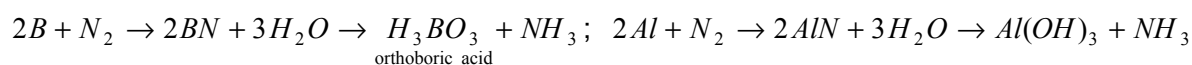
(i) **Reactivity** : Crystalline boron is unreactive while amorphous boron is reactive. Pure boron does not react with water. Aluminium is stable in air due to the formation of protective oxide film.

(ii) **Formation of oxides** :  $4B + 3O_2 \xrightarrow{700^\circ C} 2B_2O_3$  (Boric anhydride);



$B_2O_3$  is acidic.  $Al_2O_3$  is amphoteric.  $Ga_2O_3$  is amphoteric.  $In_2O_3$  and  $Tl_2O_3$  are basic.

(iii) **Formation of nitrides** : B and Al when heated in atmosphere of  $N_2$  or  $NH_3$  form nitrides which undergo hydrolysis with steam to evolve  $NH_3$



(iv) **Formation of halides** :  $B_2O_3 + 3C + 3Cl_2 \rightarrow 2BCl_3 + 3CO$ ;  $Al_2O_3 + 3C + 3Cl_2 \rightarrow 2AlCl_3 + 3CO$

$BF_3$  does not undergo hydrolysis due to strong B–F bond. It rather reacts with water to form an adduct

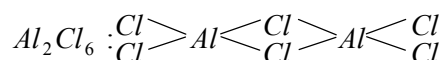
$BF_3 + H_2O \rightleftharpoons H^+[BF_3OH]^-$ ; Due to great *resistance of  $BF_3$  to hydrolysis and its tendency to act as Lewis acid*, it is widely used as catalyst in organic reactions like *Friedel Craft alkylation and acylation*.

All halides of boron are electron deficient compounds (Lewis acids).

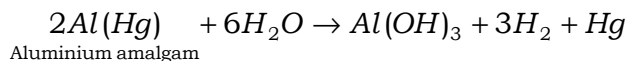
The Lewis acid strength follows the order :  $BF_3 < BCl_3 < BBr_3 < BI_3$

If the central atom is different, then the order of acidic strength is,  $BCl_3 < AlCl_3 < GaCl_3 < InCl_3$

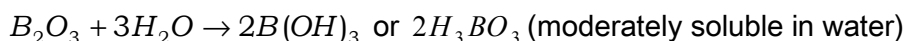
**Note** :  $\square$   $BCl_3$  does not form a dimer but  $AlCl_3$  can form dimer.



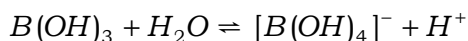
(v) **Formation of hydroxides** : Both boron and aluminium does not react with water easily. However amalgamated aluminium react with  $H_2O$  to give  $H_2$



However  $B(OH)_3$  or  $H_3BO_3$  can be obtained by dissolving  $B_2O_3$  in water.



$B(OH)_3$  is distinctly acidic and acts as lewis acid by accepting  $OH^-$  from  $H_2O$ .



However,  $Al(OH)_3$  and  $Ga(OH)_3$  are amphoteric whereas  $In(OH)_3$  and  $Tl(OH)_3$  are distinctly basic.

(vi) **Formation of hydrides** : The boron hydrides are called **boranes** with general formula  $B_nH_{n+4}$  (e.g.,  $B_2H_6$ ) and  $B_nH_{n+6}$  (e.g.,  $B_4H_{10}$ ).

### Anomalous behaviour of boron

Boron the first member of group 13 shows anomalous behaviour as compared to aluminium and other members of the group. It is due to the following reasons :

- (i) Boron has the smallest size in the group.
- (ii) It has high ionisation energy as compared to the other members.
- (iii) It has highest electronegativity in the group.
- (iv) It does not have vacant d-orbitals in its valence shell.

A few important points of difference are :

(i) *Metallic character* : Boron is a typical non-metal while other members of the group have typical metallic character. Thus, boron is a non-metal and semiconductor while Al and other members are good conductors of electricity.

(ii) *Allotropy* : Boron has two allotropic forms – *crystalline* and *amorphous*. Aluminium does not show allotropy.

### Group – 14 (Carbon Family)

Carbon is the first member of group 14 or IVA of the periodic table. It consists of five elements carbon (*C*), silicon (*Si*), germanium (*Ge*), tin (*Sn*) and lead (*Pb*). Carbon and silicon are nonmetals, germanium is metalloid and tin and lead are metals.

#### General characteristic.

(1) **Electronic configuration :**

Elements	Electronic configuration ( $ns^2 np^2$ )
${}_6C$	$1s^2, 2s^2 2p^2$ or $[He]2s^2 2p^2$
${}_{14}Si$	$1s^2, 2s^2 2p^6, 3s^2 3p^2$ or $[Ne]3s^2 3p^2$
${}_{32}Ge$	$1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}, 4s^2 4p^2$ or $[Ar]3d^{10} 4s^2 4p^2$
${}_{50}Sn$	$1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}, 4s^2 4p^6 4d^{10}, 5s^2 5p^2$ or $[Kr]4d^{10} 5s^2 5p^2$
${}_{82}Pb$	$1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}, 4s^2 4p^6 4d^{10} 4f^{14}, 5s^2 5p^6 5d^{10}, 6s^2 6p^2$ or $[Xe]4f^{14} 5d^{10} 6s^2 6p^2$

(2) **Physical properties**

(i) **Atomic radii** : The atomic radii of group 14 elements increase regularly on moving down the group mainly due to increase in the number of shells.

(ii) **Melting point and boiling point** : The m. pt. and b. pt. decreases as we move down the group from carbon to lead.

(iii) **Density** : The density of these elements increases as we move down in the group.

(iv) **Ionisation energy** : The first ionisation energies of the group 14 elements are higher than those of group 13 element. This is because of their higher nuclear charge and smaller size.

Note : □ The values of IE decreases on moving down the group, through not in a regular order.

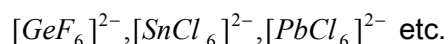
Element	<i>C</i>	<i>Si</i>	<i>Ge</i>	<i>Sn</i>	<i>Pb</i>
I.E. (kJ mol)	1086	786	760	707	715

(v) **Electronegativity** : The electronegativity of carbon is highest in this group. The electronegativity decreases from *C* to *Pb* but not in a regular manner possible due to filling of *d* and *f* orbitals.

(vi) **Oxidation state** : The elements of group 14 exhibit oxidation states of + 4 and + 2. In the + 4 oxidation state the compounds are covalent while in + 2 oxidation state compounds are ionic. + 4 Oxidation number mostly shown by *C* and *Si* and + 2 Oxidation number mostly shown by *Ge*, *Sn*, *Pb*.

