CHAPTER: 1:

MOLE CONCEPT

Part 1: Book Examples Problems:

Q·1: Calculate the weight of carbondioxide which can be obtained from the combustion of 12 gm of carbon monoxide in excess of oxygen. Also calculate the weight of oxygen consumed.

Soln:

We know,

$$\underset{(12gm)}{2CO} + \underset{(excess)}{O_2} \longrightarrow 2CO_2$$

Case (I): Calculating wt. of CO_2

Here, using principle of atom conservation,

moles of CO = moles of CO_2

or, $\frac{\text{wt of CO in gm}}{\text{molecular wt of CO}} = \frac{\text{wt. of } CO_2 \text{ in gm formed}}{\text{molecular wt of } CO_2}$

or, $\frac{12.0}{28} = \frac{x}{44}$ [∵ Let 'x' be the wt. of CO_2 obtained after combustion]

or, $x = \frac{12 \times 44}{28} = 18.85$ gm

∴ The weight of CO_2 obtained is 18.85 gm.

Case (II): Calculating wt. of O_2.

Here, using principle of atom conservation,

$\frac{1}{2}$ moles of CO = moles of O_2

or, $\frac{1}{2} \times \frac{\text{wt of CO in gm}}{\text{molecular wt of CO}} = \frac{\text{wt. of } O_2}{\text{molecular wt. of } O_2}$

let the wt. of oxygen be y, Then.

Q.3: A mi...

$\frac{1}{2} \times \frac{12}{28} = \frac{y}{32}$ or $y = \frac{1 \times 12 \times 32}{2 \times 28} = 6.85 gm.$

∴ The wt of oxygen consumed is 6.85 gm.

Q.2: A certain sulfide of iron contains 46.5% iron and 53.5% sulfur by weight. What is the empirical formula of the sulphide? (Mol wt of Fe = 55.8 and S = 32)

Sol^n:

Given,

mol. wt of Fe = 55.8 gm

mol. wt of S = 32 gm

Let the total mass of the sulphide be 100 gm.

Then,

mass of Iron in sulphide = 46.5 gm

mass of sulphur in sulphide = 53.5 gm

Now,

No. of moles of Iron (N_{Fe}) = $\frac{46.5}{55.8}$ = 0.833 moles

No. of moles of Sulphur (N_S) = $\frac{53.5}{32}$ = 1.671 moles.

Now, ratio = no. of moles of Iron : no. of moles of sulphur

$= \frac{0.833}{0.833} : \frac{1.671}{0.833}$

$= 1 : 2.006 \approx 2$

Thus, the empirical formula of iron sulphide is FeS_2.

Q.3: A certain sample of $KClO_3$ when decomposed yielded 673 cc of oxygen gas, measured at 273 K and 1 atm pressure. Calculate the original wt. of $KClO_3$ and the weight of KCl produced.

Soln:

We know,

$$2KClO_3 \longrightarrow 2KCl + 3O_2 \uparrow$$
(637 cc)

Here, stoichiometric relationship betn chemicals,

$$\frac{1}{2} \times \text{moles of } KClO_3 = \frac{1}{2} \times \text{moles of } KCl = \frac{1}{3} \times \text{moles of } O_2$$

Now, appling ~~mass~~ principle of atom conservation,

moles of O in R = moles of O in P

Using stoichiometric relationship,

$$\frac{1}{2} \times \text{moles of } KClO_3 = \frac{1}{3} \times \text{moles of } O_2$$

or, $3 \times \text{moles of } KClO_3 = 2 \times \text{moles of } O_2$

or, $$3 \times \frac{\text{wt. of } KClO_3 \text{ in gm}}{\text{Molecular wt of } KClO_3} = 2 \times \frac{\text{volume of } O_2 \text{ in litre}}{22.4 \text{ litres.}}$$

Let the original wt. of $KClO_3$ be x.

So,

$$3 \times \frac{x}{122.5} = 2 \times \frac{0.6\cancel{73}37}{22.4}$$

$$x = \frac{2 \times 0.6\cancel{73}37 \times 122.5}{3 \times 22.4} \qquad \therefore x = \cancel{2.453 \text{ gm}}\ 2.32 \text{ gm}$$

Again, Applying principle of atom conservation,

moles of K & Cl in R = moles of K & Cl in P

Using stiochiometric relationship,

$\frac{1}{2} \times$ moles of $KClO_3$ = $\frac{1}{2} \times$ moles of KCl.

or, $\frac{\text{wt. of } KClO_3 \text{ in gm}}{\text{molecular wt of } KClO_3} = \frac{\text{wt. of KCl in gram}}{\text{molecular wt of KCl}}$.

