

CHAPTER: 1:

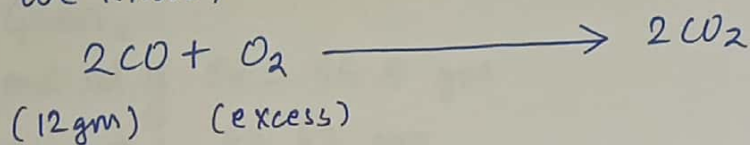
MOLE CONCEPT

Part 1: Book Examples Problems:

Q.1: Calculate the weight of carbon dioxide 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,



Case (I): Calculating wt. of CO_2

Here, using principle of atom conservation,
moles of $\text{CO} = \text{moles of CO}_2$

$$\text{or, } \frac{\text{wt of CO in gm}}{\text{molecular wt of CO}} = \frac{\text{wt. of CO}_2 \text{ in gm formed}}{\text{molecular wt of CO}_2}$$

$$\text{or, } \frac{12.0}{28} = \frac{x}{44} \quad \left[\because \text{Let 'x' be the wt. of CO}_2 \text{ obtained after combustion} \right]$$

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

\therefore 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 $\text{CO} = \text{moles of O}_2$

$$\text{or, } \frac{1}{2} \times \frac{\text{wt of CO in gm}}{\text{molecular wt of CO}} = \frac{\text{wt. of O}_2}{\text{molecular wt. of O}_2}$$

Let the wt. of oxygen be y , Then.

Q.3: A metal

$$\frac{1}{2} \times \frac{12}{28} = \frac{y}{32}$$

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

∴ 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)

Solⁿ:

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,

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

$$\text{No. of moles of Sulphur (N}_{\text{S}}) = \frac{53.5}{32} = 1.671 \text{ moles.}$$

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,



Here, stoichiometric relationship betⁿ chemicals,

$$\frac{1}{2} \times \text{moles of } \text{KClO}_3 = \frac{1}{2} \times \text{moles of } \text{KCl} = \frac{1}{3} \times \text{moles of } \text{O}_2$$

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

$$\text{moles of O in R} = \text{moles of O in P}$$

Using stoichiometric relationship,

$$\frac{1}{2} \times \text{moles of } \text{KClO}_3 = \frac{1}{3} \times \text{moles of } \text{O}_2$$

$$\text{or, } 3 \times \text{moles of } \text{KClO}_3 = 2 \times \text{moles of } \text{O}_2$$

$$\text{or, } 3 \times \frac{\text{wt. of } \text{KClO}_3 \text{ in gm}}{\text{Molecular wt of } \text{KClO}_3} = 2 \times \frac{\text{Volume of } \text{O}_2 \text{ in litre}}{22.4 \text{ litres.}}$$

Let the original wt. of KClO_3 be x .

So,

$$3 \times \frac{x}{122.5} = 2 \times \frac{0.673}{22.4}$$

$$x = \frac{2 \times 0.673 \times 122.5}{3 \times 22.4} \quad \therefore x = 2.453 \text{ gm } 2.32 \text{ gm}$$

Again, Applying principle of atom conservation,

$$\text{moles of K + Cl in R} = \text{moles of K + Cl in P}$$

Using stoichiometric relationship,

$$\frac{1}{2} \times \text{moles of } \text{KClO}_3 = \frac{1}{2} \times \text{moles of } \text{KCl}.$$

$$\text{or, } \frac{\text{wt. of } \text{KClO}_3 \text{ in gm}}{\text{molecular wt of } \text{KClO}_3} = \frac{\text{wt. of } \text{KCl in gram}}{\text{molecular wt of } \text{KCl}}.$$

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 2.322 gm 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

$$\therefore \text{mass of O} = 1.88 - 1.35 = 0.53 \text{ gm}$$

We know,



Here, stoichiometric relationship between chemicals,

$$\frac{1}{2} \times \text{moles of Ca} = \text{moles of } \text{O}_2 = \frac{1}{2} \times \text{moles of CaO}$$

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

$$\frac{1}{2} \times \text{moles of Ca} = \text{moles of } \text{O}_2$$

$$\text{or, } \frac{1}{2} \times \frac{\text{wt. of Ca in gm}}{\text{Atomic wt of Ca}} = \frac{\text{wt. of O}_2 \text{ in grams}}{\text{Atomic wt of O} \times \text{mol. wt of O}_2}$$

