

## (Chapter 7)(The p – Block Elements)

### XII

#### Intext Questions

**Question 7.1:**

Why are pentahalides more covalent than trihalides?

Answer

In pentahalides, the oxidation state is +5 and in trihalides, the oxidation state is +3. Since the metal ion with a high charge has more polarizing power, pentahalides are more covalent than trihalides.

**Question 7.2:**

Why is  $\text{BiH}_3$  the strongest reducing agent amongst all the hydrides of Group 15 elements?

Answer

As we move down a group, the atomic size increases and the stability of the hydrides of group 15 elements decreases. Since the stability of hydrides decreases on moving from  $\text{NH}_3$  to  $\text{BiH}_3$ , the reducing character of the hydrides increases on moving from  $\text{NH}_3$  to  $\text{BiH}_3$ .

**Question 7.3:**

Why is  $\text{N}_2$  less reactive at room temperature?

Answer

The two N atoms in  $\text{N}_2$  are bonded to each other by very strong triple covalent bonds. The bond dissociation energy of this bond is very high. As a result,  $\text{N}_2$  is less reactive at room temperature.

**Question 7.4:**

Mention the conditions required to maximise the yield of ammonia.

Answer

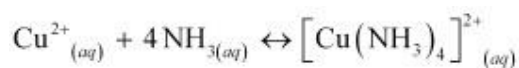
Ammonia is prepared using the Haber's process. The yield of ammonia can be maximized under the following conditions: **(i)** High pressure ( $\sim 200$  atm)  
**(ii)** A temperature of  $\sim 700$  K

(iii) Use of a catalyst such as iron oxide mixed with small amounts of  $K_2O$  and  $Al_2O_3$

**Question 7.5:**

How does ammonia react with a solution of  $Cu^{2+}$ ? Answer

$NH_3$  acts as a Lewis base. It donates its electron pair and forms a linkage with metal ion.



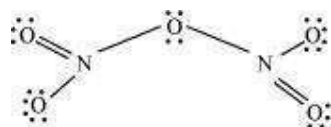
Blue

Deep blue

**Question 7.6:**

What is the covalence of nitrogen in  $N_2O_5$ ?

Answer



From the structure of  $N_2O_5$ , it is evident that the covalence of nitrogen is 4.

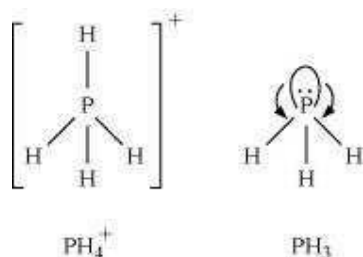
**Question 7.7:**

Bond angle in  $PH_4^+$  is higher than that in  $PH_3$ . Why?

Answer

In  $PH_3$ , P is  $sp^3$  hybridized. Three orbitals are involved in bonding with three hydrogen atoms and the fourth one contains a lone pair. As lone pair-bond pair repulsion is stronger than bond pair-bond pair repulsion, the tetrahedral shape associated with  $sp^3$  bonding is changed to pyramidal.  $PH_3$  combines with a proton to form  $PH_4^+$  in which the lone pair is absent. Due to the absence of lone pair in  $PH_4^+$ , there is no lone pair-bond pair repulsion.

Hence, the bond angle in  $PH_4^+$  is higher than the bond angle in  $PH_3$ .

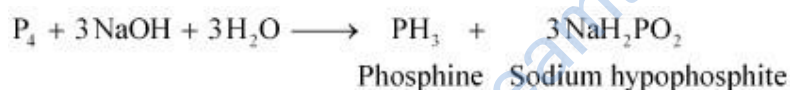


**Question 7.8:**

What happens when white phosphorus is heated with concentrated NaOH solution in an inert atmosphere of CO<sub>2</sub>?

Answer

White phosphorous dissolves in boiling NaOH solution (in a CO<sub>2</sub> atmosphere) to give phosphine, PH<sub>3</sub>.



**Question 7.9:**

What happens when PCl<sub>5</sub> is heated?

Answer

All the bonds that are present in PCl<sub>5</sub> are not similar. It has three equatorial and two axial bonds. The equatorial bonds are stronger than the axial ones. Therefore, when PCl<sub>5</sub> is heated strongly, it decomposes to form PCl<sub>3</sub>.



