Stoichiometry and calculations:

- balanced chemical reactions are stoichiometric reactions in which different reactants ratios are constant.

- except mass ratio all different ratios in stoi. rxns. ~~are~~ should be constant.

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

mole	1 mole	2 mole	1 mole	2 mole
vol. (at STP)	22.4 l	44.8 l	22.4 l	44.8 l
vol.	1 l	2 l	1 l	2 l
molecule	1 molecule	2 molecule	1 molecule	2 molecule
mass	16 gm	64 gm	44 gm	36 gm

29. During complete combustion of (methane) CH_4 gas how much CO_2 formed with 3 mole CH_4 gas.

$\Rightarrow$ $CH_4 : CO_2$

$1 : 1$

$3 \text{ mole} : x$

$\Rightarrow$ 3 mole

25. If 8 gm methane completely combust in presence of oxygen & CO_2 & water formed

$\Rightarrow$ $CH_4 : CO_2 : H_2O$

$1 : 1 : 2$

$M = \frac{8\text{gm}}{16\text{gm}} \quad \frac{1}{2}\text{ mole.}$

$CH_4 \quad CO_2 \quad H_2O$

$\frac{1}{2}\text{ mole} \quad \frac{1}{2}\text{ mole} \quad 1\text{ mole.}$

26. How much quantity methane req. at STP for prodn of 11.2 l H_2O.

$\Rightarrow$ $CH_4 : CO_2 : H_2O$

$1 : 1 : 2$

$\Rightarrow \frac{11.2}{2}$ 5.6 Ltr

$\text{mole} = \frac{5.6}{22.4} \quad \frac{1}{4}\text{ mole.}$

$CH_4 = 4\text{gm}$

27. For generation of 7.2gm H_2O how much oxygen req. for complete combustion of methane gas.

⟹ $O_2 : H_2O$

1 : 1

0.2 mole : 0.2 mole

$\frac{7.2}{36} = 0.2$ mole.

∴, 0.2×64

= 12.8 gm

28. Vol. of CO_2 & H_2O should at STP if 300 Litres methane compl. combusted with oxygen.

⟹ $CH_4 : H_2O : CO_2$

1 : 2 : 1

300 l : 600 l : 300 l

∴, H_2O = 600 l

CO_2 = 300 l.

29. How much H_2O formed if 5 l methane gas (at STP) comple. combust.

⟹ $H_2O : CH_4$

2 : 1

2(5l) : 5 l

10 l

mole = $\frac{10}{22.4}$

H_2O gm = $\frac{100}{224} \times 18$ = $\frac{225}{28}$

30. How much quantity H_2O formed if 22.4 l methane gas @ STP completely burn.

⇒ $CH_4 : H_2O$

$22.4 : 44.8$

$\therefore$ mole $= \frac{44.8}{22.4}$ | 2mole |

$= 2 \times 18$

| $= 36gm$ |

31. Quantity of methane should req. if 10gm CO_2 produced.

⇒ $CH_4 : CO_2$

$1 : 1$

$\frac{5}{22} : \frac{5}{22}$

mole $= \frac{10}{44} \quad \frac{5}{22}$ mole.

$\therefore, \frac{m}{16} = \frac{5}{22}$

$\hookrightarrow m = \frac{5 \times 16}{22}$ | $\frac{40}{11}$ gm |

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- in stoichiometric reactions, the relation between different reactant and product can also be written as

for eg: $N_2 + 3H_2 \longrightarrow 2NH_3$

$\Rightarrow \frac{\text{mole of } N_2}{1} = \frac{\text{mole of } H_2}{3} = \frac{\text{mole of } NH_3}{2}$

$\rightarrow \frac{\text{wt of } N_2}{1 \times \text{mole. wt of } N_2} = \frac{\text{wt. of } H_2}{3 \times \text{m. wt. of } H_2} = \frac{\text{wt. of } NH_3}{2 \times \text{m. wt of } NH_3}$

32. How much quantity (in mole) of Nitrogen gas required in haber process to produce 20 mole of ammonia?

$\Rightarrow N_2 + 3H_2 \longrightarrow 2NH_3$

now; $2NH_3 = 20$ moles

$N_2 = 10$ moles.

33. In above reaction, how much quantity of Hydrogen is required to produce 13gm of ammonia?

$\Rightarrow N_2 + 3H_2 \longrightarrow 2NH_3$

now; $\frac{\text{mass. mole of } H_2}{3 \times 2} = \frac{\text{mass. mole of } NH_3}{2 \times 17}$

$\frac{H_2}{3 \times 2} = \frac{13}{2 \times 17}$

$\therefore H_2 = \frac{13 \times 3}{2 \times 17} \longrightarrow \boxed{\frac{39}{17}}$ gm.

34. How many moles of Potassium Chlorate ($KClO_3$) req. to be heated to produce 11.2 ltr Oxygen at STP.

$\Rightarrow 2KClO_3 \xrightarrow{\Delta} 2KCl + 3O_2$.

