"STOICHIOMETRY"

Laws of Chemical Combination –

1. Conservation of Mass : [Antoine Lavoisier]

$$\left(\text{Total Mass of Reactants}\right) = \left(\text{Total Mass of Products}\right)$$

Limitations : i) Doesn't hold for Nuclear Rx^n's.

2. Law of Definite Proportions : [Proust]

" Ratio of mass of atoms of diff. elements in compound is always fixed, regardless of source. "

Eg: H_2O ; $\xrightarrow{\text{Mass}}$ H : O = 1 : 8

Limitations : i) Doesn't hold for isotopes.
ii) Holds only for one type of isotope.

3. Law of Multiple Proportions : [John Dalton]

"When 2 diff. elements combine to form more than 1 compound, then ratio of mass of one element combining with fixed mass of other element bears a simple ratio."

Eg: H_2O & H_2O_2

If we fix mass of H to be 2g.

Mass H_2O: 1 : 8 Mass H_2O_2: 1 : 16

$\Rightarrow O_{mass} = 16g$ $O_{mass} = 32g$

$16 : 32 = \boxed{1:2}$ ✓

Q) 2 elements X (mass 16) and Y (mass 14) combine to form A, B, C. The ratio of diff. mass of Y combining with fixed mass of X in A, B, C as 1:3:5. If 32 parts X combine with 84 parts Y in B, 16 parts of X combine with how many parts of Y in C.

A) Let us assume X is 32 parts, then

Y parts

A	B	C
28	84	140

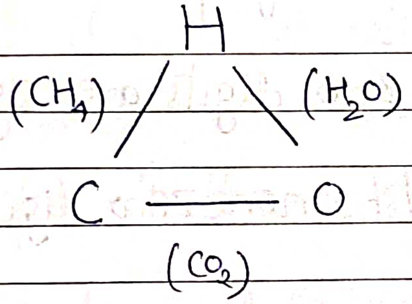
$\underset{y}{140 \text{ parts}} \rightarrow \underset{x}{32 \text{ parts}}$

$\Rightarrow \underset{y}{\boxed{70} \text{ parts}} \leftarrow \underset{x}{16 \text{ parts}}$

4. Law of Reciprocal Proportions:

"When 2 diff. elements (A & B) combine with fixed weight of other element (C) to form 2 compounds, the ratio of mass of A & B in these compounds will be an integral multiple of ratio of mass when A & B combine with each other."

Eg: 1)



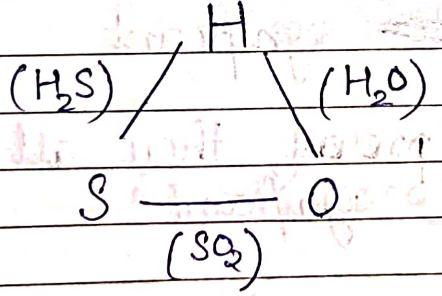
If H mass be fixed 4g

CH_4 & H_2O C:O = 12:32

Same

CO_2 C:O = 12:32

2)



If H mass be fixed 2g

H_2S & H_2O S:O = 32:16

(2X)

SO_2 S:O = 32:32

5. Gay Lussac's Law of Combining Vol.s:

"Under similar conditions of temp. & pressure, whenever gases react, ratio of their vol. of gaseous reactants & products bear simple ratio."

Eg: $H_2 + Cl_2 \longrightarrow 2HCl$

(1L) (1L) (2L)

Significant figures —

Every measurement has some error.

If no error, then ∞ significant digits.

Rules :

1. Non zero digits are significant.
2. Zeros b/w 2 non zero digits are significant.
3. All zeros before 1st non zero digit are NOT significant.
4. If decimal pt. present, then all trailing zeros ~~NOT~~ significant.
5. If decimal pt. NOT present, then all trailing zeros NOT significant.

Q) Calculate no. of significant digits.

1.	123485	6	7.)	8.00608	6
2.	0.03	1	8.)	0.200	3
3.	0.00543	3	9.)	2.00	3
4.	0.0516	3	10.)	200.00	5
5.	2.006	4	11.)	200	1
6.	4.0507	5	12.)	5 books	∞

Rounding Off —

1. If last digit > 5, 2nd last digit ++;
2. If last digit < 5, no change;
3. If last digit = 5,
   - if 2nd last digit = even, no change;
   - if 2nd last digit = odd, 2nd last digit ++;

Rules for Arithematic Operations —

1. Multiplication & Division :

$$\boxed{sig(a \cdot b) = \min\{sig(a), sig(b)\}}$$

Eg: $(2.5)(0.0005) = (0.0125)$

$Sig(2.5) = 2$

$sig(0.0005) = 1$

$$(0.0125) \downarrow 0.01\underline{2}\,\cancel{5} \; (<5) \downarrow \boxed{0.01}$$

$[sig(m) = 1]$

2. Addition & Subbraction :

Retains as many decimal places as there are in no. with least decimal places.

Eg:

$$\begin{array}{r} 5.381 \\ (+)\ 2.12 \\ \hline 7.501 \end{array} \rightarrow \boxed{7.50}$$

25/03/2022

Mole Concept –

☆

$$\boxed{1\ amu = \frac{1.99 \cdot 10^{-23}}{12} g = \frac{1}{6.022 \cdot 10^{23}} g = \frac{1}{N_A} g = 1.66 \cdot 10^{-24} g}$$

Element	Molar Mass	Element	Molar Mass
H	1 g	Cu	63.5 g
He	4 g	P	31 g
C	12 g	S	32 g
N	14 g	Cl	35.5 g
O	16 g	K	39 g
F	19 g	Ca	40 g
Na	23 g	Br	80 g
Mg	24 g	Ag	108 g
Al	27 g		

no. of moles — Weight given (g) — No. of particles — Volume by gas at S.T.P. (L)

$$\star\ \boxed{n = \frac{W}{M} = \frac{N}{N_A} = \frac{V}{22.4L}}$$

(g/mol) Molar Mass ([illegible])

$$\boxed{\left(\begin{array}{c}1 \text{ g-atom of} \\ \text{particles}\end{array}\right) = \left(\begin{array}{c}1 \text{ mole of} \\ \text{particles}\end{array}\right) = \left(\begin{array}{c}6.022 \times 10^{23} \\ \text{particles}\end{array}\right)}$$

Molar Mass : Mass of 1 mole of a substance

Q) Calculate no. of atoms in —

i) 42 g of N-atom ii) 8g of S atom

iii) 5 g-atom of Ca iv) 0.25 mole of Na

v) 16 g of Mg

A) i) $\frac{N}{N_A} = \frac{W}{M} \Rightarrow \frac{N}{N_A} = \frac{42\,\cancel{g}}{14\,\cancel{g}} \Rightarrow \boxed{N = 3N_A}$

ii) $\frac{N}{N_A} = \frac{W}{M} \Rightarrow \frac{N}{N_A} = \frac{8\,\cancel{g}}{32\,\cancel{g}} \Rightarrow \boxed{N = \left(\frac{N_A}{4}\right)}$

iii) $\frac{N}{N_A} = n \Rightarrow \boxed{N = 5N_A}$

iv) $\frac{N}{N_A} = n \Rightarrow \boxed{N = (N_A/4)}$

v) $N/N_A = W/M \Rightarrow N = N_A\left(16/24\right) \Rightarrow \boxed{N = (2N_A/3)}$

Q) 5.6 L of O_3 gas at S.T.P. Calculate –

i) No. of moles
ii) No. of molecules
iii) Mass
iv) No. of O atoms.

A) i) $n = \frac{V}{22.4L} \Rightarrow n = \frac{5.6\cancel{L}}{22.4\cancel{L}} \Rightarrow \boxed{n = 1/4}$

ii) $\frac{N}{N_A} = n \Rightarrow \boxed{N = (N_A/4)}$

iii) $n = \frac{W}{M} \Rightarrow W = (48/4) \Rightarrow \boxed{W = 12g}$

iv) No. of O atoms = 3 × (No. of O_3 molecules) = $\boxed{(3N_A/4)}$

Q) Calculate no. of $\bar{e}$ in 9.5g of PO_4^{3-}.

A) No. of $\bar{e}$ in 1 molecule of PO_4^{3-} = $15 + 4 \cdot 8 + 3 = 50$

$\frac{N}{N_A} = \frac{W}{M} \Rightarrow N = \left(\frac{9.5}{31+64}\right) N_A \Rightarrow N = \left(\frac{N_A}{10}\right)$

No. of $\bar{e} = \left(\frac{50}{10}\right) N_A = (5N_A)$

Q) What is no. of moles of O atom in 126 amu HNO_3?

A) $n = \frac{W}{M} \Rightarrow n = \frac{126 \text{ amu}}{63 \text{ g}} = \left(\frac{2}{N_A}\right)$

No. of O atoms = $3\left(\text{No. of } HNO_3 \text{ molecules}\right) = (6/N_A)$

Q) One atom of an element X weigh 6.643×10^{-23} g. Find no. of moles of atom in 20kg.

A) $M = (6.643\times10^{-23})\,g \times (6.022\times10^{23}) = (6.643)(6.022)\,g$

$n = \frac{W}{M} = \frac{20\cdot10^{3}\,g}{(6.643)(6.022)\,g} \approx \frac{20\cdot10^{3}}{40} \Rightarrow \boxed{n \approx 500}$

$[6.6\times6 = 39.6 \approx 40]$ Approximation

Q) Volume of water drop is 0.0018 mL. Find no. of water molecules in 1 drops of water.

A) 0.0018 mL of water = 0.0018 g of water

$n = \frac{W}{M} \Rightarrow n = \frac{1.8\times10^{-3}\,g}{18\,g} \Rightarrow n = 10^{-4}$

$n = \frac{N}{N_A} \Rightarrow \boxed{N = N_A/10^{4}}$

Q) Caffiene has molecular weight 194. If it contains 28.9% by mass of nitrogen, find no. of nitrogen ~~molecules~~ atoms in 1 caffiene molecule.

A) Mass of Nitrogen in Caffiene $= \left(\frac{28.9}{100}\right)(194)_{amu} \approx 2\cdot(28.9)$ amu

$[194 \approx 200]$ Approx.

$\frac{N}{N_A} = \frac{W}{M} \Rightarrow N = \cancel{N_A}\left(\frac{2\cdot28.9}{14}\right)\frac{amu}{g} \Rightarrow \boxed{N \approx 4}$

$[28.9 \approx 28]$ Approx.

Q) A metal (at. wt. = 54.94) has density of 7.42 g/cc. Calculate volume occupied by one atom of metal.

A) Mass of one atom = 54.94 amu = $\left(\frac{54.94}{N_A}\right) g$

Volume of one atom = $\left(\frac{\text{Mass}}{\text{Density}}\right) = \frac{(54.94)\,\cancel{g}\cdot 1\,cc}{(6.022\times10^{23})\,(7.42)\,\cancel{g}}$

Approx $\left[\begin{array}{l}54.94 \approx 55\\ 6.022 \approx 6\\ 7.42 \approx 7.5\end{array}\right]$ $\longleftrightarrow \approx \left(\frac{55}{6(7.5)}\right)(10^{-23})\,cc = \boxed{\left(\frac{11}{9}\right)\times 10^{-23}\,cc}$

Q) The at. wt. of A & B are 20 & 40 respectively. If 'x' g of A contains 'y' atoms, how many atoms are present in '2x' g of B?

A) $\frac{N_{(A)}}{N_A} = \frac{W_{(A)}}{M_{(A)}} \Rightarrow N_{(A)} = y = \left(\frac{N_A\, x}{20}\right)$

$\frac{N_{(B)}}{N_A} = \frac{W_{(B)}}{M_{(B)}} \Rightarrow N_{(B)} = (N_A)\left(\frac{2x}{40}\right) = y$

⇒ '2x' g of B contains 'y' atoms.

Average Molar/Atomic/Molecular Mass –

$$\boxed{M_{Avg.} = \left(\frac{n_A M_A + n_B M_B}{n_A + n_B}\right)}$$

✓ For mix of gases A & B.

Q) Calculate avg. molecular mass for air which contains 80% by mole of N_2 and rest O_2.

A) Let ∃ 100 moles ⇒ $80(N_2) + 20(O_2)$

$$M_{Avg} = \left(\frac{8\cancel{0}\cdot 28 + 2\cancel{0}\cdot 32}{10\cancel{0}}\right)g = \left(\frac{224+64}{10}\right)g = \boxed{28.8g}$$

Q) Boron has two isotopes, one with at. wt. 10.01 and other with 11.01. If avg. at. wt. of Boron is is 10.81, find % abundance of each isotope.

A)
$$\begin{tikzcd} (B_1) & & (B_2) \\ 10.01 \arrow[dr] & & 11.01 \\ & 10.81 \arrow[dl] \arrow[dr] \arrow[ur, dash] & \\ (0.2) & & (0.8) \end{tikzcd}$$

(0.2) (0.8) ⇒ (1 : 4)

% abundance of B_1 = **20%**
% abundance of B_2 = **80%**

Vapour Density (V.D.) :-

Density of any gas w.r.t. H_2 gas at similar temp. & pressure.

$$\boxed{\left(\begin{array}{c}\text{Vapour}\\\text{Density}\end{array}\right) = \left(\frac{\text{Molar Mass}}{2\ g/mol}\right) \Rightarrow \left(V.D. = \frac{M}{2g/mol}\right)}$$

29/03/2022

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	Temp.	Pressure	Vol. of 1 mol gas
S.T.P. =	273 K,	1 atm,	22.4L
N.T.P. =	273K,	1 bar,	22.7L

% Composition —

$$\boxed{\text{Mass }\% = \left(\frac{\text{Mass of specific element}}{\text{Total Mass}}\right) \times 100\%}$$

$$\boxed{\text{Mole }\% = \left(\frac{\text{Mole of specific element}}{\text{Total Mole}}\right) \times 100\%}$$

Q) A sample contains 2 mol O_2, 240g SO_3 and 1.204×10^{24} H_2O molecules. Calc. the % mass & % mole of SO_3

A) $n_{O_2} = 2$ (mol) $\quad W_{O_2} = 64$ g

$n_{SO_3} = 3$ (mol) $\quad W_{SO_3} = 240$ g

$n_{H_2O} = 2$ (mol) $\quad W_{H_2O} = 36$ g

$$\text{Mass \% of } SO_3 = \left(\frac{240}{64+240+36}\right) \times 100\% = \left(\frac{240}{340}\right) \times 100\%$$

$$= \boxed{(1200/17)\%}$$

$$\text{Mole \% of } SO_3 = \left(\frac{3}{2+3+2}\right) \times 100\%$$

$$= \boxed{(300/7)\%}$$

Q) A mix. of NO_2 and N_2O_4 has 20% by mass NO_2. Calc. mole % of NO_2.