(vii) **Ability to form complexes** : The ability of group 14 elements to form complexes is highly favoured by a high charge, small size and availability of empty orbitals. for. e.g.  $[\text{SiF}_6]^{2-}$ , four covalent and two co-ordinate bonds are formed as a result of  $sp^3d^2$  hybridization and octahedral geometry.

Thus elements like *Si*, *Ge*, *Sn* and *Pb* have and ability to increase their co-ordination number from four to Six.



(viii) **Catenation** (self linkage) : The property of elements to form long chains or rings by self-linking of their own atoms through covalent bonds is catenation. The strength of C – C bond is very high (due to small size of carbon), therefore, carbon exhibits this property to maximum. Down the group, the strength of the element-element bond decreases (due to increase in size) and the extent of catenation, therefore decreases,  $C > Si > Ge > Sn > Pb$ .

Note : □ Lead does not show catenation.

(ix) **Polymorphism and Allotropy**

**Polymorphism** (Greek : polus = much, many, morphe = form) : A substance which occurs in two form is said to be dimorphous, in three trimorphous and so on.

**Allotropy** (Greek : allos = other, tropos = manner) : It is the phenomenon of existence of the same substance (element or compound) in two or more forms, in the same physical state having different properties.

### Kinds of allotropy

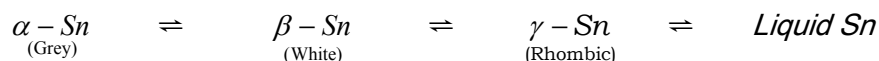
(a) *Enantiotropy* : When two forms of a solid substance exist together in equilibrium with each other at a particular temperature under normal pressure it is called enantiotropy e.g.,  $S_{(\text{Rhombic})} \rightleftharpoons S_{(\text{monoclinic})}$ .

(b) *Monotropy* : In which only one allotrope is stable, under normal conditions the other being unstable e.g. diamond and graphite, oxygen and ozone etc.

(c) *Dynamicitropy* : It is the type of allotropy in which there is a true equilibrium between the two allotropes, one changing into the other at exactly the same rate as the reverse occurs. Both allotropes are stable over a wide range of temperature. For example, liquid sulphur exist in two forms, the pale yellow mobile form called  $S_{\lambda}$  and dark viscous form called  $S_{\mu}$  in equilibrium with each other,  $S_{\lambda} \rightleftharpoons S_{\mu}$ .

**Cause of allotropy** : Generally the allotropy among solid substances is due to the difference in crystalline structure. It may also be due to the presence of different number of atoms e.g.,  $O_2$  and  $O_3$ ,  $S_8$ ,  $S_4$  and  $S_2$  etc. It may be due to the difference in nuclear spins e.g., *ortho* and *para hydrogen*.

**Different allotropic forms** : Except lead, all elements show allotropy. **Carbon** has two crystalline allotropic forms *i.e.*, diamond and graphite. **Silicon** has both crystalline and amorphous forms. **Tin** has three crystalline modifications with the following equilibrium temperature:  $232^{\circ}\text{C}$



### (3) Chemical properties

(i) **Hydrides** : All the elements of group 14 combine with hydrogen directly or indirectly to form the covalent hydrides,  $MH_4$  (M = C, Si, Ge, Sn or Pb). The number of hydrides and the ease of preparation decrease on going from carbon to lead.

The hydrides of silicon are called *silanes* having the general formula  $Si_nH_{2n+2}$ . The hydrides of germanium are called *germanes* while those of tin are called the *stannanes*. Only lead forms an unstable hydride of the formula,  $PbH_4$  called the *plumbane*.

Three hydrides of germanium, i.e.,  $GeH_4$ ,  $Ge_2H_6$  and  $Ge_3H_8$  and only two hydrides of tin i.e.,  $SnH_4$  and  $Sn_2H_6$  are well known.

(ii) **Oxides** : Carbon forms five oxides  $CO$ ,  $CO_2$ ,  $C_3O_2$  (carbon suboxide),  $C_5O_2$  and  $C_{12}O_9$ ,  $C_3O_2$  is the anhydride of malonic acid and  $CO_2$  is the anhydride of  $H_2CO_3$  (carbonic acid)  $CO_2$  is a non-polar linear molecule due to maximum tendency of C to form  $p\pi-p\pi$  multiple bond with oxygen. Si forms  $SiO_2$ . Pb forms a number of oxides.  $PbO$  can be obtained by heating  $Pb(NO_3)_2$ ,  $2Pb(NO_3)_2 \xrightarrow{\text{Heat}} 2PbO + 4NO_2 + O_2$ .

The red form of  $PbO$  is called **litharge** and the yellow form is **massicot**.  $Pb_3O_4$  (Red lead, or Sindur) is prepared by heating litharge in air at  $470^\circ\text{C}$ ,  $6PbO + O_2 \xrightarrow{470^\circ\text{C}} 2Pb_3O_4$ ,  $Pb_3O_4$  is a mixed oxide of  $PbO_2 \cdot 2PbO$ .  $Pb_2O_3$  is called lead sesquioxide.  $GeO_2$ ,  $SnO_2$  etc. are also network solids.

**Note** :  $\square$   $SiO_2$ ,  $GeO_2$ ,  $SnO_2$  and  $PbO_2$  are all solids.

$\square$   $CO_2$  and  $SiO_2$  is acidic,  $GeO_2$  is weakly acidic while  $SnO_2$  and  $PbO_2$  are amphoteric in nature.

$\square$  All the elements of group 14 except silicon from monoxides e.g.,  $CO$ ,  $GeO$ ,  $SnO$  and  $PbO$ . Out of these monoxides only  $CO$  is neutral, while all other monoxides are basic.

(iii) **Halides** : Elements of group 14 react with halogens directly to form tetrahedral and covalent halides except C where its halide is produced by the action of halogens on hydrocarbons.  $PbBr_4$  and  $PbI_4$  do not exist because  $Pb^{4+}$  is a strong oxidant and  $Br^-$  and  $I^-$  are strong reductants. Hence  $Pb^{4+}$  ion is difficult to survive in presence of strong reductants  $Br^-$  and  $I^-$  and is immediately reduced to  $Pb^{2+}$ .

### Anomalous behaviour of carbon

Carbon is found to differ in many properties from the rest of the members of group 14. This is because of the following : (i) Its smallest size (ii) Its high electronegativity (iii) Its property to catenate (iv) Absence of  $d$ -orbitals in it.

Some of the properties in which it differs from other members are :

(i) The melting and boiling points of carbon are very high as compared to the rest to the members of the family.

(ii) Carbon in its diamond form is one of the hardest substance known.

(iii) It has maximum tendency to show catenation.

(iv) Carbon has high tendency to form  $P\pi - P\pi$  multiple bonds with other elements like nitrogen, oxygen, sulphur etc. Other members of the family form  $P\pi - d\pi$  bonds and that also to a lesser extent.

(v)  $CO_2$  is a gas while the dioxides of all other members are solids.