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

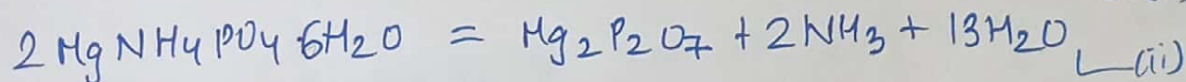
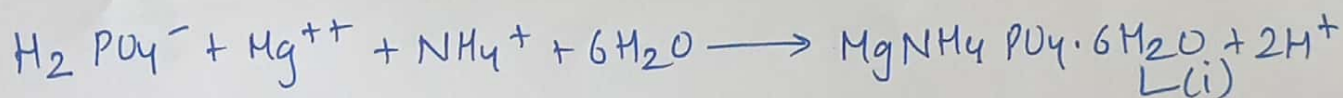
$$\text{or, } \frac{1}{2} \times \frac{1.35 \times 32}{0.53} = x \quad \therefore x = 40.90 \text{ gm.}$$

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, $\text{MgNH}_4\text{PO}_4 \cdot 6\text{H}_2\text{O}$. This is heated and then decomposed to Magnesium pyrophosphate $\text{Mg}_2\text{P}_2\text{O}_7$, which is weighed. A solⁿ of H_2PO_4^- yielded 1.054 gm of $\text{Mg}_2\text{P}_2\text{O}_7$. What weight of NaH_2PO_4 was present originally.

Solⁿ:

The reactions are;



Using principle of atom conservation, the stoichiometric relationship is;

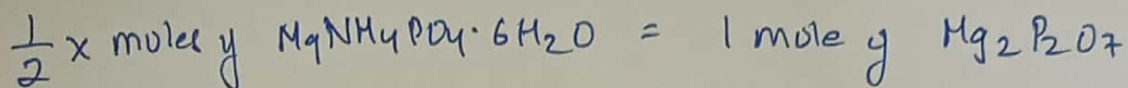
For reaction (ii);

$$\frac{1}{2} \times \text{mole of } \text{MgNH}_4\text{PO}_4 \cdot 6\text{H}_2\text{O} = 1 \text{ mole of } \text{Mg}_2\text{P}_2\text{O}_7 \quad \text{--- (iii)}$$

For reaction (i);



Using eqⁿ (iii);



$$\text{or } \frac{1}{2} \times \frac{\text{wt. of } \text{MgNH}_4\text{PO}_4 \cdot 6\text{H}_2\text{O}}{\text{molecular wt. of } \text{MgNH}_4\text{PO}_4 \cdot 6\text{H}_2\text{O}} = \frac{\text{wt. of } \text{Mg}_2\text{P}_2\text{O}_7 \text{ in gm}}{\text{molecular wt. of } \text{Mg}_2\text{P}_2\text{O}_7}$$

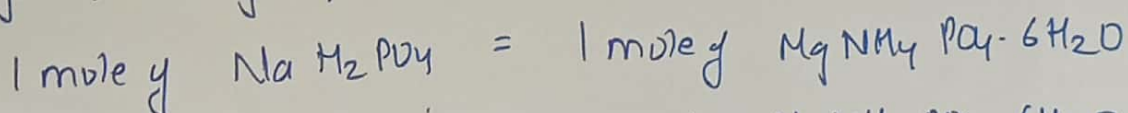
Let the wt. of $\text{MgNH}_4\text{PO}_4 \cdot 6\text{H}_2\text{O}$ be x .

Then,

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

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

Again, using eqⁿ (iv);



$$\text{or } \frac{\text{wt. of } \text{NaH}_2\text{PO}_4 \text{ in gm}}{\text{molecular wt. of } \text{NaH}_2\text{PO}_4} = \frac{\text{wt. of } \text{MgNH}_4\text{PO}_4 \cdot 6\text{H}_2\text{O}}{\text{molecular wt. of } \text{MgNH}_4\text{PO}_4 \cdot 6\text{H}_2\text{O}}$$

Let the weight of NaH_2PO_4 be y gm.

