

REASONING QUESTIONS IN P BLOCK ELEMENTS

1. Though nitrogen exhibits +5 oxidation state, it does not form pentahalide. Give reason.

Ans: Nitrogen valence electronic configuration ns^2np^3 due to absence empty d- orbitals, it can not extend its valence to 5

2. PH_3 has lower boiling point than NH_3 . Why?

Ans: Unlike NH_3 , PH_3 molecules are not associated through hydrogen bonding in liquid state. That is why the boiling point of PH_3 is lower than NH_3 .

3. Why are pentahalides more covalent than trihalides ?

Ans: Higher the positive oxidation state of central atom, more will be its Polarizing power which, in turn, increases the covalent character of bond formed between the central atom and the other atom.

4. Why is BiH_3 the strongest reducing agent amongst all the hydrides of Group 15 elements ?

Ans: Among hydrides of group 15 from NH_3 to BiH_3 as size of central atom increases M—H bond strength decreases. Hence it act as strong reducing agent.

5. Write the reaction of thermal decomposition of sodium azide.

Ans: $2 NaN_3 \rightarrow 2 Na + 3 N_2(g)$

6. Why is N_2 less reactive at room temperature?

Ans: Due to its high $N \equiv N$ bond dissociation energy

7. Why does NH_3 act as a Lewis base?

Ans: Due to presence of one lone pair of electron present on Nitrogen

8. Mention the conditions required to maximize the yield of ammonia.

Ans: Optimum Pressure & Optimum Temperature & Removal of ammonia by cooling.

9. How does ammonia react with a solution of Cu^{2+} ?

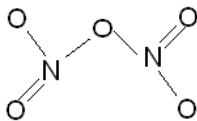
Ans: $Cu^{2+} + 4 NH_3 \rightarrow [Cu(NH_3)_4]^{+2}$ and this is deep blue in color.

10. Why does NO_2 dimerise ?

Ans: Due to presence one odd electron on Nitrogen of NO_2

11. What is the covalence of nitrogen in N_2O_5 ?

Ans: Covalency is 4 because N is bonded with 4 bonds



12. In what way can it be proved that PH_3 is basic in nature?

Ans: Phosphine is weakly basic and like ammonia, gives phosphonium compounds with acids e.g., $PH_3 + HBr \rightarrow PH_4Br$

Due to lone pair on phosphorus atom, PH_3 is acting as a Lewis base in the above reaction.

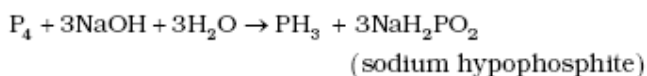
13. Bond angle in PH_4^+ is higher than that in PH_3 . Why?

Ans: Both are sp^3 hybridized. In PH_4^+ all the four orbital are bonded whereas in PH_3 there is a lone pair of electrons on P, which is responsible for lone

Pair-bond pair repulsion in PH_3 reducing the bond angle to less than $109^\circ 28'$.

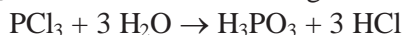
14. What happens when white phosphorus is heated with concentrated $NaOH$?

Solution in an inert atmosphere of CO_2 ?



15. Why does PCl_3 fume in moisture?

Ans: PCl_3 react with moisture and gives HCl vapours.

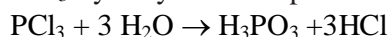


16. Are all the five bonds in PCl_5 molecule equivalent? Justify your answer.

Ans: PCl_5 has a trigonal bipyramidal structure and the three equatorial P-Cl bonds are equivalent, while the two axial bonds are different and longer than equatorial bonds.

17. What happens when PCl_5 is heated?

Ans: PCl_5 hydrolyses in the presence of moisture giving fumes of HCl.



18. Write a balanced equation for the hydrolytic reaction of PCl_5 in heavy water.

Ans: $\text{PCl}_5 + \text{D}_2\text{O} \rightarrow \text{POCl}_3 + 2\text{DCl}$

19. How do you account for the reducing behavior of H_3PO_2 on the basis of its structure ?

Ans: In H_3PO_2 , two H atoms are bonded directly to P atom which imparts Reducing character to the acid.

20. What is the basicity of H_3PO_4 ?

Ans: Three P-OH groups are present in the molecule of H_3PO_4 . Therefore, its basicity is three.

21. Phosphorous in solid state is ionic, why?

Ans: In the solid state it exists as an ionic solid, $[\text{PCl}_4]^+[\text{PCl}_6]^-$ in which the cation, $[\text{PCl}_4]^+$ is tetrahedral and the anion, $[\text{PCl}_6]^-$ octahedral.

22. Elements of Group 16 generally show lower value of first ionization enthalpy compared to the corresponding periods of group 15. Why?

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

23. H_2S is less acidic than H_2Te . Why?

Ans: Due to the decrease in bond (E-H) dissociation enthalpy down the group, acidic character increases.

24. List the important sources of sulphur.

Ans: Traces of sulphur occur as hydrogen sulphide in volcanoes. Organic materials such as eggs, proteins, garlic, onion, mustard, hair and wool contain sulphur.

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

Ans; $\text{H}_2\text{O} > \text{H}_2\text{S} > \text{H}_2\text{Se} > \text{H}_2\text{Te} > \text{H}_2\text{Po}$ As atomic size increases E-H bond strength decreases, Hence thermal stability decreases.