Let the weight of KCl produced be y. Then,

$$\frac{2.322}{122.5} = \frac{y}{74.5} \quad \text{or, } y = \frac{2.322 \times 74.5}{122.5} = 1.412 \text{ gm.}$$

Thus, the original weight of $KClO_3$ is 2.322gm and the weight of KCl produced is 1.412 gm.

Q.4: A sample of pure calcium metal weight 1.35 gm was quantitatively converted to 1.88 gm of pure CaO. If the atomic wt. of oxygen is taken to be 16, what is the atomic wt of calcium?

Soln:

Given,

mass of pure calcium metal = 1.35

mass of CaO = 1.88

$\therefore$ mass of O = 1.88 − 1.35 = 0.53 gm

We know,

$$2Ca + O_2 \longrightarrow 2CaO$$

Here, Stoichiometric relationship between chemicals,

$$\frac{1}{2} \times \text{moles of Ca} = \text{moles of } O_2 = \frac{1}{2} \times \text{moles of CaO}$$

Now, applying principle of ~~mass~~ atom conservation,
(ie, using relation (i) and (ii) (first two eqn))

$$\frac{1}{2} \times \text{moles of Ca} = \text{moles of } O_2$$

or, $\frac{1}{2} \times \frac{\text{wt. of Ca in gm}}{\text{Atomic wt of Ca}} = \frac{\text{wt. of } O_2 \text{ in grams}}{\cancel{\text{Atomic wt of O}} \text{ Mol. wt of } O_2}$

or, $\frac{1}{2} \times \frac{1.35}{x} = \frac{0.53}{32}$ [∵ Let x be the atomic wt. of Ca]

or, $\frac{1}{2} \times \frac{1.35 \times 32}{0.53} = x$ ∴ $x = 40.90$ gm.

Thus, the atomic wt of Calcium is 40.90 gm.

Q.5: In the gravimetric determination of Phosphorus, an aqueous solution of Dihydrogen phosphate Ion $H_2PO_4^-$, is treated with a mixture of ammonium and magnesium ions to precipitate Magnesium ammonium phosphate, $MgNH_4PO_4 \cdot 6H_2O$. This is heated and then decomposed to Magnesium pyrophosphate $Mg_2P_2O_7$, which is weighed. A soln of $H_2PO_4^-$ yielded 1.054 gm of $Mg_2P_2O_7$. what weight of NaH_2PO_4 was present originally.

Soln:

The reactions are;

$$H_2PO_4^- + Mg^{++} + NH_4^+ + 6H_2O \longrightarrow MgNH_4PO_4 \cdot 6H_2O + 2H^+ \quad \text{(i)}$$

$$2MgNH_4PO_4 \cdot 6H_2O = Mg_2P_2O_7 + 2NH_3 + 13H_2O \quad \text{(ii)}$$

Using principle of atom conservation, the stoichiometric relationship is;

For reaction (iii);

$$\frac{1}{2} \times \text{moles of } MgNH_4PO_4 \cdot 6H_2O = 1 \text{ mole of } Mg_2P_2O_7 \quad \text{(iii)}$$

For reaction (i);

$$1 \text{ mole of } NaH_2PO_4 = 1 \text{ mole of } MgNH_4PO_4 \cdot 6H_2O$$

Using eq^n(iii);

$\frac{1}{2} \times$ moles of $MgNH_4PO_4 \cdot 6H_2O$ = 1 mole of $Mg_2P_2O_7$

or, $\frac{1}{2} \times \frac{\text{wt. of } MgNH_4PO_4 \cdot 6H_2O}{\text{molecular wt of } MgNH_4PO_4 \cdot 6H_2O} = \frac{\text{wt. of } Mg_2P_2O_7 \text{ in gm}}{\text{molecular wt. of } Mg_2P_2O_7}$

Let the wt. of $MgNH_4PO_4 \cdot 6H_2O$ be x.

Then,

$$\frac{1}{2} \times \frac{x}{241} = \frac{1.054}{222}$$

or, $x = \frac{1.054 \times 2 \times 241}{222}$ $\therefore x = 2.288$ gm

Again, using eq^n (iv);

1 mole of NaH_2PO_4 = 1 mole of $MgNH_4PO_4 \cdot 6H_2O$

or, $\frac{\text{wt. of } NaH_2PO_4 \text{ in gm}}{\text{molecular wt. of } NaH_2PO_4} = \frac{\text{wt. of } MgNH_4PO_4 \cdot 6H_2O}{\text{molecular wt of } MgNH_4PO_4 \cdot 6H_2O}$

Let the weight of ~~to~~ 'NaH_2PO_4' be y gm.

