Long Answer Type Questions

Q.1. What happens when (only give reaction)

(i) Aluminium dissolves in dilute $\mathbf{HCl}$.

(ii) Borax dissolves in water.

(iii) Acidifying an aqueous solution of borax.

(iv) Treating boron trifluoride with $\mathbf{LiAlH_4}$ in diethyl ether.

(v) Ammonia reacts with diborane.

Ans. (i) $2Al(s) + 6HCl(aq) \rightarrow 2Al^{3+}(aq) + 6Cl^{-}(aq) + 3H_2(g)$

(ii) $Na_2B_4O_7 + 7H_2O \rightarrow 2NaOH + 4H_3BO_3$

(iii) $Na_2B_4O_7 + 2HCl + 5H_2O \rightarrow 2NaCl + 4B(OH)_3$

(iv) $4BF_3 + 3LiAlH_4 \rightarrow 2B_2H_6 + 3LiF + 3AlF_3$

(v) $3B_2H_6 + 6NH_3 \rightarrow 3[BH_2(NH_3)_2]^+[BH_4]^- \xrightarrow{\Delta} 2B_3N_3H_6 + 12H_2$

Q.2. Complete the following reactions:

(i) $\mathbf{B(OH)_3 + 2HOH \rightarrow}$

(ii) $\mathbf{2NaBH_4 + I_2 \rightarrow}$

(iii) $\mathbf{B_2H_6(g) + 6H_2O(I) \rightarrow}$

(iv) $\mathbf{B_2H_6 + 3O_2 \rightarrow}$

(v) $\mathbf{2BF_3 + 6NaH \xrightarrow{450K} B_2H_6 + 6NaF}$

Ans. (i) $B(OH)_3 + 2HOH \rightarrow [B(OH)_4]^- + H_3O^+$

(ii) $2NaBH_4 + I_2 \rightarrow B_2H_6 + 2NaI + H_2$

(iii) $B_2H_6(g) + 6H_2O(l) \rightarrow 2B(OH)_3(aq) + 6H_2(g)$

(iv) $B_2H_6 + 3O_2 \rightarrow B_2O_3 + 3H_2O$

(v) $2BF_3 + 6NaH \xrightarrow{450K} B_2H_6 + 6NaF$

Q.3. A non-metallic element of group 13 used in making bullet-proof vests is extremely hard solid of black colour. It can exist in many allotropic forms and has unusually high melting point. Its trifluoride acts as Lewis acid towards ammonia. The element exhibits maximum covalency of four. Identify the element and write

the reasons of its trifluoride with ammonia. Explain why does the trifluoride act as a Lewis acid?

Ans. Non-metallic element of group 13 is boron. It is grey-black and very hard in nature. It has high melting point, $2300^{O}C$. It exists in two allotropic forms:

(i) Crystalline solid

(ii) Amorphous powder.

It forms trifluoride, BF_3. BF_3 acts as a Lewis acid as it is an electron deficient compound.

$$BH_3 + :NH_3 \rightarrow H_3N \rightarrow BF_3$$

Adduct

NH_3 Donates an electron pair which is accepted by boron to saturate its outer shell. Maximum covalency of boron is four as its valency shell contains only four orbitals.

Q.4. A compound (A) of boron reacts with NMe_3 to give an adduct (B) which on hydrolysis gives a compound (C) and hydrogen gas. Compound (C) is an acid. Identify the compounds A, B and C. Give the reactions involved.

Ans. Since, compound 'A' of boron reacts with NMe_3 to form an adduct 'B'. Thus compound 'A' is a Lewis acid. Since, adduct 'B' on hydrolysis gives an acid 'C' and hydrogen gas, therefore, 'A' is B_2H_6 and 'C' is boric acid.

$$B_2H_6 + 2NMe_3 \rightarrow 2BH_3.NMe_3$$

Diborane (A) Adduct (B)

$$BH_3.NMe_3 + 3H_2O \rightarrow H_3BO_3 + NMe_3 + 6H_2$$

Boric acid(C)

Q.5. Complete the following reactions:

(i) $\mathbf{CaCO_3(s) + 2HCl(aq) \rightarrow}$

(ii) $\mathbf{SiO_2 + 2NaOH \rightarrow}$

(iii) $\mathbf{Fe_2O_3(s) + 3CO(g) \xrightarrow{\Delta}}$

(iv) $\mathbf{C(s) + H_2O(g) \xrightarrow{473-1273K}}$

(v) $\mathbf{2C(s) + O_2(g) + 4N_2(g) \xrightarrow{1273K}}$

Ans. (i) $CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$

Q.6. (i) Explain the formation of (a) water gas (b) Producer gas. Give their uses.

(ii) What happens when CO_2 is passed through lime water?
(a) For short duration
(b) For long duration.