(vi) Carbon shows a maximum covalency of four while other members of the family may expand their covalency to six e.g.,  $[SiCl_6]^{2-}$ ,  $[PbCl_6]^{2-}$  etc.

(vii) Carbon is not affected by alkalis whereas other members react on fusion. For example, silicon form silicates,  $Si + 2NaOH + 1/2 O_2 \rightarrow Na_2SiO_3 + H_2$   
Sodium silicate

## Group – 15 (Nitrogen family)

Nitrogen is the first member of group 15 or VA of the periodic table. It consists of five elements nitrogen (N), phosphorus (P), arsenic (As), antimony (Sb) and bismuth (Bi). The elements of this group are collectively called **pnictogens** and their compounds as pniconides. The name is derived from Greek word "Pniomigs" meaning suffocation. Pniconide contain  $M^{3-}$  species.

### General characteristic.

#### (1) Electronic configuration

Elements	Electronic configuration ( $ns^2 np^3$ )
${}_7N$	$1s^2, 2s^2 2p^3$ or $[He]2s^2 2p^3$
${}_{15}P$	$1s^2, 2s^2 2p^6, 3s^2 3p^3$ or $[Ne]3s^2 3p^3$
${}_{33}As$	$1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}, 4s^2 4p^3$ or $[Ar]3d^{10} 4s^2 4p^3$
${}_{51}Sb$	$1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}, 4s^2 4p^6 4d^{10}, 5s^2 5p^3$ or $[Kr]4d^{10} 5s^2 5p^3$
${}_{83}Bi$	$1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}, 4s^2 4p^6 4d^{10} 4f^{14}, 5s^2 5p^6 5d^{10}, 6s^2 6p^3$ or $[Xe]4f^{14} 5d^{10} 6s^2 6p^3$

#### (2) Physical properties



(i) **Physical state** : Nitrogen– (gas), phosphorus – (solid) (vaporises easily), *As*, *Sb*, *Bi*–solids.

**Note** : □ Nitrogen is the most abundant gas in the atmosphere. It constitutes about 78% by volume of the atmosphere. Phosphorus is the most reactive element in this group and its yellow form is always kept under water.

(ii) **Atomic radii** : Atomic radii increases with atomic number down the group i.e., from *N* to *Bi* due to addition of extra principal shell in each succeeding elements.

(iii) **Ionisation energy** : The ionisation values of the elements of this group decreases down the group due to gradual increases in atomic size.

(iv) **Electronegativity** : Generally the elements of nitrogen family have high value of electronegativity. This value shows a decreasing trend in moving down the group from nitrogen to bismuth.

(v) **Non-metallic and metallic character** : Nitrogen and phosphorus are non-metals, arsenic and antimony are metalloids (semi-metal) and bismuth a typical metal.

(vi) **Molecular state** : Nitrogen readily forms triple bond (two  $p\pi-p\pi$  bonds) and exists as discrete diatomic gaseous molecule ( $N \equiv N$ ) at room temperature. Phosphorus, arsenic and antimony exist in the form of discrete tetra atomic molecules such as  $P_4, As_4, Sb_4$  in which the atoms are linked to each other by single bonds.

(vii) **Melting and boiling points** : The melting points and boiling points of group 15 elements do not show a regular trend.

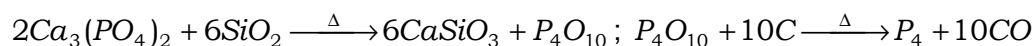
**Note** : □ M.pt. first increases from *N* to *As* and then decreases from *As* to *Bi*. Boiling point first increases from *N* to *Sb*. Boiling point of *Bi* is less than *Sb*.

(viii) **Allotropy** : All the members of group 15 except *Bi* exhibit the phenomenon of allotropy.

(a) Nitrogen exists in two solid and one gaseous allotropic forms.

(b) Phosphorus exists in several allotropic forms such as white, red, scarlet, violet and black form.

**White or yellow phosphorus** : White phosphorus is prepared from rock phosphate  $Ca_3(PO_4)_2, SiO_2$  and coke which are electrically heated in a furnace.



When exposed to light, it acquires a yellow colour.

*Red phosphorus*: It is obtained by heating yellow phosphorus, between 240 –250°C in the presence of an inert gas. Yellow phosphorus can be separated from red phosphorus by reaction with  $NaOH(aq)$  or  $KOH(aq)$  when the former reacts and the latter remains unreacted.

(c) Arsenic exists in three allotropic forms namely grey, yellow and black. Antimony also exists in three forms, viz., metallic, yellow and explosive.

(ix) **Oxidation state**: The members of the group 15 exhibit a number of positive and negative oxidation states.

*Positive oxidation states*: The electronic configuration ( $ns^2np^3$ ) for the valence shell of these elements shows that these elements can have +3 and +5 oxidation states. In moving down this group, the stability of +3 oxidation state increases. It may be pointed out here that nitrogen does not exhibit an oxidation state of +5, because it fails to expand its octet due to nonavailability of vacant  $d$ -orbitals.

*Negative oxidation states*: For example oxidation state of nitrogen is –3. The tendency of the elements to show –3 oxidation state decreases on moving down the group from  $N$  to  $Bi$ .

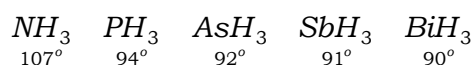
(x) **Catenation** (self linkage): Elements of group 15 also show some tendency to exhibit catenation. This tendency goes on decreasing in moving down the group due to gradual decrease in their bond ( $M-M$ ) energies.

**Note**:  Out of the various allotropic forms of phosphorus, black phosphorus is a good conductor of electricity (similarity with graphite).

- Proteins, the building blocks of our body contain 16% of nitrogen in them.
- Radioactive phosphorus ( $P^{32}$ ) is used in the treatment of **leukemia** (*blood cancer*).
- The disease caused by the constant touch with white phosphorus is called **Phossy Jaw**.

**(3) Chemical properties**

(i) **Hydrides** : All the members form volatile hydrides of the type  $AH_3$ . All hydrides are pyramidal in shape. The bond angle decreases on moving down the group due to decrease in bond pair–bond pair repulsion.



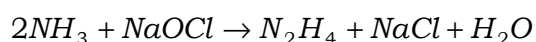
The decreasing order of basic strength of hydrides is as follows :  $NH_3 > PH_3 > AsH_3 > SbH_3 > BiH_3$ .

The increasing order of boiling points is as follows :  $PH_3 < AsH_3 < NH_3 < SbH_3$ .

$NH_3$  is thermally most stable and  $BiH_3$  is least stable. This is because in  $NH_3$ ,  $N-H$  covalent bond is the strongest due to small size of N atom. Hence, the *decomposition temperature of  $NH_3$  will be the highest.*

The increasing order of reducing character is as follows :  $NH_3 < PH_3 < AsH_3 < SbH_3 < BiH_3$

**Note** :  $\square$  Diphosphine ( $P_2H_4$ ) and hydrazine ( $N_2H_4$ ) are other two important hydrides. Hydrazine a strong reducing agent, is used in organic synthesis and rocket fuels and is prepared as follows :



$\square$  Phosphine is poisonous and does not form any complexes.

