

p-Block Elements

Multiple Choice Questions (MCQs)

Q. 1 On addition of conc. H_2SO_4 to a chloride salt, colourless fumes are evolved but in case of iodide salt, violet fumes come out. This is because

- (a) H_2SO_4 reduces HI to I_2 (b) HI is of violet colour
(c) HI gets oxidised to I_2 (d) HI changes to HIO_3

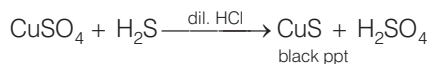
Ans. (c) Hydrogen iodide (HI) is more stronger oxidising agent than H_2SO_4 . So, it reduces H_2SO_4 to SO_2 and itself oxidises to I_2 . Colour of I_2 is violet hence on adding conc. H_2SO_4 to HI, it gets oxidised to I_2 .



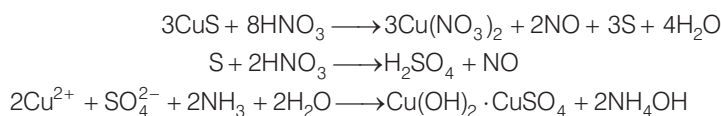
Q. 2 In qualitative analysis when H_2S is passed through an aqueous solution of salt acidified with dil. HCl, a black precipitate is obtained. On boiling the precipitate with dil. HNO_3 , it forms a solution of blue colour. Addition of excess of aqueous solution of ammonia to this solution gives

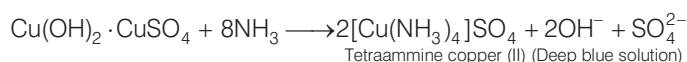
- (a) deep blue precipitate of $\text{Cu}(\text{OH})_2$
(b) deep blue solution of $[\text{Cu}(\text{NH}_3)_4]^{2+}$
(c) deep blue solution of $\text{Cu}(\text{NO}_3)_2$
(d) deep blue solution of $\text{Cu}(\text{OH})_2 \cdot \text{Cu}(\text{NO}_3)_2$

Ans. (b) In qualitative analysis when H_2S is passed through an aqueous solution of salt acidified with dil. HCl a black ppt. of CuS is obtained.



On boiling CuS with dil. HNO_3 it forms a blue coloured solution and the following reactions occur

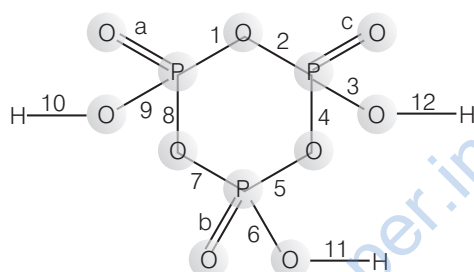




Q. 3 In a cyclotrimetaphosphoric acid molecule, how many single and double bonds are present?

- (a) 3 double bonds; 9 single bonds
- (b) 6 double bonds; 6 single bonds
- (c) 3 double bonds; 12 single bonds
- (d) Zero double bond; 12 single bonds

Ans. (c) Cyclotrimetaphosphoric acid contains three double bonds and 9 single bonds as shown below



Cyclotrimetaphosphoric acid (HPO₃)₃

a, b, c are three π bonds and numerics 1 to 12 are sigma (σ) bonds.

Q. 4 Which of the following elements can be involved in $p\pi - d\pi$ bonding?

- (a) Carbon
- (b) Nitrogen
- (c) Phosphorus
- (d) Boron

Ans. (c) Among given four elements *i.e.*, carbon, nitrogen, phosphorus and boron. Only phosphorus has vacant *d*-orbit so only phosphorus has ability to form $p\pi - d\pi$ bonding.

Q. 5 Which of the following pairs of ions are isoelectronic and isostructural?

- (a) CO_3^{2-} , NO_3^-
- (b) ClO_3^- , CO_3^{2-}
- (c) SO_3^{2-} , NO_3^-
- (d) ClO_3^- , SO_3^{2-}

Ans. (a) Compounds having same value of total number of electrons are known as isoelectronic.

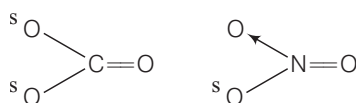
For CO_3^{2-}

$$\begin{aligned} \text{Total number of electrons} &= 6 + 8 \times 3 + 2 \\ &= 6 + 24 + 2 \\ &= 32 \end{aligned}$$

For NO_3^-

$$\begin{aligned} \text{Total number of electrons} &= 7 + 8 \times 3 + 1 \\ &= 7 + 25 \\ &= 32 \end{aligned}$$

Hence, CO_3^{2-} and NO_3^- are isoelectronic. These two ions have similar structure so they are isostructural.



Both have triangular planar structure as in both the species carbon and nitrogen are sp^2 hybridised. Hence, (a) is the correct choice.

Q. 6 Affinity for hydrogen decreases in the group from fluorine to iodine. Which of the halogen acids should have highest bond dissociation enthalpy?

- (a) HF (b) HCl (c) HBr (d) HI

Ans. (a)

HF	On moving top to bottom
HCl	• Size of halogen atom increases
HBr	• H-X bond length increases
HI	• Bond dissociation enthalpy decreases

Q. 7 Bond dissociation enthalpy of E—H (E= element) bonds is given below. Which of the compounds will act as strongest reducing agent?

Compound	NH ₃	PH ₃	AsH ₃	SbH ₃
$\Delta_{\text{diss}} (\text{E—H}) / \text{kJ mol}^{-1}$	389	322	297	255

- (a) NH₃ (b) PH₃ (c) AsH₃ (d) SbH₃

Ans. (d) On moving top to bottom, size of central atom increases. Bond length of X—H bond increases and bond dissociation energy decreases. Hence, reducing nature increases.

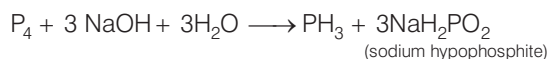
NH ₃	
PH ₃	• Bond length increases
AsH ₃	• Bond dissociation energy decreases
SbH ₃	• Reducing character increases

Hence, SbH₃ is act as strongest reducing agent among these.

Q. 8 On heating with concentrated NaOH solution in an inert atmosphere of CO₂, white phosphorus gives a gas. Which of the following statement is incorrect about the gas?

- (a) It is highly poisonous and has smell like rotten fish
 (b) It's solution in water decomposes in the presence of light
 (c) It is more basic than NH₃
 (d) It is less basic than NH₃

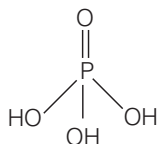
Ans. (c) White phosphorous on reaction with NaOH solution in the presence of inert atmosphere of CO₂ it produces phosphine gas which is less basic than NH₃.



