# Very Short Answer Questions

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## Very Short Answer Questions (PYQ)

**Q.1. Which allotrope of sulphur is thermally stable at room temperature?**

**[*CBSE (F) 2015*]**

**Ans.** Rhombic Sulphur

**Q.2. On adding NaOH to ammonium sulphate, a colourless gas with pungent odour is evolved which forms a blue coloured complex with $Cu^{2+}$ ion. Identify the gas.**

**[*CBSE Delhi 2016*] [HOTS]**

**Ans.** Ammonia, $NH_3$.

**Q.3. On heating Cu turnings with conc. $HNO_3$, a brown coloured gas is evolved which on cooling dimerises. Identify the gas.**

**[*CBSE (F) 2016*] [HOTS]**

**Ans.** Nitrogen dioxide ($NO_2$)

**Q.4. On heating copper turnings with conc. $H_2SO_4$, a colourless gas with pungent smell is evolved which decolourises acidified $KMnO_4$ solution. Identify the gas.**

**[*CBSE East 2016*] [*HOTS*]**

**Ans.** Sulphur dioxide ($SO_2$)

**Q.5. Write the formula of the compound of phosphorous which is obtained when conc. $HNO_3$ oxidises $P_4$.**

**[*CBSE (AI) 2017*]**

**Ans.**

$$H_3PO_4\ ,\ P_4 + 20\,HNO_3 \quad \rightarrow \quad 4H_3PO_4 + 20\,NO_2 + 4H_2O$$

**Q.6. Write the formula of the compound of iodine which is obtained when conc. $HNO_3$ oxidises $I_2$.**

**[*CBSE (AI) 2017*]**

**Ans.**

$HIO_3$

$$I_2 + 10\,HNO_3 \rightarrow 2\,HIO_3 + 10\,NO_2 + 4H_2O$$

**Q.7. Arrange the following hydrides of Group-16 elements in the increasing order of their thermal stability:**

**$H_2O$, $H_2S$, $H_2Se$, $H_2Te$**

**[*CBSE (F) 2017*]**

**Ans.** $H_2Te < H_2Se < H_2S < H_2O$

**Q.8. Write the formula of the compound of sulphur which is obtained when conc. $HNO_3$ oxidises $S_8$.**

**[*CBSE (AI) 2017*]**

**Ans.**

$H_2SO_4$

$$S_8 + 48\,HNO_3 \rightarrow 8H_2\,SO_4 + 48\,NO_2 + 16H_2O$$

**Q.9. Arrange the following hydrides of Group-16 elements in the decreasing order of their acidic strength:**

**$H_2O$, $H_2S$, $H_2Se$, $H_2Te$**

**[*CBSE (F) 2017*]**

**Ans.** $H_2Te > H_2Se > H_2S > H_2O$

**Q.10. Arrange the following hydrides of Group-16 elements in the decreasing order of their reducing character:**

**$H_2O$, $H_2S$, $H_2Se$, $H_2Te$**

**[*CBSE (F) 2017*]**

**Ans.** $H_2Te > H_2Se > H_2S > H_2O$

**Q.11. What is the covalency of nitrogen in $N_2O_5$?**

**[*CBSE Delhi 2013*]**

**Ans.** Four.

**Q. 12.**

**Which one of $PCl_4^+$ and $PCl_4^-$ is not likely to exist and why?**

**[*CBSE Delhi 2012*]**

**Ans.**

$PCl_4^-$, as phosphorus has 10 electrons which can't be accommodated in $sp^3$ hybrid orbitals.

**Q.13. Although the H-bonding in hydrogen fluoride is much stronger than that in water, yet water has a much higher boiling point than hydrogen fluoride. Why?**

**[*CBSE (F) 2012*]**

**Ans.** This is because hydrogen bonding is multidimensional in water whereas in HF it is linear.

**Q.14. Why is Bi (V) a stronger oxidant than Sb (V)?**

**[*CBSE Delhi 2009*]**

**Ans.** Because Bi (V) is more stable than Sb (V) due to inert pair effect.

**Q.15. Why is red phosphorus less reactive than white phosphorus?**

**[*CBSE (AI) 2009*]**

**Ans.** This is due to polymeric structure of red phosphorus or angular strain in P4 molecule of white phosphorus where the angle is only 60°.

Q.16. **Which one has higher electron gain enthalpy with negative sign, sulphur or oxygen?**

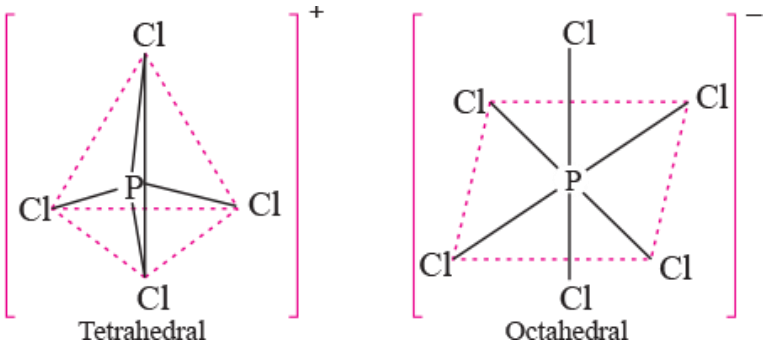
**[*CBSE (F) 2009*]**

**Ans.** Sulphur

**Q.17. Draw the structure of solid $PCl_5$.**

**[*CBSE (F) 2013*]**

**Ans.**




## Very Short Answer Questions (OIQ)

**Q.1. $PH_3$ forms bubbles when passed slowly in water but NH3 dissolves. Explain why.**

**[*NCERT Exemplar*]**

**Ans.** $NH_3$ forms hydrogen bonds with water therefore it is soluble in it but $PH_3$ cannot form hydrogen bond with water so it escapes as gas.

Q.2. **Why is nitric oxide paramagnetic in gaseous state but the solid obtained on cooling it is diamagnetic?**

**[*NCERT Exemplar*]**

**Ans.** In gaseous state $NO_2$ exists as monomer which has one unpaired electron but in solid state it dimerises to $N_2O_4$ so no unpaired electron is left hence solid form is diamagnetic.

Q.3. **In the preparation of $H_2SO_4$ by contact process, why is $SO_3$ not absorbed directly in water to form $H_2SO_4$?**

**[*NCERT Exemplar*]**

**Ans.** Acid fog is formed, which is difficult to condense.

**Q.4.**

In which one of the two structures, $NO_2^+$ and $NO_2^-$ the bond angle has a higher value?

**Ans.**

$NO_2^+$ has higher bond angle than $NO_2^-$ which has a lone pair of electrons on the central atom.

**Q. 5. The maximum number of covalent bonds formed by nitrogen is 4. Why?**

**Ans.** Nitrogen has three unpaired electrons and one lone pair of electrons, therefore, it can form **three covalent bonds and one coordinate bond**

**Q.6.**

**$BH_4^-$ and $NH_4^+$ are isolobal. Explain.**

**Ans.**

Both $BH_4^-$ **and** $NH_4^+$ have tetrahedral shapes, *i.e.*, four lobes of $sp^3$-hybridised orbitals. Hence, they are isolobal.

**Q.7. Give reasons for the least reactivity of nitrogen molecule.**

**Ans.** Due to presence of a triple bond between the two N-atoms, the bond dissociation enthalpy (941.4 kJ $mol^{-1}$) is very high. Hence, $N_2$ is the least reactive.

**Q.8. In trimethylamine, the nitrogen has a pyramidal geometry whereas in trisilylamine $N(SiH_3)_3$, it has a planar geometry.**

**Ans.** $(CH_3)_3N$ is pyramidal due to $sp^3$ hybridisation and has a lone pair of electrons. $(SiH_3)_3$ N has $sp^2$hybridisation because lone pair of nitrogen is donated to vacant *d*-orbital of Si.

**Q.9. What is the difference between the nature of π-bonds present in $H_3PO_3$ and $HNO_3$ molecules?**

**Ans.** In $H_3PO_3$, there is pπ – dπ bond whereas in $HNO_3$, there is pπ – pπ bond.

**Q.10. Write a balanced chemical equation for the reaction showing catalytic oxidation of $NH_3$ by atmospheric oxygen.**

**[*NCERT Exemplar*]**

**Ans.**

$$4\,NH_3 + 5O_2 \xrightarrow[500\ K,\ 9\ bar]{Pt/Rh\ gauge\ catalyst} 4NO + 6H_2O$$

**Q.11. Why does orthophosphoric acid exist as a syrupy liquid?**

**Ans.** Orthophosphoric acid contains three O—H groups and hence undergoes extensive H-bonding.

**Q.12. Why is $NH_3$ a good complexing agent?**

**Ans.** $NH_3$ is a good complexing agent because nitrogen has a lone pair of electrons which it can donate to form coordinate bond.

**Q.13. Why does $NH_3$ act as a Lewis base?**

**Ans.** Nitrogen atom in $NH_3$ has one lone pair of electrons which is available for donation. Therefore, it acts as a Lewis base.

**Q.14. In what way can it be proved that $PH_3$ is basic in nature?**

**Ans.** $PH_3$ reacts with acids like HI to form $PH_4I$ which shows that it is basic in nature.

$$PH_3 + HI \rightarrow PH_4I$$

Due to lone pair of electrons on P atom, $PH_3$ is acting as a Lewis base in the above reaction.

**Q.15. Why does $PCl_3$ fume in moisture?**

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

$$PCl_3 + 3H_2O \rightarrow H_3PO_3 + 3HCl$$

**Q.16. Why do boiling points of noble gases increase from helium to radon?**

**Ans.** As the size of the noble gas increases, van der Waals' forces of attraction increase accordingly and hence the boiling points increase from He to Rn.

**Q.17. Why are the Group 16 elements called chalcogens?**

**Ans.** Chalcogens means ore forming. The elements of Group 16 are called chalcogens because many metals are found as oxides and sulphides and a few such as selenides and tellurides.

**Q.18. Elements of Group 16 generally show lower value of first ionisation enthalpy compared to the corresponding periods of Group 15. Why?**

**Ans.** Due to extra stable half-filled p-orbitals electronic configurations of Group 15 elements, larger amount of energy is required to remove electrons compared to Group 16 elements.

**Q.19. Explain why the tendency to show–2 oxidation state diminishes from sulphur to polonium?**

**Ans.** Atomic size increases from sulphur to polonium, therefore, tendency to gain two electrons decreases.

**Q.20. Which of the following hyride has the largest bond angle?**

**$H_2O$, $H_2S$, $H_2Se$ or $H_2Te$**

Ans. As the electronegativity of the central atom decreases, the repulsions between element-hydrogen bond pairs decreases and hence the angle decreases accordingly. Thus, $H_2O$ has the largest bond angle (104.5°).

**Q.21. Why sulphurous acid acts as a reducing agent?**

**Ans.** Due to the presence of a lone pair of electrons on the sulphur atom, sulphurous acid can be easily oxidised to sulphuric acid. Therefore, it acts as a reducing agent.

**Q.22. Concentrated $H_2SO_4$ is used as a dehydrating agent. Explain.**

**Ans.** Sulphuric acid has a strong affinity for water. It, therefore, removes water not only from materials which contain it but frequently removes oxygen and hydrogen from other compounds in the proportion required to form water ($H_2O$).

**Q.23. Sulphur disappears when boiled with sodium sulphite. Why?**

**Ans.** When sodium sulphite is heated with sulphur, we get sodium thiosulphate which is soluble in water that is why sulphur disappears.

$$Na_2SO_3 + S \xrightarrow{\text{heat}} Na_2S_2O_3$$

**Q.24.**

**Iodine form $I_3^-$ but $F_2$ does not form $F_3^-$ ions. Why?**

**Ans.**

$I_2$, because of the presence of vacant *d*-orbitals, accepts electrons from $I^-$ ions to form $I_3^-$ ions but $F_2$ because of the absence of *d*-orbitals does not accept electrons from $F^-$ ions to form $F_3^-$ ions.

**Q.25. Why is $I_2$ more soluble in KI than in water?**

**Ans.** It is due to formation of soluble complex $KI_3$.

$I_2+KI \rightarrow KI_3$

**Q.26. Can $FCl_3$ exist? Comment.**

**Ans.** No, because F atom has no *d*-orbital and therefore it cannot expand its valance shell. Further, three big sized Cl atoms cannot be accommodated around a small F atom.

**Q. 27. In interhalogen compounds of the type $AB_5$ and $AB_7$, B is invariably fluorine. Why?**

**Ans.** Fluorine being the strongest oxidising agent, can form interhalogen compounds in +5 and +7 oxidation state.

**Q.28. Which of the three is the strongest oxidising agent:**

$ClO_4^-$, $BrO_4^-$, $IO_4^-$ ?

**Ans.**

$BrO_4^-$ is the strongest oxidising agent.

**Q.29. Fluorine exhibits only –1 oxidation state whereas other halogens exhibit +1, +3, +5 and +7 oxidation states also. Explain.**

**Ans.** Fluorine is the most electronegative element and cannot exhibit any positive oxidation state. Other halogens have *d*-orbitals and therefore, can expand their octets and show +1, +3, +5 and +7 oxidation states also.

**Q.30. Why is $F_2O$ referred to as a fluoride but $Cl_2O$ is an oxide?**

**Ans.** $F_2O$ is called oxygen fluoride because fluorine is more electronegative than oxygen whereas $Cl_2O$ is called chlorine oxide because oxygen is more electronegative than chlorine.