A) Let us consider 100 g of mix.

$$\Rightarrow W_{NO_2} = \left(\frac{20}{100}\right) \times 100g = 20g \Rightarrow W_{N_2O_4} = 80g$$

$$n_{NO_2} = \frac{W_{NO_2}}{M_{NO_2}} = \frac{20}{46} = \left(\frac{10}{23}\right)$$

$$n_{N_2O_4} = \frac{W_{N_2O_4}}{M_{N_2O_4}} = \frac{80}{92} = \left(\frac{20}{23}\right)$$

$$\text{Mole \% of } NO_2 = \left(\frac{10/23}{10/23 + 20/23}\right) \times 100\% = \left(\frac{10}{30}\right) \times 100\%$$

$$\approx \boxed{33\%}$$

Emperical & Molecular formula —

Emperical formula (E.F.) :— Simplest whole no. ratio of atoms in molecule

Molecular formula (M.F.): Actual no. of atoms in molecule.

Eg.—

Molecule	E.F.	M.F.
i) Benzene	CH	C_6H_6
ii) Glucose	CH_2O	$C_6H_{12}O_6$
iii) Water	H_2O	H_2O

whole no.

$$\boxed{(\text{Molecular Mass}) = \textcircled{n}(\text{Emperical Mass})}$$

☆Q) On analysis of 7.3g of an organic compound, it is observed that it contains 3.6g C, 1.4g N, 0.7g H. Calc. the emperical formula.

A) Observe that, $W_C + W_N + W_H = (3.6+1.4+0.7)g$
$= \boxed{5.7g \neq 7.3g}$

☆ In such a case, we consider the missing mass to be of Oxygen.

So, $W_O = 1.6g$

Elements	Mass	Mole	Simple Ratio
C	3.6g	0.3	3
N	1.4g	0.1	1
H	0.7g	0.7	7
O	1.6g	0.1	1

⇒ Emperical Formula = $\boxed{C_3NH_7O}$

Q)

A)

Q) Find molecular formula of compound having (V.D) = 74 and has 48.6% C and 8.1% H.

A) $(V.D.) = 74 \Rightarrow \boxed{M = 148\,g}$

$\boxed{W_C = \left(\frac{48.6}{100}\right)(148)\,g}$; $\boxed{W_H = \left(\frac{8.1}{100}\right)(148)\,g}$

Now, $(\text{Mass \% C}) + (\text{Mass \% H}) = \boxed{56.7\% \neq 100\%}$

$\Rightarrow \boxed{(\text{Mass \% O}) = 43.3\%}$

$\boxed{W_O = \left(\frac{43.3}{100}\right)(148)\,g}$

Element	Mass	Mole	Simple Ratio
C	$(48.6)(1.48)g$	$4(1.48)$	$4/2.7 \approx 1.5 \Rightarrow 3$
H	$(8.1)(1.48)g$	$8(1.48)$	$8/2.7 \approx 3 \Rightarrow 6$
O	$(43.3)(1.48)g$	$(2.7)(1.48)$	$2.7/2.7 = 1 \Rightarrow 2$

Emperical Formula = $\boxed{C_3H_6O_2}$

$n =$ ~~Emperi~~ $\left(\frac{\text{Molecular Mass}}{\text{Emperical Mass}}\right) = \frac{148}{(36+6+32)} \Rightarrow \boxed{n=2}$

$\Rightarrow$ Molecular Formula = $\boxed{C_6H_{12}O_4}$

Q) 3 g of compound on complete combustion with O_2 gives 4.4 g CO_2 and 1.8 g H_2O. Find its molecular formula if its molecular weight is 150 amu.

A)
$$\begin{pmatrix}C\\H\\O\end{pmatrix} + O_2 \longrightarrow \underset{(0.1)\,mol}{CO_2} + \underset{(0.1)\,mol}{H_2O}$$

$$\left(\text{Weight of Carbon in } \boxed{CHO}\right) = \left(\text{Weight of C in } CO_2\right) = \boxed{1.2\,g}$$

$$\left(\text{Weight of H in } \boxed{CHO}\right) = \left(\text{Weight of H in } H_2O\right) = \boxed{0.2\,g}$$

$$\times \quad \boxed{\left(\text{Weight of } O_2\right) = \left(\text{Weight of O in } CO_2\right) + \left(\text{Weight of O in } H_2O\right) - \left(\text{Weight of } O_2\right)}$$

× (Since eq^n NOT balanced) (Can be applied ✓ but lengthy)

$$\left(\text{Weight of O}\right) = (3 - 1.2 - 0.2)\,g = \boxed{1.6\,g}$$

Element	Mass	Mole	Simple Ratio
C	1.2g	0.1	1
H	0.2g	0.2	2
O	1.6g	0.1	1

Emperical formula = $\boxed{CH_2O}$

$\Rightarrow n = \left(\frac{\text{Molecular Mass}}{\text{Emperical Mass}}\right) = \left(\frac{150}{30}\right) \Rightarrow \boxed{n=5}$

$\Rightarrow$ Molecular formula = $\boxed{C_5H_{10}O_5}$

Q) Ratio of mass % of C and H is 6:1 in $(C_xH_yO_z)$ If one molecule contains 1/2 as much oxygen as required to burn one molecule of (C_xH_y) completely. Find emperical formula of $(C_xH_yO_z)$.

A) $\left(\frac{W_C}{W_H}\right) = \left(\frac{n_C}{n_H}\right)\left(\frac{M_C}{M_H}\right) = \left(\frac{x}{y}\right)\left(\frac{12}{1}\right) = \left(\frac{6}{1}\right) \Rightarrow \boxed{y = 2x}$

$$C_xH_y + kO_2 \longrightarrow xCO_2 + xH_2O$$

$\Rightarrow 2k = 2x + x \Rightarrow \boxed{k = 3x/2}$

$\Rightarrow z = (1/2)(2)(3x/2) \Rightarrow \boxed{z = \left(\frac{3x}{2}\right)}$

$\Rightarrow 4z = 3y = 6x \Rightarrow \boxed{\frac{x}{4} = \frac{y}{8} = \frac{z}{6}}$

$\Rightarrow$ Emperical formula = $\boxed{C_2H_4O_3}$

Stoichiometry –

For balanced eq^n,

$$aA + bB \longrightarrow cC + dD$$

$$\Rightarrow \quad \boxed{\frac{n_A}{a} = \frac{n_B}{b} = \frac{n_C}{c} = \frac{n_D}{d}}$$

Q) How many moles of N_2 and H_2 are required to form 8.2 mol NH_3.

A)
$$N_2 + 3H_2 \longrightarrow 2NH_3$$

$$\Rightarrow \frac{n_{N_2}}{1} = \frac{n_{H_2}}{3} = \frac{n_{NH_3}}{2} = 4.1$$

$$\Rightarrow \boxed{n_{N_2} = 4.1} \quad \text{and} \quad \boxed{n_{H_2} = 12.3}$$

Q) 60g of ethane completely react with O_2. Calc. mass of O_2 required and moles of CO_2 produced?

A)
$$C_2H_6 + \left(\frac{7}{2}\right)O_2 \longrightarrow 2CO_2 + 3H_2O$$

$$n_{C_2H_6} = \frac{W_{C_2H_6}}{M_{C_2H_6}} = \frac{60\,\cancel{g}}{30\,\cancel{g}} = 2 \text{ (mol)}$$

$$\frac{n_{C_2H_6}}{1} = \frac{2\,n_{O_2}}{7} = \frac{n_{CO_2}}{2} = 2$$

$\Rightarrow n_{O_2} = 7$ (mol) $\boxed{n_{CO_2} = 4 \text{ (mol)}}$

$\Rightarrow \boxed{W_{O_2} = 224\,g}$ $\Rightarrow W_{CO_2} = 176\,g$

Principle of Atom Conservation (P.O.A.C.) –

- ✓ Applicable on incomplete rx^n.
- ✓ Convert wt. to moles.
- ✓ Applicable for those reactants which get consumed.

Eg: Unbalanced Rx^n,

$$A_2B_3 + B_4C_3 \longrightarrow C_5A_2 + A_2B_5$$

For A,

$$2\,n_{A_2B_3} = 2\,n_{C_5A_2} + 2\,n_{A_2B_5}$$

$$\Rightarrow n_{A_2B_3} = n_{C_5A_2} + n_{A_2B_5}$$

For B,

$$3\,n_{A_2B_3} + 4\,n_{B_4C_3} = 5\,n_{A_2B_5}$$

Q) Find out moles of Al_2O_3 formed from 20 moles of Al reacting with O_2.

A) Unbalanced Rx^n : $Al + O_2 \longrightarrow Al_2O_3$

For Al,

$$1\, n_{Al} = 2\, n_{Al_2O_3} \Rightarrow 20 = 2\, n_{Al_2O_3}$$

$$\Rightarrow \boxed{n_{Al_2O_3} = 10 \text{ (mol)}}$$

Q) Find out hydrocarbon having 20 moles. On combustion, it gives 40 moles CO_2 & 40 moles of H_2O.

A) Unbalanced Rx^n : $C_xH_y + O_2 \longrightarrow CO_2 + H_2O$

For C,

$$x\, n_{C_xH_y} = n_{CO_2} = 40 \Rightarrow 20x = 40$$

$$\Rightarrow \boxed{x = 2}$$

For H,

$$y\, n_{C_2H_y} = 2\, n_{H_2O} = 80 \Rightarrow 20y = 80$$

$$\Rightarrow \boxed{y = 4}$$

$$\Rightarrow \boxed{\text{Compound} = C_2H_4}$$

Q)

$$(NH_4)_2SO_4 \xrightarrow{NaOH} NH_3 \xrightarrow{\Delta} N_2 \xrightarrow{Ca} Ca_3N_2$$

$(1g)$ $(xg) = ?$

A) for N,

$$2\,n_{(NH_4)_2SO_4} = n_{NH_3}$$

$$n_{NH_3} = 2\,n_{N_2}$$

$$(X) \quad 2\,n_{N_2} = 2\,n_{Ca_3N_2}$$

$$2\,n_{(NH_4)_2SO_4} = 2\,n_{Ca_3N_2} \Rightarrow n_{Ca_3N_2} = n_{(NH_4)_2SO_4}$$

$$n_{(NH_4)_2SO_4} = \frac{W}{M} = \left(\frac{1}{132}\right) = \boxed{n_{(NH_4)_2SO_4}} = n_{Ca_3N_2}$$

$$\Rightarrow \boxed{W_{Ca_3N_2}} = \left(\frac{1}{132}\right)(3\cdot40+28)g = \boxed{\left(\frac{148}{132}\right)g}$$

Q) A mix. of $MgCO_3$ and $CaCO_3$ is heated for some time, then its wt. decreases by 50%. Calc. % composition of mix.

A) Let 'n_1' moles of $MgCO_3$ & 'n_2' moles of $CaCO_3$.

$$MgCO_3 \xrightarrow{\Delta} MgO + CO_2\uparrow$$

$$CaCO_3 \xrightarrow{\Delta} CaO + CO_2\uparrow$$

~~100%~~ $$(\text{Decrease }\%) = \left(\frac{\text{Wt. of } CO_2\uparrow}{\text{Mass. of mix.}}\right) = \frac{(n_1+n_2)(44)}{(84n_1+100n_2)} = \left(\frac{1}{2}\right)$$

$$\Rightarrow 88n_1 + 88n_2 = 84n_1 + 100n_2$$

$$\Rightarrow 4n_1 = 12n_2 \Rightarrow \boxed{n_1 = 3n_2}$$

$$\left(\begin{array}{c}\%\text{ Mass}\\ \text{of } MgCO_3\end{array}\right) = \left(\frac{84n_1}{84n_1+100n_2}\right)\times 100\% = \left(\frac{252}{352}\right)\times 100\%$$

$$\approx \left(\frac{500\%}{7}\right) \approx \boxed{71.4\%}$$

$$\left(\%\text{ Mass of } CaCO_3\right) \approx \boxed{28.6\%}$$

01/04/2022

Percentage Yield –

$$\boxed{\%\text{ yield} = \left(\frac{\text{Actual Data}}{\text{Theoretical Data}}\right)\times 100\%}$$

Q) On heating 40g $CaCO_3$, 20g CaO was obtained. Calc. % yield of rx^n.

A) Balan^c: $\underset{(40)\,g}{CaCO_3} \xrightarrow{\Delta} CaO + CO_3$

$$n_{CaCO_3} = n_{CaO} \Rightarrow n_{CaO} = \left(\frac{40}{100}\right) = (0.4)$$

$$W_{CaO} = (56)\left(\frac{4}{10}\right)g \Rightarrow W_{CaO} = 22.4\,g$$

$$\%\text{ yield} = \left(\frac{\text{Actual}}{\text{Theoretical}}\right)\times 100\% = \left(\frac{20}{22.4}\right)\times 100\%$$

$$= \left(\frac{10000}{112}\right)\% \approx \boxed{89.2\%}$$

Q) Calc. moles of $KClO_4$ produced from 2840g of Cl_2 if % yield of rx^ns 1,2,3 are 80%, 100% and 50%.

Balan^c: $Cl_2 + 2KOH \xrightarrow{80\%} KCl + KClO + H_2O$

Balan^c: $3KClO \xrightarrow{100\%} KClO_3 + 2KCl$

Balan^c: $4KClO_3 \xrightarrow{50\%} 3KClO_4 + KCl$

A)

✓ $n_{Cl_2} = \left(\frac{2840}{71}\right) = 40\ (mol)$; ✓ $\frac{80\% \cdot n_{Cl_2}}{1} = \frac{n_{KClO} \cdot \cancel{80\%}}{1}$

$\Rightarrow n_{KClO} = \frac{40 \cdot 8}{10} = 32\ (mol)$

✓ $\frac{n_{KClO}}{3} = \frac{n_{KClO_3}}{1} \Rightarrow n_{KClO_3} = \left(\frac{32}{3}\right)\ (mol)$

✓ $50\% \cdot \frac{n_{KClO_3}}{4} = \frac{n_{KClO_4} \cdot \cancel{5}}{3} \Rightarrow n_{KClO_4} = \frac{1}{2} \cdot \frac{3}{4} \cdot \frac{32}{3} = 4\ (mol)$

$\Rightarrow \boxed{n_{KClO_4} = 4\ (mol)}$

Percentage Purity –

$$\boxed{\%\ purity = \left(\frac{\text{Pure substance}}{\text{Impure sample}}\right) \times 100\%}$$

Q) 50 g of 80% $CaCO_3$ is heated. Find vol. of CO_2 produced.

