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Compiled By: Dapinderjeet Singh

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P-Block Elements

Important Questions with Answers

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IMPORTANT TERMS AND DEFINITIONS

- **p-Block elements:** Elements belonging to group 12 to 18 of the periodic table are called p-Block elements
- **Representative elements:** Elements which are belonging to the s and p-blocks in the periodic table are called representative elements.
- **Inert pair effect:** The tendency of ns^2 electron pair to participate in bond formation decreases with increase in atomic size. Because of which the higher oxidation state becomes less stable with respect to lower oxidation state as the atomic number increase. This trend is called inert pair effect. It happens due to poor shielding of intervening d/f orbitals resulting in greater attraction on s electrons. We can also say that energy required to unpair the electrons is more than the energy released in the formation of two additional bonds.
- **Reductional Potential:** It is defined as the tendency of a metal in contact with its ions to become positively charged with respect to the solution is called Reductional potential. ($M^{n+} + ne^- \rightarrow M$). Always remember that lower the Reductional potential, stronger will be the reducing agent.
- **Reducing agent:** The substance that loses electrons is called reducing agent. For example: Alkali metals are good reducing agents.
- **Oxidising agent:** The substance that gains electrons in a redox reaction is called oxidising agent. For example - Interhalogen compounds are good oxidising agents
- **Heat of Hydration:** Whenever cations or anions are surrounded by water molecule, the heat which is liberated called heat of hydration. Always remember that smaller the size of ions, more will be the heat of hydration. Secondly greater the charge on ion more will be the heat of hydration.
- **Lattice Energy:** The energy required to break one mole of crystal lattice is known as lattice energy.
- **Oxo-acids:** Those acids which contain oxygen are called Oxo acid. They are formed when acid oxides dissolve in water. Example- $HClO_4$, H_3PO_4 .
- **Chalcogens:** The ore forming elements are called Chalcogens. For example- oxygen, sulphur.
- **Bleaching Powder:** It has composition $Ca(OCl).CaCl_2.Ca(OH)_2.2H$. It is prepared by reaction of dry $Ca(OH)_2$ (slaked lime) and chlorine gas. It is used for bleaching and chlorinating and also for sterilization of water.
- **Interhalogen compounds:** The compounds are formed among halogens themselves are called interhalogen compounds. For example – $BrCl$, ICl etc. These are strong oxidising agents.
- **Ionic Hydrides:** They are compounds of hydrogen with most electropositive elements like element of group I and group II. For example- NaH , CaH_2 etc.
- **Covalent Hydrides:** These are the compounds of Hydrogen with pblock elements. For example: HCl , NH_3 .
- **Congeners:** The elements of the same group are called congeners. e.g. phosphorous is congener of nitrogen.

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QUESTIONS FROM THE NITROGEN FAMILY

Ques1 There is large increase of atomic radii From N to P as compared to other elements of group 15? Explain

Ans: This is based on the concept of screening effect. The s and p electrons have done screening to much larger extent as compared to d and f electrons of other elements. Moreover the other elements have fully filled orbitals. Because of larger screening of P electrons the effective nuclear charge will be decreases and there is large increase in atomic radii of phosphorous. Always remember that the effective nuclear charge is inversely proportional to the atomic radii.

Ques2 Melting point increases from N to As and then decreases. Why?

Ans: This can be explained on the base of inert pair effect. Because of this effect the Bismuth can form only three covalent bonds instead of five and therefore the attraction among their atoms becomes weak and hence their melting point is low. It will be easily melted because of less attractions.

Ques3 Nitrogen and Phosphorous will show -3 oxidation state while other will show +5 oxidation state.

Ans: It is based on the concept of atomic radii and electronegativity values of atoms. As the size of N and P be small and high electronegativity values as compared to the other elements. Because of high electronegativity these will attract the electrons towards itself and by gaining the electrons it will acquire a noble gas configuration.

Ques4 +5 oxidation state of Bi is less stable than Sb. Why?

Or

Ques4 Moving down the group the stability of +5 oxidation state decreases while that of +3 oxidation state increases. Why?

Ans: It can be explained on the base on an inert pair effect. As a result of which s electrons of Bismuth could not take part in chemical combination. Only p electrons will take part (2p³). In p shell there will be only three electrons, s electrons will not take part. That is why +3 oxidation state of Bismuth is more stable as compared to +5 or we can also say the +5 oxidation state of Bi is less stable than Sb as Bi comes after the Sb along a group in periodic table. Moreover we can also say that the inert pair effect increases down the group and hence the stability +5 oxidation state increases and that +3 oxidation state decreases.

Ques5 PCl₅ exists while NCl₅ does not exist .Why?

Ans: It is based on the concept of vacant d orbitals. As we know that in the case of phosphorous it has 5 electrons in its valence shell and it also have a vacant d orbitals. In the excited state the electron from s orbital will jump to the vacant d orbital and result in five unpaired electrons and from PCl₅. Moreover no such vacant d orbitals are present in the case of Nitrogen. Hence NCl₅ does not exist.

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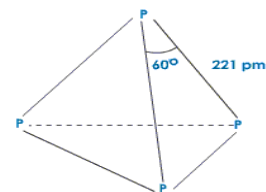
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Ques6 Molecular Nitrogen is not particularly reactive. Why?

Ans: Molecular Nitrogen is not particularly reactive because of the presence of triple bond and hence high bond dissociation energy. As a result of which the bond will not easily break and so does not react with any other molecule with an ease and hence it is less reactive.

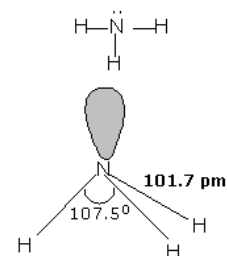
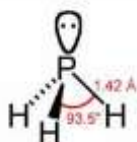
Ques7 N_2 is a gas but P_4 is a solid. Explain.