**Q.31. Why are the elements of Group 18 known as noble gases?**

**Ans.** The elements present in Group 18 have their valence shell orbitals completely filled and, therefore, react with a few elements only under certain conditions. Therefore, they are known as noble gases.

**Q.32. Out of $H_2O$ and $H_2S$, which one has higher bond angle and why?**

**[*NCERT Exemplar*]**

**Ans.** Bond angle of $H_2O$ is larger, because oxygen is more electronegative than sulphur. Therefore, bond pair electron of O—H bond will be closer to oxygen and there will be more bond pair–bond pair repulsion between bond pairs of two O—H bonds.

**Q. 33. How does xenon atom form compounds with fluorine even though the xenon atom has a closed shell configuration?**

**Ans.** This is because 1, 2 or 3 electrons from the 5*p*-orbitals can be excited to empty 5d-orbitals and thus making 2, 4 or 6 half-filled orbitals available for bond formation.

**Q.34. Explain why ozone is thermodynamically less stable than oxygen.**

**[*NCERT Exemplar*]**

**Ans.** Ozone is thermodynamically unstable with respect to oxygen as its decomposition into oxygen results in the liberation of heat ($\Delta H$ is –ve) and an increase in entropy ($\Delta S$ is +ve). These two effects reinforce each other, resulting in large negative Gibbs energy change ($\Delta G$) for its conversion into oxygen.

# Short Answer Questions-I

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## Short Answer Questions-I (PYQ)

**Q.1. Complete the following equations:**

**[*CBSE (AI) 2014*]**

**Q. $P_4 + H_2O \rightarrow$**

**Ans.** $P_4 + H_2O \rightarrow$ No reaction

**Q. $XeF_4 + O_2F_2 \rightarrow$**

**Ans.** $XeF_4 + O_2F_2 \rightarrow XeF_6 + O_2$

**Q.2. Complete the following chemical equations:**

**[*CBSE Delhi 2014*]**

**Q. $Ca_3P_2 + H_2O \rightarrow$**

**Ans.** $Ca_3P_2 + 6H_2O \rightarrow 2PH_3 + 3Ca(OH)_2$

**Q. $Cu + H_2SO_4$ (conc.) $\rightarrow$**

**Ans.** $Cu + 2H_2SO_4$ (conc.) $\rightarrow CuSO_4 + SO_2 + 2H_2O$

**Q.3. Complete the following equations:**

**[*CBSE (AI) 2014*]**

**Q. $2Ag + PCl_5 \rightarrow$**

**Ans.** $2Ag+PCl_5 \rightarrow 2AgCl+PCl_3$

**Q. $CaF_2 + H_2SO_4 \rightarrow$**

**Ans.** $CaF_2+H_2SO_4 \rightarrow 2HF+CaSO_4$

**Q.4. Complete the following equations:**

**[*CBSE (AI) 2014*]**

**Q. C + conc. $H_2SO_4 \rightarrow$**

**Ans.** $C + 2H_2SO_4(conc.) \rightarrow CO_2 + 2SO_2 + 2H_2O$

**Q. $XeF_2 + H_2O \rightarrow$**

**Ans.** $2XeF_2(s) + 2H_2O(l) \rightarrow 2Xe(g) + 4HF(aq) + O_2(g)$

**Q.5. Complete the following chemical reaction equations:**

**[*CBSE (F) 2011*]**

**Q. $PH_3 + HgCl_2 \rightarrow$**

**Ans.**

$$2\,PH_3 + 3\,\underset{\text{Mercuric chloride}}{HgCl_2} \rightarrow \underset{\text{Mercuric phosphide}}{Hg_3P_2}\downarrow + 6HCl$$

**Q.**

$$\underset{(\text{Excess})}{Br_2} + F_2 \rightarrow$$

Ans.

$$Br_2 + \underset{(\text{Excess})}{5F_2} \rightarrow 2\,BrF_5$$

**Q.6. Complete the following reactions:**

**[*CBSE Delhi 2017*]**

**Q. $NH_3 + 3Cl_2$ (excess) $\rightarrow$**

**Ans.** $NH_3 + 3Cl_2$ (excess) $\rightarrow$ $NCl_3 + 3HCl$

**Q. $XeF_6 + 2H_2O \rightarrow$**

**Ans.** $XeF_6 + 2H_2O \rightarrow XeO_2F_2 + 4HF$

**Q.7. Complete the following reactions:**

**[*CBSE Delhi 2017*]**

**Q. $Cl_2+H_2O\rightarrow$**

**Ans.** $Cl_2+H_2O\rightarrow HCl+HOCl$

**Q. $XeF_6+3H_2O\rightarrow$**

**Ans.**

$$XeF_6 + 3H_2O \rightarrow XeO_3 + 6\,HF$$

**Q.8. Complete the following chemical equations:**

**[*CBSE Delhi 2017*]**

**Q.**

$$F_2 + 2\,Cl^- \rightarrow$$

**Ans.**

$$F_2 + 2\,Cl^- \rightarrow 2F^- + Cl_2$$

**Q.**

$$2\,XeF_2 + 2H_2O \rightarrow$$

**Ans.**

$$2\,XeF_2 + 2H_2O \rightarrow 2Xe + 4HF + O_2$$

**Q.9. What happens when**

**[*CBSE Delhi 2017*]**

**Q. $(NH_4)2Cr_2O_7$ is heated**

**Write the equation.**

**Ans.**

$$(NH_4)_2\,Cr_2\,O_7 \xrightarrow{\Delta} N_2 + 4H_2O + Cr_2\,O_3$$

**Q. $H_3PO_3$ is heated?**

**Write the equation.**

**Ans.**

$$4H_3\,PO_3 \rightarrow 3H_3\,PO_4 + PH_3$$

**Q.10. $SO_3$ is passed through water?**

**Write the equation.**

**Ans.**

$$SO_3 + H_2O \rightarrow H_2SO_4$$

**Q.11. What happens when**

**[*CBSE Delhi 2017*]**

**Q. HCl is added to MnO2?**

**Write the equation involved.**

**Ans.**

$$MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + 2H_2O$$

**Q. $PCl_5$ is heated?**

**Write the equation involved.**

**Ans.**

$$PCl_5 \xrightarrow{\Delta} PCl_3 + Cl_2$$

**Q.12. Write chemical equations for the following processes:**

**[*CBSE Delhi 2010*]**

**Q. Orthophosphorous acid is heated.**

**Ans.** $4H_3PO_3 \rightarrow 3H_3PO_4 + PH_3$

**Q. $PtF_6$ and xenon are mixed together.**

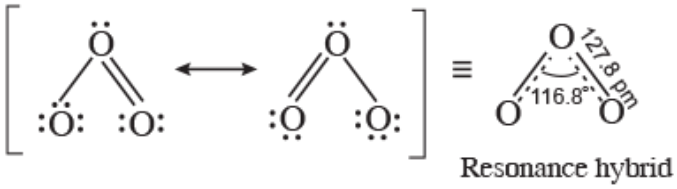
**Ans.** $PtF_6 + Xe \rightarrow Xe^+ [PtF_6]^-$

**Q.13. Draw the structures of $O_3$ and $S_8$ molecules.**

**[*CBSE (F) 2010*]**

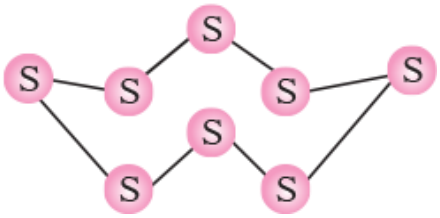
**Ans.**

(*i*) Ozone molecule




Resonance hybrid

(*ii*) $S_8$ molecule

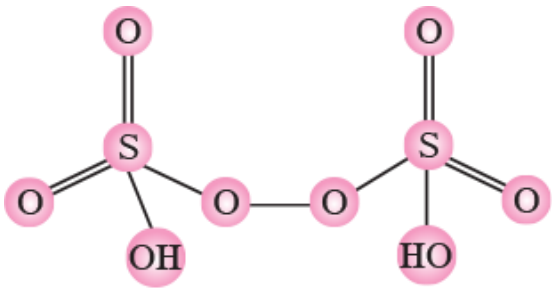



**Q.14. Draw the structures of the following:**

**[*CBSE Ajmer 2015*]**

**Q. $H_2S_2O_8$**

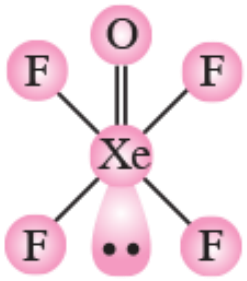
Ans.




Peroxodisulphuric acid
($H_2S_2O_8$)

**Q. $XeOF_4$**

**Ans.**



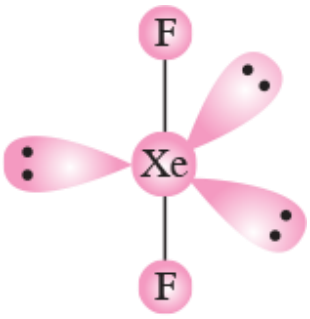

$XeOF_4(sp^3d^2)$
Square pyramidal

**Q.15. Draw the structures of the following:**

**[*CBSE (AI) 2014*]**

**Q. $XeF_2$**

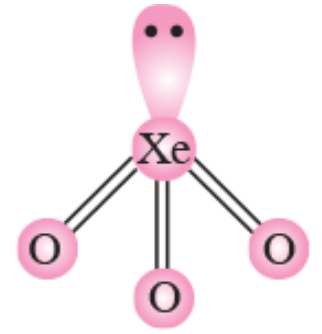
**Ans.** There are two bond pairs and three lone pairs electrons around central Xe atom in $XeF_2$. Therefore, according to VSEPR theory $XeF_2$ should be linear.




$XeF_2$

**Q. $XeO_3$**

**Ans.**



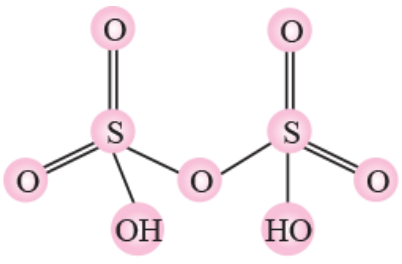

$XeO_3$, Pyramidal

**Q.16. Draw the structures of the following:**

**[*CBSE Delhi 2017*]**

**Q. $H_2S_2O_7$**

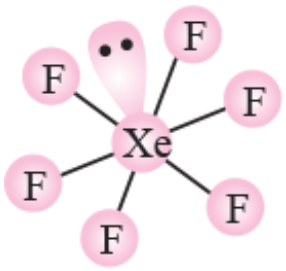
Ans.




$H_2S_2O_7$

**Q. $XeF_6$**

**Ans.**



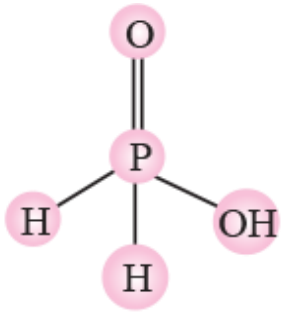

$XeF_6$
Distorted octahedral

**Q. Draw the structures of the following:**

**[*CBSE Delhi 2017*]**

**Q. $H_3PO_2$**

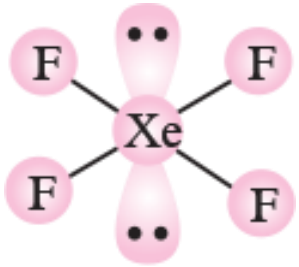
**Ans.**




Hypophosphorous acid
($H_3PO_2$)

Q. **$XeF_4$**

**Ans.**



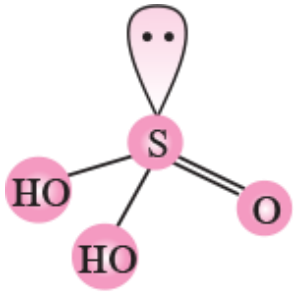

$XeF_4$
Square planar

**Q.18. Draw the structures of the following:**

[*CBSE (AI) 2017*]

**Q. $H_2SO_3$**

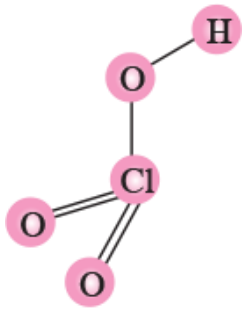
**Ans.**




Sulphurous acid
($H_2SO_3$)

**Q. $HClO_3$**

**Ans.**



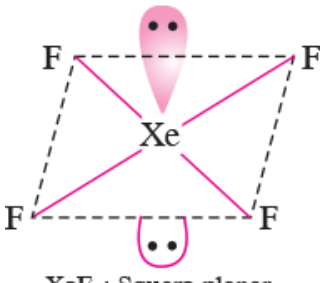

Chloric acid
($HClO_3$)

**Q. 19. Draw the structures of the following:**

[*CBSE (AI) 2017*]

**Q. $XeF_4$**

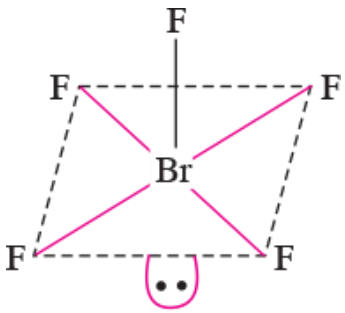
**Ans.**




$XeF_4$: Square planar

**Q. $BrF_5$**

**Ans.**




$BrF_5$: Square pyramidal

**Q.20. Account for the following:**

**[*CBSE (AI) 2014*]**

**Q. Iron on reaction with HCl forms $FeCl_2$ and not $FeCl_3$.**

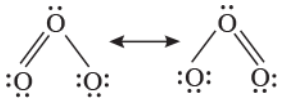
**Ans.** Iron reacts with HCl to form $FeCl_2$ and $H_2$.

$$Fe + 2HCl \rightarrow FeCl_2 + H_2$$

$H_2$ thus produced prevents the oxidation of $FeCl_2$ to $FeCl_3$.