Q. 9 Which of the following acids forms three series of salts?

- (a) H₃PO₂ (b) H₃BO₃ (c) H₃PO₄ (d) H₃PO₃

Ans. (c) Structure of H₃PO₄ is



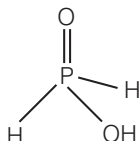
H₃PO₄ has 3—OH groups *i.e.*, has three ionisable H-atoms and hence forms three series of salts. These three possible series of salts for H₃PO₄ are as follows



Q. 10 Strong reducing behaviour of H_3PO_2 is due to

- (a) low oxidation state of phosphorus
- (b) presence of two —OH groups and one P—H bond
- (c) presence of one —OH group and two P—H bonds
- (d) high electron gain enthalpy of phosphorus

Ans. (c) Strong reducing behaviour of H_3PO_2 is due to presence of two P—H bonds and one P—OH bond

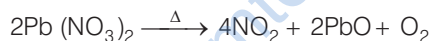


**Hypophosphorous following
(Monobasic)**

Q. 11 On heating lead nitrate forms oxides of nitrogen and lead. The oxides formed are

- (a) N_2O , PbO
- (b) NO_2 , PbO
- (c) NO , PbO
- (d) NO , PbO_2

Ans. (b) On heating lead nitrate it produces brown coloured nitrogen dioxide (NO_2) and lead (II) oxide.



Q. 12 Which of the following elements does not show allotropy?

- (a) Nitrogen
- (b) Bismuth
- (c) Antimony
- (d) Arsenic

Ans. (a) Nitrogen does not show allotropy due to its weak N—N single bond. Therefore, ability of nitrogen to form polymeric structure or more than one structure or form become less. Hence, nitrogen does not show allotropy.

Q. 13 Maximum covalency of nitrogen is

- (a) 3
- (b) 5
- (c) 4
- (d) 6

Ans. (c) Maximum covalency of nitrogen is 4 in which one electron is made available by s-orbital and 3 electrons are made available by p orbitals. Hence, total four electrons are available for bonding.

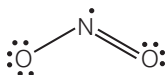
Q. 14 Which of the following statements is wrong?

- (a) Single N—N bond is stronger than the single P—P bond.
- (b) PH_3 can act as a ligand in the formation of coordination compound with transition elements.
- (c) NO_2 is paramagnetic in nature.
- (d) Covalency of nitrogen in N_2O_5 is four.

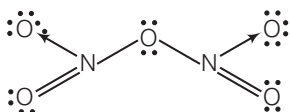
Ans. (a) True statement is that single N — N bond is weaker than the single P — P bond. This is why phosphorous show allotropy but nitrogen does not.

- (i) PH_3 acts as a ligand in the formation of coordination compound due to presence of lone pair of electrons.

- (ii) NO_2 is paramagnetic in nature due to presence of one unpaired electron.
Structure of NO_2 is



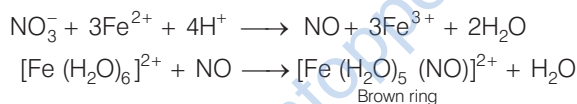
- (iii) Covalency of nitrogen in N_2O_5 is 4.



Q. 15 A brown ring is formed in the ring test for NO_3^- ion. It is due to the formation of

- (a) $[\text{Fe}(\text{H}_2\text{O})_5(\text{NO})]^{2+}$ (b) $\text{FeSO}_4 \cdot \text{NO}_2$
(c) $[\text{Fe}(\text{H}_2\text{O})_4(\text{NO})_2]^{2+}$ (d) $\text{FeSO}_4 \cdot \text{HNO}_3$

Ans. (a) When freshly prepared solution of FeSO_4 is added in a solution containing NO_3^- ion, it leads to formation of a brown coloured complex. This is known as brown ring test of nitrate.



Q. 16 Elements of group- 15 form compounds in +5 oxidation state. However, bismuth forms only one well characterised compound in +5 oxidation state. The compound is

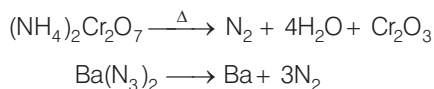
- (a) Bi_2O_5 (b) BiF_5
(c) BiCl_5 (d) Bi_2S_5

Ans. (b) Stability of + 5 oxidation state decreases top to bottom and + 3 oxidation state increases top to bottom due to inert pair effect. Meanwhile compound having + 5 oxidation state of Bi is BiF_5 . It is due to smaller size and high electronegativity of fluorine.

Q. 17 On heating ammonium dichromate and barium azide separately we get

- (a) N_2 in both cases
(b) N_2 with ammonium dichromate and NO with barium azide
(c) N_2O with ammonium dichromate and N_2 with barium azide
(d) N_2O with ammonium dichromate and NO_2 with barium azide

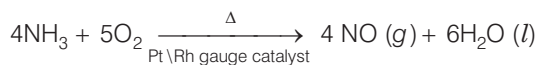
Ans. (a) On heating ammonium dichromate and barium azide it produces N_2 gas separately.



Q. 18 In the preparation of HNO_3 , we get NO gas by catalytic oxidation of ammonia. The moles of NO produced by the oxidation of two moles of NH_3 will be

- (a) 2 (b) 3 (c) 4 (d) 6

Ans. (a) Two moles of NH_3 will produce 2 moles of NO on catalytic oxidation of ammonia in preparation of nitric acid.



Q. 19 The oxidation state of central atom in the anion of compound NaH_2PO_2 will be

- (a) + 3 (b) + 5 (c) + 1 (d) - 3

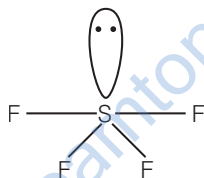
Ans. (c) Let oxidation state of P in NaH_2PO_2 is x .

$$\begin{aligned} 1 + 2 \times 1 + x + 2 \times -2 &= 0 \\ 1 + 2 + x - 4 &= 0 \\ + x - 1 &= 0 \\ x &= + 1 \end{aligned}$$

Q. 20 Which of the following is not tetrahedral in shape?

- (a) NH_4^+ (b) SiCl_4 (c) SF_4 (d) SO_4^{2-}

Ans. (c) SF_4 has sea-saw shaped as shown below

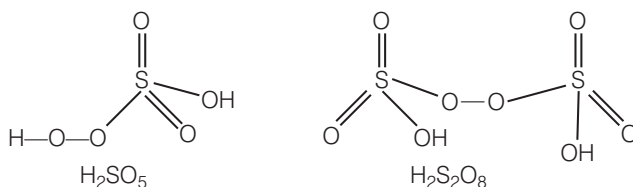


It has trigonal bipyramidal geometry having sp^3d hybridisation.