Then,

$$\frac{y}{118} = \frac{2.288}{241} \quad \text{or, } y = \frac{2.288 \times 118}{241}$$

$\therefore y = 1.121$ gm

The weight of NaH_2PO_4 present originally is 1.121 gm.

Q.6: A sample of K_2CO_3 weighing 27.6 gm was treated ~~was~~ by a series of reagents so as to convert all of its carbon to $K_2Zn_3[Fe(CN)_6]_2$. How many grams of this product were obtained?

Soln:

Here,

$$12 K_2CO_3 + \ldots\ldots \longrightarrow K_2Zn_3[Fe(CN)_6]_2$$

~~(1 mole of C)~~ ~~(12 mole of carbon)~~

Applying the principle of atom conservation, the stoichiometric relationship betn chemicals,

$$\frac{1}{12}\text{ mole of } K_2CO_3 = \cancel{\tfrac{1}{12}}\text{ 1 mole of } K_2Zn_3[Fe(CN)_6]_2$$

or, $$\frac{\text{wt of } K_2CO_3 \text{ in gm}}{\text{Molecular wt of } K_2CO_3} = 12 \times \frac{\text{wt of } K_2Zn_3[Fe(CN)_6]_2}{\text{Molecular wt of } K_2Zn_3[Fe(CN)_6]_2}$$

or, $$\frac{27.6}{138} = \frac{12}{1} \times \frac{y}{697.8}$$ [Let the wt of $K_2Zn_3[Fe(CN)_6]_2$ be y]

or, $$y = \frac{27.6 \times 697.8}{138 \times 12}$$

$\therefore y = 11.6$ gm.

$\therefore$ 11.6 gm of $K_2Zn_3[Fe(CN)_6]_2$ is obtained as product.

Q.8: One volume of a gaseous compound of Hydrogen, Carbon and Nitrogen gave upon combustion: ~~2 moles of~~ 2 volume of CO_2, 3.5 volume of H_2O and 0.5 volume of N_2, all measured at same temperature and pressure. What is the empirical formula of the compound? Can molecular formula be found from this data?

Soln:

Here,

$$\underset{1\text{ vol}}{C_xH_yN_z} \longrightarrow \underset{2\text{ vol}}{CO_2} + \underset{3.5\text{ vol}}{H_2O} + \underset{0.5\text{ vol.}}{N_2}$$

According to Avogadro's hypothesis,

1 mole — 2 mole — 3.5 mole — 0.5 mole

Here,

moles for C-atom = No. of moles of CO_2 = 2 mole

moles for H-atom = (No. of moles of H_2O) × 2 = 2 × 3.5 = 7 mole.

moles for N-atom = (No. of moles of N_2) × 2 = 2 × 0.5 = 1 mole

Hence,

Ratio of moles of C, H and N = 2 : 7 : 1

So, empirical formula = C_2H_7N

Since 1 mole of $C_xH_yN_2$ can give only ~~contains~~ 2 moles of C-atom,

Molecular formula = C_2H_7N or, $C_2H_5NH_2$
(ethylamine)

Q.7: One gram of a gaseous compound of carbon and hydrogen gives upon combustion 3.3 gm of carbon and 0.899 gm of water. In separate experiement, the density of gaseous sample is found to be 1.78 gm/L under STP. What is the empirical and molecular formula of the compound.

Soln.

Here,

$$\underset{1\ gm}{C_xH_y} + O_2 \xrightarrow{\Delta} \underset{3.3\ gm}{CO_2} + \underset{0.899\ gm}{H_2O}$$

Now,

no. of mole of C-atom = $\dfrac{\text{wt. of carbon}}{\text{Mole. } \cancel{\text{Atomic}} \text{ wt of } CO_2}$

$= \dfrac{3.3}{44} = 0.075$ ~~gm~~ mole.

No. of mole of H-atom $= \dfrac{2 \times \text{wt of } H_2O \text{ in gm}}{\text{Molecular wt of } H_2O}$

$= \dfrac{2 \times 0.899}{18} = 0.0998$

Now,

ratio = no. of moles of C-atom : no. of moles of H-atom.

$= \dfrac{0.075}{0.075} : \dfrac{0.0998}{0.075} = 1 : 1.33$

$\approx 3 : 4$

Thus, the empirical formula of the gaseous compound is C_3H_4.

So, EF weight (EF_{wt}) = 40

Now, we know,

1 litre of gas weights 1.87 gms

So,

22.4 litres of gas weights 1.87×22.4

$= 41.888$ gm

$n = \dfrac{41.888}{40} = 1.047 \approx 1$

So, molecular formula (MF) = $(EF) \times n$

$= C_3H_4$.

∴ The empirical formula is C_3H_4 and the molecular formula is C_3H_4.

