CHAPTER

16 The p-Block Elements

Section-A JEE Advanced/ IIT-JEE

A Fill in the Blanks

1. The lowest possible oxidation state of nitrogen is *(1980)*
2. Iodine reacts with hot NaOH solution. The products are NaI and ..... *(1980)*
3. ..... is a weak acid. (HF, HCl, HI) *(1981 - 1 Mark)*
4. The increase in the solubility of iodine in an aqueous solution of potassium iodide is due to the formation of ..... . *(1982 - 1 Mark)*
5. Hydrogen gas is liberated by the action of aluminium with concentrated solution of ..... . *(1987 - 1 Mark)*
6. ..... phosphorus is reactive because of its highly strained tetrahedral structure. *(1987 - 1 Mark)*
7. ..... acid gives hypo ..... ion. *(1988 - 1 Mark)*
(hydrobromic, hypobromous, perbromic, bromide, bromite, perbromate)
8. Sulphur acts as ..... agent in vulcanization of rubber. *(1989 - 1 Mark)*
9. The basicity of phosphorous acid (H_3PO_3) is ..... . *(1990 - 1 Mark)*
10. The hydrolysis of alkyl substituted chlorosilanes gives ..... . *(1991 - 1 Mark)*
11. In P_4O_{10}, the number of oxygen atoms bonded to each phosphorus atom is ..... . *(1992 - 1 Mark)*
12. The lead chamber process involves oxidation of SO_2 by atomic oxygen under the influence of ..... as catalyst. *(1992 - 1 Mark)*
13. The hydrolysis of trialkylchlorosilane R_3SiCl, yields ..... *(1994 - 1 Mark)*
14. One recently discovered allotrope of carbon (e.g., C_{60}) is commonly known as..... *(1994 - 1 Mark)*
15. Solubility of iodine in water is greatly increased by the addition of iodide ions because of the formation of ..... *(1994 - 1 Mark)*
16. A liquid which is permanently supercooled is frequently called a ..... . *(1997 - 1 Mark)*
17. Compounds that formally contain Pb^{4+} are easily reduced to Pb^{2+}. The stability of the lower oxidation state is due to ..... . *(1997 - 1 Mark)*

B True / False

1. Red phosphorus is less volatile than white phosphorus because the former has a tetrahedral structure. *(1982 - 1 Mark)*
2. When PbO_2 reacts with a dilute acid, it gives hydrogen peroxide. *(1982 - 1 Mark)*
3. Carbon tetrachloride burns in air when lighted to give phosgene. *(1983 - 1 Mark)*
4. Dil. HCl oxidizes metallic Fe to Fe^{2+}. *(1983 - 1 Mark)*
5. In aqueous solution chlorine is a stronger oxidizing agent than fluorine. *(1984 - 1 Mark)*
6. The H-N-H bond angle in NH_3 is greater than the H-As-H bond angle is AsH_3. *(1984 - 1 Mark)*
7. Carbon tetrachloride is inflammable. *(1985 - ½ Mark)*
8. Graphite is better lubricant on the moon than on the earth. *(1987 - 1 Mark)*
9. All the Al–Cl bonds in Al_2Cl_6 are equivalent. *(1989 - 1 Mark)*
10. Nitric oxide, though an odd electron molecule, is diamagnetic in liquid state. *(1991 - 1 Mark)*
11. Diamond is harder than graphite. *(1993 - 1 Mark)*
12. The tendency for catenation is much higher for C than for Si. *(1993 - 1 Mark)*
13. HBr is a stronger acid than HI because of hydrogen bonding. *(1993 - 1 Mark)*

C MCQs with One Correct Answer

1. The reddish brown coloured gas formed when nitric oxide is oxidised by air is *(1979)*
(a) N_2O_5 (b) N_2O_4
(c) NO_2 (d) N_2O_3
2. The temporary hardness of water due to calcium carbonate can be removed by adding – *(1979)*
(a) $CaCO_3$ (b) $Ca(OH)_2$
(c) $CaCl_2$ (d) HCl
3. Which of the following is most stable to heat *(1980)*
(a) HCl (b) HOCl
(c) HBr (d) HI

4. White P reacts with caustic soda. The products are PH_3 and NaH_2PO_2. This reaction is an example of *(1980)*
(a) Oxidation (b) Reduction
(c) oxidation and reduction (d) Neutralisation

5. A solution of KBr is treated with each of the following. Which one would liberate bromine *(1980)*
(a) Cl_2 (b) HI
(c) I_2 (d) SO_2

6. Which of the following is coloured *(1980)*
(a) NO (b) N_2O
(c) SO_3 (d) None

7. Lead pencil contains *(1980)*
(a) Pb (b) FeS
(c) Graphite (d) PbS

8. Ammonia can be dried by *(1980)*
(a) Conc. H_2SO_4 (b) P_2O_5
(c) Anhydrous $CuSO_4$ (d) none

9. HBr and HI reduce sulphuric acid, HCl can reduce $KMnO_4$ and HF can reduce *(1981 - 1 Mark)*
(a) H_2SO_4 (b) $KMnO_4$
(c) $K_2Cr_2O_7$ (d) none of the above

10. Which of the following statements about anhydrous aluminium chloride is correct? *(1981 - 1 Mark)*
(a) it exists as $AlCl_3$ molecules
(b) it is not easily hydrolysed
(c) it sublimes at 100°C under vacuum
(d) it is a strong Lewis base

11. Moderate electrical conductivity is shown by *(1982 - 1 Mark)*
(a) silica (b) graphite
(c) diamond (d) carborundum

12. Chlorine acts as a bleaching agent only in presence of *(1983 - 1 Mark)*
(a) dry air (b) moisture
(c) sunlight (d) pure oxygen

13. Nitrogen dioxide cannot be obtained by heating : *(1985 - 1 Mark)*
(a) KNO_3 (b) $Pb(NO_3)_2$
(c) $Cu(NO_3)_2$ (d) $AgNO_3$

14. A gas that cannot be collected over water is : *(1985 - 1 Mark)*
(a) N_2 (b) O_2
(c) SO_2 (d) PH_3

15. The compound which gives off oxygen on moderate heating is : *(1986 - 1 Mark)*
(a) cupric oxide (b) mercuric oxide
(c) zinc oxide (d) aluminium oxide

16. The bonds present in N_2O_5 are : *(1986 - 1 Mark)*
(a) only ionic (b) covalent and coordinate
(c) only covalent (d) covalent and ionic

17. Which of the following oxides of nitrogen is a coloured gas? *(1987 - 1 Mark)*
(a) N_2O (b) NO
(c) N_2O_5 (d) NO_2

18. Amongst the trihalides of nitrogen which one is least basic? *(1987 - 1 Mark)*
(a) NF_3 (b) NCl_3
(c) NBr_3 (d) NI_3

19. Bromine can be liberated from potassium bromide solution by the action of *(1987 - 1 Mark)*
(a) Iodine solution (b) Chlorine water
(c) Sodium chloride (d) Potassium iodide

20. There is no S–S bond in : *(1991 - 1 Mark)*
(a) $S_2O_4^{2-}$ (b) $S_2O_5^{2-}$
(c) $S_2O_3^{2-}$ (d) $S_2O_7^{2-}$

21. In P_4O_{10} each P atom is linked with ..... O atoms
(a) 2 (b) 3 *(1995S)*
(c) 4 (d) 5

22. H_2SO_4 cannot be used to prepare HBr from NaBr as it : *(1995S)*
(a) reacts slowly with NaBr (b) oxidises HBr
(c) reduces HBr (d) disproportionates HBr

23. Hydrolysis of one mole of peroxodisulphuric acid produces *(1996 - 1 Mark)*
(a) two moles of sulphuric acid
(b) two moles of peroxomonosulphuric acid
(c) one mole of sulphuric acid and one mole of peroxomonosulphuric acid
(d) one mole of sulphuric acid, one mole of peroxomonosulphuric acid and one mole of hydrogen peroxide.

24. Which of the following statements is correct for $CsBr_3$? *(1996 - 1 Mark)*
(a) It is a covalent compound.
(b) It contains Cs^{3+} and Br^- ions.
(c) It contains Cs^+ and Br_3^- ions
(d) It contains Cs^+, and Br^- and lattice Br_2 molecule

25. KF combines with HF to form KHF_2. The compound contains the species. *(1996 - 1 Mark)*
(a) K^+, F^- and H^+ (b) K^+, F^- and HF
(c) K^+ and $[HF_2]^-$ (d) $[KHF]^+$ and F^-

26. Sodium thiosulphate is prepared by *(1996 - 1 Mark)*
(a) reducing Na_2SO_4 solution with H_2S
(b) boiling Na_2SO_3 solution with S in alkaline medium
(c) neutralising $H_2S_2O_3$ solution with NaOH
(d) boiling Na_2SO_3 solution with S in acidic medium

27. Which of the following halides is least stable and has doubtful existence? *(1996 - 1 Mark)*
(a) CI_4 (b) GeI_4
(c) SnI_4 (d) PbI_4

28. Which one of the following oxides is neutral?
(a) CO (b) SnO_2 *(1996 - 1 Mark)*
(c) ZnO (d) SiO_2

29. Which one of the following species is not a pseudohalide? *(1997 - 1 Mark)*
(a) CNO^- (b) $RCOO^-$
(c) OCN^- (d) NNN^-

30. One mole of calcium phosphide on reaction with excess water gives *(1999 - 2 Marks)*
(a) one mole of phosphine
(b) two moles of phosphoric acid
(c) two moles of phosphine
(d) one mole of phosphorus pentoxide

31. On heating ammonium dichromate, the gas evolved is *(1999 - 2 Marks)*
(a) oxygen (b) ammonia
(c) nitrous oxide (d) nitrogen

32. In the commercial electrochemical process for aluminium extraction the electrolyte used is *(1999 - 2 Marks)*
(a) $Al(OH)_3$ in NaOH solution
(b) an aqueous solution of $Al_2(SO_4)_3$.
(c) a molten mixture of Al_2O_3 and Na_3AlF_6
(d) a molten mixture of AlO(OH) and $Al(OH)_3$

33. In compounds of type ECl_3, where E = B, P, As or Bi, the angles Cl – E– Cl for different E are in the order *(1999 - 2 Marks)*.
(a) B > P = As = Bi (b) B > P > As > Bi
(c) B < P = As = Bi (d) B < P < As < Bi

34. Electrolytic reduction of alumina to aluminium by Hall-Heroult process is carried out *(2000S)*
(a) in the presence of NaCl
(b) in the presence of fluorite
(c) in the presence of cryolite which forms a melt with lower melting temperature
(d) in the presence of cryolite which forms a melt with higher melting temperature

35. The number of P – O – P bonds in cyclic metaphosphoric acid is *(2000S)*
(a) zero (b) two
(c) three (d) four

36. Ammonia can be dried by *(2000S)*
(a) conc. H_2SO_4 (b) P_4O_{10}
(c) CaO (d) anhydrous $CaCl_2$

37. The number of S – S bonds in sulphur trioxide trimer (S_3O_9) is *(2001S)*
(a) three (b) two
(c) one (d) zero

38. Polyphosphates are used as water softening agents because they *(2002S)*
(a) form soluble complexes with anionic species
(b) precipitate anionic species
(c) form soluble complexes with cationic species
(d) precipitate cationic species

39. For H_3PO_3 and H_3PO_4 the correct choice is: *(2003S)*
(a) H_3PO_3 is dibasic and reducing
(b) H_3PO_3 is dibasic and non-reducing
(c) H_3PO_4 is tribasic and reducing
(d) H_3PO_3 is tribasic and non-reducing

40. H_3BO_3 is: *(2003S)*
(a) Monobasic and weak Lewis acid
(b) Monobasic and weak Bronsted acid
(c) Monobasic and strong Lewis acid
(d) Tribasic and weak Bronsted acid

41. $(Me)_2SiCl_2$ on hydrolysis will produce *(2003S)*
(a) $(Me)_2Si(OH)_2$ (b) $(Me)_2Si=O$
(c) $-[-O-(Me)_2Si-O-]_n-$ (d) $Me_2SiCl(OH)$

42. Total number of lone pair of electrons in $XeOF_4$ is *(2004S)*
(a) 0 (b) 1
(c) 2 (d) 3

43. The acid having O – O bond is *(2004S)*
(a) $H_2S_2O_3$ (b) $H_2S_2O_6$
(c) $H_2S_2O_8$ (d) $H_2S_4O_6$

44. Pb and Sn are extracted from their chief ores by *(2004S)*
(a) carbon reduction and self reduction respectively
(b) self reduction and carbon reduction respectively
(c) electrolysis and self reduction respectively
(d) self reduction and electrolysis respectively

45. Name of the structure of silicates in which three oxygen atoms of $[SiO_4]^{4-}$ are shared. *(2005S)*
(a) Pyrosilicate
(b) Sheet silicate
(c) Linear chain silicate
(d) Three dimensional silicate

46. Which is the most thermodynamically stable allotropic form of phosphorus? *(2005S)*
(a) red (b) white
(c) black (d) yellow

47. Which of the following is not oxidized by O_3 ? *(2005S)*
(a) KI (b) $FeSO_4$
(c) $KMnO_4$ (d) K_2MnO_4

48. Blue liquid which is obtained on reacting equimolar amounts of two gases at –30°C is? *(2005S)*
(a) N_2O (b) N_2O_3
(c) N_2O_4 (d) N_2O_5

49. When PbO_2 reacts with conc. HNO_3 the gas evolved is *(2005S)*
(a) NO_2 (b) O_2
(c) N_2 (d) N_2O

50. How can the following reaction be made to proceed in forward direction? *(2006 - 3M, –1)*
$B(OH)_3 + NaOH \rightleftharpoons NaBO_2 + Na[B(OH)_4] + H_2O$
(a) addition of borax
(b) addition of *cis* -1,2-diol
(c) addition of Na_2HPO_4
(d) addition of *trans* -1,2-diol

51. The percentage of π-character in the orbitals forming P – P bonds in P_4 is *(2007)*
(a) 25 (b) 33
(c) 50 (d) 75

52. Aqueous solution of $Na_2S_2O_3$ on reaction with Cl_2 gives – *(2008)*
(a) $Na_2S_4O_6$ (b) $NaHSO_4$
(c) NaCl (d) NaOH

53. The reaction of P_4 with **X** leads selectively to P_4O_6. The **X** is *(2009)*
(a) Dry O_2
(b) A mixture of O_2 and N_2
(c) Moist O_2
(d) O_2 in the presence of aqueous NaOH

54. Extra pure N_2 can be obtained by heating *(2011)*
(a) NH_3 with CuO
(b) NH_4NO_3
(c) $(NH_4)_2Cr_2O_7$
(d) $Ba(N_3)_2$

55. Which ordering of compounds is according to the decreasing order of the oxidation state of nitrogen? *(2012)*
(a) HNO_3, NO, NH_4Cl, N_2
(b) HNO_3, NO, N_2, NH_4Cl
(c) HNO_3, NH_4Cl, NO, N_2
(d) NO, HNO_3, NH_4Cl, N_2

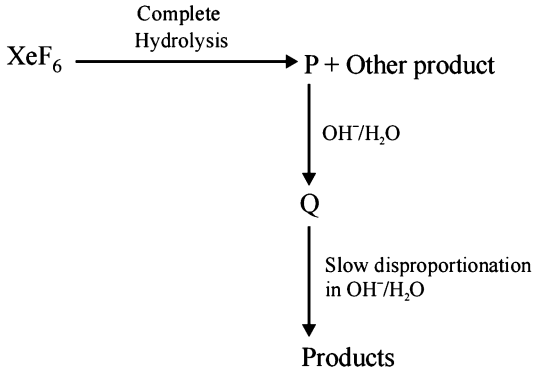
56. The reaction of white phosphorus with aqueous NaOH gives phosphine along with another phosphorus containing compound. The reaction type; the oxidation states of phosphorus in phosphine and the other product are respectively *(2012)*
(a) redox reaction; – 3 and – 5
(b) redox reaction; + 3 and + 5
(c) disproportionation reaction; – 3 and + 5
(d) disproportionation reaction; – 3 and + 3

57. The shape of XeO_2F_2 molecule is *(2012)*
(a) trigonal bipyramidal
(b) square planar
(c) tetrahedral
(d) see-saw

58. Concentrated nitric acid, upon long standing, turns yellow brown due to the formation of *(JEE Advanced 2013)*
(a) NO (b) NO_2
(c) N_2O (d) N_2O_4

59. The product formed in the reaction of $SOCl_2$ with white phosphorous is *(JEE Adv. 2014)*
(a) PCl_3 (b) SO_2Cl_2
(c) SCl_2 (d) $POCl_3$

60. Under ambient conditions, the total number of gases released as products in the final step of the reaction scheme shown below is *(JEE Adv. 2014)*



(a) 0 (b) 1
(c) 2 (d) 3

61. The increasing order of atomic radii of the following Group 13 elements is
(a) $A\ell < Ga < In < T\ell$ (b) $Ga < A\ell < In < T\ell$
(c) $A\ell < In < Ga < T\ell$ (d) $A\ell < Ga < T\ell < In$
(JEE Adv. 2016)

62. In the following reaction sequence in aqueous solution, the species X, Y and Z, respectively, are *(JEE Adv. 2016)*

$$S_2O_3^{2-} \xrightarrow{Ag^+} \underset{\text{clear solution}}{X} \xrightarrow{Ag^+} \underset{\text{white precipitate}}{Y}$$
$$\xrightarrow{\text{with time}} \underset{\text{black precipitate}}{Z}$$

(a) $[Ag(S_2O_3)_2]^{3-}, Ag_2S_2O_3, Ag_2S$
(b) $[Ag(S_2O_3)_3]^{5-}, Ag_2SO_3, Ag_2S$
(c) $[Ag(SO_3)_2]^{3-}, Ag_2S_2O_3, Ag$
(d) $[Ag(SO_3)_3]^{3-}, Ag_2SO_4, Ag$

D MCQs with One or More Than One Correct

1. In the electrolysis of alumina, cryolite is added to : *(1986 - 1 Mark)*
(a) lower the melting point of alumina
(b) increase the electrical conductivity
(c) minimise the anode effect
(d) remove impurities from alumina

2. Nitrogen(I) oxide is produced by : *(1989 - 1 Mark)*
(a) thermal decomposition of ammonium nitrate
(b) disproportionation of N_2O_4
(c) thermal decomposition of ammonium nitrite
(d) interaction of hydroxylamine and nitrous acid.

