# CHAPTER 6 p-BLOCK ELEMENTS

# **Syllabus**

- Group 16 Elements : General introduction, electronic configuration, oxidation states, occurrence, trends in physical and chemical properties, dioxygen: Preparation, Properties and uses, classification of Oxides, Ozone, Sulphur-allotropic forms; compounds of Sulphur : Preparation, Properties and uses of Sulphurdioxide; Sulphuric Acid : industrial process of manufacture, properties and uses; Oxoacids of Sulphur (Structures only).
- Group 17 Elements : General introduction, electronic configuration, oxidation states, occurrence, trends in physical and chemical properties; compounds of halogens, Preparation, properties and uses of Chlorine and Hydrochloric acid, interhalogen compounds, Oxoacids of halogens (structures only).
- Group 18 Elements : General introduction, electronic configuration, occurrence, trends in physical and chemical properties, uses.

### **Chapter Analysis**

-					
List of Topics	201	16	20	017	2018
List of Topics	D	OD	D	OD	D/OD
Draw the structure		1Q		1Q	1Q
	<u>A</u> /	(2 marks)*		(2 marks)	(2 marks)
What happens when		1Q	1Q		
	$\mathbf{C}$	(2 marks)*	(2 marks)*		
Give reason		1Q	1Q	1Q	1Q
		(1 mark)	(1 mark)	(1 mark)	(2 marks)
Complete the reactions			1Q		
			(2 marks)*		

• \* One question of 2 marks with two choices was asked.

On the basis of above analysis, it can be said that from exam point of view, Draw the Structure of Compounds, What Happens When and Give Reason are the most important type of questions asked from different topics of the chapter.

# **TOPIC-1** Group-16 Elements, Properties and Some Important Compounds

## **Revision Notes**

- Oxygen family : <sub>8</sub>O, <sub>16</sub>S, <sub>34</sub>Se, <sub>52</sub>Te, <sub>84</sub>Po
- Physical properties :
  - (i) Atomic and ionic radii : Smaller than the corresponding elements of group 15 due to increase in nuclear charge. Down the group they increase due to addition of a new shell.
  - (ii) Ionisation enthalpy : I.E.<sub>1</sub> is lower than those of corresponding elements of group 15 due to increase in nuclear charge. I.E.<sub>2</sub> is higher than those of group 15 due to smaller size of the ions and greater effective nuclear charge. Down the group I.E. decreases.
  - (iii) Electron gain enthalpy : Oxygen has less electron gain enthalpy than sulphur. From sulphur, the value again become less negative upto polonium.

- Electronegativity : More electronegative than group 15 elements. It (iv) decreases down the group due to increase in atomic size.
- Oxygen and sulphur are non-metals, selenium and tellurium are (v) metalloids and polonium is a metal.
- (vi) Melting and boiling points : Increases regularly from O to Te due to increase in size and hence greater van der Waals force. Po has lesser melting and boiling point than Te due to maximum inert pair effect.
- (vii) **Density** : Increases down the group.
- (viii) Oxidation state : Oxygen shows an oxidation state of -2 only (except  $OF_2$  and  $H_2O_2$ ). All other elements show +2, +4 and +6 oxidation states.
- Chemical properties :

(i) With hydrogen : Form hydroxide of type  $H_2E$  (E = O, S, Se, Te and Po). **Properties of hydrides :** 

- (i) Thermal stability : Decreases down the group.
- (ii) Acidic character : Increases down the group.
- (iii) Reducing nature : All are reducing agents except H<sub>2</sub>O.
- (iv) Boiling point : From  $H_2O$  to  $H_2S$  there is a sudden drop which increases from  $H_2S$  to  $H_2Te$ .
- (v) With halogens : Form halides of type  $EX_2$ ,  $EX_4$  and  $EX_6$  where E is an element of group and X is a halogen.
- **Properties of halides :**
- (i) Only hexafluorides are the only stable halides.
- (ii)All elements except selenium form dichlorides and dibromides. These dihalides are  $sp^3$  hybridised and have tetrahedral structure.

$$2Se_2Cl_2 \rightarrow SeCl_4 + 3Se$$

(a) Preparation of  $SF_4$  and  $SF_6$ :

$$3SCl_2 + 4NaF \rightarrow SF_4 + S_2Cl_2 + 4NaC$$

$$SF_4 + 2H_2Q \rightarrow 4HF + SO_2$$

(c) SF<sub>6</sub> is  $sp^3d^2$  hybridised and octahedral whereas SF<sub>4</sub> is  $sp^3d$  hybridised and is trigonal bipyramidal with one position occupied by a lone pair of electrons.

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

(iii) With oxygen : Form oxides of EO<sub>2</sub> and EO<sub>3</sub>.

Dioxygen (O<sub>2</sub>)

**Preparation** :

In laboratory,

**Properties :** 

(i) Slightly soluble in water and appreciably soluble in alkaline pyrogallol solution.

(ii) Paramagnetic.

(iii) Forms oxides with metals and non-metals.

$$\begin{split} & 2\text{Mg}(s) + \text{O}_2(g) \rightarrow 2\text{MgO}(s) \\ & \text{C}(s) + \text{O}_2(g) \rightarrow \text{CO}_2(g) \\ & 4\text{Al} + 3\text{O}_2 \rightarrow 2\text{Al}_2\text{O}_3 \\ & \text{P}_4 + 5\text{O}_2 \rightarrow \text{P}_4\text{O}_{10} \\ & 2\text{ZnS} + 3\text{O}_2 \rightarrow 2\text{ZnO} + 2\text{SO}_2 \\ & \text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O} \\ & 4\text{HCl} + \text{O}_2 \rightarrow 2\text{Cl}_2 + 2\text{H}_2\text{O} \end{split}$$

- > Classification of oxides : On the basis of chemical nature.
  - (i) Basic : Na<sub>2</sub>O, CaO, etc. metallic oxides.
  - (ii) Acidic : CO<sub>2</sub>, SO<sub>2</sub>, etc. non-metallic oxides.
  - (iii) Amphoteric : SnO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, etc. are amphoteric oxides.
  - (iv) Neutral : H<sub>2</sub>O, CO, etc. are neutral oxides.
  - (v) Poly-oxide : Oxides having oxygen more than required oxygen such as peroxide (Na<sub>2</sub>O<sub>2</sub>), super oxide (KO<sub>2</sub>), dioxide (PbO<sub>2</sub>), higher oxide ( $Mn_2O_7$ ).
  - (vi) Sub-oxide : Oxides having oxygen less than required, e.g., C<sub>3</sub>O<sub>2</sub>.

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➢ Ozone (O<sub>3</sub>)

Preparation : By subjecting pure and dry oxygen to silent electric discharge.

$$3O_2(g) \xrightarrow{\text{Discharge}} 2O_3(g), \Delta H = + 284 \text{ kJ}$$

**Properties** :

(i) Poisonous in nature.

(ii) Powerful oxidising agent. It is a stronger oxidising agent than O<sub>2</sub>.

$$PbS + 4O_3 \rightarrow PbSO_4 + 4O_2$$
$$2I^- + H_2O + O_3 \rightarrow 2OH^- + I_2 + O_2$$

Uses :

- (i) As bleaching agent.
- (ii) As disinfectant and germicide.
- (iii) For purification of air in hospitals, railway tunnels, cinema house.
- (iv) For bleaching oils, ivory flour, starch etc.

Structure :



- Allotropes of Sulphur :
  - (a) Rhombic Sulphur ( $\alpha$ -Sulphur) :
    - (i) Yellow in colour, melting point 385.8 K and specific gravity 2.06.
    - (ii) Formed by evaporating the solution of roll sulphur in CS<sub>2</sub>.
    - (iii) Insoluble in water but dissolves to some extent in benzene, alcohol and ether.
    - (iv) Readily soluble in CS<sub>2</sub>.
  - (b) Monoclinic Sulphur (β-Sulphur) :
    - (i) Melting point is 393 K and specific gravity 1.98.
    - (ii) Soluble in CS<sub>2</sub>.
    - (iii) Prepared by melting rhombic sulphur in a dish and cooling.
    - (iv) Stable above 369 K and transforms into  $\alpha$ -sulphur below it.