26. Why is H_2O a liquid and H_2S a gas ?

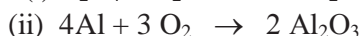
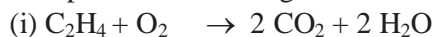
Ans: Because of small size and high electro negativity of oxygen, molecules of water are highly associated through hydrogen bonding resulting in its liquid state.

27. Which of the following does not react with oxygen directly?

Zn, Ti, Pt, Fe

Ans: Pt is a noble metal it do not react with any atmospheric gases.

28. Complete the following reactions:



29. Why does O_3 act as a powerful oxidizing agent?

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

30. How is O_3 estimated quantitatively?

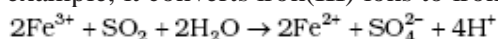
Ans: When ozone reacts with an excess of potassium iodide solution buffered with a borate buffer (pH 9.2), iodine is liberated which can be titrated against a standard solution of sodium thiosulphate. This is a quantitative method for estimating O_3 gas.

31. Which form of sulphur shows paramagnetic behavior ?

Ans: In vapour state sulphur partly exists as S_2 molecule which has two unpaired electrons in the antibonding π^* orbitals like O_2 and, hence, exhibits paramagnetism.

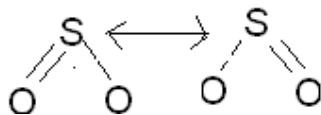
32. What happens when sulphur dioxide is passed through an aqueous solution of Fe(III) salt?

Ans: When moist, sulphur dioxide behaves as a reducing agent. For example, it converts iron(III) ions to iron(II) ions.



33. Comment on the nature of two S–O bonds formed in SO_2 molecule. Are the two S–O bonds in this molecule equal ?

Ans: Both the S–O bonds are covalent and have equal strength due to resonating Structures.



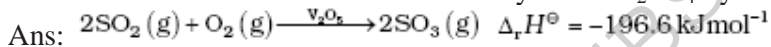
34. How is the presence of SO_2 detected ?

Ans: It is a suffocating odor gas, when SO_2 gas passed into lime water it gives Milky white ppt $Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

35. Mention three areas in which H_2SO_4 plays an important role.

Ans: The bulk of sulphuric acid produced is used in the manufacture of fertilizers (e.g., ammonium sulphate, super phosphate). Other uses are in:
 (a) petroleum refining (b) manufacture of pigments, paints and dyestuff Intermediates (c) detergent industry (d) metallurgical applications (e.g., cleansing metals before enameling, electroplating and galvanizing (e) storage batteries

36. Write the conditions to maximize the yield of H_2SO_4 by Contact process.



The reaction is exothermic, reversible and the forward reaction leads to a decrease in volume. Therefore, low temperature and high pressure are the favourable conditions for maximum yield. But the temperature should not be very low otherwise rate of reaction will become slow.

37. Why is $K_{a2} \ll K_{a1}$ for H_2SO_4 in water ?

Ans: H_2SO_4 is a very strong acid in water largely because of its first ionization to H_3O^+ and HSO_4^- . The ionisation of HSO_4^- to H_3O^+ and SO_4^{2-} is very very small. That is why $K_{a1} \ll K_{a2}$.

38. Halogens have maximum negative electron gain enthalpy in the respective periods of the periodic table. Why?

Ans: Halogens have the smallest size in their respective periods and therefore high effective nuclear charge. As a consequence, they readily accept one electron to acquire noble gas electronic configuration.

39. Although electron gain enthalpy of fluorine is less negative as compared to chlorine, fluorine is a stronger oxidizing agent than chlorine. Why?

Ans: It is due to (i) low enthalpy of dissociation of F-F bond
(ii) high hydration enthalpy of F^-

40. Fluorine exhibits only -1 oxidation state whereas other halogens exhibit $+1$, $+3$, $+5$ and $+7$ oxidation states also. Explain.

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

41. Considering the parameters such as bond dissociation enthalpy, electron gain enthalpy and hydration enthalpy, compare the oxidizing power of F_2 and Cl_2 .

Ans: Oxidizing power depends on bond dissociation enthalpy, electron gain enthalpy and hydration enthalpy out of these Fluorine has more hydration Enthalpy and less bond dissociation energy that can compensate high negative enthalpy of Chlorine .

42. Give two examples to show the anomalous behavior of fluorine.

Ans: Most of the reactions of fluorine are exothermic (due to the small and strong bond formed by it with other elements). It forms only one oxoacid while other halogens form a number of oxoacids. Hydrogen fluoride is a liquid (b.p. 293 K) due to strong hydrogen bonding. Other hydrogen halides are gases.

43. Sea is the greatest source of some halogens. Comment.

Ans: Various minerals of halogens from soil are soluble in river water hence sea gets large amount of halogens in the dissolved form.

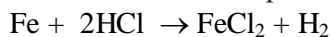
44. Write the balanced chemical equation for the reaction of Cl_2 with hot and Concentrated NaOH. Is this reaction a disproportionation reaction? Justify.

Ans: $3Cl_2 + 6NaOH \rightarrow 5NaCl + NaClO_3 + 3H_2O$

Yes, chlorine from zero oxidation state is changed to -1 and $+5$ oxidation states.

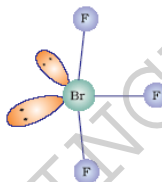
45. When HCl reacts with finely powdered iron, it forms ferrous chloride and not ferric chloride. Why?

Ans: Its reaction with iron produces H_2 .



Liberation of hydrogen prevents the formation of ferric chloride.