**Q. The two O—O bond lengths in the ozone molecule are equal.**

**Ans.** Ozone is a resonance hybrid of the following two main structures:



As a result of resonance, the two O—O bond lengths in $O_3$ are equal.

**Q.21. Account for the following:**

**[*CBSE Delhi 2014*]**

**Q. Bi(V) is a stronger oxidising agent than Sb(V).**

**Ans.** Due to inert pair effect +3 oxidation state of Bi is more stable than its +5 oxidation state while +5 oxidation state of Sb is more stable than its +3 oxidation state. Therefore, Bi (V) can accept a pair of electrons to form more stable Bi (III) more easily than Sb (V). Hence, Bi (V) is a stronger oxidising agent than Sb (V).

**Q. N—N single bond is weaker than P—P single bond.**

**Ans.** N—N single bond is weaker than P—P single bond due to large interelectronic repulsion between the lone pairs of electrons present on the N atoms of N—N bond having small bond length.

**Q.22. Account for the following:**

**[*CBSE South 2016*]**

**Q. Boiling points of interhalogens are little higher as compared to pure halogens.**

Ans. This is due to some amount of polarity associated with X—X′ bond in interhalogens whereas pure halogens are non-polar.

**Q. Out of He and Xe, which one can easily form compound and why?**

**Ans.** Xe, due to much lower ionisation enthalpy of Xe (1170 kJ $mol^{-1}$) than He (2372 kJ $mol^{-1}$).

**Q.23. State reasons for each of the following:**

**[*CBSE Delhi 2011*]**

**Q.**

**The N—O bond in $NO_2^-$ is shorter than the N—O bond in $NO_3^-$.**

Ans.

This is because the N—O bond in $NO_2^-$ is an average of a single bond and a double bond whereas the N—O bond in $NO_3^-$ is an average of two single bonds and a double bond.

**Q. $SF_6$ is kinetically an inert substance.**

**Ans.** In $SF_6$, S atom is sterically protected by six F atoms and does not allow water molecules to attack the S atom. Further, F does not have d-orbitals to accept the electrons donated by $H_2O$ molecules. Due to these reasons, $SF_6$ is kinetically an inert substance.

**Q.24. How would you account for the following:**

**[*CBSE (AI) 2011*]**

**Q. $H_2S$ is more acidic than $H_2O$.**

**Ans.** This is because bond dissociation enthalpy of H—S bond is lower than that of H—O **bond.**

**Q. Both $O_2$ and $F_2$ stabilise higher oxidation states but the ability of oxygen to stabilise the higher oxidation state exceeds that of fluorine.**

**Ans.** This is due to tendency of oxygen to form multiple bonds with metal atom.

**Q.25. Account for the following:**

**[*CBSE (F) 2014*]**

**Q. Sulphur in vapour state exhibits paramagnetism.**

**Ans.** In vapour form sulphur partly exists as $S_2$ molecules which have two unpaired electrons in the antibonding π* molecular orbitals like $O_2$ molecule and hence, exhibits paramagnetism.

**Q. $H_3PO_2$ is a stronger reducing agent than $H_3PO_3$.**

**Ans.** Acids which contains P—H bonds have reducing character. Since $H_3PO_2$ contains two P—H bonds while $H_3PO_3$ contains only one P–H bond therefore $H_3PO_2$ is a stronger reducing agent than $H_3PO_3$.

**Q.26. Account for the following:**

**[*CBSE (F) 2013*]**

**Q. White phosphorus is more reactive than red phosphorus.**

**Ans.** This is due to polymeric structure of red phosphorus or angular strain in $P_4$ molecule of white phosphorus where the angle is only 60°.

**Q. $O_3$ is a powerful oxidising agent.**

**Ans.** Due to the ease with which it liberates atoms of nascent oxygen, it acts as a powerful oxidising agent. $O_3 \rightarrow O_2 + O$ (nascent oxygen)

**Q.27. Give reasons for the following:**

**[*CBSE (AI) 2013*]**

**Q. $R_3P = O$ exists but $R_3N = O$ does not, R is an alkyl group.**

Ans. N due to the absence of *d*-orbitals, cannot form pπ – dπ multiple bonds. Thus, N cannot expand its covalency beyond four but in $R_3N{=}O$, N has a covalency of 5. So, the

compound $R_3N{=}O$ does not exist. On the other hand, P due to the presence of *d*-orbitals forms pπ – dπ multiple bonds and hence can expand its covalency beyond 4. Therefore, P forms $R_3PO$ in which the covalency of P is 5.

**Q. $PbCl_4$ is more covalent than $PbCl_2$.**

**Ans.** Because Pb is in +4 oxidation state in $PbCl_4$ and has high charge/size ratio than $Pb^{2+}$, thus polarising power of $Pb^{4+}$ is greater than $Pb^{2+}$, and hence it is more covalent.

**Q.28. Account for the following:**

**[*CBSE Delhi 2009*]**

**Q. $NH_3$ is a stronger base than $PH_3$.**

**Ans.** $NH_3$ is a stronger base than $PH_3$. This is because the lone pair of electrons on N atom in $NH_3$ is directed and not diffused as it is in $PH_3$ due to larger size of phosphorus and hence more available for donation.

**Q. Sulphur has a greater tendency for catenation than oxygen.**

**Ans.** Sulphur has a greater tendency for catenation than oxygen because S—S bond is stronger than O—O bond due to less inter-electronic repulsions.

**Q. 29. Name the two most important allotropes of sulphur. Which one of the two is stable at room temperature? What happens when the stable form is heated above 370 K?**

**[*CBSE (F) 2014*]**

**Ans.** Two most important allotropes of sulphur are rhombic sulphur and monoclinic sulphur. The stable form at room temperature is rhombic sulphur. When rhombic sulphur is heated above 370 K, it gets converted into monoclinic sulphur.

## Short Answer Questions-I (OIQ)

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

**Q. $XeF_6$ is partially hydrolysed?**

**Ans.** $XeF_6 + H_2O \rightarrow XeOF_4 + 2HF$

$XeF_6 + 2H_2O \rightarrow XeO_2F_2 + 4HF$

**Q. Sulphur dioxide is passed into aqueous solution of Fe (III) salt?**

**Ans.**

$SO_2$ acts as a reducing agent and hence reduces an aqueous solution of Fe (III) salt to Fe (II) salt.

$$SO_2 + 2H_2O \rightarrow SO_4^{2-} + 4H^+ + 2e^-$$
$$2Fe^{3+} + 2e^- \rightarrow 2Fe^{2+}$$
$$2Fe^{3+} + SO_2 + 2H_2O \rightarrow 2Fe^{2+} + SO_4^{2-} + 4H^+$$

**Q.2. Complete the following chemical reaction equations:**

**Q. $P_4(s)$ + NaOH($aq$) + $H_2O(l)$ →**

**Ans.**

$$P_4(s) + 3NaOH(aq) + 3H_2O \rightarrow \underset{\text{Phosphine}}{PH_3} + 3NaH_2PO_2$$

**Q. $I^-$ ($aq$) + $H_2O(l)$ + $O_3(g)$ →**

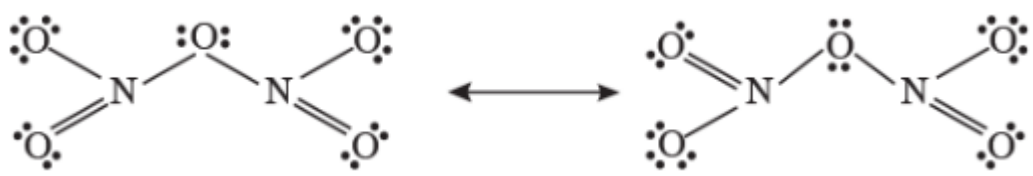
**Ans.** $2I^-(aq) + H_2O(l) + O_3(g) \rightarrow 2OH^-(aq) + I_2(s) + O_2(g)$

**Q.3. Nitric acid forms an oxide of nitrogen on reaction with $P_4O_{10}$. Write the reaction involved. Also write the resonating structures of the oxide of nitrogen formed.**

**[*NCERT Exemplar*]**

**Ans.**

$4HNO_3 + P_4O_{10} \rightarrow 4HPO_3 + 2N_2O_5$



**Q.4. Account for the following:**

**Q. Ozone acts as a powerful oxidising agent.**

**Ans.** Due to the ease with which it liberates atoms of nascent oxygen, it acts as a powerful oxidising agent.

$O_3 \rightarrow O_2 + O$ (nascent oxygen)

**Q. Noble gases have comparatively large atomic sizes.**

**Ans.** Noble gases have only Van der Waals' radii while others have covalent radii. As van der Waals' radii are larger than covalent radii, hence, noble gases have comparatively large atomic sizes.

**Q.5. Account for the following observations:**

**Q. Among the halogens, $F_2$ is the strongest oxidising agent.**

**Ans.** This is due to the

a. low enthalpy of dissociation of F—F bond.
b. high hydration enthalpy of $F^-$.

**Q. Acidity of oxo-acids of chlorine is HOCl < HOClO < $HOClO_2$ < $HOClO_3$.**

**Ans.** Oxygen is more electronegative than chlorine, therefore, dispersal of negative charge present on chlorine increases from $ClO^-$ to $Cl_4^-$ ion because number of oxygen atoms attached to chlorine is increasing. Therefore, stability of ions will increase in the order given below:

$$ClO^- < ClO_2^- < ClO_3^- < ClO_4^-$$

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

HClO < $HClO_2$ < $HClO_3$ < $HClO_4$

**Q.6. Give reasons for the following:**

**Q. $CN^-$ ion is known but $CP^-$ ion is not known.**

**Ans.** Nitrogen being smaller in size forms ρπ-ρπ multiple bonding with carbon, so $CN^-$ ion is known, but phosphorus does not form ρπ-ρπ bond as it is larger in size.

**Q. $NO_2$ dimerises to form $N_2O_4$.**

Ans. This is because $NO_2$ is an odd electron molecule and therefore gets dimerised to stable $N_2O_4$.

**Q.7. Give reasons for the following:**

**Q. $NCl_3$ gets readily hydrolysed while $NF_3$ does not.**

**Ans.** In $NCl_3$, Cl has vacant *d*-orbitals to accept the lone pair of electrons donated by O-atom of $H_2O$ molecule but in $NF_3$, F does not have *d*-orbitals.

$NCl_3 + 3H_2O \rightarrow NH_3 + 3HOCl$

$NF_3 + H_2O \rightarrow$ No reaction

**Q. Elemental nitrogen exists as a diatomic molecule whereas elemental phosphorus is a tetraatomic molecule.**

**Ans.** Nitrogen because of its small size and high electronegativity forms ρπ-ρπ multiple bonds. Thus, it exists as a diatomic molecule having a triple bond between the two N-atoms. Phosphorus due to its larger size and lower electronegativity usually does not form ρπ-ρπ multiple bonds with itself. Instead it prefers to form P–P single bonds and hence it exists as tetrahedral $P_4$ molecules.

**Q.8. Account for the following:**

**Q. $PF_5$ is known but $NF_5$ is not known.**

**Ans.** P has vacant 3*d*-orbitals in its valence shell while N does not have. As a result, P can form additional bonds to give $PF_5$ while N cannot extend its covalency beyond three and hence it forms only $NF_3$ but not $NF_5$.

**Q. Bismuth is a strong oxidising agent in the pentavalent state.**

**Ans.** As the inert pair effect is very prominent in Bi, its +5 oxidation state is less stable than its +3 oxidation state. In other words, bismuth in the pentavalent state can easily accept two electrons and thus gets reduced to trivalent bismuth.

$Bi^{5+} + 2e^- \rightarrow Bi^{3+}$

Thus, it acts as a strong oxidising agent.

**Q.9. Give reasons for the following:**

**Q. Oxygen generally exhibits an oxidation state of –2 only whereas other members of its family show oxidation states of +2, +4 and +6 as well.**

**Ans.** The electronic configuration of oxygen is $1S^2\ 2S^2\ 2P_x^2\ \ 2P_y^1\ \ 2P_z^1$ *i.e.*, it has two half-filled orbitals and there is no *d*-orbital available for excitation of electrons. Further, it is the most electronegative element of its family. Hence, it shows oxidation state of –2

only. Other elements like sulphur have d-orbitals available for excitation, thereby giving four and six half-filled orbitals. Moreover, they can combine with more electronegative elements. Hence, they show oxidation states of +2, +4 and +6 also.

**Q. Among the hydrides of Group 16, water shows unusual physical properties.**

**Ans.** Because of high electronegativity of O, the O—H in $H_2O$ forms strong intermolecular H-bonds. Thus, water exists as an associated molecule while other hydrides of Group 16 do not form H-bonds and hence exist as discrete molecules. Hence, water shows unusual physical properties, *i.e*., high boiling point, high thermal stability and weaker acidic character as compared to other hydrides of Group 16.