A) ✓ $W_{CaCO_3} = 50g \times 80\% = 40\ g$

✓ $n_{CaCO_3} = \left(\frac{40}{100}\right) = (0.4)$ (mol)

✓ $n_{CO_2} = n_{CaCO_3} = (0.4)$ (mol)

✓ $V_{CO_2} = (22.4)\,L\,(0.4) = \boxed{8.96\ L}$

Q) For decomposition rxn, pure sample of 20% by mass $KClO_3$ taken which on strong heating produces 96 g of O_2. Calc. the mass of sample taken.

A) Let mass of sample be 'x' g.

Balanc: $2KClO_3 \rightarrow 2KCl + 3O_2\uparrow$

✓ $W_{KClO_3} = 20\% \cdot x = (x/5)\ g$

✓ $n_{KClO_3} = \left(\frac{x}{5\cdot(122.5)}\right)$; ✓ $\frac{n_{KClO_3}}{2} = \frac{n_{O_2}}{3}$

$\Rightarrow n_{O_2} = \left(\frac{3}{2}\right) n_{KClO_3} = \left(\frac{3}{2}\right)\left(\frac{x}{5\cdot(122.5)}\right)$

$= \left(\frac{3x}{5\cdot 245}\right)$ (mol) $\Rightarrow$ $\boxed{x = 1225}$

✓ $W_{O_2} = (32)\left(\frac{3x}{5\cdot 245}\right)\cancel{g} = 96\,\cancel{g} \Rightarrow x = \left(\frac{96\cdot 5\cdot 245}{32\cdot 3}\right)$

Limiting Reagent –

Reagent which gets completely consumed in the rx^n

$$\boxed{(L.R.) = \min\left\{\frac{\text{Moles}}{\text{Stoichometric Coeff.}}\right\}}$$

Q) In Haber process, 56g of N_2 mixed with 10g H_2 to form NH_3. Calc. mass of NH_3 produced & mass of reactant remaining.

A) Balan^c: $N_2 + 3H_2 \longrightarrow 2NH_3$.

$W_{N_2} = 56\ g$

$n_{N_2} = \left(\frac{56}{28}\right) = 2$

$W_{H_2} = 10\ g$

$n_{H_2} = \left(\frac{10}{2}\right) = 5$

~~min~~ $\min\left\{\frac{2}{1}, \frac{5}{3}\right\} = \left(5/3\right) \Rightarrow \boxed{H_2 \text{ is } (L.R.)}$

So, $\frac{n_{NH_3}}{2} = \frac{n_{H_2}}{3} \Rightarrow n_{NH_3} = \left(\frac{2}{3}\right)(5) = \boxed{\left(\frac{10}{3}\right)}$

$\Rightarrow W_{NH_3} = \left(\frac{10}{3}\right)(17)\ g \Rightarrow \boxed{W_{NH_3} \approx 56.67\ g}$

$W_{N_2\,remain} = W_{N_2} - (28)\left(\frac{1}{3}\right)(5) = 56 - \left(\frac{140}{3}\right) = \left(\frac{28}{3}\right)$

$\Rightarrow \boxed{W_{N_2\,remain} \approx 9.33\ g}$

Q) In formation of nitric oxide from NH_3, 34 g NH_3 reacts with 160 g O_2. Calc. mass of NO produced.

A) Balanced: $2NH_3 + \frac{5}{2}O_2 \rightarrow 2NO + 3H_2O$

$W_{NH_3} = 34\,g$ $\qquad$ $W_{O_2} = 160\,g$

$n_{NH_3} = \left(\frac{34}{17}\right) = 2$ $\qquad$ $n_{O_2} = \left(\frac{160}{32}\right) = 5$

$$\min\left\{\frac{2}{2}, \frac{5}{(5/2)}\right\} = 1 \Rightarrow \boxed{NH_3 \text{ is } (L.R.)}$$

$$\frac{n_{NO}}{2} = \frac{n_{NH_3}}{2} \Rightarrow n_{NO} = 2 \Rightarrow W_{NO} = (2)(30)\,g$$

$$\Rightarrow \boxed{W_{NO} = 60g}$$

Q) Mass of N_2F_4 produced in rxn of 1.7 g NH_3 & 7.6 g F_2 is 3.56 g. What is % yield?

A) Balan^c: $2NH_3 + 5F_2 \rightarrow N_2F_4 + 6HF$

$W_{NH_3} = 1.7\,g$ $\qquad$ $W_{F_2} = 7.6\,g$

$n_{NH_3} = \left(\frac{1.7}{17}\right) = 0.1$ $\qquad$ $n_{F_2} = \left(\frac{7.6}{38}\right) = 0.2$

$$\min\left\{\frac{0.1}{2}, \frac{0.2}{5}\right\} = 0.04 \Rightarrow F_2 \text{ is } (L.R.)$$

$$n_{N_2F_4} = \frac{n_{F_2}}{5} = 0.04 \Rightarrow W_{N_2F_4} = (0.04)(104)\,g$$

$$= \frac{416}{100}g = \boxed{4.16\,g}$$

$$(\% \text{ yield}) = \left(\frac{3.56}{4.16}\right) \times 100\% \approx \boxed{85.5\%}$$

Q) 2g sample contains mix. of SiO_2 and Fe_2O_3, on very strong healing leaves 1.96g residue. What is mass % of SiO_2?

A) Unbalanc: $Fe_2O_3 \longrightarrow Fe_3O_4 + O_2$

$2 \cdot n_{Fe_2O_3} = 3 \cdot n_{Fe_3O_4}$; Let mass of Fe_2O_3 be 'x'

$$n_{Fe_3O_4} = \left(\frac{2}{3}\right)\left(\frac{x}{160}\right) = \left(\frac{x}{240}\right) \Rightarrow \boxed{W_{Fe_3O_4} = \left(\frac{232}{240}\right)x}$$

$$\Rightarrow (2-x) + \left(\frac{232}{240}\right)x = 1.96 \Rightarrow 0.04 = \left(\frac{8x}{240}\right)$$

$$\Rightarrow x = \left(\frac{240 \cdot 4}{800}\right) g \Rightarrow \boxed{x = 1.2g}$$

$$\text{Mass \% } SiO_2 = \left(\frac{0.8}{2}\right) \times 100\% = \boxed{40\%}$$

Sir's Soln: Loss in wt. is due to O_2

$$\Rightarrow \boxed{n_{O_2} = \left(\frac{0.04}{32}\right)}$$

Using this calc. $W_{Fe_2O_3}$, after balanc.

Find W_{SiO_2}, then find mass %.

Q) For rx^n $2Fe(NO_3)_3 + 3Na_2CO_3 \rightarrow Fe_2(CO_3)_3 + 6NaNO_3$. Initially if 2.5 mol $Fe(NO_3)_3$ and 3.6 mol Na_2CO_3 is taken. Find % yield if 6.3 mol $NaNO_3$ is obtained.

A) $\min\left\{\frac{2.5}{2}, \frac{3.6}{3}\right\} = 1.2 \Rightarrow \boxed{Na_2CO_3 \text{ is (L.R.)}}$

$$\frac{n_{NaNO_3}}{6} = \frac{n_{Na_2CO_3}}{3} \Rightarrow n_{NaNO_3} = (2)(3.6) = 7.2$$

$$\% \text{ yield} = \left(\frac{6.3}{7.2}\right) \times 100\% \approx \boxed{87.5\%}$$

Q) 0.8 mol mix. of CO and CO_2 requires exactly 40 g NaOH for complete conversion of CO_2 into Na_2CO_3. How many moles of NaOH would be furthur ~~required converted~~ required to convert the rest to Na_2CO_3, if CO in mix is completely oxidised to CO_2.

A) Let 'n_1' mol CO_2 & 'n_2' mol CO.

Balanc: $2NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$ -(i)

$$\frac{n_{NaOH(i)}}{2} = \frac{n_{CO_2(i)}}{1} \Rightarrow n_1 = \frac{40}{2 \cdot 40} = 0.5$$

Balanc: $2NaOH + \underset{\text{(from CO)}}{CO_2} \longrightarrow Na_2CO_3 + H_2O$ -(ii)

$$\frac{n_{NaOH(ii)}}{2} = n_{CO_2(ii)} = n_2 = 0.3 \Rightarrow \boxed{n_{NaOH(ii)} = 0.6 \text{ (mol)}}$$

☆Q) A mix. of NH_4NO_3 and $(NH_4)_2HPO_4$ contains 30.4% mass of N. find ratio of mass of 2 components [$NH_4NO_3 : (NH_4)_2HPO_4$]

A) ~~Let n~~ % by mass of N in $NH_4NO_3 = \left(\frac{28}{80}\right) \times 100\% = 35\%$

% by mass of N in $(NH_4)_2HPO_4$

$$= \left(\frac{28}{132}\right) \times 100\% \approx 21\%$$

(NH_4NO_3) $((NH_4)_2HPO_4)$

35 % 21 %

30.4 %

9.4 % 4.6 % $\approx \boxed{2 : 1}$

Q) In preparation of Fe from Fe_2O_3 by rxn

$$Fe_2O_3 + C \longrightarrow Fe + CO_2$$

How much 80% pure Fe could be produced from 120 kg of 90% pure Fe_2O_3.

A) Balanc: $Fe_2O_3 + \frac{3}{2}C \longrightarrow 2Fe + \frac{3}{2}CO_2$

$$\left(\frac{W_{Fe_2O_3}}{160}\right)(90\%) = \left(\frac{W_{Fe}}{2\cdot 56}\right)\cdot(80\%) \longleftarrow \left[\frac{n_{Fe_2O_3}}{n_{Fe}} = \frac{8}{9}\right]$$

$$\Rightarrow W_{Fe} = \left(\frac{120\cdot 10^3\cdot 90\cdot 2\cdot 56}{160\cdot 80}\right) g \Rightarrow \boxed{W_{Fe} = 94.5 \text{ kg}}$$

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Solution: Homogenous mix. ~~of 2~~ of 2 or more compounds

Solute: Substance which lose their identity/physical prop^ts.

Solvent: Substance which retain their identity/physical prop^ts.

A → Solvent ; B → Solute ; S → Solution

- Conc.
  - Qualatative
    - Dilute Sol^n
    - Conc. Sol^n
  - Quantitative
    - Volume dependant (Temp. dependant)
      - % v/v
      - % w/v
      - Molarity
      - Normality
      - Formality
    - Mass dependant (Temp. independant)
      - % w/w
      - Mole fraction
      - Molality
      - Parts per million

Concentration: Amt. of solute present in a fixed amt. of solution.

1) % V/~~W~~ — Vol. of solute (in mL) present in 100 mL of sol^n.

$$\boxed{\% V/V_{\text{of solute}} = \left(\frac{\overset{(\text{in mL})}{V_B}}{\underset{(\text{in mL})}{V_S}}\right) \times 100\%}$$

Q) How many mL of C_2H_5OH should be added in 250 mL of water to obtain a sol^n containing 80% v/v solvent?

A) Let 'x' mL be required,

$$\left(\begin{array}{c}\% V/V \\ \text{of Solvent}\end{array}\right) = \left(\frac{250}{250+x}\right) \times 100\% = 80\%$$

$$\Rightarrow (250) = \left(\frac{4}{5}\right)(250+x)$$

$$\Rightarrow \boxed{x = 62.5 \text{ mL}}$$

2) % W/V — Wt. of solute (in g) present in 100 mL sol^n.

$$\boxed{\left(\begin{array}{c}\% W/V \\ \text{of solute}\end{array}\right) = \left(\frac{\overset{(\text{in g})}{W_B}}{\underset{(\text{in mL})}{V_S}}\right) \times 100\%}$$

Q) How much H_2SO_4 ~~should be added~~ is present in 500 mL of aq. sol^n containing 25% w/v of H_2SO_4 if $\rho_{sol^n} = 1.25 \frac{g}{mL}$? Also find out wt. of water.

A) $$\left(\frac{W_B}{V_S}\right) \times 100\% = \% \, W/v \Rightarrow \left(\frac{1}{4}\right) = \left(\frac{W_B}{500}\right)$$

$$\Rightarrow \boxed{W_B = 125 g}$$

$$W_w = W_S - W_B = (1.25)(500) - 125$$
$$= (625 - 125) \Rightarrow \boxed{W_w = 500 g}$$

3) **Molarity (M)** — No. of moles of solute present in 1 L sol^n.

$$\boxed{M \text{ (Molarity)} = \left(\frac{n_B \text{ (in mol)}}{V_S \text{ (in L)}}\right)}$$

Q) Find molarity of sol^n if 30g of urea (mol. wt. 60g) is dissolved in 2L of sol^n.

A) $$M = \left(\frac{n_A}{V_S}\right) \Rightarrow M = \left(\frac{30}{60}\right)\left(\frac{1}{2}\right) \frac{mol}{L}$$

$$\Rightarrow \boxed{M = 0.25 \frac{mol}{L}}$$

☆ $$\boxed{M\ (\text{Molarity}) = \frac{(\%\ W/v)\cdot 10}{M_B}}$$

M_B — Molar Mass of Solute

---

4) % W/W — It is wt. of solute (in g) present in 100 g of solⁿ.

$$\boxed{\begin{pmatrix}\%\ w/w \\ \text{of solute}\end{pmatrix} = \left(\frac{W_B}{W_S}\right) \times 100\%}$$

W_B (in g), W_S (in g)

Q) 5 mol of glucose are dissolved in 2L solⁿ, If $\rho_{soln} = 1.5\ \frac{g}{mol}$, then calc.

i) % W/v ii) % W/w iii) M

A) iii) $M\ (\text{Molarity}) = \left(\frac{5}{2}\right)\frac{mol}{L} = \boxed{2.5\ \frac{mol}{L}}$

i) $M = \frac{(\%\ W/v) \times 10}{M_B} \Rightarrow (\%\ W/v) = \frac{(2.5)(180)}{10}$

$\Rightarrow (\%\ W/v) = \boxed{45\%}$

iii) $(\%\ W/w) = \left(\frac{W_B}{W_S}\right) \times 100\% = \frac{5\cdot 180}{2000\cdot(1.5)} \times 100\%$

$= \boxed{30\%}$

☆ $$\boxed{M = \frac{(\%W/w)\cdot \overset{\text{(in g/mL)}}{\rho_s}\cdot 10}{M_B}\ ,\quad (\%W/v) = (\%W/w)\overset{\text{(in g/mL)}}{\rho_s}}$$

5) Mole fraction (X) — No. of mol of solute in 1 mol sol^n.

$$\boxed{X_B = \left(\frac{n_B}{n_S}\right)}$$

Note: Sum of Mole fraction of all components is 1.