46. Deduce the molecular shape of BrF_3 on the basis of VSEPR theory.



2 lp and 3 bp as VSEPR theory it has trigonal bipyramidal shape.

47. Why is ICl more reactive than I_2 ?

Ans: In general, interhalogen compounds are more reactive than halogens due to weaker $X-X^1$ bonding than $X-X$ bond. Thus, ICl is more reactive than I_2 .

48. Why are the elements of Group 18 known as noble gases ?

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

49. Noble gases have very low boiling points. Why?

Ans: Noble gases being monatomic have no interatomic forces except weak dispersion forces and therefore, they are liquefied at very low Temperatures. Hence, they have low boiling points.

50. Does the hydrolysis of XeF_6 lead to a redox reaction?

Ans: No, the products of hydrolysis are XeOF_4 and XeO_2F_2 where the oxidation states of all the elements remain the same as it was in the reacting state.

51. Why is helium used in diving apparatus?

Ans: It is used as a diluent for oxygen in modern diving apparatus because of its Very low solubility in blood.

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

Ans: $\text{XeF}_6 + 2\text{H}_2\text{O} \rightarrow \text{XeO}_2\text{F}_2 + 4\text{HF}$

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

Ans: Radon is radioactive with very short half-life which makes the study of Chemistry of radon difficult.

54. Halogens have maximum negative electron gain enthalpy in the respective periods of the periodic table. Why?

Ans: Halogens have maximum negative electron gain enthalpy in the corresponding periods. This is due to the fact that the atoms of these elements have only one electron less than stable noble gas configurations.

55. AgCl is soluble in water, whereas it is insoluble in aqueous ammonia solution.

Ans: Ammonia react with AgCl forms $[\text{Ag}(\text{NH}_3)_2]\text{Cl}$ complex which is soluble in water.

56. Give the reason for bleaching action of Cl_2 .

Ans: Chlorine water on standing loses its yellow colour due to the formation of HCl and HOCl . Hypochlorous acid (HOCl) so formed, gives nascent oxygen which is responsible for oxidising and bleaching properties of chlorine.

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

Ans: poisonous gases such as phosgene (COCl_2), tear gas (CCl_3NO_2), mustard gas ($\text{ClCH}_2\text{CH}_2\text{SCH}_2\text{CH}_2\text{Cl}$).

58. Why does the reactivity of nitrogen differ from phosphorus?

Ans: Nitrogen can form multiple bonds and has more bond dissociation energy due to which it is less reactive. Phosphorous can not form multiple bonds.

59. Why does NH_3 form hydrogen bond but PH_3 does not?

Ans: Electronegativity of N is more than P.

60. The HNH angle value is higher than HPH , HAsH and HSbH angles. Why?

Ans: Due to more electronegative nature of Nitrogen it causes more repulsion, hence bond angle is more.

61. Why does $\text{R}_3\text{P}=\text{O}$ exist but $\text{R}_3\text{N}=\text{O}$ does not (R = alkyl group)?

Ans: Nitrogen can not form $d\pi-p\pi$ multiple bond due absence of empty d - orbitals.

62. Explain why NH_3 is basic while BiH_3 is only feebly basic.

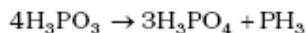
Ans: Due to small size of 'N' it has more electron density and act as strong base.

63. Nitrogen exists as diatomic molecule and phosphorus as P_4 . Why?

Ans: 'N' can form multiple bonds whereas P can not hence its tri valency is utilized in tetrahedron structure.

64. Give the disproportionation reaction of H_3PO_3 .

Ans: phosphorous acid on heating disproportionates to give orthophosphoric acid (or phosphoric acid) and phosphine.



65. Can PCl_5 act as an oxidizing as well as a reducing agent? Justify.

Ans: In PCl_5 oxidation state of P is +5, it can not increase its oxidation state more than it hence it can not act as reducing agent. But it can change its oxidation state to +3 and act as oxidizing agent.

66. Why is dioxygen a gas but sulphur a solid?

Ans: Due to small size Oxygen can form multiple bonds where as S can't hence S bond with S_8 molecule and exist in solid.

67. Knowing the electron gain enthalpy values for $\text{O} \rightarrow \text{O}^-$ and $\text{O} \rightarrow \text{O}^{2-}$ as -141 and 702 kJ mol^{-1} respectively, how can you account for the formation of a large number of oxides having O^{2-} species and not O^- ?

Ans: Higher second electron gain enthalpy is compensated by high hydration energy and more lattice energy.

68. Why are halogens strong oxidizing agents?

Ans: Since halogens are having high electron gain enthalpy they act as strong oxidizing agents.

69. Explain why fluorine forms only one oxoacid, HOF.

Ans: 'F' can form only -1 oxidation state, due to small size and absence of empty d-orbitals, hence it forms only one oxoacid HOF

70. Explain why in spite of nearly the same electro negativity, oxygen forms Hydrogen bonding while chlorine does not.

Ans: Due to small size of Oxygen as compared to Sulphur.

71. Why are halogens colored?

Ans: All halogens are coloured. This is due to absorption of radiations in visible region which results in the excitation of outer electrons to higher energy level. By absorbing different quanta of radiation, they display different colours. For example, F_2 , has yellow, Cl_2 , greenish yellow, Br_2 , red and I_2 , violet colour.