Q 9: A 1 gm mixture of cuprous oxide and cupric oxide, CuO was quantitatively reduced to 0.839 gm of metallic copper. What was the weight of CuO in original sample?

Soln.

Given,

Atomic wt of Cu = 63.5 gm

We know,

$$Cu_2O + CuO \longrightarrow Cu + O_2$$

(Mix wt = 1gm) (0.839 gm)

Using principle of atom conservation,

mole of Cu in R = moles of Cu in P

2 x moles of Cu_2O + 1x mole of CuO = 1x mole of Cu

$$2 \times \frac{\text{wt of } Cu_2O \text{ in gm}}{\text{Mol. wt of } Cu_2O} + 1 \times \frac{\text{wt of CuO}}{\text{Mol wt of CuO}} = \frac{\text{wt of Cu}}{\text{Atomic wt of Cu}}$$

Let 'w' be the weight of CuO, then.

wt of Cu_2O = 1-w

So,

$$2 \times \frac{(1-w)}{143} + \frac{w}{79.5} = \frac{0.839}{63.5}$$

or, $$\frac{2-2w}{143} + \frac{w}{79.5} = \frac{0.839}{63.5}$$

or, $$2 \times 79.5 - 2 \times 79.5w + 143w = \frac{0.839}{63.5} \times 143 \times 79.5$$

$\therefore$ w = 0.55 gm

$\therefore$ The weight of CuO in original sample is 0.55 gm.

Q.10: A mixture of aluminium and zinc weighing 1.67 gm was completely dissolved in acid and evolved 1.69 litres of Hydrogen measured at STP. What is the weight of Aluminium in original mixture?

Soln.

Given,

wt of mixture of aluminium and zinc = 1.67 gm

volume of hydrogen evolved = 1.69 litres.

The reactions are;

$$Zn + 2H^+ \longrightarrow Zn^{++} + H_2$$

$$Al + 3H^+ \longrightarrow Al^{3+} + 3/2\, H_2$$

Let the weight of Al be x such that weight of Zn = $1.67 - x$ gm.

Using principle of atom conservation,

1 moles of Zn + $\frac{3}{2}$ moles of Al = 1 mole of H_2

or, $$\frac{1.67 - x}{63.5} + \frac{3}{2} \times \frac{x}{27} = \frac{1.69}{22.4}$$

or, $$\frac{1.67 - x}{63.5} + \frac{3x}{54} = \frac{1.69}{22.4}$$

or, $$\frac{1.67 \times 18 - 18x + 63.5x}{63.5 \times 18} = \frac{1.69}{22.4}$$

or, $$\frac{1.69}{22.4} \times 63.5 \times 18 = 30.06 + 45.5x$$

or, $$x = \frac{-30.06 + \left(\frac{1.69}{22.4} \times 63.5 \times 18\right)}{45.5}$$

$\therefore x = 1.23$ gm

The weight of Al is 1.23 gm.

Q.11: A carefully purified sample of Potassium Chlorate $KClO_3$, weighing 4.008 gm, was quantitatively decomposed to 2.438 gm of potassium chloride (KCl) and oxygen. The potassium chloride was dissolved in water and treated with a silver nitrate solution. The result was a precipitate of silver chloride, AgCl weighing 4.687 gm. Under further treatment, the silver chloride was found to contain 3.351 gm of silver. What are the weights of Silver, chlorine and potassium relative to O = 15.999 ?

Soln:

The sequence of reactions;

$$2KClO_3 \xrightarrow[\Delta]{} 2KCl + 3O_2 \quad \text{— (i)}$$

(4.008 gm) (2.438 gm)

(ii) $KCl_{(aq)} + AgNO_{3\,(aq)} \longrightarrow AgCl$ — (ii)

(4.687 gm)

wt. of Ag = 3.531 gm.

From reaction (i);

Using principle of atom conservation, the stoichiometric relationship is;

$$\frac{1}{2} \times \text{moles of KCl} = \frac{1}{3} \text{ moles of } O_2$$

So, $\text{moles of } O_2 = \frac{3}{2} \times \text{moles of KCl.}$

or, $\frac{(4.008 - 2.438)}{32} \times \frac{2}{3} = \text{moles of KCl.}$

∴ Moles of KCl = 0.0327 moles

Also,

$$\text{Mol. wt of KCl} = \frac{\text{given wt of KCl}}{\text{Moles of KCl}} = \frac{2.438}{0.0327} = 74.55 \text{ gm/mol.}$$

From reaction (ii);

Using principle of atom conservation, the stoichiometric ~~coefficient is,~~ relationship is,

1 mole of Ag = 1 mole of KCl.