Then,

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

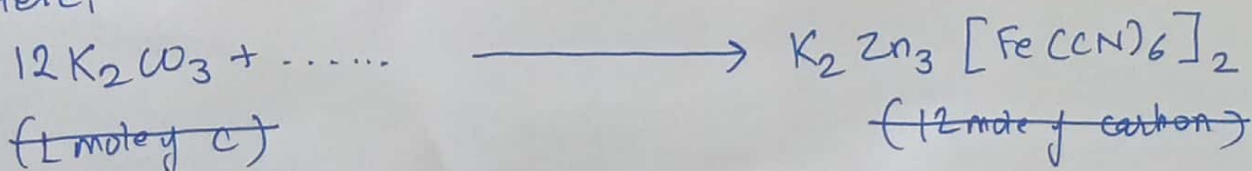
$$\therefore y = 1.121 \text{ gm}$$

The weight of NaH_2PO_4 present originally is 1.121 gm.

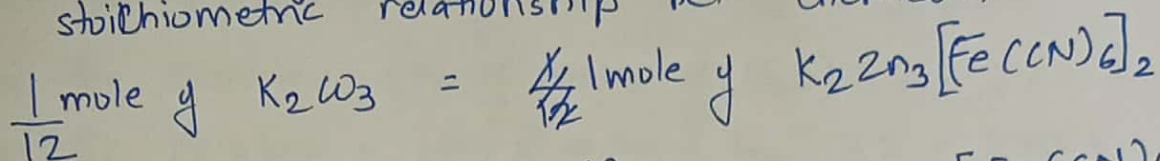
Q.6: A sample of K_2CO_3 weighing 27.6 gm was treated ~~was~~ by a series of reagents so as to convert all of its carbon to $\text{K}_2\text{Zn}_3[\text{Fe}(\text{CN})_6]_2$. How many grams of this product were obtained?

Solⁿ:

Here,



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



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

$$\text{or, } \frac{27.6}{138} = \frac{12}{12} \times \frac{y}{697.8} \quad \left[\begin{array}{l} \text{Let the wt. of } K_2Zn_3[Fe(CN)_6]_2 \\ \text{be } y \end{array} \right]$$

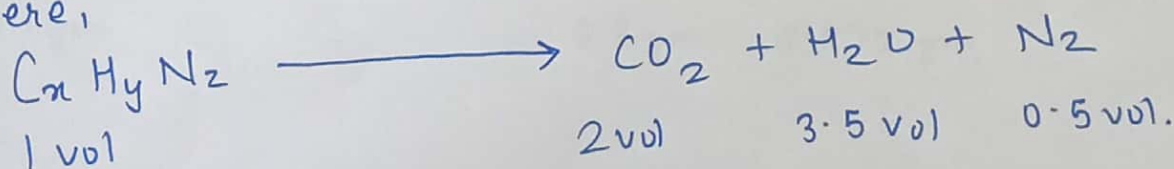
$$\text{or, } y = \frac{27.6 \times 697.8}{138 \times 12}$$

$$\therefore y = 11.6 \text{ gm.}$$

\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~~ 2 volume of CO_2 , 3.5 ~~moles~~ 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,



According to Avogadro's hypothesis,

$$\begin{array}{ccccccc} 1 \text{ mole} & & 2 \text{ mole} & & 3.5 \text{ mole} & & 0.5 \text{ mole} \end{array}$$

Here,

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

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

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

Hence,

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

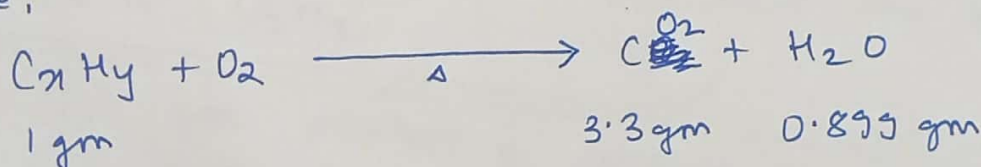
So empirical formula = $\text{C}_2\text{H}_7\text{N}$

Since 1 mole of $\text{C}_x\text{H}_y\text{N}_z$ can give only 2 moles of C-atom.