Ans: It is based on the concept of catenation property. Phosphorous exists as P_4 molecule i.e. each phosphorous will form P-P bond with other three Phosphorous atoms. While N-N bond is weak because of interelectronic repulsion by non bonding electrons. Because of which catenation tendency is weaker in Nitrogen. That is why N_2 exist as a gas and P_4 exists as a solid N_2 is a gas but P_4 is a solid



Ques8 NH_3 has higher bond angle than PH_3 . Why?

Ans: This can be explained on the base of size and electronegativity value of Nitrogen. As the size of Nitrogen is small and has high electronegativity value as compared to phosphorous, the electron repulsion is maximum and the bond angle is larger in NH_3 .



Ques9 Out of NH_3 and PH_3 which is more basic and Why?

Ans: This can be explained on the base of size of Nitrogen atom. As we see in the structures both Nitrogen and Phosphorous have a lone pair of electrons, but the size of nitrogen is small. So a lone pair is concentrated on small region and that is why electron density is maximum in case of ammonia. So it can donate electron pair easily as compared to phosphine and behave as Lewis base.

Ques10 NH_3 is weakest reducing agent than PH_3 . Why?

Ans: This can be explained on the base of stability of hydrides. Greater the instability of hydrides greater will be the reducing nature. As we go down the group the size of central atom goes on increasing. So, M-H bond length also goes on increasing and strength will be decreasing and so reducing character goes on increasing. The size of nitrogen is smaller than phosphorous, that is why the stability of NH_3 will be greater and hence the reducing character must be larger. (Reducing character express in terms of hydrogen releasing tendency)

Ques11 NH_3 is soluble in water while PH_3 is not.

Ans: This can be explained on the concept of Hydrogen Bonding. NH_3 can participate in H-bonding with water, because of the high electronegativity value of N, the H bonded to it, and the lone pair of electrons on the N. P has the hydrogens, and the lone pair of electrons, but it does not have a high electronegativity value, so it does not H-bond to water as much.

Ques12 PH_3 has lower boiling point than NH_3 . Why?

Ans: This is based on the Electronegativity values of P and N. The nitrogen atom in ammonia being more electronegative (3.0) than phosphorous atom in phosphine (2.0). That is why ammonia exhibit intermolecular Hydrogen bonding which is almost absent in phosphine. PH_3 has lower boiling point than NH_3 .

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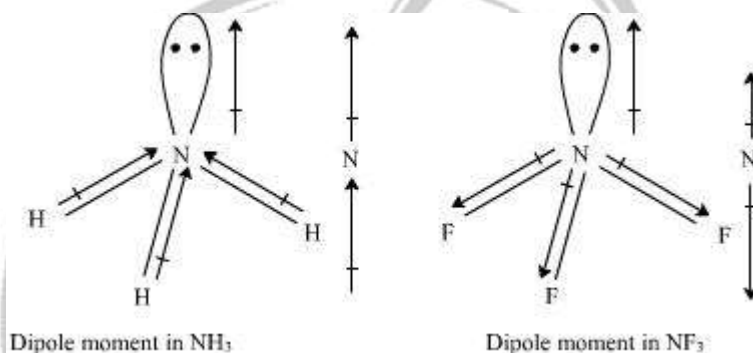
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Ques13 NF_3 does not act as Lewis base.

Ans: This is based on the Electronegativity value of F. As we know that fluorine is the most electronegative atom has electronegativity value equal to 4.0. Because of which it can withdraw the electrons from ammonia towards itself. Thus N, atom is devoid of its electron donor character and hence does not act as Lewis base.

Ques14 NF_3 has lower dipole moment than NH_3 .

Ans: Although both NH_3 and PF_3 have a pyramidal structure with lone pair of electrons on Nitrogen and Phosphorous. Directions of dipoles in case of three N-F bonds are towards F because F is more electronegative than N and oppose the effect of unshared electron pair on nitrogen. On the other hand the directions of three N-H bonds are towards N in case of ammonia and add the effect of electron pair. Hence NF_3 has lower dipole moment than NH_3 .



Ques15 Ammonia is good complexing agent. Why?

Ans: Ammonia is good complexing agent because of the presence of lone pair of electrons on nitrogen can easily form the coordinate or dative bond. Therefore ammonia can form coordinate complexes with cations having vacant d orbitals e.g. $\text{Ag}^+ + 2\text{NH}_3 \rightarrow [\text{Ag}(\text{NH}_3)_2]^+$

Ques16 Explain why trihalides of nitrogen cannot be hydrolysed while those of other elements group 15 get hydrolysed.

Ans: This can be explained on the base of vacant d orbitals. As we know that first step in hydrolysis is the formation coordinate bond by water with the central atom. Trihalides of nitrogen cannot be hydrolysed because they cannot form coordinate bond with water due to the absence vacant d orbitals in the valence shell of nitrogen. Trihalides of other member can be easily hydrolysed because they can form coordinate bond with water due to the presence of vacant d orbitals in the valence shell of central atom.

Ques17 All the bonds of PCl_5 are not equivalent.

Ans: All the bonds of PCl_5 are not equivalent, it includes two types of bonds. These are P-Cl (e) bonds called equatorial bonds and P-Cl (a) bonds are called axial bonds. Now the electron pair of axial bonds experiencing repulsion from the electron pairs of three equatorial bonds at right angles to it in space. At the same time the electron pair of equatorial bond is under repulsion from the electrons pairs of two axial bonds at right angle to it. That is why because of greater repulsion the bond length of axial bonds is slightly more than of equatorial bond.

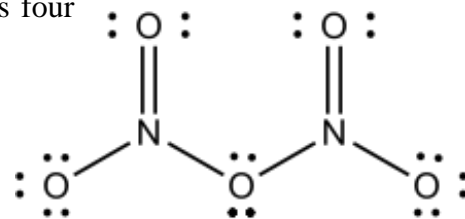
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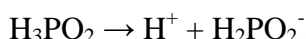
Ques18 What is the covalence of N_2O_5

Ans: Covalence of Nitrogen in the above structure is 4 because it has four shared pair of electrons.

