

# The p-Block Elements (Group 15 to 18)

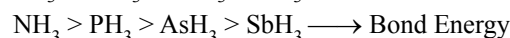
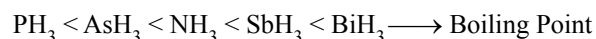
## SHORT NOTES

### 15<sup>th</sup>-Group Elements

#### Nitrogen Family

- Nitrogen and phosphorus are **non-metals**, arsenic and antimony are **metalloids** and bismuth is a **typical metal**.
- Except nitrogen, all the elements show allotropy.
- Bismuth hardly forms any compound in  $-3$  oxidation state.
- The only well characterised Bi (V) compound is  $\text{BiF}_5$ .
- In the case of nitrogen, all oxidation states from  $+1$  to  $+4$  tend to disproportionate in acid solution. For example,
 
$$3\text{HNO}_2 \rightarrow \text{HNO}_3 + \text{H}_2\text{O} + 2\text{NO}$$
- In case of phosphorus, nearly all intermediate oxidation states disproportionate into  $+5$  and  $-3$  both in alkali and acid.

- The oxides of the type  $\text{E}_2\text{O}_3$  of nitrogen and phosphorus are purely acidic, that of arsenic and antimony are amphoteric and those of bismuth are predominantly basic.



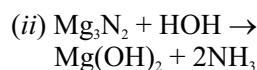
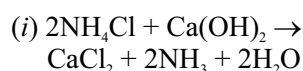
$\Rightarrow$  Pentaoxide of 15<sup>th</sup> group element is acidic.  $\text{N}_2\text{O}_3$ ,  $\text{P}_2\text{O}_3$  are acidic,  $\text{As}_2\text{O}_3$ ,  $\text{Sb}_2\text{O}_3$  are amphoteric with  $\text{Bi}_2\text{O}_3$  is basic.

$\Rightarrow$  Trihalide of 15<sup>th</sup> group elements are covalent except  $\text{BiF}_3$ .

#### Oxides of Nitrogen and Its Structure

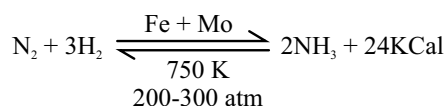
Name	Formula	Oxidation state of nitrogen	Common methods of preparation	Physical appearance and chemical nature	Structure
Dinitrogen oxide [Nitrogen oxide]	$\text{N}_2\text{O}$	+1	$\text{NH}_4\text{NO}_3 \xrightarrow{\text{Heat}} \text{N}_2\text{O} + 2\text{H}_2\text{O}$	Colourless gas, neutral	$\text{N} \equiv \text{N} \rightarrow \text{O}$
Nitrogen monoxide [Nitrogen (II) oxide]	$\text{NO}$	+2	$2\text{NaNO}_2 + 2\text{FeSO}_4 + 3\text{H}_2\text{SO}_4 \rightarrow \text{Fe}_2(\text{SO}_4)_3 + 2\text{NaHSO}_4 + 2\text{H}_2\text{O} + 2\text{NO}$	Colourless gas, neutral	$\text{N} = \text{O}$
Dinitrogen trioxide [Nitrogen (III) oxide]	$\text{N}_2\text{O}_3$	+3	$2\text{NO} + \text{N}_2\text{O}_4 \xrightarrow{250\text{K}} 2\text{N}_2\text{O}_3$	Blue solid, acid blue liquid ( $-30^\circ\text{C}$ )	$\text{O}=\text{N}-\text{N}=\text{O}$
Nitrogen dioxide [Nitrogen (IV) oxide]	$\text{NO}_2$	+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	$\text{O}=\text{N}-\text{N}=\text{O}$
Dinitrogen tetroxide [Nitrogen (IV) oxide]	$\text{N}_2\text{O}_4$	+4	$2\text{NO}_2 \xrightleftharpoons[\text{Heat}]{\text{Cool}} \text{N}_2\text{O}_4$	Colourless solid/liquid, acidic	$\text{O}=\text{N}-\text{N}=\text{O}$
Dinitrogen pentaoxide [Nitrogen (V) oxide]	$\text{N}_2\text{O}_5$	+5	$4\text{HNO}_3 + \text{P}_4\text{O}_{10} \rightarrow 4\text{HPO}_3 + 2\text{N}_2\text{O}_5$	Colourless solid, acidic	$\text{O}=\text{N}-\text{O}-\text{N}=\text{O}$