**Q.10. Account for the following:**

**Q. Compounds of fluorine with oxygen are called fluorides of oxygen and not the oxides of fluorine.**

**Ans.** This is because fluorine is more electronegative than oxygen.

Q. **Sulphur disappears when boiled with sodium sulphite.**

**Ans.** When sodium sulphite is heated with sulphur, we get sodium thiosulphate which is soluble in water that is why sulphur disappears.

$$Na_2SO_3 + S \xrightarrow{\text{Heat}} Na_2S_2O_3$$

**Q.11. Assign a reason for each of the following:**

**[*NCERT Exemplar*]**

**Q. $SCl_6$ is not known but $SF_6$ is known.**

**Ans.** Due to small size of fluorine, six $F^-$ ions can be accommodated around sulphur whereas chloride ion is comparatively larger in size, therefore, there will be interionic repulsion.

**Q. Sulphur hexafluoride is used as a gaseous electrical insulator.**

**Ans.** $SF_6$ is a colourless, odourless and non-toxic gas at room temperature. It is thermally stable and chemically inert. Because of its inertness and high tendency to suppress internal discharges, it is used as a gaseous electrical insulator in high voltage generators and switch gears.

**Q.12. Answer the following question:**

**Q. Why is HF acid stored in wax coated glass bottles?**

**Ans.** HF does not attack wax but reacts with glass. It dissolves $SiO_2$ present in glass forming hydrofluorosilicic acid.

$SiO_2 + 6HF \rightarrow H_2SiF_6 + 2H_2O$

**Q. $ClF_3$ exists but $FCl_3$ does not. Explain.**

**Ans.**

- **a.** Cl has vacant d-orbitals and hence can show an oxidation state of +3 but F has no *d*-orbitals, so, it cannot show positive oxidation states. Since F can show only –1 oxidation state, $FCl_3$ does not exist.
- **b.** Because of bigger size, Cl can accommodate three small F atoms around it while F being smaller cannot accommodate three large sized Cl atoms around it.

**Q.13. Give reasons:**

**Q. $NH_3$ has a higher proton affinity than $PH_3$.**

**Ans.** When $NH_3$ or $PH_3$ accepts a proton, an additional N—H or P—H bond is formed.

$H_3N : + H^+ \rightarrow NH+4$

$H_3P : + H^+ \rightarrow PH+4$

Due to the bigger size of P than N, P—H bond thus formed is much weaker than the N—H bond. Thus, NH3 has higher proton affinity than $PH_3$.

**Q. NO (Nitric oxide) is paramagnetic in the gaseous state but diamagnetic in the liquid and solid states.**

**Ans.** NO has an odd number of electrons (11 valence electrons) and hence is paramagnetic in the gaseous state. But in liquid and solid states, it exists as a symmetrical or asymmetrical dimer and hence is diamagnetic in these states.

**Q.14. Name three oxoacids of nitrogen. Write the disproportionation reaction of that oxoacid of nitrogen in which nitrogen is in + 3 oxidation state.**

**[*NCERT Exemplar*]**

**Ans.**

i. Nitrous acid, $HNO_2$

ii. Nitric acid, $HNO_3$

iii. Hyponitrous acid, $H_2N_2O_2$

In $HNO_2$, nitrogen is in +3 oxidation state.

$$3HNO_2 \xrightarrow{\text{Disproportionation}} HNO_3 + H_2O + 2NO$$

# Short Answer Questions-II

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## Short Answer Questions-II (PYQ)

**Q.1. Complete the following chemical equations:**

**[*CBSE (F) 2011*]**

**Q. $P_4 + SO_2Cl_2$ →**

**Ans.** $P_4 + 10SO_2Cl_2 \rightarrow 4PCl_5 + 10SO_2$

Q. **$Fe^{3+} + SO_2 + H_2O$ →**

**Ans.**

$$2Fe^{3+} + SO_2 + 2H_2O \rightarrow 2Fe^{2+} + 4H^+ + SO_4^{2-}$$

**Q.**

$$XeF_6 + \underset{(\text{excess})}{H_2O} \rightarrow$$

**Ans.**

$$XeF_6 + \underset{(\text{excess})}{3H_2O} \rightarrow XeO_3 + 6\,HF$$

**Q.2. Complete the following equations:**

**[*CBSE (F) 2013*]**

**Q. $PCl_3 + H_2O$ →**

**Ans.** $PCl_3 + 3H_2O \rightarrow H_3PO_3 + 3HCl$

**Q. $XeF_2 + PF_5$ →**

**Ans.** $XeF_2 + PF_5 \rightarrow [XeF]^+ [PF_6]^-$

**Q.**

$$NaN_3 \xrightarrow{\text{Heat}}$$

**Ans.**

$$2\,NaN_3 \xrightarrow{\text{Heat}} 2Na + 3N_2$$

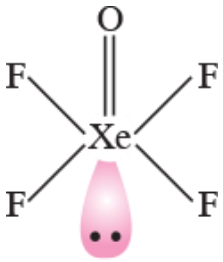
**Q.3. Answer the following question :**

**[*CBSE Delhi 2014*]**

**Q. Draw the structures of the following molecules:**

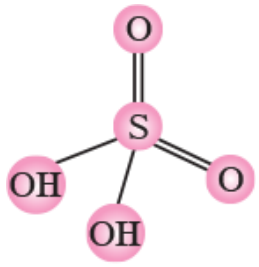
a. **$XeOF_4$**
b. **$H_2SO_4$**

**Ans. (a)**




$XeOF_4$

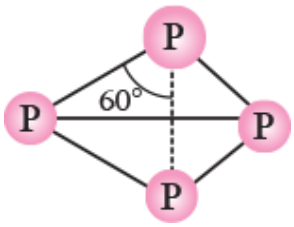
**(b)**



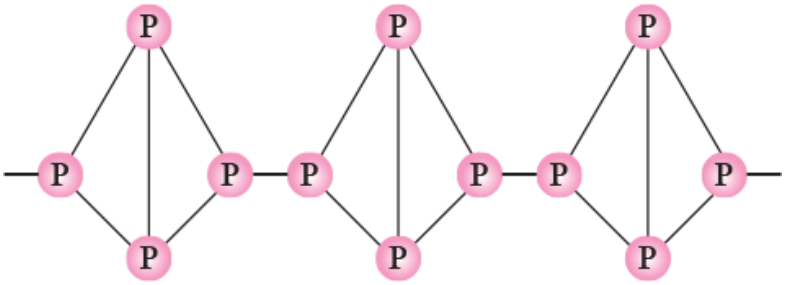

$H_2SO_4$

**Q. Write the structural difference between white phosphorus and red phosphorus.**

**Ans.** White phosphorus consists of discrete tetrahedral $P_4$ molecule with six P—P covalent bonds.




Red phosphorus has polymeric structure in which $P_4$ tetrahedra are linked together through P—P covalent bond to form chain.




**Q.4. Give reasons for the following:**

**[*CBSE Guwahati 2015*]**

**Q. $NH_3$ has a higher boiling point than $PH_3$.**

**Ans.** Due to small size and high electronegativity of N, $NH_3$ undergoes extensive intermolecular H-bonding and hence exist as an associated molecule. In contrast due to low electronegativity of P, $PH_3$ does not undergo H-bonding and thus exist as a discrete molecule. That is why, boiling point of $NH_3$ is higher than $PH_3$.

**Q. $H_2Te$ is more acidic than $H_2S$.**

**Ans.** Bond dissociation enthalpy of H—Te bond is less than H—S bond as size of Te is larger than that of S. So, it is more acidic than $H_2S$.

**Q. Chlorine water on standing loses its yellow colour.**

**Ans.** $Cl_2 + H_2O \rightarrow HCl + HOCl$

Due to formation of hydrochloric acid and hypochlorous acid chlorine water loses yellow colour on standing.

**Q.5. How would you account for the following:**

**[*CBSE (AI) 2010*]**

**Q. The electron gain enthalpy with negative sign is less for oxygen than that for sulphur.**

**Ans.** This is due to smaller size of oxygen the electron cloud is distributed over a small region of space, making electron density high which repels the incoming electrons.

**Q. Phosphorus shows greater tendency for catenation than nitrogen.**

**Ans.** Because P—P bond is stronger than N—N bond.

**Q. Fluorine never acts as the central atom in polyatomic interhalogen compounds.**

**Ans.** Fluorine never acts as the central atom in polyatomic interhalogen compounds since it is the most electronegative element of the group.

**Q.6. Account for the following:**

**[*CBSE (F) 2015*]**

**Q. Bond angle in $NH_4^+$ is higher than $NH_3$.**

**Ans.** N atom both in $NH_3$ and $NH_4^+$ is $sp^3$ hybridised. In $NH_4^+$ all the four orbitals are bonded whereas in $NH_3$there is a lone pair on N , which is responsible for lone pair-bond pair repulsion in $NH_3$ reducing the bond angle from 109°28' to 107°.

**Q.** N atom both in $NH_3$ and NH+4 is $sp^3$ hybridised. In NH+4 all the four orbitals are bonded whereas in $NH_3$there is a lone pair on N , which is responsible for lone pair-bond pair repulsion in $NH_3$ reducing the bond angle from 109°28' to 107°.

**Ans.** Due to high electronegativity and small size of oxygen, $H_2O$ undergoes extensive intermolecular H-bonding and exists as an associated molecule. On the other hand, due to low electronegativity of S, $H_2S$ is unable to form effective H-bonds and exists as a discrete molecule which are held by weak Van der Waal forces. To overcome these forces only small amount of energy is required. Therefore $H_2S$ has lower boiling point than $H_2O$.

**Q. Reducing character decreases from $SO_2$ to $TeO_2$.**

**Ans.** Because the stability of + 4 oxidation state increases from S to Te on moving down the group in group 16 due to inert pair effect.

**Q.7. Give reasons for the following:**

**[*CBSE Chennai 2015*]**

**Q. Dinitrogen is a gas but phosphorus is a solid.**

**Ans.** Nitrogen due to small size and high electronegativity forms pπ – pπ multiple bonds and exist as a diatomic molecule. These molecules are held together by weak Van der Waal forces and hence $N_2$ exist as a gas at room temperature. In contrast due to larger size and lower electronegativity P does not form pπ – pπ bond with itself rather it prefer to form single P–P bonds and exist as tetrahedral $P_4$ molecules. Due to bigger size, the force of attraction holding $P_4$ molecules are quite strong and cannot broken by the collision of molecules at room temperature and hence solid at room temperature.

**Q. Bond angle decreases from $H_2O$ to $H_2Te$.**

**Ans.** As we move down the group from O to Te, the size of central atom goes on increasing and its electronegativity goes on decreasing. Consequently, the bond pairs of electrons tend to lie away from the central atom as we move from $H_2O$ to Te. As a result of this the force of repulsion between the bond pairs decreases as we move from O to Te and hence the bond angle decreases in the same order.

**Q. Halogens have the maximum negative electron gain enthalpy.**

**Ans.** Halogens have one electron less than the nearest noble gas configuration. Therefore, they have a strong tendency to accept an additional electron to acquire nearest noble gas configuration and hence they have maximum negative electron gain enthalpy.

**Q.8. Account for the following:**

**[*CBSE (F) 2014*]**

**Q. The molecules $NH_3$ and $NF_3$ have dipole moments which are of opposite directions.**

**Ans.** This is because in $NH_3$ nitrogen is more electronegative than hydrogen while in $NF_3$, nitrogen is less electronegative than fluorine.

**Q. Bi is a strong oxidising agent in the +5 state.**

**Ans.** Due to inert pair effect Bi in +3 state is much more stable than in +5 state. Therefore, Bi in +5 state accepts two electrons and get reduced to more stable +3 state. Hence Bi is strong oxidising agent in +5 state.

**Q. $PCl_5$ is known but $NCl_5$ is not known.**

**Ans.** Nitrogen with n = 2, has *s* and *p* orbitals only. It does not have *d* orbitals to expand its covalency beyond four. Hence, $NCl_5$ is not known. $PCl_5$ is known as *P* has vacant

3*d* orbital to which 3*s* electrons can be excited to make available five half filled orbitals needed for the formation of five P—Cl bonds.

**Q.9. Explain the following observations:**

**[*CBSE (AI) 2012*]**

**Q. $H_2S$ is more acidic than $H_2O$.**

**Ans.** Due to smaller size of O as compared to S, the bond dissociation enthalpy of O–H bond is higher than that of S–H bond. As a result, in aqueous solution, S–H bond can break more easily to form $H^+$ ion than O–H bond. Hence, $H_2S$ is more acidic than $H_2SO$.

**Q. Fluorine does not exhibit any positive oxidation state.**

**Ans.** This is because fluorine is the most electronegative element and it does not have *d* orbitals.

**Q. Helium forms no real chemical compound.**

**Ans.** This is because the valence shell orbital of helium is completely filled ($1s^2$) and it has high ionisation enthalpy and more positive electron gain enthalpy.

**Q.10. Give reasons:**

**[*CBSE Delhi 2017*]**

**Q. Thermal stability decreases from $H_2O$ to $H_2Te$.**

Ans. As the size of the element E increases down the group E–H bond dissociation enthalpy decreases therefore thermal stability decreases from $H_2O$ to $H_2Te$.

**Q. Fluoride ion has higher hydration enthalpy than chloride ion.**

**Ans.** This is due to small size and high charge of fluoride ion, *i.e*., high charge density of fluoride ion.

**Q. Nitrogen does not form pentahalide.**

**Ans.** Nitrogen has only four (one *s* and three *p*) orbitals in its valence shell. It does not have *d* orbitals to expand its covalency beyond four. That is why it does not form pentahalides.