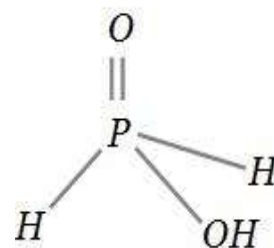


Ques19 Why Hypophosphorous acid is monobasic (H_3PO_2)

Ans: In the structure, there is one P=O bond, one P-OH bond and two P-H bonds. So it has only one OH bond i.e. have only one ionisable hydrogen atom. That is why it behaves as a monobasic acid.

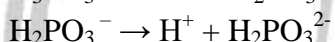
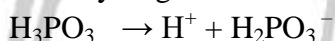


Always remember that because of two P-H bonds the acid as well as its salts behaves as reducing agents.



Ques20 Why orthophosphorous acid behaves as dibasic or diprotic?

Ans: It has one P=O bonds, one P-H and two P-OH bonds. So because of two P-OH bonds it has two ionisable hydrogen. That is why it behaves as a dibasic acid.



It is also a strong reducing agent.

Ques21 What is the formula of Nessler reagent?

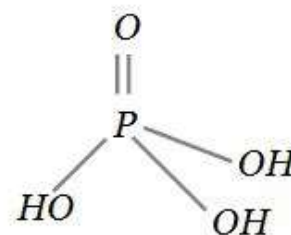
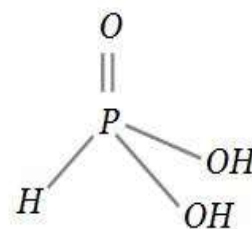
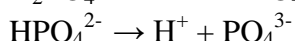
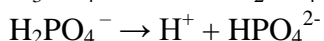
Ans: The formula for Nessler reagent is K_2HgI_4 .

Ques22 What is the formula for nitrolim?

Ans: $CaCN_2$

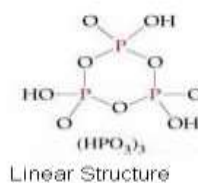
Ques23 Orthophosphoric acid is tribasic Why?

Ans: It has one P=O bonds and three P-OH bonds. So because of three P-OH bonds it has three ionisable hydrogen. That is why it behaves as a tribasic acid.

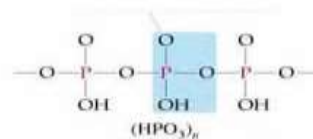


Ques24 Metaphosphoric acid is monobasic. Why?

Ans: Metaphosphoric acid has only one O-H bonds, so it has only one ionisable hydrogen. So it behaves as monobasic acid. But always remember that HPO_3 does not exist as discrete unit or single molecule It is in the polymeric form $(HPO_3)_n$. The linear and cyclic structure are :



Linear Structure



Cyclic Structure

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Ques25 Phosphorous acid can act both as oxidizing agent as well as reducing agent while phosphoric acid is only oxidizing agent.

Ans: This is explained on the oxidation state of two acids. In Phosphorous acid (H_3PO_3), the oxidation state of P is +3. So it is in a position to increase its oxidation state (acts as reducing agent) as well as decrease it (oxidising agent). But the oxidation state of phosphorous in phosphoric acid is +5. Since it cannot increase beyond this oxidation state. So we can say that it cannot act as reducing agent. However it can behave as oxidising agent by decreasing its oxidation state.

Ques26 NCl_3 is an endothermic compound while NF_3 is exothermic compound.

Ans: Because NCl_3 is a stable compound and NF_3 is unstable explosive because of high electronegativity of Fluorine atom. So energy is required in case of NCl_3 as compared to NF_3 .

Ques27 Why pentahalides are more covalent than trihalides?

Ans: It is based on the concept of oxidation state of central atom. Higher the positive oxidation state more will be the polarizing, greater will be the covalent character of bond formed between the central atom and the other atom according to Fajan's rules. In pentahalides, the central atom is in +5 oxidation state while in trihalides central atom is in +3 oxidation state. So pentahalides are more covalent than trihalides.

Ques28 What happens when PCl_5 is heated?

Ans: PCl_5 included two types of bonds axial and equatorial bonds. Since axial bonds are weaker than equatorial bonds. So when PCl_5 is heated less stable axial bonds are broken to form PCl_3 .



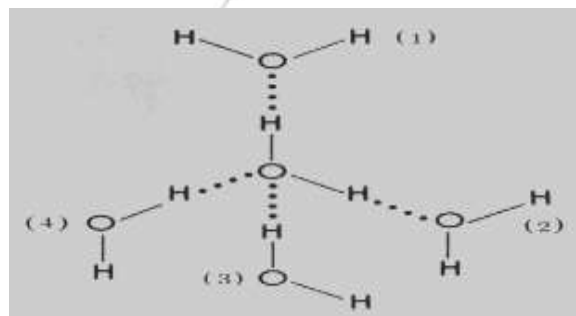
Ques29 Why does $\text{R}_3\text{P}=\text{O}$ exists but $\text{R}_3\text{N}=\text{O}$ does not?

Ans: It is based on the concept of vacant d orbitals. As Nitrogen due to the absence vacant d orbitals cannot form $p\pi-d\pi$ bond. As a result of which Nitrogen cannot exceed its valency beyond 4 but in $\text{R}_3\text{N}=\text{O}$ N, has valency of 5, so it does not exists. On the other hand P due to the presence of vacant d orbitals forms $p\pi-d\pi$ multiple bonds and can exceed their valency beyond 4. That is why $\text{R}_3\text{P}=\text{O}$ exists

QUESTIONS FROM OXYGEN FAMILY

Ques1 Why H_2O is a liquid and H_2S is a gas?

Ans: This is based on the concept of hydrogen bonding. The electronegativity difference between the O (3.5) and H (2.1) in case of water is more than the S (2.5) and H (2.1) in the case of H_2S . So we can say that O-H bond is more polar than the S-H bond of H_2S . Because of which there is a intermolecular hydrogen bonding in H_2O , which is almost absent in the



case of H_2S . That is why the water molecule get associated and consequently exists as liquid at room temperature. The association in H_2S is almost negligible and it exists as gas at room temperature.

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Ques2 Why does O_3 act as a powerful oxidising agent?