#### Preparation

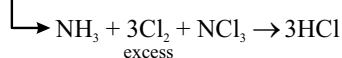
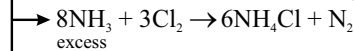
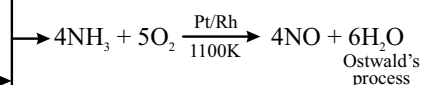


#### Manufacturing

##### Haber Process



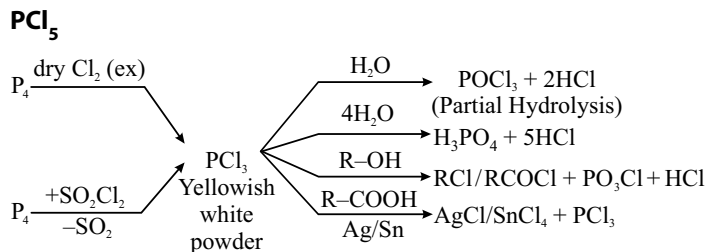
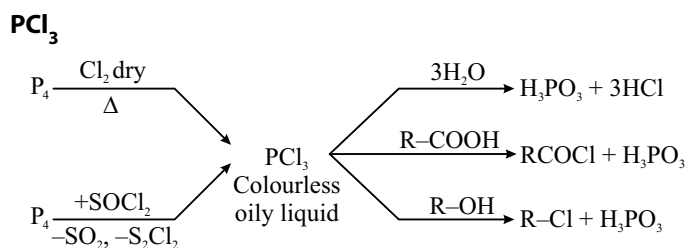
MOP  $\text{NH}_3$  Properties



Concentration of nitric acid	Metal	Main products
Very Dilute $\text{HNO}_3$	Mg, Mn	$\text{H}_2$ + metal nitrate
	Fe, Zn, Sn	$\text{NH}_4\text{NO}_3$ + metal nitrate
	Cu, Ag, Hg	No reaction
Dilute $\text{HNO}_3$	Fe, Zn	$\text{N}_2\text{O}$ + metal nitrate
	Pb, Cu, Ag	$\text{NO}$ + metal nitrate
Conc. $\text{HNO}_3$	Sn	$\text{NO}_2$ + $\text{H}_2\text{SnO}_3$ (Metastannic acid)
Conc. $\text{HNO}_3$	Fe, Co, Ni, Cr, Al	Rendered passive

### Oxoacids of Phosphorus

Name	Formula	Oxidation state of nitrogen	Characteristic bonds and their number	Preparation
Hypophosphorus (Phosphinic)	$\text{H}_3\text{PO}_2$	+ 1	One P — OH	white $\text{P}_4$ + alkali
Orthophosphorous (Phosphonic)	$\text{H}_3\text{PO}_3$	+ 3	Two P — OH One P — H One P = O	$\text{P}_2\text{O}_3$ + $\text{H}_2\text{O}$
Pyrophosphorous	$\text{H}_4\text{P}_2\text{O}_5$	+ 3	Two P — OH Two P — H Two P = O	$\text{PCl}_3$ + $\text{H}_3\text{PO}_3$
Hypophosphoric	$\text{H}_4\text{P}_2\text{O}_6$	+ 4	Four P — OH Two P = O One P — P	red $\text{P}_4$ + alkali
Orthophosphoric	$\text{H}_3\text{PO}_4$	+ 5	Three P — OH One P = O	$\text{P}_4\text{O}_{10}$ + $\text{H}_2\text{O}$
Pyrophosphoric	$\text{H}_4\text{P}_2\text{O}_7$	+ 5	Four P — OH Two P = O One P — O — P	heat phosphoric acid
Metaphosphoric*	$(\text{HPO}_3)_n$	+ 5	Three P — OH Three P = O Three P — O — P	phosphorous acid + $\text{Br}_2$ , heat in a sealed tube