Molecular formula = $\text{C}_2\text{H}_7\text{N}$ or, $\text{C}_2\text{H}_5\text{NH}_2$
(diethylamine)

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 experiment, 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,



Now,

$$\begin{aligned} \text{no. of mole of C-atom} &= \frac{\text{wt. of carbon}}{\text{Mole. Atomic wt of CO}_2} \\ &= \frac{3.3}{44} = 0.075 \text{ gm mole.} \end{aligned}$$

$$\begin{aligned}\text{No. of mole of H-atom} &= \frac{2 \times \text{wt of H}_2\text{O in gm}}{\text{Molecular wt of H}_2\text{O}} \\ &= \frac{2 \times 0.899}{18} = 0.0998\end{aligned}$$

Now,

$$\begin{aligned}\text{ratio} &= \text{no. of moles of C-atom} : \text{no. of moles of H-atom.} \\ &= \frac{0.075}{0.075} : \frac{0.0998}{0.075} = 1 : 1.33 \\ &\approx 3 : 4\end{aligned}$$

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

$$\text{So, EF weight (EFwt)} = 40$$

Now, we know,

$$1 \text{ litre of gas weights } 1.87 \text{ gms}$$

$$\begin{aligned}\text{So, } 22.4 \text{ litres of gas weights } &1.87 \times 22.4 \\ &= 41.888 \text{ gm}\end{aligned}$$

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

$$\begin{aligned}\text{So, molecular formula (MF)} &= (\text{EF}) \times n \\ &= \text{C}_3\text{H}_4.\end{aligned}$$

\therefore The empirical formula is C_3H_4 and the molecular formula is C_3H_4 .

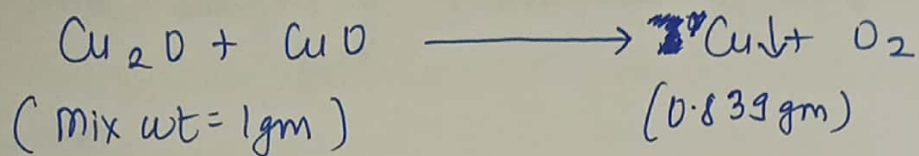
Q.9: A 1 gm mixture of cuprous oxide and cupric oxide, CuO was quantitatively reduced to 0.839 gm of metallic copper. What was the weight of CuO in original sample?

Soln.

Given,

Atomic wt of Cu = 63.5 gm

We know,



Using principle of atom conservation,

mole of Cu in R = moles of Cu in P

$$2 \times \text{mole of Cu}_2\text{O} + 1 \times \text{mole of CuO} = 1 \times \text{mole of Cu}$$

$$2 \times \frac{\text{wt. of Cu}_2\text{O in gm}}{\text{mol. wt of Cu}_2\text{O}} + 1 \times \frac{\text{wt of CuO}}{\text{mol wt of CuO}} = \frac{\text{wt. of Cu}}{\text{Atomic wt of Cu}}$$

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

$$\text{wt of Cu}_2\text{O} = 1 - w$$

So,

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

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

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

$$\therefore w = 0.55 \text{ gm}$$

\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;



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

Using principle of atom conservation,

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

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

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

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

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

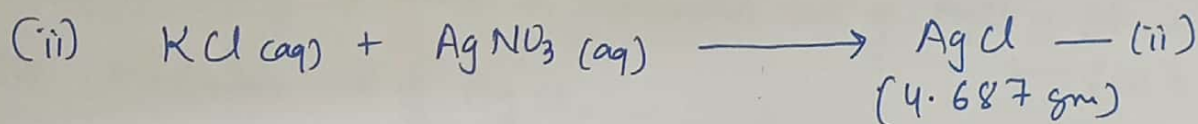
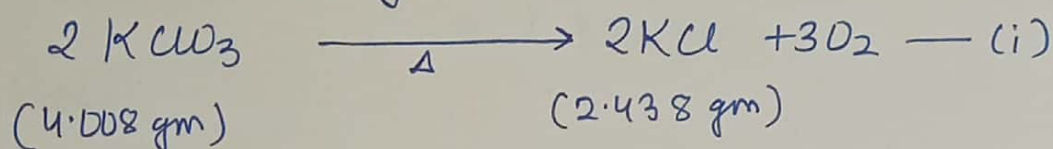
$$\text{or, } x = \frac{-30.06 + \left(\frac{1.69}{22.4} \times 63.5 \times 18 \right)}{45.5}$$

$\therefore x = 1.23$ 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;



$$wt. \text{ of } Ag = 3.351 \text{ gm.}$$

From reaction (i);

Using principle of atom conservation, the stoichiometric relationship is;

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

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

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

$$\therefore \text{Molar of } KCl = 0.0327 \text{ moles}$$

Also,

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

From reaction (ii);