Ans: Upon heating, Ozone readily decomposes to give molecular oxygen O_2 which is more stable with nascent oxygen (O). The released nascent oxygen readily takes part in oxidation reactions. Therefore Ozone act as powerful oxidising agent.

(Remember that Oxidising agents give oxygen to another substance or remove hydrogen from it.)

Ques3 H_2S acts only as reducing agent while SO_2 can act as both reducing agent and an oxidising agent.

Ans: In H_2S , the oxidation state of sulphur is -2. It can only increase its oxidation state but cannot decrease it. That is why it can only act as a reducing agent. In SO_2 the oxidation state of S is +4. It is in a position to undergo decrease as well increase in oxidation state. Thus, SO_2 can act both as an oxidising agent and reducing agents.

Ques4 Covalency of oxygen cannot exceed 2.

Ans: Oxygen atom does not have vacant d orbital in the valence shell. Oxygen can have only two unpaired electrons in its valence shell ($1s^2 2s^2 2p_x^2 2p_y^1, 2p_z^1$), so it can show maximum covalency of two in its compounds.

Ques5 Sulphur is solid while O_2 is gas at room temperature.

Ans: This can be explained on the base of the size of the atom. The size of oxygen atom is small and in O_2 the oxygen atoms are linked to each other by a double bond because of PII-PII bonding is possible in this case. That is why oxygen exists in the gaseous state as discrete molecule. Multiple bonding is not so effective in the case of Sulphur because of its large size. Therefore S atoms cannot linked to each other by double bonds. In order to complete its octet, each sulphur atom is linked with two sulphur atoms on both sides resulting in puckered ring (S_8). Molecular sulphur (S_8) is a solid since the vander wall's forces of attractions are strong in the molecules.

Ques6 Compounds of fluorine and oxygen are called fluorides and not oxides.

Ans: This is because of higher electronegativity of fluorine (4.0) than that of oxygen (3.5). As we know that in writing the name of the compound, the electropositive element is written first, the compounds of fluorine and oxygen are called oxy-fluorides. For example, F_2O is known as Oxygen difluoride and not fluoride oxide.

Ques7 Bond angle in H_2S is lower than that of H_2O .

Ans: This is based on the concept of electronegativity of atoms. As we know that oxygen is more electronegative than sulphur, therefore the electron density around oxygen in water is more than around sulphur in H_2S . As greater the electron density, greater will be the repulsion between the electrons. That is why bond angle of water is more than that of hydrogen Sulphide.

Ques8 SF_6 is known compound while SH_6 is unknown. Why?

Ans: In both the above compounds, Sulphur is expected to show oxidation state of +6. This can only happen if two electrons from filled ($3s$ and $3p$) orbitals are promoted to vacant $3d$ orbitals. Only atoms of high electronegativity such as fluorine (4.0) can cause the promotion of electrons while the same is not possible with hydrogen with comparatively less electronegativity (2.1). Thus, SF_6 can exists while SH_6 does not exists.

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Ques9 H₂S is stronger acid than water.

Ans: H₂S is stronger acid than water because S-H bond is longer than O-H bond, as a result of which bond dissociation enthalpy of S-H bond is less than that of O-H bond. So release of H⁺ is easier in the case of H₂S and hence it is a strong acid as compared to H₂O.

Ques10 SO₂ can act both as oxidising agent and reducing agent while SO₃ can act as only oxidising agent.

Ans: In SO₂ the oxidation state of S is +4. Since it can undergo an increase as well as decrease in its oxidation state, it can act both as reducing agent and oxidising agent. On the other hand, oxidation state of S in SO₃ is +6 which is the maximum that it can have. So it can only decrease its oxidation state, SO₃ can act only as an oxidising agent.

Ques11 Write the order of thermal stability of the hydrides of group 16 elements?

Ans: The thermal stability of the hydrides of group 16 elements decreases from H₂O to H₂Te as
H₂O > H₂S > H₂Se > H₂Te

Ques12 Sulphur in vapour state shows paramagnetic character. Why?

Ans: In the vapour state sulphur exists as S₂ molecules. S₂ molecule like O₂ molecule has two unpaired electrons in the antibonding molecular orbitals and hence shows paramagnetism.

Ques13 SF₆ is not easily hydrolysed whereas SF₄ is easily hydrolysed.

Ans: In SF₄, the Sulphur atom has +4 oxidation state and can extend same to +6 by accepting electrons from H₂O molecules. Therefore it can be easily hydrolysed. But in SF₆ the oxidation state of Sulphur is +6 and cannot increase the same any more. Therefore it cannot be easily hydrolysed.

Ques14 The electron gain enthalpy with negative sign is less for oxygen than that of sulphur.

Ans: Because of the compact nature of oxygen atom, oxygen has less negative electron gain enthalpy than sulphur.

Ques15 Sulphur has a greater tendency for catenation than oxygen.

Ans: The property of catenation depends upon the strength of the element, element bond. Since sulphur S-S bond strength is more than O-O bond strength. So sulphur has greater tendency for catenation than oxygen.

Ques16 In the structure of HNO₃, the NO bond is shorter than the N-OH bond.

Ans: Due to smaller size of N-O than N-OH, the N-O bond length in HNO₃ is smaller than N-OH bond length.

Ques17 H₂S is less acidic than H₂Te. Why?

Ans: It is based on the concept of Bond Dissociation Enthalpy which decreases along a group as a result of which acidic strength increases.

QUESTIONS FROM THE HALOGEN FAMILY

Ques1 Halogens are coloured explain?

Ans: Because their molecules absorb visible light radiation. & as result of which the electron of valence shell will jump to higher energy levels. The value of excitation depends upon the size of atoms. Smaller the size of an atom greater will be the energy required from excitation. Fluorine due to its small size, requires a large amount of energy for excitation and absorbs violet light of high energy. Therefore, it appears yellow. Iodine due to its large size requires smaller excitation energy and absorbs yellow light of lower energy. Hence it

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appears violet. Similarly the colour of other halogens can be accounted for on the basis of light absorbed and transmitted by them.