$\square$  Phosphine forms vortex rings of  $P_2O_5$  in the form of white smoke when it comes in contact with air due to combustion. This is due to impurities of diphosphine ( $P_2H_4$ ).

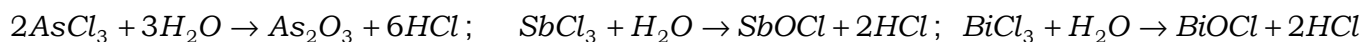
$\square$  Phosphine is used to prepare smoke screens in warfare. Calcium phosphide reacts with water to form phosphine which burns to give clouds of  $P_2O_5$  which acts as smoke screens.

$\square$  Liquor ammonia is a concentrated solution of  $NH_3$  in water.

$\square$  Ammonia will not burn in air, but burns in pure  $O_2$  with a yellowish flame to produce  $N_2$  and  $H_2O$ .

(ii) **Halides** : The members of the family form trihalides ( $MX_3$ ) and pentahalides ( $MX_5$ ). The trihalides are  $sp^3$ -hybridized with distorted tetrahedral geometry and pyramidal shape while pentahalides are  $sp^3d$ -hybridized and are trigonal bipyramidal in shape. The trihalides are hydrolysed by water and ease of hydrolysis decreases when we move down the group. Hence,  $NCl_3$  is easily hydrolysed but  $SbCl_3$  and  $BiCl_3$  are partly and reversibly hydrolysed.  $NF_3$  is not hydrolysed due to lack of vacant d-orbital with nitrogen.  $PF_3$  and  $PF_5$

are also not hydrolyzed because the P – F bond is stronger than P – O covalent bond. The hydrolysis products of the other halides are as follows :  $NCl_3 + 3H_2O \rightarrow NH_3 + 3HOCl$ ;  $PCl_3 + 3H_2O \rightarrow H_3PO_3 + 3HCl$



Their basic character follows this decreasing order as  $NI_3 > NBr_3 > NCl_3 > NF_3$ . Except  $NF_3$ , the trihalides of nitrogen are unstable and decompose with explosive violence.  $NF_3$  is stable and inert.  $NCl_3$  is highly explosive. Trifluorides and trichlorides of phosphorus and antimony act as Lewis acid. The acid strength decreases down the group. For example, acid strength of tri-chlorides is in the order ;  $PCl_3 > AsCl_3 > SbCl_3$ .

Nitrogen does not form pentahalides due to non-availability of vacant  $d$ -orbitals. The pentachloride of phosphorus is not very stable because axial bonds are longer (and hence weaker) than equatorial bond. Hence,  $PCl_5$  decomposes to give  $PCl_3$  and  $Cl_2$ ;  $PCl_5 \rightleftharpoons PCl_3 + Cl_2$

The instability of  $PCl_5$  makes it a very good chlorinating agent. All pentahalides act as Lewis acids since they can accept a lone pair of electron from halide ion.

**Note** :  $\square$  Solid  $PCl_5$  is an ionic compound consisting of  $[PCl_4]^+$   $[PCl_6]^-$ ,  $[PCl_4]^+$  has a tetrahedral structure, while  $[PCl_6]^-$  has an octahedral structure.

$\square$  Since,  $PCl_5$  reacts readily with moisture it is kept in well stoppered bottles.

$\square$   $PI_5$  does not exist due to large size of I atoms and lesser electronegativity difference between phosphorus and iodine.

$\square$  Down the group, the tendency to form pentahalides decreases due to inert pair effect. e.g.,  $BiF_5$  does not exist.

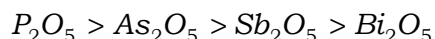
(iii) **Oxides** : These elements form oxides of the type  $X_2O_3$ ,  $X_2O_4$  and  $X_2O_5$ .

(a) **Oxides of Nitrogen** : Nitrogen forms two more oxides i.e.,  $N_2O$  and  $NO$  and both are neutral. Nitrous oxide ( $N_2O$ ) has a sweet taste and its main use is as anaesthetic. When inhaled in mild quantities it causes hysterical laughter so it is also called **Laughing gas**. Nitric oxide ( $NO$ ) can be obtained by treating a mixture of sodium nitrite and ferrous sulphate with dil.  $H_2SO_4$ . Other oxides of nitrogen are :  $NO_2$ ,  $N_2O_3$ ,  $N_2O_5$ .

The acidic strength of oxides :  $N_2O < NO < N_2O_3 < N_2O_4 < N_2O_5$ .

(b) *Oxides of phosphorus*:  $P_4O_6$  (Phosphorus trioxide),  $P_4O_{10}$  (Phosphorus pentoxide)

(c) *Oxides of other elements*: The decreasing order of stability of oxides of group 15 follows as



Except  $P_2O_5$ , all pentoxides show oxidising properties. Also  $P_2O_5$  is acidic in nature.  $N_2O_5$  is the strongest oxidising agent. The nature of oxides of group 15 elements is as follows :

$N_2O_3$  and  $P_2O_3$  (acidic) ;  $As_2O_3$  and  $Sb_2O_3$  (amphoteric) ;  $Bi_2O_3$  (basic)

(iv) **Oxyacids** : Oxyacids of nitrogen are  $HNO_2$ ,  $HNO_3$ ,  $H_4N_2O_4$  and  $HNO_4$ , which are explosive.  
(Nitroxylic acid) (Pernitric acid)

**Note** :  $HNO_3$  is called aqua fortis and prepared from air (Birkel and Eyde process) and  $NH_3$  (Ostwald process). It acts as a strong oxidising agent.

*Oxyacids of phosphorus are :*

(a)  $H_3PO_2$  (Hypophosphorus acid) : Reducing agent and monobasic.

(b)  $H_3PO_3$  (Orthophosphorus acid) : Reducing agent and dibasic.

(c)  $H_3PO_4$  (Orthophosphoric acid) : Weak tribasic acid.

(d)  $H_4P_2O_7$  (Pyrophosphoric acid) : It is obtained by heating  $H_3PO_4$  to  $220^\circ\text{C}$ . It is tetrabasic.

(e)  $HPO_3$  (Metaphosphoric acid) : It is formed by the dehydration of  $H_3PO_4$  at  $316^\circ\text{C}$ . Also exists as a trimer and is monobasic.

(f)  $H_4P_2O_6$  (Hypophosphoric acid) : Tetrabasic

(g)  $H_4P_2O_5$  (Pyrophosphoric acid) : Dibasic acid

### Anomalous behaviour of nitrogen

Nitrogen is known to differ from other members of the family because of the following facts :

(i) Its small size (ii) Its high electronegativity (iii) Its high ionisation energy (iv) non-availability of  $d$ -orbital in the valence shell. (v) Its capacity to form  $p\pi-p\pi$  multiple bonds.

