empirical formula & molecular formula

molecular mass = 2 × V.D.

Ques An organic compound contains carbon 40%, H = 6.66%, & rest is oxygen. The vapour density of compound is 30. Find out empirical & molecular formula of compound.

C = 40%, H = 6.66%, O = 40 + 6.66 = 46.66 → 53.34

Vapour density = 30

	%	At wt	% / At wt	Simple
C	40	12	40/12 = 3.33	1
H	6.66	1	6.66/1 = 6.66	2
O	53.34	16	53.34/16 = 3.33	1

empirical formula = CH_2O

molecular formula = $(E.F)_n$

$= C_2H_4O_2$

$n = \frac{m}{e} = \frac{2 \times 30}{30} = 2$

equivalent concept:

→ **equivalent weight** H = 1g, O = 8g, Cl = 35.5g

Such weight of element which combines with 1g of hydrogen or 8g of oxygen or 35.5 g of Cl is equal to the equivalent weight of the element.

For eg: CH_4

16g 4g

4g ⟶ 12g

1g ⟶ $\frac{12}{4}$ = 3g of C.

equivalent weight = $\frac{\text{Atomic mass}}{\text{charge}}$

$AlCl_3$: 27, 106.5

27g → 106.5

35g → $\frac{106.5}{27}$ × 35 = 9.4

SO_3: 32, 48

32g → 24

8g → $\frac{24}{32} \times 8$ = 6 = 3

N_2O_5: 28, 80

$\frac{80}{8}$ = 10 = 2.8

NH_3: 17g, 3g

$\frac{17}{3}$ = 4.67

CCl_4: 12

12 → 142.0

35.5 → $\frac{142}{12}$ × 35.5 = 35.5

SO_2: 32

32g → 32

8g → $\frac{32}{32} \times 8$ = 8g

Gram ⇒ equivalent weight of any subst = $\frac{\text{Molecular weight}}{\text{n-factor or Valence factor.}}$

N-factor or Valence factor

(1) In case of Acid :-

n factor of an acid is equal to the Basicity

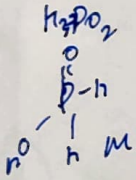
Generally Basicity is equal to the no. of replacable hydrogen atom - (Not true), Generally replacable hydrogen atom are those which are attached with oxygen atom or halogen atom.

$$\text{equivalent weight of an Acid} = \frac{\text{molecular wt}}{\text{Basicity}}$$

H_3PO_2 H_3PO_3 H_3PO_4

⇒ H_3PO_2

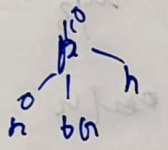
molecular wt :-



m/1

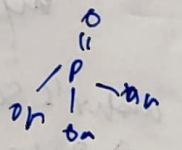
H_3PO_3

molwt :-



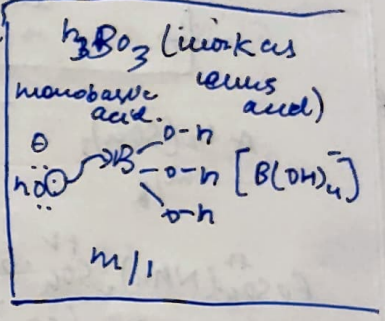
m/2

H_3PO_4



m/3

H_3BO_3 (Boric acid) is not a protonic acid but it can accept 1 OH^- ion & convert it into $[B(OH)_4]^-$ so the basicity of H_3BO_3 is 1



$H_3PO_4 + 2NaOH \longrightarrow Na_2HPO_4 + 2H_2O$

mole Ratio 1 : 2

nf = 2 : 1

(2) In case of a base :- n-factor of a base is equal to the acidity.
generally acidity is equal to the no. of OH group

equivalent wt of base → mol. wt / Acidity

NaOH $Ba(OH)_2$ $Al(OH)_3$ NH_3

m/1 m/2 m/3  ⇒ m/1

(3) In case of salt :-
n-factor of a salt is equal to the total +ve charge or -ve charge

equivalent wt of salt = mol. wt / Total +ve / Total -ve

$Al_2(SO_4)_3$ $FeCl_2$ Na_3PO_4 $AlCl_3$

m/6 m/2 m/3 m/3

$FeSO_4.(NH_4)_2SO_4.6H_2O$ ⇒ mohr's salt ⇒ Fe/4

$K_2SO_4.Al_2(SO_4)_3.24H_2O$ ⇒ Potash Alum

m/8

Ans

$3Zn^{2+} + 2K_4(Fe(CN)_6)^{-4} \longrightarrow K_2Zn_3[Fe(CN)_6] + 6K^+$

$K_4(Fe(CN)_6)^{-4}$ m/6

3 : 2 (m/3)

$f_1 = 2 : 3$

smallest Division. AN ATOM

(iii) In case of Oxidising & Reducing agent

n-factor of an oxidising or reducing agent is equall to the total mole of e^- loosed or gained by 1 mole of the subs.