Q. 21 Which of the following are peroxyacids of sulphur?

- (a) H_2SO_5 and $\text{H}_2\text{S}_2\text{O}_8$ (b) H_2SO_5 and $\text{H}_2\text{S}_2\text{O}_7$
 (c) $\text{H}_2\text{S}_2\text{O}_7$ and $\text{H}_2\text{S}_2\text{O}_8$ (d) $\text{H}_2\text{S}_2\text{O}_6$ and $\text{H}_2\text{S}_2\text{O}_7$

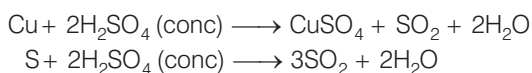
Ans. (a) Peroxyacids of sulphur must contain one —O—O— bond as shown below



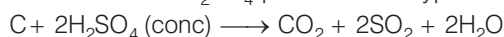
Q. 22 Hot conc. H_2SO_4 acts as moderately strong oxidising agent. It oxidises both metals and non-metals. Which of the following element is oxidised by conc. H_2SO_4 into two gaseous products?

- (a) Cu (b) S (c) C (d) Zn

Ans. (c) H_2SO_4 is a moderately strong oxidising agent which oxidises both metals and non-metals as shown below



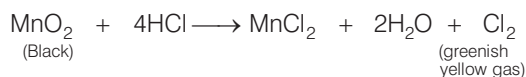
While carbon on oxidation with H_2SO_4 produces two types of oxides CO_2 and SO_2 .



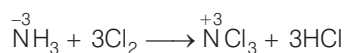
Q. 23 A black compound of manganese reacts with a halogen acid to give greenish yellow gas. When excess of this gas reacts with NH_3 an unstable trihalide is formed. In this process the oxidation state of nitrogen changes from

- (a) - 3 to + 3 (b) - 3 to 0
(c) - 3 to + 5 (d) 0 to - 3

Ans. (a) Black coloured compound MnO_2 reacts with HCl to produce greenish yellow coloured gas of Cl_2



Cl_2 on further treatment with NH_3 produces NCl_3 .



NH_3 (- 3) changes to NCl_3 (+3) in the above reaction. Hence, (a) is the correct choice.

Q. 24 In the preparation of compounds of Xe, Bartlett had taken $\text{O}_2^+ \text{Pt F}_6^-$ as a base compound. This is because

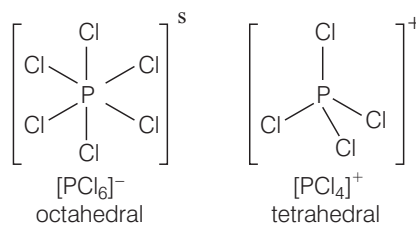
- (a) both O_2 and Xe have same size.
(b) both O_2 and Xe have same electron gain enthalpy.
(c) both O_2 and Xe have almost same ionisation enthalpy.
(d) both Xe and O_2 are gases.

Ans. (c) Bartlett had taken $\text{O}_2^+ \text{Pt F}_6^-$ as a base compound because O_2 and Xe both have almost same ionisation enthalpy. The ionisation enthalpies of noble gases are the highest in their respective periods due to their stable electronic configurations.

Q. 25 In solid state PCl_5 is a

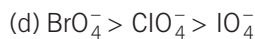
- (a) covalent solid
(b) octahedral structure
(c) ionic solid with $[\text{PCl}_6]^+$ octahedral and $[\text{PCl}_4]^-$ tetrahedral
(d) ionic solid with $[\text{PCl}_4]^+$ tetrahedral and $[\text{PCl}_6]^-$ octahedral

Ans. (d) In solid state PCl_5 exists as an ionic solid with $[\text{PCl}_4]^+$ tetrahedral and $[\text{PCl}_6]^-$ octahedral.



Q. 26 Reduction potentials of some ions are given below. Arrange them in decreasing order of oxidising power.

Ion	ClO_4^-	IO_4^-	BrO_4^-
Reduction potential E^-/V	$E^\circ = 1.19\text{ V}$	$E^s = 1.65\text{ V}$	$E^s = 1.74\text{ V}$



Thinking Process

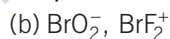
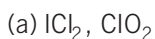
This problem is based on concept of standard reduction potential of species and oxidising property.

Ans. (c) Greater the SRP value of species higher will be its oxidising power.

Species	E°_{cell}	
ClO_4^-	1.19V	↓ SRP of species increases. Oxidising power increase.
IO_4^-	1.65V	
BrO_4^-	1.74V	

Here, SRP = standard reduction potential.

Q. 27 Which of the following is isoelectronic pair?



Ans. (b) Isoelectronic pair have same number of electrons

	BrO_2^-	BrF_2^+
Total number of electrons	$= 35 + 2 \times 8 + 1 = 52$	$= 35 + 9 \times 2 - 1 = 52$

Hence, (b) is the correct choice, while in another cases this value is not equal.

ICl_2	ClO_2
$53 + 2 \times 17 = 87$	$17 + 16 = 33$
ClO_2	BrF
$17 + 16 = 33$	$35 + 9 = 44$
CN^-	O_3
$= 6 + 7 + 1 = 14$	$= 8 \times 3 = 24$

Hence, only (b) is the correct choice.

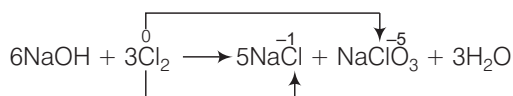
Multiple Choice Questions (More Than One Options)

Q. 28 If chlorine gas is passed through hot **NaOH** solution, two changes are observed in the oxidation number of chlorine during the reaction. These are and

- (a) 0 to +5 (b) 0 to +3 (c) 0 to -1 (d) 0 to +1

Ans. (a, c)

When chlorine gas is passed through hot NaOH solution it produces NaCl and NaClO₃.



Oxidation state varies from 0 to -1 and 0 to +5.

Hence, (a) and (c) are correct choices.

Q. 29 Which of the following options are not in accordance with the property mentioned against them?

- (a) $\text{F}_2 > \text{Cl}_2 > \text{Br}_2 > \text{I}_2$ Oxidising power
 (b) $\text{MI} > \text{MBr} > \text{MCl} > \text{MF}$ Ionic character of metal halide
 (c) $\text{F}_2 > \text{Cl}_2 > \text{Br}_2 > \text{I}_2$ Bond dissociation enthalpy
 (d) $\text{HI} < \text{HBr} < \text{HCl} < \text{HF}$ Hydrogen-halogen bond strength

Ans. (b, c)

$\text{F}_2 > \text{Cl}_2 > \text{Br}_2 > \text{I}_2$ As ability to gain electron increases oxidising property increases. Here, F is the most electronegative element having highest value of SRP hence it has highest oxidising power.