3. The compounds used as refrigerant are
(a) NH_3 *(1990 - 1 Mark)*
(b) CCl_4
(c) CF_4
(d) CF_2Cl_2
(e) CH_2F_2

4. The major role of fluorspar (CaF_2), which is added in small quantities in the electrolytic reduction of alumina dissolved in fused cryolite (Na_3AlF_6), is *(1993 - 1 Mark)*
(a) as a catalyst
(b) to make the fused mixture very conducting
(c) to lower the temperature of the melt
(d) to decrease the rate of oxidation of carbon at the anode.

5. The material used in the solar cells contains
(a) Cs *(1993 - 1 Mark)*
(b) Si
(c) Sn (d) Ti

6. Sodium nitrate decomposes above 800° C to give
(a) N_2 (b) O_2 *(1998 - 2 Marks)*
(c) NO_2 (d) Na_2O

7. White phosphorus (P_4) has *(1998 - 2 Marks)*
   (a) six P-P single bonds
   (b) four P-P single bonds
   (c) four lone pairs of electrons
   (d) PPP angle of 60°

8. Ammonia, on reaction with hypochlorite anion, can form *(1999 - 3 Marks)*
   (a) NO (b) NH_4Cl
   (c) N_2H_4 (d) HNO_2

9. A solution of colourless salt H on boiling with excess NaOH produces a non-flammable gas. The gas evolution ceases after sometime. Upon addition of Zn dust to the same solution, the gas evolution restarts. The colourless salt (s) H is (are) *(2008)*
   (a) NH_4NO_3 (b) NH_4NO_2
   (c) NH_4Cl (d) $(NH_4)_2SO_4$

10. The nitrogen oxide(s) that contain(s) N-N bond(s) is(are)
    (a) N_2O (b) N_2O_3 *(2009)*
    (c) N_2O_4 (d) N_2O_5

11. Which of the following halides react(s) with $AgNO_3$(aq) to give a precipitate that dissolves in $Na_2S_2O_3$(aq)?
    (a) HCl (b) HF *(2012)*
    (c) HBr (d) HI

12. With respect to graphite and diamond, which of the statement(s) given below is (are) correct ? *(2012)*
    (a) Graphite is harder than diamond.
    (b) Graphite has higher electrical conductivity than diamond.
    (c) Graphite has higher thermal conductivity than diamond.
    (d) Graphite has higher C–C bond order than diamond.

13. The correct statement(s) about O_3 is(are)
    (a) O—O bond lengths are equal *(JEE Adv. 2013-II)*
    (b) Thermal decomposition of O_3 is endothermic
    (c) O_3 is diamagnetic in nature
    (d) O_3 has a bent structure

14. For the reaction *(JEE Adv. 2014)*

$$I^- + ClO_3^- + H_2SO_4 \rightarrow Cl^- + HSO_4^- + I_2$$

The correct statement(s) in the balanced equation is/are
    (a) Stoichiometric coefficient of HSO_4^- is 6
    (b) Iodide is oxidized
    (c) Sulphur is reduced
    (d) H_2O is one of the products

15. The correct statement(s) for orthoboric acid is/are *(JEE Adv. 2014)*
    (a) It behaves as a weak acid in water due to self ionization.
    (b) Acidity of its aqueous solution increases upon addition of ethylene glycol
    (c) It has a three dimensional structure due to hydrogen bonding
    (d) It is a weak electrolyte in water

16. The correct statement(s) regarding, (i) HClO, (ii) $HClO_2$, (iii) $HClO_3$ and (iv) $HClO_4$, is(are) *(JEE Adv. 2015)*
    (a) The number of Cl=O bonds in (ii) and (iii) together is two
    (b) The number of lone pairs of electrons on Cl in (ii) and (iii) together is three
    (c) The hybridization of Cl in (iv) is sp^3
    (d) Amongst (i) to (iv), the strongest acid is (i)

17. Under hydrolytic conditions, the compounds used for preparation of linear polymer and for chain termination, respectively, are *(JEE Adv. 2015)*
    (a) CH_3SiCl_3 and $Si(CH_3)_4$
    (b) $(CH_3)_2SiCl_2$ and $(CH_3)_3SiCl$
    (c) $(CH_3)_2SiCl_2$ and CH_3SiCl_3
    (d) $SiCl_4$ and $(CH_3)_3SiCl$

18. The crystalline form of borax has *(JEE Adv. 2016)*
    (a) tetranuclear $[B_4O_5(OH)_4]^{2-}$ unit
    (b) all boron atoms in the same plane
    (c) equal number of sp^2 and sp^3 hybridized boron atoms
    (d) one terminal hydroxide per boron atom

19. The nitrogen containing compound produced in the reaction of HNO_3 with P_4O_{10} *(JEE Adv. 2016)*
    (a) can also be prepared by reaction of P_4 and HNO_3
    (b) is diamagnetic
    (c) contains one N-N bond
    (d) reacts with Na metal producing a brown gas

E Subjective Problems

1. Account for the following. Limit your answer to two sentences
   (i) Hydrogen bromide cannot be prepared by action of concentrated sulphuric acid or sodium bromide.
   (i) When a blue litmus paper is dipped into a solution of hypochlorous acid, it first turns red and then later gets decolourised. *(1979)*

2. Write balanced equation involved in the preparation of
   (i) Anhydrous aluminium chloride from alumina.
   (ii) Bleaching powder from slaked lime.
   (iii) Tin metal from cassiterite
   (iv) Chlorine from sodium chloride.
   (v) Nitric oxide from nitric acid. *(1979)*

3. State with balanced equations, what happens when :
   (i) Tin is treated with moderately concentrated nitric acid.
   (ii) Aluminium is reacted with hot concentrated caustic soda solution *(1979)*

4. Give structural formula for the following :
   (*i*) Phosphorous acid, H_3PO_3 *(1981 - 1 Mark)*
   (*ii*) Pyrophosphoric acid, $H_4P_2O_7$ *(1981 - 1 Mark)*

5. Complete the following equations (no balancing is needed)

(*i*) $HCO_3^- + Al^{3+} \longrightarrow Al(OH)_3 + ...$ ***(1981 - 1 Mark)***

(*ii*) $AlBr_3 + K_2Cr_2O_7 + H_3PO_4 \longrightarrow K_3PO_4 + AlPO_4 + H_2O + ... + ...$ ***(1981 - 1 Mark)***

6. Give reasons for the following :

(*i*) Carbon acts as an abrasive and also as a lubricant. ***(1981 - 1 Mark)***

(*ii*) Sulphur melts to a clear mobile liquid at 119°C, but on further heating above 160°C, it becomes viscous. ***(1981 - 1 Mark)***

(*iii*) In the preparation of hydrogen iodide from alkali iodides, phosphoric acid is preferred to sulphuric acid ***(1982 - 1 Mark)***

(*iv*) Orthophosphoric acid, H_3PO_4, is tribasic, but phosphorous acid, H_3PO_3, is dibasic. ***(1982 - 1 Mark)***

(*v*) A bottle of liquor ammonia should be cooled before opening the stopper. ***(1983 - 1 Mark)***

(*vi*) Solid carbon dioxide is known as dry ice. ***(1983 - 1 Mark)***

(*vii*) Anhydrous HCl is a bad conductor of electricity but aqueous HCl is a good conductor; ***(1985 - 1 Mark)***

(*viii*) Graphite is used as a solid lubricant; ***(1985 - 1 Mark)***

(*ix*) Fluorine cannot be prepared from fluorides by chemical oxidation. ***(1985 - 1 Mark)***

(*x*) The mixture of hydrazine and hydrogen peroxide with a copper(II) catalyst is used as a rocket propellant. ***(1987 - 1 Mark)***

(*xi*) Orthophosphorus acid is not tribasic acid. ***(1987 - 1 Mark)***

(*xii*) The molecule of magnesium chloride is linear whereas that of stannous chloride is angular. ***(1987 - 1 Mark)***

(*xiii*) Valency of oxygen is generally two whereas sulphur shows valency of two, four and six. ***(1988 - 1 Mark)***

(*xiv*) H_3PO_3 is a dibasic acid. ***(1989 - 1 Mark)***

(*xv*) Phosphine has lower boiling point than ammonia. ***(1989 - 1 Mark)***

(*xvi*) Ammonium chloride is acidic in liquid ammonia solvent. ***(1991 - 1 Mark)***

(*xvii*) The hydroxides of aluminium and iron are insoluble in water. However, NaOH is used to separate one from the other. ***(1991 - 1 Mark)***

(*xviii*) Bond dissociation energy of F_2 is less than that of Cl_2. ***(1992 - 1 Mark)***

(*xix*) Sulphur dioxide is a more powerful reducing agent in an alkaline medium than in acidic medium. ***(1992 - 1 Mark)***

(*xx*) The experimentally determined N – F bond length in NF_3 is greater than the sum of the single covalent bond radii of N and F. ***(1995 - 2 Marks)***

(*xxi*) Mg_3N_2 when reacted with water gives off NH_3 but HCl is not obtained from $MgCl_2$ on reaction with water at room temperature. ***(1995 - 2 Marks)***

(*xxii*) $(SiH_3)_3N$ is a weaker base than $(CH_3)_3N$. ***(1995 - 2 Marks)***

7. State with balanced equations what happens when :

(*i*) White phosphorous (P_4) is boiled with a strong solution of sodium hydroxide in an inert atmosphere. ***(1982/87 - 1 Mark)***

(*ii*) Sodium iodate is treated with sodium bisulphite solution. ***(1982 - 1 Mark)***

(*iii*) Dilute nitric acid is slowly reacted with metallic tin. ***(1987 - 1 Mark)***

(*iv*) Potassium permanganate is reacted with warm solution of oxalic acid in the presence of sulphuric acid. ***(1987 - 1 Mark)***

(*v*) Iodate ion reacts with bisulphite ion to liberate iodine. ***(1988 - 1 Mark)***

(*vi*) Phosphorus reacts with nitric acid to give equimolar ratio of nitric oxide and nitrogen dioxide. ***(1988 - 1 Mark)***

(*vii*) Hypophosphorous acid is heated. ***(1989 - 1 Mark)***

(*viii*) Sodium bromate reacts with fluorine in presence of alkali. ***(1989 - 1 Mark)***

(*ix*) Sodium chlorate reacts with sulphur dioxide in dilute sulphuric acid medium. ***(1989 - 1 Mark)***

(*x*) Write balanced equations for the preparation of crystalline silicon from $SiCl_4$. ***(1990 - 1 Mark)***

(*xi*) Write balanced equations for the preparation of phosphine from CaO and white phosphorus. ***(1990 - 2 Marks)***

(*xii*) Write balanced equations for the preparation of ammonium sulphate from gypsum, ammonia and carbon dioxide. ***(1990 - 1 Mark)***

(*xiii*) Aqueous solution of sodium nitrate is heated with zinc dust and caustic soda solution. ***(1990 - 1 Mark)***

(*xiv*) Sodium iodate is added to a solution of sodium bisulphite. ***(1990 - 1 Marks)***

(*xv*) Sodium nitrite is produced by absorbing the oxides of nitrogen in aqueous solution of washing soda. ***(1991 - 1 Mark)***

(*xvi*) Nitrogen is obtained in the reaction of aqueous ammonia with potassium permanganate. ***(1991 - 1 Mark)***

(*xvii*) Elemental phosphorus reacts with conc. HNO_3 to give phosphoric acid. ***(1991 - 1 Mark)***

(*xviii*) Sulphur is precipitated in the reaction of hydrogen sulphide with sodium bisulphite solution. ***(1991 - 1 Mark)***

(*xix*) Phosphorus is treated with concentrated nitric acid. ***(1997 - 1 Mark)***

OR

Manufacture of phosphoric acid from phosphorus. ***(1997 - 1 Mark)***

(*xx*) Reaction of aluminium with aqueous sodium hydroxide. ***(1997 - 1 Mark)***

(*xxi*) Aluminium sulphide gives a foul odour when it becomes damp. Write a balanced chemical equation for the reaction. ***(1997 - 2 Marks)***

(*xxii*) $P_4O_{10} + PCl_5 \rightarrow$ ***(1998 - 1 Mark)***

(*xxiii*) $SnCl_4 + C_2H_5Cl + Na \rightarrow$ ***(1998 - 1 Mark)***

8. Show with equations how the following compound is prepared (equations need not be balanced) sodium thiosulphate from sodium sulphite. ***(1982 - 1 Mark)***

9. Give balanced equations for the extraction of aluminium from bauxite by electrolysis. ***(1982 - 2 Marks)***

10. State the conditions under which the following preparation is carried out. Give the necessary equations which need not be balanced : Alumina from aluminium. ***(1983 - 1 Mark)***

11. Write down the resonance structures of nitrous oxide. ***(1985 - 2 Marks)***

OR

Write the two resonance structures of N_2O that satisfy the octet rule. ***(1990 - 1 Mark)***

12. Write down the balanced equations for the reactions when:

(*i*) a mixture of potassium chlorate, oxalic acid and sulphuric acid is heated; ***(1985 - 1 Mark)***

(*ii*) ammonium sulphate is heated with a mixture of nitric oxide and nitrogen dioxide. ***(1985 - 1 Mark)***

13. What happens when :

(*i*) hydrogen sulphide is bubled through an aqueous solution of sulphur dioxide. ***(1985 - 1 Mark)***

(*ii*) tin is treated with concentrated nitric acid. ***(1985 - 1 Mark)***

(*iii*) Pb_3O_4 is treated with nitric acid. ***(1985 - 1 Mark)***

14. Arrange the following in :

(*i*) increasing bond strength ***(1986 - 1 Mark)***
HCl, HBr, HF, HI

(*ii*) $HOCl$, $HOClO_2$, $HOClO_3$, $HOClO$ in increasing order of thermal stability. ***(1988 - 1 Mark)***

(*iii*) CO_2, N_2O_5, SiO_2, SO_3 in the order of increasing acidic character. ***(1988 - 1 Mark)***

(*iv*) Increasing order of extent of hydrolysis :
$CCl_4, MgCl_2, AlCl_3, PCl_5, SiCl_4$ ***(1991 - 1 Mark)***

15. Mention the products formed in the following :

(*i*) Chlorine gas is bubbled through a solution of ferrous bromide. ***(1986 - 1 Mark)***

(*ii*) Iodine is added to a solution of stannous chloride. ***(1986 - 1 Mark)***

(*iii*) Sulphur dioxide gas, water vapour and air are passed over heated sodium chloride. ***(1986 - 1 Mark)***

16. Write the two resonance structures of ozone which satisfy the octet rule. ***(1991 - 1 Mark)***

17. $PbS \xrightarrow[\text{air}]{\text{heat in}} A + PbS \xrightarrow{B} Pb + SO_2$; Identify A and B. ***(1991 - 2 Marks)***

18. Complete and balance the following chemical reactions :

(i) Red phosphorus is reacted with iodine in presence of water. ***(1992 - 1 Mark)***
$P + I_2 + H_2O \rightarrow$ ..... + ...

(ii) Anhydrous potassium nitrate is heated with excess of metallic potassium. ***(1992 - 1 Mark)***
$KNO_3(s) + K(s) \rightarrow$ ..... + ...

(iii) $NH_3 + NaOCl \rightarrow$ ..... + ... ***(1993 - 1 Mark)***

(iv) $Sn + 2KOH + 4H_2O \longrightarrow$ ..... + ... ***(1994 - 1 Mark)***

19. Draw the structure of P_4O_{10} and identify the number of single and double P—O bonds. ***(1996 - 3 Marks)***

20. Gradual addition of KI solution to $Bi(NO_3)_3$ solution initially produces a dark brown precipitate which dissolves in excess of KI to give a clear yellow solution. Write chemical equations for the above reactions. ***(1996 - 2 Marks)***

21. Complete the following chemical equations :

(a) $KI + Cl_2 \rightarrow$ (b) $KClO_3 + I_2 \rightarrow$

Justify the formation of the products in the above reactions. ***(1996 - 2 Marks)***

22. A soluble compound of a poisonous element M, when heated with Zn/H_2SO_4 gives a colourless and extremely poisonous gaseous compound N, which on passing through a heated tube gives a silvery mirror of element M. Identify M and N. ***(1997 - 2 Marks)***

23. Draw the structure of a cyclic silicate, $(Si_3O_9)^{6-}$ with proper labelling. ***(1998 - 4 Marks)***

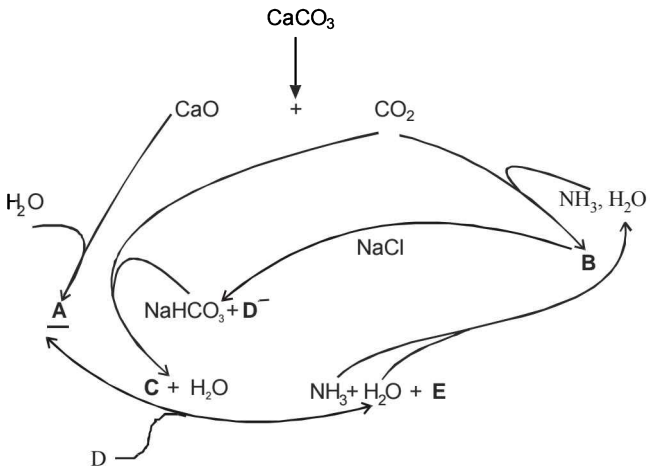
24. Thionyl chloride can be synthesized by chlorinating SO_2 using PCl_5. Thionyl chloride is used to prepare anhydrous ferric chloride starting from its hexahydrated salt. Alternatively, the anhydrous ferric chloride can also be prepared from its hexahydrated salt by treating with 2, 2 – dimethoxypropane. Discuss all this using balanced chemical equations. ***(1998 - 6 Marks)***

25. Reaction of phosphoric acid with $Ca_5(PO_4)_3F$ yields a fertilizer "triple superphosphate". Represent the same through balanced chemical equation. *(1998 - 2 Marks)*

26. In the following equation, *(1999 - 6 Marks)*
$A + 2B + H_2O \rightarrow C + 2D$
($A = HNO_2$, $B = H_2SO_3$, $C = NH_2OH$). Identify D. Draw the structures of A, B, C and D.

27. In the contact process for industrial manufacture of sulphuric acid some amount of sulphuric acid is used as a starting material. Explain briefly. What is the catalyst used in the oxidation of SO_2? *(1999 - 4 Marks)*

28. The Haber process can be represented by the following scheme;



Identify A, B, C, D and E. *(1999 - 5 Marks)*

29. Give an example of oxidation of one halide by another halogen. Explain the feasibility of the reaction *(2000 - 2 Marks)*.