> eqvt wt. of an oxidising or reduc. ag. = mole. wt / Total moles of e^- loosed or gained by 1 mole

(1) $H_2O_2 \longrightarrow O_2$

$2+n=0$

$n=2 \rightarrow$ m/2

1 mole of $H_2O_2 \rightarrow$ 1 mole

(2) $N_2 \longrightarrow NH_3$

$m_1 = m/6$ $\quad m_2 = m/3$

E_1 $\quad E_2$

$E_2 - E_1 = \frac{m}{3} - \frac{m}{6} = \frac{2m_2 - m}{1}$

(3) $Na_2S_2O_3 \longrightarrow Na_2S_4O_6$

$m_1 = m/11$ $\quad m_2$

E_1 $\quad E_2$ $m_2/2$

$E_2 - E_1 = \frac{m_2 - 2m_1}{2}$

(4) $Cu_2S \longrightarrow Cu^{2+} + SO_2$

$-2\times1e^- \quad -6e^-$

$= 8e^-$

$E = m/8$

(5) $Cu^{+2}S^{-2} \longrightarrow Cu^{2+} + S^{+4}O_2$

$-1\times2e^- \quad -6e^-$

m/4

(6) $Fe^{2+}C_2^{+3}O_4^{2-} \longrightarrow Fe^{3+} + C^{+4}O_2$

$-1e \quad -2\times1e$

m/3

(7) $Fe_xS_y \longrightarrow Fe_2^{+3}O_3 + S^{+4}O_2$

$+1e \quad -2\times6$

m/11

(5) In case of disproportionation

Disproportionation is that phenomenon in which same element is oxidised & as well as reduced

$$\overset{+2}{HNO_2} \longrightarrow \overset{+5}{HNO_3} + \overset{+2}{NO}$$

$$\overset{+3}{HNO_2} \longrightarrow \overset{+5}{HNO_3}, \; m/2$$

$$\overset{+2}{HNO_2} \longrightarrow \overset{+2}{NO_2}, \; m/1$$

eqv. wt. of $HNO_2 \longrightarrow \frac{m}{2} + \frac{m}{3} = \frac{3}{2} m$ of HNO_2

$$nf \text{ of } HNO_2 = \frac{m}{n \cdot f} = \frac{m}{2/3} = \frac{3}{2} m$$

(1) $Cu^{+} \longrightarrow Cu^{2+} + Cu$

$\overset{1+}{Cu} \longrightarrow Cu^{2+}$ $m/1$

$\overset{+1}{Cu} \longrightarrow Cu$ $m/1$

eqvt of $Cu \longrightarrow \frac{m}{1} + \frac{m}{1} = \frac{2m}{2}$ $nf = $ of $Cu = \frac{2N}{2}$

$$nf = Cu = \frac{m}{1/1} = \frac{1m}{2}$$

(6) $Cl_2 \longrightarrow Cl^{-} + ClO_3^{-}$

$\overset{0}{Cl_2} \longrightarrow \overset{1-}{Cl^-}$ $m/2$ $\qquad \frac{m}{2} + \frac{m}{10}$

$Cl_2 \longrightarrow \overset{+5}{ClO_3^-}$ $m/10$ $\qquad \frac{5m + m}{10} = \frac{6m}{10}$

$$= \frac{3M}{5}$$

$nf = 5/3$

Oxidising & reducing agt

NH_3 → Always R.A Range of N: -3 → +5

HNO_2 → Both.

HNO_3 → Always O.A

* If an element is present with lowest oxidation no. then it behaves as R.A only.

* If an element is present in its lowest & highest oxidation no. it behaves as O.A & R.A both.

* If an element is present in its highest oxidation no. then it behaves as O.A.

Equivalent Concept

According to this concept equivalents or milleq. of each reactant & each product are same.