**Q.11. Give reasons for the following:**

**[*CBSE (AI) 2017*]**

**Q. Red phosphorus is less reactive than white phosphorus.**

**Ans.** Red phosphorus is less reactive than white phosphorus as the white phosphorus molecule possess angular strain in $P_4$ molecule where the bond angles are only 60°.

**Q. Electron gain enthalpies of halogens are largely negative.**

**Ans.** Halogens have one electron less than the nearest noble gas. Therefore, they readily accept one electron to attain nearest noble gas configuration and hence they have large negative values of electron gain enthalpies.

**Q. $N_2O_5$ is more acidic than $N_2O_3$.**

**Ans.** In $N_2O_5$, N is in +5 oxidation state whereas in $N_2O_3$ it is in +3 oxidation state. Higher the +ve oxidation state of the atom, more will be its acidic character.

## Short Answer Questions-II (OIQ)

**Q.1. Illustrate how copper and zinc give different products on reaction with $HNO_3$.**

**[*HOTS*]**

**Ans. With conc. $HNO_3$:**

$$2\,HNO_3 \rightarrow H_2O + 2\,NO_2 + O$$
$$Cu + O \rightarrow CuO$$
$$CuO + 2\,HNO_3 \rightarrow Cu(NO_3)_2 + H_2O$$
$$Cu + 4\,HNO_3 \rightarrow Cu(NO_3)_2 + 2H_2O + 2\,NO_2$$

$$Zn + 2\,HNO_3 \rightarrow Zn(NO_3)_2 + 2H$$
$$HNO_3 + H \rightarrow H_2O + NO_2 \,]\times 2$$
$$Zn + 4\,HNO_3 \rightarrow Zn(NO_3)_2 + 2H_2O + 2\,NO_2$$

**With dil $HNO_3$:**

$$2\,HNO_3 \rightarrow H_2O + 2NO + 3O$$
$$Cu + O \rightarrow CuO\,]\times 3$$
$$CuO + 2\,HNO_3 \rightarrow Cu(NO_3)_2 + H_2O]\times 3$$

$$3Cu + 8\,HNO_3 \rightarrow 3\,Cu(NO_3)_2 + 4H_2O + 2\,NO$$

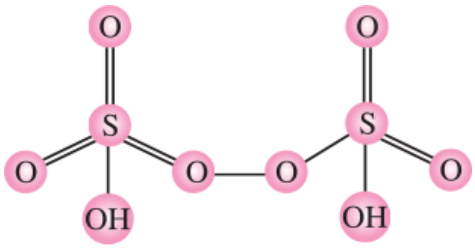
$$Zn + 2\,HNO_3 \rightarrow Zn(NO_3)_2 + 2H] \times 4$$
$$HNO_3 + 8H \rightarrow 3H_2O + NH_3$$
$$NH_3 + HNO_3 \rightarrow NH_4NO_3$$
$$NH_4NO_3 \rightarrow N_2O + 2H_2O$$

$$4Zn + 10\,HNO_3 \rightarrow 4\,Zn(NO_3)_2 + 5H_2O + N_2O$$

**Q.2. Draw the structures of the following:**

**Q. $H_2S_2O_8$**

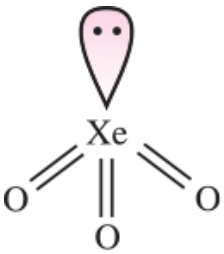
**Ans.**




Peroxodie sulphuric acid
($H_2S_2O_8$)

**Q. $XeO_3$**

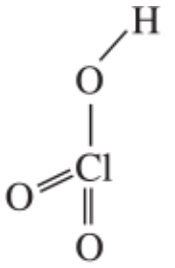
**Ans.**




Pyramidal
($XeO_3$)

**Q. $HOClO_2$**

**Ans.**



Chloric acid

**Q.3. Answer the following question :**

**[*CBSE Sample Paper 2016*]**

**Q. Write balanced chemical equations for the following:**

a. **Complete hydrolysis of $XeF_6$.**
b. **Disproportionation reaction of orthophosphorus acid.**

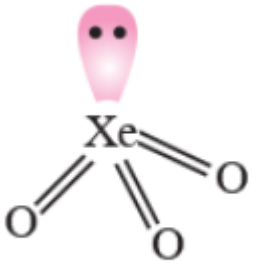
**Ans.**

a. $XeF_6 + 3H_2O \rightarrow XeO_3 + 6HF$

b. $4H_3PO_3 \xrightarrow{\Delta} 3H_3PO_4 + PH_3$

**Q. Draw the structure of a noble gas species which is isostructural with $BrO_3^-$.**

**Ans.** $XeO_3$ is isostructural with $BrO_3^-$.



Pyramidal

**Q.4. Answer the following question :**

**Q. Complete the following chemical equations.**

a. **$NH_4Cl$ (*aq*) + $NaNO_2$ (*aq*) →**
b. **$P_4$ + 3NaOH + $3H_2O$ →**

**Ans.**

a. $NH_4Cl\,(aq) + NaNO_2\,(aq) \rightarrow N_2(g) + 2H_2O(l) + NaCl\,(aq)$

b. $P_4 + 3NaOH + 3H_2O \rightarrow \underset{\text{Phosphine}}{PH_3} + 3\,NaH_2PO_2$

**Q.**

**Why is $K_{a_2} << K_{a_1}$ for $H_2SO_4$ in water?**

**Ans.**

$K_{a_2} << K_{a_1}$, because $HSO_4^-$ ion has much less tendency to donate a proton to $H_2O$ as compared to $H2SO_4$.

**Q.5. Explain the following observations giving appropriate reasons:**

**Q. Ozone is thermodynamically unstable with respect to oxygen.**

**Ans.** $2O_3\,(g) \rightarrow 3O_2\,(g)$

Ozone is thermodynamically unstable with respect to oxygen as its decomposition into oxygen results in the liberation of heat ($\Delta H$ = –ve) and increase in entropy ($\Delta S$ = + ve). These two factors reinforce each other, resulting in large – ve $\Delta G$ (= $\Delta H - T\Delta S$) for its conversion into oxygen.

**Q. The HEH bond angle of the hydrides of group 15 elements decreases as we move down the group.**

**Ans.** As we move from $NH_3$ to $BiH_3$, the size of the central atom goes on increasing and its electronegativity goes on decreasing. Due to this, the bond pair of electrons tend to lie away from the central atom. As a result, the repulsion between the pairs decreases as we move from $NH_3$ to $BiH_3$. Consequently the bond angle decreases as we go down the group from NH3 to $BiH_3$.

**Q. Bleaching effect of chlorine is permanent.**

**Ans.**

$Cl_2 + H_2O \rightarrow [HCl + HOCl] \rightarrow 2HCl + [O]$

Coloured substance + [O] → Coloured substance

As the bleaching action of chlorine is due to oxidation, therefore, it is permanent.

**Q.6. Give reasons for the following:**

**Q. ICl is more reactive than $I_2$.**

**Ans.** ICl is more reactive than $I_2$ because I—Cl bond is weaker than I—I bond. Consequently, ICl breaks easily to form halogen atoms which readily bring about the reactions.

**Q. Helium is used in diving apparatus.**

**Ans.** Helium is used as a diluent for oxygen in modern diving apparatus because of its very low solubility in blood.

**Q. $H_2O$ is a liquid and $H_2S$ is a gas.**

**Ans.** Due to small size and high electronegativity of oxygen, molecules of water are associated through hydrogen bonding, resulting in its liquid state. On the other hand, $H_2S$ molecules are not associated through H-bonding. Hence, it is a gas.

**Q.7. Account for the following**

**Q. Chlorine water has both oxidising and bleaching properties.**

**Ans.** Chlorine water produces nascent oxygen which is responsible for bleaching action and oxidation.

$Cl_2 + H_2O \rightarrow 2HCl + [O]$

**Q. $H_3PO_2$ and $H_3PO_3$ act as good reducing agents while $H_3PO_4$ does not.**

**Ans.** Both $H_3PO_2$ and $H_3PO_3$ have P—H bonds, so they act as reducing agents. $H_3PO_4$, has no P—H bond but has O—H bonds, so it cannot act as a reducing agent.

**Q. On addition of ozone gas to KI solution, violet vapours are obtained**

**Ans.** Ozone gas acts as a strong oxidising agent, so it oxidises iodide ions to iodine.

$2I^-(aq) + H_2O(l) + O_3(g) \rightarrow 2OH^- (aq) + I_2(g) + O_2(g)$

$I_2$ vapours evolved have violet colour.

**Q.8. Give reasons for the following:**

**Q. Nitric oxide becomes brown when released in air.**

**Ans.** Nitric oxide readily combines with $O_2$ of air to form nitrogen dioxide which is brown in colour.

$$\underset{\text{Nitric oxide}}{2\,NO} + O_2 \rightarrow \underset{\text{Nitrogen dioxide}}{2\,NO_2}$$
( Colourless ) ( Brown )

**Q. Solid phosphorus pentachloride exhibits some ionic character.**

**Ans.** Solid $PCl_5$ exists as $[PCl_4]^+ [PCl_6]^-$ and hence exhibits some ionic character.

**Q. Ammonia acts as a ligand.**

**Ans.** Due to the presence of lone pair of electrons on N, $NH_3$ acts as a ligand.

$$\underset{\text{Silver chloride}}{AgCl} + 2\,NH_3 \rightarrow \underset{\text{Diam min } e \text{ silver } (I) \text{ chloride}}{[Ag(NH_3)_2]\,Cl}$$

**Q.9. Account for the following:**

**Q. Both NO and $ClO_2$ are odd electron species but NO dimerises while $ClO_2$ does not.**

**Ans.** In NO, the odd electron on N is attracted by only one O-atom but in $ClO_2$, the odd electron on Cl is attracted by two O-atoms. Thus, the odd electron on N in NO is localised while the odd electron on Cl in $ClO_2$ is delocalised. Consequently, NO has a tendency to dimerise but $ClO_2$ does not.

**Q. Bleaching of flowers by chlorine is permanent while that by sulphur dioxide is temporary.**

**Ans.** $Cl_2$ bleaches coloured material by oxidation.

$Cl_2 + H_2O \rightarrow 2HCl + O$

Coloured material + [O] → Colourless

Hence, bleaching is permanent.

In contrast, $SO_2$ bleaches coloured material by reduction and hence bleaching is temporary since when the bleached colourless material is exposed to air, it gets oxidised and the colour is restored.

$SO_2 + 2H_2O \rightarrow H_2SO_4 + 2H$

Coloured material + H → Colourless material $\underset{\text{oxidation}}{\overset{\text{aerial}}{\rightarrow}}$ Colourless material

**Q. Sulphur exhibits greater tendency for catenation than selenium.**

**Ans.** As we move from S to Se, the atomic size increases and hence the strength of E—E bond decreases. Thus, S—S bond is much stronger than Se—Se bond. Consequently, S shows greater tendency for catenation than selenium.

**Q.10. Assign appropriate reasons for each of the following statements:**

**Q. Metal fluorides are more ionic in nature than metal chlorides.**

**Ans.** According to Fajan's rule, a bigger anion is more easily polarised than a smaller anion. As a result, same metal cation can polarise a bigger $Cl^-$ ion more easily than the smaller $F^-$ ion. In other words, for the same metal, the metal fluoride is more ionic than metal chloride. So, in general, we can easily say that metal fluorides are more ionic than metal chlorides.

**Q. Addition of $Cl_2$ to KI solution gives it a brown colour but excess of $Cl_2$ turns it colourless.**

**Ans.** $Cl_2$ being a stronger oxidising agent than $I_2$ first oxidises KI to give $I_2$ which imparts brown colour to the solution.

$$2\,KI\,(aq) + Cl_2\,(g) \quad \rightarrow \quad 2\,KCl\,(aq) + \underset{\text{Brown}}{I_2\,(s)}$$

If $Cl_2$ is passed in excess, the $I_2$ thus formed gets further oxidised to iodic acid ($HIO_3$) which is colourless.

$$5\,Cl_2 + I_2 + 6H_2O \quad \rightarrow \quad 10HCl + \underset{(\text{Colourless})}{2\,HIO_3}$$

**Q. Perchloric acid is a stronger acid than sulphuric acid.**

**Ans.** The oxidation state of Cl in perchloric acid is +7 while that of S in sulphuric acid is +6. Greater the oxidation state of central atom, more readily the O–H bond breaks and hence stronger is the acid.

**Q.11. Give reasons for the following:**

**Q. Noble gases are mostly inert.**

**Ans.** Noble gases are mostly inert because of the following reasons:

**a.** They have completely filled $ns^2np^6$ electronic configurations in their valence shells.
**b.** Electron gain enthalpies of noble gases are positive.
**c.** They have high ionisation enthalpies.

**Q. Noble gases form compounds with fluorine and oxygen only.**

**Ans.** Fluorine and oxygen are the most electronegative elements and hence are very reactive. So, they form compounds with noble gases, particularly xenon.

**Q. Neon is generally used for warning signals.**

**Ans.** Neon lights are visible from long distances even in fog and mist and hence neon is generally used for warning signals.