Q) Find mole fractions of water and urea if 30g of urea is dissolved in 45g of water.

A) $n_{water} = \left(\frac{45}{18}\right) = \boxed{2.5}$; $n_{urea} = \left(\frac{30}{60}\right) = \boxed{0.5}$

$X_{water} = \left(\frac{2.5}{2.5+0.5}\right) = \boxed{\left(\frac{5}{6}\right)}$; $X_{urea} = \left(\frac{0.5}{2.5+0.5}\right) = \boxed{\left(\frac{1}{6}\right)}$

Q) A sol^n contains 28% w/w of KOH. If $\rho_s = 1.25\ \frac{g}{mL}$, find X_{KOH}, (% w/v) and M.

A)

✓ $(\%\ w/v) = (\%\ w/w) \times \rho_s = 28\cdot(1.25)\ \% = \boxed{35\ \%}$

✓ $M = \frac{(\%w/v)\cdot 10}{M_B} = \left(\frac{35\cdot 10}{56}\right) = \boxed{6.25}$

✓ In 100g sol^n, 28 g KOH.

$\Rightarrow n_{KOH} = \left(\frac{28}{56}\right)$; $n_{water} = \left(\frac{72}{18}\right)$

$\Rightarrow \boxed{X_{KOH}} = \frac{1/2}{1/2 + 4} = \boxed{\frac{1}{9}}$

---

6) Molality (m) —

Moles of solute present in 1 kg of ~~sol^n~~ solvent

$$\boxed{m\ (\text{Molality}) = \left(\frac{n_B}{W_A}\right)} \text{ (in kg)}$$

Q) Find molality of 20% w/v NaOH sol^n having density 1.1 $\frac{g}{mL}$.

A) Consider 1 ~~kg~~ L of sol^n $\Rightarrow \boxed{W_S = 1100\ g}$

$\Rightarrow W_{NaOH} = \left(\frac{20}{100}\right)(1000) = 200\ g \Rightarrow n_{NaOH} = \left(\frac{200}{40}\right) = 5$

$\Rightarrow \boxed{W_A = 900\ g}$ ~~$\Rightarrow m = \frac{200 \times 1000}{900}$~~

$\Rightarrow m = \left(\frac{5}{900}\right) \times 1000 = \boxed{\frac{50}{9}}$

☆ Q) Which is more conc. 1 M sol^n or 1 m sol^n ($\rho_s = 1 \frac{Kg}{L}$)

A) M = Mole of solute in 1 L sol^n.

$\Rightarrow$ 1 M $\longleftrightarrow$ 1 mol in 1 L sol^n

Now, Mass of solvent < Mass of Sol^n $\Rightarrow$ Solvent < 1 kg

$$\boxed{m_1} = \frac{1\text{ mol}}{(<1\text{ kg})} \boxed{>} 1\,\frac{\text{mol}}{\text{kg}} = \boxed{1\text{ m}}$$

$$\updownarrow$$

$$\boxed{1\text{ M}} \Rightarrow$$ 1 M > 1 m in terms of conc.

---

7) Parts per million (ppm) –

Wt. of solute (in g) dissolved in 10^6 g of sol^n.

$$\boxed{\text{ppm} = \left(\frac{W_B}{W_S}\right)\times 10^6 \approx \left(\frac{W_B}{W_A}\right)\times 10^6}$$

(if $W_B \ll W_A$)

8/04/2022

8) Normality (N) –

It is no. of gram equivalents dissolved in 1L of sol^n.

$$\boxed{N = \left(\frac{\text{no. of g-equiv. of solute}}{\underbrace{V_S}_{(\text{in L})}}\right) = \left(\frac{eq_B}{V_S}\right)}$$

$$\boxed{eq_B = \left(\frac{\text{Given wt.}}{\text{Equiv. wt.}}\right) = \left(\frac{W_B}{E_B}\right)}$$

$$\boxed{E_B = \left(\frac{\text{Molar Mass}}{n\text{-factor}}\right) = \left(\frac{M_B}{n\text{-factor}}\right)}$$

$$\Rightarrow \quad N = \left(\frac{eq_B}{V_S}\right) = \left(\frac{W_B}{V_S E_B}\right) = \left(\frac{W_B}{V_S M_B}\right)(n\text{ factor})$$

☆

$$\Rightarrow \quad N = \left(\frac{W_B}{M_B}\right)\frac{(n\,\text{factor})}{(V_S)} \Rightarrow \boxed{N = (n\,\text{factor})\,M}$$

n factor –

For Acids:

$$\boxed{(n\,\text{factor}) = \text{Basicity}}$$

(no. of H^+ released)

Acid	Basicity
HCl	1
H_2SO_4	1, 2
H_3PO_4	3
H_3PO_3	2
H_3PO_2	1
H_3BO_3	1

For Bases:

$$\boxed{(n\,\text{factor}) = \text{Acidity}}$$

(no. of OH^- released or H^+ accepted)

Bases	Acidity
$NaOH$	1
$Mg(OH)_2$	2
NH_3	1

Q) Find normality of 20g NaOH in 500 mL solⁿ.

A) $n_{NaOH} = \left(\frac{20}{40}\right)\frac{g}{g/mol} = \boxed{0.5\text{ mol}}$

$M = \left(\frac{0.5}{1/2}\right)\frac{mol}{L} = \boxed{1\text{ M}}$; $(n\,\text{factor})_{NaOH} = \boxed{1}$

$$\Rightarrow \quad N = 1\,M \times 1\,\frac{N}{M} \Rightarrow \boxed{N = 1N}$$

Q) Calc. normality of 250 cm^3 sol^n containing 8.2 g H_3PO_3.

A) $V_s = 250\ cm^3 = 250 mL = \boxed{(1/4)\ L}$; $(n\ factor)_{H_3PO_3} = \boxed{2}$

$n_{H_3PO_4} = \left(\frac{8.2}{82}\right)\frac{g}{g/mol} = \boxed{0.1\ mol}$;

$M = \left(\frac{0.1}{1/4}\right)\frac{mol}{L} = 0.4\ M \Rightarrow \boxed{N} = (0.4M)\left(2\frac{N}{M}\right) = \boxed{0.8N}$

9) Formality (F) —

It is no. of formula units of solute in 1L of sol^n.

$$\boxed{F = \left(\frac{\text{No. of Formula Units}}{\underbrace{V_s}_{(in\ L)}}\right)}$$

☆ Relationship b/w Conc. Terms —

1) $\boxed{N = M \cdot (n\text{-}factor)}$

2) $\boxed{(eq) = (mol) \cdot (n\text{-}factor)}$

3) $\boxed{M = \left(\frac{(\%\ w/v) \cdot 10}{M_B}\right)}$

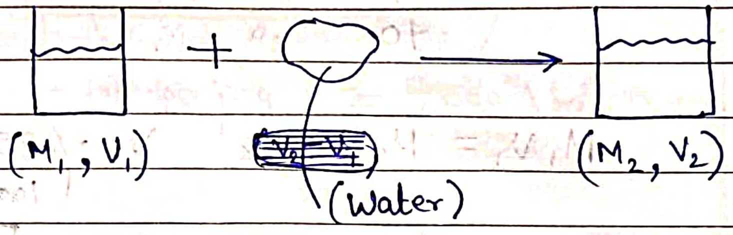
4) $\boxed{m = \left(\frac{1000\ M}{1000\rho_s - M M_B}\right)}$

5) $\boxed{m = \left(\frac{1000\ x_B}{M_A x_A}\right)}$

6) $\boxed{M = \left(\frac{1000 \rho_s x_B}{M_A x_A + M_B x_B}\right)}$

Dilution & Mixing :-

Dilution :



Since no. of mol remain same, so.

$$\boxed{M_1 V_1 = M_2 V_2}$$

(before dil.) (after dil)

Q) What vol. of 4 M H_2SO_4 solⁿ taken to form 5L of 1.96% w/v H_2SO_4?

A) $M_1 = 4 \text{ M}$, $V_1 = ?$, $M_2 = \frac{(1.96)\cdot 10}{98} = 0.2 \text{ M}$,

$V_2 = 5 \text{ L}$.

$$M_1 V_1 = M_2 V_2 \Rightarrow V_1 = \left(\frac{(0.2)\cdot 5}{4}\right) \text{L}$$

$$\Rightarrow \boxed{V_1 = 250 \text{ mL}}$$

Q) 20g of NaOH is dissolved in 200 mL solⁿ. What vol. should be taken to form 2L of 0.01 M solⁿ?

A) $(\% w/v) = \boxed{10 \%}$

$M = \frac{(10)\cdot 10}{40} \Rightarrow M = \boxed{(25) M}$

$M_1 V_1 = M_2 V_2 \Rightarrow V_1 \cdot \left(\frac{25}{10}\right) = \left(\frac{1}{100}\right)(2) L$

$\Rightarrow V_1 = \left(\frac{2}{250}\right) L \Rightarrow \boxed{V_1 = 8 mL}$

Q) 18 % w/w HCl of $\rho_s = 1.2 \frac{g}{mL}$ is taken to form 3.6 w/v % HCl with 50 mL. Calc. vol. of conc. HCl taken.

A) $(\% w/v)_{Initial} = 18\cdot(1.2)\% \Rightarrow M_1 = \left(\frac{18\cdot(1.2)\cdot 10}{36.5}\right) M$

$(\% w/v)_{final} = 3.6 \% \Rightarrow M_2 = \left(\frac{(3.6)\cdot 10}{36.5}\right) M$

$M_1 V_1 = M_2 V_2 \Rightarrow V_1 = \left(\frac{(3.6)\cdot 10}{18\cdot(1.2)\cdot 10}\right)(50) mL$

$\Rightarrow \boxed{V_1 = \left(\frac{25}{3}\right) mL}$

☆ Q) 100 mL of 1M H_2SO_4 sol^n with density 1.5 g/mL is mixed with 400 mL of water. Calc. final molarity of H_2SO_4 sol^n, if its density is $1.25 \frac{g}{mL}$.

A) $M_1 = 1\,M$, $V_1 = 100\,mL$.

$$V_2 = \left(\frac{W_2}{\rho_s}\right) = \left(\frac{\rho_{H_2SO_4} V_{H_2SO_4} + \rho_{H_2O} V_{H_2O}}{\rho_s}\right)$$

$$= \left(\frac{1.5\cdot100 + 1\cdot400}{1.25}\right)\frac{g}{g/mL} = \left(\frac{550}{1.25}\right) mL$$

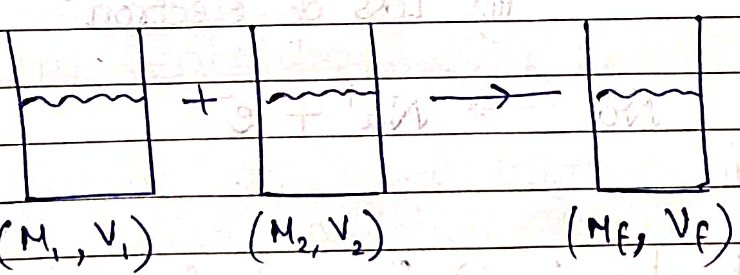
$$\Rightarrow \boxed{V_2 = 440\ mL}.$$

☆ Note: $V_2 \neq (100 + 400)\,mL$ bcoz density of solⁿs is diff.

Now, $M_1 V_1 = V_2 M_2 \Rightarrow 1\cdot100\ mL\cdot M = 440\ mL\cdot M_2$

$$\Rightarrow M_2 = \left(\frac{10}{44}\right)M \Rightarrow \boxed{M_2 \approx 0.227\ M}$$

Mixing:



Since no. of mol same,

$$\boxed{M_1 V_1 + M_2 V_2 = M_f V_f}$$

☆ For adding 2 sol^ns with diff. density, we use,

$$\boxed{\underbrace{\rho_1 V_1}_{(Sol^n 1)} + \underbrace{\rho_2 V_2}_{(Sol^n 2)} = \underbrace{\rho_f V_f}_{(final\ Sol^n)}}$$

This is a consequence of Conservation of Mass.

24/05/2022

Readox Rx^n

Oxidation: i) Add^n of oxygen
ii) Removal of hydrogen
iii) Loss of electron.

Eg: $Na \longrightarrow Na^+ + e^-$

Reduction: i) Removal of oxygen
ii) Add^n of hydrogen
iii) Gain of $\bar{e}$.

Eg: $\bar{e} + Cl \longrightarrow Cl^-$

Oxidising Agent :

Those substances which oxidise the other substance and themselves get reduced is known as oxidising agent.

Eg : HNO_3, $KMnO_4$, $K_2Cr_2O_7$, etc.

Reducing Agent :

Those substances which reduce the other substance and themselves get oxidised is known as reducing agent.

Eg : $LiAlH_4$, Ni, $NaBH_4$, etc.

Oxidation State

Charge present on atom in a combined state is called oxidation ~~no~~ state

Rules for Oxidation state. —

1) For neutral molecule :

Sum of oxd^n state of all atoms in a molecule is zero.

2) For ions :

Sum of oxd^n state of all atoms in an ion is equal to charge on ion.

3) For any 2 atoms :

$\underset{+1}{A} - \underset{-1}{B}$ $\underset{+2}{A} = \underset{-2}{B}$ $\underset{+3}{A} \equiv \underset{-3}{B}$ $\underset{0}{A} - \underset{0}{A}$

where B is more EN than A.

4) For Alkali Metals : (Li, Na, K, Rb, Cs)

$\boxed{O.S. = +1}$ (always in combined state)

5) For Alkali Earth Metals : (Be, Mg, Ca, Sr, Ba)

$\boxed{O.S. = +2}$ (always in combined state)

6) For Fluorine :

$\boxed{O.S. = -1}$ (always in combined state)

7) For Hydrogen :

With Metals, $\boxed{O.S. = -1}$ (always) Eg : NaH, MgH_2, etc.

With Non-metals, $\boxed{O.S. = +1}$ (always) Eg : NH_3, H_2O, etc.

8) For Oxygen :

Generally, $\boxed{O.S. = -2}$

Exceptions : fluoride, peroxide, superoxide, ozonide, etc.