The main points of difference are :

(a) Nitrogen is a gas ( $N_2$ ) while other members are solids.

(b) Nitrogen is diatomic while other elements like phosphorus and arsenic form tetra-atomic molecules ( $P_4, As_4$ ).

(c) Nitrogen form five oxides ( $N_2O, NO, N_2O_3, N_2O_4$  and  $N_2O_5$ ) while other members of the family form two oxides (tri and pentoxides).

(d) Hydrides of nitrogen show H-bonding while those of other elements do not.

(e) Nitrogen does not show pentacovalency because of absence of  $d$ -orbitals while all other elements show pentacovalency.

(f) Nitrogen does not form complexes because of absence of  $d$ -orbitals while other elements show complex formation e.g.,  $[PCl_6]^-$ ,  $[AsCl_6]^-$  etc.

(g) The hydride of nitrogen ( $NH_3$ ) is highly basic in nature while the hydrides of other elements are slightly basic.

(h) Except for  $NF_3$ , other halides of nitrogen e.g.,  $NCl_3, NBr_3$  and  $NI_3$  are unstable while the halides of other elements are fairly stable.

## Group – 16 (Oxygen family)

Oxygen is the first member of group 16 or VIA of the periodic table. It consists of five elements Oxygen ( $O$ ), sulphur ( $S$ ), selenium ( $Se$ ), tellurium ( $Te$ ) and polonium ( $Po$ ). These (except polonium) are the ore forming elements and thus called **chalcogens**.

### General characteristic.

#### (1) Electronic configuration

Elements	Electronic configuration ( $ns^2 np^4$ )
${}_8O$	$1s^2, 2s^2 2p^4$ or $[He]2s^2 2p^4$
${}_{16}S$	$1s^2, 2s^2 2p^6, 3s^2 3p^4$ or $[Ne]3s^2 3p^4$
${}_{34}Se$	$1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}, 4s^2 4p^4$ or $[Ar]3d^{10} 4s^2 4p^4$

## S and P Blocks elements

$_{52}Te$	$1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}, 4s^2 4p^6 4d^{10}, 5s^2 5p^4$ or $[Kr]4d^{10} 5s^2 5p^4$
$_{84}Po$	$1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}, 4s^2 4p^6 4d^{10} 4f^{14}, 5s^2 5p^6 5d^{10}, 6s^2 6p^4$ or $[Xe]4f^{14} 5d^{10} 6s^2 6p^4$

### (2) Physical properties

(i) **Physical state** : Oxygen is gas while all others solids.

(ii) **Atomic radii** : Down the group atomic radii increases because the increases in the number of inner shells overweighs the increase in nuclear charge.

(iii) **Ionisation energy** : Down the group the ionisation energy decrease due to increase in their atomic radii and shielding effect.

(iv) **Electronegativity** : Down the group electronegativity decreases due to increase in atomic size.

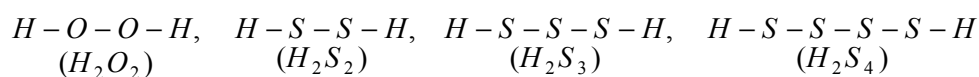
(v) **Electron affinity** : Element of this group have high electron affinity electron affinity decreases down the group.

(vi) **Non – metallic and metallic character** : These have very little metallic character because of their higher ionisation energies.

(vii) **Nature of bonding** : Compound of oxygen with non metals are predominantly covalent. S, Se, and Te because of low electronegativities show more covalent character.

(viii) **Melting and boiling points** : The m. pt. and b. pt increases on moving down the group.

(ix) **Catenation** : Oxygen has some but sulphur has greater tendency for catenation.



(x) **Allotropy** :

Oxygen	$O_2$ and $O_3$
–	
Sulphur	– Rhombic , monoclinic, plastic sulphur
Selenium	– Red (non-metallic) grey (metallic)
Tellurium	– Non-metallic and metallic (more stable)
Polonium	– $\alpha$ and $\beta$ (both metallic)

(xi) **Oxidation states** : Oxygen  $\rightarrow$   $-2$  and  $-1$  oxidation state. These element shows  $+2$ ,  $+4$  and  $+6$  oxidation state.

### (3) Chemical properties

(i) **Hydrides** :  $H_2O, H_2S, H_2Se, H_2Te$  and  $H_2Po, H_2O$  - colourless and odourless.  $H_2S, H_2Se, H_2Te$  and  $H_2Po$  - colourless, unpleasant smell.

Increasing order of reducing power of hydrides :  $H_2O < H_2S < H_2Se < H_2Te$

Increasing order of bond angles in hydrides :  $H_2Te < H_2Se < H_2S < H_2O$

The order of stability of hydrides :  $H_2O > H_2S > H_2Se > H_2Te$

The order of increasing acidic nature of hydrides :  $H_2O < H_2S < H_2Se < H_2Te$

(ii) **Oxides** : These elements form monoxides ( $MO$ ), (dioxides  $MO_2$  increasing order of acidic nature of oxides is  $TeO_3 < SeO_3 < SO_3$

(iii) **Oxacids** :  $H_2SO_3, H_2SO_4, H_2S_2O_3, H_2SO_5, H_2S_2O_8, H_2S_2O_7, H_2S_2O_6$

(iv) **Halides** : Oxygen :  $OF_2, Cl_2O, Br_2O$

Sulphur :  $S_2F_2, S_2Cl_2, SF_2, SCl_2, SBr_2, SF_4, SCl_4$  and  $SF_6$

Selenium and tellurium :  $SeF_6$  and  $TeF_6$

## Group – 17 (Halogen family)

Fluorine is the first member of group 17 or VIIA of the periodic table. It consists of five elements Fluorine ( $F$ ), Chlorine ( $Cl$ ), bromine ( $Br$ ), iodine ( $I$ ) and astatine ( $At$ ). These are known as halogen because their salts are found in sea water. Halogen is a greek word meaning a sea salt.

### General characteristics.

#### (1) Electronic configuration

Elements	Electronic configuration ( $ns^2 np^5$ )
${}_9F$	$1s^2, 2s^2 2p^5$ or $[He]2s^2 2p^5$



## S and P Blocks elements

$_{17}Cl$	$1s^2, 2s^2 2p^6, 3s^2 3p^5$ or $[Ne]3s^2 3p^5$
$_{35}Br$	$1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}, 4s^2 4p^5$ or $[Ar]3d^{10} 4s^2 4p^5$
$_{53}I$	$1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}, 4s^2 4p^6 4d^{10}, 5s^2 5p^5$ or $[Kr]4d^{10} 5s^2 5p^5$
$_{85}At$	$1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}, 4s^2 4p^6 4d^{10} 4f^{14}, 5s^2 5p^6 5d^{10}, 6s^2 6p^5$ or $[Xe]4f^{14} 5d^{10} 6s^2 6p^5$

### (2) Physical properties

(i) **Physical state** : Halogens exist as diatomic covalent molecules.