30. Draw the molecular structures of XeF_2, XeF_4 and XeO_2F_2 indicating the location of lone pair(s) of electrons. *(2000 - 3 Marks)*

31. Give reason(s) why elemental nitrogen exists as a diatomic molecule whereas elemental phosphorus as a tetraatomic molecule. *(2000 - 2 Marks)*

32. Compound (X) on reduction with $LiAlH_4$ gives a hydride (Y) containing 21.72% hydrogen along with other products. The compound (Y) reacts with air explosively resulting in boron trioxide. Identify (X) and (Y). Give balanced reactions involved in the formation of (Y) and its reaction with air. Draw the structure of (Y). *(2001 - 5 Marks)*

33. Starting from $SiCl_4$, prepare the following in steps not exceeding the number given in parentheses (give reactions only):
(i) Silicon (1)
(ii) Linear silicone containing methyl groups only (4)
(iii) Na_2SiO_3 (3) *(2001 - 5 Marks)*

34. Write balanced equations for the reactions of the following compounds with water : *(2002 - 5 Marks)*
(i) Al_4C_3
(ii) CaNCN
(iii) BF_3
(iv) NCl_3
(v) XeF_4

35. How is boron obtained from borax? Give chemical equations with reaction conditions. Write the structure of B_2H_6 and its reaction with HCl. *(2002 - 5 Marks)*

36. Write down reactions involved in the extraction of Pb. What is the oxidation number of lead in litharge? *(2003 - 2 Marks)*

37. Identify the following: *(2003 - 4 Marks)*

$$Na_2CO_3 \xrightarrow{SO_2} A \xrightarrow{Na_2CO_3} B \xrightarrow[\Delta]{\text{Elemental S}} C \xrightarrow{I_2} D$$

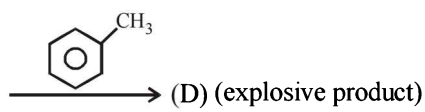
Also mention the oxidation state of S in all the compounds.

38. AlF_3 is insoluble in anhydrous HF but it becomes soluble in presence of little amount of KF. Addition of boron trifluoride to the resulting solution causes reprecipitation of AlF_3. Explain with balanced chemical equations. *(2004 - 2 Marks)*

39. How many grams of CaO are required to neutralize 852 gm of P_4O_{10}? Draw structure of P_4O_{10} molecule. *(2005 - 2 Marks)*

40. Write the structures of $(CH_3)_3N$ and $(Me_3Si)_3N$. Are they isostructural? Justify your answer. *(2005 - 2 Marks)*

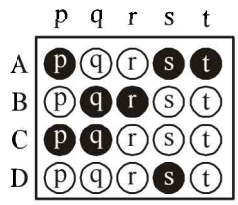
41. $(B) \xleftarrow{NaBr + MnO_2} (A) \xrightarrow{Conc.HNO_3} (C)$



Identify the missing compounds. Give the equation from A to B and A to C. *(2005 - 4 Marks)*

F Match the Following

DIRECTIONS (Q. 1 to 3) : *Each question contains statements given in two columns, which have to be matched. The statements in Column-I are labelled A, B, C and D, while the statements in Column-II are labelled p, q, r, s and t. Any given statement in Column-I can have correct matching with ONE OR MORE statement(s) in Column-II. The appropriate bubbles corresponding to the answers to these questions have to be darkened as illustrated in the following example :*
If the correct matches are A-p, s and t; B-q and r; C-p and q; and D-s then the correct darkening of bubbles will look like the given.



1. Match gases under specified conditions listed in **Column I** with their properties/laws in **Column II**. Indicate your answer by darkening the appropriate bubbles of the 4 × 4 matrix given in the ORS. *(1995S)*

Column I	**Column II**
(A) Explosive	(p) NaN_3
(B) Artificial gem	(q) Fe_3O_4
(C) Self reduction	(r) Cu
(D) Magnetic material	(s) Al_2O_3
	(t) $Pb(N_3)_2$
	(u) Fe_2O_3
	(v) Cu
	(w) SiC

2. Match the following : *(2006 - 6M)*

Column I	**Column II**
(A) $Bi^{3+} \longrightarrow (BiO)^+$	(p) Heat
(B) $[AlO_2]^- \longrightarrow Al(OH)_3$	(q) Hydrolysis
(C) $[SiO_4]^{4-} \longrightarrow [Si_2O_7]^{6-}$	(r) Acidification
(D) $[B_4O_7]^{2-} \longrightarrow [B(OH)_3]$	(s) Dilution by water

3. Match each of the diatomic molecules in **Column I** with its property/properties in **Column II**. *(2009)*

Column I	**Column II**
(A) B_2	(p) Paramagnetic
(B) N_2	(q) Undergoes oxidation
(C) O_2^-	(r) Undergoes reduction
(D) O_2	(s) Bond order ≥ 2
	(t) Mixing of 's' and 'p' orbital

DIRECTIONS (for Q. 4) : *Following question has matching lists. The codes for the lists have choices (a), (b), (c) and (d) out of which ONLY ONE is correct.*

4. The unbalanced chemical reactions given in List I show missing reagent or condition (?) which are provided in List II. Match List I with List II and select the correct answer using the code given below the lists *(JEE Adv. 2013-II)*

List I	**List II**
P. $PbO_2 + H_2SO_4 \xrightarrow{?} PbSO_4 + O_2 +$ other product	1. NO
Q. $Na_2S_2O_3 + H_2O \xrightarrow{?} NaHSO_4 +$ other product	2. I_2
R. $N_2H_4 \xrightarrow{?} N_2 +$ other product	3. Warm
S. $XeF_2 \xrightarrow{?} Xe +$ other product	4. Cl_2

Codes :

	P	Q	R	S
(a)	4	2	3	1
(b)	3	2	1	4
(c)	1	4	2	3
(d)	3	4	2	1

G Comprehension Based Questions

PASSAGE - 1

The noble gases have closed-shell electronic configuration and are monoatomic gases under normal conditions. The low boiling points of the lighter noble gases are due to weak dispersion forces between the atoms and the absence of other interatomic interactions.

The direct reaction of xenon with fluorine leads to a series of compounds with oxidation numbers +2, +4 and +6. XeF_4 reacts violently with water to given XeO_3. The compounds of xenon exhibit rich stereochemistry and their geometries can be deduced considering the total number of electron pairs in the valence shell.

1. Argon is used in arc welding because of its *(2007)*
- (a) low reactivity with metal
- (b) ability to lower the melting point of metal
- (c) flammability
- (d) high calorific value

2. The structure of XeO_3 is *(2007)*
- (a) linear (b) planar
- (c) pyramidal (d) T-shaped

3. XeF_4 and XeF_6 are expected to be *(2007)*
- (a) oxidizing
- (b) reducing
- (c) unreactive
- (d) strongly basic

PASSAGE - 2

There are some deposits of nitrates and phosphates in earth's crust. Nitrates are more soluble in water. Nitrates are difficult to reduce under the laboratory conditions but microbes do it easily. Ammonia forms large number of complexes with transition metal ions. Hybridization easily explains the ease of sigma donation capability of NH_3 and PH_3. Phosphine is a flammable gas and is prepared from white phosphorous.

4. Among the following, the correct statement is *(2008)*
- (a) Phosphates have no biological significance in humans
- (b) Between nitrates and phosphates, phosphates are less abundant in earth's crust
- (c) Between nitrates and phosphates, nitrates are less abundant in earth's crust
- (d) Oxidation of nitrates is possible in soil

5. Among the following, the correct statement is
- (a) Between NH_3 and PH_3, NH_3 is a better electron donor because the lone pair of electrons occupies spherical s-orbital and is less directional
- (b) Between NH_3 and PH_3 , PH_3 is a better electron donor because the lone pair of electrons occupies sp^3 orbital and is more directional
- (c) Between NH_3 and PH_3 , NH_3 is a better electron donor because the lone pair of electrons occupies sp^3 orbital and is more directional
- (d) Between NH_3 and PH_3 , PH_3 is a better electron donor because the lone pair of electrons occupies spherical s-orbital and is less directional

6. White phosphorus on reaction with NaOH gives PH_3 as one of the products. This is a
- (a) dimerization reaction
- (b) disporportionation reaction
- (c) condensation reaction
- (d) precipitation reaction

PASSAGE - 3

Bleaching powder and bleach solution are produced on a large scale and used in several household products. The effectiveness of bleach solution is often measured by iodometry. *(2012 - II)*

7. Bleaching powder contains a salt of an oxoacid as one of its components. The anhydride of that oxoacid is
- (a) Cl_2O
- (b) Cl_2O_7
- (c) ClO_2
- (d) Cl_2O_6

8. 25 mL of household solution was mixed with 30 mL of 0.50 M KI and 10 mL of 4N acetic acid. In the titration of the liberated iodine, 48 mL of 0.25 N $Na_2S_2O_3$ was used to reach the end point. The molarity of the household bleach solution is
- (a) 0.48 M
- (b) 0.96 M
- (c) 0.24 M
- (d) 0.024 M

PASSAGE - 4

The reactions of Cl_2 gas with cold-dilute and hot-concentrated NaOH in water give sodium salts of two (different) oxoacids of chlorine, P and Q, respectively. The Cl_2 gas reacts with SO_2 gas, in presence of charcoal, to give a product R. R reacts with white phosphorus to give a compound S. On hydrolysis, S gives an oxoacid of phosphorus, T. *(JEE Adv. 2013)*

9. P and Q, respectively, are the sodium salts of
- (a) Hypochlorus and chloric acids
- (b) Hypochlorus and chlorus acids
- (c) Chloric and perchloric acids
- (d) Chloric and hypochlorus acids

10. R, S and T respectively, are
- (a) SO_2Cl_2, PCl_5 and H_3PO_4
- (b) SO_2Cl_2, PCl_3 and H_3PO_3
- (c) $SOCl_2$, PCl_3 and H_3PO_2
- (d) $SOCl_2$, PCl_5 and H_3PO_4

H Assertion & Reason Type Questions

This question contains STATEMENT-1 (Assertion/ Statement) and STATEMENT-2 (Reason/Explanation) and has 4 choices (a), (b), (c) and (d) out of which ONLY ONE is correct.

(a) Statement-1 is True, Statement-2 isTrue; Statement-2 is a correct explanation for Statement-1

(b) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1

(c) Statement-1 is True, Statement-2 is False

(d) Statement-1 is False, Statement-2 is True.

1. **Statement-1 :** Although PF_5, PCl_5 and PBr_5 are known,the pentahalides of nitrogen have not been observed
Statement-2 : Phosphorus has lower electronegativity than nitrogen. ***(1994 - 2 Marks)***
2. **Statement-1 :** F atom has less electron affinity than Cl atom.
Statement-2 : Additional electrons are repelled more effectively by 3*p* electrons in Cl atom than by 2*p* electrons in F atom. ***(1998 - 2 Marks)***
3. **Statement-1 :** $Al(OH)_3$ is amphoteric in nature
Statement-2 : Al–O and O–H bonds can be broken with equal ease in $Al(OH)_3$. ***(1998 - 2 Marks)***
4. **Statement-1 :** Between $SiCl_4$ and CCl_4, only $SiCl_4$ reacts with water.
Statement-2 : $SiCl_4$ is ionic and CCl_4 is covalent. ***(2001S)***
5. **Statement-1 :** In water, orthoboric acid behaves as a weak monobasic acid.
because
Statement-2 : In water, orthoboric acid acts as a proton donor. ***(2007)***
6. **Statement-1 :** Boron always forms covalent bond.
because
Statement-2 : The small size of B^{3+} favours formation of covalent bond. ***(2007)***
7. **Statement-1 :** Pb^{+4} compounds are stronger oxidising agents than Sn^{4+} compounds ***(2008)***
Statement-2 : The higher oxidation states for the group 14 elements are more stable for the heavier members of the group due to 'inert pair effect'.

I Integer Value Correct Type

1. The coordination number of Al in the crystalline state of $AlCl_3$ is ***(2009)***
2. The value of *n* in the molecular formula $Be_nAl_2Si_6O_{18}$ is ***(2010)***
3. Reaction of Br_2 with Na_2CO_3in aqueous solution gives sodium bromide and sodium bromate with evolution of CO_2 gas. The number of sodium bromide molecules involved in the balanced chemical equation is ***(2011)***
4. Among the following, the number of compounds than can react with PCl_5 to give $POCl_3$ is ***(2011)***
O_2, CO_2, SO_2, H_2O, H_2SO_4, P_4O_{10}
5. The total number of lone pairs of electrons in N_2O_3 is ***(JEE Adv. 2015)***
6. Three moles of B_2H_6 are completely reacted with methanol. The number of moles of boron containing product formed is ***(JEE Adv. 2015)***

Section-B JEE Main / AIEEE

1. Alum helps in purifying water by [2002]
   (a) forming Si complex with clay partiles
   (b) sulphate part which combines with the dirt and removes it
   (c) coagulaing the mud particles
   (d) making mud water soluble.

2. In XeF_2, XeF_4, XeF_6 the number of lone pairs on Xe are respectively [2002]
   (a) 2, 3, 1
   (b) 1, 2, 3
   (c) 4, 1, 2
   (d) 3, 2, 1.

3. In case of nitrogen, NCl_3 is possible but not NCl_5 while in case of phosphorous, PCl_3 as well as PCl_5 are possible. It is due to [2002]
   (a) availability of vacant *d* orbitals in P but not in N
   (b) lower electronegativity of P than N
   (c) lower tendency of H-bond formation in P than N
   (d) occurrence of P in solid while N in gaseous state at room temperature.

4. Which of the following statements is true? [2002]
   (a) HF is less polar than HBr
   (b) absolutely pure water does not contain any ions
   (c) chemical bond formation take place when forces of attraction overcome the forces of repulsion
   (d) in covalency transference of electron takes place.

5. Number of sigma bonds in P_4O_{10} is [2002]
   (a) 6
   (b) 7
   (c) 17
   (d) 16.

6. Oxidation number of Cl in $CaOCl_2$ (bleaching power) is:
   (a) zero, since it contains Cl_2 [2002]
   (b) – 1, since it contains Cl^-
   (c) + 1, since it contains ClO^-
   (d) + 1 and – 1 since it contains ClO^- and Cl^-

7. What may be expected to happen when phosphine gas is mixed with chlorine gas ? [2003]
   (a) PCl_3 and HCl are formed and the mixture warms up
   (b) PCl_5 and HCl are formed and the mixture cools down
   (c) PH_3 . Cl_2 is formed with warming up
   (d) The mixture only cools down

8. Concentrated hydrochloric acid when kept in open air sometimes produces a cloud of white fumes. The explanation for it is that [2003]
   (a) oxygen in air reacts with the emitted HCl gas to form a cloud of chlorine gas
   (b) strong affinity of HCl gas for moisture in air results in forming of droplets of liquid solution which appears like a cloudy smoke.
   (c) due to strong affinity for water, concentrated hydrochloric acid pulls moisture of air towards itself. This moisture forms droplets of water and hence the cloud.
   (d) concentrated hydrochloric acid emits strongly smelling HCl gas all the time.

9. Graphite is a soft solid lubricant extremely difficult to melt. The reason for this anomalous behaviour is that graphite
   (a) is an allotropic form of diamond [2003]
   (b) has molecules of variable molecular masses like polymers
   (c) has carbon atoms arranged in large plates of rings of strongly bound carbon atoms with weak interplate bonds
   (d) is a non-crystalline substance

10. Glass is a [2003]
   (a) super-cooled liquid
   (b) gel
   (c) polymeric mixture
   (d) micro-crystalline solid

11. Which one of the following substances has the highest proton affinity ? [2003]
   (a) H_2S
   (b) NH_3
   (c) PH_3
   (d) H_2O

12. For making good quality mirrors, plates of float glass are used. These are obtained by floating molten glass over a liquid metal which does not solidify before glass. The metal used can be [2003]
   (a) tin
   (b) sodium
   (c) magnesium
   (d) mercury

13. Which among the following factors is the most important in making fluorine the strongest oxidizing halogen ? [2004]
(a) Hydration enthalpy
(b) Ionization enthalpy
(c) Electron affinity
(d) Bond dissociation energy

14. Which one of the following statement regarding helium is **incorrect**? [2004]
(a) It is used to produce and sustain powerful superconducting magnets
(b) It is used as a cryogenic agent for carrying out experiments at low temperatures
(c) It is used to fill gas balloons instead of hydrogen because it is lighter and non-inflammable
(d) It is used in gas-cooled nuclear reactors

15. Beyllium and aluminium exhibit many properties which are similar. But, the two elements differ in [2004]
(a) forming covalent halides
(b) forming polymeric hydrides
(c) exhibiting maximum covalency in compounds
(d) exhibiting amphoteric nature in their oxides

16. Aluminium chloride exists as dimer, Al_2Cl_6 in solid state as well as in solution of non-polar solvents such as benzene. When dissolved in water, it gives [2004]
(a) $[Al(OH)_6]^{3-} + 3HCl$
(b) $[Al(H_2O)_6]^{3+} + 3Cl^-$
(c) $Al^{3+} + 3Cl^-$
(d) $Al_2O_3 + 6HCl$

17. Excess of KI reacts with $CuSO_4$ solution and then $Na_2S_2O_3$ solution is added to it. Which of the statements is **incorrect** for this reaction ? [2004]
(a) $Na_2S_2O_3$ is oxidised
(b) CuI_2 is formed
(c) Cu_2I_2 is formed
(d) Evolved I_2 is reduced

18. The number of hydrogen atom(s) attached to phosphorus atom in hypophosphorous acid is [2005]
(a) three (b) one
(c) two (d) zero

19. The correct order of the thermal stability of hydrogen halides (H – X) is [2005]
(a) HI > HCl < HF > HBr
(b) HCl < HF > HBr < HI
(c) HF > HCl < HBr > HI
(d) HI < HBr > HCl < HF

20. Heating an aqueous solution of aluminium chloride to dryness will give [2005]
(a) $Al(OH)Cl_2$
(b) Al_2O_3
(c) Al_2Cl_6
(d) $AlCl_3$

21. In silicon dioxide [2005]
(a) there are double bonds between silicon and oxygen atoms
(b) silicon atom is bonded to two oxygen atoms
(c) each silicon atom is surrounded by two oxygen atoms and each oxygen atom is bonded to two silicon atoms
(d) each silicon atom is surrounded by four oxygen atoms and each oxygen atom is bonded to two silicon atoms.