Ques2 Why fluorine shows always -1 oxidation state?

Ans: Because of the absence of vacant d orbitals on the other hand the halogen have vacant d orbitals e they can show -1,+1,+2,+3 also.

Ques3 Why F_2 is strongest oxidising agent than Cl_2 instead the Electron affinity value is less than Cl_2 ?

Ans: On the basis of Electron affinity values the chlorine should be the strongest oxidising agents as it has high value of Electron affinity. But Fluorine is the strongest oxidising agent. This is because the electron affinity values related to the change of a gaseous atom into anion. On the other hand, oxidation involves the change of molecule into anions in solution and involves the following steps:

- Conversion of halogen molecule into atoms. During this step, energy equal to bond dissociation energy is absorbed.
- The atom gains an electron to form an anion and during this step energy equal to electron affinity is released.
- During the third step, anions get hydrated and energy known as hydration energy is released.

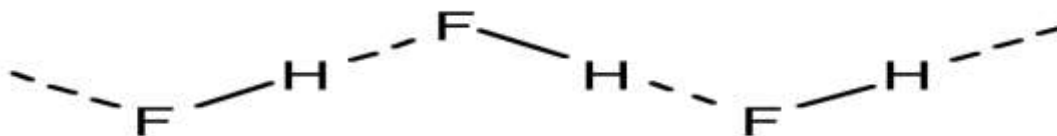
So, we can say that formation of hydrated ions is favoured, if

- dissociation energy is low
- electron affinity is high
- heat of hydration is high

On the basis of combined effect of all these factors, fluorine is the strongest oxidising agent and oxidising power decreases down the group.

Ques4 Why HF is liquid at room temperature?

Ans: This is based on the effect of hydrogen bonding. As fluorine is the most electronegative element and has very small size. Because of which HF gets associated due to intermolecular hydrogen bonding and exists as liquids at room temperature.



Ques5 Why HF is the least acidic while HI is the strongest acidic?

Ans: If we judge according to concept of Electronegativity value the HF be the strongest acidic. It can be explained on the base of bond dissociation enthalpy which is maximum in the case of HF, as a result of which the release of H^+ will be difficult and it behave as weak acid. Moreover because of hydrogen bonding in HF hydrogen atom gets trapped in HF bond and their release will be more difficult.



Ques6 Arrange the following in decreasing order of their acidic character



Ans: It is based on the concept of Electronegativity of the halogen atom. Greater the electronegativity of halogen atom greater will be the electron withdrawing tendency and

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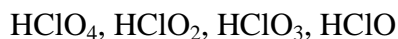
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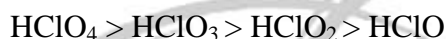
easier will be the release of H^+ and more is the acidic character. So chlorine is more electronegative than Br and I. That is why the decreasing order of acidic strength is:



Ques7 Arrange the following in increasing order of their acidic character



Ans: It is based on the stability of ion formed after the release of H^+ ion. Acid will be stronger if it ionizes to greater extent and it is only possible if ion formed from it is more stable. Now we know negatively charged ion formed by loss of proton from an acid are always stabilized by delocalization of negative charge. Greater the no. of oxygen atom greater will be delocalization & strong will be stability of ion & stronger is the acid. ClO^- is minimum stable and ClO_4 is maximum stable. So that is why $HClO_4$ is maximum acidic in nature. Therefore the increasing order of acidic character is:



Ques8 Why ICl is more reactive than I_2 ?

Ans: ICl is polar in nature due to the electronegativity difference between the two halogen atoms, as a result of which the bond is weak between the two. On the other hand I_2 is a non polar molecule as the two halogens are same and there is no electronegativity difference.

Ques9 Iodine is more soluble in KI solution than in water?

Ans: Iodine is covalent in nature and therefore it does not dissolve in water which is polar. In KI solution, iodine reacts to form KI_3 which is ionic in nature. Therefore it becomes soluble in water.

Ques10 ClF_3 exists but FCl_3 does not.

Ans: Chlorine has vacant 3d orbitals and the electron can be promoted from filled 3p orbital to the vacant 3d orbital. So chlorine can show a covalency of three in its compounds and a molecule of ClF_3 exists. But on the other hand Fluorine has no vacant 2d orbitals and can exhibit only covalency of one in its compounds. That is why the molecule of FCl_3 does not exist.

Ques11 Ferric Iodide is unstable but ferric chloride is stable.

Ans: Iodide ion is strong reducing agent and reduces Fe^{3+} ion to Fe^{2+} . Therefore ferric iodide does not exist (FeI_3) while ferrous iodide exists (FeI_2). On the other hand, chloride ion being a weak reducing agent cannot reduce Fe^{3+} . As a result ferric chloride exists. ($FeCl_3$)

Ques12 Why halogens have low melting points?

Ans: Halogens exist as diatomic molecules (X_2) and are non polar. The attractive forces which keep them in solid state are weak van der Waals forces. That is why halogens have low melting points.

Ques13 Fluorine never acts as the central atom in polyatomic interhalogen compounds

Ans: Fluorine because of its smaller size cannot accommodate larger sized other halogen atoms around it.

Ques14 Write two uses of ClO_2 .

Ans: i) It is a powerful oxidizing agent ii) It is a stronger chlorinating agent and its bleaching power is 30 times higher than that of Cl_2

Ques15 Why interhalogen compounds are strong oxidizing agents.

Ans: Due to weak X-X bond in interhalogen compounds, they act as oxidizing agents.

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QUESTIONS FROM THE NOBLE GASES

Ques1 Noble gas elements form compounds only with fluorine and oxygen.

Ans: Noble gas elements have symmetrical electronic configuration and therefore high ionization enthalpies. So all their occupied orbitals are filled, they normally cannot form any compounds. However the elements like fluorine and oxygen with high electronegativity values can cause the promotion of electrons from filled valence p orbitals to the vacant d orbitals. But always remember that this is only possible in the case of Xenon because their ionization energy is minimum and the promotion of electrons is rather easy.