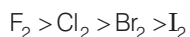


This is the incorrect order of ionic character of metal halide.

Correct order can be written as



As electronegativity difference between metal and halogen increases ionic character increases.



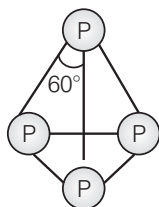
This is incorrect order of bond dissociation energy. Correct order is $\text{Cl}_2 > \text{Br}_2 > \text{F}_2 > \text{I}_2$ due to electronic repulsion among lone pairs in F_2 molecule.

Q. 30 Which of the following is correct for P_4 molecule of white phosphorus?

- (a) It has 6 lone pairs of electrons (b) It has six P — P single bonds
 (c) It has three P — P single bonds (d) It has four lone pairs of electrons

Ans. (b, d)

Structure of P_4 molecule can be represented as



It has total four lone pairs of electrons situated at each P-atom.

It has six P—P single bond.

Q. 31 Which of the following statements are correct?

- (a) Among halogens, radius ratio between iodine and fluorine is maximum.
- (b) Leaving F — F bond, all halogens have weaker X — X bond than X — X' bond in interhalogens.
- (c) Among interhalogen compounds maximum number of atoms are present in iodine fluoride.
- (d) Interhalogen compounds are more reactive than halogen compounds.

Ans. (a, c, d)

- (a) Among halogens, radius ratio between iodine and fluorine is maximum because iodine has maximum radius and fluorine has minimum radius.
- (b) It can be correctly stated as in general interhalogen compounds are more reactive than halogen. This is because X — X' bond in interhalogen is weaker than X — X bond in halogens except F—F bond.
- (c) Among interhalogen compounds maximum number of atoms are present in iodine fluoride because radius ratio of iodine and fluorine has maximum value.
- (d) Interhalogen compounds are more reactive than halogen due to weaker X — X' bond as compared to X — X of halogen compounds.

Q. 32 Which of the following statements are correct for SO₂ gas?

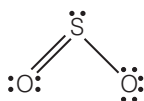
- (a) It acts as bleaching agent in moist conditions.
- (b) Its molecule has linear geometry.
- (c) Its dilute solution is used as disinfectant.
- (d) It can be prepared by the reaction of dilute H₂SO₄ with metal sulphide.

Ans. (a, c)

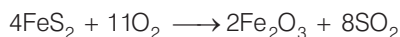
- (a) In moist condition SO₂ gas acts as a bleaching agent.
e.g., it converts Fe (III) to Fe (II) ion and decolourises acidified KMnO₄ (VII).



- (b) is incorrect it has bent structure.



- (c) Its dilute solution is used as a disinfectant.
- (d) It can be prepared by the reaction of O₂ with sulphide ore,



while metal on treatment with H₂SO₄ produces H₂S.

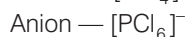
Hence, options (a) and (c) are correct choices.

Q. 33 Which of the following statements are correct?

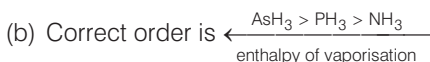
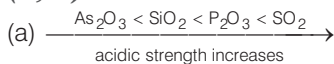
- (a) All the three N — O bond lengths in HNO₃ are equal.
- (b) All P — Cl bond lengths in PCl₅ molecule in gaseous state are equal
- (c) P₄ molecule in white phosphorus have angular strain therefore white phosphorus is very reactive
- (d) PCl₅ is ionic in solid state in which cation is tetrahedral and anion is octahedral.

Ans. (c, d)

- (a) All the three N—O bond lengths in HNO_3 are not equal.
 (b) All P—Cl bond lengths in PCl_5 molecule in gaseous state are not equal. Axial bond is longer than equatorial bond.
 (c) P_4 molecule in white phosphorous have angular strain therefore white phosphorous is very reactive.
 (d) PCl_5 is ionic in solid state in which cation is tetrahedral and anion is octahedral.

**Q. 34** Which of the following orders are correct as per the properties mentioned against each?

- (a) $\text{As}_2\text{O}_3 < \text{SiO}_2 < \text{P}_2\text{O}_3 < \text{SO}_2$ Acid strength.
 (b) $\text{AsH}_3 < \text{PH}_3 < \text{NH}_3$ Enthalpy of vaporisation.
 (c) $\text{S} < \text{O} < \text{Cl} < \text{F}$ More negative electron gain enthalpy.
 (d) $\text{H}_2\text{O} > \text{H}_2\text{S} > \text{H}_2\text{Se} > \text{H}_2\text{Te}$ Thermal stability.

Ans. (a, d)

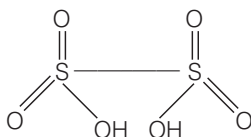
- (c) $\text{S} < \text{O} < \text{Cl} < \text{F}$ More negative electron gain enthalpy
 (d) $\text{H}_2\text{O} > \text{H}_2\text{S} > \text{H}_2\text{Se} > \text{H}_2\text{Te}$ Thermal stability decreases on moving top to bottom due to increase in its bond length.

Q. 35 Which of the following statements are correct?

- (a) S—S bond is present in $\text{H}_2\text{S}_2\text{O}_6$
 (b) In peroxosulphuric acid (H_2SO_5) sulphur is in + 6 oxidation state
 (c) Iron powder along with Al_2O_3 and K_2O is used as a catalyst in the preparation of NH_3 by Haber's process
 (d) Change in enthalpy is positive for the preparation of SO_3 by catalytic oxidation of SO_2

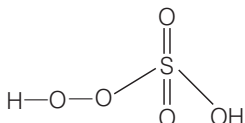
Ans. (a, b)

- (a) Structure of $\text{H}_2\text{S}_2\text{O}_6$ is as shown below



It contains one S—S bond.

- (b) In peroxosulphuric acid (H_2SO_5) sulphur is in + 6 oxidation state.
 Structure of H_2SO_5 is



Let oxidation state of S = x

$$2 \times (+1) + x + 3 \times (-2) + 2 \times (-1) = 0$$

$$x - 6 = 0$$

$$x = 6$$

- (c) During preparation of ammonia, iron oxide with small amount of K_2O and Al_2O_3 is used as a catalyst to increase the rate of attainment of equilibrium.
- (d) Change in enthalpy is negative for preparation of SO_3 by catalytic oxidation of SO_2 .

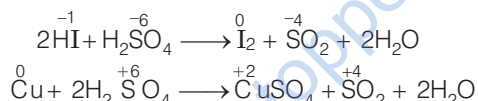
Q. 36 In which of the following reactions conc. H_2SO_4 is used as an oxidising reagent?