72. What inspired N. Bartlett for carrying out reaction between Xe and PtF_6 ?

Ans: In March 1962, Neil Bartlett, then at the University of British Columbia, observed the reaction of a noble gas. First, he prepared a red compound which is formulated as O_2PtF_6 . He, then realised that the first ionization enthalpy of molecular oxygen (1175 kJ mol^{-1}) was almost identical with that of xenon (1170 kJ mol^{-1}). He made efforts to prepare same type of compound with Xe and was successful in preparing another red colour

compound $\text{Xe}\cdot\text{PtF}_6$ - by mixing PtF_6 and xenon. After this discovery, a number of xenon compounds mainly with most electronegative elements like fluorine and oxygen, have been synthesised.

73. With what neutral molecule is ClO^- isoelectronic? Is that molecule a Lewis base?

Ans: ClF is isoelectronic with ClO^- and it has lone pairs hence act as Lewis base.

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

(i) F_2 , Cl_2 , Br_2 , I_2 - increasing bond dissociation enthalpy.

(ii) HF , HCl , HBr , HI - increasing acid strength.

(iii) NH_3 , PH_3 , AsH_3 , SbH_3 , BiH_3 - increasing base strength.

Ans: (i) $\text{Cl}_2 > \text{Br}_2 > \text{F}_2 > \text{I}_2$ As atomic size increases bond dissociation energy decreases and since F is extremely small size and cause repulsion between lone pairs of two F atoms of F_2 molecule.

(ii) $\text{HF} < \text{HBr} < \text{HCl} < \text{HI}$ as atomic size increases from F to I bond strength decreases and acidity increases.

(iii) $\text{BiH}_3 < \text{SbH}_3 < \text{AsH}_3 < \text{PH}_3 < \text{NH}_3$ as size increases from N to Bi electron density decreases and basicity decreases.

75. Give the formula and describe the structure of a noble gas species which is isostructural with:

(i) ICl_4^- (ii) IBr_2^- (iii) BrO_3^-

Ans: (i) XeCl_4 ($2\text{lp} + 4\text{bp} = 6$, sp^3d^2 occupied with 2 lone pairs over all geometry is square planar)

(ii) XeBr_2 ($2\text{bp} + 4\text{lp} = 6$, sp^3d^2 occupied with 2 lone pairs over all geometry is linear)

(iii) XeO_3 ($3\text{bp} + 1\text{lp} = 4$, sp^3 occupied by one lone pair, pyramidal shape).

76. Why do noble gases have comparatively large atomic sizes?

Ans: Noble gases exist as mono atomic gases, there is no overlapping of atomic orbitals like in other compounds. Here atomic radius is considered as van der Waals' radii. Hence atomic radii are comparatively large.

77. Why does the reactivity of nitrogen differ from phosphorus?

Ans: Due to small size, multiple bond formation, absence of empty d-orbitals.

78. The increase in the atomic size from As to Bi is small as compared from N to P, justify your answer.

Ans: There is a considerable increase in covalent radius from N to P. However, from As to Bi only a small increase in covalent radius is observed. This is due to the presence of completely filled d and/or f orbitals in heavier members.

78. Why N differs in its properties as compared with rest of elements of group 15.

Ans: Nitrogen differs from the rest of the members of this group due to its smaller size, high electronegativity, high ionisation enthalpy and non-availability of d orbitals.

79. Except N other elements of group 15 don't form $\text{p}\pi$ - $\text{p}\pi$ multiple bond. Explain?

Ans: Heavier elements of this group do not form $\text{p}\pi$ - $\text{p}\pi$ bonds as their atomic orbitals are so large and diffuse that they cannot have effective overlapping.

80. Why N-N bond is weaker than the single P-P bond?

Ans: N-N bond is weaker than the single P-P bond because of high inter electronic repulsion of the non-bonding electrons, owing to the small bond length.

81. N has low catenation as compared with C. Comment.

Ans: Due to its weak N-N single bond energy.

82. Based on what property white phosphorus is used in Holms signals & smoke screens?

Ans: It undergoes spontaneous combustion.

83. Red P is chemically less reactive compared with White P. Give reason.

Ans: Due to its polymeric structure it will have more bonds to break in chemical reaction.

84. Oxygen exists as diatomic molecule (O_2) whereas sulphur exists as polyatomic molecule (S_8). Give reason.

Ans: Oxygen exists as diatomic molecule (O_2) whereas sulphur exists as polyatomic molecule (S_8) because due to large size of S it cannot form multiple bonds.

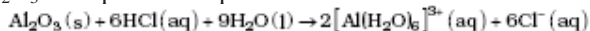
84. Why oxygen shows anomalous behavior as compared with its congeners?

Ans: It is due to its small size, High Electro negativity, More Ionization Enthalpy and absence of empty d- orbitals.

85. The stability of + 6 oxidation state decreases down the group and stability of + 4 oxidation state increase in group 16, Explain.

Ans: It is due to inert pair effect.

85. Al_2O_3 is amphoteric explain with chemical reactions.



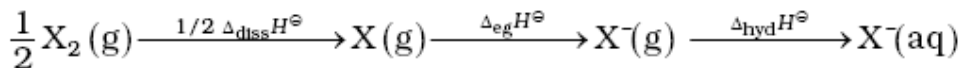
Ans: $\text{Al}_2\text{O}_3 (\text{s}) + 6\text{NaOH}(\text{aq}) + 3\text{H}_2\text{O}(\text{l}) \rightarrow 2\text{Na}_3[\text{Al}(\text{OH})_6](\text{aq})$

86. During dilution of sulphuric acid it must be added to water but water should not be added to acid. Explain?

Ans: It dissolves in water with the evolution of a large quantity of heat. Hence, care must be taken while preparing sulphuric acid solution from concentrated sulphuric acid. The concentrated acid must be added slowly into water with constant stirring.