Both rhombic and monoclinic sulphur have S<sub>8</sub> molecules.

#### Shape of S<sub>8</sub> and S<sub>6</sub> molecules :



Sulphur dioxide (SO<sub>2</sub>) : Preparation :

$$\begin{array}{l} \mathrm{S}+2\mathrm{H}_{2}\mathrm{SO}_{4}\rightarrow3\mathrm{SO}_{2}+2\mathrm{H}_{2}\mathrm{O}\\ \mathrm{(conc.)}\\ \mathrm{Cu}+2\mathrm{H}_{2}\mathrm{SO}_{4}\rightarrow\mathrm{Cu}\mathrm{SO}_{4}+\mathrm{SO}_{2}+2\mathrm{H}_{2}\mathrm{O}\\ \mathrm{(conc.)}\\ \mathrm{Na}_{2}\mathrm{SO}_{3}+2\mathrm{HCl}\rightarrow2\mathrm{Na}\mathrm{Cl}+\mathrm{SO}_{2}+\mathrm{H}_{2}\mathrm{O}\\ \mathrm{(dil.)}\end{array}$$

#### **Properties :**

- (i) Colourless gas with pungent, suffocating odour.
- (ii) Highly soluble in water.
- (iii)

$$SO_2 + H_2O \rightleftharpoons H_2SO_3$$
  
(Sulphurous acid)

$$\begin{split} & 2NaOH + SO_2 ~\rightarrow Na_2SO_3 + H_2O \\ & Na_2SO_3 + H_2O + SO_2 ~\rightarrow 2NaHSO_3 \\ & Cl_2 + SO_2 ~\rightarrow SO_2Cl_2 \\ & O_2 + 2SO_2 ~\rightarrow 2SO_3 \end{split}$$

(iv) SO<sub>2</sub> act as reducing agent.

$$\begin{split} & 2Fe^{3+} + SO_2 + 2H_2O \rightarrow 2Fe^{2+} + SO_4^{-2-} + 4H^+ \\ & 5SO_2 + 2MnO_4^- + 2H_2O \rightarrow 5SO_4^{-2-} + 4H^+ + 2Mn^{2+} \end{split}$$

Uses :

(i) Used in refining petroleum and sugar.

(ii) As bleaching agent for wool and silk.

(iii) As anti-chlor, disinfectant and preservative.

➢ Sulphuric acid (H₂SO₄)

Preparation : By contact process which involves 3 steps :

(i) Burning of sulphur or sulphide ores in air :

 $S\,+\,O_2\,\rightarrow SO_2$ 

(ii) Conversion of  $SO_2$  to  $SO_3$  with oxygen in the presence of a catalyst  $V_2$ 

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

(iii) Absorption of  $SO_3$  in  $H_2SO_4$  to give oleum. Oleum is diluted with water to get  $H_2SO_4$  of desired concentration.

$$\begin{array}{l} \mathrm{SO}_3 + \mathrm{H}_2 \mathrm{SO}_4 \rightarrow \mathrm{H}_2 \mathrm{S}_2 \mathrm{O}_7 \\ (\mathrm{Oleum}) \\ \mathrm{H}_2 \mathrm{S}_2 \mathrm{O}_7 + \mathrm{H}_2 \mathrm{O} \rightarrow 2 \mathrm{H}_2 \mathrm{SO}_4 \end{array}$$

#### **Properties :**

(i) Colourless, dense, oily liquid with a specific gravity of 1.84 at 298 K.

(ii) Low volatility.

(iii) Strong acidic character.

(iv) Strong affinity for water.

(v) Acts as an oxidising agent.

$$\begin{array}{c} & & \text{Curr} + 2\text{H}_2\text{SO}_4 \rightarrow \text{CuSO}_4 + \text{SO}_2 + 2\text{H}_2\text{O}\\ \text{(conc.)} \\ & & \text{S} + 2\text{H}_2\text{SO}_4 \rightarrow 3\text{SO}_2 + 2\text{H}_2\text{O}\\ \text{(conc.)} \\ & & \text{C} + 2\text{H}_2\text{SO}_4 \rightarrow \text{CO}_2 + 2\text{SO}_2 + 2\text{H}_2\text{O}\\ \text{(conc.)} \end{array}$$

(vi) Acts as a dehydrating agent.

$$C_{12}H_{22}O_{11} \xrightarrow{H_2SO_4} 12C + 11H_2O$$

Uses :

(i) In petroleum refining.

(ii) Manufacture of pigments, paints and dye stuff.

(iii) Detergent industry.

(iv) In storage batteries.

Oxoacids of Sulphur :





Q. 1. Write the formula of the compound of sulphur which is obtained when conc. HNO<sub>3</sub> oxidises S<sub>8</sub>.

**R** [CBSE OD Set-2 2017]

(1 mark each)

1

[CBSE Marking Scheme 2017]

is obtained when cone. HND3 exidises Se [Topper's Answer 2017]

- Q. 2. Write the formulae of any two oxoacids of R [CBSE Comptt. OD 2015] Ans. H<sub>2</sub>SO<sub>3</sub> (Sulphurous acid) and H<sub>2</sub>SO<sub>4</sub> (Sulphuric
- $\frac{1}{2} + \frac{1}{2}$



R [CBSE Delhi 2012]

Q. 5. Predict the shape and the asked angle (90° or more or less) in the following case  $SO_3^{2-}$  and the angle 0—<u>S</u>—O. U [CBSE Delhi 2012] Ans. Pyramidal :

#### Angle : O—S—O more than 90°

#### Answering Tip

- Draw the structures with lone pair of electrons (if present). Avoid over-writing.
- Q. 6. Arrange the following hydrides of Group-16 elements in the increasing order of their thermal stability : H<sub>2</sub>O, H<sub>2</sub>S, H<sub>2</sub>Se, H<sub>2</sub>Te.

#### Q. 7. Account for the following:

1/2

1/2

Oxygen shows catenation behaviour less than sulphur. A&E [CBSE Delhi 2013]

Ans. Bond energy of S—S bond (213 kJ mol<sup>-1</sup>) is greater than O – O bond (138 kJ mol<sup>-1</sup>). Due to small size of oxygen atom there is greater lp–bp repulsion in O – O, resulting in weakening of O – O bond more than in S–S bond. Therefore, the tendency of catenation in oxygen is lower than sulphur.

#### Q. 8. Oxygen is a gas but sulphur a solid. Explain. [CBSE OD 2012; KVS]

**Ans.** Oxygen being smallest in size is capable of forming  $p\pi - p\pi$  bond and exists as  $O = O(O_2 \text{ molecule})$  while sulphur being larger in size is not able to form  $p\pi - p\pi$  bond.

(2 marks each)

# Short Answer Type Questions

**AI** Q. 1. What happens when :

- (i) conc. H<sub>2</sub>SO<sub>4</sub> is added to Cu ?

### Ans.(i) $Cu + 2H_2SO_4 \rightarrow CuSO_4 + SO_2 + 2H_2O$ (ii) $SO_3 + H_2O \rightarrow H_2SO_4$ [CBSE Marking Scheme 2017

#### **Answering Tip**

- Give balanced chemical equation
- Q. 2. What happens when :

(ii)  $SO_3$  is passed through water ?

Ans. (i)  $H_2SO_4 + CaF_2 - 2HF + CaSO_4$  1 (conc.)

(ii)  $SO_3 + H_2O \rightarrow H_2SO_4$  1 [CBSE Marking Scheme 2016]

### Answering Tip

Cive balanced chemical equation.