- (a) $CaF_2 + H_2SO_4 \longrightarrow CaSO_4 + 2HF$
- (b) $2HI + H_2SO_4 \longrightarrow I_2 + SO_2 + 2H_2O$
- (c) $Cu + 2H_2SO_4 \longrightarrow CuSO_4 + SO_2 + 2H_2O$
- (d) $NaCl + H_2SO_4 \longrightarrow NaHSO_4 + HCl$

Ans. (b, c)

In the above given four reactions, (b) and (c) represent oxidising behaviour of H_2SO_4 . As we know that oxidising agent reduces itself as oxidation state of central atom decreases.

Here,



Q. 37 Which of the following statements are true?

- (a) Only type of interactions between particles of noble gases are due to weak dispersion forces.
- (b) Ionisation enthalpy of molecular oxygen is very close to that of xenon.
- (c) Hydrolysis of XeF_6 is a redox reaction.
- (d) Xenon fluorides are not reactive.

Ans. (a, b)

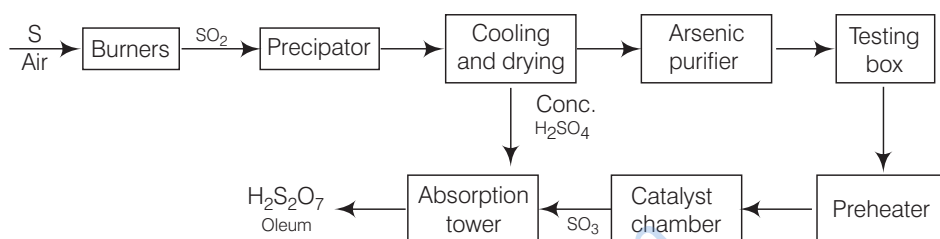
- (a) Only one type of interactions between particles of noble gases are due to weak dispersion forces.
- (b) Ionisation enthalpy of molecular oxygen is very close to that of xenon. This is the reason for the formation of xenon oxides.
- (c) Hydrolysis of XeF_6 ($\overset{+6}{Xe}F_6 + 3\overset{+1}{H_2}\overset{-2}{O} \longrightarrow \overset{+6}{Xe}\overset{-2}{O_3} + 3\overset{+1}{H}\overset{-1}{F}$) is not a redox reaction.
- (d) Xenon fluorides are highly reactive hydrolysis readily even by traces of water.

Short Answer Type Questions

Q. 38 In the preparation of H_2SO_4 by Contact process, why is SO_3 not absorbed directly in water to form H_2SO_4 ?

Ans. In Contact process SO_3 is not absorbed directly in water to form H_2SO_4 because the reaction is highly exothermic, acid mist is formed. Hence, the reaction becomes difficult to handle.

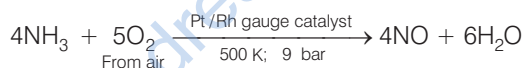
Note



Flow chart of Contact process

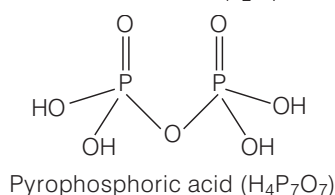
Q. 39 Write a balanced chemical equation for the reaction showing catalytic oxidation of NH_3 by atmospheric oxygen.

Ans. Ammonia (NH_3) on catalytic oxidation by atmospheric oxygen in presence of Rh/Pt gauge at 500K under pressure of 9 bar produces nitrous oxide. Balanced chemical reaction can be written as



Q. 40 Write the structure of pyrophosphoric acid.

Ans. Molecular formula of pyrophosphoric acid is $\text{H}_4\text{P}_2\text{O}_7$ and its structure is as follows

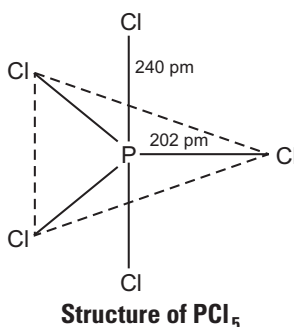


Q. 41 PH_3 forms bubbles when passed slowly in water but NH_3 dissolves. Explain why?

Ans. Dissolution of NH_3 and PH_3 in water can be explained on the basis of H-bonding. NH_3 forms H-bond with water so it is soluble but PH_3 does not form H-bond with water so it remains as gas and forms bubble in water.

Q. 42 In PCl_5 , phosphorus is in sp^3d hybridised state but all its five bonds are not equivalent. Justify your answer with reason.

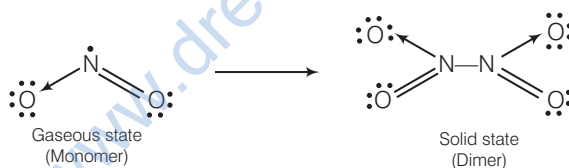
Ans. It has trigonal bipyramidal geometry, in which two Cl atoms occupy axial position while three occupy equatorial positions. All five P—Cl bonds are not identical. There are two types of bond lengths (i) Axial bond lengths (ii) Equatorial bond lengths



Thus, difference in bond length is due to fact that axial bond pairs suffer more repulsion as compared to equatorial bond pairs.

Q. 43 Why is nitric oxide paramagnetic in gaseous state but the solid obtained on cooling it is diamagnetic?

Ans. In gaseous state, NO_2 exists as a monomer which has one unpaired electron but in solid state, it dimerises to N_2O_4 so no unpaired electron left. Therefore, NO_2 is paramagnetic in gaseous state but diamagnetic in solid state.

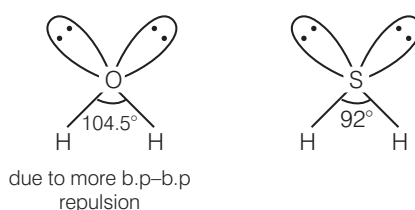


Q. 44 Give one reason to explain why ClF_3 exists but FCl_3 does not exist?

Ans. Existence of ClF_3 and FCl_3 can be explained on the basis of size of central atom. Because fluorine is more electronegative as compared to chlorine and has smaller size. Thus, one large Cl atom can accommodate three smaller F atoms but reverse is not true.

Q. 45 Out of H_2O and H_2S , which one has higher bond angle and why?

Ans. Bond angle of H_2O ($\text{H—O—H} = 104.5^\circ$) is larger than that of H_2S ($\text{H—S—H} = 92^\circ$) 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.



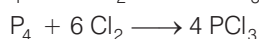
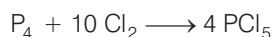
Q. 46 SF_6 is known but SCl_6 is not. Why?

Ans. Fluorine atom is smaller in size so, six F^- ions can surround a sulphur atom. The case is not so with chlorine atom due to its large size. So, SF_6 is known but SCl_6 is not known due to interionic repulsion between larger Cl^- ions.

