STOICHIOMETRY

Short Answer Questions:

1. Balance the following redox reaction by ion- electron method taking place in acidic medium

$$Cr_2O_7^{2-} + NO_2^- \rightarrow Cr^{3+} + NO_3^-$$

Solution: Writing oxidation numbers

$$\overset{+6}{Cr_2}\,\overset{-2}{O_7^{-2}} + \overset{+3}{N}\,\overset{-2}{O_2^-} \rightarrow \overset{+3}{Cr^{+3}} + \overset{+5}{N}\,\overset{-2}{O_3^-}$$

Locating atoms undergoing change in oxidation numbers

$$\overset{+6}{Cr_2}\,O_7^{-2} + \overset{+3}{N}\,O_2^- \rightarrow \overset{+3}{Cr^{+3}} + \overset{+5}{N}\,O_3^-$$

Dividing the reaction into two halves and balancing in acidic medium, separately

Oxidation half-reaction: Reduction half-reaction

$NO_2^- \rightarrow NO_3^-$ $\qquad$ $Cr_2O_7^{-2} \rightarrow 2Cr^{+3}$

Step1:Balance oxygen atoms

$NO_2^- + H_2O \rightarrow NO_3^-$ $\qquad$ $Cr_2O_7^{-2} \rightarrow 2Cr^{+3} + 7H_2O$

Step2: Balance hydrogen atoms in acidic medium

$NO_2^- + H_2O \rightarrow NO_3^- + 2H^+$ $\qquad$ $Cr_2O_7^{-2} + 14H^+ \rightarrow 2Cr^{+3} + 7H_2O$

Step3: Balance the charge

$NO_2^- + H_2O \rightarrow NO_3^- + 2H^+ + 2e^-$ ...... (a) $\quad$ $Cr_2O_7^{-2} + 14H^+ + 6e^- \rightarrow 2Cr^{+3} + 7H_2O$ …… (b)

Equalising the electrons and adding the two halves.

eq (a) × 3 + eq (b) × 1, we get

$$3NO_2^- + 3H_2O \rightarrow 3NO_3^- + 6H^+ + 6e^-$$

$$Cr_2O_7^{-2} + 14H^+ + 6e^- \rightarrow 2Cr^{+3} + 7H_2O$$

$Cr_2O_7^{-2} + 3NO_2^- + 8H^+ \rightarrow 2Cr^{+3} + 3NO_3^- + 4H_2O$. This is the balanced equation.

2. Balance the following redox reaction by ion electron method taking place in acidic medium

$$MnO_4^{-1} + SO_3^{-2} \rightarrow Mn^{2+} + SO_4^{-2}$$

Solution: Writing oxidation numbers

$$\overset{+7}{Mn}\overset{-2}{O_4^-} + \overset{+4}{S}\overset{-2}{O_3^{-2}} \rightarrow \overset{+2}{Mn^{+2}} + \overset{+6}{S}\overset{-2}{O_4^{-2}}$$

Locating atoms undergoing change in oxidation numbers

$$\overset{+7}{Mn}O_4^- + \overset{+4}{S}O_3^{-2} \rightarrow \overset{+2}{Mn^{+2}} + \overset{+6}{S}O_4^{-2}$$

Dividing the reaction into two halves and balancing in acidic medium, separately

Oxidation half-reaction:

$$SO_3^{2-} \rightarrow SO_4^{2-}$$

Reduction half-reaction:

$$MnO_4^- \rightarrow Mn^{+2}$$

Step1:Balance oxygen atoms

$$SO_3^{2-} + H_2O \rightarrow SO_4^{2-}$$

$$MnO_4^- \rightarrow Mn^{+2} + 4H_2O$$

Step2: Balance hydrogen atoms in acidic medium

$$SO_3^{2-} + H_2O \rightarrow SO_4^{2-} + 2H^+$$

$$MnO_4^- + 8H^+ \rightarrow Mn^{+2} + 4H_2O$$

Step3: Balance the charge

$SO_3^{2-} + H_2O \rightarrow SO_4^{2-} + 2H^+ + 2e^-$ **...... (a)**

$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{+2} + 4H_2O$ **.... (b)**

Equalising the electrons and adding the two halves.

eq (a) × 5 + eq (b) × 2, we get

$$5SO_3^{2-} + 5H_2O \rightarrow 5SO_4^{2-} + 10H^+ + 10e^-$$

$$2MnO_4^- + 16H^+ + 10e^- \rightarrow 2Mn^{+2} + 8H_2O$$

$$2MnO_4^- + 5SO_3^{2-} + 6H^+ \rightarrow 2Mn^{+2} + 5SO_4^{2-} + 3H_2O$$

This is the balanced equation.