2.3. How is O<sub>3</sub> estimated quantitatively?

C [NCERT]

- **Ans.** When ozone reacts with potassium iodide (KI) solution buffered with a borate buffer (pH = 9.2) then iodine ( $I_2$ ) is liberated that can be titrated against a standard solution of sodium thiosulphate using starch as indicator. **2**
- Q. 4. Write the conditions to maximise the yield of  $H_2SO_4$  by contact process.
- Ans. The conditions used to maximise the yield of  $H_2SO_4$ by contact process :
  - (i) High pressure
  - (ii) Low temperature
- (iii)  $V_2O_5$  is used as catalyst (any two) 2

### (3 marks each)

U [NCERT]

# Long Answer Type Questions-I

#### Q. 1. Give reasons for the following :

- (i)  $(CH_3)_3 P = O$  exists but  $(CH_3)_3 N = O$  does not.
- (ii) Oxygen has less electron gain enthalpy with negative sign than sulphur.
- (iii)  $H_3PO_2$  is a stronger reducing agent than  $H_3PO_3$ . A&E [CBSE OD Set-1, 2, 3 2014]
- Ans. (i) Because as N can't form 5 covalent bonds as its maximum covalency is three. The octet cannot be extended as it doesn't have *d* orbital, while P can extend its octet as it has empty *d* orbital.
- (ii) This is due to very small size of oxygen atom, repulsion between electrons is large in relatively small 2*p* sub-shell.
- (iii) In H<sub>3</sub>PO<sub>2</sub> there are 2P H bonds, whereas in H<sub>3</sub>PO<sub>3</sub> there is 1 P-H bond.
   1
   [CBSE Marking Scheme 2014]

#### Q. 2. How is SO<sub>2</sub> an air pollutant?

- Ans. Sulphur dioxide causes harm to the environment in many ways :
  - (i) When it combines with water vapour it forms sulphuric acid (H<sub>2</sub>SO<sub>4</sub>). This causes acid rain. Acid rain damages soil, plants, and buildings, especially those made of marble. 1

120

- (ii) Even in very low concentrations, SO<sub>2</sub> causes irritation in the respiratory tract. It causes throat and eye irritation and can also affect the larynx to cause breathlessness.
- (iii) It is extremely harmful to plants. Plants exposed to sulphur dioxide for a long time lose colour from their leaves. This condition is known as chlorosis. This happens because the formation of chlorophyll is affected by the presence of sulphur dioxide. 1

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# **TOPIC-2** Group-17 Elements, Properties and Some Important Compounds

### **Quick Review**

- $\blacktriangleright \text{ Halogen family : } {}_9F, {}_{17}Cl, {}_{35}Br, {}_{53}I, {}_{85}At.$
- Physical Properties :
  - (i) Atomic and ionic radii : They are the smallest in their respective periods due to increase in nuclear charge. Down the group, they increase.
  - (ii) Oxidation state : Fluorine shows -1 only. Other elements show oxidation states +1, +3, +5 and +7.
  - (iii) Ionisation enthalpy : Higher than the corresponding members of group 16. Down the group, it decreases.
  - (iv) Electron gain enthalpy : Have maximum negative electron gain enthalpy in the corresponding periods.
  - (v) Metallic character : Due to very high ionisation enthalpies they are non-metals. The last element I, shows some metallic character as it can form I<sup>+</sup> by loss of electrons.
  - (vi) Electronegativity : These are the most electronegative elements in their respective periods. Down the group, electronegativity decreases.
  - (vii)  $F_2$  and  $Cl_2$  are gases,  $Br_2$  is a liquid while  $I_2$  is solid
  - (viii) All halogens are coloured.
  - (ix) Melting points and boiling points : Increases down the group due to increase in size and nuclear charge causing greater van der Waals forces of attraction.
  - (x) Bond dissociation enthalpy : Bond dissociation enthalpy decreases from  $Cl_2$  to  $I_2$  *i.e.*,  $Cl_2 > Br_2 > F_2 > I_2$ .
- > Chemical Properties :
  - (a) Highly reactive : The reactivity decreases down the group. Fluorine is the strongest oxidising halogen. A halogen oxidise halide ions of higher atomic number.

$$\begin{split} F_2 + 2X^- &\rightarrow 2F^- + X_2 \qquad & (X = \text{Cl, Br or I}) \\ \text{Cl}_2 + 2X^- &\rightarrow 2\text{Cl}^- + X_2 \qquad & (X = \text{Br or I}) \\ \text{Br}_2 + 2I^- &\rightarrow 2\text{Br}^- + \text{I}_2 \end{split}$$

Fluorine oxidises water to oxygen whereas chlorine and bromine react with water to form corresponding hypothalic and hypohalous acids.

$$\begin{aligned} 2F_2(g) + 2H_2O(l) &\to 4H^+(aq) + 4F^-(aq) + O_2(g) \\ X_2(g) + H_2O(l) &\to HX(aq) + HOX(aq) \end{aligned} (X = Cl \text{ or } Br) \end{aligned}$$

(b) Towards hydrogen : All elements form hydrides of the type HX (X = F, Cl, Br, I).

- (i) Physical state : Except HF which is a liquid because of H-bonding, all are gases.
- (ii) Thermal stability : It decreases down the group due to increase in bond length.
- (iii) Reducing character : It increases from HF to HI due to decrease of stability.
- (iv) Acidic strength : HF < HCl < HBr < HI.
- (c) Towards halogens : They react with all elements except He, Ne and Ar to form binary halides.

(d) Towards metal :

(i) With particular metal, ionic character is

M-F > M-Cl > M-Br > M-I.

- (ii) With metals having low I.E., halides are ionic.
- (iii) With metals having high I.E., halides are covalent.

- (iv) With metals showing more than one oxidation states, halides with higher oxidation states are more covalent.
- (v) Metals show highest oxidation state in fluorides.
- (e) Towards oxygen : Halogens form many binary compounds with oxygen, but most of them are unstable. Cl, Br and I form oxides in their oxidation state +1 to +7. Their stability decreases in the order I > Cl > Br.



**(f)** Oxoacids : Because of high electronegativity and small size, fluorine forms only one oxoacid, HOF (hypofluorous acid). The other halogens form acid of the type HOX—hypohalous acid, HOXO–halous acid, HOXO<sub>2</sub> – halic acid and HOXO<sub>3</sub> – perhalic acid.

Acidic strength : HClO > HBrO > HIO Acidic strength of oxoacids containing the same halogen :  $HOCl > HClO_2 < HClO_3 < HClO_4$ (g) Structure of oxoacids of Chlorine : 0= Hypochlorous Chlorous Ó acid acid Chlor erchloric acid ➤ Chlorine (Cl<sub>2</sub>) **Preparation** :  $MnCl_2 + Cl_2 + 2H_2O$  $\xrightarrow{CuCl_2} 2KCl + 2MnCl_2 + 8H_2O + 5Cl_2$   $\xrightarrow{CuCl_2} 2Cl_2 + 2H_2O \text{ (Deacon's process)}$ In laboratory, (i)  $4NaCl + MnO_2 + 4H_2SO_4 \rightarrow MnCl_2 + 4NaHSO_4 + 2H_2O + Cl_2$ (ii) (iii) Electrolytic process : By electrolysis of brine.  $\rightarrow$  H<sub>2</sub> + 2OH<sup>-</sup>; Na<sup>+</sup> + OH<sup>-</sup>  $\rightarrow$  NaOH At cathode :  $2H_2O + 2e$  $e^{-}$ ; Cl + Cl  $\rightarrow$  Cl<sub>2</sub> At anode :  $Cl^- \rightarrow Cl^+$ **Properties** : It is a greenish yellow gas with a pungent suffocating smell. (i) Soluble in water. (ii) (iii) About 2.5 times heavier than air. With metals and non-metals form chlorides. (iv)  $2Al + 3Cl_2 \rightarrow 2AlCl_3; \ 2Na + Cl_2 \rightarrow 2NaCl$  $2Fe\,+\,3Cl_2\rightarrow 2FeCl_3;\,\,S_8\,+\,4Cl_2\,\rightarrow 4S_2Cl_2$  $P_4 + 6Cl_2 \rightarrow 4PCl_3; H_2 + Cl_2 \rightarrow 2HCl_3$ Reacts with compounds containing hydrogen to form HCl (v)  $H_2S + Cl_2 \rightarrow 2HCl + S; C_{10}H_{16} + 8Cl_2 \rightarrow 16HCl + 10C$  $NH_3 + 3Cl_2 \rightarrow NCl_3 + 3HCl; 8NH_3 + 3Cl_2 \rightarrow 6NH_4Cl + N_2$ (excess) (explosive) (excess) With cold and dilute alkalies (vi)  $2NaOH + Cl_2 \rightarrow NaCl + NaOCl + H_2O$ (cold and dilute) (vii) With hot and concentrated alkalies  $6NaOH + 3Cl_2 \rightarrow 5NaCl + NaClO_3 + 3H_2O$ 

(viii) With dry slaked lime, it gives bleaching powder.