Ques2 Noble gas elements have very low melting and boiling point.

Ans: Noble gases exist as monoatomic gases and the only attractive force in them are the weak vander Waal's forces. As a result they have very low melting and boiling point.

Ques3 Helium and neon do not form compounds with fluorine.

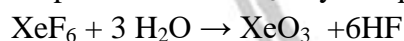
Ans: Both helium and neon do not form compounds with fluorine because of the absence of vacant d orbitals in their valence shell. So there is no scope for any electron promotion or the formation of half filled orbitals.

Ques4 Xenon does not form fluorides such as XeF_3 and XeF_5 .

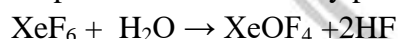
Ans: We know that Xe have fully filled electronic configuration as all the electrons are paired. By the promotion of One, two or three electrons from the filled p-orbitals to the vacant d orbitals in the valence shell, two, four or six half filled orbitals are formed. That is why Xenon can combine only with even number of fluorine atoms. In other words we can also say that it does not form fluorides such as XeF_3 and XeF_5 .

Ques5 How XeO_3 and XeOF_4 is prepared?

Ans: Preparation of XeO_3 : By complete hydrolysis of XeF_6 .



Preparation of XeOF_4 : By partial hydrolysis of XeF_6 .



Ques6 Why ease of liquefy noble gases increases with increase in atomic number?

Ans: The ease liquefaction depends upon the magnitude of attractive forces in the molecules. The attractive force in case of noble gases are vander Waal's forces and their magnitude increases with increase in atomic size. Since atomic size increases down the group, the ease of liquefaction increases down the group.

Ques7 Why do noble gases have comparatively large atomic sizes?

Ans: Noble gases have large atomic sizes in their respective periods because the atomic radii in case of noble gases are vander Waal's radii which have greater magnitude as compared to covalent radii in case of other elements.

Ques8 No chemical compound of helium is known.

Ans: Since helium has completely filled $ns^2 np^6$ configuration in their valence shell.

Ques9 Neon is generally used for warning signals. Why?

Ans: As Neon light are visible from long distances even in fog and mist. That is why these are used for warning signals.

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STRUCTURES OF OXIDES OF NITROGEN

N_2O_4 Dinitrogen tetraoxide	+4	colourless liquid	
NO_2 Nitrogen dioxide	+4	brown gas	
N_2O_5 Dinitrogen pentaoxide	+5	colourless gas	
Oxide	Oxidation state of 'N'	Physical appearance	Structure
N_2O Nitrous oxide	+1	colourless gas	$N \equiv N \rightarrow O$
NO Nitric oxide	+2	colourless	$N = O$
N_2O_3 Dinitrogen trioxide	+3	blue solid	

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Structure of Oxoacids of Phosphorous

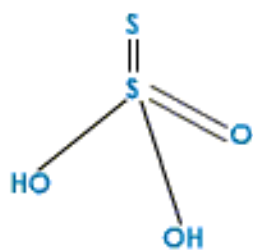
Name	Oxidation state of P and Basicity	Structure
Hypophosphorous acid H_3PO_2	+1 (Monobasic)	
Phosphorous acid H_3PO_3	+3 (Dibasic)	
Hypophosphoric acid $\text{H}_4\text{P}_2\text{O}_6$	+4 (Tetrabasic)	
Orthophosphoric acid H_3PO_4	+5 (Tribasic)	
Metaphosphoric acid (HPO_3) _n	+5 (Monobasic)	
Pyrophosphoric acid (Diphosphoric acid). $\text{H}_4\text{P}_2\text{O}_7$	+5 (Tetrabasic)	

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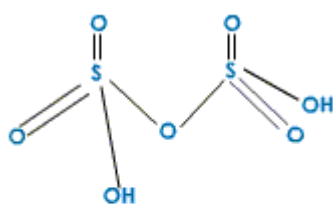
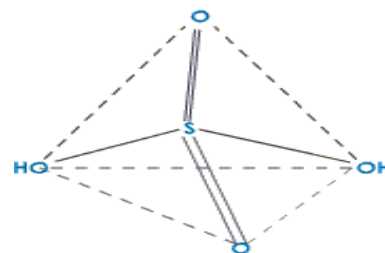
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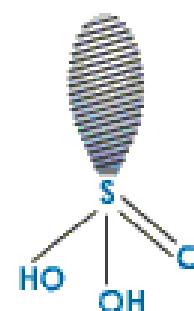
Structure of Oxoacids of Sulphur



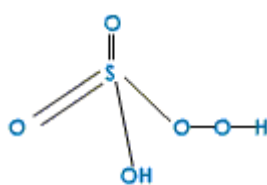
$\text{H}_2\text{S}_2\text{O}_3$ (+2)
Thiosulphuric acid



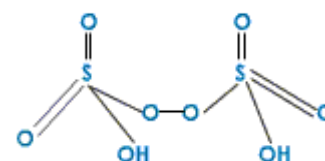
$\text{H}_2\text{S}_2\text{O}_7$ (+6)
Disulphuric acid
(or Pyrosulphuric acid)