**Q.12. A colourless inorganic salt A decomposes at about 250°C to give only two products B and C leaving no residue. The oxide C is a liquid at room temperature and is neutral to litmus paper while B is neutral oxide. White phosphorus burns in excess of B to produce strong dehydrating agent. Give balanced equations for above processes.**

**[*HOTS*]**

**Ans.** A = $NH_4NO_3$ (Ammonium nitrate), B = $N_2O$ (Nitrous oxide), C = $H_2O$

Reactions involved:

$$\underset{\text{Ammonium nitrate}}{\underset{(A)}{NH_4NO_3}} \xrightarrow{250^\circ C} \underset{\text{Nitrous oxide}}{\underset{(B)}{N_2O}} + \underset{(C)}{2H_2O}$$

$$\underset{(B)}{10N_2O} + P_4 \rightarrow 10N_2 + \underset{\text{Phosphorus pentoxide}}{\underset{(\text{dehydrating agent})}{P_4O_{10}}}$$

**Q.13. On reaction with $Cl_2$, phosphorus forms two types of halides 'A' and 'B'. Halide A is yellowish-white powder but halide 'B' is colourless oily liquid. Identify A and B and write the formulas of their hydrolysis products.**

**[*NCERT Exemplar*]**

**Ans.** A = $PCl_5$ (Yellowish white powder)

$P_4 + 10Cl_2 \rightarrow 4PCl_5$

B = $PCl_3$ (Colourless oily liquid)

$P_4 + 6Cl_2 \rightarrow 4PCl_3$

Hydrolysis products are formed as follows:

$PCl_3 + 3H_2O \rightarrow H_3PO_3 + 3HCl$

$PCl_5 + 4H_2O \rightarrow H_3PO_4 + 5HCl$

# Long Answer Questions

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## Long Answer Questions (PYQ)

**Q.1. Answer the following question :**

**Q. Account for the following:**

**[*CBSE (F) 2017*]**

a. **$BiH_3$ is the strongest reducing agent in Group 15 elements hydrides.**
b. **$Cl_2$ acts as a bleaching agent.**
c. **Noble gases have very low boiling points.**

**Ans. (a)** On moving down the group atomic size increases, therefore, E–H bond strength decreases. Thus, Bi–H bond is the weakest amongst the hydrides of group 15 and hence $BiH_3$ is the strongest reducing agent.

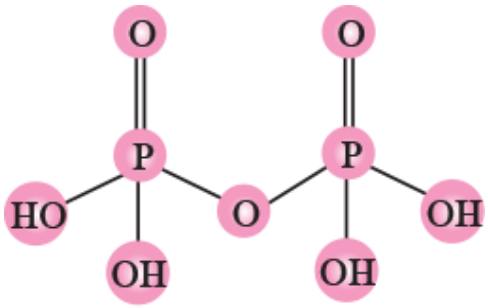
**(b)** In the presence of moisture or in aqueous solution, $Cl_2$ liberates nascent oxygen
$Cl_2 + H_2O \rightarrow 2HCl + [O]$
The bleaching action of $Cl_2$ is due to oxidation which is permanent.
Coloured substance + [O] → Colourless substance

**(c)** Noble gases being monoatomic have no interatomic forces except weak dispersion forces and therefore they have very low boiling points.

**Q. Draw the structures of the following:**

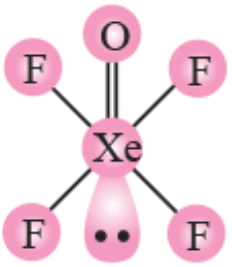
a. **$H_4P_2O_7$**
b. **$XeOF_4$**

**Ans. (a)**



Pyrophosphoric acid
($H_4P_2O_7$)

**(b)**




Square pyramidal
$XeOF_4$

**Q.2. Answer the following question :**

**Q. Although nitrogen and chlorine have nearly same electronegativity yet nitrogen forms hydrogen bonding while chlorine does not. Why?**

**[*CBSE (F) 2017*]**

**Ans.** Atomic size of nitrogen is smaller than chlorine. Due to this electron density per unit volume on nitrogen atom is higher than that of chlorine atom. Therefore, nitrogen form hydrogen bonds while chlorine does not although nitrogen and chlorine have nearly same electronegativity.

**Q. What happens when $F_2$ reacts with water?**

**Ans.** It oxidises $H_2O$ to $O_2$.

$2F_2(g) + 2H_2O(l) \rightarrow 4H^+(aq) + 4F^-(aq) + O_2(g)$

**Q. Write the name of the gas evolved when $Ca_3P_2$ is dissolved in water.**

**Ans.** Phosphine ($PH_3$).

$Ca_3P_2 + 6H_2O \rightarrow 3Ca(OH)_2 + 2PH_3$

**Q. Write the formula of a noble gas species which is isostructural with $Br_2^-$ .**

**Ans.** $XeF_2$.

$IBr_2^-$ has 2 bond pairs and 3 lone pairs, therefore, it should be linear. Like $IBr_2^-$ $XeF_2$ has 2 bond pairs and 3 lone pairs, therefore, it is also linear.

**Q. Complete the equation:**

**$[Fe(H_2O)_6]^{2+}$ + NO →**

**Ans.**

$$[Fe(H_2O)_6]^{2+} + NO \rightarrow \underset{(\text{Brown ring})}{[Fe(H_2O)_5 NO]^{2+}} + H_2O$$

**Q.3. Answer the following question :**

**Q. Complete the following chemical reaction equations:**

a. **$P_4$ + $SOCl_2$ →**
b. **$XeF_4$ + $H_2O$ →**

**Ans. (a)** $P_4 + 8SOCl_2 \rightarrow 4PCl_3 + 4SO_2 + 2S_2Cl_2$

**(b)** $6XeF_4 + 12H_2O \rightarrow 4Xe + 2XeO_3 + 24HF + 3O_2$

**Q. Explain the following observations giving appropriate reasons:**

a. **The stability of +5 oxidation state decreases down the group in Group 15 of the periodic table.**
b. **Solid phosphorus pentachloride behaves as an ionic compound.**
c. **Halogens are strong oxidising agents.**

**[*CBSE Delhi 2010*]**

**Ans. (a)** The stability of +5 oxidation state decreases down the group in Group 15 of the periodic table. The +3 oxidation state becomes more and more common on moving down the group from N to Bi. This is because of inert pair effect.

**(b)** Solid $PCl_5$ behaves as an ionic compound because it is a salt containing the tetrahedral cation $[PCl_4]^+$and octahedral anion $[PCl_6]^-$.

**(c)** Halogens are strong oxidising agents because they have high electron affinities, so, they pick up electrons from other substances.

**Q.4. Answer the following question :**

**Q. Give reasons for the following:**

a. **Bond enthalpy of $F_2$ is lower than that of $Cl_2$.**
b. **$PH_3$ has lower boiling point than $NH_3$.**

**Ans. (a)** Bond dissociation enthalpy decreases as the bond distance increases from $F_2$ to $I_2$ because of the corresponding increase in the size of the atom as we move from F to I.

The F—F bond dissociation enthalpy is, however, smaller than that of Cl—Cl and even smaller than that of Br—Br. This is because F atom is very small and hence the three lone pairs of electrons on each F atom repel the bond pair holding the F-atoms in molecule resulting lower bond enthalpy than $Cl_2$.

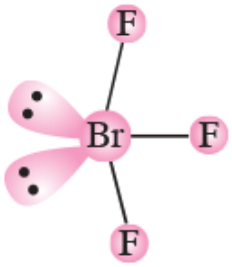
**(b)** Unlike $NH_3$, $PH_3$ molecules are not associated through hydrogen bonding in liquid state. That is why the boiling point of $PH_3$ is lower than $NH_3$.

**Q. Draw the structures of the following molecules:**

a. **$BrF_3$**
b. **$(HPO_3)_3$**
c. **$XeF_4$**

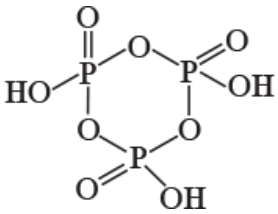
**[CBSE Delhi 2013]**

**Ans. (*a*)** $BrF_3$

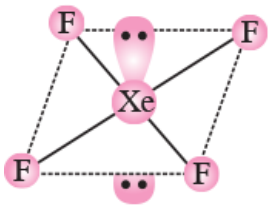



Slightly bent "T"

**(*b*)** $(HPO_3)_3$




**(*c*)** $XeF_4$




Square planar

**Q.5. Answer the following question :**

**Q. Account for the following:**

a. **Acidic character increases from HF to HI.**
b. **There is large difference between the melting and boiling points of oxygen and sulphur.**
c. **Nitrogen does not form pentahalide.**

**Ans. (a)** As the size of halogen atom increases from F to I, the bond dissociation enthalpy of H—X bond decreases from H—F to H—I. Due to this acidic character increases from HF to HI.

**(b)** Because of small size and high electronegativity oxygen forms pπ-pπ multiple bonds and exists as a diatomic, $O_2$ molecule. These molecules are held together by weak Van der Waal forces. Sulphur on the other hand due to its higher tendency for catenation and lower tendency for pπ-pπ multiple bond formation, forms octa-atomic, $S_8$ molecule. Because of bigger size of $S_8$ molecule than $O_2$molecule the force of attraction holding the $S_8$ molecules together are much stronger than $O_2$molecules. Hence, there is large difference between the melting and boiling points of oxygen and sulphur.

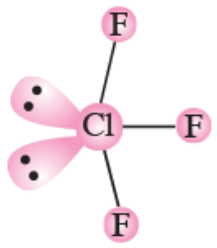
**(c)** Nitrogen with $n$ = 2, has s and $p$-orbitals only. It does not have d-orbitals to expand its covalency beyond four. Due to this it does not form pentahalide.

**Q. Draw the structures of the following:**

a. **$ClF_3$**
b. **$XeF_4$**

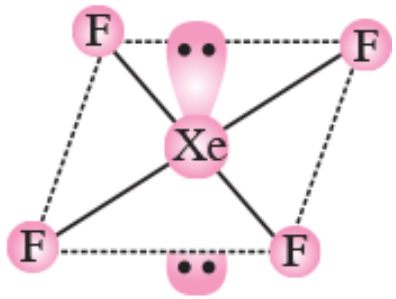
**[*CBSE Delhi 2015*]**

**Ans. (a)**




$ClF_3$: Slightly bent "T"

**(b)**



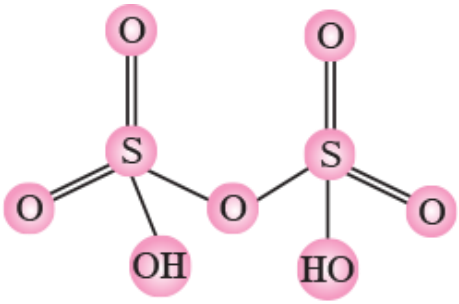

$XeF_4$: Square planar

**Q.6. Answer the following question :**

**Q. Draw the structures of the following:**

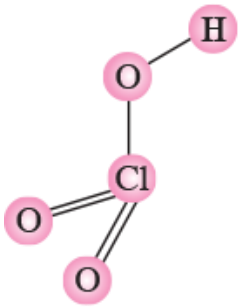
a. $H_2S_2O_7$
b. $HClO_3$

**Ans. (*a*)**




Pyrosulphuric acid (Oleum)
($H_2S_2O_7$)

**(*b*)**




Chloric acid
($HClO_3$)

**Q. Give an explanation for each of the following observations:**

a. **In the structure of $HNO_3$, the N—O bond (121 pm) is shorter than the N—OH bond (140 pm).**
b. **All the P—Cl bonds in $PCl_5$ are not equivalent.**
c. **ICl is more reactive than $I_2$.**

**Ans. (a)** Due to resonance, N—O bond length is the average of single and double bond whereas N—OH bond is purely single bond.

**(b)** $PCl_5$ has trigonal bipyramidal structure in which the three equatorial P—Cl bonds are equivalent, while the two axial bonds are longer than equatorial bonds. This is due to the fact that axial bond pairs suffer more repulsion as compared to equatorial bond pairs.

**(c)** This is because I—Cl bond has lower bond dissociation enthalpy than I—I bond.

**Q.7. Answer the following question :**

**Q. Which allotrope of phosphorus is more reactive and why?**

**Ans.** White or yellow phosphorus is more reactive than the other allotropes because it is less stable due to angular strain in the $P_4$ molecule of white phosphorus where the angles are only 60°.

**Q. How the supersonic jet aeroplanes are responsible for the depletion of ozone layers?**

**Ans.** Nitrogen oxides (particularly nitric oxide) emitted from the exhaust system of supersonic jet aeroplanes are responsible for depletion of ozone layer.

$NO(g) + O_3(g) \rightarrow NO_2(g) + O_2(g)$

**Q. $F_2$ has lower bond dissociation enthalpy than $Cl_2$. Why?**

**Ans.** Bond dissociation enthalpy of $F_2$ is lower than $Cl_2$ due to small size of fluorine and relatively larger electron-electron repulsion among the lone pairs in $F_2$ molecule where they are much closer to each other than in case of $Cl_2$.

**Q. Which noble gas is used in filling balloons for meteorological observations?**

**Ans.** Helium, as it is non-inflammable and light gas.

**Q. Complete the equation: $XeF_2 + PF_5 \rightarrow$**

**[*CBSE Delhi 2015*]**

**Ans.** $XeF_2 + PF_5 \rightarrow [XeF]^+ [PF_6]^-$

**Q.8. Answer the following question :**

**Q. Complete the following chemical reaction equations:**

a. **$AgCl(s) + NH_3(aq) \rightarrow$**
b. **$P_4(s) + NaOH(aq) + H_2O(l) \rightarrow$**

**Ans. (a)** $AgCl + 2NH_3 \rightarrow [Ag(NH_3)_2]^+ Cl^-$

**(b)** $P_4 + 3NaOH + 3H_2O \rightarrow PH_3 + 3NaH_2PO_2$

**Q. Explain the following observations:**

a. **$H_2S$ is less acidic than $H_2Te$.**
b. **Fluorine is a stronger oxidising agent than chlorine.**
c. **Noble gases are the least reactive elements.**

**[*CBSE (F) 2010]***

**Ans. (a)** This is because bond dissociation enthalpy of H—Te bond is less than H—S as the size of Te is larger than S.