 $2Ca(OH)_2 + 2Cl_2 \rightarrow Ca(OCl)_2 + CaCl_2 + 2H_2O$ 

Chlorine water on standing loses its yellow colour. HOCl formed gives nascent oxygen. (ix)

$$Cl_2 + H_2O \rightarrow HCl + HOCl$$

$$HOC1 \rightarrow HC1 + O$$

It oxidises ferrous to ferric, sulphite to sulphate, sulphur dioxide to sulphuric acid and iodine to iodic acid. (x)

$$\begin{array}{l} 2\text{FeSO}_4 + \text{H}_2\text{SO}_4 + \text{Cl}_2 \rightarrow \text{Fe}_2(\text{SO}_4)_3 + 2\text{HCl} \\ \text{Na}_2\text{SO}_3 + \text{Cl}_2 + \text{H}_2\text{O} \rightarrow \text{Na}_2\text{SO}_4 + 2\text{HCl} \end{array}$$

$$\begin{array}{l} \mathrm{SO}_2 + 2\mathrm{H}_2\mathrm{O} + \mathrm{Cl}_2 \rightarrow \mathrm{H}_2\mathrm{SO}_4 + 2\mathrm{HCl} \\ \mathrm{I}_2 + 6\mathrm{H}_2\mathrm{O} + 5\mathrm{Cl}_2 \rightarrow 2\mathrm{HIO}_3 + 10\mathrm{HCl} \end{array}$$

Uses :

(i) For bleaching cotton and textiles.

(ii) In sterilising drinking water.

(iii) In the extraction of gold and platinum.

(iv) Manufacture of dyes, drugs, refrigerant and other organic compounds like CHCl<sub>3</sub>, DDT, CCl<sub>4</sub>, etc.

Hydrogen Chloride (HCl) :

Preparation : In laboratory

$$NaCl + H_2SO_4 \xrightarrow{420 \text{ K}} NaHSO_4 + HCl$$

NaHSO<sub>4</sub> + NaCl  $\xrightarrow{823 \text{ K}}$  Na<sub>2</sub>SO<sub>4</sub> + HCl HCl gas can be dried by passing conc. H<sub>2</sub>SO<sub>4</sub> through it. Properties :

- (i) Colourless and pungent smelling gas.
- (ii) Extremely soluble in water.
- (iii) When three parts of conc. HCl and one part of conc. HNO3 are mixed aqua-regia is formed which is used for dissolving noble metals *e.g.*, gold, platinum.

Au + 4H<sup>+</sup> + NO<sub>3</sub><sup>-</sup> + 4Cl<sup>-</sup> 
$$\rightarrow$$
 AuCl<sub>4</sub> + NO + 2H<sub>2</sub>O  
 $Pt + 16H^+ + 4NO_{-} + 18Cl^- \rightarrow 3PCO_{-}^{2} + 4NO_{-} + 8H_{-}O_{-}$ 

$$3Pt + 16H^{-} + 4NO_3 + 18CI \rightarrow 3PtCI_6^{-} + 4NO + 8H_2C$$

(iv) Reacts with NH<sub>3</sub> giving white fumes of NH<sub>4</sub>C

$$NH_3 + HCl - NH_4Cl$$

(v) Decomposes salts of weaker acids.

$$\begin{array}{l} Na_2CO_3+2HCl \rightarrow 2NaCl+H_2O+CO_2\\ NaHCO_3+HCl \rightarrow NaCl+H_2O+CO_2\\ Na_2SO_3+2HCl \rightarrow 2NaCl+H_2O+SO_2 \end{array}$$

Uses :

- (i) In the manufacture of chlorine, glucose and  $NH_4Cl$ . (ii) For extracting alwa from 1
- (ii) For extracting glue from bones and purifying bone black.
- Interhalogen Compounds : Halogen combines amongst themselves to form a number of compounds known as interhalogen compounds. Their general formula are XX', XX<sub>3</sub>', XX<sub>5</sub> and XX<sub>7</sub> where X is halogen of larger size and higher electropositivity and X of smaller size.

**Preparation** :

$$\begin{array}{cccc} Cl_2 &+& F_2 & \xrightarrow{437 \ \text{K}} & 2 \mbox{Cl}_2 &+& Scl_2 \rightarrow 2 \mbox{ICl}_3 \\ (Equal volume) & & (excess) \\ Cl_2 &+& 3F_2 & \xrightarrow{573 \ \text{K}} & 2 \mbox{Cl}_3; \\ (excess) & & (Diluted with \\ & water) \\ I_2 &+& \mbox{Cl}_2 \rightarrow 2 \mbox{ICl}; \\ (Equimolar) & & (excess) \end{array}$$

#### **Properties :**

- (i) Covalent compounds.
- (ii) Diamagnetic in nature.
- (iii) More reactive than halogens.
- (iv) Undergo hydrolysis.

$$XX' + H_2O \rightarrow HX' + HOX$$

- > Structure : On the basis of VSEPR theory,  $XX_3$  compounds have bent 'T' shape,  $XX_5$  compounds have square pyramidal and IF<sub>7</sub> has pentagonal bipyramidal shape. Uses :
  - (i) As non-aqueous solvents.
  - (ii) As fluorinating agents.
  - (iii) ClF<sub>3</sub> and BrF<sub>3</sub> are used for the production of UF<sub>6</sub> in the enrichment of  $^{235}$ U.

### Know the Terms

- Pseudohalide ions : CN<sup>-</sup>, SCN<sup>-</sup> and OCN<sup>-</sup> ions are called pseudohalide ions while (CN)<sub>2</sub>, (SCN)<sub>2</sub> and (OCN)<sub>2</sub> are known as pseudohalogens.
- > Bleaching powder :  $Ca(ON)_2 + Cl_2 \rightarrow CaOCl_2 + H_2O$ Bleaching

Powder

# Objective Type Questions

A. Multiple choice Questions:

Q. 1. Affinity for hydrogen decreases in the group from fluorine to iodine. Which of the halogen acids should have highest bond dissociation enthalpy?
 (a) HF
 (b) HCl

(c) HBr (d) HI

U [NCERT Exemp. Q. 6, Page 91]

**Ans. Correct option :** (a)

*Explanation* : F being smallest has the shortest HF bond and therefore HF has the highest bond dissociation energy.