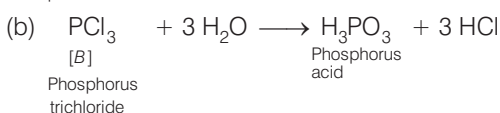
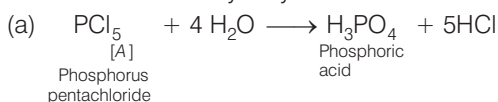
Q. 47 On reaction with Cl_2 , phosphorus forms two types of halides 'A' and 'B'. Halide 'A' is yellowish-white powder but halide 'B' is colourless oily liquid. Identify A and B and write the formulae of their hydrolysis products.

Ans. Phosphorus on reaction with Cl_2 forms two types of halides A and B.

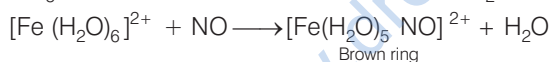
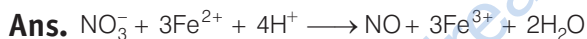
'A' is PCl_5 and 'B' is PCl_3 .



When 'A' and 'B' are hydrolysed

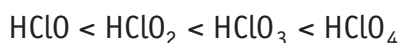


Q. 48 In the ring test of NO_3^- ion, Fe^{2+} ion reduces nitrate ion to nitric oxide, which combines with Fe^{2+} (aq) ion to form brown complex. Write the reactions involved in the formation of brown ring.

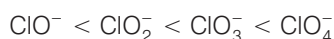


This test is known as brown ring test of nitrates generally used to identify the presence of nitrate ion in given solution.

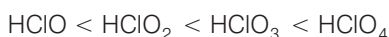
Q. 49 Explain why the stability of oxoacids of chlorine increases in the order given below.



Ans. Oxygen is more electronegative than chlorine, therefore dispersal of negative charge present on chlorine increases from ClO^- to ClO_4^- ion because number of oxygen atoms attached to chlorine is increasing. Therefore, stability of ions will increase in the order given below



Due to increase in stability of conjugate base, acidic strength of corresponding acid increases in the same order



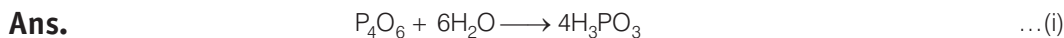
Q. 50 Explain why ozone is thermodynamically less stable than oxygen?

Ans. Ozone is thermodynamically less stable than oxygen because its decomposition into oxygen results in the liberation of heat (ΔH is negative) and an increase in entropy (ΔS is positive). These two effects reinforce each other, resulting in large negative Gibbs energy change (ΔG) for its conversion into oxygen.

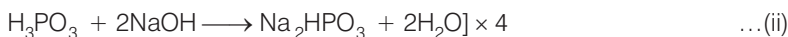
Q. 51 P_4O_6 reacts with water according to equation $P_4O_6 + 6H_2O \longrightarrow 4H_3PO_3$. Calculate the volume of 0.1 M NaOH solution required to neutralise the acid formed by dissolving 1.1 g of P_4O_6 in H_2O .

💡 Thinking Process

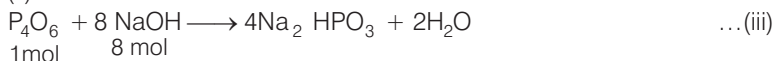
This problem includes conceptual mixing of chemical properties of oxides of phosphorus, mole concept and stoichiometry.



Neutralisation



Adding Eqs. (i) and (ii)



Number of moles of P_4O_6 ,

$$n = \frac{m}{M} = \frac{1.1}{220} = \frac{1}{200} \text{ mol}$$

(Molar mass of $P_4O_6 = (4 \times 31) + (6 \times 16) = 220$)

\therefore Product formed by 1 mole of P_4O_6 is neutralised by 8 moles NaOH

\therefore Product formed by $\frac{1}{200}$ moles of P_4O_6 will be neutralised by NaOH

$$= 8 \times \frac{1}{200} = \frac{8}{200} \text{ mole NaOH}$$

Given, Molarity of NaOH = 0.1 M = 0.1 mol/L

$$\text{Molarity} = \frac{\text{Number of moles}}{\text{Volume in litres}}$$

$$\text{Volume} = \frac{\text{Number of moles}}{\text{Molarity}} = \frac{8}{200} \times \frac{1}{0.1} = 0.4 \text{ L or } 400 \text{ mL}$$

\therefore 400 mL NaOH is required.

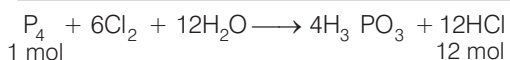
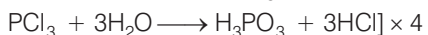
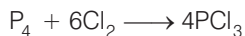
Q. 52 White phosphorus reacts with chlorine and the product hydrolyses in the presence of water. Calculate the mass of HCl obtained by the hydrolysis of the product formed by the reaction of 62 g of white phosphorus with chlorine in the presence of water.

💡 Thinking Process

This problem is based on concept of chemical reaction of phosphorus and stoichiometry.

Write balanced chemical reaction and then calculate the amount of HCl produced.

Ans. Equations for the reactions



$$31 \times 4 = 124 \text{ g}$$

$$12 \times 36.5 = 438.0 \text{ g}$$

\therefore 124 g of white phosphorus produces HCl = 438 g

\therefore 62 g of white phosphorus will produces

$$HCl = \frac{438}{124} \times 62 = 219.0 \text{ g HCl}$$

Q. 53 Name three oxoacids of nitrogen. Write the disproportionation reaction of that oxoacid of nitrogen in which nitrogen is in + 3 oxidation state.

Ans. Three oxoacids of nitrogen having oxidation state + 3 are

(a) HNO_2 , nitrous acid

(b) HNO_3 , nitric acid

(c) Hyponitrous acid, $\text{H}_2\text{N}_2\text{O}_2$

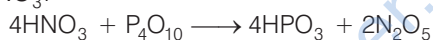
In HNO_2 , N is in + 3 oxidation state

Disproportionation reaction

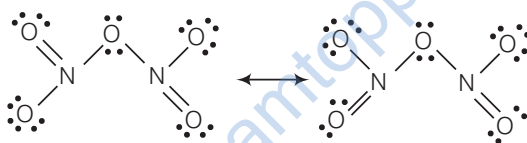


Q. 54 Nitric acid forms an oxide of nitrogen on reaction with P_4O_{10} . Write the reaction involved. Also write the resonating structures of the oxide of nitrogen formed.

Ans. P_4O_{10} being a dehydrating agent, on reaction with HNO_3 removes a molecule of water and forms anhydride of HNO_3 .