Ans. (i) Preparation of water gas and producer gas-

(a) $C(s) + H_2O(g) \rightarrow CO(g) + H_2(g)$

(b) $2C(s) + O_2 + 4N_2(g) \rightarrow 2CO(g) + 4N_2(g)$

(Producer gas)

Water gas and producer gas are used as fuel.

(ii) (a) $Ca(OH)_2 + CO_2 \rightarrow Ca(HCO_3)_2$

(Soluble)

(b) $CaCO_3 + CO_2 + H_2O \rightarrow Ca(HCO_3)_2$

(Soluble)

Q.7. Give reason for the following observations: -

(i) The tendency for catenation decreases down the group in group 14.

(ii) PbO_2 is a stronger oxidizing agent than SnO_2.

(iii) No from of elemental silicon is comparable to graphite.

(iv) Oxide of carbon is regarded as anhydride of carbonic acid.

(v) Silicon shows a higher covalency than carbon.

Ans. (i) It is due to decrease in bond dissociation energy which is due to increase in atomic size.

$C - C > Si - Si > Ge - Ge > Sn - Sn > Pb - Pb$

(ii) PbO_2 is stronger oxidizing agent than SnO_2 because Pb^{2+} is more stable than Pb^{4+} whereas Sn^{4+} is more stable than Sn^{2+}.

(iii) Because it cannot form $p\pi - p\pi$ bond due to large size.

(iv) CO_2 is regarded as a hydride of carbonic acid because it dissociates into water and CO_2.

$H_2CO_3 \rightarrow H_2O + CO_2$

(v) Because of the presence of vacant d-orbitals silicon can show a covalency up to six while C because of the absence of d-orbitals can not have a covalency of more than four.

Q.8. A tetravalent element forms monoxide and overheated element (1273 K), producer gas is obtained. Monoxide of the element is a powerful reducing agent and reduces ferric oxide to iron. Identify the element and write formulas of its monoxide and dioxide. Write chemical equations for the formation of producer gas reduction of ferric oxide with the monoxide.

Ans. Producer gas is a mixture of CO and N_2 therefore, the tetravalent element is carbon and its monoxide and dioxide are CO and CO_2 respectively.

$$2C(s) + O_2(g) + 4N_2(g) \xrightarrow{1273K} 2CO(g) + 4N_2 \text{ Producer gas}$$

The carbon monoxide is a strong reducing agent and reduces ferric oxide to ion.

$$Fe_2O_3(s) + 3CO(g) \xrightarrow{\Delta} 2Fe(s) + 3CO(g)$$

Q.9. (i) How is HNO_3 prepared commercially?

(ii) Write chemical equation of the reactions involved.

(iii) What concentration by mass of HNO_3 can be obtained?

(iv) Give any two uses of HNO_3.

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

(ii) $$4NH_3(g) + 5NO_2(g) \underset{9\text{ bar}}{\overset{\text{Pt,500K}}{\rightarrow}} \underset{+6H_2O(l)}{4NO(g)}$$

$$2NO(g) + O_2 \rightarrow 2NO_2(g)$$

$$3NO_2(g) + H_2O(l) \rightarrow 2HNO_3(aq) + NO(g)$$

(iii) 68% by mass,

(iv) (a) It is used in the manufacture fertilizers, explosives.

(b) It is used as lab regent.

Q.10. Explain the following:

(i) Pentahalides are more covalent than trihalides.
(ii) BiH_3 the strongest reducing agent amongst all the hydrides of group.
(iii) NH_3 is basic while BiH_3 us only feebly basic.
(iv) Nitrogen exists as diatomic molecule and phosphorus as P_4.

(v) $R_3P = O$ exists but $R_3N = O$ does not ($R =$ alkyl group).

Ans. (i) In pentahalides, the oxidation state is +5 and in trihalides, the oxidation state is +3. Since the metal ion with a high charge has more polarizing power, pentahalides are more covalent than trihalides.

(ii) As we move down a group, the atomic size increase and the stability of the hydrides of group 15 elements decrease. Since the stability of hydrides decrease on moving from NH_3 to BiH_3, the reducing on moving from NH_3 to BiH_3.

(iii) Nitrogen has a small size due to which the lone pair of electrons is concentrated in a small region. This means that the charge density per unit volume is high.

On moving down a group, the size of the central atom increases and the charge gets distributed over a large area decreasing the electron density. Hence, the electron donating capacity decreases on moving down the group.

(iv) Nitrogen owing to its small has a tendency to from $p\pi - p\pi$ multiple bonds with itself. Nitrogen thus forms a very stable diatomic molecule, N_2. On moving down a group, the tendency to form $p\pi - p\pi$ bonds decrease (because of the large size of heavier elements). Therefore, phosphorus (like other heavier metals) exists in the P_4 state.

(v) N (unlike P) lacks the d-orbital. This restricts nitrogen to expand its coordination number beyond four. Hence, $R_3N = O$ does not exist.