Q. 2. Reduction potentials of some ions are given below. Arrange them in decreasing order of oxidising power.

 $ClO_4^-$ 

Ion

Reduction  $E^{\Theta} = 1.19V \quad E^{\Theta} = 1.65V \quad E^{\Theta} = 1.65V$ 

 $IO_4^-$ 

BrO<sub>4</sub>

(a)  $ClO_4^- > IO_4^- > BrO_4^-$ 

- (b)  $IO_4^- > BrO_4^- > ClO_4^-$
- (c)  $BrO_4^- > IO_4^- > ClO_4^-$
- (d)  $BrO_4^- > ClO_4^- > IO_4^-$

A [NCERT Exemp. Q. 26, Page 94] Ans. Correct option : (c)

*Explanation*: The higher the reduction potential, the higher is its tendency to get reduced. Hence, the order of oxidising power is :

 $BrO_4^- > IO_4^- > ClO_4^-$ 

Q. 3. Which of the following is iso-electronic pair?

(a) ICl <sub>2</sub> , ClO <sub>2</sub>	(b) $BrO_{2'}^{-}BrF_{2}^{+}$
(c) ClO <sub>2</sub> , BrF	(d) CN <sup>-</sup> , O <sub>3</sub>

Explanation :

(a)  $ICl_2 = 53 + 2 \times 17 = 87$   $ClO_2 = 17 + 16 = 33$ (b)  $BrO_2^- = 35 + 2 \times 8 + 1 = 52$   $BrF_2^+ = 35 + 9 \times 2 - 1 = 52$ (c)  $ClO_2 = 17 + 16 = 33$ 

BrF = 35 + 9 = 44

(d) 
$$CN^- = 6 + 7 + 1 = 14$$

$$O_3 = 8 \times 3 = 24$$

Q. 4. A black compound of manganese reacts with a halogen acid to give greenish yellow gas. When excess of this gas reacts with NH<sub>3</sub> an unstable trihalide is formed. In this process the oxidation state of nitrogen changes from :

(a) -3 to +3. (b) -3 to 0. (d) 0 to - 3. (c) -3 to +5. A&E [NCERT Exemp. Q. 23, Page 93] Ans. Correct option : (a) Explanation :  $MnO_2 + 4HCl \rightarrow MnOl_2 + 2H_2O + Cl$ (Greenish yellow gas)  $NH_3 + 3Cl_2 \rightarrow NCl_3 + 3HCl$ When excess of chlorine tense with ammonia then  $NCl_3$  and HO will form. In this reaction on left-hand side chlorine have (-3) oxidation state and on the right-hand chlorine have (+3) oxidation state. B. Answer the following: Q. 1. Write the formula of the compound of iodine Which is obtained when conc.  $HNO_3$  oxidises  $I_2$ . **R** [CBSE OD Set-3 2017] Ans. HIO<sub>3</sub> 1 [CBSE Marking Scheme 2017] Q. 2. Name two poisonous gases which can be prepared from chlorine gas. R [CBSE Delhi 2013] Ans. Phosgene (COCl<sub>2</sub>), tear gas (CCl<sub>3</sub>NO<sub>2</sub>), mustard gas [C<sub>4</sub>H<sub>8</sub>Cl<sub>2</sub>S]. (Any two)  $\frac{1}{2} + \frac{1}{2}$ Q. 3. Draw the structure of BrF<sub>3</sub> molecule. R [CBSE Delhi 2013] Ans. 1 [T-shape] **Answering Tip** 

- Draw the structure with lone pair of electrons (if present). Avoid over-writing.
- **PI**Q. 4. Fluorine exhibits only –1 oxidation state whereas other halogens exhibit +1, +3, +5 and +7 oxidation states also. Why is it so ?

A&E [CBSE Comptt. Delhi 2013]

- Ans. Fluorine has no *d*-orbital for excitation of electrons and it is most electronegative element. Hence, it shows oxidation state of –1 only.
- AIQ. 5. Bond enthalpy of fluorine is lower than that of chlorine why ? A&E [CBSE Comptt. OD 2013] OR

Bond enthalpy of  $F_2$  is less than of  $Cl_2$ . <u>A&E</u> [CBSE Delhi 2013]

(1 mark each)

Ans. Bond enthalpy of F—F is smaller due to greater repulsive interactions between the lone pair of one F atom with those of other. The repulsive interaction arise due to greater concentration of electron density on each F atom because of its extremely small size.

#### Q. 6. HF is a weaker acid than HCl why ?

#### A&E [CBSE Comptt. OD 2013]

Ans. Since H—F bond is strongest with higher bond dissociation energy than HCl, hence it is weakest acid among all the halogen acids.

#### Answering Tip

- Be specific about the key word in the answer. Avoid unnecessary explanation.
- Q. 7. Give reason for the following :

 $F_2$  is more reactive than  $ClF_3$  but  $ClF_3$  is more reactive than  $Cl_2$ . A&E [CBSE Comptt. Delhi 2013]

Q. 9. Give reason for the following:

Electron gain enthalpies of halogens are largely negative.

**Ans.** Interhalogen compounds are more reactive than halogen compounds. But in case of fluorine due to the small size of fluorine, it has high electronegativity and low bond energy so it is more reactive than  $ClF_3$ . Therefore  $ClF_3$  is more reactive than  $Cl_2$ . **1** 

Q. 8. Give reason for the following :

#### PbCl<sub>4</sub> is more covalent than PbCl<sub>2</sub>.

#### A&E [CBSE OD 2013]

Ans. Due to high oxidising power, halogens combine directly with most metals to form their corresponding halides. But if the metal exhibit more than one oxidation state, the halide in higher oxidation state will be more covalent than the one in lower oxidation state. Therefore PbCl<sub>4</sub> is more covalent than PbCl<sub>2</sub> as Pb exhibits more than one oxidation states. 1

A&E [CBSE O.D. Set-2, 2017]

Ans	(b) Electron gain enthalpie	of hologens are	Sargely negative.
0.5	because, they require	only one electron	there stable no consigurati
-	60	- Oth	, 00
	n	, cill	[Topper's Answer 2017

#### **Detailed Answer:**

Halogens are smallest in size in their respective periods resulting in high effective nuclear charge. They accept one electron to attain noble gas electronic configuration. Hence, they have negative electron gain enthalpy. **1** 

Q. 10. Give reasons: Fluoride ion has higher hydration enthalpy than chloride ion.

A&E [CBSE Delhi Set-1, 2, 3, 2017]

Ans.Due to small size of fluoride ion/high charge density of fluoride ion/high charge size ratio of fluoride ion. 1 [CBSE Marking Scheme 2017]

#### **Detailed Answer**: The size of fluorid

The size of fluoride ion is smaller to the chloride ion. So, on dissolving in water, the hydration energy released in the case of fluoride ion is higher than chloride ion because of stronger interactions between the water and ion molecules.

Q. 11. Assign reason for the following: Reducing character increase from HF to HI. [A&E] [CBSE O.D. Set-2, 2016]



#### **Detailed Answer:**

As we move from HF to HI, the thermal stability of these hydrides decreases as bond dissociation enthalpy of HX bond decreases. So, on moving from HF to HI, the hydrogen is available for reduction. Therefore, reducing character increases.

#### Answering Tip

• While stating the reason, write the cause and the consequence.

1

#### Q. 12. Give reasons: ICl is more reactive than $I_2$ .

#### A&E [CBSE OD (Central) 2016]

Ans. Inter halogen compound ICl are more reactive than halogens Cl<sub>2</sub> because X–X (I–Cl) bond in inter halogens is weaker than Cl–Cl bond in halogens except F–F bond. 1

#### Answering Tip

• Briefly explain the reason.