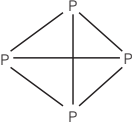
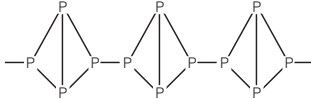
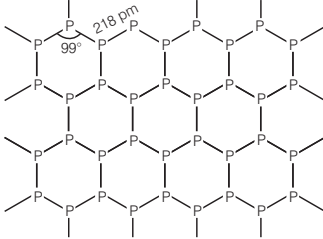
Resonating structures of N_2O_5 are



Q. 55 (i) white phosphorus (ii) red phosphorus and (iii) black phosphorus. Write the difference between white red and black phosphorus on the basis of their structure and reactivity.

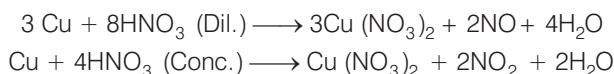
Phosphorus has three allotropic forms —

Ans.

	White phosphorus	Red phosphorus	Black phosphorus
1.	It is less stable form of P	More stable than white P.	It is most stable form of P
2.	It is highly reactive. 	Less reactive than white P. 	It is least reactive. 
3.	It has regular tetrahedron structure.	It has polymeric structure.	It has a layered structure.

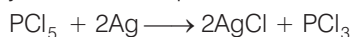
Q. 56 Give an example to show the effect of concentration of nitric acid on the formation of oxidation product.

Ans. Effect of concentration of nitric acid on the formation of oxidation product can be understood by its reaction with conc HNO_3 . Dilute and concentrated nitric acid give different oxidation products on reaction with copper metal.

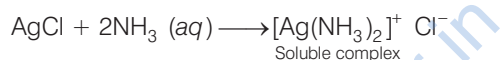


Q. 57 PCl_5 reacts with finely divided silver on heating and a white silver salt is obtained, which dissolves on adding excess aqueous NH_3 solution. Write the reactions involved to explain what happens.

Ans. PCl_5 on reaction with finely divided silver produced silver halide.

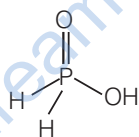


AgCl on further reaction with aqueous ammonia solution produces a soluble complex of $[\text{Ag}(\text{NH}_3)_2]^+ \text{Cl}^-$



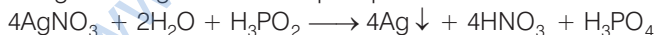
Q. 58 Phosphorus forms a number of oxoacids. Out of these oxoacids, phosphinic acid has strong reducing property. Write its structure and also write a reaction showing its reducing behaviour.

Ans. Among various forms of oxoacids, phosphinic acid has stronger reducing property.



Structure of phosphinic acid

Reaction showing reducing behaviour of phosphinic acid is as follows



Matching The Columns

Q. 59 Match the compounds given in Column I with the hybridisation and shape given in Column II and mark the correct option.

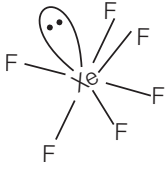
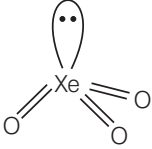
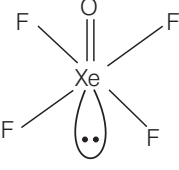
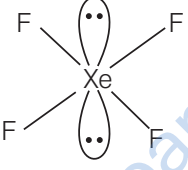
Column I	Column II
A. XeF_6	1. sp^3d^3 -distorted octahedral
B. XeO_3	2. sp^3d^2 -square planar
C. XeOF_4	3. sp^3 -pyramidal
D. XeF_4	4. sp^3d^2 -square pyramidal

Codes

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

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

Ans. (a) A. → (1) B. → (3) C. → (4) D. → (2)

S. No.	Compound	Hybridisation
A.		sp^3d^3 -distorted octahedral
B.		sp^3 -pyramidal
C.		sp^3d^2 -square pyramidal
D.		sp^3d^2 -square planar

Q. 60 Match the formulas of oxides given in Column I with the type of oxide given in Column II and mark the correct option.

Column I	Column II
A. Pb_3O_4	1. Neutral oxide
B. N_2O	2. Acidic oxide
C. Mn_2O_7	3. Basic oxide
D. Bi_2O_3	4. Mixed oxide

Codes

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

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

Ans. (b) A. → (4) B. → (1) C. → (2) D. → (3)

Formulas of the compound	Type of oxide
A. Pb_3O_4 ($PbO \cdot Pb_2O_3$)	Mixed oxide
B. N_2O	Neutral oxide
C. Mn_2O_7	Acidic oxide
D. Bi_2O_3	Basic oxide

Mn_2O_7 on dissolution in water produces acidic solution.

Bi_2O_3 on dissolution in water produces basic solution.

Q. 61 Match the items of Columns I and II and mark the correct option.

Column I	Column II
A. H_2SO_4	1. Highest electron gain enthalpy
B. CCl_3NO_2	2. Chalcogen
C. Cl_2	3. Tear gas
D. Sulphur	4. Storage batteries

Codes

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

Ans. (a) A. → (4) B. → (3) C. → (1) D. → (2)

A. H_2SO_4 is used in storage batteries.

B. CCl_3NO_2 is known as tear gas.

C. Cl_2 has highest electron gain enthalpy.

D. Sulphur is a member of chalcogen *i.e.*, ore producing elements.

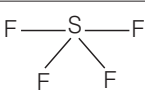
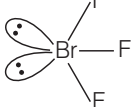
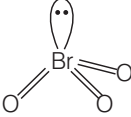
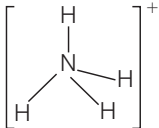
Q. 62 Match the species given in Column I with the shape given in Column II and mark the correct option.

Column I	Column II
A. SF_4	1. Tetrahedral
B. BrF_3	2. Pyramidal
C. BrO_3^-	3. Sea-saw shaped
D. NH_4^+	4. Bent T-shaped

Codes

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

Ans. (b) A. → (3) B. → (4) C. → (2) D. → (1)

	Species	Shape	Structure
A.	SF_4	Sea-saw shaped	
B.	BrF_3	Bent T-shaped	
C.	BrO_3^-	Pyramidal	
D.	NH_4^+	Tetrahedral	

Q. 63 Match the items of Columns I and II and mark the correct option.

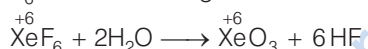
Column I	Column II
A. Its partial hydrolysis does not change oxidation state of central atom.	1. He
B. It is used in modern diving apparatus.	2. XeF ₆
C. It is used to provide inert atmosphere for filling electrical bulbs.	3. XeF ₄
D. Its central atom is in sp^3d^2 hybridisation.	4. Ar

Codes

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

Ans. (c) A. → (2) B. → (1) C. → (4) D. → (3)

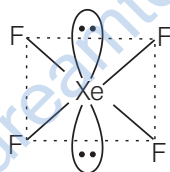
(A) Partial hydrolysis of XeF₆ does not change oxidation state of central atom.