Q.11. (i) What is the covalence of nitrogen in N_2O_5?

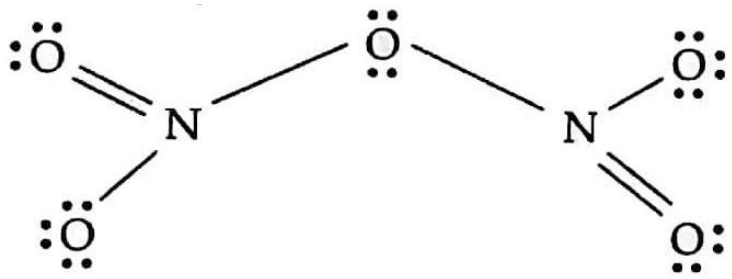
(ii) Draw the structure of H_3PO_3 molecule. [Comptt. Outside Delhi, 2013]

(iii) What is the basicity of H_3PO_4?

(iv) Draw the structure of (HPO_4)?

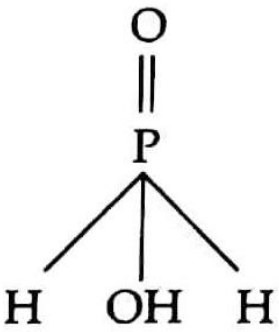
(v) Draw the structure of $H_4P_2O_7$ and find out its basicity.

Ans. (i)

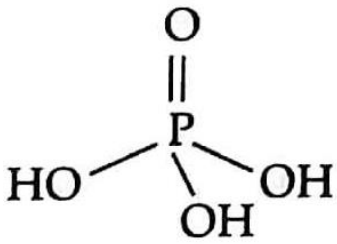


From the structure if N_2O_5, it is evident that the covalence of nitrogen is 4.

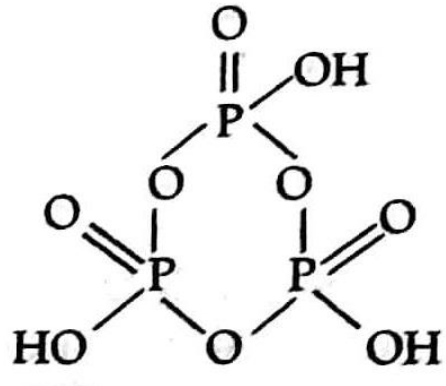
(ii)



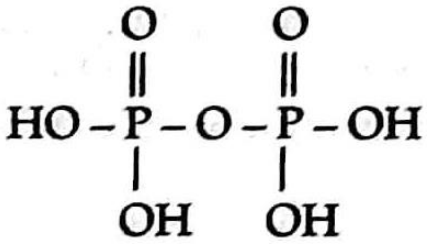
(iii) The basicity of H_3PO_4 is three due to availability of three hydrogen atoms which can be released in aqueous solution.



(iv)



(v) As four OH group are present, the basicity is 4.



Q.12. Complete the following reactions:

(i) $\mathbf{NH_4CI(aq) + NaNO_2(aq) \rightarrow}$

(ii) $\mathbf{3Mg + N_2 \xrightarrow{Heat}}$

(iii) $\mathbf{(NH_4)_2SO_4 + 2NaOH \rightarrow}$

(iv) $\mathbf{NaNO_3 + H_2SO_4 \rightarrow}$

(v) $\mathbf{P_4 + 3NaOH + 3H_2O}$

Ans.

(i) $NH_4CI(aq) + NaNO_2(aq) \rightarrow 2NH_3 + 2H_2O + Na_2SO_4$

(ii) $3Mg + N_2 \xrightarrow{Heat} Mg_3N_2$

(iii) $(NH_4)_2SO_4 + 2NaOH \rightarrow 2NH_3 + 2H_2O + Na_2SO_4$

(iv) $NaNO_3 + H_2SO_4 \rightarrow NaHSO_4 + HNO_3$

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

Q.13. Write balanced equation for the following reactions:

(i) Copper metal with conc. $\mathbf{HNO_3}$.

(ii) Zinc metal with conc. $\mathbf{HNO_3}$.

(iii) Carbon is treated with conc. $\mathbf{HNO_3}$.

(iv) Sulphur is treated with conc. $\mathbf{HNO_3}$.

(v) Phosphorus is treated with conc. $\mathbf{HNO_3}$.

Ans.

(i) $Cu + 4HNO_3(conc.) \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$

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

(iii) $C + 48HNO_3(conc.) \rightarrow 8H_2SO_4 + 48NO_2 + 16H_2O$

(iv) $S_8 + 48HNO_3(conc.) \rightarrow 8H_2SO_4 + 48NO_2 + 16H_2O$

(v) $P_4 + 20HNO_3(conc.) \rightarrow 4H_3PO_4 + 20NO_2 + 4H_2O$