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



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

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

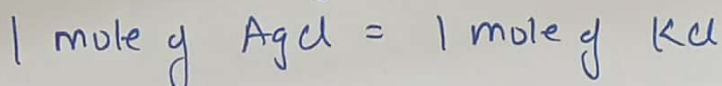
Now,

$$\begin{aligned} \text{Weight of chlorine} &= 4.687 - 3.351 \\ &= 1.336 \text{ gm} \end{aligned}$$

Here,

$$\text{Atomic wt of chlorine} = \text{Molecular wt of AgCl} - \text{At. wt of Ag.} \quad \text{--- (iii)}$$

For molecular wt of AgCl,



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

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

Using in eqⁿ (iii), we get

$$\begin{aligned} \text{Atomic wt of Chlorine} &= 143.3 \text{ gm/mol} - 107.98 \text{ gm/mol} \\ &= 35.32 \text{ gm/mol.} \end{aligned}$$

So,

$$\begin{aligned} \text{Atomic wt of potassium} &= 74.55 \text{ gm/mol} - 35.32 \text{ gm/mol} \\ &= 39.23 \text{ gm/mol.} \end{aligned}$$

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,

$$\text{Atomic wt of Sb} = 121.8$$

We know,

$$\text{Atomic wt of Oxygen} = 16$$

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

$$\text{wt of oxygen} = 24.73 \text{ gm}$$

$$\text{wt of Antimony} = 100 - 24.73 = 75.27 \text{ gm}$$

Now,

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

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

So,

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

$$= 1 : 2.5$$

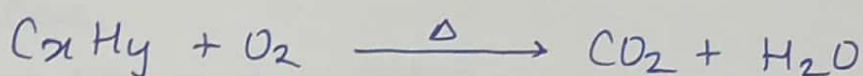
$$= 2 : 5$$

∴ 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,



Given,

wt. of hydrocarbon = 0.210 gm

density of hydrocarbon = 1.87 gm/L

wt. of CO_2 = 0.660 gm.

Here,

$$\begin{aligned}\text{No. of moles of C-atom} &= \text{no. of moles of } \text{CO}_2 \\ &= \frac{0.660}{44} = 0.015 \text{ moles.}\end{aligned}$$

So,

$$\begin{aligned}\text{Wt. of C-atom} &= \cancel{\text{wt.}} \text{ No. of moles} \times \text{At. wt. of C} \\ &= 0.015 \times 12 \\ &= 0.18 \text{ gm.}\end{aligned}$$

$$\begin{aligned}\therefore \text{The weight of Hydrogen} &= 0.210 - 0.180 \\ &= 0.03 \text{ gm}\end{aligned}$$

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

Now,

$$\begin{aligned}\text{Relative no. of moles} &= \frac{\text{no. of moles of C}}{\text{no. of moles of H}} \\ &= \frac{0.015}{0.015} : \frac{0.03}{0.015} \\ &= 1 : 2\end{aligned}$$

∴ The empirical formula is CH_2 .

Now,

$$\text{EF weight} = 14 \text{ gm}$$

We know,

~~1.8~~ 1. litre of hydrocarbon weighs 1.87 gm

So,

$$\begin{aligned}22.4 \text{ litres of hydrocarbon weighs} &= 1.87 \times 22.4 \\ &= 41.888 \text{ gm}\end{aligned}$$

Now,

$$n = \frac{\text{MFwt}}{\text{EFwt}} = \frac{41.888}{14} \approx 3$$

So,

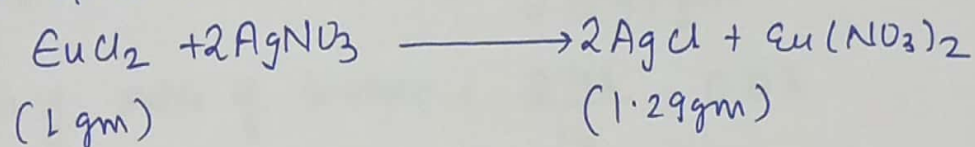
$$\begin{aligned}\text{Molecular formula} &= (\text{empirical formula}) \times n \\ &= (\text{CH}_2) \times 3 \\ &= \text{C}_3\text{H}_6.\end{aligned}$$

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,



According to principle of atom conservation, the stoichiometric relationship is

$$1 \text{ mole of } \text{EuCl}_2 = \frac{1}{2} \times \text{no. of moles of AgCl}$$

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

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

$$\therefore x = 151.32 \text{ gm/mol.}$$

\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?