**Question 7.10:**

Write a balanced equation for the hydrolytic reaction of PCl<sub>5</sub> in heavy water. Answer



Therefore, the net reaction can be written as

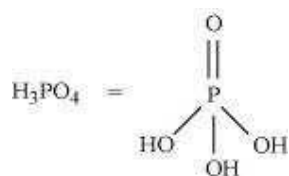


**Question 7.11:**

What is the basicity of  $\text{H}_3\text{PO}_4$ ?

Answer

$\text{H}_3\text{PO}_4$



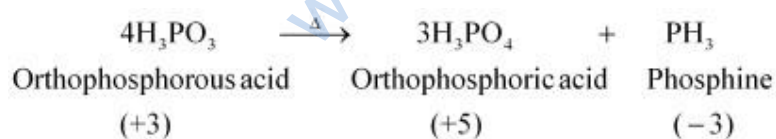
Since there are three OH groups present in  $\text{H}_3\text{PO}_4$ , its basicity is three i.e., it is a tribasic acid.

**Question 7.12:**

What happens when  $\text{H}_3\text{PO}_3$  is heated?

Answer

$\text{H}_3\text{PO}_3$ , on heating, undergoes disproportionation reaction to form  $\text{PH}_3$  and  $\text{H}_3\text{PO}_4$ . The oxidation numbers of P in  $\text{H}_3\text{PO}_3$ ,  $\text{PH}_3$ , and  $\text{H}_3\text{PO}_4$  are +3, -3, and +5 respectively. As the oxidation number of the same element is decreasing and increasing during a particular reaction, the reaction is a disproportionation reaction.

**Question 7.13:**

List the important sources of sulphur.

Answer

Sulphur mainly exists in combined form in the earth's crust primarily as sulphates [gypsum ( $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ), Epsom salt ( $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ ), baryte ( $\text{BaSO}_4$ )] and sulphides [(galena ( $\text{PbS}$ ), zinc blends ( $\text{ZnS}$ ), copper pyrites ( $\text{CuFeS}_2$ )].

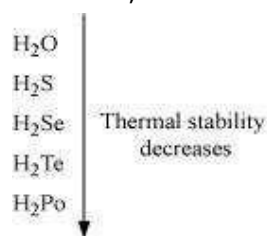
**Question 7.14:**

Write the order of thermal stability of the hydrides of Group 16 elements.

Answer

The thermal stability of hydrides decreases on moving down the group. This is due to a decrease in the bond dissociation enthalpy (H–E) of hydrides on moving down the group.

Therefore,

**Question 7.15:**

Why is H<sub>2</sub>O a liquid and H<sub>2</sub>S a gas?

Answer

H<sub>2</sub>O has oxygen as the central atom. Oxygen has smaller size and higher electronegativity as compared to sulphur. Therefore, there is extensive hydrogen bonding in H<sub>2</sub>O, which is absent in H<sub>2</sub>S. Molecules of H<sub>2</sub>S are held together only by weak van der Waal's forces of attraction.

Hence, H<sub>2</sub>O exists as a liquid while H<sub>2</sub>S as a solid.

**Question 7.16:**

Which of the following does not react with oxygen directly?

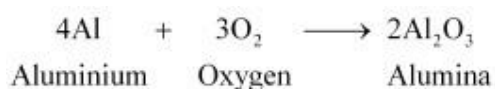
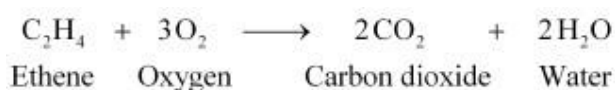
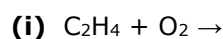
Zn, Ti, Pt, Fe

Answer

Pt is a noble metal and does not react very easily. All other elements, Zn, Ti, Fe, are quite reactive. Hence, oxygen does not react with platinum (Pt) directly.

**Question 7.17:**

Complete the following reactions:



(i)

(ii)



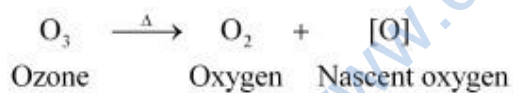
Answer

**Question 7.18:**

Why does  $O_3$  act as a powerful oxidising agent?