22. The structure of diborane (B_2H_6) contains [2005]
(a) four 2c-2e bonds and four 3c-2e bonds
(b) two 2c-2e bonds and two 3c-3e bonds
(c) two 2c-2e bonds and four 3c-2e bonds
(d) four 2c-2e bonds and two 3c-2e bonds

23. Which of the following statements is true? [2006]
(a) $HClO_4$ is a weaker acid than $HClO_3$
(b) HNO_3 is a stronger acid than HNO_2
(c) H_3PO_3 is a stronger acid than H_2SO_3
(d) In aqueous medium HF is a stronger acid than HCl

24. The increasing order of the first ionization enthalpies of the elements B, P, S and F (Lowest first) is [2006]
(a) B < P < S < F
(b) B < S < P < F
(c) F < S < P < B
(d) P < S < B < F

25. What products are expected from the disproportionation reaction of hypochlorous acid? [2006]
(a) HCl and Cl_2O
(b) HCl and $HClO_3$
(c) $HClO_3$ and Cl_2O
(d) $HClO_2$ and $HClO_4$

26. Identify the incorrect statement among the following. [2007]
(a) Br_2 reacts with hot and strong NaOH solution to give NaBr and H_2O.
(b) Ozone reacts with SO_2 to give SO_3.
(c) Silicon reacts with $NaOH_{(aq)}$ in the presence of air to give Na_2SiO_3 and H_2O.
(d) Cl_2 reacts with excess of NH_3 to give N_2 and HCl.

27. Regular use of the following fertilizers increases the acidity of soil? [2007]
(a) Ammonium sulphate
(b) Potassium nitrate
(c) Urea
(d) Superphosphate of lime.

28. Which one of the following is the correct statement?
(a) Boric acid is a protonic acid [2008]
(b) Beryllium exhibits coordination number of six
(c) Chlorides of both beryllium and aluminium have bridged chloride structures in solid phase
(d) $B_2H_6.2NH_3$ is known as 'inorganic benzene'

29. Which one of the following reactions of xenon compounds is not feasible? [2009]
(a) $3XeF_4 + 6H_2O \longrightarrow 2Xe + XeO_3 + 12HF + 1.5O_2$
(b) $2XeF_2 + 2H_2O \longrightarrow 2Xe + 4HF + O_2$
(c) $XeF_6 + RbF \longrightarrow Rb[XeF_7]$
(d) $XeO_3 + 6HF \longrightarrow XeF_6 + 3H_2O$

30. Which of the following statement is wrong? [2011]
(a) The stability of hydride increases from NH_3 to BiH_3 in group 15 of the periodic table.
(b) Nitrogen cannot form $d\pi - p\pi$ bond.
(c) Single N – N bond is weaker than the single P – P bond.
(d) N_2O_4 has two resonance structures.

31. Which of the following statements regarding sulphur is incorrect? [2011]
(a) S_2 molecule is paramagnetic.
(b) The vapour at 200°C consists mostly of S_8 rings.
(c) At 600°C the gas mainly consists of S_2 molecules.
(d) The oxidation state of sulphur is never less than +4 in its compounds.

32. Boron cannot form which one of the following anions? [2011]
(a) BF_6^{3-} (b) BH_4^-
(c) $B(OH)^-_4$ (d) BO_2^-

33. The molecule having smallest bond angle is : [2012]
(a) NCl_3 (b) $AsCl_3$
(c) $SbCl_3$ (d) PCl_3

34. Among the following oxoacids, the correct decreasing order of acid strength is: [JEE M 2014]
(a) $HOCl > HClO_2 > HClO_3 > HClO_4$
(b) $HClO_4 > HOCl > HClO_2 > HClO_3$
(c) $HClO_4 > HClO_3 > HClO_2 > HOCl$
(d) $HClO_2 > HClO_4 > HClO_3 > HOCl$

35. Which one of the following properties is **not** shown by NO? [JEE M 2014]
(a) It is diamagnetic in gaseous state
(b) It is neutral oxide
(c) It combines with oxygen to form nitrogen dioxide
(d) It's bond order is 2.5

36. The correct statement for the molecule, CsI_3 is: [JEE M 2014]
(a) It is a covalent molecule.
(b) It contains Cs^+ and I_3^- ions.
(c) It contains Cs^{3+} and I^- ions.
(d) It contains Cs^+, I^- and lattice I_2 molecule.

37. Which among the following is the most reactive ? [JEE M 2015]
(a) I_2
(b) ICl
(c) Cl_2
(d) Br_2

38. **Assertion:** Nitrogen and oxygen are the main components in the atmosphere but these do not react to form oxides of nitrogen.
Reason: The reaction between nitrogen and oxygen requires high temperature. [JEE M 2015]
(a) The assertion is incorrect, but the reason is correct
(b) Both the assertion and reason are incorrect
(c) Both assertion and reason are correct, and the reason is the correct explanation for the assertion
(d) Both assertion and reason are correct, but the reason is not the correct explanation for the assertion

39. Which one has the highest boiling point ? [JEE M 2015]
(a) Kr
(b) Xe
(c) He
(d) Ne

40. The pair in which phosphorous atoms have a formal oxidation state of + 3 is : [JEE M 2016]
(a) Orthophosphorous and hypophosphoric acids
(b) Pyrophosphorous and pyrophosphoric acids
(c) Orthophosphorous and pyrophosphorous acids
(d) Pyrophosphorous and hypophosphoric acids

41. The reaction of zinc with dilute and concentrated nitric acid, respectively, produces: [JEE M 2016]
(a) NO and N_2O
(b) NO_2 and N_2O
(c) N_2O and NO_2
(d) NO_2 and NO

16 The p-Block Elements

Section-A : JEE Advanced/ IIT-JEE

A

1. –3 2. $NaIO_3$ 3. HF 4. KI_3 5. sodium hydroxide
6. white/ yellow 7. hypobromous, bromide 8. cross-linking 9. two
10. silicones 11. 4 12. Nitric oxide 13. trialkylchlorosilanol 14. fullerene
15. I_3^- complex ion 16. glass 17. inert-pair effect

B

1. F 2. F 3. F 4. T 5. F 6. T 7. F 8. T 9. F 10. T
11. T 12. T 13. F

C

1. (c) 2. (b) 3. (a) 4. (c) 5. (a) 6. (d) 7. (c) 8. (d) 9. (d) 10. (c)
11. (b) 12. (b) 13. (a) 14. (c) 15. (b) 16. (b) 17. (d) 18. (a) 19. (b) 20. (d)
21. (c) 22. (b) 23. (d) 24. (c) 25. (c) 26. (b) 27. (d) 28. (a) 29. (b) 30. (c)
31. (d) 32. (c) 33. (b) 34. (c) 35. (c) 36. (c) 37. (d) 38. (c) 39. (a) 40. (a)
41. (c) 42. (b) 43. (c) 44. (b) 45. (b) 46. (c) 47. (c) 48. (b) 49. (b) 50. (b)
51. (d) 52. (b) 53. (b) 54. (d) 55. (b) 56. (c) 57. (d) 58. (b) 59. (a) 60. (c)
61. (b) 62. (a)

D

1. (a, b) 2. (a, d) 3. (a, d) 4. (b, c) 5. (b) 6. (a, b, d) 7. (a, c, d) 8. (c) 9. (a,b) 10. (a,b,c)
11. (a, c, d) 12. (b,d) 13. (a, c, d) 14. (a, b, c) 15. (b, d) 16. (b, c) 17. (b) 18. (a, c, d) 19. (b, d)

E

14. (i) $HI < HBr < HCl < HF$, (ii) $HOCl < HOClO < HOClO_2 < HOClO_3$
(iii) $SiO_2 < CO_2 < N_2O_5 < SO_3$, (iv) $CCl_4 < MgCl_2 < AlCl_3 < SiCl_4 < PCl_5$
17. [A]-PbO, [B]-heat in the absence of air
19. 12, 4
22. M= As, N= AsH_3
27. vanadium pentoxide
28. $Ca(OH)_2, NH_4HCO_3, Na_2CO_3, NH_4Cl, CaCl_2$
A B C D E
32. BCl_3 or BBr_3, B_2H_6
36. O.N. of Pb in PbO is +2
37. $NaHSO_3$ (OS = +4), Na_2SO_3 (OS = +4), $Na_2S_2O_3$ (OS = –2), $Na_2S_4O_6$ (OS = +2.5)
A B C D
39. 1008 g
41. Conc. H_2SO_4, Br_2, NO_2^+, TNT
A B C D

F

1. (A)-t; (B)-s; (C)-v; (D)-u
2. (A)-q; (B)-s; (C)-p; (D)-r
3. (A)-p, r, t; (B)-s, t ; (C)-p, q, r ; (D)-p, r, s
4. (d)

G 1. (a) 2. (c) 3. (a) 4. (c) 5. (c) 6. (b) 7. (a) 8. (c) 9. (a) 10. (a)

H 1. (b) 2. (c) 3. (a) 4. (c) 5. (c) 6. (a) 7. (c)

I 1. 6 2. 3 3. 5 4. 4 5. 8 6. 6

Section-B : JEE Main/ AIEEE

1. (c) 2. (d) 3. (a) 4. (c) 5. (d) 6. (d) 7. (d) 8. (a) 9. (c) 10. (a)
11. (b) 12. (d) 13. (d) 14. (c) 15. (c) 16. (b) 17. (b) 18. (c) 19. (c) 20. (b)
21. (d) 22. (d) 23. (b) 24. (b) 25. (b) 26. (d) 27. (a) 28. (c) 29. (d) 30. (a)
31. (d) 32. (a) 33. (c) 34. (c) 35. (a) 36. (b) 37. (b) 38. (c) 39. (b) 40. (c) 41. (c)

Section-A JEE Advanced/ IIT-JEE

A. Fill in the Blanks

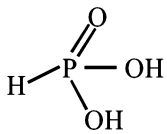
1. **–3;**
2. **$NaIO_3$**

$$3I_2 + 6NaOH \xrightarrow[(hot)]{} 5NaI + NaIO_3 + 3H_2O$$

3. **HF;** HF is the weakest of the three, because the ionisation (*i.e.* acidic character) of HX is a multistep process and when its ΔH, heat of ionisation, is calculated it comes out to be the minimum. This is due to the strong H – F bond, large heat of hydration (because of H-bonding) and low value of electron affinity of F-atom.
4. **KI_3;** complexes are more soluble in water as compared to normal salts. [$KI + I_2 \longrightarrow KI_3$]
5. **sodium hydroxide;**

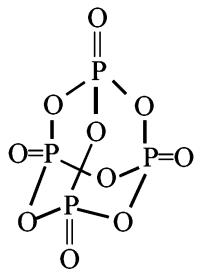
$$Al + 2NaOH + 2H_2O \longrightarrow 2NaAlO_2 + 3H_2$$

6. **white/ yellow; NOTE :** In white phosphorus, each phosphorus atom is linked to the other three atoms by covelent bonds. PPP bond angle is 60°, due to which the molecule remains under strain and hence is active in nature.
7. **Hypobromous; bromite.** $HBrO \rightleftharpoons H^+ + BrO^-$
8. **cross-linking;**
9. **two;**



[It contains two replaceable hydrogens.]

10. **Silicones;**
11. **four.**



In each P atom is linked to 4 oxygen atoms

12. **Nitric oxide. [NO]**
The mixture containing SO_2, air and nitric oxide, when treated with steam, sulphuric acid is formed.

$$2SO_2 + \underbrace{O_2 + 2H_2O}_{\text{Air}} + \underset{\text{(Catalyst)}}{[NO]} \rightarrow 2H_2SO_4 + [NO]$$

13. **Trialkylchlorosilanol;** The hydrolysis of R_3SiCl, yields $R_3Si(OH)$ which condenses to give $R_3Si-O-SiR_3$

$$R_3SiO-\boxed{H+H-O}-SiR_3 \longrightarrow R_3-Si-O-Si-R_3$$

14. **Fullerene**
15. **I_3^- complex ion;** $I_2 + I^- \longrightarrow I_3^-$
16. **glass**
17. **inert-pair effect ;** When ns^2 electrons of outermost shell do not participate in bonding it is called inert pair and the effect is called inert pair effect.

B. True/False

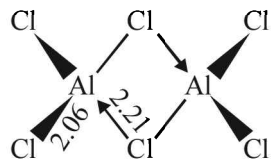
1. **False :** Red phosphorus is ***polymeric substance***. It exist as chains of P_4 tetrahedra linked together. Therefore, it is less volatile than white phosphorus.
2. **False :** PbO_2 is a dioxide and it *does not* give hydrogen peroxide when it reacts with a dilute acid.

$$PbO_2 + 4HCl \rightarrow PbCl_2 + Cl_2 + 2H_2O$$

3. **False :** CCl_4 gives phosgene with superheated steam

$$CCl_4 + H_2O \rightarrow COCl_2 + 2HCl$$

4. **True :** $Fe + 2HCl \rightarrow FeCl_2 + H_2$ [In $FeCl_2$, Fe is in +2 state.]
5. **False :** Since halogens have high electron affinities, they easily pick up electrons from other substances. Hence halogens are *oxidising agents*. The oxidising power decreases from fluorine to iodine. Since fluorine is the strongest oxidising agent it will oxidise any of the other halide ions in solution or when dry. Similarly, Cl_2 will displace Br^- and I^- ions from their solutions and Br_2 will displace I^- ions.
NOTE : In general, *a halogen of low atomic number will oxidise the halide ion of higher atomic number.*
6. **True :**
NOTE : The central element in the metal hydrides of group 15 elements is although in sp^3 hybrid state, the H – M – H bond angle is less than the normal tetrahedral bond angle of 109° 28'; *e.g.* the bond angle, H – N – H in NH_3 is 106° 45'. This is due to greater repulsion between a lone pair and a bond pair of electrons than between the two bond pairs of electrons.
The decrease in bond angle from 106° 45' in ammonia to about 90° in AsH_3 can be explained by the fact that in the latter case sp^3 hybridisation becomes less and less distinct with the increasing size of their electron clouds, *i.e.*, pure *p* orbitals (instaed of sp^3 hybrid orbitals) are used for M – H bonding and the lone pair of electrons is present in spherical *s*-orbital.
7. **False :** because of its high thermal stability. CCl_4 is most stable as compared to other tetrachlorides of the group.
8. **True :** Graphite is better lubricant on the moon than on the earth because of lack of gravitation pull on the moon, where friction is already less than earth.
9. **False :** The structure of Al_2Cl_6 is as under :



Structure of Al_2Cl_2

Bond distance between aluminium-chlorine bond forming bridge is greater (2.21 Å) than the distance between aluminium-chlorine bond present in the end (2.06 Å).

10. **True :** The molecule of NO has eleven valence electrons (5 due to N and 6 due to O). It is impossible for all of them to be paired, hence the nitric oxide molecule contains an *odd electron* which makes gaseous nitric oxide *paramagnetic*.

$$:N \overset{\bullet\bullet\bullet}{=\!=} O:$$

NOTE : In the liquid and solid states, nitric oxide is polymerised to a dimer which is *diamagnetic*.

11. **True :** In diamond, each carbon atom is in sp^3 hybridised state and is linked to four other neighbouring carbon atoms held at the corners of a regular tetrahedron by covalent bonds. Owing to very strong covalent bonds by which the atoms are held together, **diamond is the hardest substance known**. Graphite has a two dimensional sheet like structure and carbon in sp^2 hybridised state is attached to three other carbon atoms by three σ bonds forming a hexagonal planar structure. Due to wide separation and weak interlayer bonds, the two adjacent layers can easily slide over each other; hence **graphite is soft**.

12. **True :** The property of catenation in carbon is due to the fact that in carbon atom, the number of valence electrons (4) is equal to the number of valence orbitals (one 2*s* + three 2*p*). Hence carbon in the tetravalent state is fully saturated, *i.e.*, it has neither any vacant orbital nor any lone pair of electrons on its atom due to which the C – C bond is extremely stable.

NOTE : The reason for greater tendency of carbon for catenation than silicon may further be explained by the fact that the C – C bond energy is approximately of the same magnitude as the energies of the bond between C and other elements. On the other hand, the Si – Si bond is weaker than the bonds between silicon and other elements.

13. **False :** None amongst, HBr and HI, HI exhibit hydrogen bonding. HI is a stronger acid than HBr because of its higher dissociation constant, K_a. HI has a stronger tendency to release protons to water molecules and hence is a stronger acid.

C. MCQs with One Correct Answer

1. **(c)** $\underset{\text{Nitric oxide (colourless)}}{NO} + O_2 \longrightarrow \underset{\text{Nitrogen dioxide (reddish brown coloured)}}{NO_2}$

2. **(b)** Temporary hardness of water is due to presence of bicarbonates of Ca and Mg and it is removed by adding $Ca(OH)_2$ to hard water and precipitating these soluble bicarbonates in the form of insoluble salts.

$$Ca(HCO_3)_2 \xrightarrow{\Delta} CaCO_3\downarrow + CO_2\uparrow + H_2O$$

$$Mg(HCO_3)_2 \xrightarrow{\Delta} Mg(OH)_2\downarrow + 2CO_2\uparrow$$

3. **(a)** Due to highest bond dissociation energy.

4. **(c)** $\overset{0}{P_4} + 3NaOH + 3H_2O \longrightarrow \overset{+3}{PH_3} + 3NaH_2\overset{-1}{P}O_2$

It is redox reaction.

(i) Oxidation number increases during oxidation reaction and decreases during reduction reaction.

(ii) In a neutralisation reaction acids and bases reacts together to form salt and water.

5. **(a)** $\because$ Cl_2 is more reactive than bromine.

6. **(d)** All are colourless gases.

7. **(c)**

8. **(d)** None; it reacts with all given compounds. It forms addition compounds with them.

It can be dried over any metal oxide.

9. **(d)** HI and HBr (in that order) are the strongest reducing hydracids and hence they reduce H_2SO_4. HCl is quite stable and hence is oxidised by strong oxidising agent like $KMnO_4$. HF is not a reducing agent. In the smallest F^- ion, the electron which is to be removed during oxidation is closest to the nucleus and therefore most difficult to be removed. Therefore, HF is a poor reducing agent.

10. **(c)** $AlCl_3$ exists as a dimer (Al_2Cl_6). It is a strong Lewis acid as it has an incomplete octet and has a tendency to gain electrons. $AlCl_3$ undergoes hydrolysis easily and forms an acidic solution.

$$AlCl_3 + 3H_2O \rightarrow Al(OH)_3 + 3HCl$$

Option (c) is true that $AlCl_3$ sublimes at 100°C under vacuum.