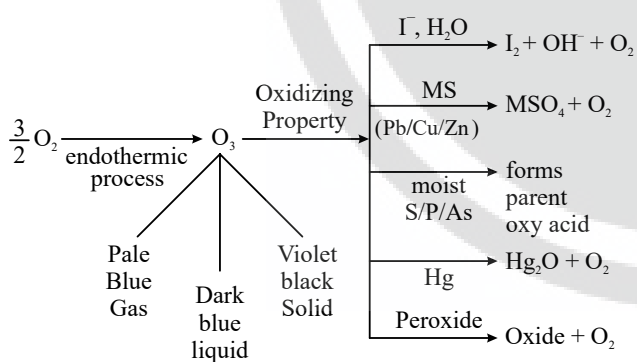


## 16<sup>th</sup>-Group Elements

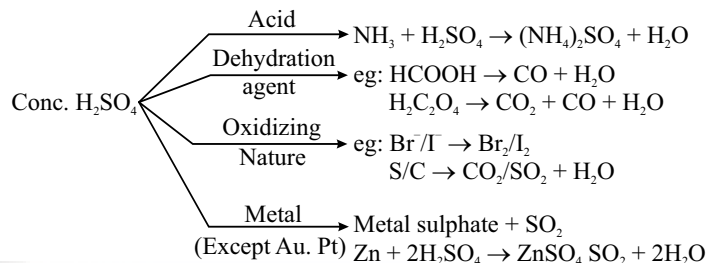
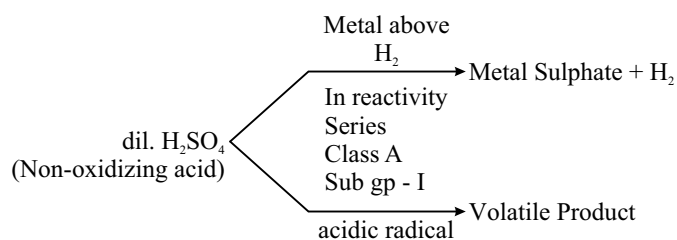
### Oxygen Family

- Oxygen is the most abundant of all the elements on earth crust.
- Oxygen and sulphur are non-metals, selenium and tellurium are metalloids, whereas polonium is a metal.
- Polonium hardly shows -2 oxidation state.
- Reducing property of dioxide decreases from SO<sub>2</sub> to TeO<sub>2</sub>, SO<sub>2</sub> is reducing while TeO<sub>2</sub> is an oxidising agent.
- Sulphur hexafluoride, SF<sub>6</sub> is an exceptionally stable for steric reasons.
- The well known monohalides are dimeric in nature. Examples are S<sub>2</sub>F<sub>2</sub>, S<sub>2</sub>Cl<sub>2</sub>, S<sub>2</sub>Br<sub>2</sub>, Se<sub>2</sub>Cl<sub>2</sub> and Se<sub>2</sub>Br<sub>2</sub>.

### Ozone



Gases	Absorbent
O <sub>3</sub>	Turpentine Oil/Oil of cinnamon.
NO	FeSO <sub>4</sub>
SO <sub>2</sub>	NaOH
CO	Cu <sub>2</sub> Cl <sub>2</sub>
O <sub>2</sub>	Pyrogalol

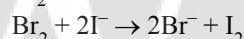
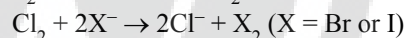
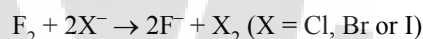


## 17<sup>th</sup>-Group Elements

- The electron affinity values (in KJ mol<sup>-1</sup>) for 17 group element are given below:

F	Cl	Br	I
333	349	325	296

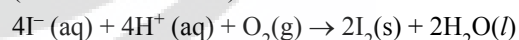
- All halogens are coloured. For example, F<sub>2</sub> has yellow gas, Cl<sub>2</sub> greenish yellow gas, Br<sub>2</sub> red liquid and I<sub>2</sub> violet coloured solid.
- They react with metals and non-metals to form halides and the reactivity of the halogens decreases down the group. i.e. the order is F<sub>2</sub> > Cl<sub>2</sub> > Br<sub>2</sub> > I<sub>2</sub>.
- In general, a halogen oxidises halide ions of higher atomic number.



- Reaction with water:



(where X = Cl or Br)



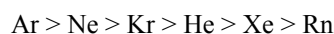
- Halogens form many oxides with oxygen but most of them are unstable.
- Flourine forms two oxides OF<sub>2</sub> and O<sub>2</sub>F<sub>2</sub>. However, only OF<sub>2</sub> is thermally stable at 298 K.

These oxides are essentially oxygen fluoride because of the higher electronegativity of fluorine than oxygen. Both are strong fluorinating agents.

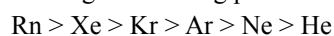
- O<sub>2</sub>F<sub>2</sub> oxidises plutonium to PuF<sub>6</sub> and the reaction is issued in removing plutonium as PuF<sub>6</sub> from spent nuclear fuel.
- A combination of kinetic and thermodynamic factors lead to the generally decreasing order of stability of oxides formed by halogens, I > Cl > Br.
- I<sub>2</sub>O<sub>5</sub> is a very good oxidising agent and is used in the estimation of carbon monoxide.

## 18<sup>th</sup>-Group Elements

### 1. Relative Abundance:



### 2. Melting and Boiling point:

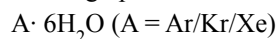


### 3. He has the lowest boiling point among all elements.

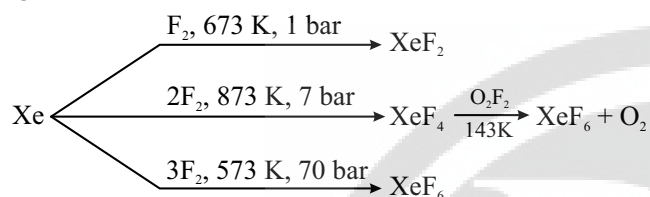
### 4. Noble gases are monoatomic, colourless, odourless, sparingly soluble in water and diffusing through most commonly used laboratory materials.

### 5. $\text{O}_2[\text{PtF}_6]$ is the first noble gas compound.

### 6. Ar, Kr and Xe form clathrate compounds when pass in ice with high pressure.

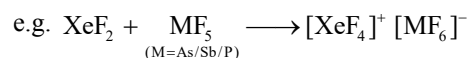


### Preparation of Xe-Fluoride



### Properties

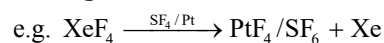
#### Fluoride donor:



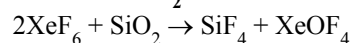
#### Fluoride acceptor:



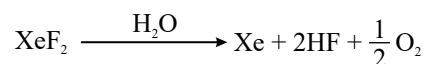
#### Fluoride agents:



#### Reaction with $\text{SiO}_2$ :

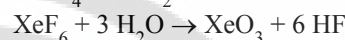
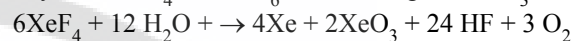


#### Hydrolysis



#### Preparation of Xe-oxide

Hydrolysis of  $\text{XeF}_4$  and  $\text{XeF}_6$  with water gives  $\text{XeO}_3$ .



Partial hydrolysis of  $\text{XeF}_6$  gives oxyfluorides,  $\text{XeOF}_4$  and  $\text{XeO}_2\text{F}_2$ .