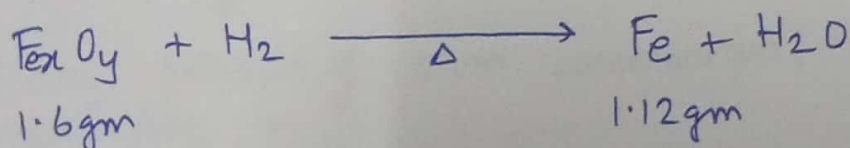
Soln,

Given,

$$\text{At. wt of Fe} = 55.8$$

$$\text{At. wt of O} = 16$$

and,



Now,

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

$$\begin{aligned}\text{wt. of oxygen in compound} &= 1.6 - 1.12 \\ &= 0.48 \text{ gm}\end{aligned}$$

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

Now,

$$\begin{aligned}\text{Relative no. of moles} &= \text{no. of moles of Fe} : \text{no. of moles of O} \\ &= \frac{0.020}{0.020} : \frac{0.030}{0.020} \\ &= 1 : 1.5 \\ &= 2 : 3\end{aligned}$$

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

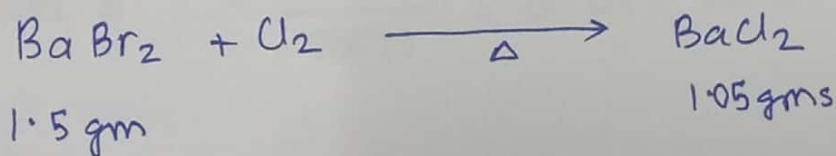
Q.5: When Barium Bromide is heated in a stream of chloride gas, it is completely converted to Barium chloride (BaCl_2). From 1.5 gm BaBr_2 only 1.05 gm of BaCl_2 is obtained. Calculate the atomic wt of Barium from this data.

Solⁿ:

Given;

$$\text{At. wt. of Br} = 79.9$$

The reaction is,



Using principle of atom conservation, the stoichiometric relationship is.

$$1 \text{ mole of BaBr}_2 = 1 \text{ mole of BaCl}_2.$$

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

$$\text{or, } 1.5x + 106.5 = 1.05x + 167.79$$

$$\text{or, } 0.45x = 61.29$$

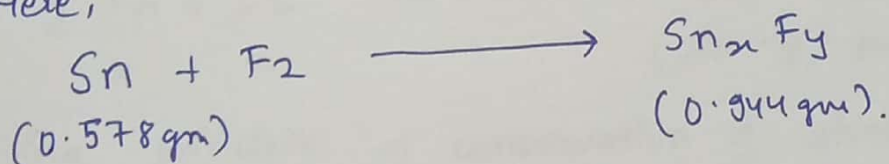
$$\therefore x = 136.2 \text{ gm/mol}$$

\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,



Now,

$$\begin{aligned} \text{weight of fluorine} &= (0.944 - 0.578) \text{ gm} \\ &= 0.366 \text{ gm} \end{aligned}$$

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

$$\text{no. of moles of F} = \frac{0.366}{\cancel{18} 19} = 0.019 \text{ moles.}$$

Now,

$$\begin{aligned} \text{relative no. of moles} &= \text{no. of moles of Sn} : \text{no. of moles of F} \\ &= \frac{4.869 \times 10^{-3}}{4.869 \times 10^{-3}} : \frac{0.019}{4.869 \times 10^{-3}} \\ &= 1 : 4 \end{aligned}$$

\therefore The empirical formula of Tin oxide is SnF_4 .

So, the equation is: $\text{Sn} + 2\text{F}_2 \longrightarrow \text{SnF}_4$.

(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:

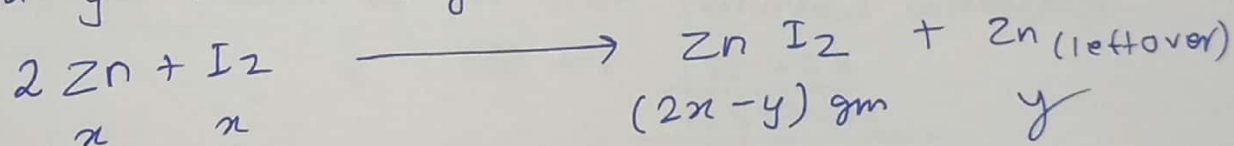
Given,

Atomic wt. of iodine = 126.9

Atomic wt. of zinc = 65.38

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

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



Using principle of conservation of atom, the stoichiometric relationship is

~~$$\begin{aligned}
 & \frac{1}{2} \times \text{no. of moles of Zn} = 1 \times \text{no. of moles of ZnI}_2 \\
 \text{or, } & \frac{x}{65.38} = \frac{2 \times (2x-y)}{317.3}
 \end{aligned}$$~~