$F_2$  – gas,  $Cl_2$  – gas,  $Br_2$  – corrosive liquid,  $I_2$  – volatile solid.

(ii) **Melting and boiling points** : They increase with increase in atomic number.

(iii) **Ionization energy** : The I.E. decreases on moving down the group.

(iv) **Electron affinity** :  $F < Cl > Br > I$  or  $Cl > F > Br > I$ .

(v) **Electronegativity** :  $F > Cl > Br > I$ .

(vi) **Bond energy** :

Element	$F - F$	$Cl - Cl$	$Br - Br$	$I - I$
Bond length (Å)	1.42	1.99	2.28	2.67
Bond dissociation energy (kcal/mole)	38	57	45.5	35.6

(vii) **Colour** :  $F$  – Light yellow ,  $Cl$  – Greenish yellow,  $Br$  – Reddish brown,  $I$  – Deep violet.

(viii) **Oxidation state** : All exhibit –1 Oxidation state Except fluorine other element also show +3 ,+5, +7 oxidation state.

(ix) **Oxidising power** :  $F_2 > Cl_2 > Br_2 > I_2$ .

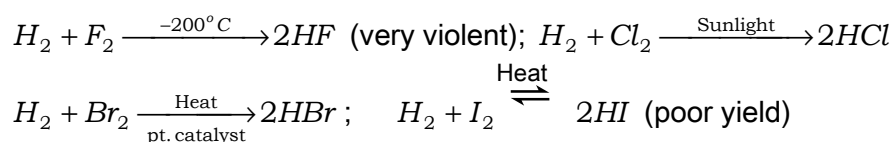
(x) **Solubility** : Halogen being non polar in nature do not dissolve in water  $2F_2 + 2H_2O \rightarrow 4HF + O_2$ ,  $3F_2 + 3H_2O \rightarrow 6HF + O_3$  (fluorine highly soluble)  $Cl_2$  and  $Br_2$  are fairly soluble.  $I_2$  is a least soluble in water.

### (3) Chemical properties

(i) **Reactivity** : The halogen are most reactive elements due to their low bond dissociation energy, high electron affinity and high enthalpy of hydration of halide ion.  $F > Cl > Br > I$

(ii) **Reaction with  $H_2O$**  : Fluorine decomposes water to  $O_2$  and  $O_3$ ,  $Cl_2$  and  $Br_2$  decomposes water in the presence of sunlight,  $Cl_2 + H_2O \xrightarrow{h\nu} HCl + HClO$ ;  $Br_2 + H_2O \xrightarrow{h\nu} HBr + HOBr$ . Iodine does not decompose water.

(iii) **Reaction with hydrogen** : Form covalent halides.



Acidic strength in aqueous solution is in the order,  $HI > HBr > HCl < HF$ .

Reducing character of hydrides follow the order,  $HI > HBr > HCl > HF$ .

Boiling point  $HF > HI > HBr > HCl$ . Thermal stability,  $H-F > H-Cl > H-Br > H-I$ .

$HCl$  is also called Muriatic acid.

### (iv) Oxides and oxo-acids

**Oxides** : Oxides are predominantly covalent :  $OF_2(+1), O_2F_2(-1), Cl_2O(+1), ClO_2(+4), Cl_2O_6(+6)$   
 $Cl_2O_7(+7), Br_2O(+1), BrO_2(+4), BrO_3(+6), I_2O_5(+5)$

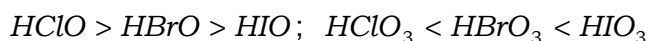
**Oxo-acids** : *Hypohalous acid*  $\rightarrow HClO(+1), HBrO(+1), HIO(+1)$

*Halous acid*  $\rightarrow HClO_2(+3)$ , etc.

*Halic acid*  $\rightarrow HClO_3(+5), HBrO_3(+5), HIO_3(+5)$

*Perhalic acid*  $\rightarrow HClO_4(+7), HBrO_4(+7), HIO_4(+7)$

All oxyacids, of halogens are monobasic. Order of thermal stability :  $HClO_4 > HClO_3 > HIO_2 > HClO$

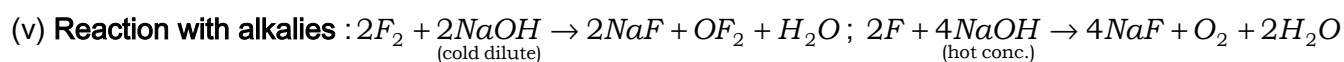


Order of strength of oxoacids of the same halogen :  $HClO_4 > HClO_3 > HClO_2 > HClO$  .

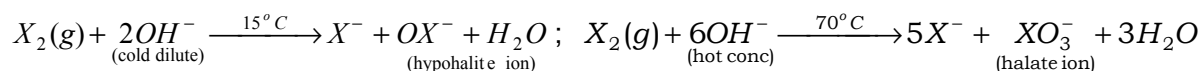
Order of strength of oxoacids of different halogen having same oxidation state is  $HClO > HBrO > HIO$

Oxidising power :  $HClO_4 < HClO_3 < HClO_2 < HClO$

The perchlorates are strong oxidising agent.  $ClO_4^- < BrO_4^- > IO_4^-$

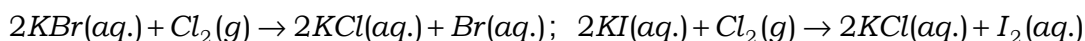


Halogen other than fluorine ( $Cl_2, Br_2, I_2$ ) react with  $NaOH$  as follows :



(vi) **Bleaching action of halogen** :  $Cl_2$  acts as bleaching agent, its bleaching action is permanent  $Cl_2$  water can also act as ink remover.

(vii) **Reaction with other halides** :



(viii) **Inter halogen compounds** :

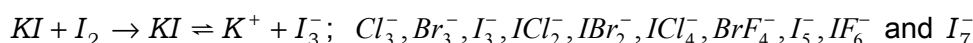
$AX$  type  $\rightarrow ClF, BrF, IF, BrCl, ICl, IBr$  etc.

$AX_3$  type  $\rightarrow ClF_3, BrF_3, IF_3, ICl_3$

$AX_5$  type  $\rightarrow ClF_5, BrF_5, IF_5$

$AX_7$  type  $\rightarrow IF_7$  .

(ix) **Polyhalides** :



(x) **Pseudohalogen and pseudohalides** :

Pseudohalogen	Pseudohalide
---------------	--------------

Cyanogen $-(CN)_2$	Cyanide $CN^-$
Oxocyanogen $-(OCN)_2$	Cyanate $OCN^-$
Thiocyanogen $-(SCN)_2$	Thiocyanate $SCN^-$
Selenocyanogen $-(SeCN)_2$	Selenocyanate $- SeCN^-$

(xi) **Freons** : Freon -11 is  $CCl_3F$

Freon -12 is  $CCl_2F_2$  and it is marketed under the popular brand names such as '**Freon**' and '**Genetron**'

Freon -113 is  $CCl_2F$ .  $CClF_2$

Freon -114 is  $CClF_2$ .  $CClF_2$

Freon -115 is  $CClF_2$ .  $CF_3$

These cause ozone depletion.