#### Short Answer Type Questions (2 marks each) Q. 1. Draw the structures of the following: Answering Tip (i) $H_2SO_3$ • Draw the structures with lone pair of electrons (if (ii) HClO<sub>3</sub> **R** [CBSE OD Set-1 2017] present). Avoid over-writing. Ans. (i) (ii) Q. 3. Complete the following chemical equations : (i) $Ca_3P_2 + H_2O_2$ (ii) $3Cu + H_2SO_4$ (conc.) $\rightarrow$ R S OR HO Arrange the following in the order of property 0 indicated against each set : HO (i) HF, HCl, HBr, HI – increasing bond dissociation 1+1**C**enthalpy. [CBSE Marking Scheme 2017] (ii) H<sub>2</sub>O, H<sub>2</sub>S, H<sub>2</sub>Se, H<sub>2</sub>Te – increasing acidic Answering Tip U [CBSE Delhi 2014] character. • Draw the correct shape with lone pair of electron Ans. (i) $Ca_3P_2 + 6H_2O \rightarrow 3Ca(OH)_2 + 2PH_3$ (if present). Avoid over-writing. (ii) $Cu + 2H_2SO_4$ (conc.) $\rightarrow CuSO_4 + 2H_2O + SO_2$ 1 Q. 2. Draw the structures of the following: Answering Tip (i) $H_2S_2O_8$ Balance the chemical equation. E OD Set-2 2017] (ii) ClF<sub>3</sub> OR Ans. (i) (i) H - I < H - Br < H - CI < H - F1 (ii) H<sub>2</sub>O < H<sub>2</sub>S < H<sub>2</sub>Se < H<sub>2</sub>Te 1 (O)[CBSE Marking Scheme 2014] Q. 4. Arrange the following in order of property 1 indicated for each set : (ii) (i) $F_{2}$ , $Cl_{2}$ , $Br_{2}$ , $I_{2}$ – increasing bond dissociation enthalpy. (ii) PH<sub>3</sub>, AsH<sub>3</sub>, BiH<sub>3</sub>, SbH<sub>3</sub>, NH<sub>3</sub> – increasing base F strength. [CBSE SQP 2016; DDE] **Ans. (i)** $I_2 < F_2 < Br_2 < Cl_2$ 1 (ii) $BiH_3 < SbH_3 < AsH_3 < PH_3 < NH_3$ 1 F Answering Tip 1 [CBSE Marking Scheme 2017] Clear your concept on bond dissociation enthalpy of halogen. OR **AI** Q. 5. What happens when (i) HCl is added to MnO<sub>2</sub>? (ii) PCl<sub>5</sub> is heated ? Write the equation involved. R [CBSE Delhi Set-3 2017] Ans. (i) $MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + 2H_2O$ 1 Bent - T-shop (ii) $PCl_5 \xrightarrow{\Delta} PCl_3 + Cl_2$ 2 [Topper's Answer 2017] [CBSE Marking Scheme 2017]

# Q. 13. Account for the following: Iron on reaction with HCl forms $\text{FeCl}_2$ and not $\text{FeCl}_3$ .

#### A&E [CBSE Delhi 2014]

Ans. Because HCl is a mild oxidising agent and formation of hydrogen gas prevents the formation of FeCl<sub>3</sub>. 1

#### Answering Tip

• While stating the reason, write the cause and the consequence.

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#### Answering Tip

- Balance the chemical equation.
- Q. 6. Account for the following:
  - (i) The two oxygen-oxygen bond lengths in ozone molecule are identical.
- (ii) Most of the reactions of fluorine are exothermic. <u>A&E</u> [CBSE Comptt. Delhi Set-1 2017]
- Ans. (i) Due to resonance the two O-O bond lengths are identical.
- (ii) Due to strong bond formed by it with other elements. 1

#### [CBSE Marking Scheme 2017]

#### **Detailed Answer:**

(i) In ozone, the central oxygen atom forms one single bond with a terminal oxygen atom and double bond with other terminal oxygen atom. The  $\pi$  electrons of double bond are delocalised over the three oxygen atoms. This results into resonance hybrids with the average bond distance of the single and double bond.



- Q. 7. Account for the following:
  - (i) Two S-O bond lengths in  $SO_2$  are equal.
- (ii) Fluorine shows only -1 oxidation state in its compounds. A&E [CBSE Compt. Delhi Set-2 2017]
- Ans. (i) Due to resonance the two S-O bond lengths are identical.
  - (ii) Absence of d-orbitals and most electronegative element. 1

[CBSE Marking Scheme 2017]

- Q. 8. Account for the following:
  - (i) Bond angle in  $NH_4^+$  is higher than that in  $NH_3$ .
  - (ii) ICl is more reactive than  $I_2$ .

#### A&E [CBSE Comptt. Delhi Set-3 2017]

- Ans. (i) In  $NH_4^+$ , all are bond pairs whereas in ammonia the lone pair of electron on nitrogen repels the bond pairs and reduces the bond angle. 1
- (ii) I-Cl bond is weaker than I-I bond / low bond dissociation enthalpy in I-Cl.

[CBSE Marking Scheme 2017]

- Q. 9. Arrange the following in the order of property indicated against each set:
  - (a) F<sub>2</sub>, Cl<sub>2</sub>, Br<sub>2</sub>, l<sub>2</sub> (increasing bond dissociation enthalpy)

(b) H<sub>2</sub>O, H<sub>2</sub>S, H<sub>2</sub>Se, H<sub>2</sub>Te (increasing acidic character)

OR

- Answer the following questions :
- (i) Write the formula of the neutral molecule which is isoelectronic with ClO.
- (ii) Draw the shape of  $H_2S_2O_7$ .

$$\overline{\mathsf{U}} + \overline{\mathsf{R}} \ [\text{CBSE SQP 2017}]$$

Ans. (a) 
$$I_2 < F_2 < Br_2 < Cl_2$$
  
(b)  $H_2O < H_2S < H_2Se < H_2Te$ 



Q. 10. Give reasons :

(i) When  $Cl_2$  reacts with excess of  $F_2$ ,  $ClF_3$  is formed and not  $FCl_3$ .

(ii) Dioxygen is a gas while Sulphur is a solid at room temperature.

#### A&E [CBSE Delhi OD 2018]

- Ans. (ii) F cannot show positive oxidation state as it has highest electronegativity/Because Fluorine cannot expand its covalency / As Fluorine is a small sized atom, it cannot pack three large sized Cl atoms around it. 1
  - (iii) Oxygen has multiple bonding whereas sulphur shows catenation / Due to  $p\pi$ - $p\pi$  bonding in oxygen whereas sulphur does not / Oxygen is diatomic therefore held by weak intermolecular force while sulphur is polyatomic held by strong intermolecular forces. 1

[CBSE Marking Scheme 2018]

Q. 11. Draw the structures of the following :





# Cong Answer Type Questions-I

- Q. 1. Considering the parameters such as bond dissociation enthalpy, electron gain enthalpy and hydration enthalpy, compare the oxidizing power of F<sub>2</sub> and Cl<sub>2</sub>. □ [NCERT]
- Ans. F<sub>2</sub> is a stronger agent than Cl<sub>2</sub> because
  (i) Bond dissociation enthalpy of fluorine is less than that of chlorine.
  - (ii) Electron gain enthalpy of fluorine is less than that of chlorine. 1

(iii) F– has high hydration enthalpy. 1

Q. 2. Explain why the stability of oxoacids of chlorine increases in the order given below : HClO < HClO<sub>2</sub> < HClO<sub>3</sub> < HClO<sub>4</sub>

A&E [NCERT Exemp. Q. 49, Page 97]

**Ans.**Oxygen is more electronegative than chlorine; therefore, dispersal of negative charge present on chlorine increases from ClO to ClO<sub>4</sub> ion because numbers of oxygen atoms are attached to chlorine increases. Therefore, stability of ions will increase in the order given below :

$$ClO < ClO_2 < ClO_2 < ClO_z$$

Thus due to increase in stability of conjugate base, acidic strength of corresponding acid increases in the following order :

$$HCIO < HCIO_2 < HCIO_5 < HCIO_4$$
 1<sup>1</sup>/<sub>2</sub>

I¢

# TOPIC-3 Group-18 Elements, Properties and Some Important Compounds

### **Revision Notes**

- > Noble gases :  $_{2}$ He,  $_{10}$ Ne,  $_{18}$ Ar,  $_{36}$ Kr,  $_{54}$ Xe,  $_{86}$ Ra.
- Also known as rare gases as they are present in very small amounts in the air. Or as inert gases as they were considered chemically unreactive.
- > Electronic configuration :  $ns^2np^6$  (except the which has  $1s^2$ )
- Physical Properties :
  - (i) Gases
  - (ii) Atomic radii increases down the group and highest in their respective periods.
  - (iii)Highest ionisation enthalpy in their respective periods. Down the group, it decreases due to increase in atomic size.
  - (iv) Large positive values of electron gain enthalpy as noble gases have stable electronic configuration and no tendency to accept electron.
  - (v) Low melting points and boiling points due to weak dispersion forces. Down the group they increase because of increase in van der Waals forces.
  - (vi) Liquefaction : They are difficult to liquify. Down the group, the ease of liquefaction increases.
- > In 1962, Bartlett studied the given reaction :

$$O_2 + PtF_6 \rightarrow O_2^+[PtF_6]^-$$
  
Dioxygenyl hexafluoro  
platinate

As ionisation enthalpy of molecular oxygen was almost similar to xenon, below reaction was also found to occur :

$$Xe + PtF_6 \xrightarrow{289 \text{ K}} Xe^+ [PtF_6]^-$$

Preparation of Xenon fluorides : Xenon forms three binary fluorides, XeF<sub>2</sub>, XeF<sub>4</sub> and XeF<sub>6</sub>.