~~or, 4.687~~ or, $\frac{3.531}{\text{atomic wt of Ag}} = 0.0327$

$\therefore$ Atomic wt of Ag = 107.98 gm/mol.

Now,

weight of chlorine = 4.687 − 3.351
= 1.336 gm

Here,

Atomic wt of chlorine = Molecular wt of AgCl − At. wt of Ag. — (iii)

For molecular wt of AgCl,

1 mole of AgCl = 1 mole of KCl

or, $\frac{4.687}{\text{Mol. wt of AgCl}} = 0.0327$

$\therefore$ Mol. wt of AgCl = 143.3 gm/mol.

Using in eq^n (iii), we get

Atomic wt of Chlorine = 143.3 gm/mol − 107.98 gm/mol
= 35.32 gm/mol.

So,

Atomic wt of potassium = 74.55 gm/mol − 35.32 gm/mol
= 39.23 gm/mol.

So, atomic wt of silver, chlorine, potassium w.r.t O = 15.999 is 107.98, 35.32 and 39.23 gm/mol respectively.

Exercise Problems:

Q.1): An oxide of Antimony is found to contain 24.73% oxygen. what is the empirical formula?

Soln:

Given,

Atomic wt of Sb = 121.8

We know,

Atomic wt. of Oxygen = 16

Let the total mass of the Antimony oxide be 100gm.

Then,

wt. of oxygen = 24.73 gm

wt of Antimony = 100 - 24.73 = 75.27 gm

Now,

no. of moles of oxygen = $\frac{24.73}{16}$ = 1.545

no. of moles of Antimony = $\frac{75.27}{121.8}$ = 0.617

So,

ratio of i.e. relative no. of moles = $\frac{0.617}{0.617} : \frac{1.545}{0.617}$

= 1 : 2.5

= 2 : 5

∴ The empirical formula for the Antimony oxide is Sb_2O_5.

Q.27: When 0.210 gm of a compound containing only hydrogen and carbon was burned, 0.660 gm of CO_2 was recovered. What is the empirical formula of this compound? A determination of the density of this hydrocarbon gave a value of 1.87 gm/L at STP. What is the molecular formula of the compound?

Soln:

Here,

$$C_xH_y + O_2 \xrightarrow{\Delta} CO_2 + H_2O$$

Given,

wt. of hydrocarbon = 0.210 gm

density of hydrocarbon = 1.87 gm/L

wt. of CO_2 = 0.660 gm.

Here,

No of moles of C-atom = no. of moles of CO_2

$= \frac{0.660}{44} = 0.015$ moles.

So,

wt. of C-atom = ~~0.01~~ No. of moles x At. wt of C

$= 0.015 \times 12$

$= 0.18$ gm.

∴ The weight of Hydrogen = $0.210 - 0.180$

$= 0.03$ gm

No. of moles of H = $\frac{0.03}{1} = 0.03$ moles.

Now,

Relative no. of moles = ~~0.03~~ no of moles of C : no of moles of H

$$= \frac{0.015}{0.015} : \frac{0.03}{0.015}$$

$$= 1 : 2$$

∴ The empirical formula is CH_2.

Now,

EF weight = 14 gm

We know,

~~1 g~~ 1. litre of ~~hydrogen~~ carbon hydrocarbon weighs 1.87 gm

So,

22.4 litres of hydrocarbon weighs 1.87×22.4

$= 41.888$ gm

Now,

$$n = \frac{MF\,wt}{EF\,wt} = \frac{41.888}{14} \approx 3$$

So,

Molecular formula = (Empirical formula) × n

$= (CH_2) \times 3$

$= C_3H_6$.

The empirical formula is CH_2 and the molecular formula is C_3H_6.

Q.3: A sample of europium dichloride ($EuCl_2$) weighing 1 gm is treated with excess aqueous silver nitrate, and all the chloride is recovered as 1.29 gm of AgCl. What is the atomic mass of Europium?

Soln

~~We~~ Given,

$$EuCl_2 + 2AgNO_3 \longrightarrow 2AgCl + Eu(NO_3)_2$$

(1 gm) (1.29 gm)

According to principle of atom conservation, the stoichiometric relationship is

$$1 \text{ mole of } EuCl_2 = \frac{1}{2} \times \text{no. of moles of } AgCl$$

or, $2 \times \frac{1}{x+71} = \frac{1.29}{107.9 + 35.5}$ [$\because$ Let the at. wt of Eu be x]

or, $\frac{2 \times 143.4}{1.29} = x + 71$

$\therefore x = 151.32$ gm/mol.

$\therefore$ The atomic wt. of Europium is 151.32 gm/mol.

Q.47: A sample of an oxide of iron weighing 1.6 gm was heated in a stream of hydrogen gas until it was completely converted to 1.12 gm metallic iron. What is the empirical formula of the iron oxide?