For Fluoride,

i) OF_2 $\boxed{O.S. = +2}$ ii) O_2F_2 $\boxed{O.S. = +1}$

For Peroxide (O_2^{2-}),

i) H_2O_2 $\boxed{O.S. = -1}$ ii) Na_2O_2 $\boxed{O.S. = -1}$

For Superoxide (O_2^-), i) KO_2 $\boxed{O.S. = -1/2}$ → Avg. Oxd^n State

For Ozonide, i) KO_3 $\boxed{O.S. = -1/3}$ → Avg. Oxd^n State

Q) Find O.S. in following species :—

1) HCl A) $+1+x=0 \Rightarrow \boxed{x=-1}$

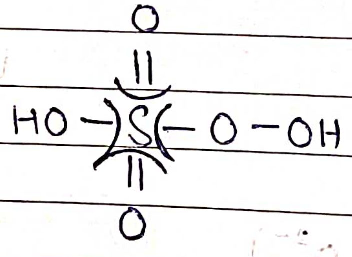
2) $HClO_3$ A) $+1+x+3(-2)=0 \Rightarrow \boxed{x=+5}$

3) F_2O A) $2(-1)+x=0 \Rightarrow \boxed{x=+2}$

4) PO_4^{3-} A) $x+4(-2)=-3 \Rightarrow \boxed{x=+5}$

☆ 5) H_2SO_5 A) $2(+1)+x+5(-2)=0 \Rightarrow (x=8)$ X

(Caro's Acid)

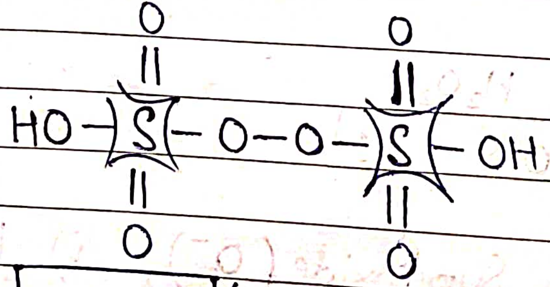


$$HO-\overset{O}{\underset{O}{\overset{\|}{\underset{\|}{S}}}}-O-OH$$

$\boxed{O.S.=6}$
$(2+1+1+2=6)$

☆ 6) $H_2S_2O_8$ A)

(Marshell's Acid)



$$HO-\overset{O}{\underset{O}{\overset{\|}{\underset{\|}{S}}}}-O-O-\overset{O}{\underset{O}{\overset{\|}{\underset{\|}{S}}}}-OH$$

$\boxed{O.S.=6}$ $(2+2+1+1=6)$

7) NH_4NO_3

A) NH_4^+

$x+4(+1)=1 \Rightarrow \boxed{x=-3}$

NO_3^-

$x+3(-2)=-1 \Rightarrow \boxed{x=5}$

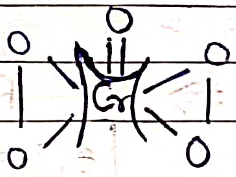
☆8) $CaOCl_2$

A) OCl^- $-2 + x = -1 \Rightarrow \boxed{x = +1}$

$CaCl^+$ $2 + x = 1 \Rightarrow \boxed{x = -1}$

☆9) CrO_5

A)



$\boxed{O.S. = 6}$

$(2+1+1+1+1 = 6)$

10) $(NH_4)_2 Cr_2O_7$

A) $(NH_4^+)_2$

$x + 4(1) = 1$

$\Rightarrow \boxed{x = -3}$

$Cr_2O_7^{2-}$

$2x + 7(-2) = -2$

$\Rightarrow \boxed{x = 6}$

11) Fe_2O_3 A) $2x + 3(-2) = 0 \Rightarrow \boxed{x = +3}$

12) Fe_3O_4 A) $FeO \cdot Fe_2O_3$

$x + (-2) = 0$ $\Rightarrow \boxed{x = +2}$

$2x + 3(-2) = 0$ $\Rightarrow \boxed{x = 3}$

☆13) Pb_3O_4 A) $2PbO \cdot PbO_2$

$x + (-2) = 0$ $\Rightarrow \boxed{x = 2}$

$x + 2(-2) = 0$ $\Rightarrow \boxed{x = +4}$

☆ 14) C_3O_2
(Carbon suboxide)

A) $$O=\underset{\boxed{+2}}{C}=\underset{\boxed{0}}{C}=\underset{\boxed{+2}}{C}=O$$

15) $K_4[Fe(CN)_6]$

A) $$K_4^+\ [Fe(CN)_6]^{-4} \Rightarrow \underset{\boxed{O.S. = +2}}{Fe^{+2}}\quad (CN^-)_6 \Rightarrow {}^-\underset{+2}{C}\equiv \underset{-3}{N}$$

16) $K_4[Fe(SCN)_6]$

A) $$K_4^+\ [Fe(SCN)_6]^{-4} \Rightarrow \underset{\boxed{O.S. = +2}}{Fe^{2+}}\quad (SCN^-)_6 \Rightarrow S(CN^-)$$

$$x + (-1) = (-1)$$
$$\Rightarrow \boxed{x = 0}$$

25/05/2022

Types of Redox $Rx^n s$

1) Intermolecular –

Atoms of two diff. substance undergo oxd^n and red^n $rx^n s$.

$$\overset{+6\ \text{———}\ Red^n\ \text{———}\ +3}{}$$

Eg: $$\underset{+6}{Cr_2}O_7^{2-} + \underset{-1}{Cl^-} \longrightarrow \underset{+3}{Cr}Cl_3 + \underset{0}{Cl_2}$$

$$-1\ \text{———}\ Oxd^n\ \text{———}\ 0$$

2) Intramolecular —

Atoms of single substance undergo oxd^n and red^n rx^ns.

$$\text{Eg:}\quad \overset{-3\ \text{———}\ \text{Oxd}^n\ \text{———}\ 0}{\underset{+6\ \text{———}\ \text{Red}^n\ \text{———}\ +3}{(NH_4)_2Cr_2O_7 \longrightarrow N_2 + Cr_2O_3 + H_2O}}$$

3) Disproportionation —

Atom of same element gets oxdidised and reduced in same rx^n.

$$\text{Eg:}\quad \overset{0\ \text{———}\ \text{Oxd}^n\ \text{———}\ +7}{\underset{0\ \text{———}\ \text{Red}^n\ \text{———}\ -1}{I_2 + OH^- \longrightarrow IO_4^- + I^-}}$$

☆ **Note:** This rx^n is given by those atoms whose O.S. lies b/w max. & min. O.S. values.

4) Comproportionation —

Reverse of disproportionation

$$\text{Eg:}\quad \overset{-1\ \text{———}\ \text{Oxd}^n\ \text{———}\ 0}{\underset{+5\ \text{———}\ \text{Red}^n\ \text{———}\ 0}{I^- + IO_3^- + H^- \longrightarrow I_2 + H_2O}}$$

Q) Identify following $rx^n s$. —

1) $MnO_4^- + C_2O_4^{2-} \longrightarrow MnO + CO_2$

+7 —— Red^n —— +2

A) $MnO_4^- + C_2O_4^{2-} \longrightarrow MnO + CO_2$

+3 —— Oxd^n —— +4

Intermolecular

2) $NaOH + Cl_2 \longrightarrow NaCl + NaOCl$

0 —— Red^n —— -1

A) $NaOH + Cl_2 \longrightarrow NaCl + NaOCl$

0 —— Oxd^n —— +1

Disproportionation

-2 —— Oxd^n —— +2

3) $F_2 + NaOH \longrightarrow NaF + OF_2$

0 —— Red^n —— -1

Intermolecular

Balancing of Redox Rxⁿs.

1) Oxidation No. Method -

☆ Q) Balance $MnO_4^- + C_2O_4^{2-} \longrightarrow Mn^{2+} + CO_2 + H_2O$

A) i) Balance atoms other than O and H,

$$MnO_4^- + C_2O_4^{2-} \longrightarrow Mn^{2+} + 2CO_2 + H_2O$$

ii) Identify oxdⁿ and redⁿ,

+3 — Oxdⁿ by $\boxed{2e^-}$ — +4

$$\underset{+7}{Mn}O_4^- + \underset{+3}{C_2}O_4^{2-} \longrightarrow \underset{+2}{Mn}^{2+} + 2\underset{+4}{C}O_2 + H_2O$$

+7 — Redⁿ by $\boxed{5e^-}$ — +2

iii) Cross Multiply,

$$2MnO_4^- + 5C_2O_4^{2-} \longrightarrow 2Mn^{2+} + 10CO_2 + H_2O$$

iv) Use H_2O to balance no. of O atoms,

$$2MnO_4^- + 5C_2O_4^{2-} \longrightarrow 2Mn^{2+} + 10CO_2 + H_2O$$

(28 O atoms) (21 O atoms)

$$16H^+ + \boxed{2MnO_4^- + 5C_2O_4^{2-} \longrightarrow 2Mn^{2+} + 10CO_2 + 8H_2O}$$

2) Ion electron Method →

i) Write O.S. of all atoms undergoing oxd^n & red^n.

ii) Seperate half oxd^n & half red^n rx^{n}s.

iii) Balance all the atoms except oxygen and hydrogen in both half rx^{n}s.

iv) Add e^- as per oxd^n or red^n

v) Balance O by H_2O

vi) Acidic Medium, balance H by H^+

Basic Medium, balance H by H^+
add OH^- to eliminate H^+

vii) Make e^- equal in both half rx^n and add them.

Q) Balance $MnO_4^- + C_2O_4^{2-} \xrightarrow{H^+} Mn^{2+} + CO_2 + H_2O$

A)
+7 —— Red^n by $\boxed{5e^-}$ —— +2

$\underline{Mn}O_4^- + \underline{C}_2O_4^{2-} \longrightarrow \underline{Mn}^{2+} + \underline{C}O_2 + H_2O$

+3 —Oxd^n by $\boxed{1e^-}$ — +4

Half Oxd^n Rx^n,

$$C_2O_4^{2-} \longrightarrow 2CO_2 + 2e^- \quad — (i)$$

Half Red^n Rx^n,

$$MnO_4^- + 5e^- \longrightarrow Mn^{2+}$$

$$MnO_4^- + 5e^- \longrightarrow Mn^{2+} + 4H_2O$$

$$MnO_4^- + 5e^- + 8H^+ \longrightarrow Mn^{2+} + 4H_2O \quad — (ii)$$

5(i) + 2(ii),

$$\boxed{2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \longrightarrow 2Mn^{2+} + 10CO_2 + 8H_2O}$$

Q) Balance $ClO_3^- + Fe^{2+} \xrightarrow{H^+} Cl^- + Fe^{3+} + H_2O$

A)

$$\overset{+5 \text{ — Red}^n \text{ by } \textcircled{6e^-} \text{ — } -1}{ClO_3^- + Fe^{2+} \longrightarrow Cl^- + Fe^{3+} + H_2O}$$

$$+2 \text{ — Oxd}^n \text{ by } \textcircled{1e^-} \text{ — } +3$$

Half Oxd^n Rx^n,

$$Fe^{2+} \longrightarrow Fe^{3+} + e^- \quad — ①$$

Half Red^n Rx^n,

$$ClO_3^- + 6e^- \longrightarrow Cl^-$$

$$ClO_3^- + 6e^- \longrightarrow Cl^- + 3H_2O$$

$$ClO_3^- + 6e^- + 6H^+ \longrightarrow Cl^- + 3H_2O \quad — ②$$

6① + ②,

$$\boxed{6Fe^{2+} + ClO_3^- + 6H^+ \longrightarrow 6Fe^{3+} + Cl^- + 3H_2O}$$

Q) Balance: $CuS + NO_3^- \xrightarrow{H^+} Cu^{2+} + S_8 + NO + H_2O$

A)

-2 —— Oxd^n ($2e^-$) —— 0

$$CuS + NO_3^- \longrightarrow Cu^{2+} + S_8 + NO$$

$+5$ —— Red^n ($3e^-$) —— $+2$

Half Oxd^n Rx^n,

$$CuS \longrightarrow Cu^{2+} + S_8 + 2e^-$$

$$8CuS \longrightarrow 8Cu^{2+} + S_8 + 16e^- \quad — (i)$$

Half Red^n Rx^n,

$NO_3^- + 3e^- \longrightarrow NO$

$NO_3^- + 3e^- \longrightarrow NO + 2H_2O$

$NO_3^- + 3e^- + 4H^+ \longrightarrow NO + 2H_2O$ — (ii)

3(i) + 16(ii),

$$\boxed{24\,CuS + 64H^+ + 16NO_3^- \longrightarrow 3S_8 + 24Cu^{2+} + 16NO + 32H_2O}$$

Q) Balance $S_2O_4^{2-} + Ag_2O \xrightarrow{OH^-} Ag + SO_3^{2-}$

A)

$$\overset{+3\ —\ \text{Oxd}^n\ (1e^-)\ —\ +4}{\underbrace{S_2O_4^{2-}} + \underbrace{Ag_2O} \longrightarrow \underbrace{Ag} + \underbrace{SO_3^{2-}}}$$

$$+1\ —\ \text{Red}^n\ (1e^-)\ —\ 0$$

Half Oxd^n Rx^n,

$S_2O_4^{2-} \longrightarrow SO_3^{2-} + e^-$

$S_2O_4^{2-} \longrightarrow 2SO_3^{2-} + 2e^-$

$2H_2O + S_2O_4^{2-} \longrightarrow 2SO_3^{2-} + 2e^-$

$$2H_2O + S_2O_4^{2-} \longrightarrow 2SO_3^{2-} + 2e^- + 4H^+$$

$$4OH^- + S_2O_4^{2-} \longrightarrow 2SO_3^{2-} + 2e^- + 2H_2O \quad —(i)$$

Half Redⁿ Rxⁿ,

$$Ag_2O + 2e^- \longrightarrow 2Ag + H_2O$$

$$2H^+ + Ag_2O + 2e^- \longrightarrow 2Ag + H_2O$$

$$H_2O + Ag_2O + 2e^- \longrightarrow 2Ag + 2OH^- \quad —(ii)$$

(i) + (ii),

$$\boxed{2OH^- + S_2O_4^{2-} + Ag_2O \longrightarrow 2SO_3^{2-} + 2Ag + H_2O}$$

Q) Balance $Cl_2 + OH^- \longrightarrow Cl^- + ClO_4^-$

A)