$$\begin{array}{l} \operatorname{Xe}(g) + \operatorname{F}_2(g) & \xrightarrow{673 \text{ K}, 1 \text{ bar}} \operatorname{XeF}_2(s) \\ (\text{excess}) \\ \end{array} \\ \operatorname{Xe}(g) + 2\operatorname{F}_2(g) & \xrightarrow{873 \text{ K}, 7 \text{ bar}} \operatorname{XeF}_4(s) \\ \operatorname{Xe}(g) + 3\operatorname{F}_2 & \xrightarrow{573 \text{ K}, 60 \cdot 70 \text{ bar}} \operatorname{XeF}_6(s) \\ (1:20 \text{ ratio}) \end{array}$$

#### (3 marks each)

 $1\frac{1}{2}$ 

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

Preparation of Xenon trioxide (XeO<sub>3</sub>) :

 $\begin{array}{l} 6\text{XeF}_4+12\text{H}_2\text{O} \rightarrow 2\text{XeO}_3+4\text{Xe}+3\text{O}_2+24\text{HF}\\ \text{XeF}_6+3\text{H}_2\text{O} \rightarrow \text{XeO}_3+6\text{HF} \end{array}$ 

Preparation of Xenon oxyfluorides :



Helium	Neon	Argon	Krypton	Xenon
(i) To lift weather balloons and air ships.	For advertising	To create an inert atmosphere.	For runway and approach lights in airports.	In electric flash bulbs for high speed photography.
(ii) As breathing mixture.	For filling sodium vapour lamps.	In geiger counters.	In high efficiency miner's cap lamps.	In gas filled lamps.
(iii)For inflating the tyres of aeroplanes.	In beacon light.	To date the age of rocks.		

# **Very Short Answer-Objective Type Questions** (1 mark each)

#### A. Multiple choice Questions:

- Q. 1. In the preparation of compounds of Xe, Bartlett had taken  ${O_2}^+ PtF_6^-$  as a base compound. This is because
  - (a) both O<sub>2</sub> and Xe have same size.
  - (b) both O<sub>2</sub> and Xe have same electron gain enthalpy.
  - (c) both O<sub>2</sub> and Xe have same ionisation enthalpy.(d) both Xe and O<sub>2</sub> are gases.
    - U [NCERT Exemp. Q. 24, Page 94]

**Ans. Correct option :** (c)

*Explanation* : Bartlett had taken  $O_2^+ PtF_6^-$  as a base compound because  $O_2$  and Xe both have almost same ionisation enthalpy. The ionisation enthalpies of noble gases are the highest in their respective periods due to their stable electronic configurations.

Q. 2. Which one of the following does not exist?

(a) XeOF <sub>4</sub>	(b) NeF <sub>2</sub>
(c) XeF <sub>2</sub>	(d) XeF <sub>6</sub>
	R [NCERT Ex. Q. 7.37, Page 214]
Ans. Correct option	: (b)

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#### B. Match the following :

Q. 1. Match the species given in Column I with those mentioned in Column II.

S. No.	Column I	S. No.	Column II
(A)	XeF <sub>6</sub>	(1)	$sp^3d^3$ – distorted octahedral
(B)	XeO <sub>3</sub>	(2)	$sp^3d^2$ – square planar
(C)	XeOF <sub>4</sub>	(3)	<i>sp</i> <sup>3</sup> – pyramidal
(D)	XeF <sub>4</sub>	(4)	<i>sp<sup>3</sup>d<sup>2</sup></i> – square pyramidal
Codes :			

(a)	A (1)	B (3)	C (4)	D (2)
(b)	A (1)	B (2)	C (4)	D (3)
(c)	A (4)	B (3)	C (1)	D (2)
(d)	A (4)	B (1)	C (2)	D (3)

[NCERT Exemp. Q. 59, Page 97]

**Ans. Correct Code :** (a)

Column I	Column II	Explanation
(A)	(1)	F $F$ $F$ $F$ $F$ $F$ $F$ $F$ $F$ $F$
(B)	(3)	$x^{e} = 0$ $sp^{3}$ – pyramidal
(C)	(4)	$sp^{3}d^{2}$ – square pyramidal
(D)	(2)	$F \qquad f \qquad $

C. Answer the following:

Q. 1. Draw the structure of  $XeF_2$  molecule.



#### Answering Tip

Ans. XeF<sub>2</sub>:

- Draw the structures showing the lone pairs.
- Q. 2. Draw the molecular structure of XeF<sub>6</sub>.



1

1

Ans. XeF<sub>6</sub>: F

Answering Tip

- Draw the structures showing the lone pairs. Q. 3. Complete the following chemical equation :
- $\begin{array}{c} XeF_4 \rightarrow SbF_5 \rightarrow & [A] [CBSE Delhi 2012] \\ Ans. XeF_4 \rightarrow SbF_5 \rightarrow [XeF_3]^+ [SbF_6]^- & 1 \end{array}$

Q. 4. Helium is used in diving equipment.

A [CBSE Delhi 2013] Ans. Helium is used as a diluent for oxygen in modern diving apparatus because of its very low solubility in blood. 1

Q. 5. What inspired N. Bartlett for carrying out reaction between Xe and PtF<sub>6</sub>?

U [CBSE Delhi 2013; DDE]

Ans. First ionisation enthalpy of molecular oxygen was almost similar with that of Xenon. Thus, after preparing red coloured compound  $O_2^+[PtF_6]^-$ ,

Bartlett got inspired for carrying out reaction between Xe and  $PtF_6$  and made efforts to prepare  $Xe^+[PtF_6]^-$  by mixing Xe and  $PtF_6$ . **1** 



#### Answering Tip

• Draw the structures showing the lone pairs.

#### Q. 7. XeF<sub>6</sub> undergoes complete hydrolysis?

R [CBSE SQP 2017]

**Ans.** When  $XeF_6$  undergoes complete hydrolysis, it forms

 $XeF_6 + 3H_2O \rightarrow 6HF + XeO_3$  1 [CBSE Marking Scheme 2017]

R [CBSE Comptt. Delhi/OD 2013]





metals but  $O_2$  exceeds  $F_2$  in doing so.

by Valence Bond approach.

(ii) Structures of Xenon fluoride cannot be explained

A&E [CBSE Delhi 2012]

**Ans. (a)** Acidic character increases from HF to HI due to increase in size as a result attraction force decreases and acidity increase.

HF < HCl < HBr < HI Increasing order of acidity size increase (i) ClF<sub>3</sub>

(ii) XeF<sub>4</sub>

Ans. (i) ClF<sub>3</sub>:

(ii) XeF<sub>4</sub>:

oxygen.



# Long Answer Type Questions-

#### (3 marks each)

ALQ. 1. (i) Arrange the hybrids of group 16 in increasing order of their acidic character. Justify your answer. (ii) Draw structure of XeOF<sub>4</sub>.