$AlCl_3$ is a **Lewis acid**.

11. **(b)** Graphite shows moderate electrical conductivity due to the presence of unpaired or free fourth valence electron on each carbon atom.

12. **(b)** Bleaching action of chlorine is only in presence of moisture where nascent oxygen is displaced from H_2O.

$$Cl_2 + H_2O \rightarrow HCl + HClO \text{ (unstable)}$$

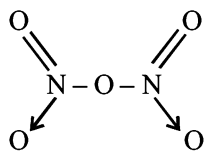
$$HClO \rightarrow HCl + |O|$$

13. **(a)** Only nitrates of heavy metals and lithium decompose on heating to produce NO_2.

14. **(c)** SO_2 is highly soluble in water and therefore cannot be collected over water.

15. **(b)** $2HgO \xrightarrow{\Delta} 2Hg + O_2$

16. **(b)**



The structure clearly shows the presence of covalent and co-ordinate bonds.

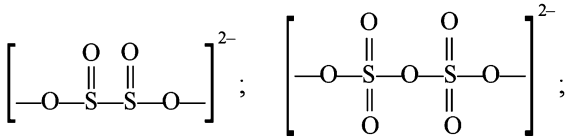
17. **(d)** NO_2 is reddish brown coloured gas. Rest of the oxides are colourless.

18. **(a)** Least basic trihalogen of nitrogen is NF_3 because of the highest electronegativity of fluorine.

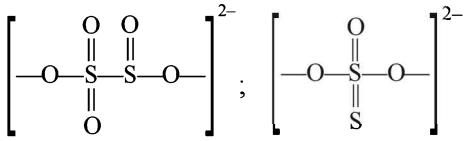
19. **(b)** Chlorine is stronger oxidising agent than bromine therefore, chlorine water will liberate bromine from KBr solution.

$$2KBr + Cl_2 \rightarrow 2KCl + Br_2$$

20. (d) In $S_2O_7^{2-}$ there is an S–O–S bond unlike in other. So S–S bond is absent as can be seen from the structure drawn.



$S_2O_4^{2-}$ $S_2O_7^{2-}$



$S_2O_5^{2-}$ $S_2O_3^{2-}$

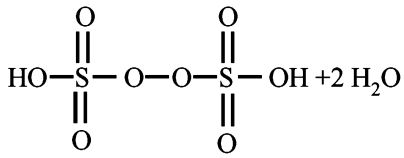
21. (c) In P_4O_{10}, each P atom is linked to 4 oxygen atoms as can be confirmed by its structure. It is linked to three oxygen atoms by single bond and with one oxygen atom by double bond. [For structure refer to Q.11 of Section A]

22. (b) HBr is not prepared by heating NaBr with conc. H_2SO_4 because HBr is a strong reducing agent and reduce H_2SO_4 to SO_2 and is itself oxidised to bromine.

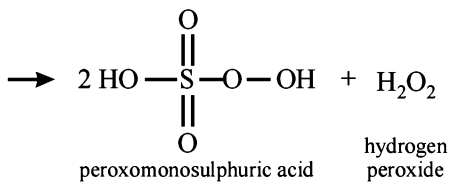
$NaBr + H_2SO_4 \longrightarrow NaHSO_4 + HBr$

$H_2SO_4 + 2HBr \longrightarrow SO_2 + Br_2 + 2H_2O$

23. (d)



peroxodisulphuric acid



peroxomonosulphuric acid hydrogen peroxide

24. (c) $CsBr_3$ may be represented as $Cs^+Br_3^-$

25. (c) $KF + HF \rightarrow KHF_2 \rightleftharpoons K^+ + (HF_2)^-$

26. (b) $Na_2SO_3 + S \xrightarrow[\text{medium}]{\text{In alkaline}} Na_2S_2O_3$

27. (d) Due to inert pair effect.

28. (a) CO is an example of neutral oxide.

29. (b) The species called as pseudohalide ions are these are monovalent and made by electronegative atoms. They possess properties similar to halide ion. The corresponding dimers of these pseudohalide ions are called pseudohalogens. $RCOO^-$ is **not** is pseudohalide.

30. (c) $Ca_3P_2 + 6H_2O \rightarrow 3Ca(OH)_2 + 2PH_3$; i.e 2 moles of phosphine are produced.

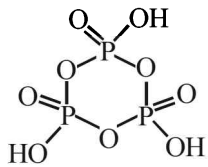
31. (d) $(NH_4)_2Cr_2O_7 \rightarrow N_2 + Cr_2O_3 + 4H_2O$

32. (c) Al_2O_3 is electrolyte, while Na_3AlF_6 is used to decrease the melting point of Al_2O_3 and to increase the conductivity.

33. (b) In BCl_3, $H = \frac{1}{2}(3+3+0-0) = 3$; sp^2 hybridization (bond angle = 120°) similarly PCl_3 $AsCl_3$ and $BiCl_3$ are found to have sp^3 hybridized central atom with one lone pair of electrons on the central atom. The bond angle ≤ 109°28′, since the central atoms belong to the same group, the bond angle of the chlorides decreases as we go down the group. Thus the order of bond angle is, $BCl_3 > PCl_3 > AsCl_3 > BiCl_3$.

34. (c) Cryolite reduces the melting temperature.

35. (c) In cyclic metaphosporic acid number of P–O–P bonds is three.



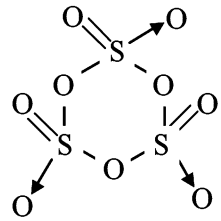
36. (c) NH_3 does not react with CaO while other reacts with NH_3

$2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$

$P_4O_{10} + 12NH_3 \rightarrow 4(NH_4)_3PO_4 + 6H_2O$

$CaCl_2 + 8H_2O \rightarrow CaCl_2.8H_2O$

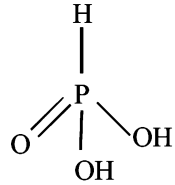
37. (d) In sulphur trioxide trimer S_3O_9 (also called γ–sulphur trioxide) two sulphur atoms are linked to each other via O atoms, hence there is no S –S bond.



38. (c) $2Ca^{2+} + Na_2[Na_4(PO_3)_6]$

$\longrightarrow 4Na^+ + Na_2[Ca_2(PO_3)_6]$ (water soluble)

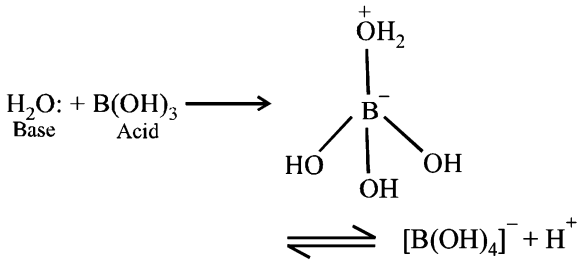
39. (a) The structure of H_3PO_3 is as follows: There are only two –OH groups and hence **dibasic**. The oxidation number of P in this acid is +3. Whereas P can have +5 oxidation state also. Therefore, H_3PO_3 can be oxidised which means H_3PO_3 is a **reducing agent**.



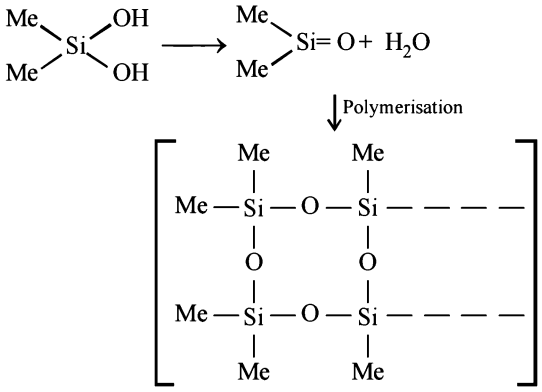
40. (a) The central boron atom in boric acid, H_3BO_3 is electron-**deficient.**

NOTE : Boric acid is a Lewis acid with one p–orbital vacant. There is no **d-orbital of suitable energy in boron atom. So, it can accommodate only**

one additional electron pair in its outermost shell.



41. **(c)** **TIPS/FORMULAE:**
It appears at the first sight that Me_2SiCl_2 on hydrolysis will produce $Me_2Si(OH)_2$ which ultimately upon loss of water, will form $Me_2Si=O$.
But silicon atom, because of its very large size in comparison to oxygen, is unable to form π-bond. Thus, the product of hydrolysis is polymeric in nature.



42. **(b)** In $XeOF_4$, Xenon is sp^3d^2 hybridised and has one lone pair.

43. **(c)** Among oxyacids of sulphur, only Caro's acid (H_2SO_5) and Marshall's acid ($H_2S_2O_8$) have the O – O linkage.

44. **(b)** Tin can be extracted only by carbon reduction method, while lead can be extracted by self as well as carbon reduction method.

$$SnO_2 + C \longrightarrow Sn + CO_2 \uparrow$$

$$PbS + 2PbO \longrightarrow 3PbO + SO_2$$

45. **(b)** Two dimensional sheet structures are formed when three oxygen atoms of each $[SiO_4]^{4-}$ tetrahedral are shared.

46. **(c)** The ignition temperature of black phosphorus is highest among all its allotropes, hence is most stable.

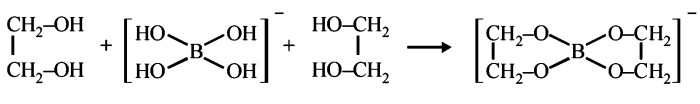
47. **(c)** In $KMnO_4$ manganese is already present in its highest possible oxidation state i.e. +7.So no further oxidation is possible.

48. **(b)** $NO(g) + NO_2(g) \xrightarrow{-30°C} \underset{\text{(blue liquid)}}{N_2O_3}$

49. **(b)** PbO_2 is a powerful oxidizing agent and liberate O_2 when treated with acids.

$$2PbO_2 + 4HNO_3 \longrightarrow 2Pb(NO_3)_2 + 2H_2O + O_2 \uparrow$$

50. **(b)** *cis*-1,2-diol forms chelated complex ion with the product, $[B(OH)_4]^-$ causing the reaction to proceed in forward direction.



Stable chelated complex ion

51. **(d)** In P_4, the P–P linkage is formed by sp^3–sp^3 hybridised orbital overlapping. So the percentage of π-character will be 75%.

52. **(b)** The following reaction occurs

$$Na_2S_2O_3 + 4Cl_2 + 5H_2O \longrightarrow 2\,NaHSO_4 + 8HCl.$$

53. **(b)** $P_4 + 3O_2 \xrightarrow{\text{in presence of } N_2} P_4O_6$

Here N_2 acts as a diluent and thus retards further oxidation. Reaction of P_4 under other three conditions.

(a) $P_4 + 3O_2 \longrightarrow P_4O_6 \xrightarrow{2O_2} P_4O_{10}$

(c) In moist air, P_4O_6 is hydrolysed to form H_3PO_3

$$P_4O_6 + 6H_2O \longrightarrow 4H_3PO_3$$

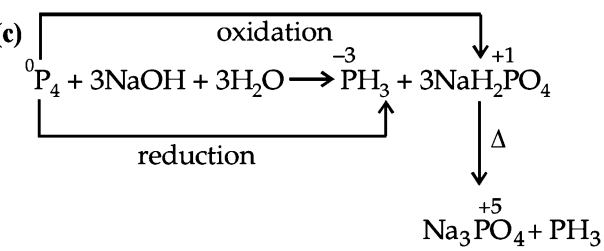
(d) In presence of NaOH,

$$P_4 + 3OH^- + 3H_2O \longrightarrow PH_3 + 3H_2PO_2^-$$

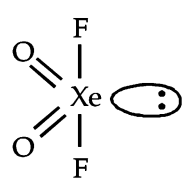
54. **(d)** $Ba(N_3)_2 \longrightarrow Ba + 3N_2$

55. **(b)** $\overset{+5}{H}\overset{+2}{N}O_3, \overset{+2}{N}O, \overset{0}{N_2}, \overset{-3}{N}H_4Cl$

56. **(c)**



57. **(d)** XeO_2F_2 has trigonal bipyramidal geometry, due to presence of lone pair of electrons on equitorial position, its shape is *see-saw*.

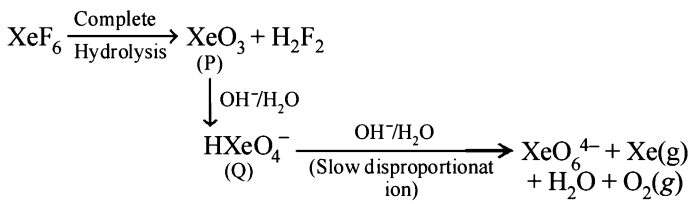


58. **(b)** The slow decomposition of HNO_3 is represented by the eqn.

$$\underset{\text{(yellow-brown)}}{4HNO_3 \rightarrow 4NO_2 + 2H_2O + O_2}$$

59. **(a)** $\underset{\text{white phosphorus}}{P_4} + 8SOCl_2 \rightarrow 4PCl_3 + 4SO_2 + 2S_2Cl_2$

60. **(c)**



61. **(b)** Atomic radii increases on moving down a group. However due to poor shielding effect of *d* orbit, atomic radius of Ga is smaller than Al (**anomaly**). Thus the correct order is Ga < Al < In < Tl

62. **(a)**

$$S_2O_3^{2-} \xrightarrow{Ag^+} \underset{\text{(X)}\\\text{clear solution}}{\left[Ag(S_2O_3)_2\right]^{3-}} \xrightarrow{Ag^+} \underset{\text{(Y)}\\\text{white precipitate}}{Ag_2S_2O_3\downarrow} \xrightarrow{\text{on standing}} \underset{\text{(Z)}\\\text{black precipitate}}{Ag_2S\downarrow}$$

So, X, Y and Z are $[Ag(S_2O_3)_2]^{3-}$, $Ag_2S_2O_3$ and Ag_2S respectively.

D. MCQs with One or More Than One Correct

1. **(a, b)** Because of high melting point (2050°C), pure alumina cannot be electrolysed. Hence a mixture of alumina, cryolite (m.p. 1000°C) and calcium fluoride (to lower the temperature of the melt) is electrolysed at about 900°C.
NOTE : The function of cryolite is to increase the electrical conductivity of the electrolyte, and to lower the temperature of the melt.

2. **(a, d)** $NH_4NO_3 \longrightarrow N_2O + 2H_2O$
$NH_2OH.HCl + NaNO_2 \longrightarrow N_2O + NaCl + 2H_2O$

3. **(a, d)** NH_3 and CF_2Cl_2 (freon-12) are used as refrigerants.

4. **(b, c)** To make the fused mixture very conducting and to reduce the temperature of the melt.

5. **(b)** Silicon is used in solar cells.

6. **(a,b,d)** Sodium nitrate on decomposition upto 500°C gives $NaNO_2$ and oxygen.

$$2NaNO_3 \xrightarrow{\Delta} 2NaNO_2 + O_2\uparrow$$

While at higher temperature (i.e. above to 800°C), $NaNO_2$ further decomposes into Na_2O, N_2 and O_2.

$$2NaNO_2 \xrightarrow{800°C} Na_2O + 3/2O_2\uparrow + N_2\uparrow$$

7. **(a,c,d)** The four atoms in a P_4 molecule are situated at the corners of a tetrahedron. There are six P - P single bonds with PPP bond angle equal to 60°. Each phosphorus has a lone pair of electrons.

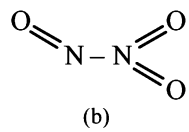
8. **(c)** $2NH_3 + OCl^- \rightarrow NH_2.NH_2 + H_2O + Cl^-$

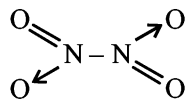
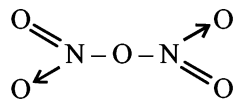
9. **(a,b)** When ammonium salt NH_4NO_3 or NH_4NO_2 (ammonium salts are colourless) is boiled with excess of NaOH, ammonia (NH_3) gas is evolved as follows:
$NH_4NO_2 + NaOH \longrightarrow NaNO_2 + NH_3 + H_2O$
$NH_4NO_3 + NaOH \longrightarrow NaNO_3 + NH_3 + H_2O$
The NH_3 gas evolved is non-flammable gas.
When the gas evolution ceases we are left with $NaNO_2$ or $NaNO_3$ in solution.
These salts get reduced when Zn is added to this solution containing salt ($NaNO_2$ or $NaNO_3$) and excess NaOH and NH_3 gas is evolve.

$$NaNO_2 + 6(H) \xrightarrow{Zn/NaOH} NaOH + NH_3 + H_2O$$

$$NaNO_3 + 8(H) \xrightarrow{Zn/NaOH} NaOH + NH_3 + 2H_2O$$

Thus the colourless salt [H] is either NH_4NO_2 or NH_4NO_3.
Thus (a) and (b) are correct answers.
[**NOTE :** NaCl formed has no reaction with NaOH]

10. **(a,b,c)** $\underset{\text{(a)}}{N \equiv N \rightarrow O}$  (b)

 (c)  (d)

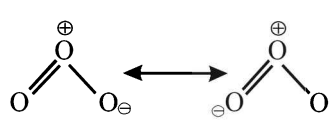
11. **(a, c, d)**

$$HX + AgNO_3 \longrightarrow AgX\downarrow + HNO_3 \ (X = Cl, Br, I)$$

$$AgX + 2Na_2S_2O_3 \longrightarrow Na_3[Ag(S_2O_3)_2] + NaX$$

12. **(b, d)**
(a) Diamond is harder than graphite.
(b) Graphite is good conductor of electricity as each carbon is attached to three C-atoms leaving one valency free, which is responsible for electrical conduction, while in diamond, all the four valencies of carbon are satisfied, hence insulator.
(c) Diamond is better thermal conductor than graphite. Whereas electrical conduction is due to availability of free electrons; thermal conduction is due to transfer of thermal vibrations from atom to atom. A compact and precisely aligned crystal like diamond thus facilitates fast movement of heat.
(d) In graphite, C – C bond acquires double bond character, hence higher bond order than in diamond.

13. **(a, c, d)**



Ozone is diamagnetic in nature (due to presence of paired electron) and both the O – O bond length are equal. It has a bent structure.