Ex: $2H_2 + O_2 \longrightarrow 2H_2O$

$2\times2 = 4g$ $\quad 32g$ $\quad 36(2\times18)g$

$\left(\frac{w}{E}\right)\frac{4}{1} = 4eq\left(\frac{32}{8}\right) = 4eq \quad \frac{36}{9} = 4eq$

$$N = \frac{\text{no. of eq}^u}{V(in\ l)} = \frac{w/E}{V(in\ l)}$$

$$N \times V_{(l)} = \frac{w}{E}$$

$$N \times V(in\ ml)$$

$$\frac{w}{E} \times 1000\ (in\ ml)$$

milliequivalents of A = Millicquivalent of B

$N_A \times V_A(in\ ml) = N_B \times V_B(in\ ml)$

$\frac{w_A}{E_A} \times 1000 = \frac{w_B}{E_B} \times 1000.$

Ques 1g HCl is mixed with 1g. NaOH in 1 l water then the nature of Sol^n become acidic, Alkaline, Neutral.

HCl = 36.5
NaOH = 40

$HCl + NaOH \longrightarrow NaCl + H_2O$

36.5 $\quad$ 40 $\quad$ 18

$w/E = \frac{1}{36.5} \quad \frac{1}{40}$

eq. of HCl > eq. of NaOH. (Acidic

Ques 1g HNO_3 (63) is mixed with 1g KOH(56) in 1 l water then the nature of Sol^n become

eq of $HNO_3 = 1/63$ $\quad$ eq of $KOH = 1/56$ $\quad$ Alkaline

eq of KOH > eq of HNO_3

Ques Calculate the volume of N/5 NaOH required to neutralize CH_3COOH resulting from the hydrolysis of 4.4 g of $CH_3COOC_2H_5$

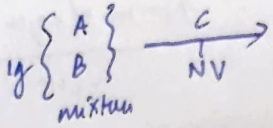
$\frac{1}{5} \times V = \frac{w_B}{E_B} \times 1000$

$\frac{1}{5} \times V = \frac{4.4}{88} \times 1000$

$\frac{1}{5} \times V = \quad V = \frac{5000}{20} = 250\ ml$

calculation of % composition or % purity of the compound

* Simple Titration

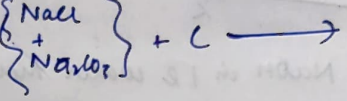


If Both A & B react with C

then m.eq. of A + m.eq. of B = m.eq of C

$$\frac{x}{\text{eq. wt}} \times 1000 + \frac{(1-x)}{\text{eq. wt}} \times 1000 = NV$$

Ques 1g of a mixture of NaCl & Na_2CO_3 is completely reacted with 100 ml $\frac{N}{10}$ HCl. Then calculate the % comp. of a mixture.



$$\frac{x}{53} \times 1000 + \frac{(1-x)}{1} \times 1000 \Rightarrow \frac{1}{10} \times 100$$

$$1000\left(\frac{x}{53} + (1-x)\right) = \frac{1}{10} \times 100$$

$$1000\left(\frac{x}{53}\right)$$

$$\frac{x}{53} \times 1000 = \frac{1}{10} \times 100$$

So in the above ques only Na_2CO_3 reacts with HCl.

Salt of strong Acid & Base do not react with acid & base

$$\frac{x}{53} \times 1000 = 10$$

$$\therefore x = 0.53 \text{ g } Na_2CO_3$$

$$\% \text{ of } Na_2CO_3 = \frac{0.53}{1} \times 100 = 53\%$$

$$\% \text{ of NaCl} = 47\%$$

equivalent wt of a gas

when any gas (except CO, NO & N_2O (neutral)) dissolve in water to form acid or base the n-factor of a gas is equal to the n-factor of the acid or base produced

eg:- $CO_2 + H_2O \longrightarrow H_2CO_3$
($n_f = 2$) ($n_f = 2$)

$SO_3 + H_2O \longrightarrow H_2SO_4$
($n_f = 2$) ($n_f = 2$)

$NH_3 + H_2O \longrightarrow NH_4OH$
($n_f = 1$) ($n_f = 1$)

ques 0.5 g fuming H_2SO_4 (conc. $H_2SO_4 + SO_3$) is completely reacted with 26.7 ml of 0.4 N NaOH. Calculate the % of free SO_3 in fuming H_2SO_4