F

**U** + **R** [CBSE Comptt. Delhi Set-1, 2, 3 2017]



### Square pyramidal [CBSE Marking Scheme 2017]

F

#### Answering Tip

- Draw the structures with lone pair of electrons (if present). Avoid over-writing.
- Q. 2. (i)  $F_2$  has lower bond dissociation enthalpy than Cl<sub>2</sub>. Why ?
  - (ii) Which noble gas is used in filling balloons for meteorological observations ?
  - (ii) Complete the following equation :

F

$$XeF_2 + PF_5 \rightarrow$$

A&E [CBSE Delhi 2015]

- **Ans.** (i)  $F_2$  has lower bond dissociation energy than  $Cl_2$ because the size of F<sub>2</sub> is much smaller than Cl<sub>2</sub> as a result interelectronic repulsion works and make F<sub>2</sub> weak. 1
  - (ii) Helium is used in filling balloons for meteorological observations. 1

(iii) 
$$XeF_2 + PF_5 \rightarrow [XeF]^+ [PF_6]^-$$

#### Answering Tip

1

- While stating the reason, write the cause and the consequence.
- Q. 3. (i) Compare the oxidizing action of  $F_2$  and  $Cl_2$ by considering parameters such as bond dissociation enthalpy, electron gain enthalpy and hydration enthalpy.
  - (ii) Write the conditions to maximize the yield of H<sub>2</sub>SO<sub>4</sub> by contact process. U [CBSE 2015]
- **Ans.** (i)  $F_2$  is the stronger oxidising agent than chlorine :
  - (a) Low enthalpy of dissociation of F-F bond.
  - (b) Less negative electron gain enthalpy of F.
  - (c) High hydration enthalpy of F<sup>-</sup> ion.
  - (ii) The main reaction in contact process is

$$2SO_2 + O_2 \rightleftharpoons 2SO_3$$

This reaction is reversible and conditions to increase the yield of  $SO_3$  are :

1

1

1 1

1

 $1\frac{1}{2}$ 

(a) High pressure

(b) Low temperature (optimum temperature 720 K) should be maintained and

(c)  $V_2O_5$  as catalyst.  $1\frac{1}{2}$ 

- Q. 4. (i) Draw the structure of a noble gas species which is isostructural with BrO<sub>3</sub><sup>-</sup>.
- (ii) Considering the parameters such as bond dissociation enthalpy, electron gain enthalpy and hydration enthalpy, compare the oxidising power of F<sub>2</sub> and Cl<sub>2</sub>.
- (iii) Why is  $K_{a_2} << K_{a_1}$  for  $H_2SO_4$  in water ?

#### OR

**Explain the following :** 

- (i) Hydrogen fluoride is a weaker acid than hydrogen chloride in aqueous solution.
- (ii) SF<sub>6</sub> is inert towards hydrolysis.
- (iii) Out of noble gases only Xenon is known to form established chemical compounds.

#### A&E [CBSE SQP 2016]

1

1

1

1

1

**Ans. (i)** XeO<sub>3</sub> is isostructural with  $BrO_3^-$ . (pyramidal structure)

C

XeO<sub>3</sub>

Pyramidal

(ii) The bond dissociation enthalpy of E-F bond is lower

 $F^-$  ion is much higher than that of  $CI^-$  ion.

stronger oxidizing agent than Cl<sub>2</sub>.

dissociation constants.  $K_{a_2} << K_{a_1}$ .

H<sub>2</sub>SO<sub>4</sub>.

than that of Cl-Cl bond and hydration enthalpy of

These two factors more than compensate the less

negative electron gain enthalpy of F<sub>2</sub>. Thus, F<sub>2</sub> is a

This is because the negatively charged HSO<sub>4</sub><sup>-</sup> ion

resonance stabilized which has much less tendency

to donate a proton to H<sub>2</sub>O as compared to neutral

less readily than HCl in aqueous solution to give H<sup>+</sup>

hence does not allow H2O molecules to attack the S

molecule. Also, F does not have d-orbitals to accept

**OR** (i) Due to stronger H-F bond than HCl bond, HF ionises

ions. Therefore, HF is a weaker acid than HCl.

the electrons donated by H<sub>2</sub>O molecules.

(ii) In  $SF_{6'}$  S is sterically protected by six F atoms and

(iii) H<sub>2</sub>SO<sub>4</sub> ionises in two stages and hence has two

(iii) Except radon which is radioactive, Xenon has least ionisation energy among noble gases and hence it readily forms chemical compounds particularly with  $O_2$  and  $F_2$ .

#### Q. 5. (i) Draw the structure of the following



[CBSE Marking Scheme 2015]

- Q. 6. (i) What happens when :
  - (a) chlorine gas reacts with cold and dilute solution of NaOH ?
  - (b) XeF<sub>2</sub> undergoes hydrolysis ?
  - (ii) Assign suitable reasons for the following :

(a) Out of noble gases only Xenon is known to form established chemical compounds.

U + A & E [CBSE Comptt. Delhi/OD 2018]

- Ans. (i) (a)  $2NaOH + Cl_2 \rightarrow NaCl + NaOCl + H_2O$  1 (b)  $2XeF_2(s) + 2H_2O(l) \rightarrow 2Xe(g) + 4HF(aq) + O_2(g)$ 1
- (ii) Xe has least ionization energy among the noble gases and hence it forms chemical compounds particularly with  $O_2$  and  $F_2$ . 1

[CBSE Marking Scheme 2018]



• Balance the chemical equations. Draw the structures with lone pair of electrons (if present). Avoid overwriting.

(5 marks each)

- Q. 2. (i) Write balanced equations for the following
  - (a) Chlorine reacts with dry slaked lime.
  - (b) Carbon reacts with concentrated H<sub>2</sub>SO<sub>4</sub>.
  - (ii) Describe the contact process for the manufacture of sulphuric acid with special reference to the reaction conditions, catalysts used and the yield in R + U [CBSE Comptt. Delhi 2015]

Ans. (i) (a)  $2Ca(OH)_2 + 2Cl_2 \rightarrow Ca(OCl)_2 + CaCl_2 + 2H_2O$ 

**b)** C + 2H<sub>2</sub>SO<sub>4</sub>(conc.) 
$$\rightarrow$$
 CO<sub>2</sub> + 2SO<sub>2</sub> + 2H<sub>2</sub>O

(ii) It is manufactured by Contact Process which

- (a) burning of sulphur or sulphide ores in air to
- (b) conversion of  $SO_2$  to  $SO_3$  by the reaction with oxygen in the presence of a catalyst  $(V_2O_5)$ .

absorption of SO<sub>3</sub> in H<sub>2</sub>SO<sub>4</sub> to give Oleum  $(H_2S_2O_7)$ . The oleum obtained is diluted to give 1

$$O_2(g) + O_2(g) \xrightarrow{V_2O_5} 2SO_3(g)$$

Reaction condition - pressure of 2 bar and

[CBSE Marking Scheme 2015]

- (a) Reducing character decreases from SO<sub>2</sub> to TeO<sub>2</sub>.
- (c) Xenon forms compounds with fluorine and

- A & E + R [CBSE Comptt. OD Set-1, 2, 3 2017]
- Ans. (i) (a) Stability of higher oxidation state decreases down the group from S to Te/Stability of lower oxidation state increases down the group from S to
  - (b)  $ClO_3$  is more stable than  $ClO^-/ClO_3^-$  is a weak conjugate base than ClO<sup>-</sup>/Due to higher oxidation
  - (c) Fluorine and oxygen are most electronegative and
  - (a)  $4NaCl + MnO_2 + 4H_2SO_4 \rightarrow MnCl_2 + 4NaHSO_4 +$

 $2H_2O + Cl_2$  1

(b)  $6XeF_4$ +  $12H_2O \rightarrow 4Xe + 2XeO_3 + 24HF + 3O_2$  1 [CBSE Marking Scheme 2017]

#### Answering Tip

• (ii) Given balanced chemical reactions. Write all the products formed.