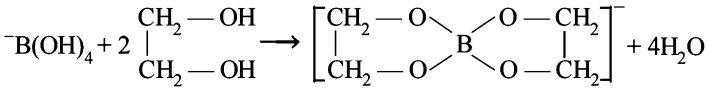
14. **(a, b, d)** Balanced chemical equation is

$$\overset{-1}{6I^-} + ClO_3^- + 6H_2SO_4 \rightarrow Cl^- + 6HSO_4^- + 3\overset{0}{I_2} + 3H_2O$$

15. **(b, d)** H_3BO_3 does not undergo self ionization. However, it acts as a weak acid in water (hence it is a weak electrolyte in water).

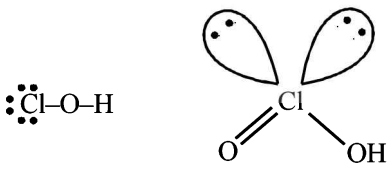
$$H_3BO_3 + H_2O \rightarrow B(OH)_4^- + H^+$$

Addition of *cis*-diols (e.g., ethylene glycol) to aqueous solution of orthoboric acid leads to complex formation, thus acidity of aqueous solution of orthoboric acid is increased.

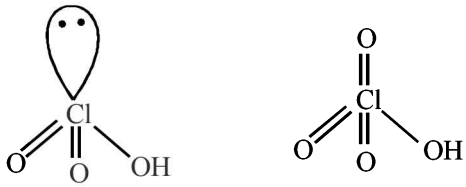


It arranges to planner sheets due to H-bonding.

16. (b, c)



(i) (ii)

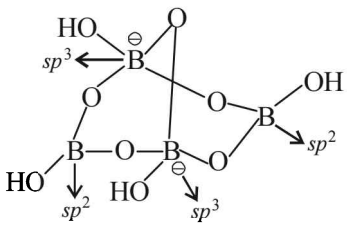


(iii) (iv)

Number of Cl = O bonds in (ii) and (iii) together is 3
Number of lone pairs on Cl in (ii) and (iii) together is 3
Hybridisation of Cl in all the four is sp^3
Strongest acid is $HClO_4$ (iv)

17. (b) $(CH_3)_2SiCl_2$ form linear polymer on hydrolysis and $(CH_3)_3SiCl$ is a chain terminator.

18. (a, c, d) Structure of borax



Correct formula of borax is $Na_2[B_4O_5(OH)_4].8H_2O$

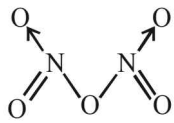
(A) Borax has tetranuclear. $[B_4O_5(OH)_4]^{2-}$ unit
(B) Only two 'B' atom lie in same plane
(C) two Boron are sp^2 and two are sp^3 hybridised.
(D) one terminal hydroxide per boran atom.

19. (b, d)

$$P_4O_{10} + 4HNO_3 \xrightarrow{\text{dehydration of } HNO_3} \underset{\text{(required product)}}{4(HPO_3)} + 2N_2O_5$$

(A) $P_4 + 20HNO_3 \longrightarrow 4H_3PO_4 + 20NO_2\uparrow + 4H_2O$

(B) N_2O_5 is diamagnetic in nature

(C) $N_2O_5 \rightarrow$ 

N_2O_5 contains one N–O–N bond not N–N bond.

(D) $Na + N_2O_5 \rightarrow NaNO_3 + NO_2\uparrow$ (Brown gas)

E. Subjective Problems

1. (i) HBr is a reducing agent and it reduces H_2SO_4 to SO_2.
(ii) Acids turn blue litmus red, so HClO also turns blue litmus red. The colour of litmus is decolourised because HClO is also a strong oxidising agent.

2. (i) $\underset{\text{Alumina}}{Al_2O_3} + 3C + 3Cl_2 \longrightarrow \underset{\text{Aluminium chloride}}{2AlCl_3} + 3CO$

(ii) $\underset{\text{Slaked lime}}{Ca(OH)_2} + Cl_2 \longrightarrow \underset{\text{bleaching powder}}{CaOCl_2} + H_2O$

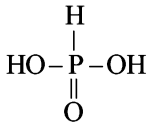
(iii) $\underset{\text{Cassiterite}}{SnO_2} + 2C \longrightarrow \underset{\text{Tin}}{Sn} + 2CO$

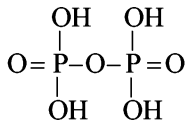
(iv) $\underset{\text{Sodium chloride}}{2NaCl} + MnO_2 + 2H_2SO_4 \xrightarrow{\Delta} Na_2SO_4 + MnSO_4 + 2H_2O + Cl_2$

(v) $3Cu + \underset{\text{Nitric acid}}{8HNO_3} \longrightarrow \underset{\text{Nitric oxide}}{2NO} + 3Cu(NO_3)_2 + 4H_2O$

3. (i) $Sn + 4HNO_3 \longrightarrow \underset{\text{Metastanic acid}}{H_2SnO_3} + 4NO_2 + H_2O$

(ii) $2Al + 2NaOH + 2H_2O \longrightarrow \underset{\text{Sod. aluminate}}{2NaAlO_2} + 3H_2$

4. (*i*) 

(*ii*) 

5. (*i*) $HCO_3^- + Al^{3+} \rightarrow Al(OH)_3 + CO_3^{2-}$

(*ii*) $AlBr_3 + K_2Cr_2O_7 + H_3PO_4 \rightarrow K_3PO_4 + AlPO_4 + H_2O + Br_2 + Cr^{3+}$

6. (*i*) Carbon exists in various allotropic forms like diamond, graphite, coal, etc. Diamond consists of a three-dimensional structure of sp^3 hybridised carbon atoms bonded through very strong covalent bonds. It makes it hard and useful as an abrasive.
Graphite, on the other hand, is made up of a two dimensional sheet like structure made of sp^2 hybridised carbon atoms. These layers of carbon atoms are held together by relatively weak van der Waal's forces and can, therefore, slip over one another imparting lubricating properties to graphite.

(*ii*) Sulphur consists of S_8 rings held together by weak van der Waal's forces. As sulphur melts at 119°C, these van der Waal's forces are overcome and S_8 rings slip and roll over one another giving rise to a clear mobile liquid. Above 160°C, the S_8 rings begin to open up and form long chains which gets tangled with each other, thereby gradually increasing the viscosity.

(*iii*) **NOTE :** HI cannot be prepared by heating hydrogen iodide with conc. H_2SO_4 because it is a strong reducing agent and reduces H_2SO_4 to SO_2 and is itself oxidised to iodine.

$H_2SO_4 + 2HI \rightarrow SO_2 + I_2 + 2H_2O$

Hence HI is prepared by heating iodides with conc. phosphoric acid.

$3KI + H_3PO_4 \rightarrow K_3PO_4 + 3HI$

(*iv*) In H_3PO_4 and H_3PO_3 the P atom is attached to 3 and 2 OH groups respectively. The H atom of these P – OH bonds are ionisable. This clearly shows that H_3PO_4 is tribasic and H_3PO_3 is dibasic.

(*v*) Liquor ammonia possesses high vapour pressure at room temperature and thus before opening a bottle of liquor ammonia, it should be cooled to lower the pressure of NH_3 inside the bottle, otherwise NH_3 will bump out of the bottle.

(*vi*) Solid CO_2 is technically known as **dry ice** because it sumblimes without leaving any stain on surface.

(*vii*) Anhydrous HCl, being a non-polar covalent compound, is a bad conductor however an aqueous solution of HCl is ionised (Fajan's rule) to give H^+ and Cl^- ions and is a good conductor.

(*viii*) In graphite, out of four valence electrons, only three form covalent bonds (sp^2 hybridisation) with three other carbon atoms. This forms hexagonal rings as sheets of one atom thickness. These sheets are held together by weak attractive forces. One electron of each carbon atom is free and this enables these thin sheets to slide over one another. For this reason graphite is a soft material with lubricating properties.

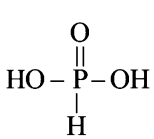
(*ix*) The standard reduction potential of fluorine is highest and thus it cannot be oxidized by any reagent.

$$\left(\frac{1}{2}\right) F_2 + e \longrightarrow F^-; \quad E^\circ_{RP} = \text{maximum}$$

(*x*) The mixture of N_2H_4 and H_2O_2 (in presence of Cu (II) catalyst) is used as a rocket propellant because the reaction is highly exothermic and large volume of gases are evolved, which can propel a rocket.

$$\underset{\text{Hydrazine}}{N_2H_4} + \underset{\text{Hydrogen peroxide}}{2H_2O_2} \xrightarrow{Cu(II)} N_2(g)\uparrow + 4H_2O(g)\uparrow$$

(*xi*) Orthophosphorus acid is a dibasic acid as it has 2–OH groups in its formula :



(*xii*) In $MgCl_2$, Mg is *sp* hybridised while in $SnCl_2$, Sn is sp^2 hybridised (hence the molecule is angular).

(*xiii*) **NOTE :** Oxygen is the 2nd most electronegative element after the fluorine and thus invariably show negative oxidation state.

Further more, it has $2s^2 2p^4$ configuration and thus requires only two electrons to complete its octet to show –2 oxidation state. Although sulphur also possess ns^2np^4 configuration but due to availability of d-orbitals in their outer most shell –2, +2, +4, +6 oxidation state are also shown. Oxygen, however, shows only –2 oxidation state due to non-availability of *d*-orbitals in its outermost shell.

(*xiv*) **NOTE :** H_3PO_3 is a dibasic acid because it contains two OH groups in its molecule.

In the two P–OH bonds, the hydrogen is ionisable. [For structure see part (xi)]

(*xv*) **NOTE :** As compared to P, N atom has higher electronegativity and small size and shows H-bonding.

Thus ammonia molecule show association where as phosphine does not.

(*xvi*) It is due to self ionization of NH_3, the reaction is

$$2NH_3 \rightarrow NH_4^+ + NH_2^-$$

Thus on addition of NH_4Cl the concentration of NH_4^+ radical increases and therefore NH_4Cl acts as an acid in liquid NH_3.

(*xvii*) In excess of NaOH the hydroxide of Al becomes soluble due to the formation of meta-aluminate.

(*xviii*) The repulsive forces between fluorine atoms are high due to its small size and high electronegativity. It makes dissociation of F – F bond easy. So bond dissociation energy of F_2 is less than Cl_2

(*xix*) The reducing nature of SO_2 is represented as

$$SO_2 + 2OH^- \rightarrow SO_4^{2-} + 2H^+ + 2e^-$$

Hence with the increase of OH^- (alkalinity) the forward reaction is favoured.

(*xx*) Nitrogen and fluorine both are small and have high electron density, they repel the bonded pair of electrons leading to larger bond length than expected.

(*xxi*) N^{3-} being smaller in size and high charge present on it make it more susceptible to hydrolysis :

$$N^{3-} + 3H_2O \rightarrow NH_3 + 3OH^-$$

Cl^- being a weak conjugate base does not undergo hydrolysis. $MgCl_2$ is stronger electrolyte and so it is not hydrolysed

(*xxii*) In $(SiH_3)_3N$, lone pair of electrons on nitrogen is involved in $p\pi - d\pi$ back bonding, while in $(CH_3)_3N$ no such $p\pi - d\pi$ back bonding is possible because of absence of d orbitals in carbon so $(CH_3)_3N$ is more basic than $(SiH_3)_3N$.

7. (*i*) Phosphine gas (PH_3) is evolved when white phosphorous is boiled with aqueous NaOH or alcoholic solution of potassium hydroxide.

$$P_4 + 3NaOH + 3H_2O \rightarrow \underset{\text{Sod. Hypophosphite}}{NaH_2PO_2} + PH_3\uparrow$$

(*ii*) This is a method used to prepare I_2.

$$5NaHSO_3 + 2NaIO_3 \rightarrow 3NaHSO_4 + 2Na_2SO_4 + I_2 + H_2O$$

(*iii*) $4Sn + \underset{\text{(dilute)}}{10HNO_3} \rightarrow 4Sn(NO_3)_2 + NH_4NO_3 + 3H_2O$

(*iv*) $2KMnO_4 + 3H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5[O]$

$5H_2C_2O_4 + 5[O] \rightarrow 10CO_2\uparrow + 5H_2O$

(*v*) $2IO_3^- + 5HSO_3^- \rightarrow I_2 + H_2O + 3HSO_4^- + 2SO_4^{2-}$

(*vi*) $4P + 10HNO_3 + H_2O \rightarrow 5NO + 5NO_2 + 4H_3PO_4$

(*vii*) $2H_3PO_2 \xrightarrow{Heat} \underset{\text{Phosphine}}{PH_3} + H_3PO_4$

(*viii*) $NaBrO_3 + F_2 + 2NaOH \rightarrow NaBrO_4 + 2NaF + H_2O$

(*ix*) $NaClO_3 + SO_2 + 10H^+ \rightarrow NaCl + S + 5H_2O$

(*x*) $3SiCl_4 + \underset{\text{(molten)}}{4Al} \xrightarrow{\Delta} 4AlCl_3\uparrow + 3Si$

(*xi*) $15CaO + 4P_4 \xrightarrow{\Delta} 5Ca_3P_2 + 3P_2O_5\uparrow$

$Ca_3P_2 + 6H_2O \rightarrow 3Ca(OH)_2 + 2PH_3\uparrow] \times 5$

$15CaO + 4P_4 + 30H_2O \rightarrow 15Ca(OH)_2 + 3P_2O_5 + 10PH_3\uparrow$

(*xii*) $CaSO_4 + 2NH_3 + CO_2 + H_2O \rightarrow CaCO_3\downarrow + (NH_4)_2SO_4$

(*xiii*) $NaNO_2 + 6H \xrightarrow{Zn/NaOH} NaOH + NH_3 + H_2O$

(*xiv*) $2NaIO_3 + 5NaHSO_3 \rightarrow 2Na_2SO_4 + 3NaHSO_4 + I_2 + H_2O$

(*xv*) $Na_2CO_3 + NO + NO_2 \rightarrow 2NaNO_2 + CO_2$

(*xvi*) $4KMnO_4 + 2H_2O \rightarrow 4MnO_2 + 4KOH + 3O_2$

$4NH_3 + 3O_2 \rightarrow 2N_2 + 6H_2O$

(*xvii*) $P_4 + 20HNO_3 \xrightarrow[\text{catalyst}]{I_2\ \text{as}} 4H_3PO_4 + 20NO_2 + 4H_2O$

(*xviii*) $2H_2S + NaHSO_3 + H^+ \rightarrow 3S\downarrow + 3H_2O + Na^+$

(*xix*) $[2HNO_3 \rightarrow H_2O + 2NO_2 + [O]] \times 10$

$P_4 + 10[O] \rightarrow P_4O_{10}$

$P_4O_{10} + 6H_2O \rightarrow 4H_3PO_4$

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

(*xx*) $2Al + 2NaOH + 6H_2O \rightarrow \underset{\text{Sodium meta-aluminate}}{2NaAlO_2} + 2H_2O + 3H_2O$

(*xxi*) $Al_2S_3 + 6H_2O \rightarrow 2Al(OH)_3\downarrow + \underset{\text{(foul odour)}}{3H_2S\uparrow}$

Foul odour, on damping of Al_2S_3 is due to formation of H_2S gas, which smells like rotten eggs.

(*xxii*) $P_4O_{10} + 6PCl_5 \rightarrow 10POCl_3$

(*xxiii*) $SnCl_4 + 2C_2H_5Cl + Na \rightarrow C_4H_{10} + Na_2[SnCl_6]$

8. By boiling Na_2SO_3 solution with powder of sulphur in absence of air sodium thiosulphate is prepared. Unreacted S is removed, filtrate is evaporated to give crystals of sod. thiosulphate.

$Na_2SO_3 + S \rightarrow Na_2S_2O_3$

9. Extraction of aluminium from bauxite :

$4AlF_3 + (\textit{from cryolite}) \rightleftharpoons 4Al^{3+} + 12F^-$

At cathode : $4Al^{3+} + 12e^- \rightarrow 4Al$

At anode : (i) $12F^- \rightarrow 6F_2 + 12e^-$

(ii) $2Al_2O_3 + 6F_2 \rightarrow 4AlF_3 + 3O_2$

10. $Al + NaOH \xrightarrow{aq.} NaAlO_2 \xrightarrow{2H_2O} Al(OH)_3 \xrightarrow{heat} Al_2O_3\,(\text{Alumina})$

11. N_2O has two principal resonance structures :

$$\bar{:}\ddot{N} = \overset{+}{N} = \ddot{O}: \longleftrightarrow :N \equiv \overset{+}{N} - \ddot{\underset{..}{O}}\bar{:}$$

12. (*i*) $KClO_3 + 2H_2C_2O_4 + H_2SO_4 \rightarrow KHSO_4 + HCl + 6CO_2 + 3H_2O$

(*ii*) $(NH_4)_2SO_4 + NO + NO_2 \rightarrow 2N_2 + 3H_2O + H_2SO_4$

13. (*i*) H_2S oxidises into S,

$SO_2 + 2H_2S \rightarrow 3S + 2H_2O$

(*ii*) $Sn + \underset{\text{conc.}}{4HNO_3} \rightarrow \underset{\text{meta stannic acid}}{H_2SnO_3} + 4NO_2 + H_2O$

(*iii*) $Pb_3O_4 + 4HNO_3 \rightarrow 2Pb(NO_3)_2 + 2H_2O + PbO_2\downarrow$

14. (*i*) $HI < HBr < HCl < HF$

The strength of H–X bond decreases from HF to HI. The larger is H–X bond length, lower is the bond energy, lesser is the bond strength.

(*ii*) $HOCl < HOClO < HOClO_2 < HOClO_3$

As the number of oxygen atoms increase, the -ve charge dispersal becomes more and more from Cl atom due to more electronegativity of oxygen atom and thus lesser is the charge on Cl atom, more will be its stability.

(*iii*) $SiO_2 < CO_2 < N_2O_5 < SO_3$.

Among oxides of the non-metals, the acidic strength increases with oxidation state. Hence SO_3 (O.S. of S = +6) is most acidic followed by N_2O_5 (O.S. of N = +5) and CO_2 and SiO_2 (O.S. of C and Si = +4). Further CO_2 is more acidic than SiO_2 because of small size of C-atom.

(*iv*) Since *carbon* has no *d*-orbital, it cannot extend its coordination number beyond four, its halides are not attacked (hydrolysed) by water. On the other hand, silicon have vacant *d*-orbitals to which water molecules can coordinate and hence their halides are hydrolysed by water.