$\Rightarrow \frac{\text{mole of } KClO_3}{2} = \frac{\text{mole of } O_2}{3}$

$\frac{11.2}{22.4}$

$\Rightarrow \text{mole} = \frac{\text{given volume}}{22.4}$

3 | 22.4

$= \frac{11.2}{22.4} \frac{1}{2}$.

$\Rightarrow \frac{KClO_3}{2} = \frac{1}{2 \times 3} \Rightarrow \boxed{KClO_3 = \frac{1}{3} \text{ mole}}$

35. If 1/2 mole of oxygen combined with aluminium to form respective metal oxide; find weight of aluminium used in reaction.

$\Rightarrow 3O_2 + 4Al \longrightarrow 2Al_2O_3$

$\Rightarrow \frac{\text{mole of Al}}{4} = \frac{\text{mole of } O_2}{3}$

$\frac{\text{wt. of Al}}{4 \times \text{atomic wt.}} = \frac{\text{mole } O_2}{3}$.

$\frac{Al}{4 \times 27} = \frac{1/2}{3}$

wt. $Al = \frac{2 \times 4 \times 27}{6}$

$\boxed{Al = 18 \text{ gm}}$

Limiting reagent & Excess reagent :-

- during chemical reactions those reagent consume first are 'limiting reagents' (LR).

- after completion of the reaction remaining reagent are 'excess reagent' (ER).

- LR and ER in stoichiometric reactions can be find as following:

• $\frac{\text{Given mole}}{\text{Stoichiometric coefficient}}$ | situation in control when ratio (1:1)

If LR is available in rxn's than final product quantity decides by LR.

36. Find out the LR and ER in following reactions:

(i) $N_2 + 3H_2 \longrightarrow 2NH_3$
(2 mole) (5 mole)

(ii) $N_2 + 3H_2 \longrightarrow 2NH_3$
(1.4 ~~mole~~ gm) (0.6 gm)

(iii) $PCl_3 + Cl_2 \longrightarrow PCl_5$
(45 gm) (90 gm)

$\Longrightarrow$ (a) $\frac{2}{1} : \frac{5}{3} \longrightarrow 2 : 1.67$

∴ N_2 = ER H_2 = LR.

(b) $\frac{1.4}{1} : \frac{0.6}{3} \longrightarrow$ ~~1.4 : 0.2~~ 7 : 1

∴ N_2 = ER H_2 = LR

(b) $\frac{\text{given mass}}{\text{molec. mass}}$ = mole

$\Longrightarrow$ 1/2 : 1   (0.5 : 1)

$\Longrightarrow \frac{1.4}{28} \frac{1}{20} = \frac{0.6}{6} \frac{1}{10}$

$\frac{1}{1} \frac{3}{3} \to .5 : 1$

∴ H_2 = ER N_2 = LR.

PCl_5
P=31
Cl_2=70
PCl_3=137.5
Cl_3=35.5×3

(c) $\frac{45}{137.5}$: $\frac{90}{71}$

27.5

$\longrightarrow \frac{90}{27.5} = \frac{90}{71}$

$\frac{18}{55} = \frac{90}{71}$

∴, Cl_2 = ER
PCl_3 = LR

37.(i) In haber process 5 mole Nitrogen and 40 mole Hydrogen reacts to form what quantity of ammonia?
(ii) If LR is precent than find out remaining reagent quantity after completing rxn.

$\Rightarrow N_2 + 3H_2 \longrightarrow 2NH_3$
5 mole   40 mole

(a) 5 mole   4 mole ⟶ ?

$(\frac{5}{1} = \frac{40}{3}\ 13.3)$

N = LR
H_2 = ER

$\frac{\text{mole of N}}{1} = \frac{\text{mole of } NH_3}{2}$

$\frac{5}{1} = \frac{\text{mole } NH_3}{2}$

mole of NH_3 = 10 mole

(b) H_2 used = 15 mole
∴, remaining H_2
= 40 mole − 15 mole
= 25 mole

38. 3 mole of sodium carbonate reacted with 6 mole of HCl. Find volume of CO_2 gas produced at STP.

$\Rightarrow$ $Na_2CO_3 + 2HCl \longrightarrow 2NaCl + CO_2 + H_2O$

3 mole 6 mole

G:- $\frac{3}{1} : \frac{6}{2}$ $\therefore$ 3 : 3

1 : 1 (no LR or ER).

$\therefore$ CO_2 = 3 mole.

$\therefore$ volume = 3×22.4

= 67.2 l

39. In above question, if 6 mole of sodium carbonate is treated with 4 mole of HCl than find out the volume of CO_2 at STP.

$\Rightarrow$ $Na_2CO_3 + 2HCl \longrightarrow 2NaCl + CO_2 + H_2O$

6 mole 4 mole.

HCl : CO_2

2 : 1

4 : ?

G:- $\frac{6}{1} : \frac{4}{2}$ $\therefore$ 6 : 2

HCl is LR.

$\therefore$ 2HCl $\longrightarrow$ 4 mole

as HCl : CO_2 $\longrightarrow$ 2 : 1.

$\therefore$ CO_2 $\longrightarrow$ 2 mole

$= 2 \times 22.4$

= 44.8 l