0 — Redⁿ ⓵e^- — -1

$$Cl_2 + OH^- \longrightarrow Cl^- + ClO_4^-$$

0 — Oxdⁿ ⑦e^- — $+7$

Half Redⁿ Rxⁿ,

$$2e^- + Cl_2 \longrightarrow 2Cl^- \quad —(i)$$

Half Oxd^n Rx^n,

$$Cl_2 \longrightarrow 2ClO_4^- + 14e^-$$

$$8H_2O + Cl_2 \longrightarrow 2ClO_4^- + 14e^- + 16H^+$$

$$16OH^- + Cl_2 \longrightarrow 2ClO_4^- + 14e^- + 8H_2O \quad -(ii)$$

7(i) + (ii),

$$\boxed{8Cl_2 + 16OH^- \longrightarrow 2ClO_4^- + 8H_2O + 14Cl^-}$$

Q) Balance $H_2 + ReO_4^- \xrightarrow{OH^-} ReO_2 + H_2O$

A) +7 — Red^n ($3e^-$) — +4

$$H_2 + ReO_4^- \longrightarrow ReO_2 + H_2O$$

0 —— oxd^n ($1e^-$) —— +1

Half Oxd^n Rx^n,

$$H_2 \longrightarrow H_2O + 2e^-$$

$$H_2 \longrightarrow 2H^+ + 2e^-$$

$$2OH^- + H_2 \longrightarrow 2H_2O + 2e^- \quad -(i)$$

Half Red^n Rx^n,

$$ReO_4^- + 3e^- \rightarrow ReO_2$$

$$4H^+ + ReO_4^- + 3e^- \rightarrow ReO_2 + 2H_2O$$

$$2H_2O + ReO_4^- + 3e^- \rightarrow ReO_2 + 4OH^- \quad \text{— (ii)}$$

3(i) + 2(ii),

$$\boxed{3H_2 + 2ReO_4^- \rightarrow 2ReO_2 + 2H_2O + 2OH^-}$$

Q) Balance $P_4 + OH^- \rightarrow PH_3 + H_2PO_2^-$

A) 0 —— Oxd^n ($1e^-$) —— +1

$$P_4 + OH^- \rightarrow PH_3 + H_2PO_2^-$$

0 — Red^n ($3e^-$) — −3

Half Red^n Rx^n,

$$P_4 + 12e^- \rightarrow 4PH_3$$

$$12H^+ + P_4 + 12e^- \rightarrow 4PH_3$$

$$12H_2O + P_4 + 12e^- \rightarrow 4PH_3 + 12OH^- \quad \text{— (i)}$$

Half Oxd^n Rx^n,

$$P_4 \longrightarrow 4H_2PO_2^- + 4e^-$$

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

$$8OH^- + P_4 \longrightarrow 4H_2PO_2^- + 4e^- \quad \text{(ii)}$$

(i) + 3(ii),

$$\boxed{3OH^- + P_4 + 3H_2O \longrightarrow 3H_2PO_2^- + PH_3}$$

27/5/22

3) Algebric Eq^n Method —

Principle — Conserve no. of atoms of an element and total charge on both sides of eq^n.

☆ Q) Balance $MnO_4^- + C_2O_4^{2-} + H^+ \longrightarrow Mn^{2+} + CO_2 + H_2O$

A) $a\,MnO_4^- + b\,C_2O_4^{2-} + c\,H^+ \longrightarrow d\,Mn^{2+} + e\,CO_2 + f\,H_2O$

Apply P.O.A.C and Conservation of Charge, For Mn, $\boxed{a=d}$

For O, $4a+4b=2e+f$

For C, $2b=e$

For H, $c=2f$

Charge Conservation, $-a-2b+c=2d$

Solving gives, assuming $\boxed{a=2}$

$\boxed{b=5}$, $\boxed{c=16}$, $\boxed{d=2}$, $\boxed{e=10}$, $\boxed{f=8}$

$$\boxed{2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \rightarrow 2Mn^{2+}\ 10CO_2 + 8H_2O}$$

Q) Balance $KMnO_4 + FeSO_4 + H_2SO_4 \rightarrow K_2SO_4 + MnSO_4 + Fe_2(SO_4)_3 + H_2O$

A) $a\,KMnO_4 + b\,FeSO_4 + c\,H_2SO_4 \rightarrow d\,K_2SO_4 + e\,MnSO_4 + f\,H_2O + g\,Fe_2(SO_4)_3$

For Mn, $a=e$ For O, $4a+4b+4c=4d+4e+f+12$

For K, $a=2d$ For H, $2c=2f$

For Fe, $b=2g$ For S, $b+c=d+e+3g$

Solving gives, assuming $\boxed{d=1}$

$\boxed{a=2}$, $\boxed{b=10}$, $\boxed{c=8}$, $\boxed{e=2}$, $\boxed{f=8}$, $\boxed{g=5}$

$$\boxed{2KMnO_4 + 10FeSO_4 + 8H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 8H_2O + 5Fe_2(SO_4)_3}$$

☆ $\boxed{E_{A_aB_b} = E_A + E_B}$

Equivalent Wt

$$\boxed{E = \frac{M}{(n\text{-factor})}}$$

n - factor

Charge transferred per mole of substance.

1) For Ions, $\boxed{n_f = |\text{Total Charge on ions}|}$ Eg - SO_4^{2-} $n_f = 2$

2) For Salts, $\boxed{n_f = |\text{Total Charge on Cation}| = |\text{Total Charge on Anion}|}$

Eg - i) $MgSO_4$ $n_f = +2$ Mg^{2+}

ii) $Al_2(SO_4)_3$ $2Al^{3+}$ $n_f = +6$

★ (Mohr's Salt) iii) $FeSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$ $n_f = 4$ ☆

★ (Potash Alum) iv) $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$ $n_f = 8$

3) For Acids, $\boxed{n_f = \text{Basicity}}$

Basicity : No. of H^+ released or OH^- gained

Eg — i) H_2SO_4 $n_f = 2$

☆ If rx^n is given then n_f is no. of H^+ released or OH^- gained during rx^n

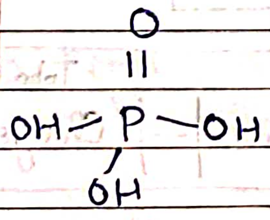
Eg : $H_2SO_4 + NaOH \longrightarrow NaHSO_4 + H_2O$

$n_f = 1$

If rx^n not given, n_f is taken as max. basicity

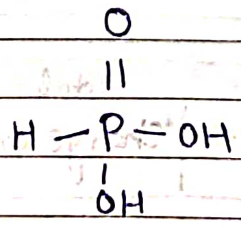
☆

H_3PO_4



$n_f = 3$

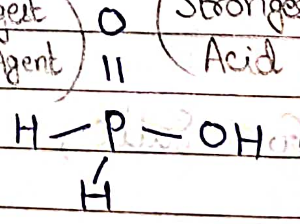
H_3PO_3



$n_f = 2$

H_3PO_2

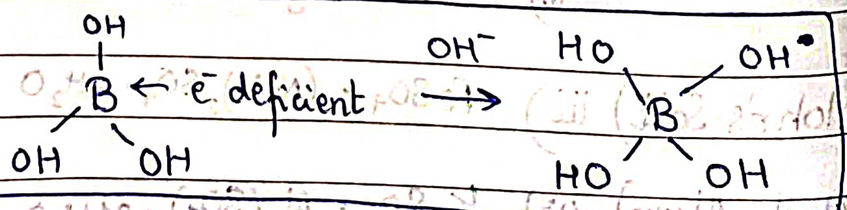
(Strongest Red^n Agent) (Strongest Acid)



$n_f = 1$

☆ H_3BO_3

$n_f = 1$



4) For Bases, $\boxed{n_f = \text{Acidity}}$

Acidity – No. of OH^- released or H^+ gained

Eg: i) $NaOH$ OH^- $n_f = 1$

★ ii) $\ddot{N}H$ NH_4^+ $n_f = 1$

5) For Oxd^n & Red^n Agents (for Intermolecular)

i) $KMnO_4$:

MnO_4^-
- Acidic — Mn^{2+}, $\boxed{n_f = 5}$
- Neutral — MnO_2, $\boxed{n_f = 3}$
- Basic — MnO_4^{2-}, $\boxed{n_f = 1}$

Eg: i) $MnO_4^- + Fe^{2+} + H^+ \longrightarrow Mn^{2+} + Fe^{3+}$

$n_f = 5$ $n_f = 1$ $n_f = 5$ $n_f = 1$

ii) $MnO_4^- + I^- + H^+ \longrightarrow Mn^{2+} + I_2 + H_2O$

$n_f = 5$ $n_f = 1$ $n_f = 5$ $n_f = 1/2$

ii) $K_2Cr_2O_7$: $Cr_2O_7^{2-} \xrightarrow{\text{Acidic}} Cr^{3+}$

$\boxed{n_f = 6}$ $\boxed{n_f = 3}$

iii) H_2O_2 :

As oxdⁿ agent, $H_2O_2 \longrightarrow H_2O$

$\boxed{n_f = 2}$ $\boxed{n_f = 1}$

As redⁿ agent, $H_2O_2 \longrightarrow O_2$

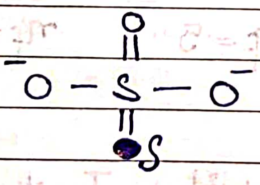
$\boxed{n_f = 2}$ $\boxed{n_f = 2}$

iv) Thiosulphate ;

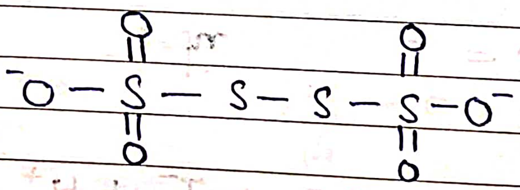
$S_2O_3^{2-} \longrightarrow S_4O_6^{2-}$

$\boxed{n_f = 1}$ $\boxed{n_f = 2}$

Thiosulphate Tetrathionate



$^{-}O-S(=O)(=S)-O^{-}$



$^{-}O-S(=O)_2-S-S-S(=O)_2-O^{-}$

Q) Calc. n_f in each half rx^n —

1) $NH_3 \longrightarrow N_2O_3$

A) $NH_3 \longrightarrow N_2O_3$ $\quad$ $NH_3 \longrightarrow N_2O_3$

-3 $\quad$ +3 $\quad$ $n_f = 6$ $\quad$ $n_f = 12$

2) $I_2 \longrightarrow IO_3^-$

A) $I_2 \longrightarrow IO_3^-$ $\quad$ $I_2 \longrightarrow IO_3^-$

0 $\quad$ +5 $\quad$ $n_f = 10$ $\quad$ $n_f = 5$

3) $Fe_2(C_2O_4)_3 \longrightarrow Fe^{3+} + CO_2$

+3 $\quad$ +4

A) $Fe_2(C_2O_4)_3 \longrightarrow Fe^{3+} + CO_2$

$n_f = 6$ $\quad$ $n_f = 1$

Special Cases —

(works even for same atoms)

1) If more than 1 atom such undergoes oxd^n (or red^n), the total n_f is the sum of n_f of all ~~the~~ atoms.

Eg - i) $\overset{+2}{Fe}\,\overset{+3}{C_2}O_4 \longrightarrow \overset{+3}{Fe^{3+}} + \overset{+4}{C}O_2$

$$n_f = (3-2) + 2(4-3)$$

$$\Rightarrow n_f = 3$$

iv) $$\overset{0}{3S^{2-}} \longrightarrow \overset{+6}{2SO_4^{2-}} + \overset{+4}{SO_2}$$

★ $n_f = 2(6-0)+1(4-0) \Rightarrow n_f = 16$

ii) $$\overset{+3}{As_2}\,\overset{-2}{S_3} \longrightarrow H_3\overset{+5}{As}O_4 + \overset{+6}{SO_4^{2-}}$$

$n_f = 2(5-3)+3(6+2)$

$\Rightarrow n_f = 28$

iii) $$K_4[\underset{+2}{Fe}(\underset{+2}{C}\underset{-3}{N})_6] \longrightarrow K^+ + \underset{+3}{Fe^{3+}} + \underset{+4}{CO_2} + \underset{+5}{NO_3^-}$$

$n_f = (3-2)+6(4-2)+6(5+3) \Rightarrow n_f = 61$

2/6/22

6) For Oxd^n and Red^n Agents (for Intramolecular)

Case 1 –

If the no. e^- exchanged in oxd^n is equal to no. e^- exchanged in red^n.

$$\boxed{n_f = \left(\text{no. of } e^- \text{ exchanged in oxd}^n \text{ or red}^n\right)}$$

Eg –

i) $$\overset{-3 \text{ — Red}^n \text{ — } 0}{NH_4NO_2 \xrightarrow{\Delta} N_2 + H_2O}$$
$+3$ — Oxd^n — 0

$\Rightarrow n_f = 3$

$$\overset{-3 \;\text{— oxd}^n\text{ —}\; 0}{}$$

ii) $$\underset{+6\;\text{— Red}^n\text{ —}\;+3}{\overset{-3\;\text{— oxd}^n\text{ —}\;0}{(NH_4)_2Cr_2O_7 \longrightarrow N_2 + Cr_2O_3}}$$

$\Rightarrow$ $n_f = 6$

Case 2 –

If no. of e^- exchanged in oxd^n is **NOT** equal to no. e^- exchanged in red^n

$$\boxed{n_f = \left| \begin{pmatrix}\text{no. of } e^- \text{ exchanged} \\ \text{in oxd}^n\end{pmatrix} - \begin{pmatrix}\text{no. of } e^- \text{ exchanged} \\ \text{in red}^n\end{pmatrix} \right|}$$

★ For applying, rx^n **MUST** be balanced

+3 — Red^n — +2

Eg – ★ $Fe_2S_3 \longrightarrow 2FeSO_4 + SO_2$

−2 +6 +4

oxd^n

Oxd^n: $n_f(S_3) = 2\cdot(6+2) + 1\cdot(4+2) = 22$

Red^n: $n_f(Fe_2) = 2\cdot(3-2) = 2$

$n_f(Fe_2S_3) = |22-2| \Rightarrow n_f = 20$

7) For Oxd^n and Red^n Agents (for Disproportionation)

$$\boxed{n_f = \frac{n_1 n_2}{n_1 + n_2}}$$; n_1 = no. of e^- exchanged in oxd^n

n_2 = no. of e^- exchanged in red^n

$0 \text{ — Red}^n \text{ — } -1$

Eg - i) $Br_2 + OH^- \rightarrow Br^- + BrO_3^- + H_2O$

$0 \text{ — Oxd}^n \text{ — } +5$

$n_1 = 10$, $n_f = \left|\frac{10 \cdot 2}{10+2}\right| \Rightarrow n_f = \frac{5}{3}$

$n_2 = 2$

★Q) Find n_f (HCl) in,

$2KMnO_4 + 16\,HCl \rightarrow 2KCl + 2MnCl_2 + 5Cl_2 + 8H_2O$

A) $2\overset{+7}{KMnO_4} + 2HCl + 4HCl + \overset{-1}{10HCl} \longrightarrow$

$2KCl + \underset{+5}{2MnCl_2} + \underset{0}{5Cl_2} + 8H_2O$

★ Only 10 out of 16 Cl atoms lose e^-.