(B) He is used in modern diving apparatus.

(C) Ar is used to provide inert atmosphere for filling electrical bulbs

(D) Central atom (Xe) of XeF₄ is in sp^3d^2 hybridisation.



Square planar geometry

Assertion and Reason

In the following questions a statement of Assertion (A) followed by a statement of Reason (R) is given. Choose the correct answer out of the following choices.

- Both Assertion and Reason are correct statements, and Reason is the correct explanation of the Assertion.
- Both Assertion and Reason are correct statements, and Reason is not the correct explanation of the Assertion.
- Assertion is correct, but Reason is wrong statement.
- Assertion is wrong but Reason is correct statement.
- Both Assertion and Reason are wrong statements.

Q. 64 Assertion (A) N₂ is less reactive than P₄.

Reason (R) Nitrogen has more electron gain enthalpy than phosphorus.

Ans. (c) Assertion is true, but reason is false.

N_2 is less reactive than P_4 due to high value of bond dissociation energy which is due to presence of triple bond between two N-atoms of N_2 molecule.

Q. 65 Assertion (A) HNO_3 makes iron passive.

Reason (R) HNO_3 forms a protective layer of ferric nitrate on the surface of iron.

Ans. (c) Assertion is true, but reason is false.

HNO_3 makes iron passive due to formation of passive form of oxide on the surface. Hence, Fe does not dissolve in conc HNO_3 solution.

Q. 66 Assertion (A) HI cannot be prepared by the reaction of KI with concentrated H_2SO_4 .

Reason (R) HI has lowest H—X bond strength among halogen acids.

Ans. (b) Both assertion and reason are correct statements, but reason is not the correct explanation of the assertion.

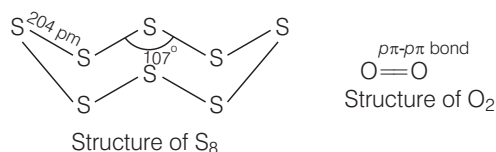
HI cannot be prepared by the reaction of KI with concentrated H_2SO_4 because HI is converted into I_2 on reaction with H_2SO_4 .

Q. 67 Assertion (A) Both rhombic and monoclinic sulphur exist as S_8 but oxygen exists as O_2 .

Reason (R) Oxygen forms $p\pi - p\pi$ multiple bond due to small size and small bond length but $p\pi - p\pi$ bonding is not possible in sulphur.

Ans. (a) Both assertion and reason are correct statements, and reason is the correct explanation of the assertion.

Both rhombic and monoclinic sulphur exist as S_8 but oxygen exists as O_2 , because oxygen forms $p\pi - p\pi$ multiple bond due to its small size and small bond length. But $p\pi - p\pi$ bonding is not possible in sulphur due to its bigger size as compared to oxygen.

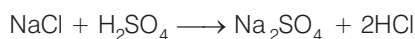


Q. 68 Assertion (A) NaCl reacts with concentrated H_2SO_4 to give colourless fumes with pungent smell. But on adding MnO_2 the fumes become greenish yellow.

Reason (R) MnO_2 oxidises HCl to chlorine gas which is greenish yellow.

Ans. (a) Both assertion and reason are correct statements, and reason is the correct explanation of the assertion.

NaCl reacts with concentrated H_2SO_4 to give colourless fumes with pungent smell. Pungent smell is due to formation of HCl.



But on adding MnO_2 the fumes become greenish yellow due to formation of chlorine gas.

Q. 69 Assertion (A) SF_6 cannot be hydrolysed but SF_4 can be.

Reason (R) Six F-atoms in SF_6 prevent the attack of H_2O on sulphur atom of SF_6 .

Ans. (a) Assertion and reason both are true and reason is the correct explanation of assertion.

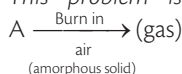
SF_4 can be hydrolysed but SF_6 can not because six F-atoms in SF_6 prevent the attack of H_2O on sulphur atoms of SF_6 .

Long Answer Type Questions

Q. 70 An amorphous solid "A" burns in air to form a gas "B" which turns lime water milky. The gas is also produced as a by-product during roasting of sulphide ore. This gas decolourises acidified aqueous KMnO_4 solution and reduces Fe^{3+} to Fe^{2+} . Identify the solid "A" and the gas "B" and write the reactions involved.

Thinking Process

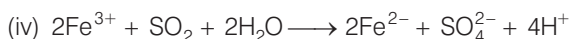
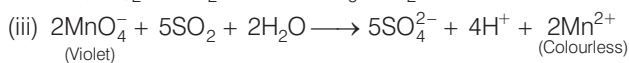
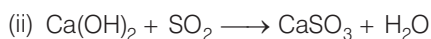
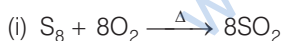
This problem is based on concept of properties of sulphur and its oxide.



Amorphous solid A gives B is a gas which turns lime water milky and also produced as a by product during roasting of sulphide ore. This gas decolourises acidified aqueous KMnO_4 solution and reduces Fe^{3+} to Fe^{2+} . Hence, compound B (g) must be SO_2 .

Ans. Since, the by-product of roasting of sulphide ore is SO_2 , so A is S_8 ; 'A' = S_8 ; 'B' = SO_2

Reactions



Q. 71 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' and 'C' and also write reactions involved and draw the structures of 'B' and 'C'.

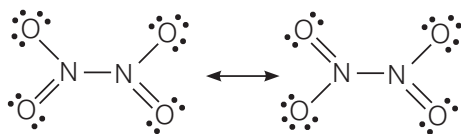
Thinking Process

This problem is based on preparation and properties of NO_2 .

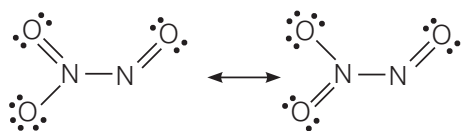
Ans. $\text{Pb(NO}_3)_2$ on heating produces a brown coloured gas which may be NO_2 . Since, on reaction with N_2O_4 and on heating it produces N_2O_3 and N_2O_4 respectively.

Structures

(i) N_2O_4



(ii) N_2O_3



Q. 72 On heating compound (A) gives a gas (B) which is a constituent of air. This gas when treated with 3 moles 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.

Ans. The main constituents of air are nitrogen (78%) and oxygen (21%). Only N_2 reacts with three moles of H_2 in the presence of a catalyst to give NH_3 (ammonia) which is a gas having basic nature. On oxidation, NH_3 gives NO_2 which is a part of acid rain. So, the compounds A to D are as



Reactions involved can be given, as