$S = 32$ $32+3(16)$
$O = 16$

$2(1) + 32 + 4(16)$
$2 + 32 + 64$
$98 + 80$
$= \frac{98}{2} 40$

$$\frac{x}{\text{eqwt}} \times 1000 + \frac{(0.5-2)}{\text{eqwt}} \times 1000 = \frac{1}{0.4} \times 1000 \; 26.7 \times 0.4$$

$$\frac{x}{49} \times 1000 + \frac{(0.5-x)}{40} \times 1000 = \frac{1}{0.4} \times 1000 \; 26.7 \times 0.4$$

$$1000\left(\frac{x}{49} + \frac{(0.5-x)}{40}\right) = \frac{1}{0.4} \times 1000 \; 26.7 \times 0.4$$

$$40x + 49(0.5 - x) = \frac{1}{0.4} \; 26.7 \times 0.4$$

$$40x + 24.5 - 49x = \frac{1}{0.4} \; 26.7 \times 0.4$$

$$= 0.13 g$$

$$\% \text{ of } SO_3 = \frac{0.13}{0.50} \times 100$$

$$= 26\%$$

★ Back Titration

· 1g $\left[\begin{matrix}A\\B\end{matrix}\right]$ —C, NV→ left C = D, N'V' =

Q. 1g mixture ($CaCO_3$ + impurities) is reacted with 100ml N/2 H_2SO_4. The excess acid required 15 ml 1N NaOH calculate the % purity of limestone

$CaCO_3 = 100$

$eq.wt = \frac{100}{2} = 50$

$\frac{w}{eq} \times 1000 = \frac{N}{2} \times 100$

$\frac{w}{50} \times 1000 \times \frac{20}{100} = 15$

$w = 0.75\ g$

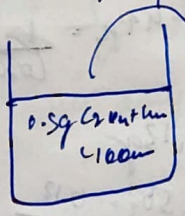
H_2SO_4 total me = 50
" left = 35
used = 15

%S

$= 75\%$.

Qu. 0.5 g of an oxalate sample ($C_2O_4^{2-}$ + impurities) is dissolved in water & diluted upto 100ml 10ml of this soln is completely oxidise with 15ml N/20 $KMnO_4$. calculate % purity of sample.

0.5g ($C_2O_4^{2-}$ + imp)



10ml = 15 ml N/20 $KMnO_4$

Total m.e of $KMnO_4$ = $15 \times \frac{N}{20}$ $KMnO_4$

$Ca^{2+} + C_2O_4^{2-} \rightarrow CaC_2O_4$

me of pure $C_2O_4^{2-}$ = me of $KMnO_4$

$\frac{w_B}{eq} \times 1000 = \frac{15}{20} \times \frac{1}{20}$

$\frac{w_B}{44} \times 1000 = \frac{15}{2}$

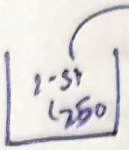
$= 0.33$ g of pure $C_2O_4^{2-}$

% Purity = $\frac{0.33}{0.5} \times 100 = 66\%$.

① [illegible] ... those have same no. of electrons protons but

calculation of No. of water of crystalisation

Q. 2.75 g $Na_2CO_3 \cdot nH_2O$ is dissolved in water & diluted upto 250 ml. 10 ml of this sol^n is completely neutralised with 15 ml $\frac{N}{19.5}$ HCl. Find the value of n or no. of water of crystalisation



10 ml 15 ml $\frac{N}{10}$ HCl

Total meq of $Na_2CO_3 \cdot nH_2O$ = 375 ml $\frac{N}{19.5}$

$\frac{2.75}{E} \times 1000 = 375 \times \frac{1}{19.5}$

$\frac{2.75}{E} \times 1000 = 375 \times \frac{1}{19.5}$

$\frac{2.75}{E} \times 1000 = \frac{375}{13}$

$E = 13 \times 11 = 143$

$\frac{106 + 18n}{2} = 143$

$106 + 18n = 286$

$18n = 180$

$n = 10$

$\frac{2.75}{E} \times 1000 = 15.75$

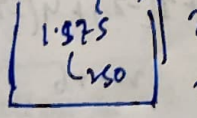
$\frac{2.75}{E} = \frac{15.75}{1000}$

$2.75 = 15.750$

$\frac{2.75}{15.750}$

Q. 1.575 g $\underset{\text{COOH}}{\overset{14}{\underset{|}{\text{C}}}}\text{OOH} \cdot \overset{\times 14}{n}H_2O$ is dissolved in water & diluted upto 250 ml

25 ml of this sol^n is neutralised with 25 ml $\frac{N}{10}$ NaOH. Find out the value of n.