$16\ HCl \longrightarrow 10e^-$

$\Rightarrow 1\ HCl \longrightarrow (5/8)\ e^-$

$\Rightarrow \boxed{n_f = 5/8}$

Q) 2 mol N_2H_4 loses 16 mol e^-, is being converted to a new compound X. Assuming that all N appears in new compound, find oxd^n state of N in X.

A) M-1:

$2N_2H_4\ \cancel{+16e} \longrightarrow X + 16e^-$

$4N \leftrightarrow 16e^- \Rightarrow 1N \leftrightarrow 4e^-$

$$\begin{pmatrix}\text{Oxd}^n \text{ of N} \\ \text{in X}\end{pmatrix} = \begin{pmatrix}\text{Oxd}^n \text{ of N} \\ \text{in } N_2H_4\end{pmatrix} + 4$$

$$\Rightarrow \left(\text{Oxd}^n \text{ of N in X}\right) = 2$$

M-2 :

$$2\overset{-2}{N_2H_4} \longrightarrow \overset{+x}{X} + 16e^-$$

We have, $2(x-(-2)) = \frac{16}{2} \Rightarrow \boxed{x=+2}$

☆ Q) find n_f of $KHC_2O_4 \cdot H_2C_2O_4 \cdot 4H_2O$ when it acts as red^n agent.

A)
$$C_2O_4^{2-} \longrightarrow CO_2$$
$$+3 \text{ — Oxd}^n\text{ — } +4$$

$$\underset{+3}{KHC_2O_4} \cdot \underset{+3}{H_2C_2O_4} \cdot 4H_2O \longrightarrow \underset{+4}{CO_2}$$

$$n_f = 2\cdot(4-3) + 2(4-3) \Rightarrow \boxed{n_f = 4}$$

Law of Equivalence

It states that 1 eq. of element/compound combines with 1 eq. of another.

In chemical rx^{n}s, eq.s react in equal amt. to give same no. of eq.s of product.

$$\boxed{eq. = \frac{W}{E} = n_f\cdot(\text{moles})}$$ $$\boxed{eq. = NV_{(\text{in } L)}}$$

Eg – i) $aA + bB \longrightarrow nN + mM$

$$eq._A = eq._B = eq._N = eq._M$$

ii) $M + N \longrightarrow M_mN_n$

$$eq._M = eq._N = eq._{M_mN_n}$$

Q) Find no. of mol of $KMnO_4$ needed to oxidise 1 mol Cu_2S in acidic medium.

$$KMnO_4 + Cu_2S \longrightarrow Mn^{2+} + Cu^{2+} + SO_2$$

A) $KMnO_4 \longrightarrow Mn^{2+}$

$n_f = 5$

$$\underset{+1\ \ -2}{Cu_2S} \longrightarrow \underset{+2}{Cu^{2+}} + \underset{+4}{SO_2}$$

$$n_f = 2(2-1) + 1(4+2) \Rightarrow n_f = 8$$

$$5\, n_{KMnO_4} = 8 \cdot 1 \Rightarrow n_{KMnO_4} = 1.6 \text{ mol}$$

Q) Find no. of mol of oxalate ion oxidised by 1 mol MnO_4^- in acidic medium.

A) $$C_2O_4^{2-} + MnO_4^- \longrightarrow Mn^{2+} + CO_2$$

$n_f = 2$ $\qquad$ $n_f = 5$

$$5 \cdot 1 = 2\, n_{C_2O_4^{2-}} \Rightarrow n_{C_2O_4^{2-}} = 2.5 \text{ mol}$$

Q) How many mL of 0.02M $KMnO_4$ solⁿ would be required to exactly titrate 25 mL of 0.2 M $Fe(NO_3)_2$ solⁿ in acidic medium?

A)
$$KMnO_4 \rightarrow Mn^{2+}$$
$$n_f = 5$$

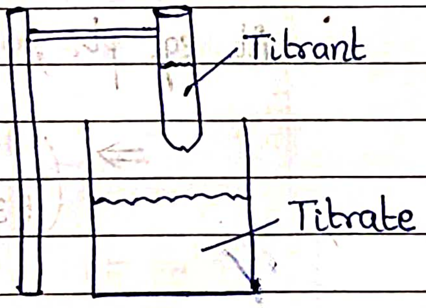
$$Fe(NO_3)_2 \longrightarrow Fe^{3+}$$
$$n_f = 1$$

$$N_1V_1 = N_2V_2 \Rightarrow \left(\frac{0.02}{5}\right) V_1 = \left(\frac{0.2}{1}\right)(25) \text{ mL} \quad X$$

$$\rightarrow 5(0.02)\, V_1 = 1(0.2)(25) \text{ mL}$$

$$\Rightarrow \boxed{V_1 = 50 \text{ mL}}$$

Titration



Equiv Pt :
eq. of Titrant = eq. of Titrate

Endpt. : (Equiv Pt. + 1 drop)
Pt. at which color change occurs

Types :

1) Simple
2) Back
3) Iodiometric & Iodometric
4) Double
5) Conductometric (12th Class)

3/6/22

1) Simple –

Q) To neutrilise completely 20 ml of 1 M H_3PO_4 solⁿ, find vol. of 0.1 M KOH solⁿ required.

A) At eq. pt., $n_f MV = n_f MV$

$$\Rightarrow 3 \cdot 1M \cdot 20\,ml = 1 \cdot (0.1)M \cdot V$$

$$\Rightarrow \boxed{V = 600\ mL}$$

Q) 0.7 g of sample of $Na_2CO_3 \cdot xH_2O$ is dissolved in water whose vol is made to 100 mL. 20 mL of this solⁿ requires 20 mL 1/10 N HCl for complete neutralisation. Find x.

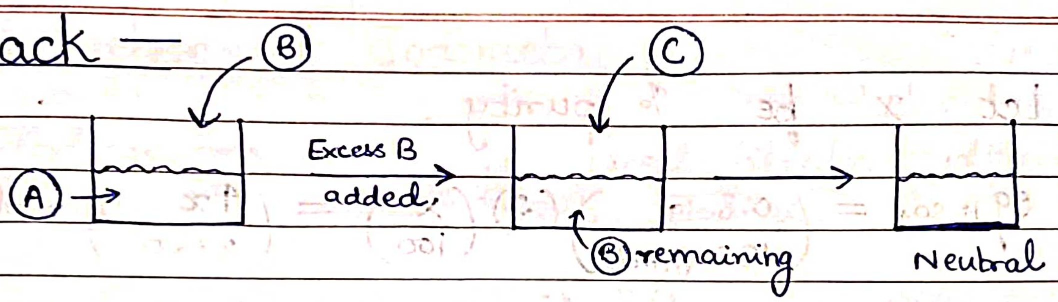
A) $$N_{Na_2CO_3} = \left(\frac{0.7}{106+18x}\right)\cdot\left(\frac{2}{0.1}\right)\frac{mol}{L} = \left(\frac{7}{53+9x}\right)\frac{mol}{L}$$

At eq. pt.; $N_1V_1 = N_2V_2$

$$\Rightarrow \left(\frac{7}{53+9x}\right)\cdot 20 = \frac{1}{10}\cdot 20$$

$$\Rightarrow x = \frac{17}{9} \Rightarrow \boxed{x \approx 2}$$

2) Back —



$$eq._{B\,Total} = eq._A + eq._C$$

$$eq._{B\,remain} = eq._C$$

Q) 5.3 g M_2CO_3 is dissolved in 150 mL 1N HCl. The unused acid required 100 mL of 0.5 N NaOH. Find eq. w.t. of M.

A) $$meq._{M_2CO_3} = \frac{5.3\ g}{(2M+60)\ g/mol} \cdot 2 \cdot 1000 = \left(\frac{5.3}{M+30}\right) \cdot 1000\ mol$$

$$meq_{HCl} = (150\ mL)(1\ N) = 150\ mol$$

$$meq_{NaOH} = (100\ mL)(0.5\ N) = 50\ mol$$

We have, $$meq_{HCl} = meq_{M_2CO_3} + meq_{NaOH}$$

$$\Rightarrow \quad 150 = \left(\frac{5300}{M+30}\right) + 50 \Rightarrow \boxed{M = \frac{E_M}{1} = 23}$$

Q) 0.8 g impure $(NH_4)_2SO_4$ was boiled with 100 mL 0.2 N NaOH solⁿ till all NH_3 appears. Remaining solⁿ dil. to 250 mL. 25 mL of this Solⁿ was neutralised using 5 mL 0.2 N H_2SO_4 solⁿ. find % purity of $(NH_4)_2SO_4$

A) Let 'x' be % purity.

$$eq_{H_2SO_4} = \left(\frac{0.8\ g}{132\ g/mol}\right)(2)\left(\frac{x}{100}\right) = \left(\frac{4x}{33000}\right) mol$$

$$eq._{NaOH} = \left(\frac{100}{1000}\ L\right)(0.2\ N) = \left(\frac{2}{100}\right) mol$$

$$eq_{NaOH\ left} = \left(\frac{2}{100}\right) - \left(\frac{4x}{33000}\right) mol$$

After dil., $eq_{\substack{NaOH\\ taken\\ after\ dil}} = \left(\frac{2}{1000}\right) - \left(\frac{4x}{330000}\right)$

We have, $eq._{\substack{NaOH\\ after\ dil}} = eq._{\substack{H_2SO_4\ added\\ later}}$

$$\Rightarrow \left(\frac{2}{1000}\right) - \left(\frac{4x}{330000}\right) = \left(\frac{1}{1000}\right)$$

$$\Rightarrow x = \frac{330}{4} \Rightarrow \boxed{x = 82.5}$$

3) Idiometric & Iodometric :

i) **Iodiometric** : It is direct titration of hyposolⁿ with Iodine.

Hyposolⁿ ⟶ Solⁿ of $Na_2S_2O_3$

Indicator Used : Starch

Rxⁿ : $Na_2S_2O_3 + I_2 \longrightarrow I^- + Na_2S_4O_6$

$n_f = 1$ $n_f = 2$

$$\boxed{\text{eq. of } Na_2S_2O_3 = \text{eq. of } I_2}$$

ii) **Iodometric** : It is indirect titration of hyposolⁿ with Iodine.

Rxⁿ : (Oxdⁿ Agent) + $I^- \longrightarrow I_2$

$Na_2S_2O_3 + I_2 \longrightarrow I^- + Na_2S_4O_6$

Indicator Used : Starch (Use <u>ONLY</u> if Oxdⁿ Agent has <u>NO</u> iodine in it.)

$$\boxed{\text{eq. of Oxd}^n \text{ Agent} = \text{eq. of } Na_2S_2O_3 = \text{eq. of } I_2}$$

Q) A sol^n of $Na_2S_2O_3$ is standardized iodometrically against 0.167g $KBrO_3$. This requires 50 mL of $Na_2S_2O_3$ sol^n. What is normality of hyposol^n?

A) $$\underset{+5}{KBrO_3} \longrightarrow \underset{-1}{Br^-} \qquad n_f = 6$$

$$eq(KBrO_3) = eq.(Na_2S_2O_3)$$

$$\Rightarrow \left(\frac{0.167\ g}{167\ g/mol}\right) \cdot 6 = \left(\frac{50\ L}{1000}\right) N$$

$$\Rightarrow \boxed{N = 0.12N}$$

Q) Sulphur content of steel sample is determined by converting it to H_2S gas, absorbing the gas in 10 mL (0.005M) I_2 & then back titrating the excess I_2 with 0.002M $Na_2S_2O_3$. If 10 mL of $Na_2S_2O_3$ is required for titration, how many mg of sulphur are in sample?

Rx^n: $H_2S + I_2 \longrightarrow S + 2I^- + 2H^+$

$$I_2 + 2S_2O_3^{2-} \longrightarrow 2I^- + S_4O_6^{2-}$$

A) We have,

$$m\text{-}eq(I_2) = m\text{-}eq(Na_2S_2O_3) + m\text{-}eq(H_2S)$$

$$2\cdot(5\cdot10^{-3})\cdot 10 = 1\cdot(2\cdot10^{-3})\cdot 10 + m\text{-}eq(H_2S)$$

$$\Rightarrow \quad m\text{-}eq(H_2S) = 8\cdot10^{-2}$$

Now, $S \longrightarrow H_2S$

$$\Rightarrow m\text{-}eq(S) = m\text{-}eq(H_2S)$$

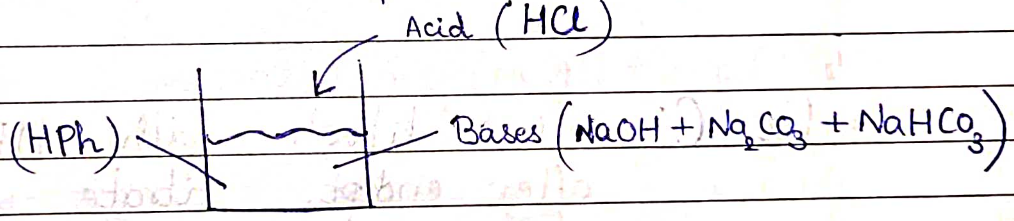
Hence, $m\text{-}eq(S) = 8\cdot10^{-2} \Rightarrow Mass(S) = \left(\frac{32}{2}\right)\cdot 8\cdot10^{-2}\ mg$

$$\Rightarrow \boxed{Mass = 1.28\ mg}$$

7/6/22

4) Double —

Case A: With Phenopthlein (HPh)



$$HCl + NaOH \longrightarrow NaCl + H_2O$$

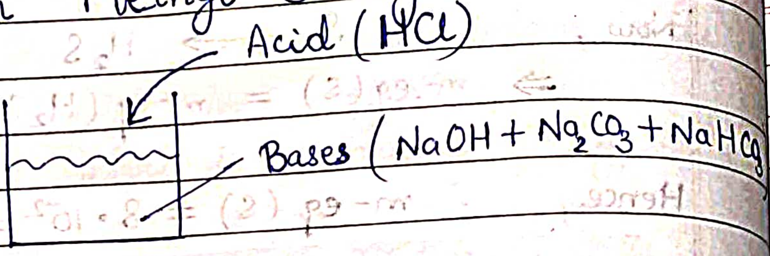
$$HCl + \underset{(n_f=1)}{Na_2CO_3} \longrightarrow NaHCO_3 + \cancel{H_2O}\ NaCl$$

☆ (HPh) changes color immediately after half neutralisation of Na_2CO_3 to $NaHCO_3$.

$$\boxed{eq(HCl) = eq(NaOH) + \underset{(\text{with } n_f=1)}{eq(Na_2CO_3)}}$$

$$\boxed{\underset{\text{remain}}{eq(NaHCO_3)} = \underset{\text{initial}}{eq(NaHCO_3)} + \underset{\text{new}}{eq(NaHCO_3)}}$$

Case B: With Methyl Orange (MeOH)



$$HCl + NaOH \rightarrow NaCl + H_2O$$

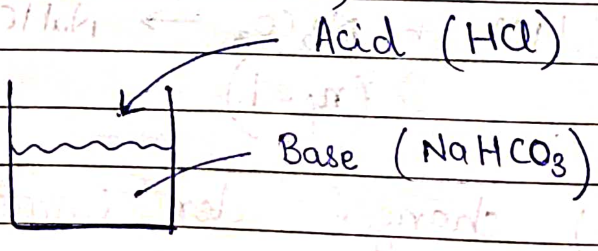
$$HCl + \underset{n_f = 2}{Na_2CO_3} \rightarrow NaCl + H_2O + CO_2$$

$$HCl + NaHCO_3 \rightarrow NaCl + H_2O + CO_2$$

$$\boxed{eq(HCl) = eq.(NaOH) + \underset{(\text{with } n_f = 2)}{eq.(Na_2CO_3)} + eq(NaHCO_3)}$$

Case C: first titrate with HPh, then after endpt., titrate with MeOH.