Answer

Ozone is not a very stable compound under normal conditions and decomposes readily on heating to give a molecule of oxygen and nascent oxygen. Nascent oxygen, being a free radical, is very reactive.



Therefore, ozone acts as a powerful oxidising agent.

**Question 7.19:**

How is  $O_3$  estimated quantitatively?

Answer

Quantitatively, ozone can be estimated with the help of potassium iodide. When ozone is made to react with potassium iodide solution buffered with a borate buffer (pH 9.2), iodine is liberated. This liberated iodine can be titrated against a standard solution of sodium thiosulphate using starch as an indicator. The reactions involved in the process are given below.



Iodide                  Ozone                          Iodine



Sodium                          Sodium  
thiosulphate                  tetrathionate

**Question 7.20:**

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

Answer

SO<sub>2</sub> acts as a reducing agent when passed through an aqueous solution containing Fe(III) salt. It reduces Fe(III) to Fe(II) i.e., ferric ions to ferrous ions.



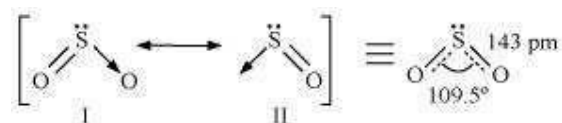
**Question 7.21:**

Comment on the nature of two S–O bonds formed in SO<sub>2</sub> molecule. Are the two S–O bonds in this molecule equal?

Answer

The electronic configuration of S is 1s<sup>2</sup> 2s<sup>2</sup> 2p<sup>6</sup> 3s<sup>2</sup> 3p<sup>4</sup>.

During the formation of SO<sub>2</sub>, one electron from 3p orbital goes to the 3d orbital and S undergoes sp<sup>2</sup> hybridization. Two of these orbitals form sigma bonds with two oxygen atoms and the third contains a lone pair. p-orbital and d-orbital contain an unpaired electron each. One of these electrons forms pn- pn bond with one oxygen atom and the other forms pn- dn bond with the other molecule. This is the reason SO<sub>2</sub> has a bent structure. Also, it is a resonance hybrid of structures **I** and **II**.



Both S–O bonds are equal in length (143 pm) and have a multiple bond character.

**Question 7.22:**

How is the presence of SO<sub>2</sub> detected?

Answer

SO<sub>2</sub> is a colourless and pungent smelling gas.

It can be detected with the help of potassium permanganate solution. When SO<sub>2</sub> is passed through an acidified potassium permanganate solution, it decolorizes the solution

as it reduces  $\text{MnO}_4^-$  ions to  $\text{Mn}^{2+}$  ions.



**Question 7.23:**

Mention three areas in which H<sub>2</sub>SO<sub>4</sub> plays an important role.

Answer

Sulphuric acid is an important industrial chemical and is used for a lot of purposes. Some important uses of sulphuric acid are given below.

- (i) It is used in fertilizer industry. It is used to make various fertilizers such as ammonium sulphate and calcium super phosphate.
- (ii) It is used in the manufacture of pigments, paints, and detergents.
- (iii) It is used in the manufacture of storage batteries.

**Question 7.24:**

Write the conditions to maximize the yield of H<sub>2</sub>SO<sub>4</sub> by Contact process.

Answer

Manufacture of sulphuric acid by Contact process involves three steps.

1. Burning of ores to form SO<sub>2</sub>
2. Conversion of SO<sub>2</sub> to SO<sub>3</sub> by the reaction of the former with O<sub>2</sub> (V<sub>2</sub>O<sub>5</sub> is used in this process as a catalyst.)
3. Absorption of SO<sub>3</sub> in H<sub>2</sub>SO<sub>4</sub> to give oleum (H<sub>2</sub>S<sub>2</sub>O<sub>7</sub>)

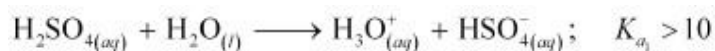
The key step in this process is the second step. In this step, two moles of gaseous reactants combine to give one mole of gaseous product. Also, this reaction is exothermic. Thus, in accordance with Le Chatelier's principle, to obtain the maximum amount of SO<sub>3</sub> gas, temperature should be low and pressure should be high.