Soln:

Given,

At. wt of Fe = 55.8

At. wt of O = 16

and,

$$Fe_xO_y + H_2 \xrightarrow{\Delta} Fe + H_2O$$

1.6 gm 1.12 gm

Now,

no. of moles of Fe $= \frac{1.12}{55.8} = 0.020$ moles

wt. of oxygen in compound $= 1.6 - 1.12$
$= 0.48$ gm

$\therefore$ no. of moles of O-atom $= \frac{0.48}{16} = 0.03$

Now,
Relative no. of moles = no. of moles of Fe : no. of moles of O

$$= \frac{0.020}{0.020} : \frac{0.030}{0.020}$$

$$= 1 : 1.5$$

$$= 2 : 3$$

$\therefore$ The empirical formula of the iron-oxide is Fe_2O_3.

Q.5: When Barium Bromide is heated in a stream of chloride gas, it is completely converted to Barium chloride ($BaCl_2$). From 1.5 gm $BaBr_2$ only 1.05 gm of $BaCl_2$ is obtained. Calculate the atomic wt of Barium from this data.

Soln:

Given;
At. wt. of Br = 79.9
The reaction is,

$$\underset{1.5\text{ gm}}{BaBr_2} + Cl_2 \xrightarrow{\Delta} \underset{1.05\text{ gms}}{BaCl_2}$$

Using principle of atom conservation, the stoichiometric relationship is.

1 mole of $BaBr_2$ = 1 mole of $BaCl_2$.

or, $$\frac{1.5}{x + 79.9 \times 2} = \frac{1.05}{x + 71}$$

or, $1.5x + 106.5 = 1.05x + 167.79$

or, $0.45x = 61.29$

$\therefore x = 136.2$ gm/mol

$\therefore$ The atomic wt of Barium is 136.2 gm/mol.

Q.6>: A 0.578 gm sample of pure tin is treated with gaseous fluorine until the weight of the resulting compound is measured at 0.944 gm. What is the empirical formula of the tin fluoride? Write an equation for its synthesis.

Soln:

Here,

$$\underset{(0.578\,gm)}{Sn} + F_2 \longrightarrow \underset{(0.944\,gm)}{Sn_xF_y}$$

Now,

weight of fluorine $= (0.944 - 0.578)$ gm
$= 0.366$ gm

no. of moles of Sn $= \dfrac{0.578}{\cancel{0.944}\ 118.7} = 4.869 \times 10^{-3}$ moles.

no. of moles of F $= \dfrac{0.366}{\cancel{\ }19} = 0.019$ moles.

Now,
relative no. of moles = no. of moles of Sn : no. of moles of F

$$= \frac{4.869\times10^{-3}}{4.8689\times10^{-3}} : \frac{0.019}{4.689\times10^{-3}}$$

$$= 1:4$$

$\therefore$ The empirical formula of Tin oxide is SnF_4.
So, the equation is: $Sn + 2F_2 \longrightarrow SnF_4$.

(Q.7): Equal weights of zinc metal and iodine are mixed together and the iodine is completely converted to ZnI_2. what fraction by weight of original zinc remains unreacted?

Soln:

Given,

Atomic wt. of iodine = 126.9

Atomic wt of zinc = 65.38

According to question, equal mass of the reactants react and certain amount ~~is~~ of zinc is left unreacted.

Let 'x' be the weight of reactants combining and 'y' be the original zinc that is leftover.

$$\underset{x}{2Zn} + \underset{x}{I_2} \longrightarrow \underset{(2x-y)\text{ gm}}{ZnI_2} + \underset{y}{Zn_{(\text{leftover})}}$$

Using principle of conservation of atom, the stoichiometric relationship is

$\frac{1}{2} \times$ no. of moles of Zn $= 1 \times$ no. of moles of ZnI_2

or, $\frac{x}{65.38} = 2 \times \frac{(2x-y)}{317.3}$

or, $\frac{x}{65.38} = \frac{4x-2y}{317.3}$

or, $317.3x = 261.52x - 130.76y$

or,

$\frac{1}{2} \times$ no. of moles of Zn $= 1 \times$ no. of moles of ZnI_2 ~~+ 1 × no. of moles of Zn unreacted~~.