## Group – 18 (Noble gases)

Helium is the first member of group 18 or zero of the periodic table. It consists of six elements helium (*He*), Neon (*Ne*), argon (*Ar*), krypton (*Kr*), xenon (*Xe*) and radon (*Rn*). Zero group occupies the intermediate position between the elements of VIIA (17th) and IA (1st) groups. These are collectively called as **inactive gases** or **inert gases**. However, these are now called **noble gases** as some compounds of these gases have been obtained under certain specific conditions.

### General characteristics

#### (1) Electronic configuration

Elements	Electronic configuration ( $ns^2 np^6$ )
${}_2He$	$1s^2$

## S and P Blocks elements

$_{10} \text{Ne}$	$1s^2, 2s^2 2p^6$
$_{18} \text{Ar}$	$1s^2, 2s^2 2p^6, 3s^2 3p^6$
$_{36} \text{Kr}$	$1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}, 4s^2 4p^6$
$_{54} \text{Xe}$	$1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}, 4s^2 4p^6 4d^{10} 4f^{14}, 5s^2 5p^6$
$_{86} \text{Rn}$	$1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}, 4s^2 4p^6 4d^{10} 4f^{14}, 5s^2 5p^6 5d^{10}, 6s^2 6p^6$

### (2) Physical properties

(i) **Atomic radii** : The atomic radii of noble gases increases on moving down the group and their atomic radii correspond to the van der Waal's radii.

(ii) **Boiling points** : The m.pt. and b.pt. increases from *He* to *Rn*, because of increase in magnitude of Vander Waal's forces.

(iii) **Polarizability** : The polarizability increases down the group,  $He < Ne < Ar < Kr < Xe$

(iv) **Ionisation energy and electron affinity** : Noble gases have stable  $ns^2np^2$  fully filled electronic configuration, so these have no tendency to add or lose electron. Therefore, ionisation energy of noble gases is very high. On the other hand their electron affinity is zero.

(v) **Heat of vaporisation** : They possess very low values of heat of vapourisation, because of presence of very weak Vander Waal's forces of attraction between their monoatomic molecules. However the value of heat of vaporisation increases with atomic number down the group and this shows that there is an increasing polarizability of the larger electronic clouds of the elements with higher atomic number.

(vi) **Solubility in water** : They are slightly soluble in water. Their solubility generally increases with the increase in atomic number down the group.

(vii) **Adsorption by charcoal** : All of them except helium are adsorbed by coconut charcoal at low temperature. The extent of adsorption increases down the group.

(viii) **Characteristic spectra** : All of them give characteristic spectra, by which they can be identified.

(ix) **Liquification of gases** : It is difficult to liquify noble gases as their atoms are held by weak Vander Waal's forces. Ease of liquification increases down the group from *He* to *Rn*. Helium has the lowest boiling point (4.18 K) of any known substance. The ease of liquification increases down the group due to increase in intermolecular forces.

### Some important points.

#### Group – 13 (Boron family)

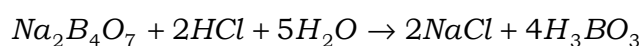
(1)  $BF_3$  is a colourless gas,  $BCl_3$  is a colourless fuming liquid (B. pt.  $13^\circ C$ ).  $BBr_3$  is also a colourless fuming liquid (b. pt.  $90^\circ C$ ) while  $BI_3$  is a white fusible solid (m.pt.  $310^\circ C$ ).

(2)  $AlCl_3$  is a low melting solid which sublimes at  $183^\circ C$ .

(3) The important mineral of boron is borax ( $Na_2B_4O_7 \cdot 10H_2O$ ). The crude form of it is called **Tincal**. Borax can be prepared from colemanite,  $Ca_2B_6O_{11} + 2Na_2CO_3 \rightarrow Na_2B_4O_7 + 2NaBO_2 + 2CaCO_3$   
(water insoluble)

(4)  $CaCO_3$  is removed and the filtrate is concentrated to get crystals of borax. Sodium metaborate is converted to borax by passing  $CO_2$ ,  $4NaBO_2 + CO_2 \rightarrow Na_2B_4O_7 + Na_2CO_3$

(5) Borax when treated with conc.  $HCl$  or  $H_2SO_4$  gives crystals of boric acid.



(6) Slippery nature of boric acid is due to hydrogen bonding in it which gives it a layer structure.

(7) *Inorganic naphthalene* : On heating borazine or by passing silent electric discharge through it, gives a product analogous to naphthalene (known as Inorganic naphthalene) and inorganic diphenyl.

(8) Hybridisation of boron in diborane is  $sp^3$  while in  $BCl_3$  it is  $sp^2$ .

(9) Due to back bonding and resonance the B – F bond in  $BF_3$  gets a bond order of 1.33.

(10) Boric acid is used as antiseptic and eye wash under the name '*Boric lotion*'.

(11) Aluminium displaces  $H_2$  from acid but boron does not.

(12)  $B_4C_3$  (Boron carbide) is one of the hardest known artificial substance and is called **Norbia**.

(13) Aluminium is bluish white metal with a brilliant lustre which is soon destroyed by the formation of an oxide layer on it.

(14) Gallium is a low melting solid (m.pt.  $29.8^{\circ}\text{C}$ ) and is liquid on a particular warm day.

(15) Gallium readily supercools, *i.e.*, remains liquid even at temperatures several degrees below its melting (freezing) point.

(16) Maximum covalency of boron is four while that of *Al* is six.

(17) Highly toxic element of group 13 is thallium.

(18) All the metalloids (*e.g.*, *B*, *Si*, *As*, *Sb*, *Tl* etc.) belong to *p*-block.

#### **Group – 14 (Carbon Family)**

(1) Carbon can occur both in very hard and very soft forms.

(2)  $\text{PbCl}_2$  is ionic while  $\text{PbCl}_4$  is covalent.

(3)  $\text{CO}_2$  is heavier than air and can be poured from one container to another like a liquid.

(4) Dry ice (solid  $\text{CO}_2$ ) is a molecular solid (Vander Waal's solid).

(5) Diamond is insoluble in any solvent and on heating to  $1800\text{--}2000^{\circ}\text{C}$  in the absence of air gives graphite.

(6) Artificial graphite is made by **Acheson process**.

(7) Industrial lubricant, *oildag* is a suspension of graphite in oil and colloidal solution of graphite is called **aquadag**.

(8) Anthracite is the purest form of coal while lamp black is the softest form.

(9) Broken glass pieces added during glass making is known as cullet.

(10) Lead compounds are poisonous.

(11) Tin is the only element which has maximum number of isotopes.

(12) Glass is a supercooled liquid.

(13) Carbon in group 14 elements has maximum tendency to form multiple bonds.