25 ml = $25 \times \frac{N}{10}$

$25 = 250$ ml $\frac{N}{10}$

$\frac{1.575}{E} \times 1000 = 25 \times \frac{1}{10}$

$E = 63$

$\frac{14 + 18n}{2} = 63$

$14 + 18n = 126$

$n = 7$

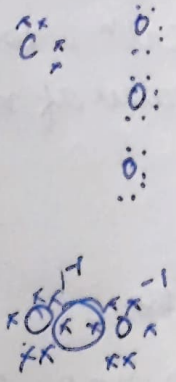
Redox

Oxidation no.

① CO_3^{2-}

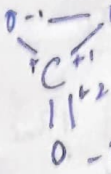
$x + 3(-2) = 0$

$x = +6$ [X]



CO_3

$x + 1(-2) + 2(-1) = 0$



S -2 to +6

Cl -1 to +7

N -3 to +5

Mn -1 to +7

Cr -2 to +6

② HNO_3

Oxidation no. of N

$1 + x + 3(-2) = 0$

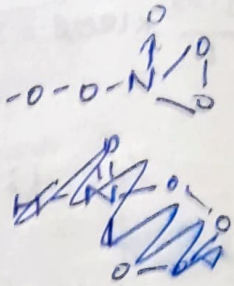
$1 + x + (-10) = 0$

$x - 9 = 0$

$x = 9$

$\Rightarrow 1 + x + 1(-1) + 1(-2) = 0$

$x = +5$



③ H_2SO_5 (Caro's Acid)

Oxidation of S

$2(1) + x + 5(-2) = 0$

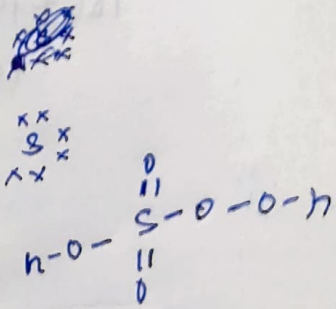
$2 + x + (-10) = 0$

$x - 8 = 0$

$x = 8$

$\Rightarrow 2(1) + x + 3(-2) + 2(-1) = 0$

$x = +6$



④ Cr_2O_3

Oxidation of Cr.

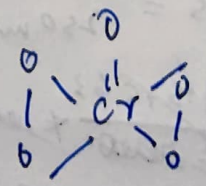
$x + 3(-2) = 0$

$x + (-6) = 0$

$x = +6$

$x + 2(-2) + 4(-2) = 0$

$x = +6$



$K_2Cr_2O_7$ → $K_2Cr_2O_8$

$3(+1) + n + 8(-1) = 0$

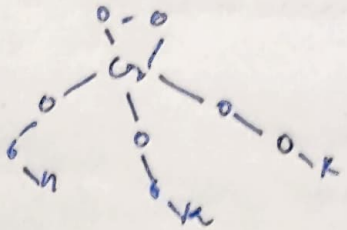
$n = +5$

$2(+1) + n + 7(-2) = 0$

$2 + n - 14 = 0$

$n - 12 = 0$

$n = +12$ (X)



* SOME SPECIAL CASE

(1) Bleaching Powder ($CaOCl_2$) it is a type of mixed salt
it exist as $Ca^{2+}(OCl^-)Cl^-$

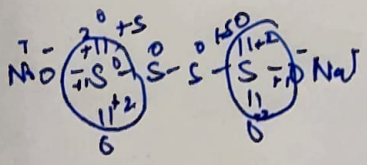
OCl^- : $-2 + n = -1$, $n = +1$

Cl^- : $n = -1$

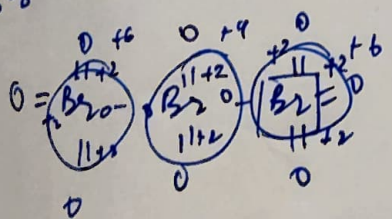
(2) Fe_3O_4 it is a mixture of $\overset{+2}{FeO} + \overset{+3}{Fe_2O_3}$

(3) Red lead or Minimum or Sindoor (Pb_3O_4)
it exist as $2\overset{+2}{PbO}.\overset{+4}{PbO_2}$

(4) $Na_2S_4O_6$ → Sodium Tetrathionate



(5) Br_3O_8



* oxidation state is the average of oxidation no.