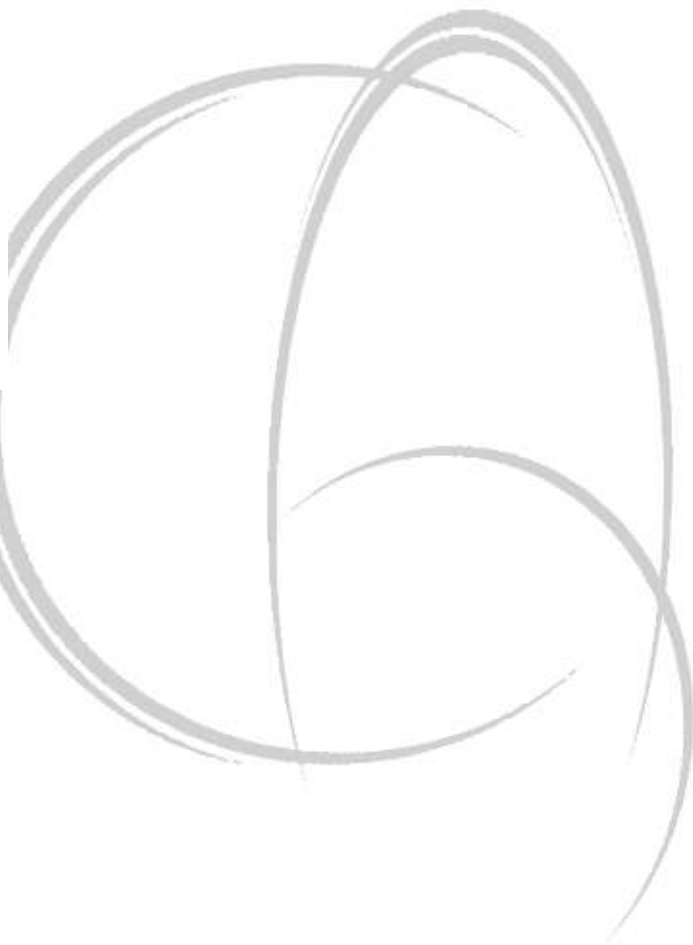
H_2SO_3 (+4)
Sulphurous acid



H_2SO_5 (+6)
Peroxymonosulphuric acid



$\text{H}_2\text{S}_2\text{O}_8$ (+6)
Peroxydisulphuric acid
(or Marshall's acid)

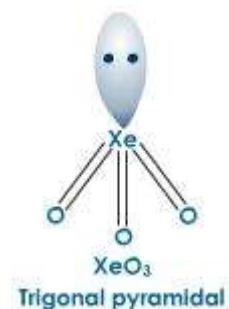
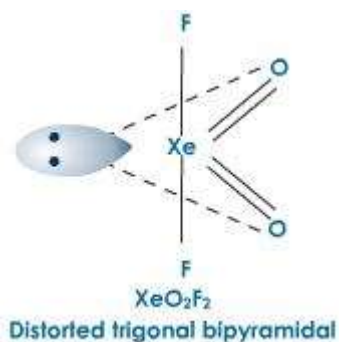
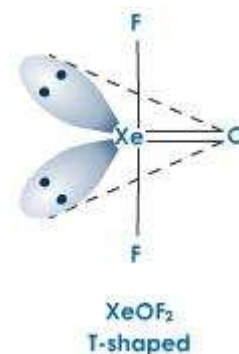
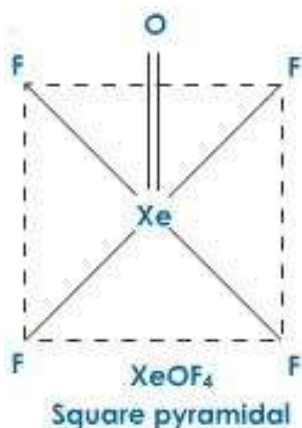
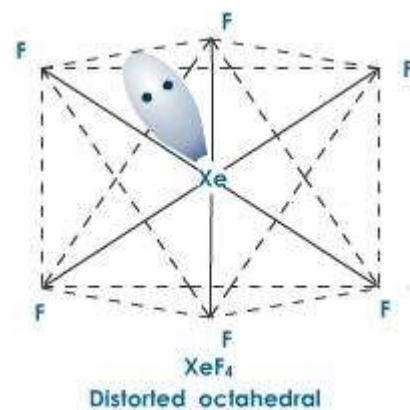
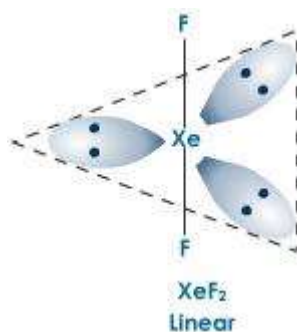
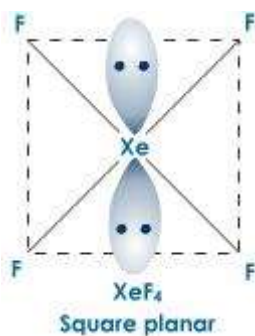


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Structure of Compounds of Xenon



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MANUFACTURE OF AMMONIA BY HABER PROCESS (INDUSTRIAL PREPARATION)

Ammonia can be manufactured by Haber process which involves the following reaction, which is a reversible reaction:

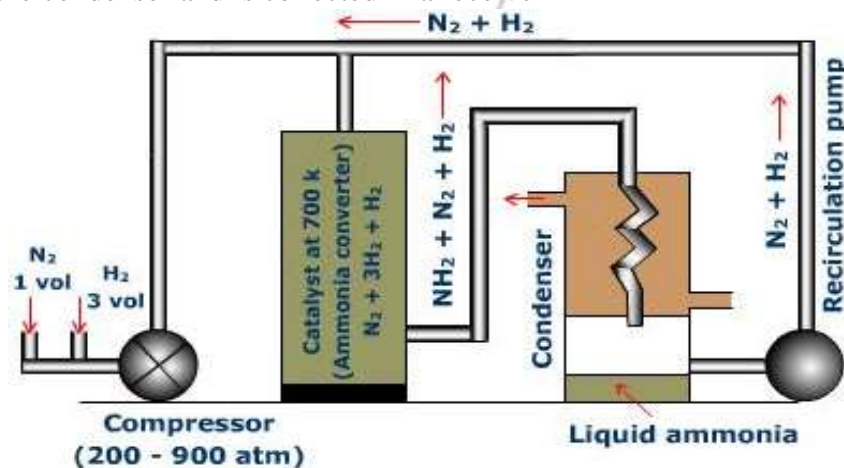


Le Chatlier Principle: The process provides an excellent illustration of Le Chatelier's Principle. If we examine the above equation, we see that 4 volumes of the reacting gases form 2 volumes of ammonia. Le Chatelier's Principle predicts that the forward reaction will be favoured by applying a stress on the system such as to reduce the overall volume. This is achieved by increasing the pressure on the reacting system.