(14) Carbogen (mixture of  $O_2 + 5-10\%CO_2$ ) is given to pneumonia patients and victims of  $CO$  poisoning for artificial respiration.

(15) Solid  $CO_2$  is called dry ice or drikold because it sublimates without melting. With ether it produces  $-100^\circ C$  temperature and forms an excellent freezing mixture.

(16)  $Sn$  upon reaction with  $NaOH$  forms sodium stannite and with conc.  $HNO_3$  forms metastannic acid.



$Pb$  reacts with  $NaOH$  to form sodium plumbite and  $Si$  reacts to give sodium silicate.



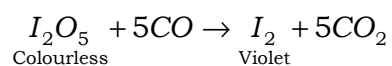
(17)  $SnCl_4 \cdot 5H_2O$  (Butter of tin or oxymuriate of tin) and pink salt  $(NH_4)_2 \cdot SnCl_6$  are used as mordant in dyeing.

(18)  $2PbCO_3 \cdot Pb(OH)_2$  White lead. It can be prepared by **Dutch process** or **Carter process** and is used in white paints.

(19) Quartz is purest and most common variety of silica.

(20)  $HF$  is used for **etching** of glass.

(21)  $CO$  converts  $I_2O_5$  to form  $I_2$  which gives violet colour with  $CCl_4$  or  $CS_2$



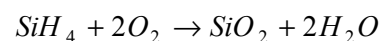
(22) Graphite on oxidation with conc.  $HNO_3$  gives graphitic acid ( $C_{11}H_4O_5$ ).

(23) Graphite on oxidation with alkaline  $KMnO_4$  gives mellitic acid or benzen hexacarboxylic acid  $[C_6(COOH)_6]$  and oxalic acid.

(24) Water gas or synthesis is also known as blue gas (burns with blue flame).

(25) Quartz glass used in the manufacture of optical instruments and chemical apparatus is called vitreosil.

(26) When  $(SiH_4 + H_2)$  mixture is bubbled through water and the bubbles come in contact with air, it burns with a luminous flame. As a result vortex rings of finely divided silica are obtained.





(27)  $CO$  act as a good ligand due to the presence of lone pair of electrons on carbon  $[:C = \overset{\cdot\cdot}{C}:]$ .  $CO$  acts as a  $\pi$ -acid ligand.

(28) Lead pipes are not used for carrying water due to the formation of soluble  $Pb(OH)_2$  which gives  $Pb^{2+}$  which are highly poisonous. This is called **Plumbosolvency**.  $Pb + O_2 + H_2O \rightarrow Pb(OH)_2$

### Group – 15 (Nitrogen family)

(1) Down the group the basic character of oxides increases due to increase in metallic character.

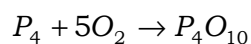
(2) Unlike other oxides of nitrogen, nitrous oxides,  $N_2O$  is not poisonous. It has a faint sweet smell. It is considerably soluble in fats, a property which has been used in making self-whipping cream. Cream is packaged with  $N_2O$  under pressure to increase its solubility. When the pressure is released, the  $N_2O$  escapes to form tiny bubbles which produces whipped cream.

(3) All oxides of nitrogen (except  $NO$  and  $N_2O$ ) and phosphorus are acidic in nature.

(4)  $NO$  and  $NO_2$  are paramagnetic. It is due to the presence of unpaired electron in their molecules.

(5)  $P_4S_3$  is used in strike anywhere matches.

(6) *Flowers of phosphorus*.  $P_4O_{10}$  can be prepared by burning phosphorus in excess of air and collected as snowy powder called *Flowers of phosphorus*.



(7)  $As_4O_6$  is called white arsenic and is a poison.

(8) As oxidation state of an element increases, the acidic nature of its oxide also increases e.g.,  $As_2O_5$  is more acidic than  $As_2O_3$ .

(9)  $NCl_3$  is an explosive compound.

(10)  $NO_2$  is called mixed anhydride because it gives a mixture of  $HNO_2$  and  $HNO_3$  upon dissolution in water.

(11) Hypophosphoric acid,  $H_4P_2O_6$  and pyrophosphoric acid,  $H_4P_2O_7$  are both tetrabasic acids, yet these two acids form only two series of salts each.

(12) Cyclic polyphosphates can be represented by the general formula  $(HPO_3)_n$ .

- (13)  $SbF_3$  is called **Swarts reagent**. It is used as a fluorinating agent for various compounds of non-metals.
- (14) Nitric acid,  $HNO_3$  is called **aqua fortis** meaning strong water because it attacks nearly all the metals.
- (15) Fuming nitric acid contains dissolved  $NO_2$  in conc.  $HNO_3$ . It is obtained by distilling conc.  $HNO_3$  with a little starch. Some of the nitric acid is reduced by starch to  $NO_2$  which dissolve in the remaining acid to form fuming nitric acid.
- (16) The yellow colour of commercial nitric acid is due to the presence of dissolved nitrogen dioxide,  $NO_2$ . This colour can be removed by warming the acid to 60 – 80°C and bubbling dry air through it.
- (17) Nitric acid forms a constant boiling mixture with water (*b.p.* 121°C) which contains 68%  $HNO_3$ . As such, nitric acid cannot be concentrated beyond 68% by heating.
- (18) In tooth paste,  $CaHPO_4 \cdot 2H_2O$  is added as a mild abressive and polishing agent.
- (19) Nitric acid attacks proteins giving a yellow nitro compound called *Xanthoprotein*. Hence nitric acid stains skin. This is used as a test for proteins.
- (20)  $HNO_3$  has smell resembling with bleaching powder.
- (21) *Amatol* is 80%  $NH_4NO_3$  + 20% *TNT* and is used as an explosive.
- (22) Certain types of bacteria (Acetobactor) are helpful in the fixation of nitrogen by leguminous plants.
- (23) Traces of arsenic is detected using Marsh test.
- (24)  $BiOCl$  is called *pearl white*.

### Group – 16 (Oxygen family)

- (1) **Priestley** and **Scheele** discovered oxygen in 1774.
- (2) The name oxygen was given by A. L. Lavoisier in 1777.
- (3) M. Faraday, in 1848, noted that oxygen was paramagnetic.
- (4) Vulcanization of rubber by heating with sulphur was discovered by Charls Good year in 1839.
- (5) Commercially, oxygen is obtained by fractional distillation of liquid air.
- (6) Another name for sulphur is '**brimstone**'

### Group – 17 (Halogen family)

- (1) At room temperature, liquid halogen is bromine while solid halogen is iodine.
- (2) Bromine was discovered by **Ballard** and iodine was discovered by **Courtois**.
- (3) *NaBr* and *KBr* are used as **sedatives**.

### Group – 18 (Noble gases)

- (1) Argon is the most abundant noble gas in atmosphere.
- (2) The noble gases neither act as oxidising agent nor as reducing agent.
- (3) The only compound of krypton studied in detail is krypton difluoride  $KrF_2$ .

\*\*\*