**(b)** Fluorine is a stronger oxidising agent than chlorine due to low dissociation enthalpy of F—F bond and high hydration enthalpy of F– ions.

**(c)** Noble gases are the least reactive elements due to fully filled outermost shells, high ionisation enthalpy and positive electron gain enthalpy.

**Q.9. Answer the following question :**

**Q. Complete the following reaction equations:**

a. $\mathbf{XeF_2 + PF_5 \rightarrow}$

b. $Cl_2\,(g) + \underset{(\text{hot and conc.})}{NaOH\,(aq)} \rightarrow$

**Ans.**

a. $XeF_2 + PF_5 \rightarrow [XeF]^+ [PF_6]^-$

b. $3\,Cl_2\,(g) + \underset{(\text{Hot and conc.})}{6\,NaOH\,(aq)} \rightarrow 5NaCl + NaClO_3 + 3H_2O$

**Q. Explain the following observations:**

a. **+3 oxidation state becomes more and more stable from As to Bi in the group.**
b. **Sulphur in vapour state exhibits paramagnetism.**
c. **Fluorine does not exhibit any positive oxidation state.**

**[*CBSE (F) 2009*]**

**Ans. (a)** This is due to inert pair effect.

**(b)** In vapour state sulphur partly exists as $S_2$ molecule having two unpaired electrons in the anti bonding π* orbitals like $O_2$ and, hence exhibits paramagnetism.

**(c)** This is because fluorine is the most electronegative element and does not have d-orbitals in its valence shell.

**Q.10. Answer the following question :**

**Complete the following reaction equations:**

a. **$PCl_5 + H_2O$ (excess) →**
b. **$F_2 + H_2O$ →**

**[*CBSE (F) 2009*]**

**Ans. (a)** $PCl_5 + 4H_2O$ (excess) $\rightarrow H_3PO_4 + 5HCl$

**(b)** $2F_2(g) + 2H_2O(l) \rightarrow 4H^+(aq) + 4F^-(aq) + O_2(g)$

**Q. Explain the following observations:**

a. **No distinct chemical compound of helium is known.**
b. **Phosphorus has a greater tendency for catenation than nitrogen.**
c. **In solutions of $H_2SO_4$ in water, the second dissociation constant $K_{a_2}$, is less than the first dissociation constant $K_{a_1}$.**

**Ans.**

a. This is due to small size, high ionisation enthalpy and stable electronic configuration of helium.
b. This is because P–P single bond is stronger than N–N single bond.
c. $K_{a_2} << K_{a_1}$, because $HSO_4^-$ ion has much less tendency to donate a proton to $H_2O$ as compared to neutral $H_2SO_4$.

**Q.11. Answer the following question :**

**Q. What happens when**

a. **chlorine gas is passed through a hot concentrated solution of NaOH?**
b. **sulphur dioxide gas is passed through an aqueous solution of a Fe(III) salt?**

**Ans.**

a. $3\,Cl_2 + \underset{(\text{Hot and conc.})}{6\,NaOH} \rightarrow 5NaCl + NaClO_3 + 3H_2O$

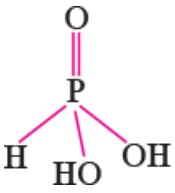
b. $2Fe^{3+} + SO_2 + 2H_2O \rightarrow 2Fe^{2+} + SO_4^{2-} + 4H^+$

**Q. Answer the following:**

a. **What is the basicity of $H_3PO_3$ and why?**
b. **Why does fluorine not play the role of a central atom in interhalogen compounds?**
c. **Why do noble gases have very low boiling points?**

**[*CBSE (AI) 2011*]**

**Ans. (a)**




Two, as the structure of $H_3PO_3$ has two P—OH bonds.

**(b)** This is due to smaller size and absence of d orbitals in the valence shell of fluorine.

**(c)** Noble gases being monoatomic gases have no interatomic forces except weak dispersion forces, therefore they have low boiling points.

**Q.12. Answer the following question :**

**Q. Account for the following:**

a. **Ozone is thermodynamically unstable.**
b. **Solid $PCl_5$ is ionic in nature.**
c. **Fluorine forms only one oxoacid HOF.**

**Ans. (a)** Ozone is thermodynamically unstable with respect to oxygen as its decomposition into oxygen results in the liberation of heat (DH is –ve) and an increase

in entropy (DS is +ve). These two effects reinforce each other, resulting in large negative Gibbs energy change (DG) for its conversion into oxygen.

**(b)** In solid state, $PCl_5$ exists as $[PCl_4]^+ [PCl_6]^-$ and conducts electricity on melting.

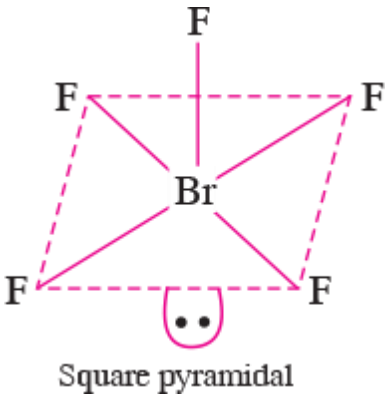
**(c)** Due to small size and high electronegativity, fluorine, forms only one oxoacid HOF.

**Q. Draw the structures of**

a. **$BrF_5$**
b. **$XeF_4$**

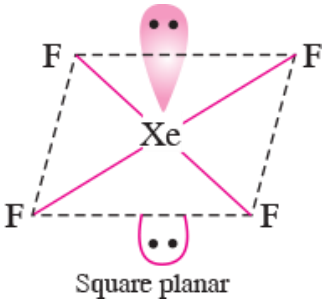
**[*CBSE Delhi 2016*]**

**Ans. (a)**



Square pyramidal

**(b)**



Square planar

**Q.13. Answer the following question :**

**Q. Complete the following chemical reaction equations:**

a. **$P_4 + SO_2Cl_2 \rightarrow$**
b. **$XeF_6 + H_2O \rightarrow$**

**Ans. (a)** $P_4 + 10SO_2Cl_2 \rightarrow 4PCl_5 + 10SO2$

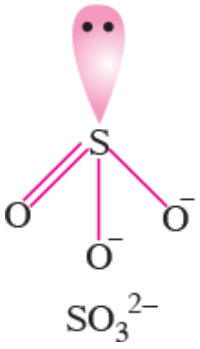
**(b)** $XeF6 + 3H_2O \rightarrow XeO_3 + 6HF$

**Q. Predict the shape and the asked angle (90° or more or less) in each of the following cases:**

a. $SO_3^{2-}$ and the angle O—S—O

b. $ClF_3$ and the angle F—Cl—F

c. $XeF_2$ and the angle F—Xe—F

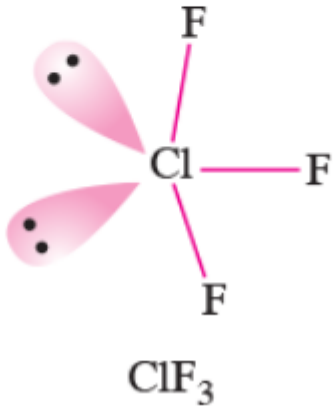



**[*CBSE Delhi 2012*]**

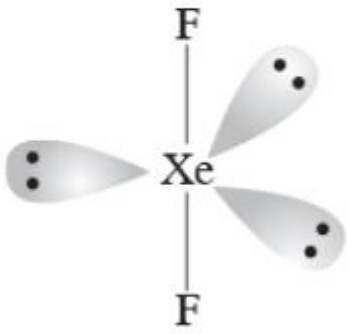
**Ans.**

a. There are three bond pairs and one lone pair of electrons around S atoms in $SO_3^{2-}$. Therefore, according to VSEPR theory, $SO_3^{2-}$ should be pyramidal. The angle O—S—O is greater than 90°.

b. There are three bond pairs and two lone pairs of electrons around Cl atom in $ClF_2$. Therefore, according to VSEPR theory, $ClF_3$ should be bent T-shaped. The angle F—Cl—F is less than 90°.



c. There are two bond pairs and three lone pairs of electrons around Xe atoms in $XeF_2$. Therefore according to VSEPR theory, $XeF_2$ should be linear. The angle F—Xe—F is greater than 90°.




$XeF_2$

**Q.14. Answer the following question :**

**Q. Complete the following chemical equations:**

a. **$XeF_4 + SbF_5 \rightarrow$**
b. **$Cl_2 + F_2$(excess) $\rightarrow$**

**Ans.**

a. $XeF_4 + SbF_5 \rightarrow [XeF_3]^+[SbF_6]^-$

b. $Cl_2 + 3F_2(\text{excess}) \xrightarrow{573K} 2ClF_3$

**Q. Explain each of the following:**

a. **Nitrogen is much less reactive than phosphorus.**

b. **The stability of +5 oxidation state decreases down group 15.**

c. **The bond angles (O—N—O) are not of the same value in $NO_2^-$ and $NO_2^+$**

*[CBSE Delhi 2012]*

**Ans.**

a. As N≡N triple bond $(941.4\ kJ\ mol^{-1})$ is much stronger than P—P single bond $(213\ kJ\ mol^{-1})$, therefore nitrogen is much less reactive than phosphorus.

b. Due to inert pair effect stability of +5 oxidation decreases down the group 15.

c. In $NO_2^-$, nitrogen has a lone pair of electrons. As lone pair-bond pair repulsion is greater than bond pair-bond pair repulsion, thus O—N—O bond angle in $NO_2^-$ is less then $NO_2^+$.

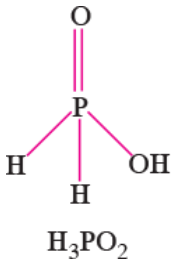
**Q.15. Answer the following question :**

**Q. Draw the structures of the following molecules:**

**(a) $H_3PO_2$**

**(b) $ClF_3$**

**Ans. (a)**



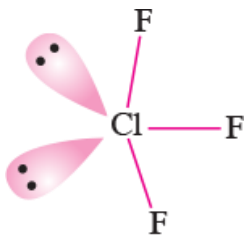

$H_3PO_2$

**(b)** No. of electron pairs around central atom Cl = 5

No. of bond pairs = 3

No of lone pairs = 2

The shape would be slightly bent T




$ClF_3$

**Q. Explain the following observations:**

a. **Oxygen is a gas but sulphur a solid.**
b. **Despite having greater polarity, hydrogen fluoride boils at a lower temperature than water.**
c. **The halogens are coloured.**

**[*CBSE (AI) 2012*]**

**Ans. (a)** Because of its small size, oxygen is capable of forming ρπ–ρπ bond and exists as diatomic $O_2$molecule. The intermolecular forces in oxygen are weak van der Waals force, due to which it is a gas at room temperature. On the other hand, sulphur, due to its larger size prefers to form S–S single bond and exist as octaatomic $S_8$ molecule having puckered ring structure. Because of larger size the force of attraction holding the $S_8$ molecules together are much stronger. Hence sulphur is a solid at room temperature.

**(b)** This is because in $H_2O$ hydrogen bond formed is three dimensional whereas in H–F it is linear.

**(c)** All halogens are coloured. This is due to absorption of radiation in visible region which results in the excitation of outer electrons to higher energy level while the remaining light is transmitted. The colour of the halogen is the colour of transmitted light.

## Long Answer Questions (OIQ)

**Q.1. Answer the following question :**

**Q. When conc. $H_2SO_4$ was added into an unknown salt present in a test tube, a brown gas (A) was evolved. This gas intensified when copper turnings were also added into this test tube. On cooling, the gas (A) changed into a colourless gas (B).**

a. **Identify the gases A and B.**
b. **Write the equations for the reactions involved.**

**Ans.**

$A = NO_2(g), \qquad B = N_2O_4\ (g)$

$$MNO_3 + H_2SO_4 \xrightarrow{\text{Heat}} MHSO_4 + HNO_3$$

$$4\,HNO_3 \xrightarrow{\text{Heat}} \underset{\substack{\text{Nitrogen dioxide}\\ (\text{Brown gas})}}{4\,NO_2} + 2H_2O + O_2$$

$$\underset{\text{Copper turnings}}{Cu} + 4\,HNO_3 \xrightarrow{\text{Heat}} Cu(NO_3)_2 + 2H_2O + 2\,NO_2$$

$$\underset{(\text{Brown gas})}{2\,NO_2} \underset{\text{Heat}}{\overset{\text{Cool}}{\rightleftharpoons}} \underset{(\text{Colourless})}{N_2O_4}$$

**Q. Arrange the following in order of property indicated for each set:**

a. **$F_2$, $Cl_2$, $Br_2$, $I_2$ —increasing bond dissociation enthalpy.**
b. **HF, HCl, HBr, HI—increasing acid strength.**
c. **$NH_3$, $PH_3$, $AsH_3$, $SbH_3$, $BiH_3$—increasing base strength.**

**[HOTS]**

**Ans. (a)** $I_2 < F_2 < Br_2 < Cl_2$

Bond dissociation enthalpy decreases with increase in the size of the atom as we move from Cl to I. The low F—F bond dissociation enthalpy is due to the fact that F atom is very small in size and hence the three lone pair of electrons on each F atom repel the bond pair of F—F bond very strongly.