87. Oxidising ability of halogens is $\text{F}_2 > \text{Cl}_2 > \text{Br}_2 > \text{I}_2$ give reason.

Ans: The decreasing oxidising ability of the halogens in aqueous solution Down the group is evident from their standard electrode potentials which are dependent on the parameters indicated below:



88. Ionic character of metal halides decreases from MF to MI. Give reason.

Ans: The ionic character of the halides decreases in the order

$\text{MF} > \text{MCl} > \text{MBr} > \text{MI}$ where M is a monovalent metal.

As electronegativity/Electron gain enthalpy decreases Ionic character increases.

89. Ionic character of Metal chlorides decreases as oxidation state increases, Explain.

Ans: As oxidation state increases Ionization energy increases hence ionic Character decreases.

the halides in higher oxidation state will be more covalent than the one in lower oxidation state .For e.g., SnCl_4 , PbCl_4 , SbCl_5 and UF_6 are more covalent than SnCl_2 , PbCl_2 , SbCl_3 and UF_4 respectively.

90. What is the maximum valence of Elements of Group 15.

Maxmum valency = group No. - 10 = 15 - 10 = 5

- In the case of nitrogen, all oxidation states from +1 to +4 tend to disproportionate in acid solution. For example,

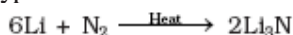
$$3\text{HNO}_2 \rightarrow \text{HNO}_3 + \text{H}_2\text{O} + 2\text{NO}$$
- In the laboratory, dinitrogen is prepared by treating an aqueous solution of ammonium chloride with sodium nitrite.

$$\text{NH}_4\text{Cl}(\text{aq}) + \text{NaNO}_2(\text{aq}) \rightarrow \text{N}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}) + \text{NaCl}(\text{aq})$$
- It can also be obtained by the thermal decomposition of ammonium dichromate.

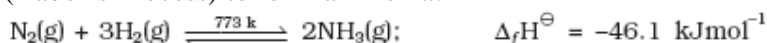
$$(\text{NH}_4)_2\text{Cr}_2\text{O}_7 \xrightarrow{\text{Heat}} \text{N}_2 + 4\text{H}_2\text{O} + \text{Cr}_2\text{O}_3$$
- Very pure nitrogen can be obtained by the thermal decomposition of sodium or barium azide.

$$\text{Ba}(\text{N}_3)_2 \rightarrow \text{Ba} + 3\text{N}_2$$

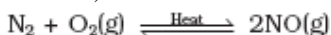
- At higher temperatures, it directly combines with some metals to form predominantly ionic nitrides and with non-metals, covalent nitrides. A few typical reactions are:



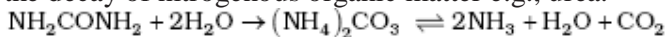
- It combines with hydrogen at about 773 K in the presence of a catalyst (Haber's Process) to form ammonia:



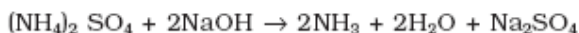
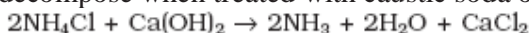
- Dinitrogen combines with dioxygen only at very high temperature (at about 2000 K) to form nitric oxide, NO.



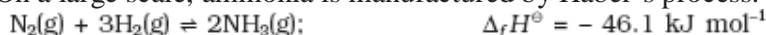
- Ammonia is present in small quantities in air and soil where it is formed by the decay of nitrogenous organic matter e.g., urea.



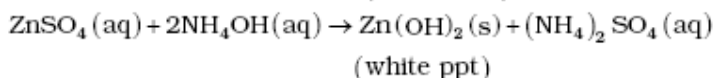
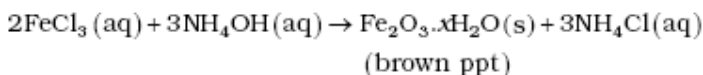
- On a small scale ammonia is obtained from ammonium salts which decompose when treated with caustic soda or lime.



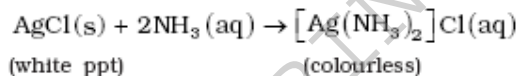
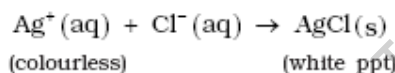
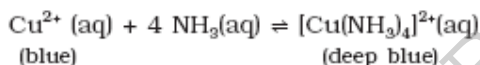
- On a large scale, ammonia is manufactured by Haber's process.



- It forms ammonium salts with acids, e.g., NH_4Cl , $(\text{NH}_4)_2\text{SO}_4$, etc. As a weak base, it precipitates the hydroxides of many metals from their salt solutions. For example,



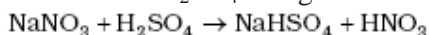
- Ammonia donate lone pair to the metal ions and form different complex compounds, by this metals ions can be detected.