$= \frac{1}{2} \times$ no. of moles of I_2

No. of moles of Zn in reactant side = $\frac{x}{65.38}$

No. of moles of I_2 in reactant side = $\frac{x}{253.8}$

Since some zinc is left over after reaction during formation of ZnI_2,

$$y = \left(\frac{x}{65.38} - \frac{x}{253.8}\right)$$

$$= \frac{253.8x - 65.38x}{16593.444} \quad \therefore y = \frac{188.42x}{16593.444}$$

So, the fraction of Zn that remained unreacted

$$= \frac{\frac{188.42x}{16593.444}}{\frac{x}{65.38}}$$

$$= \frac{188.42x}{16593.444} \times \frac{65.38}{x}$$

$$= 0.74$$

$\therefore$ ~~The~~ 0.74 fraction by weight of zinc remains unreactant.

Q.8): A 4.22 gm sample of a mixture of $CaCl_2$ and NaCl was treated to precipitate all the calcium as $CaCO_3$, which was then heated and converted to pure CaO. The final weight of the CaO was 0.959 gm. What was the % by weight of $CaCl_2$ in the original mixture?

Soln.

Reaction:

$$\underbrace{CaCl_2 + NaCl}_{4.22\ gm} \longrightarrow CaCO_3 \xrightarrow{\Delta} \underbrace{CaO}_{0.959\ gm}$$

Using principle of atom conservation, the stoichiometric coefficients is;

no. of moles of Ca in $CaCl_2$ = no of moles of Ca in CaO

or, $\frac{\text{wt. of } CaCl_2}{\text{mol. wt of } CaCl_2} = \frac{\text{wt. of CaO}}{\text{Mol. wt of CaO}}$

Let 'x' be the wt. of $CaCl_2$. Then,

or, $\frac{x}{111} = \frac{0.959}{56}$

or, $x = \frac{0.959 \times 111}{56}$ $\quad \therefore x = 1.900$ gm

So, % of weight of $CaCl_2$ in mixture $= \frac{1.9}{4.22} \times 100\%$

$= 45.02\%$

45.02% of the reactant mixture consists of $CaCl_2$.

Q.9: An alloy of Aluminium and Copper was treated with aqueous HCl. The aluminium dissolved according to the reaction. $Al + 3H^+ \longrightarrow Al^{3+} + 3/2 H_2$, but the copper remained as pure metal. A 0.35 gm sample of alloy gave 415 cc of H_2 measured at STP. What is the % of weight of Al in the alloy?

Soln:

Given reaction;

$$Al + 3H^+ \longrightarrow Al^{3+} + \frac{3}{2} H_2$$

Using principle of conservation of atoms, the stoichiometric relationship becomes,

$1 \times$ no. of moles of Al $= \frac{1r}{3/2} \times$ no. of moles of H_2

or, $\frac{3}{2} \times \frac{\text{wt of Al}}{\text{At. wt of Al}} = \frac{\cancel{\text{wt of}}\ \text{volume of } H_2 \text{ in cc}}{22400 \text{ cc}}$

or, $\frac{3}{2} \times \frac{x}{27} = \frac{415}{22400}$ [∵ Let the weight of Al be x.]

or, $x = \frac{415 \times 2 \times 27}{3 \times 22400}$ ∴ $x = 0.333$ gm

Now,

% of Al in alloys $= \frac{0.333}{0.350} \times 100\%$

$= 95.14\%$

The alloy contains 95.14% Aluminium.

Q.10): A sample of pure lead weighing 2.07 gm is dissolved in nitric acid to give a solution of lead nitrate. This solution is treated with hydrochloric acid, chlorine gas and ammonium chloride. The result is the ~~pr~~ precipitation of Ammonium hexachloroplumbate $[(NH_4)_2PbCl_6]$ {~~45~~ 456.2}. what is the maximum weight of the product that can be obtained from the lead sample?

Soln:

Given reaction,

$$\underset{(2.07\text{ gm})}{Pb} + H_3NO_3 \longrightarrow Pb(NO_3)_2 + HCl + Cl_2 + NH_4Cl \rightarrow \underset{(456.2\text{ gm})}{(NH_4)_2PbCl_6}$$

Using the principle of atom conservation;

No of mole of Pb = ~~No~~ of mole of $(NH_4)_2PbCl_6$

or, $\frac{\text{wt of Pb}}{\text{At wt of Pb}} = 1 \times \frac{x}{\text{Mol. wt of } (NH_4)_2PbCl_6}$ [∵ Let x be the maximum wt of product.]

or, $\frac{2.07}{207.2} = 1 \times \frac{x}{456.2}$

or $x = \frac{2.07 \times 456.2}{207.2}$ ∴ $x = 4.5576$ gm.