3. Iodate oxidises chromic hydroxide and gives iodide and chromate in basic medium.

Solution: The ionic skeleton equation is written as

$$IO_3^- + Cr(OH)_3 \xrightarrow{OH^-} I^- + CrO_4^{-2}$$

Writing oxidation numbers

$$\overset{+5}{I}\overset{-2}{O_3^-} + \overset{+3}{Cr}(\overset{-2}{O}\overset{+1}{H})_3 \rightarrow \overset{-1}{I^-} + \overset{+6}{Cr}\overset{-2}{O_4^{-2}}$$

Locating atoms undergoing change in oxidation numbers

$$\overset{+5}{I}O_3^- + \overset{+3}{Cr}(OH)_3 \rightarrow \overset{-1}{I^-} + \overset{+6}{Cr}O_4^{-2}$$

Dividing the reaction into two halves and balancing in basic medium, separately

Oxidation half-reaction:

$$Cr(OH)_3 \longrightarrow CrO_4^{-2}$$

Reduction half-reaction:

$$IO_3^- \longrightarrow I^-$$

Step1: Balance oxygen atoms

$$Cr(OH)_3 + H_2O \longrightarrow CrO_4^{-2}$$

$$IO_3^- \longrightarrow I^- + 3H_2O$$

Step2: Balance hydrogen atoms

$$Cr(OH)_3 + H_2O + 5OH^- \longrightarrow CrO_4^{-2} + 5H_2O$$

$$IO_3^- + 6H_2O \longrightarrow I^- + 3H_2O + 6OH^-$$

Step3: Balance charge

$Cr(OH)_3 + 5OH^- \longrightarrow CrO_4^{-2} + 4H_2O + 3e^-$ **...... (a)**

$IO_3^- + 3H_2O + 6e^- \longrightarrow I^- + 6OH^-$ **…... (b)**

Equalising the elements and adding the two halves

eq (a) × 2 + eq (b) × 1, we get

$$2Cr(OH)_3 + 10OH^- \longrightarrow 2CrO_4^{-2} + 8H_2O + 6e^-$$

$$IO_3^- + 3H_2O + 6e^- \longrightarrow I^- + 6OH^-$$

$IO_3^- + 2Cr(OH)_3 + 4OH^- \rightarrow$ **$I^- + 2\ CrO_4^{2-} + 5H_2O$ This is the balanced equation.**

4. White phosphorous reacts with aqueous caustic soda to give hypophosphite and phosphine.

Solution: The ionic skeleton equation is

$$P_4 \xrightarrow{OH^-} PH_3 + H_2PO_2^-$$

Writing oxidation numbers

$$\overset{0}{P_4} \rightarrow \overset{-3}{P}\overset{+1}{H_3} + \overset{+1}{H_2}\overset{+1}{P}\overset{-2}{O_2^-}$$

Locating atoms undergoing change in oxidation numbers

$$\overset{0}{P_4} \rightarrow \overset{-3}{P}H_3 + H_2\overset{+1}{P}O_2^-$$

d) Dividing the reaction into two halves and balancing in acidic medium, separately

Oxidation half-reaction:

$$P_4 \longrightarrow H_2PO_2^-$$

Step1: Balance phosphorous atoms

$$P_4 \longrightarrow 4H_2PO_2^-$$

Step2: Balance oxygen atoms

$$P_4 + 8H_2O \longrightarrow 4H_2PO_2^-$$

Step3:Balance hydrogen atoms

$$P_4 + 8H_2O + 8OH^- \longrightarrow 4H_2PO_2^- + 8H_2O$$

Step4: Balance charge

$P_4 + 8OH^- \longrightarrow 4H_2PO_2^- + 4e^-$ **..... (a)**

Reduction half-reaction:

$$P_4 \longrightarrow PH_3$$

$$P_4 \longrightarrow 4PH_3$$

$$P_4 \longrightarrow 4PH_3$$

$$P_4 + 12H_2O \longrightarrow 4PH_3 + 12OH^-$$

$P_4 + 12H_2O + 12e^- \longrightarrow 4PH_3 + 12OH^-$ **…(b)**

Equalising the electrons and adding the two halves

eq (a) × 3 + eq (b) × 1, we get

$$3P_4 + 24OH^- \longrightarrow 12H_2PO_2^- + 12e^-$$

$$P_4 + 12H_2O + 12e^- \longrightarrow 4PH_3 + 12OH^-$$

$$4P_4 + 12OH^- + 12H2O \longrightarrow 4PH_3 + 12H_2PO_2^-$$

$P_4 + 3OH^- + 3H2O \longrightarrow PH_3 + 3H_2PO_2^-$. This is the balanced equation.

5. A carbon compound contains 12.8% carbon, 2.1% hydrogen, 85.1% bromine. The molecular weight of the compound is 187.9. Calculate the molecular formula.

Solution:

Step1: Percentage composition of the elements present in the compound.

C	H	Br
12.8	2.1	85.1

Step2: Dividing with the respective atomic weights of the elements.

12.8/12= 1.067   2.1/1= 2.1   85.1/80= 1.067

Step3: Dividing by the smallest number to get simple atomic ratio.