NOTE : Increasing order of extent of hydrolysis

$CCl_4 < MgCl_2 < AlCl_3 < SiCl_4 < PCl_5$

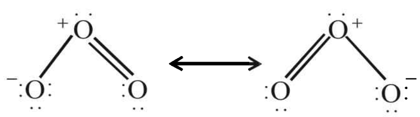
15. (*i*) $2FeBr_2 + 3Cl_2 \rightarrow 2FeCl_3 + 2Br_2$

(*ii*) $2SnCl_2 + 2I_2 \rightarrow SnCl_4 + SnI_4$

(*iii*) $SO_2 + H_2O + \frac{1}{2}O_2 \rightarrow H_2SO_4$

$H_2SO_4 + 2NaCl \rightarrow Na_2SO_4 + 2HCl$

16. The two resonating structures of ozone are :



17. $3PbS \xrightarrow[air]{\text{heat in}} \underset{(A)}{2PbO} + PbS$

$$\xrightarrow{\text{heat in the absence of air (B)}} 3Pb + SO_2$$

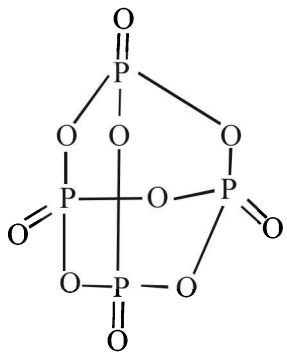
18. (i) $2P + 3I_2 + 6H_2O \rightarrow 2H_3PO_4 + 6HI$

(ii) $2KNO_3 + 10K \rightarrow 6K_2O + N_2$

(iii) $2NH_3 + NaOCl \rightarrow \underset{\text{Hydrazine}}{H_2N.NH_2} + NaCl + H_2O$

(iv) $Sn + 2KOH + 4H_2O \rightarrow K_2Sn(OH)_6 + 2H_2$

19.



Number of P – O single bonds = 12

Number of P – O double bonds = 4

20. At first $Bi(NO_3)_3$ hydrolyses to give nitric acid which, being an oxidising agent, oxidises potassium iodide liberating free iodine responsible for dark brown precipitate. Iodine dissolves in excess of potassium iodide forming soluble KI_3 imparting yellow colour to solution

$$Bi(NO_3)_3 + H_2O \longrightarrow [Bi(OH)(NO_3)_2] + HNO_3$$

$$NO_3^- + 4H^+ + 3e^- \longrightarrow NO_2 + 2H_2O \,] \times 2$$

$$2I^- \longrightarrow I_2 + 2e^- \,] \times 3$$

$$2NO_3^- + 8H^+ + 6I^- \longrightarrow 2NO + 4H_2O + \underset{\text{(dark brown ppt)}}{3I_2 \downarrow}$$

$$KI + I_2 \longrightarrow \underset{\text{(Yellow solution)}}{KI_3}$$

21. (a) $2KI + Cl_2 \rightarrow 2KCl + I_2$

Since Cl_2 is more powerful oxidising agent than I_2, Cl_2 is able to displace I^- to form I_2.

$2I^- \rightarrow I_2 + 2e^-$, $E° = +0.54\,V$ ...(i)

$Cl_2 + 2e^- \rightarrow 2Cl^-$ $E° = 1.36V$ ...(ii)

On subtracting eq. (i) from eq. (ii), we get

$$Cl_{2(g)} + 2I^-_{(aq)} + \rightarrow 2Cl^-_{(aq)} + I_{2(s)} \quad E° = 0.82V$$

(b) $2KClO_3 + I_2 \rightarrow 2KIO_3 + Cl_2$.

Here ClO_3^- is more powerful oxidising agent than IO_3^-, so Cl is displaced by I.

$2IO_3^- + 12H^+ + 10e^- \rightarrow I_2 + 6H_2O$, $E° = 1.195V$ ...(i)

$2ClO_3^- + 12H^+ + 10e^- \rightarrow Cl_2 + 6H_2O, E° = 1.47V$ ..(ii)

On subtracting eq. (i) from eq. (ii), we get

$2ClO_3^- + I_2 \rightarrow 2IO_3^- + Cl_2$ $E° = 0.275V$

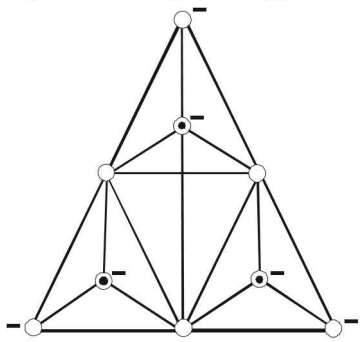
22. The poisonous element M may be As. So on the basis of the given facts,

$$AsCl_3 + 6H \xrightarrow{Zn/H_2SO_4} \underset{(N)}{AsH_3} + 3HCl$$

$$2AsH_3 \xrightarrow{\Delta} \underset{(M)}{2As} + 3H_2 \uparrow$$

Hence M = As; N = As H_3

23. In cyclic $Si_3O_9^{6-}$, three tetrahedra of SiO_4^{2-} are joined together sharing two oxygen atoms per tetrahedron.



Structure of $Si_3O_9^{6-}$;

Dark circle represents Si and open circle represents oxygen atom/ion

24. $SO_2 + PCl_5 \rightarrow \underset{\text{Thionyl chloride}}{SOCl_2} + POCl_3$

$$FeCl_3.6H_2O + 6SOCl_2 \rightarrow FeCl_3 + 12HCl + 6SO_2$$

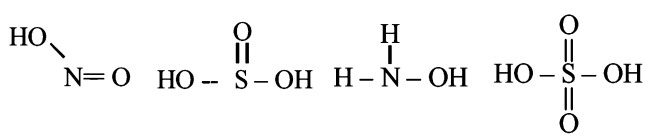
$$FeCl_3.6H_2O + 6CH_3 - C(OCH_3)_2 - CH_3 \rightarrow FeCl_3 + 12CH_3OH + 6CH_3COCH_3$$

25. $7H_3PO_4 + Ca_5(PO_4)_3F \rightarrow \underset{\text{Triple superphosphate}}{5Ca(H_2PO_4)_2} + HF$

26. The reaction is

$$\underset{(A)}{HNO_2} + \underset{(B)}{2H_2SO_3} + H_2O \rightarrow \underset{(C)}{NH_2OH} + \underset{(D)}{2H_2SO_4}$$

The structures of A, B, C and D are as follows.



(A) (B) (C) (D)

27. Sulphur trioxide produced in the contact process is absorbed by sulphuric acid forming $H_2S_2O_7$. It is not dissolved in water as it gives a dense fog of sulphuric acid particles.

The catalyst used in the contact process is vanadium pentoxide.

28. In such a case

A = $Ca(OH)_2$, B = NH_4HCO_3, C = Na_2CO_3, D = NH_4Cl and E = $CaCl_2$

$$CaO + H_2O \longrightarrow \underset{(A)}{Ca(OH)_2}$$

$$NH_3 + CO_2 + H_2O \longrightarrow \underset{\text{Sod. Bicarbonate(B)}}{NH_4HCO_3}$$

$$NH_4HCO_3 + NaCl \longrightarrow \underset{}{NaHCO_3} + \underset{\text{Amm. chloride(D)}}{NH_4Cl}$$

$$2NaHCO_3 \xrightarrow{\Delta} \underset{\text{Sod. carbonate (C)}}{Na_2CO_3} + H_2O + CO_2$$

$$Ca(OH)_2 + 2NH_4Cl \longrightarrow \underset{\text{(E)}}{CaCl_2} + \underset{\text{can be used again}}{2NH_3} + 2H_2O$$

29. More electronegative halogen displaces lesser electronegative halogen from its halide. Thus,

$$Cl_2 + 2KBr\,(\text{or } 2KI) \longrightarrow 2KCl + Br_2\,(\text{or } I_2)$$

30. **TIPS/Formulae :**

Use the formula

H (hydridisation), $H = \frac{1}{2}(V + M - C + A)$ where

V = number of electron in valence shell of central atom

M = number of monovalent atoms surrounding the central atom

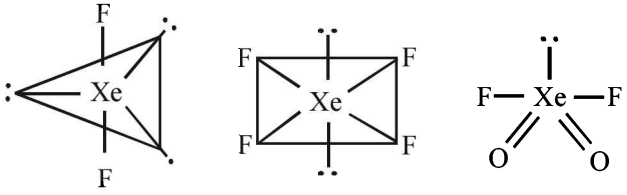
C = Charge on cation

A = Charge on anion

XeF_2 : $H = \frac{1}{2}(8+2-0+0) = 5$ Hence hybridisation is sp^3d, and thus its structure is linear.

XeF_4 : $H = \frac{1}{2}(8+4-0+0) = 6$, Hence hybridisation is sp^3d^2. and thus its structure is square planar.

XeO_2F_2 : $H = \frac{1}{2}(8+2-0+0) = 5$, Hence hybridisation is sp^3d. and shape is see saw.



XeF_2 XeF_4 XeO_2F_2

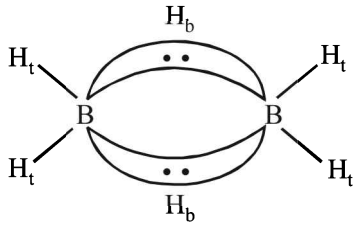
31. Elemental nitrogen exists as a diatomic molecule because nitrogen can form $p\pi$ - $p\pi$ multiple bonds which is not possible in case of phosphorus due to repulsion between non-bonded electrons of the inner core. There is no such repulsion in case of smaller nitrogen atoms as they have only $1s^2$ electrons in their inner core.

32. Since B_2O_3 is formed by reaction of (Y) with air, (Y) therefore should be B_2H_6 in which % of hydrogen is 21.72. The compound (X) on reduction with $LiAlH_4$ gives B_2H_6. Thus it is boron trihalide. The reactions are shown as:

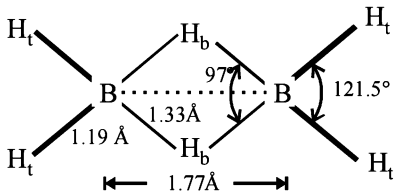
$$\underset{\text{(X)}}{4BX_3} + 3LiAlH_4 \longrightarrow \underset{\text{(Y)}}{2B_2H_6} + 3LiX + 3AlX_3 \quad (X = Cl \text{ or } Br)$$

$$\underset{\text{(Y)}}{B_2H_6} + 3O_2 \longrightarrow B_2O_3 + 3H_2O + \text{heat}$$

Structure of B_2H_6 is as follows:



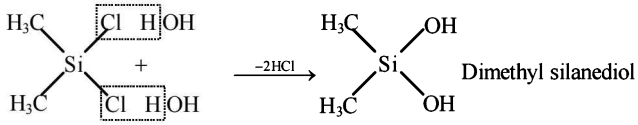
or

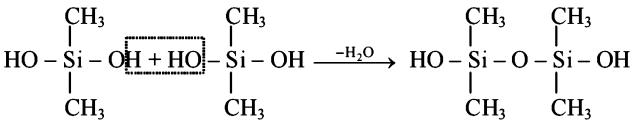


Thus the diborane molecule has **four** two-centre- two -electron bonds ($2c-2e$ bonds) also called usual bonds and **two** three-centre-two -electron bonds ($3c-2e$) also called **banana bonds**. Hydrogen attached to usual and banana bonds are called H_t (terminal H) and H_b (bridged H) respectively.

33. (i) $SiCl_4 + 2Mg(\text{or } Zn) \longrightarrow Si + 2MgCl_2\,(\text{or } ZnCl_2)$

(ii) $SiCl_4 + 2CH_3MgCl \longrightarrow (CH_3)_2SiCl_2 + 2MgCl_2$





Polymerisation continues on both ends to give linear silicone.

(iii) $SiCl_4 + 2Mg \longrightarrow Si + 2MgCl_2$

$Si + Na_2CO_3 \longrightarrow Na_2SiO_3 + C$

$SiCl_4 + 4H_2O \longrightarrow Si(OH)_2 + 4HCl$

$Si(OH)_2 \xrightarrow{\text{heat}} SiO_2 + 2H_2O$

$SiO_2 + 2NaOH \longrightarrow Na_2SiO_3 + H_2O$

34. (i) $Al_4C_3 + 12H_2O \longrightarrow 4Al(OH)_3 + 3CH_4 \uparrow$

(ii) $CaCNCN + 3H_2O \longrightarrow CaCO_3 \downarrow + 2NH_3$

Ammonia formed dissolves in water to form NH_4OH

$CaCNCN + 5H_2O \longrightarrow 2NH_4OH + CaCO_3 \downarrow$

(iii) $4BF_3 + 3H_2O \longrightarrow 3HBF_4 + B(OH)_3$

(iv) $NCl_3 + 3H_2O \longrightarrow NH_3 + 3HOCl$

(v) $3XeF_4 + 6H_2O \longrightarrow XeO_3 + 2Xe + \frac{3}{2}O_2 + 12HF$

35. **NOTE :** When hot concentrated HCl is added to borax ($Na_2B_4O_7.10H_2O$) the sparingly soluble H_3BO_3 is formed which on subsequent heating gives B_2O_3 which is reduced to boron on heating with Mg, Na or K

$Na_2B_4O_7(\text{anhydrous}) + 2HCl(\text{ hot, conc.})$

$\longrightarrow 2NaCl + H_2B_4O_7$

$H_2B_4O_7 + 5H_2O \longrightarrow 4H_3BO_3\downarrow$

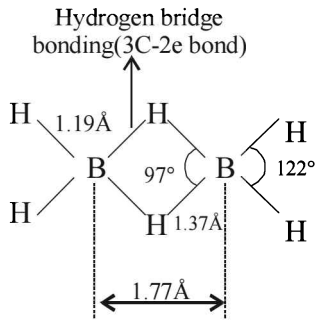
$2H_3BO_3 \xrightarrow{\text{strong heating}} B_2O_3 + 3H_2O$

$B_2O_3 + 6K \longrightarrow 2B + 3K_2O$ or

$B_2O_3 + 6Na \longrightarrow 2B + 3Na_2O$ or

$B_2O_3 + 3Mg \longrightarrow 2B + 3MgO$

Structure of B_2H_6



$B_2H_6 + HCl \longrightarrow B_2H_5Cl + H_2$

[**NOTE :** Normally this reaction takes place in the presence of Lewis acid ($AlCl_3$)]

36. $2PbS + 3O_2 \longrightarrow 2PbO + 2SO_2$

$PbS + 2O_2 \longrightarrow PbSO_4$

$PbS + 2PbO \longrightarrow 3Pb + SO_2$

$PbS + PbSO_4 \longrightarrow 2Pb + 2SO_2$

Oxidation number of Pb in litharge (PbO) is +2

37. $Na_2CO_3 + 2SO_2 + H_2O \rightarrow \underset{(A)}{2NaHSO_3} + CO_2$;

$2NaHSO_3 + Na_2CO_3 \rightarrow \underset{(B)}{2Na_2SO_3} + H_2O + CO_2$

$Na_2SO_3 + S \rightarrow \underset{(C)}{2Na_2S_2O_3}$

$2Na_2S_2O_3 + I_2 \rightarrow \underset{(D)}{2Na_2S_4O_6} + 2NaI$

Oxidation states of 'S' are : +4 in (A), (+6) in B and +2 in (C), +2.5 in (D)

38. HF is weakly dissociated, while KF is highly dissociated giving a high concentration of F^- which leads to the formation of soluble AlF_6^{3-}.

$AlF_3 + 3\,KF \rightarrow K_3[AlF_6]$

Since BF_3 is more acidic than AlF_3, it pulls out F^- from AlF_6^{3-} reprecipitating AlF_3.

$K_3[AlF_6] + 3BF_3 \rightarrow 3KBF_4 + AlF_3\downarrow$

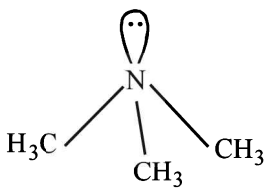
39. $6\,CaO + P_4O_{10} \longrightarrow 2Ca_3(PO_4)_2$

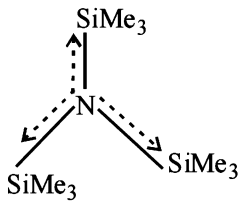
Moles of $P_4O_{10} = \dfrac{852}{284} = 3$

Moles of $CaO = 3 \times 6 = 18$; wt. of $CaO = 18 \times 56 = 1008$ g

For structure of P_4O_{10} : See question 20 of this section.

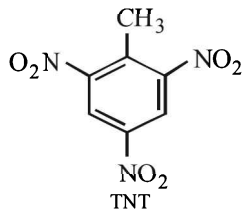
40. $(CH_3)_3N$ and $(Me_3Si)_3N$ are not isostructural, the former is pyramidal while the latter is trigonal planar. Silicon has vacant *d* orbitals which can accommodate lone pair of electrons from N (back bonding) leading to planar shape.





41. A. Conc. H_2SO_4 B. Br_2

C. NO_2^+ D.



Reactions involved are

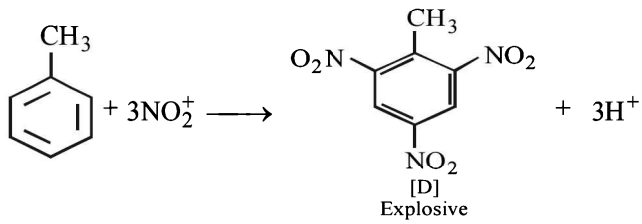
$2\,NaBr + 2\,H_2SO_4 + MnO_2$

[A]

$\longrightarrow Na_2SO_4 + MnSO_4 + \underset{\text{[B]}}{Br_2\uparrow} + 2\,H_2O$

Brown fumes and pungent smell

$H_2SO_4 + HNO_3 \longrightarrow \underset{\text{[C]}}{HSO_4^- + NO_2^+} + H_2O$



[D]
Explosive

F. Match the Following

1. **(A)-(t),** $Pb(N_3)_2$ is an explosive
(B)-(s), Al_2O_3 is used to prepare artificial gun
(C)-(v), Extraction of copper involves self-reduction process.
(D)-(u), Fe_2O_3 is a magnetic material.