∴ The maximum weight of $(NH_4)_2PbCl_6$ obtained is 4.5576 gm

Q.11: A 0.596 gm sample of a gaseous compound containing only Boron and Hydrogen occupies 484 cc at STP. When the compound was ignited in excess oxygen, all the hydrogen was recovered as 1.17 gm of H_2O, and the boron was present as B_2O_3. What is the empirical formula, the molecular formula and the molecular weight of Boron-Hydrogen compound? What weight of B_2O_3 was produced by the combustion? (At. wt. of B = 10.8)

Soln:

$$B_xH_y + O_2 \longrightarrow H_2O + B_2O_3$$

0.596 gm (of B_xH_y), 1.17 gm (of H_2O)

484 cc at STP.

Now,

484 cc of B_xH_y weighs 0.596 gm

so,

22400 cc of B_xH_y weighs $\frac{0.596 \times \cancel{484}\ 22400}{\cancel{22400}\ 484}$ gm

∴ Mol wt of B_xH_y = 27.58 gm/mol. —(i)

Also,

$y \times$ no. of moles of B_xH_y = $2\times$ no. of moles of H_2O

or, $y \times \frac{0.596}{27.58} = 2 \times \frac{1.17}{18}$

or, $y = \frac{2 \times 1.17 \times 27.58}{0.596 \times 18}$ $\therefore y = 6.01 \approx 6$

From (i):

$x \times 10.8 + 6 \times 1 = 27.58$

$\therefore x = 1.99 \approx 2$

Hence, the molecular formula is B_2H_6.

So, the ratio of relative moles = 2:6
= 1:3

$\therefore$ The empirical formula is BH_3.

Now, we know,

$$B_2H_6 + O_2 \longrightarrow H_2O + B_2O_3$$

Here,

no. of moles of B_2H_6 = No. of moles of B_2O_3

or, $\frac{\text{wt of } B_2H_6}{\text{mol. wt of } B_2H_6} = \frac{\text{wt. of } B_2O_3}{\text{mol. wt of } B_2O_3}$

or, $\frac{0.596}{27.6} = \frac{z}{69.6}$ [$\because$ Let the weight of B_2O_3 be z]

$\therefore z = 1.503$ gm

$\therefore$ The weight of B_2O_3 produced is 1.503 gm after combustion.

Q.12: A sample of an unknown oxide of barium gave upon exhaustive heating 5 gm of pure BaO and 366 cc of oxygen gas measured at STP. What is the empirical formula of the unknown oxide? What weight of oxide are present initially?

Soln:

~~Ba_xO_y~~ $Ba_xO_y + O_2 \longrightarrow BaO + O_2 \uparrow$

(5gm) (366cc)

Given,

At. wt of Ba = 137.33.

Here,

No. of moles of Oxygen $= \frac{366}{22400} = 0.016$ mole

~~Using principle of atom conservation,~~

~~$x \times$ no. of moles of Ba_xO_y = $1 \times$ no. of moles of BaO~~

No. of moles of BaO $= \frac{5}{153.33} = 0.032$ mole.

Now,

ratio of relative moles of ~~0.016~~ BaO : O_2

$= \frac{0.032}{0.016} : \frac{0.016}{0.016}$

$= 2 : 1$

~~So,~~

~~We have,~~

~~$Ba_xO_y + O_2 \longrightarrow 2BaO + O_2$~~

So,

ratio of relative moles of BaO : O

$= \frac{0.032}{0.016} : \frac{0.032}{0.016}$

$= 1 : 1$

Hence, the empirical formula is BaO_2.

~~Now,~~

$\cancel{BaO_2 + O_2 \longrightarrow BaO + O_2}$

Q<13>: A fraction of KBr and NaBr weighing 0.56 gm was treated with aq Ag^+ and all bromide ion was recovered as 0.97 gm of pure AgBr. What was the fraction by weight of KBr in sample?

Soln.

We have,

$$\underbrace{KBr + NaBr}_{0.56\,gm} + Ag^+ \longrightarrow \underbrace{AgBr}_{0.97\,gm}$$

Given,

At wt of Ag = 107.98

At wt of Br = 79.9.

Now,

$$\text{no. of moles of AgBr} = \frac{0.97}{(107.98 + 79.9)} = 5.162 \times 10^{-3} \text{ moles.}$$

Using principle of atom conservation;

$1 \times$ no. of moles of KBr + $1 \times$ no. of moles of NaBr = $1 \times$ no. of moles of AgBr

or, $$\frac{x}{118.9} + \frac{0.56 - x}{102.9} = 5.162 \times 10^{-3}$$

or, $102.9x + 118.9(0.56 - x) = 5.162 \times 10^{-3} \times 118.9 \times 102.9$

or, $102.9x + 66.584 - 118.9x = 63.156$

or, $16x = 3.428$ $\therefore x = 0.214$

$$\therefore \text{Fraction by wt. of KBr} = \frac{0.214}{0.56} = 0.38$$

$\therefore$ The fraction of KBr in sample is 0.38.