1.067/1.067= 1   2.1/1.067= 2   1.067/1.067= 1

The empirical formula is CH_2Br. Empirical formula weight 12 + (2 x 1) + 80 = 94

The molecular weight = 187.9 (given)

$$n = \frac{187.9}{94} = 2$$

The molecular formula = (empirical formula)$_2$ $= (CH_2Br)_2 = C_2H_4Br_2$

6. What are disproportination and Comproportination reaction? Give one example to each.

Ans). The reactions in which the same element undergoing both oxidation and reduction simultaneously are called Disproportionation.

Examples;

a) Reaction of white phosphorous in aqueous caustic soda solution.

$$P_4 + 3NaOH + 3H_2O \rightarrow PH_3 + 3NaH_2PO_2$$

b) Reaction of hot concentrated potash with bromine.

$$6KOH + 3Br_2 \rightarrow 5KBr + KBrO_3 + 3H_2O$$

Comproportionation: The reverse of disproportionation is comproportionation. In a comproportionation reaction, two species with the same element in two different oxidation states form single product. The element in the product is in an intermediate oxidation state, between that in reactants.

Ex; Divalent silver oxidises metallic silver and it self is reduced to monovalent silver.

$$AgSO_4 + Ag \rightarrow Ag_2SO_4$$

7. Calculater the molarity of NaOH in a solution prepared by dissolving 4gm in enough water to form 250ml of the solution.

Solution: $Molarity = \frac{weightofsoluteX1000}{GMWXvolumeofsolutioninml} = \frac{4X1000}{40X250} = 0.4M$

Very Short Answer Questions

1. How many moles of glucose are present in 540 gm of glucose?

Ans. Molar mass of glucose is 180gm

Number of moles= weight/GMW= 540/180= 3moles.

2. Calculate the weight of 0.1 mole of Na_2CO_3?

Ans. Weight of 0.1 mole of Na_2CO_3= moles GMW= 0.1x106=10.6 gm

3.How many glucose molecules are present in 5.23 gm of glucose (Molecular weight of glucose is 180U)?

Ans. GMW i.e. 180 gm of Glucose= $6.023x10^{23}$ molecules.

5.23 gm of glucose = ?

$\therefore$ No. of glucose molecules= $\frac{5.23}{180} X\, 6.023 X 10^{23}$ = $1.75 \text{ x } 10^{22}$ molecules

4. Calculate the number of molecules present in $1.12 \text{ x } 10^{-7}$ c.c. of a gas a STP?

Solution: At STP, 22400 cc = 6.022×10^{23} molecules

At STP, $1.12 \text{ x } 10^{-7}$ c.c =?

Number of molcecules present in $1.12 \text{ x } 10^{-7}$ c.c at STP

$$= \frac{1.12 X 10^{-7}}{22400} X\, 6.023 \times 10^{23} = 3.01 \text{ x } 10^{12}$$

5. Empirical formula of a compound is CH_2O molecular weight is 90, find molecular formula of that compound?

Solution: Empirical formula of the compound = CH_2O

Empirical formula weight = (12) + (2 x 1) + 1(1 x 16) = 30

Molecular weight given = 90

$$\because \quad n = \frac{\text{Molecular weight}}{\text{Empirical formula weight}} = \frac{90}{30} = 3$$

Molecular formula =(Empirical formula)Xn= (CH_2O) X3 = $C_3 H_6O_3$

6. Calculate the oxidation number of chromium in (i) $Cr_2O_7^{-2}$ (ii) CrO_4^{-2}

Ans. Oxidation number of chromium in (i) $Cr_2O_7^{-2}$ $= 2x + 7(-2) = -2 \Rightarrow x = +6$

(ii) $CrO_4^{-2} = x + 4(-2) = -2 \Rightarrow x = +6$

7. Calculate the volume occupied by 2.5 Moles of a gas at STP?

Ans. volume of 1mole of a gas at STP= 22.4 lit

∴ Volume of 2.5 moles of a gas at STP= 2.5 X22.4 lit= 56 lit.

8. What volume of CO_2 is obtained at STP by heating 10gms of $CaCO_3$?

Ans. $CaCO_3 \rightarrow CaO + CO_2$

1 mole of $CaCO_3$ gives 1 mole of CO_2 i.e. 22.4 lit at STP

i.e. 100 gms of $CaCO_3$ gives 22.4 lit CO_2at STP

∴ Volume of CO_2 at STP given by 10 gms $CaCO_3$ $= \frac{10}{100} X\, 22.4 = 2.24 lit$

9. State (i) Law of definite proportions (ii) Law of multiple proportions

Ans. (i) Law of definite proportions states that "A given chemical substance always contains the same elements combined in a fixed proportion by weight."

(ii) Law of multiple proportions states that "If two elements chemically combine to give two or more compounds, then the weight of one element which combine with fixed weight of the other element in those compounds bear a simple multiple ratio to one another".

10. What is a red-ox reaction? Give an example?

Ans. The reaction in which both oxidation and reduction takes place simultaneously is called a Red-Ox reaction.

Ex; $Zn + CuSO_4 \longrightarrow Cu + ZnSO_4$

In the above reaction zinc under goes Oxidation and copper ion under goes reduction.