2. **(A)-(q),** Bi^{3+} hydrolyses to yield BiO^+ ion
(B)-(s), AlO_2^- on dilution yields a white ppt. of $Al(OH)_3$
(C)-(p), When heated $(SiO_4)^{4-}$ changes to $(Si_2O_7)^{6-}$
(D)-(r), When acidified $(B_4O_7)^{2-}$ gives $B(OH)_3$ (or H_3BO_3)

3. **(A) – p, r, t ; (B) – s,t ; (C) – p, q, r ; (D) – p, r, s**

(A) B_2 $\sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \pi 2p_y^1 = \pi 2p_z^1$

Bond order = 1 Paramagnetic

(B) N_2 $\sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \sigma 2p_x^2, \pi 2p_y^2 = \pi 2p_z^2$

Bond order = 3 Diamagnetic

(C) O_2^- $\sigma 1s^2, \sigma^* 1s^2; \sigma 2s^2 . \sigma^* 2s^2; \sigma 2p_x^2, \pi 2p_y^2$

$= \pi 2p_z^2, \pi^* 2p_y^2 = \pi^* 2p_z^1$

Bond order = 1.5 Paramagnetic

(D) O_2 $\sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \sigma 2p_x^2, \pi 2p_y^2$

$= \pi 2p_z^2, \pi^* 2p_y^1 = \pi^* 2p_z^1$

Bond order = 2 Paramagnetic

4. **(d)** (P)

$$2PbO_2 + 2H_2SO_4 \xrightarrow{\text{Warm}} 2PbSO_4 + 2H_2O + O_2$$

(Q)

$$Na_2S_2O_3 + 5H_2O + 4Cl_2 \longrightarrow 2NaHSO_4 + 8HCl$$

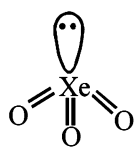
(R) $N_2H_4 + 2I_2 \longrightarrow N_2 + 4HI$

(S) $XeF_2 + 2NO \longrightarrow Xe + 2NOF$

G. Comprehension Based Questions

1. **(a)** Argon, being a noble gas, will not react with the metals, thus, can be used in arc welding.

2. **(c)** In XeO_3 there are total of 4 electron pairs around central atom. Out of which 3 are bonding electron pair and one is non-bonding electron pair. This combination provides sp^3-hybridization and pyramidal shape.



3. **(a)** All xenon fluorides are strongly oxidizing, XeF_4 can act as reducing agent (with F_2) as well as oxidizing agent but XeF_6 can only function as an oxidizing agent.

$$6XeF_4 + 12H_2O \longrightarrow 4Xe + 2XeO_3 + 24HF + 3O_2$$

$$XeF_6 + 3H_2O \longrightarrow XeO_3 + 6HI$$

4. **(c)** We know that phosphates have a biological significance in human, therefore statement (a) is not correct.

Since nitrates are more soluble in water so they are less abundant in earth's crust where as phosphates are less soluble in water and so they are more abundant in earth's crust. Thus statement (b) is False and statement (c) is correct.

NOTE : In nitrates (NO_3^-) nitrogen is in + 5 oxidation state which is the highest oxidation state exhibited by nitrogen. Because of this nitrates can not be oxidized (oxidation means increase in oxidation state). Hence statement (d) is not correct.

The correct answer is (c).

5. **(c)** In case of group 15 (nitrogen group), on moving down the group there occurs a decrease in bond angle of metal hydrides. This decrease in bond angle of metal hydrides of this group may be attributed to the increased p- character in the bond pair which results in more s- character in lone pair orbital.

NOTE : The directional character is more for sp^3 hybrid orbital than a s- orbital.

Thus the correct answer is (c).

6. **(b)** The reaction between NaOH and white phosphorus (P_4) can be represented as follows:

$$\underset{\text{(white Phosphorus)}}{P_4} + 3NaOH + 3H_2O \longrightarrow 3NaH_2PO_2 + \underset{\text{(Phosphine)}}{PH_3}$$

NOTE : In this reaction Phosphorus is oxidised as well as reduced so it is a disproportionation reaction.

$\therefore$ The correct answer is (b).

7. **(a)** $Ca(OCl)Cl \longrightarrow Ca^{2+} + {}^-OCl + Cl^-$

^-OCl (Hypochlorite ion) is anion of the acid HOCl which on dehydration gives Cl_2O.

$$2HOCl \longrightarrow H_2O + Cl_2O$$

8. **(c)** Number of millimole of hypo $= 0.25 \times 48$

$= 2 \times$ millimole of Cl_2

$$\therefore \text{Number of millimole of } Cl_2 = \frac{0.25 \times 48}{2} = 6$$

millimole of Cl_2 = millimole of $CaOCl_2$

Molarity of bleaching solution

$$= \frac{\text{Millimoles of } CaOCl_2}{\text{Vol.(in mL) of } CaOCl_2} = \frac{6}{25} = 0.24$$

9. **(a)** $Cl_2 + 2NaOH(\text{dil.}) \xrightarrow{\text{cold}} \underset{\text{(P)}}{NaOCl} + NaCl + H_2O$

$$3Cl_2 + 6NaOH(\text{conc.}) \xrightarrow{\text{hot}} \underset{\text{(Q)}}{NaClO_3} + 5NaCl + 3H_2O$$

(P) and (Q) are salts of HOCl and $HClO_3$ respectively.

10. **(a)** $SO_2 + Cl_2 \xrightarrow[\text{Catalyst}]{\text{Charcoal}} \underset{\text{(R)}}{SO_2Cl_2}$

$$\underset{\text{(R)}}{10SO_2Cl_2} + P_4 \rightarrow \underset{\text{(S)}}{4PCl_5} + 10SO_2$$

$$\underset{\text{(S)}}{PCl_5} + 4H_2O \rightarrow \underset{\text{(T)}}{H_3PO_4} + 5HCl$$

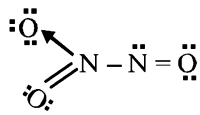
H. Assertion & Reason Type Questions

1. **(b)** Nitrogen cannot form pentahalides because it cannot expand its octet due to non-availability of d-orbitals. So E is not correct explanation of S.
2. **(c)** F has slightly less electron affinity than chlorine because F has very small atomic size (only two shells). Hence there is a tendency of electron-electron repulsion, which results in less evolution of energy in the formation of F^- ion. Assertion is correct but reason incorrect.
3. **(a)** Both assertion and reason are correct and reason explains assertion.
4. **(c)** $SiCl_4$ undergoes hydrolysis due to the presence of empty *d* orbitals in the valence shell of Si, while C has no vacant *d* orbitals to accommodate electron pairs donated by water molecules during hydrolysis.
5. **(c)** Statement-1 is correct but statement-2 incorrect. Orthoboric acid (H_3BO_3) is soluble in water and behaves as weak monobasic acid. It does not donate protons like most acids, but rather it accepts OH^- ions. It is, therefore, Lewis acid, and is better written as $B(OH)_3$.

$$B(OH)_3 + 2H_2O \rightleftharpoons H_3O^+ + [B(OH)_4]^-;\ {}_pK_a = 9.25$$

6. **(a)** Both statements are true. Boron forms only covalent compounds (bonds) because small sized B ion polarizes the corresponding anion largely.
7. **(c)** **NOTE :** In group 14 elements, the lower (and not higher) oxidation states are more stable for heavier members of the group due to inert pair effect.
Thus Pb^{4+} is less stable as compared to Sn^{4+} (lead is heavier than Tin). Therefore Pb^{4+} acts as a strong oxidising agent than Sn^{4+}. Hence statement 1 is false and statement 2 is true. Thus the correct answer is option (c).

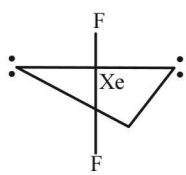
I. Integer Value Correct Type

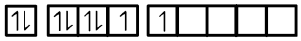
1. Coordination number of Al is 6. It exists in *ccp* lattice with 6 coordinate layer structure.
2. Total cationic charge = Total anionic charge
$2n + 6 + 24 = 36 \Rightarrow n = 3$
3. **5**
$$3Br_2 + 3Na_2CO_3 \longrightarrow 5NaBr + NaBrO_3 + 3CO_2$$
4. **4**
$$PCl_5 + SO_2 \longrightarrow POCl_3 + SOCl_2$$
$$PCl_5 + H_2O \longrightarrow POCl_3 + 2HCl$$
$$PCl_5 + H_2SO_4 \longrightarrow POCl_3 + SO_2Cl_2 + 2HCl$$
$$6PCl_5 + P_4O_{10} \longrightarrow 10POCl_3$$
5. **(8)** 
Number of lone pairs = 8
6. **(6)** $3B_2H_6 + 18CH_3OH \rightarrow 6B(OCH_3)_3 + 18H_2$

Section-B JEE Main/ AIEEE

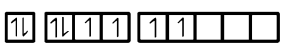
1. **(c)** Alum furnishes Al^{3+} ions which bring about coagulation of negatively charged clay particles, bacteria etc.
2. **(d)** In the formation of XeF_2, sp^3d hybridisation occurs which gives the molecule a trigonal bipyramidal structure.

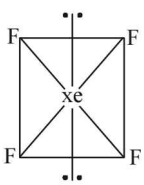
Ground state configuration



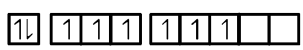

Excited state configuration

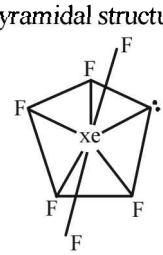
In the formation of XeF_4, sp^3d^2 hybridization occurs which gives the molecule an octahedral structure.

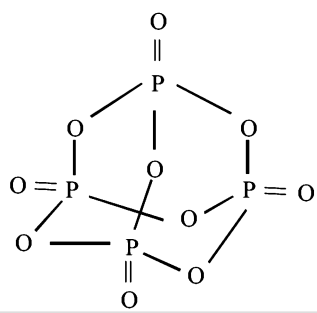

Excited state config.



In the formation of XeF_6, sp^3d^3 hybridization occurs which gives the molecule a pentagonal bipyramidal structure.





3. **(a)** ${}_7N = 1s^2\ 2s^2\ 2p^3$; ${}_{15}P = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$
NOTE : In phosphorous the 3d- orbitals are available. Hence phosphorous can from pentahalides also but nitrogen can not form pentahalide due to absence of d-orbitals
4. **(c)**
5. **(d)** 

6. **(d)** $CaOCl_2$ — or it can also be written as

$$\underset{x_1}{Ca}(\underset{x_2}{OCl})Cl$$

hence oxidation no of Cl in OCl^- is

$$-2+x_2=-1$$
$$x_2=2-1=+1$$

now oxidation no. of another Cl is –1 as it is present as Cl^-.

7. **(d)** On mixing phosphine with chlorine gas PCl_5 and HCl forms. The mixture cools down.

$$PH_3+4Cl_2 \longrightarrow PCl_5+3HCl$$

8. **(a)** $4HCl+\underset{air}{O_2} \rightarrow 2Cl_2+2H_2O$

cloud of white fumes

9. **(c)** In graphite, carbon is sp^2 hybridized. Each carbon is thus linked to three other carbon atoms forming hexagonal rings. Since only three electrons of each carbon are used in making hexagonal ring, fourth electron of each carbon is free to move. This makes graphite a good conductors of heat and electricity.
Further graphite has a two dimensional sheet like structure. These various sheets are held together by weak van der Waal's force of attraction. due to these weak forces of attraction, one layer can slip over the other. This makes graphite soft and a good lubricating agent.

10. **(a)** Glass is a translucent or transparent amorphous supercooled solid solution or we can say super cooled liquid of silicates and borats having a general formula $R_2O.MO.6SiO_2$. where R = Na or K and M = Ca, Ba, Zn or Pb.

11. **(b)** Among the given compounds, the $\dot{N}H_3$ is most basic. Hence has highest proton affinity

12. **(d)** It is mercury because it exists as liquid at room temperature.

13. **(d)** The fluorine has low dissociation energy of F - F bond and reaction of atomic fluorine is exothermic in nature

14. **(c)** Helium is heavier than hydrogen although it is non-inflammable

15. **(c)** The maximum valency of beryllium is +2 while that of aluminium is +3.

16. **(b)** $Al_2Cl_6+12H_2O \rightleftharpoons 2[Al(H_2O)_6]^{3+}+6Cl^-$

17. **(b)** $\overset{-1}{4KI}+2CuSO_4 \rightarrow \overset{0}{I_2}+Cu_2I_2+2K_2SO_4$

$\overset{0}{I_2}+2\overset{2+}{Na_2}\overset{}{S_2}O_3 \rightarrow \overset{+2.5}{Na_2}\overset{}{S_4}O_6+2\overset{-1}{NaI}$

In this CuI_2 is **not** formed.

18. **(c)** Hypophosphorous acid $H-O-\overset{H}{\underset{H}{P}}\rightarrow O$

Two H-atoms are attached to P atom.

19. **(c)** The H–X bond strength decreases from HF to HI. i.e. HF > HCl > HBr > HI. Thus HF is most stable while HI is least stable. This is evident from their decomposition reaction: HF and HCl are stable upto 1473K, HBr decreases slightly and HI dissociates considerably at 713K. The decreasing stability of the hydrogen halide is also reflected in the values of dissociation energy of the H–X bond

H – F	H – Cl	H – Br	H – I
135kcal mol^{-1}	103kcal mol^{-1}	87kcal mol^{-1}	71kcal mol^{-1}

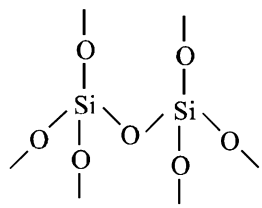
20. **(b)** The solution of aluminium chloride in water is acidic due to hydrolysis.

$$AlCl_3+3H_2O \longrightarrow Al(OH)_3+3HCl.$$

On heating it till dryness $Al(OH)_3$ is converted into Al_2O_3

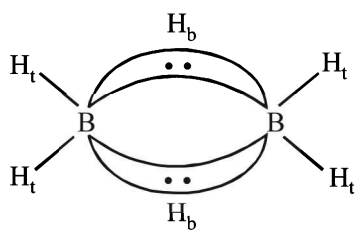
$$Al(OH)_3 \xrightarrow{\Delta} Al_2O_3+3H_2O$$

21. **(d)** In SiO_2 (quartz), each of O-atom is shared between two SiO_4^{4-} tetrahedra.



22. **(d)** In diborane structure B_2H_6 there are two 2c-2e bonds and two 3c–2e bonds (see structure of diborane).

Structure of B_2H_6 :



23. **(b)** The $\overset{+5}{HNO_3}$ is stronger than $\overset{+3}{HNO_2}$. The more the oxidation state of N, the more is the acid character.

24. **(b)** The correct order of ionisation enthalpies is

$$F>P>S>B$$

NOTE : On moving along a period ionization enthalpy increases from left to right and decreases from top to bottom in a group. But this trend breaks up in case of atom having fully or half filled stable orbitals.
In this case P has a stable half filled electronic configuration hence its ionisation enthalpy is greater in comparision to S. Hence the correct order is

$$B<S<P<F.$$

25. **(b)** During disproportionation same compound undergo simultaneous oxidation and reduction.

Oxidation

$$\overset{-}{3HO}\overset{+}{Cl} \longrightarrow 2HCl+\overset{+5}{HClO_3}$$

$\overset{-1}{}$ redution

26. **(d)** Chlorine reacts with excess of ammonia to produce ammonium chloride and nitrogen.

27. **(a)** $(NH_4)_2SO_4+2H_2O \longrightarrow 2H_2SO_4+NH_4OH$

H_2SO_4 is strong acid and increases the acidity of soil.

28. (c) The correct formula of inorganic benzene is $B_3N_3H_6$ so (d) is incorrect statement

Boric acid (H_3BO_3 or $B(OH)_3$) is a lewis acid so (a) is incorrect statement.

The coordination number exhibited by beryllium is 4 and not 6 so statement (b) is incorrect.

Both $BeCl_2$ and $AlCl_3$ exhibit bridged structures in solid state so (c) is correct statement.

29. (d) The products of the concerned reaction react each other forming back the reactants.

$$XeF_6 + 3H_2O \longrightarrow XeO_3 + 6HF$$

30. (a) The ease of formation and stability of hydrides decreases rapidly from NH_3 to BiH_3. This is evident from their dissociation temperature which decreases from NH_3 to BiH_3. As we go down the group the size of central atom increases and thus metal-hydrogen bond becomes weaker due to decreased overlap between the large central atom and small hydrogen atom.

$NH_3 > PH_3 > AsH_3 > SbH_3 > BiH_3$

(most stable) (least stable)

31. (d) Oxidation of sulphur varies from -2 to $+6$ in its various compounds.

32. (a) Boron cannot form BF_6^{3-} due to non-availability of d-orbitals.

33. (c) All the members form volatile halides of the type AX_3. All halides are pyramidal in shape. The bond angle decreases on moving down the group due to decrease in bond pair-bond pair repulsion.

NCl_3	PCl_3	$AsCl_3$
107°	94°	92°

34. (c) Acidic strength increases as the oxidation number of central atom increases.

Hence acidic strength order is

(+7) (+5) (+3) (+1)

$HClO_4 > HClO_3 > HClO_2 > HClO$

35. (a) Nitric oxide is paramagnetic in the gaseous state because of the presence of one unpaired electron in its outermost shell.

The electronic configuration of NO is

$$\sigma_{1s}^2\,\sigma_{1s}^{*2}\,\sigma_{2s}^2\sigma_{2s}^{*2}\sigma_{2p_z}^2\,\pi_{2p_x}^2 = \pi_{2p_y}^2\,\pi_{2p_x}^{*1}$$

36. (b) CsI_3 dissociates as

$CsI_3 \rightarrow Cs^+ + I_3^-$

37. (b) ICl

Order of reactivity of halogens

$Cl_2 > Br_2 > I_2$

But, the interhalogen compounds are generally more reactive than halogens (except F_2), since the bond between two dissimilar electronegative elements is weaker than the bond between two similar atoms i.e, X – X

38. (c) Nitrogen and oxgen in air do not react to form oxides of nitrogen in atmosphere because the reaction between nitrogen and oxygen requires high temperature.

39. (b) Xe. As we move down the group, the melting and boiling points show a regular increase due to corresponding increase in the magnitude of their van der waal forces of attraction as the size of the atom increases.

40. (c) Phosphorous acids contain P in +3 oxidation state.

Acid	Formula	Oxidation state of Phosphorous
Pyrophosphorous acid	$H_4P_2O_5$	+3
Pyrophosphoric acid	$H_4P_2O_7$	+5
Orthophosphorous acid	H_3PO_3	+3
Hypophosphoric acid	$H_4P_2O_6$	+4

41. (c) Reaction of Zn with dil. HNO_3

$$4Zn + 10HNO_3(dil) \longrightarrow 4Zn(NO_3)_2 + 5H_2O + N_2O$$

(Zn reacts differently with very dilute HNO_3)

Reaction of Zn with conc. HNO_3

$$Zn + 4HNO_3(conc.) \longrightarrow Zn(NO_3)_2 + 2H_2O + 2NO_2$$