**Question 7.25:**

Why is  $K_{a_2} \ll K_{a_1}$  for  $\text{H}_2\text{SO}_4$  in water?

Answer



It can be noticed that  $K_{a_1} \gg K_{a_2}$ . This is because a neutral  $\text{H}_2\text{SO}_4$  has a much higher tendency to lose a proton than the negatively charged  $\text{HSO}_4^-$ . Thus, the former is a much stronger acid than the latter.

**Question 7.26:**

Considering the parameters such as bond dissociation enthalpy, electron gain enthalpy and hydration enthalpy, compare the oxidising power of  $\text{F}_2$  and  $\text{Cl}_2$ .

Answer

Fluorine is a much stronger oxidizing agent than chlorine. The oxidizing power depends on three factors.

1. Bond dissociation energy
2. Electron gain enthalpy
3. Hydration enthalpy

The electron gain enthalpy of chlorine is more negative than that of fluorine. However, the bond dissociation energy of fluorine is much lesser than that of chlorine. Also, because of its small size, the hydration energy of fluorine is much higher than that of chlorine. Therefore, the latter two factors more than compensate for the less negative electron gain enthalpy of fluorine. Thus, fluorine is a much stronger oxidizing agent than chlorine.

**Question 7.27:**

Give two examples to show the anomalous behaviour of fluorine.

Answer

**Anomalous behaviour of fluorine**

- (i) It forms only one oxoacid as compared to other halogens that form a number of oxoacids.
- (ii) Ionisation enthalpy, electronegativity, and electrode potential of fluorine are much higher than expected.

**Question 7.28:**

Sea is the greatest source of some halogens. Comment.

Answer

Sea water contains chlorides, bromides, and iodides of Na, K, Mg, and Ca. However, it primarily contains NaCl. The deposits of dried up sea beds contain sodium chloride and carnallite,  $\text{KCl} \cdot \text{MgCl}_2 \cdot 6\text{H}_2\text{O}$ . Marine life also contains iodine in their systems. For example, sea weeds contain upto 0.5% iodine as sodium iodide. Thus, sea is the greatest source of halogens.

**Question 7.29:**

Give the reason for bleaching action of  $\text{Cl}_2$ .

Answer

When chlorine reacts with water, it produces nascent oxygen. This nascent oxygen then combines with the coloured substances present in the organic matter to oxidize them into colourless substances.



Coloured substances +  $[\text{O}] \rightarrow$  Oxidized colourless substance

**Question 7.30:**

Name two poisonous gases which can be prepared from chlorine gas.

Answer

Two poisonous gases that can be prepared from chlorine gas are

- (i) Phosgene ( $\text{COCl}_2$ )
- (ii) Mustard gas ( $\text{ClCH}_2\text{CH}_2\text{SCH}_2\text{CH}_2\text{Cl}$ )

**Question 7.31:**

Why is ICl more reactive than I<sub>2</sub>?

Answer

ICl is more reactive than I<sub>2</sub> because I–Cl bond in ICl is weaker than I–I bond in I<sub>2</sub>.

**Question 7.32:**

Why is helium used in diving apparatus?

Answer

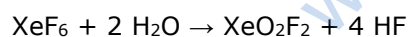
Air contains a large amount of nitrogen and the solubility of gases in liquids increases with increase in pressure. When sea divers dive deep into the sea, large amount of nitrogen dissolves in their blood. When they come back to the surface, solubility of nitrogen decreases and it separates from the blood and forms small air bubbles. This leads to a dangerous medical condition called bends. Therefore, air in oxygen cylinders used for diving is diluted with helium gas. This is done as He is sparingly less soluble in blood.

**Question 7.33:**

Balance the following equation:  $\text{XeF}_6 + \text{H}_2\text{O} \rightarrow \text{XeO}_2\text{F}_2 + \text{HF}$

Answer

**Balanced equation**



**Question 7.34:**

Why has it been difficult to study the chemistry of radon?

Answer

It is difficult to study the chemistry of radon because it is a radioactive substance having a half-life of only 3.82 days. Also, compounds of radon such as RnF<sub>2</sub> have not been isolated. They have only been identified.