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

~~$$\text{or, } 317.3x = 261.52x - 135.76y$$~~

~~$$\begin{aligned}
 & \frac{1}{2} \times \text{no. of moles of Zn} = 1 \times \text{no. of moles of ZnI}_2 + 1 \times \text{no. of moles of Zn unreacted.} \\
 & = 1 \times \text{no. of moles of I}_2
 \end{aligned}$$~~

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

$$\text{No. of moles of I}_2 \text{ in reactant side} = \frac{x}{253.8}$$

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

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

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

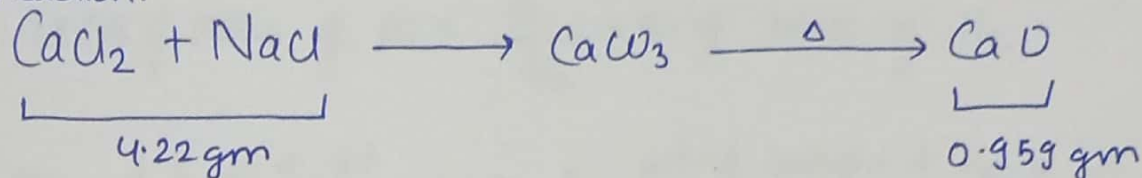
$$= 0.74$$

\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:



Using principle of atom conservation, the stoichiometric coefficients is;

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

$$\text{or, } \frac{\text{wt. of CaCl}_2}{\text{mol. wt of CaCl}_2} = \frac{\text{wt. of CaO}}{\text{mol. wt of CaO}}$$

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

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

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

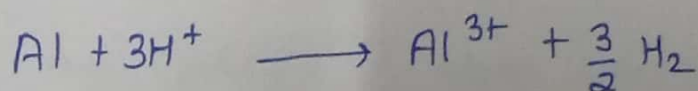
$$\text{So, \% of weight of CaCl}_2 \text{ in mixture} = \frac{1.9}{4.22} \times 100\% \\ = 45.02\%$$

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. $\text{Al} + 3\text{H}^+ \longrightarrow \text{Al}^{3+} + 3/2 \text{H}_2$, 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;



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

$$1 \times \text{no. of moles of Al} = \frac{1}{3/2} \times \text{no. of moles of H}_2$$

$$\text{or, } \frac{3}{2} \times \frac{\text{wt. of Al}}{\text{At. wt. of Al}} = \frac{\text{wt. of volume of H}_2 \text{ in cc}}{22400 \text{ cc}}$$

$$\text{or, } \frac{3}{2} \times \frac{x}{27} = \frac{415}{22400} \quad \left[\because \text{Let the weight of Al be } x \right]$$

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

Now,

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

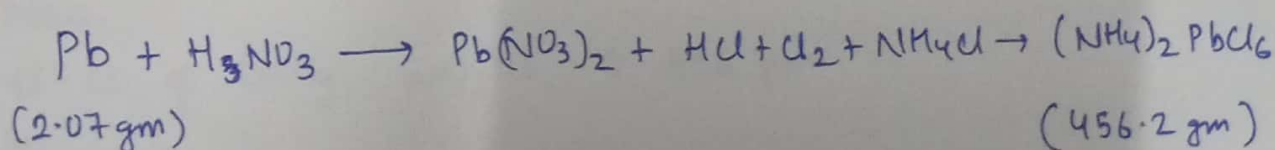
$$= 95.14\%$$

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 precipitation of Ammonium hexachloroplumbate $[(\text{NH}_4)_2\text{PbCl}_6]$ (456.2). What is the maximum weight of the product that can be obtained from the lead sample?