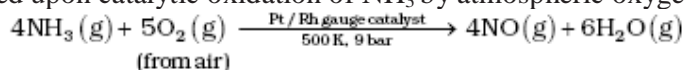
- Nitrogen (I) Oxide [Nitrous Oxide] $\text{NH}_4\text{NO}_3 \xrightarrow{\text{Heat}} \text{N}_2\text{O} + 2\text{H}_2\text{O}$
- Nitrogen (II) Oxide [Nitric Oxide] $2\text{NaNO}_2 + 2\text{FeSO}_4 + 3\text{H}_2\text{SO}_4 \rightarrow \text{Fe}_2(\text{SO}_4)_3 + 2\text{NaHSO}_4 + 2\text{H}_2\text{O} + 2\text{NO}$
- Nitrogen (III) Oxide [di Nitrogen Tri Oxide] $2\text{NO} + \text{N}_2\text{O}_4 \xrightarrow{250\text{K}} 2\text{N}_2\text{O}_3$
- Nitrogen di Oxide [Nitrogen (IV) Oxide] $2\text{Pb}(\text{NO}_3)_2 \xrightarrow{673\text{K}} 4\text{NO}_2 + 2\text{PbO}$



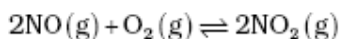
- Nitrogen (IV) Oxide [di Nitrogen tetroxide]
- Nitrogen (V) Oxide [di Nitrogen pentoxide] $4\text{HNO}_3 + \text{P}_4\text{O}_{10} \rightarrow 4\text{H}_3\text{PO}_3 + 2\text{N}_2\text{O}_5$
- In the laboratory, nitric acid is prepared by heating KNO_3 or NaNO_3 and concentrated H_2SO_4 in a glass retort.



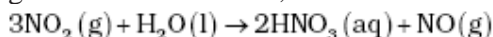
- On a large scale it is prepared mainly by Ostwald's process. This method is based upon catalytic oxidation of NH_3 by atmospheric oxygen.



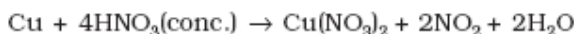
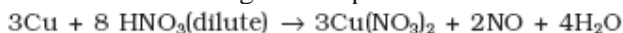
- Nitric oxide thus formed combines with oxygen giving NO_2 .



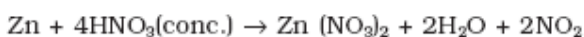
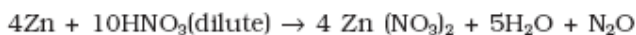
- Nitrogen dioxide so formed, dissolves in water to give HNO_3 .



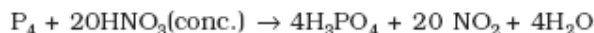
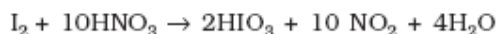
- Concentrated nitric acid is a strong oxidizing agent and attacks most metals except noble metals such as gold and platinum.



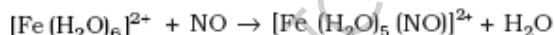
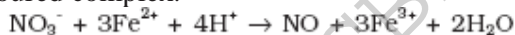
- Zinc reacts with dilute nitric acid to give N_2O and with concentrated acid to give NO_2 .



- Concentrated nitric acid also oxidises non-metals and their compounds. Iodine is oxidised to iodic acid, carbon to carbon dioxide, sulphur to H_2SO_4 , and phosphorus to phosphoric acid.

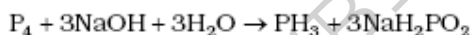


- *Brown Ring Test*: The familiar brown ring test for nitrates depends on the ability of Fe^{2+} to reduce nitrates to nitric oxide, which reacts with Fe^{2+} to form a brown coloured complex.



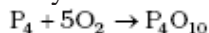
(brown)

- It dissolves in boiling NaOH solution in an inert atmosphere giving PH_3 .

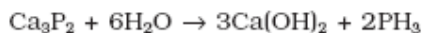


(sodium hypophosphite)

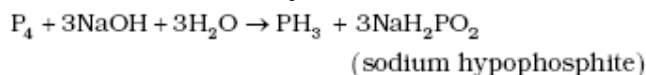
- It readily catches fire in air to give dense white fumes of P_4O_{10} .



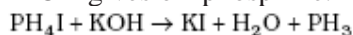
- Phosphine is prepared by the reaction of calcium phosphide with water or dilute HCl .



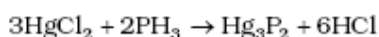
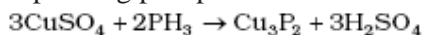
- In the laboratory, it is prepared by heating white phosphorus with concentrated NaOH solution in an inert atmosphere of CO₂.



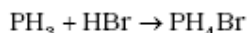
- it is absorbed in HI to form phosphonium iodide (PH₄I) which on treating with KOH gives off phosphine.



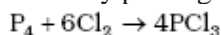
- When absorbed in copper sulphate or mercuric chloride solution, the corresponding phosphides are obtained.



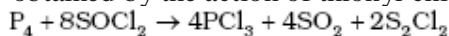
- Phosphine is weakly basic and like ammonia, gives phosphonium compounds with acids e.g.,



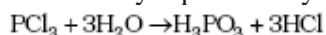
- It is obtained by passing dry chlorine over heated white phosphorus.



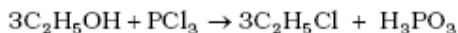
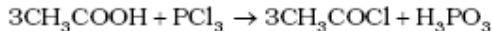
- It is also obtained by the action of thionyl chloride with white phosphorus.



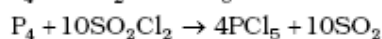
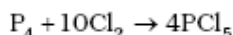
- It is a colourless oily liquid and hydrolyses in the presence of moisture.