We note also that heat is evolved in the process (ΔH is negative - the reaction is exothermic). The forward reaction will therefore be promoted by a reduction in temperature, thus improving the yield of ammonia at equilibrium. However, at low temperatures the rate of attaining the equilibrium is so slow as to make the process impracticable. So, in order to carry out the process, a temperature of about $500\text{ }^{\circ}\text{C}$ is used, and even so, it has to be speeded up by the use of an iron oxide catalyst. The equilibrium mixture contains about 25-30% ammonia. This gas is easily liquefied, thus enabling its separation from the unreacted nitrogen and hydrogen, which are recycled.

Detail of the process

- i) **Production of hydrogen and nitrogen:** Hydrogen required for the process is obtained by the electrolysis of water. Nitrogen is obtained by the fractional distillation of liquefied air.
- ii) **Compression:** Nitrogen and hydrogen are mixed in 1:3 by volume. Mixture is compressed to a pressure of 200-900 atmosphere with the help of compressor.
- iii) **Conversion to ammonia:** Purified gases mixture is led into a cylindrical steel chamber known as catalyst chamber. It is packed with finely divided iron (catalyst) and molybdenum (promoter). The chamber is heated to about 700 K. In this chamber hydrogen and nitrogen combine to form ammonia. The reaction being exothermic tends to raise the temperature. Therefore once the reaction start, the external heating is stopped as the heat produce during the reaction maintains the required temperature.
- iv) **Condensation:** The gases coming out of the catalyst chamber contain 10-20% NH_3 . These are passed through the condenser and is collected in a receiver
- v) **Recirculation:** The uncondensed gases are recirculated over the catalyst with the help of a recirculation pump, to get more ammonia.



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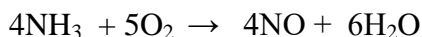
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MANUFACTURE OF NITRIC ACID BY OSTWALD PROCESS (INDUSTRIAL PREPARATION)

Nitric acid is prepared on large scale by the catalytic oxidation of ammonia and process is known as Ostwald process.

Principle: The ammonia gas is obtained by the oxygen of air in the presence of platinum gauze or platinum catalyst heated to above 1070K. Nitric oxide is formed during the process:



Nitric oxide is cooled when it combine with more oxygen to form nitrogen dioxide.



Nitrogen dioxide is converted to nitric acid by mixing it with water and air



The NO which is produced is then recycled

Detail of the process:

- i) **Oxidation of ammonia:** A mixture of ammonia and dust free air in the ratio 1:10 by volume is passed through a converter made of steel and packed with a platinum gauze or a catalyst containing 90% platinum and 10% rhodium. The later is preferred these days because we know that the platinum gauze gets rusted during the process and its efficiency is reduced Converter is heated electrically to about 1070K when Nitric acid is formed As the reaction is exothermic that is why heating is required only at the beginning
- ii) **Oxidation of Nitric oxide:** The gases coming out of the converter are a mixture of nitric oxide, nitrogen and oxygen. These are cooled to about 325K with the help of cooler and mixed with more air. The mixture is passed through an oxidation chamber where nitrogen dioxide is formed.
- iii) **Absorption of Nitrogen dioxide:** The vapours of nitrogen dioxide are then introduced into the absorption tower which is packed with acid proof stones. Water sprayed from the top of this tower dissolve nitrogen dioxide in the presence of oxygen forming dilute nitric acid.
- iv) **Concentration of acid:** The dilute Nitric acid obtained above is concentrated by distillation under reduced pressure in the presence of concentrated sulphuric acid.

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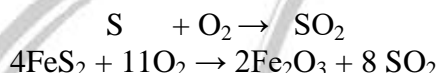
MANUFACTURE OF SULPHURIC ACID BY CONTACT PROCESS

Le-Chatlier principle: According to Le Chaltier the following conditions are favorable to get maximum yield of Sulphuric acid:

- 1) High concentration of reactants
- 2) Low temperature is required as forward reaction is exothermic. But an optimum temperature of 623-723 K must be maintained.
- 3) High pressure is required but it is likely to cause the corrosion of the vessel in which oxidation is carried out. Normally the pressure of 2 to 3 atmosphere is maintained.
- 4) In order to accelerate the reaction the presence of catalyst is quite helpful. V_2O_5 act as a catalyst.
- 5) Gases must be completely free from dust and poisonous gases like arsenic oxide before they are passed through the catalyst.

Detail of the process:

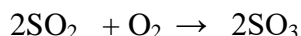
- i) **Pyrite or Sulphur burners:** Here Sulphur or iron pyrite is burn in excess of air to form Sulphur dioxide.



- ii) **Purifying Unit:** The impurities are removed from the gaseous mixture by following steps
- a) Dust chamber: Steam is introduced from top f the chamber which helps in settling of dust particles
 - b) Coolers: Temperature of gases is lowered by passing through the coolers.
 - c) Scrubber: gases are introduced into a washing tower (packed with quartz) known as scrubber which dissolve mist and any other soluble impurities.
 - d) Dyeing tower: A spray of concentrated H_2SO_4 is used for drying of gases.
 - e) Arsenic purifier: It is provided with a number of shelves which contain freshly precipitated ferric hydroxide. It absorbs the impurity of arsenic oxide which is poisonous.

- iii) **Testing Box:** The purity of gases are checked in this box .A strong beam of light is sent into this box at right angles. In case the gases are pure the path of light remains invisible. If the gases still contain dust or other particles the path of light as well as particles become visible

- iv) **Converter or Contact tower:** The pure gases coming out of the testing box are heated in ore heater to about 723-823 K. After that these are then introduced into converter which is cylindrical chamber made of iron and contain in it iron tubes packed with catalyst. In the converter sulphur dioxide is oxidized to sulphur trioxide



Since the forward reaction is exothermic, heat is evolved in the reaction and this maintains the temperature needed for the reaction.

- v) **Absorption tower:** SO_3 from the converter is passed through this tower packed with acid proof flint pieces. Pure concentrated sulphuric acid is sprayed from the top in order to absorbs sulphur trioxide and form oleum or fuming sulphuric acid