**(b)** As the size of atom increases from F to I, the bond dissociation enthalpy of H—X bond decreases from H—F to H—I. Therefore, the acid strength increases in the opposite order:

HF < HCl < HBr < HI.

**(c)** As we move from $NH_3$ to $BiH_3$, the size of the central atom increases. Consequently, the electron density on the central atom decreases and hence the basic strength decreases as we move from $NH_3$to $BiH_3$.
Therefore, the basic strength increases in the order:

$BiH_3 < SbH_3 < AsH_3 < PH_3 < NH_3$.

**Q.2. Account for the following :**

**Q. a. When NaBr is heated with conc. $H_2SO_4$, $Br_2$ is produced but when NaCl is heated with conc. $H_2SO_4$, HCl is produced.**

**(b) $H_2S$ acts only as a reducing agent but $SO_2$ acts both as a reducing agent as well as an oxidising agent.**

**(c) The acid strength decreases in the order: HCl > $H_2S$ > $PH_3$ .**

**Ans.**

**(a)** When NaBr is heated with conc. $H_2SO_4$, HBr is first produced which being a reducing agent reduces $H_2SO_4$ to $SO_2$ while HBr itself gets oxidised to $Br_2$.

$NaBr + H_2SO_4 \rightarrow NaHSO_4 + HBr$
$2HBr + H_2SO_4 \rightarrow 2H_2O + SO_2 + Br_2$

As a result, only $Br_2$ is produced.

Similarly, NaCl reacts with conc. $H_2SO_4$ to form HCl. Since HCl does not act as a reducing agent, it does not get oxidised to $Cl_2$.

$NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl$
$HCl + H_2SO_4 \rightarrow$ No action

As a result, only HCl is produced.

**(b)** The minimum oxidation number (O.N) of S is –2 while its maximum O.N is +6. In $SO_2$, the O.N of sulphur is +4, hence, it cannot only increase its O.N by losing electrons but also reduce its O.N by gaining electrons. Thus, it acts both as a reducing agent as well as an oxidising agent.
In contrast, in $H_2S$, S has an O.N of –2. Thus, it can only increase its O.N by losing electrons and hence acts only as a reducing agent.

**(c)** Greater the polarity of the H–A bond, more easily the bond break and hence greater is the acid strength. As the electronegativity of atom A decreases in the order; Cl > S > P, therefore the polarity of the bond decreases in the order HCl > H–S > H–P and hence the acid strength decreases in the same order HCl > $H_2S$ > $PH_3$.

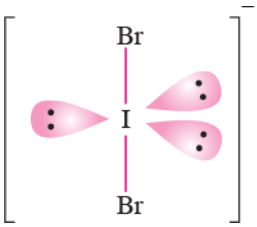
**Q. Give the formula and describe the structure of a noble gas species which is isostructural with $IBr_2^-$.**

**[*HOTS*]**

**Ans.** Total number of electron pairs around central atom I

$= 5e^- \begin{cases} b.p = 2 \\ l.p = 3 \end{cases}$

Therefore, according to VSEPR theory, $IBr_2^-$ should be linear.




Now a noble gas compound having 10 electrons in the valence shell of central atom is $XeF_2$ (8 + 2 × 1 = 10). As it has 2 bond pairs and 3 lone pairs around Xe therefore like $IBr_2^-$, $XeF_2$ is also linear.

**Q.3. Answer the following question :**

**Q. Arrange the following in the order of property indicated against each set:**

a. **HF, HCl, HBr, HI — increasing bond dissociation enthalpy**
b. **$H_2O$, $H_2S$, $H_2Se$, $H_2Te$ — increasing acidic character**

**Ans. (a)** Shorter the bond length, higher is the bond dissociation enthalpy of hydrogen halide. As the atomic size increases down the group the E–H (E = F, Cl, Br, I) bond length increases and hence the bond dissociation enthalpy increases in the reverse order *i.e.*,
HI < HBr < HCl < HF

**(b)** $H_2O < H_2S < H_2Se < H_2Te$
The increase in acidic character from $H_2O$ to $H_2Te$ is due to decrease in bond enthalpy for dissociation of H—E (E = O, S, Se, Te) bond down the group.

**Q. $X_2$ is a greenish yellow gas with pungent smell and used in purification of water. On dissolving water it gives a solution which turns blue litmus red. When it is passed through NaBr solution $Br_2$ is obtained.**

a. **Identify the gas.**
b. **What are products obtained when $X_2$ reacts with ammonia? Give chemical equations.**
c. **What happens when $X_2$ reacts with cold and dilute NaOH solution? Write chemical equation and give the name of reaction.**

**Ans.**

a. $X_2 = Cl_2$

b. $\underset{(\text{excess})}{8\,NH_3} + 3\,Cl_2 \rightarrow 6\,NH_4Cl + N_2$

$\underset{(\text{excess})}{NH_3} + 3\,Cl_2 \rightarrow \underset{(\text{oxidation})}{NCl_3} + 3\,HCl$

c. $\underset{(\text{cold and dil.})}{2\,NaOH} + Cl_2 \rightarrow NaCl + NaOCl + H_2O$, Disproportionation reaction

**Q.4. Explain the following:**

**[*CBSE Sample Paper 2016*]**

**Q. Hydrogen fluoride is a weaker acid than hydrogen chloride in aqueous solution.**

**Ans.** It is due to

- **a.** Higher H—F bond dissociation energy than H—Cl.
- **b.** Stronger H-bonding of F – ion with $H_3O^+$ than $Cl^-$,

**Q. $PCl_5$ is ionic in nature in the solid state.**

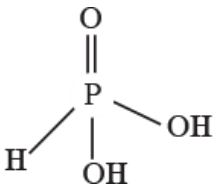
**Ans.** This is because in solid state $PCl_5$ exists as $[PCl_4]^+$ $[PCl_6]^-$ in which cation is tetrahedral and the anion is octahedral. On melting, these ions become free to move and hence it conducts electricity.

**Q. $SF_6$ is inert towards hydrolysis.**

**Ans.** In $SF_6$, S atom is sterically protected by six F atoms and does not allow water molecules to attack the S atom. Further, F does not have d-orbitals to accept the electrons donated by $H_2O$ molecules. Due to these reasons, $SF_6$ is kinetically an inert substance.

**Q. $H_3PO_3$ is diprotic.**

**Ans.**




Since it contains only two ionisable H-atoms which are present as OH-groups, it is diprotic.

**Q. Out of noble gases only xenon is known to form established chemical compounds.**

**Ans.** Except radon which is radioactive, xenon has least ionization enthalpy among noble gases hence it forms compounds particularly with $O_2$ and $F_2$.

**Q.5. Answer the following question :**

**Q. Account for the following:**

a. **$SnCl_4$ is more covalent than $SnCl_2$.**
b. **Tendency to form pentahalides decreases down the group in group 15 of the periodic table.**

**Ans. (a)**The oxidation states of central atom Sn in $SnCl_4$ and $SnCl_2$ are +4 and +2 respectively. +4 state of Sn has higher polarising power which, inturn, increase the covalent character of bond formed between the central atom and the other atoms.

**(b)** This is due to inert pair effect. The stability of +5 oxidation state decreases down the group in group 15.

**Q. Complete the following chemical equations:**

a. $P_4 + SO_2Cl_2 \rightarrow$

b. $XeF_2 + H_2O \rightarrow$

c. $I_2 + \underset{(\text{conc})}{HNO_3} \rightarrow$

**Ans. (a)** $P_4 + 10SO_2Cl_2 \rightarrow 4PCl_5 + 10SO_2$

**(b)** $2XeF_2 + 2H_2O \rightarrow 2Xe + 4HF + O_2$

**(c)** $2HNO_3$ (conc.) $\rightarrow H_2O + 2NO_2 + (O)] \times 5$

$$I_2 + 5(O) \rightarrow I_2O_5$$
$$I_2O_5 + H_2O \rightarrow 2\,HIO_3$$
$$\overline{I_2 + 10\,HNO_3\,(\text{conc.}) \rightarrow 2\,HIO_3 + 10\,NO_2 + 4H_2O}$$

**Q.6. An element ‘A’ exists as a yellow solid in standard state. It forms a volatile hydride ‘B’ which is a foul smelling gas and is extensively used in qualitative analysis of salts. When treated with oxygen, ‘B’ forms an oxide ‘C’ which is a colourless, pungent smelling gas. This gas when passed through acidified $KMnO_4$ solution, decolourises it. ‘C’ gets oxidised to another oxide ‘D’ in the presence of a heterogeneous catalyst. Identify ‘A’, ‘B’, ‘C’, ‘D’ and also give the chemical equation of reaction of ‘C’ with acidified $KMnO_4$ solution and for conversion of ‘C’ to ‘D’.**

**[*HOTS*]**

**Ans.**

'A' = Sulphur, 'B' = $H_2S$ gas, 'C' = $SO_2$ gas, 'D' = $SO_3$ gas

Reactions are:

$$\begin{aligned} MnO_4^- + 8H^+ + 5e^- &\rightarrow Mn^{2+} + 4H_2O] \times 2 \\ SO_2 + 2H_2O &\rightarrow SO_4^{2-} + 4H^+ + 2e^-] \times 5 \end{aligned}$$

$$2MnO_4^- + 5SO_2 + 2H_2O \rightarrow 2Mn^{2+} + 5SO_4^{2-} + 4H^+$$

$$\underset{\text{Sulphur dioxide}}{2SO_2(g)} + O_2(g) \xrightarrow{V_2O_5(s)} \underset{\text{Sulphur trioxide}}{2SO_3(g)}$$

*(C)* *(D)*

**Q.7. On heating compound (A) gives a gas (B) which is a constituent of air. This gas when treated with 3 mol of hydrogen ($H_2$) in the presence of a catalyst gives another gas (C) which is basic in nature. Gas C on further oxidation in moist condition gives a compound (D) which is a part of acid rain. Identify compounds (A) to (D) and also give necessary equations of all the steps involved.**

**[*NCERT Exemplar*] [*HOTS*]**

**Ans.**

A = $NH_4NO_2$ , B = $N_2$, C = $NH_3$, D = $HNO_3$

Equations of all the steps involved:

i. $\underset{(A)}{NH_4NO_2} \rightarrow \underset{(B)}{N_2} + 2H_2O$

ii. $\underset{(B)}{N_2} + 3H_2 \rightarrow \underset{(C)}{2NH_3}$

iii. $\underset{(C)}{4NH_3} + 5O_2 \rightarrow 4NO + 6H_2O$

$2NO + O_2 \rightarrow 2NO_2$

$3NO_2 + H_2O \rightarrow \underset{(D)}{2HNO_3} + NO$

**Q.8. On heating, lead (II) nitrate gives a brown gas "A". The gas "A" on cooling changes to colourless solid "B". Solid "B" on heating with NO changes to a blue solid 'C'. Identify 'A', 'B', 'C' and also write reactions involved and draw the structures of 'B' and 'C'.**

**[*NCERT Exemplar*] [*HOTS*]**

**Ans.**

$$2Pb(NO_3)_2 \xrightarrow[673\ K]{\Delta} 2PbO + \underset{(A)}{4NO_2} + O_2$$

(Brown colour)

$$2NO_2 \underset{\text{On heating}}{\overset{\text{On cooling}}{\rightleftharpoons}} \underset{(B)}{N_2O_4}$$

*(Colourless solid)*

$$2NO + N_2O_4 \xrightarrow[250\ K]{\Delta} \underset{(C)}{2N_2O_3}$$

*(Blue solid)*

Structure if $N_2O_4$

Structure if $N_2O_3$

**Q.9. A translucent white waxy solid (A) on heating in an inert atmosphere is converted to its allotropic form (B). Allotrope (A) on reaction with very dilute aqueous KOH liberates a highly poisonous gas (C) having rotten fish smell. With excess of chlorine it forms (D) which hydrolyses to compound (E). Identify compounds (A) to (E).**

**[*HOTS*]**

**Ans.** A = White phosphorus B = Red phosphorus

C = Phosphine ($PH_3$) D = Phosphorus pentachloride ($PCl_5$)

E = Phosphoric acid ($H_3PO_4$)

**Reactions are:**

$$\underset{\text{White phosphorus}}{\underset{(A)}{P_4(s)}} \xrightarrow[\text{Inert gas}]{\Delta} \underset{\text{Red phosphorus}}{\underset{(B)}{P_4(s)}}$$

$$\underset{\text{White phosphorus}}{\underset{(A)}{P_4(g)}} + 3\,\text{KOH}\,(\text{aq}) + 3H_2O \xrightarrow{\Delta} \underset{\text{Potassium hypophosphite}}{3\,\text{KH}_2\,\text{PO}_2\,(\text{aq})} + \underset{\text{Phosphine}}{\underset{(C)}{\text{PH}_3\,(g)}}$$

$$\underset{\text{Phosphine}}{\underset{(C)}{\text{PH}_3\,(g)}} + 4\,\text{Cl}_2\,(g) \rightarrow \underset{\text{Phosphorus pentachloride}}{\underset{(D)}{\text{PCl}_5\,(g)}} + 3\,\text{HCl}\,(g)$$

$$\underset{\text{Phosphorus pentachloride}}{\underset{(D)}{\text{PCl}_5\,(g)}} + 4H_2O\,(l) \rightarrow \underset{\text{Phosphoric acid}}{\underset{(E)}{H_3\,\text{PO}_4\,(\text{aq})}} + 5\,\text{HCl}\,(\text{aq})$$