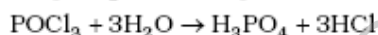
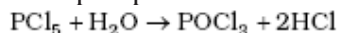
- It reacts with organic compounds containing –OH group such as CH₃COOH, C₂H₅OH.



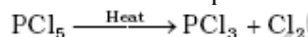
- Phosphorus pentachloride is prepared by the reaction of white phosphorus with excess of dry chlorine.



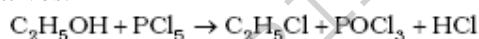
- PCl₅ is a yellowish white powder and in moist air, it hydrolyses to POCl₃ and finally gets converted to phosphoric acid.



- When heated, it sublimes but decomposes on stronger heating.



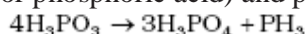
- It reacts with organic compounds containing –OH group converting them to chloro derivatives.



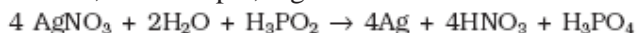
- Finely divided metals on heating with PCl₅ give corresponding chlorides.



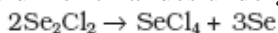
- phosphorous acid on heating disproportionates to give orthophosphoric acid (or phosphoric acid) and phosphine.



- The acids which contain P–H bond have strong reducing properties. Thus, hypophosphorous acid is a good reducing agent as it contains two P–H bonds and reduces, for example, AgNO_3 to metallic silver.

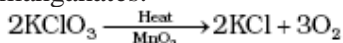


- These dimeric halides undergo disproportionation as given below:

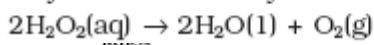


- Dioxygen can be obtained in the laboratory by the following ways:

(i) By heating oxygen containing salts such as chlorates, nitrates and permanganates.



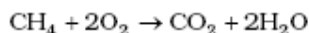
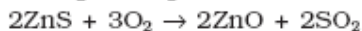
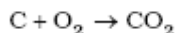
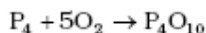
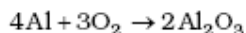
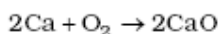
(iii) Hydrogen peroxide is readily decomposed into water and dioxygen by catalysts such as finely divided metals and manganese dioxide.



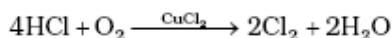
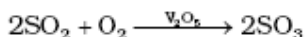
(ii) By the thermal decomposition of the oxides of metals low in the electrochemical series and higher oxides of some metals.



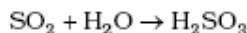
Some of the reactions of dioxygen with metals, non-metals and other compounds are given below:



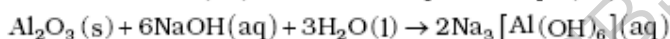
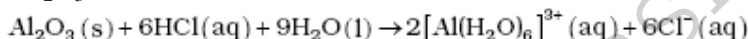
Some compounds are catalytically oxidised. For e.g.,



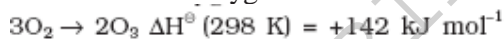
- SO_2 combines with water to give H_2SO_3 , an acid.



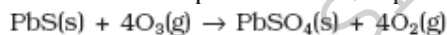
- Al_2O_3 reacts with acids as well as alkalies.



- When a slow dry stream of oxygen is passed through a silent electrical discharge, conversion of oxygen to ozone (10%) occurs. The product is known as ozonised oxygen.

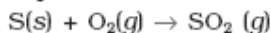


- it oxidizes lead sulphide to lead sulphate and iodide ions to iodine.

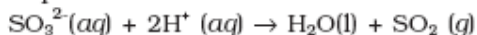


- Nitrogen oxides emitted from the exhaust systems of supersonic jet aeroplanes might be slowly depleting the concentration of the ozone layer in the upper atmosphere.

Sulphur dioxide is formed together with a little (6-8%) sulphur trioxide when sulphur is burnt in air or oxygen:



In the laboratory it is readily generated by treating a sulphite with dilute sulphuric acid.



Industrially, it is produced as a by-product of the roasting of sulphide ores.

- $$4\text{FeS}_2(\text{s}) + 11\text{O}_2(\text{g}) \rightarrow 2\text{Fe}_2\text{O}_3(\text{s}) + 8\text{SO}_2(\text{g})$$

$$2\text{NaOH} + \text{SO}_2 \rightarrow \text{Na}_2\text{SO}_3 + \text{H}_2\text{O}$$

$$\text{Na}_2\text{SO}_3 + \text{H}_2\text{O} + \text{SO}_2 \rightarrow 2\text{NaHSO}_3$$

$$\text{SO}_2(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow \text{SO}_2\text{Cl}_2(\text{l})$$

$$2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \xrightarrow{\text{V}_2\text{O}_5} 2\text{SO}_3(\text{g})$$
- When moist, sulphur dioxide behaves as a reducing agent. For example, it converts iron(III) ions to iron(II) ions and decolorizes acidified potassium permanganate(VII) solution

$$2\text{Fe}^{3+} + \text{SO}_2 + 2\text{H}_2\text{O} \rightarrow 2\text{Fe}^{2+} + \text{SO}_4^{2-} + 4\text{H}^+$$

$$5\text{SO}_2 + 2\text{MnO}_4^- + 2\text{H}_2\text{O} \rightarrow 5\text{SO}_4^{2-} + 4\text{H}^+ + 2\text{Mn}^{2+}$$
- The key step in the manufacture of H_2SO_4 is the catalytic oxidation of SO_2 with O_2 to give SO_3 in the presence of V_2O_5 (catalyst).