Solⁿ:

Given reaction,



Using the principle of atom conservation;

$$\text{No of mole of Pb} = \text{No of mole of } (\text{NH}_4)_2\text{PbCl}_6$$

$$\text{or, } \frac{\text{wt of Pb}}{\text{At wt of Pb}} = 1 \times \frac{x}{\text{Mol. wt of } (\text{NH}_4)_2\text{PbCl}_6} \quad \left[\because \text{Let } x \text{ be the maximum wt of product.} \right]$$

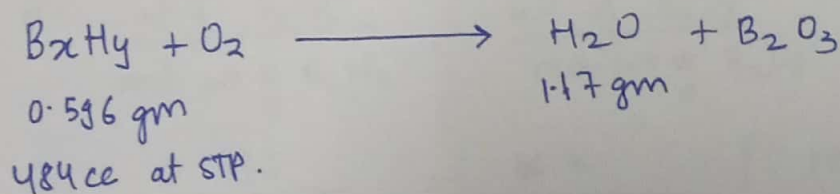
$$\text{or, } \frac{2.07}{207.2} = 1 \times \frac{x}{456.2}$$

$$\text{on } x = \frac{2.07 \times 456.2}{207.2} \quad \therefore x = 4.5576 \text{ gm.}$$

\therefore The maximum weight of $(\text{NH}_4)_2\text{PbCl}_6$ 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:



Now,

484 cc of B_xH_y weighs 0.596 gm

So,

$$22400 \text{ cc of } \text{B}_x\text{H}_y \text{ weighs } \frac{0.596 \times 22400}{484} \text{ gm}$$

$$\therefore \text{Mol wt of } \text{B}_x\text{H}_y = 27.58 \text{ gm/mol. — (i)}$$

Also,

$$y \times \text{no. of moles of } B_2H_6 = 2 \times \text{no. of moles of } H_2O$$
$$\text{or, } y \times \frac{0.596}{27.58} = 2 \times \frac{1.17}{18}$$

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

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 .

$$\text{So, the ratio of relative moles} = \frac{2}{6} = 1:3$$

\therefore The empirical formula is BH_3 .

Now, we know,



Here,

$$\text{no. of moles of } B_2H_6 = \text{No. of moles of } B_2O_3$$

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

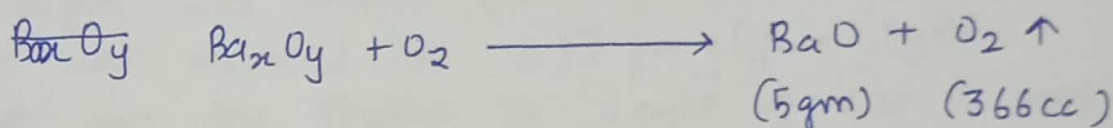
$$\text{or, } \frac{0.596}{27.6} = \frac{z}{69.6} \quad \left[\because \text{let the weight of } B_2O_3 \text{ be } z \right]$$

$$\therefore z = 1.503 \text{ gm}$$

\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 5gm 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:



Given,

$$\text{At. wt of Ba} = 137.33.$$

Here,

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

~~Using principle of atom conservation,~~

$$\cancel{x \times \text{No. of moles of Ba}_x\text{O}_y} = \cancel{1 \times \text{No. of moles of BaO}}$$

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

Now,

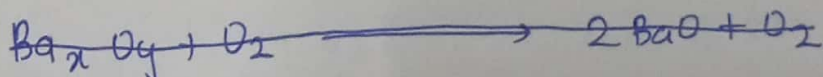
ratio of relative moles of ~~0.032~~ BaO : O₂

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

$$= 2:1$$

So,

~~we have,~~



So,

ratio of relative moles of BaO : O

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

$$= 1:1$$

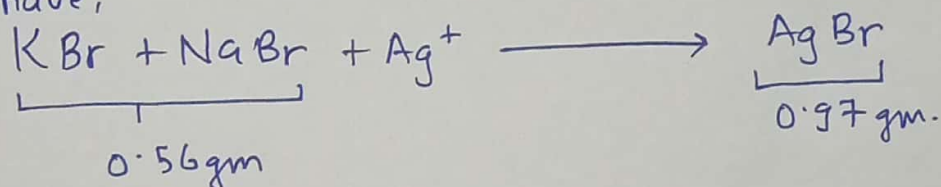
Hence, the empirical formula is BaO_2 .

Now,



Q(13): A fraction of KBr and NaBr weighing 0.56 gm was treated with 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,



Given,

$$\text{At wt of Ag} = 107.98$$

$$\text{At wt of Br} = 79.9$$

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;

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

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

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

$$\text{or, } 102.9x + 66.584 - 118.9x = 63.156$$

$$\text{or, } 16x = 3.428 \quad \therefore x = 0.214$$

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

\therefore The fraction of KBr in sample is 0.38 .