After 1st endpt. add MeOH,



$$HCl + NaHCO_3 \rightarrow NaCl + H_2O + CO_2$$

$$\boxed{eq(HCl) = \underset{(\text{initial})}{eq(NaHCO_3)} + \underset{(\text{new})}{eq(NaHCO_3)}}$$

Q) A sol^n contains mix. of Na_2CO_3 and NaOH. Using HPh indicator, 25 mL of mix. req. 19.5 mL of 1 N HCl for endpt. With MeOH indicator, 25 mL of same sol^n req. 25 mL of 1 N HCl for endpt. Calc. g/L of NaOH and Na_2CO_3.

A) Let there be 'a' mol Na_2CO_3 & 'b' mol NaOH

With HPh, $m\text{-}eq(HCl) = m\text{-}eq(NaOH) + m\text{-}eq(Na_2CO_3)$ (with $n_f = 1$)

$$\Rightarrow \boxed{19.5 = 1000 \cdot b \cdot 1 + 1000 \cdot a \cdot 1} \text{ — ①}$$

With MeOH, $meq(HCl) = meq(NaOH) + meq(Na_2CO_3)$ (with $n_f = 2$)

$$\Rightarrow \boxed{25 = 1000b + 2000a} \text{ — ②}$$

Solving ① & ②, $\boxed{\begin{array}{l} a = 5.5 \cdot 10^{-3} \text{ mol} \\ b = 14 \cdot 10^{-3} \text{ mol} \end{array}}$

$M_a = \left(\frac{5.5}{25}\right) M \Rightarrow (\% \, w/v)_a = \left(\frac{5.5}{25}\right) \cdot \frac{106}{10} = 2.332$

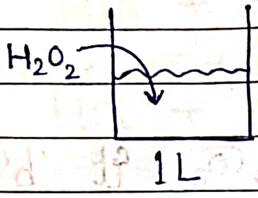
$\Rightarrow 100 mL \rightarrow 2.332 \text{ g } Na_2CO_3$

$\Rightarrow \boxed{23.32 \text{ g/L } Na_2CO_3}$

Similarly, $\boxed{22.4 \text{ g/L NaOH}}$

Volume Strength of H_2O_2 –

$$\boxed{\begin{pmatrix}\text{Vol.}\\ \text{Strength}\end{pmatrix} = \begin{pmatrix}\text{Vol. of } O_2 \text{ released by 1L}\\ H_2O_2 \text{ sol}^n \text{ at S.T.P}\end{pmatrix}}$$



$$\xrightarrow{\Delta} H_2O + \frac{1}{2}O_2$$

1 mol ⟶ 1/2 mol

n mol ⟶ $n/2$ mol

M mol ⟶ $M/2$ mol

|Molarity|

For O_2, $n = \dfrac{V}{22.4} \Rightarrow \dfrac{M}{2} = \dfrac{V}{22.4}$

$$\Rightarrow \boxed{M = \frac{V}{11.2}}$$

Molarity

(Volume of O_2)

(Vol. Strength of H_2O_2)

$$\Rightarrow \boxed{N = \frac{V}{5.6}}$$

Normality

Q) To a 25 mL H_2O_2 sol^n, excess of acidified sol^n of KI was added. Iodine liberated req. 20 mL of 0.3 N $Na_2S_2O_3$ sol^n. Calc. vol. strength of H_2O_2 sol^n.

A) In first rx^n, $\quad$ m-eq (H_2O_2) = meq (KI) = meq (I_2)

In second rx^n, $\quad$ m-eq (I_2) = m-eq ($Na_2S_2O_3$)

$$\Rightarrow \quad meq\,(H_2O_2) = meq\,(Na_2S_2O_3)$$

$$\Rightarrow \quad 25 \cdot N = 20 \cdot (0.3) \Rightarrow N = 6/25$$

$$\Rightarrow \quad V = (5.6)(6/25) \Rightarrow \boxed{V = 1.344\ L}$$

% Oleum Strength by Mass –

$$\text{Oleum} = H_2SO_4 + \underbrace{SO_3}_{\text{free } SO_3} = H_2S_2O_7$$

In 100g oleum, $\quad \underset{(xg)}{SO_3} + H_2O \rightarrow H_2SO_4$

By Stoichiometry, $n_{SO_3} = n_{H_2O} \Rightarrow$

$$\boxed{\left(\frac{\underbrace{x}_{\text{Weight of } SO_3 \text{ in 100g oleum}}}{80}\right) = \frac{(\%\ \text{oleum strength}) - 100}{18}}$$

★ $\boxed{(\%\ \text{oleum strength}) - 100 = \left(\text{Wt. of } H_2O \text{ added to react all} \rightarrow \text{free } SO_3 \text{ in 100g oleum}\right)}$

Q) Calc, in 109 % oleum strength, % of free SO_3 available in oleum.

A) $\left(\frac{W_{SO_3}}{80}\right) = \frac{(\%\text{oleum strength}) - 100}{18} = \frac{9}{18}$

$\Rightarrow W_{SO_3} = 40\,g \Rightarrow \boxed{(\%\text{ Mass}) = 40\%}$

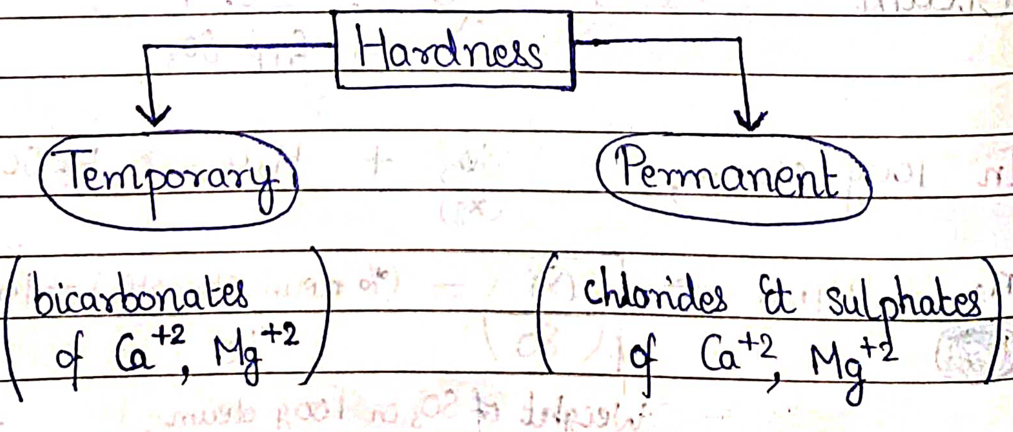
Q) Find max. possible value of oleum strength.

A) Max. oleum strength when 100 g SO_3 in 100 g Oleum

$\left(\frac{100}{80}\right) = \frac{(\%\text{ oleum str.}) - 100}{18} \Rightarrow \boxed{(\%\text{ oleum str.})_{max.} = 122.5}$

Hardness of Water

Hard water doesn't form lather with soaps.



$Ca(HCO_3)_2$, $Mg(HCO_3)_2$ $CaCl_2$, $CaSO_4$, $MgCl_2$, $MgSO_4$

10/6/22

Removal of Temporary Hardness —

1) Heating :

$$Mg(HCO_3)_2 \xrightarrow{\Delta} MgCO_3 \downarrow + H_2O + CO_2$$

2) Clark's process (Add^n of $Ca(OH)_2$) :

$$Mg(HCO_3)_2 + Ca(OH)_2 \longrightarrow MgCO_3 \downarrow + CaCO_3 \downarrow + 2H_2O$$

3) Add^n of Na_2CO_3 :

$$Ca(HCO_3)_2 + Na_2CO_3 \longrightarrow CaCO_3 + 2NaHCO_3$$

Removal of Permanent Hardness —

1) Add^n of Na_2CO_3 & Na_3PO_4 :

$$CaSO_4 + Na_2CO_3 \longrightarrow CaCO_3 \downarrow + Na_2SO_4$$

$$3\,CaSO_4 + 2Na_3PO_4 \longrightarrow Ca_3(PO_4)_2 \downarrow + 3Na_2SO_4$$

2) Permutit Process (Add^n of Sodium Zeolite) :

$$Ca^{2+} + Na_2Z \longrightarrow CaZ \downarrow + 2Na^+$$

$Na_2Z = Na_2Al_2Si_2O_8 \cdot xH_2O$ (Sodium alumino ortho silicate)

3) **Calgon Process** : $Na_2[Na_4(PO_3)_6]$ (Sodium hexameta phosphate)

$$2CaSO_4 + Na_2[Na_4(PO_3)_6] \longrightarrow Na_2[Ca_2(PO_3)_6]\downarrow + 2Na_2$$

4) **Ion Exchange Resin Process** :

(Hard Water) → **Cation Exchange Resin**
(Insoluble organic compounds containing $-COOH$, $-SO_3H$ in which Ca^{2+}, Mg^{2+} get replaced by H^+)

↓ ← (Water becomes soft)

Anion Exchange Resin
(Insoluble organic compounds containing $-OH^-$ in which Cl^-, SO_4^{2-} is by $-OH^-$)

↓

$$H^+ + OH^- \longrightarrow H_2O$$

(demineralised)

Calc. Hardness of Water.

Hardness of sub.s calc. w.r.t. $CaCO_3$, ALWAYS.

We need to find Conc. of $CaCO_3$ in ppm.

Q) Find hardness of a sample of water containing 12 mg of $MgSO_4$ per kg of H_2O.

A) $eq(MgSO_4) = eq(CaCO_3)$

$$\Rightarrow 2\left(\frac{12 \cdot 10^{-3}}{120}\right) = 2\left(\frac{W}{100}\right) \Rightarrow W = 10^{-2} g$$

$$ppm = \left(\frac{W_{CaCO_3}}{W_S}\right) \times 10^6 \approx \left(\frac{10^{-2}}{10^3}\right) \times 10^{-6} \Rightarrow \boxed{ppm = 10}$$

Cl available in Bleaching Powder

$$CaOCl_2 \longleftrightarrow \underbrace{CaCl_2}_{\text{does NOT release } Cl_2}, Ca(OCl)_2$$

We want to to find wt. of Cl available for release from a sample of bleaching powder on rxn with dil. acid and CO_2.

Eg: $CaOCl_2 + 2HCl \longrightarrow CaCl_2 + Cl_2 + H_2O$

Q) 3.55 g of sample of bleaching powder suspended in H_2O was treated with enough acetic acid and KI solⁿ. Iodine thus liberated req. 80 mL of 0.2 M hyposolⁿ for titration. Calc. % available Cl.

A) $eq(CaOCl_2) = eq(Cl_2) = eq(Na_2S_2O_4)$

$$\Rightarrow \left(\frac{W}{35.5}\right) = 1 \cdot \frac{80}{10^3} \cdot \frac{2}{10}$$

$$\Rightarrow W = \frac{16 \cdot (3.55)}{10^2}\,g$$

$$(\%\ Cl\ available) = \frac{16 \cdot (3.55)}{10^2} \cdot \frac{1}{3.55} \cdot 100\% = \boxed{16\%}$$

General Method for n_f

'n_f' for any species in any rx^n is defined as

Definition

$$\boxed{n_f(A) = \left(\frac{\text{No. of } e^- \text{ exchanged in total } rx^n}{\text{Stoi. Coeff}(A) \text{ in balan}^c\ rx^n}\right)}$$

Eg: $NH_4^+ + NO_2^- \longrightarrow N_2 + H_2O$

$$2NH_4^+ \longrightarrow N_2 + 6e^- + 8H^+$$
$$8H^+ + 2NO_2^- + 6e^- \longrightarrow N_2 + 4H_2O$$

We see, $2NH_4^+ \longleftrightarrow 6e^-$

$$\Rightarrow n_f(NH_4^+) = 3$$

$$2N_2 \longleftrightarrow 6e^-$$
$$\Rightarrow n_f(N_2) = 3$$

Eg: $Br_2 \longrightarrow Br^- + BrO_3^-$

$Br_2 \longrightarrow 2BrO_3^- + 10e^-$

$\boxed{Br_2 + 2e^- \longrightarrow 2Br^-} \times 5$

We see, $6\,Br_2 \longleftrightarrow 10e^- \Rightarrow \boxed{n_f(Br_2) = 5/3}$

Short Tricks –

1) For balancing intramol / disprop. rx^ns using Oxd^n No. Method, break main atom into 2 halves $(1 = 1/2 + 1/2)$ & apply.

(See NCERT Chem, Redox Rx^{n}s, Q8.19, Q8.21)

2) When aliquot is taken from sol^n, conc. remains same.