$$2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \xrightarrow{\text{V}_2\text{O}_5} 2\text{SO}_3(\text{g}) \quad \Delta_r H^\ominus = -196.6 \text{ kJ mol}^{-1}$$

$$\text{SO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{H}_2\text{S}_2\text{O}_7$$

(Oleum)
- Sulphuric acid, because of its low volatility can be used to manufacture more volatile acids from their corresponding salts.

$$2 \text{MX} + \text{H}_2\text{SO}_4 \rightarrow 2 \text{HX} + \text{M}_2\text{SO}_4 \quad (\text{X} = \text{F}, \text{Cl}, \text{NO}_3)$$

(M = Metal)
- Sulphuric acid removes water from organic compounds; it is evident by its charring action on carbohydrates.

$$\text{C}_{12}\text{H}_{22}\text{O}_{11} \xrightarrow{\text{H}_2\text{SO}_4} 12\text{C} + 11\text{H}_2\text{O}$$
- metals and non-metals are oxidized by concentrated sulphuric acid, which is reduced to SO_2 .

$$\text{Cu} + 2 \text{H}_2\text{SO}_4(\text{conc.}) \rightarrow \text{CuSO}_4 + \text{SO}_2 + 2\text{H}_2\text{O}$$

$$3\text{S} + 2\text{H}_2\text{SO}_4(\text{conc.}) \rightarrow 3\text{SO}_2 + 2\text{H}_2\text{O}$$

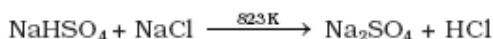
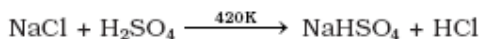
$$\text{C} + 2\text{H}_2\text{SO}_4(\text{conc.}) \rightarrow \text{CO}_2 + 2 \text{SO}_2 + 2 \text{H}_2\text{O}$$
- In general, a halogen oxidizes halide ions of higher atomic number.

$$\text{F}_2 + 2\text{X}^- \rightarrow 2\text{F}^- + \text{X}_2 \quad (\text{X} = \text{Cl}, \text{Br} \text{ or } \text{I})$$

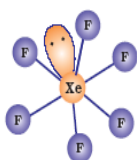
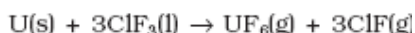
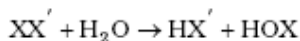
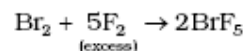
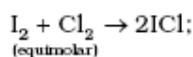
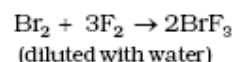
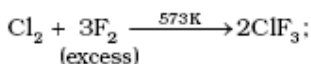
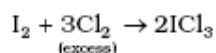
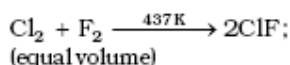
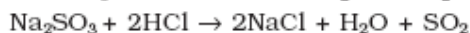
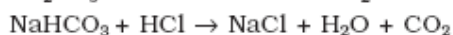
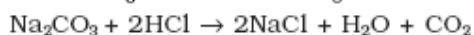
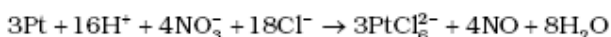
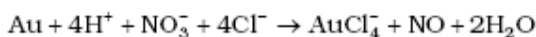
$$\text{Cl}_2 + 2\text{X}^- \rightarrow 2\text{Cl}^- + \text{X}_2 \quad (\text{X} = \text{Br} \text{ or } \text{I})$$

$$\text{Br}_2 + 2\text{I}^- \rightarrow 2\text{Br}^- + \text{I}_2$$
- I^- can be oxidised by oxygen in acidic medium; just the reverse of the reaction observed with fluorine.

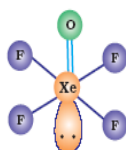
In laboratory, it is prepared by heating sodium chloride with concentrated sulphuric acid.



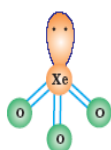
When three parts of concentrated HCl and one part of concentrated HNO_3 are mixed, aqua regia is formed which is used for dissolving noble metals, e.g., gold, platinum.



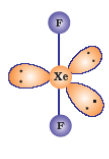
(c) Distorted octahedral



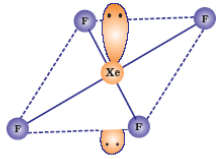
(d) Square pyramidal



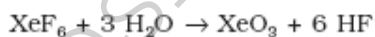
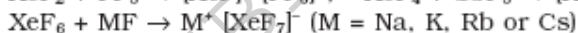
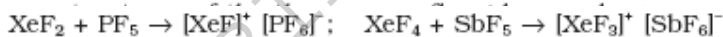
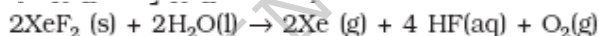
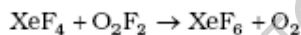
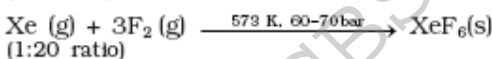
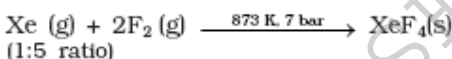
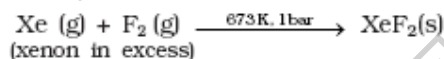
(e) Pyramidal



(a) Linear



(b) Square planar



Partial hydrolysis of XeF_6 gives oxyfluorides, XeOF_4 and XeO_2F_2 .

