EQUIVALENT CONCEPT AND VOLUMENTRIC ANALYSIS

1. INTRODUCTION

(a) All chemical combinations are followed by the law of equivalence.

(b) As per the law of equivalence, for the two reacting substances A and B, the number of equivalents of A reacted = the number of equivalents of B reacted.

(c) Let us consider x factor for A in the reaction is x_A and x factor for B = x_B. Let the amounts A and B reacted are w_A and w_B respectively. Let the formula wt. of A and B are M_A and M_B respectively.

$\therefore$ the no. equivalents of A reacted = $\dfrac{w_A}{\dfrac{M_A}{x_A}}$

$\therefore$ the no. of equivalents of B reacted = $\dfrac{w_B}{\dfrac{M_B}{x_B}}$

$\therefore \dfrac{w_A x_A}{M_A} = \dfrac{w_B x_B}{M_B}$

(d) for a couple of reaction

$aA + bB \longrightarrow dD + eE$ x factor = x_1

$dD + eE \longrightarrow gG + hH$ x factor = x_2

If $x_1 \neq x_2$, the law of equivalence is followed, but the entire calculation by equivalent concept becomes complicated as equivalent wt. of D in first reaction and second reaction are not same.

(e) To, solve the problems of stoichiometry based on coupling reactions, by equivalent concept, individual step of the reactions are to be studied carefully.

(f) If balanced chemical equations for the reactions given or if balancing of the chemical equations can be done easily, it is advisable to follow the mole concept rather than equivalent concept to eliminate mistakes.

(g) For acid-base reactions or for single step reaction, one can solve the problem by calculating the equivalent wts of the reactants and products involved, with the aid of x factors.

2. DEFINITION OF EQUIVALENT WEIGHT

(a) The equivalent weight of an element is that weight of the element that will combine with or replace directly or indirectly 1.0 gm (1 gm-atom) of H, 35.5 gm (1 gm atom) of Cl or 8.0 gm. (½ gm-atom) of O or 108 gm (1 gm-atom) of Ag.

(b) In the reaction

$$Mg + Cl_2 \longrightarrow MgCl_2$$

1 atom of Mg loses 2 electrons to become Mg^{2+} ion. If we start with 1 gm-atom or 1 mole or 24 gm of Mg, we have N_A (6.023×10^{23}) number of Mg atoms which would lose $2N_A$ number of electrons and form N_A number of Mg^{2+} ions. Therefore, we get $2N_A$ number of electrons from 24 gm of Mg. So, N_A number of electrons can be obtained from $\frac{24}{2}$ = 12 gm of Mg. Thus the equivalent weight of Mg = 12.

(c) So we can also define equivalent weight of an element in otherway. Thus equivalent weight of an element is that weight of the element which loses or gained Avogadro number (N_A) of electrons.

(d) From the concept of the determination of oxidation state of the elements, you can easily calculate the number of electron transferred in a particular process. So, you can also calculate the amount of reactant which transferred N_A number of electrons. Thereby, you can find the equivalent weight of the element.

(e) For example, in the reaction

$$\overset{0}{4Na} + O_2 = 2\overset{+1}{Na_2}O$$

O.S. of Na in pure state = 0

O.S. of Na in Na_2O = +1

$\therefore$ change in O.S. per gm-atom of Na = 1

$\therefore$ no.of elect. released per g-atom of Na = N_A

Hence, equi. wt. of Na = atomic wt of Na = 23

(f) For example, in the reaction

$$\overset{0}{S} + O_2 = \overset{+4}{S}O_2$$

O.S. of S in pure state = 0

O.S. of S in SO_2 = + 4

$\therefore$ change in O.S. per gm-atom of S = 4

$\therefore$ no.of elect. released per gm-atom of S = $4N_A$

Hence equivalent weight of S in the given reaction $\dfrac{\text{atomic wt of S}}{4} = \dfrac{32}{4} = 8$

(g) Let us find the equivalent wt.of Na and S as per definition. As per the equation given in (e),32 gm Oxygen combines with 4 × 23 gm of Na

∴ 8 gm Oxygen combines with $\frac{4 \times 23}{32} \times 8$ gm of Na

= 23 gm of Na

∴ the equivalent weight of Na = 23

As per the equation given in (f)

32 gm sulphur combines with 2 ×16 gm of oxygen

2 × 16 gm of oxygen combines with 32 gm of S.

∴ 8 gm of oxygen combines with

$\frac{32}{2 \times 16} \times 8$ gm of S

= 8 gm of S

∴ the equivalent weight of S = 8

So, you must realise the importance of change in O.S. while calculating the equivalent weight.

(h) Earlier we have discussed about "x" factor, which can be applied confidently while calculating the equivalent weight of the substances in the redox reactions. Equivalent weight of element

$$= \frac{\text{Atomic wt of the element}}{\text{x factor}}$$

Equivalent weight of compound

$$= \frac{\text{Formula wt of the compound}}{\text{x factor}}$$

(i) Let us apply the formula mentioned above. For example, in the reaction

$$K\overset{+7}{Mn}O_4 \longrightarrow \overset{2+}{Mn}$$

the value of x in the given equation

= 7 – 2 = 5

∴ equiv. wt. of $KMnO_4$

$$= \frac{\text{mol. wt. of } KMnO_4}{5} = \frac{158}{5} = 31.6$$

For example, in the reaction

$$K\overset{+7}{Mn}O_4 \longrightarrow \overset{+4}{Mn}O_2$$

x = 7 – 4 = 3.

∴ equiv. wt. of $KMnO_4$

$$= \frac{\text{mol. wt. of } KMnO_4}{3} = \frac{158}{3}.$$

Thus, it is evident that the equivalent weight of the substances may vary depending on the "x" factor.

2.1 The gram-equivalent weight or gram equivalent or simply equivalent and Determination of equivalent weights for various substances

(a) Equivalent weight when expressed in grams the amount we get is known as gram-equivalent weight.

(b) For the sake of simplicity, we introduce a term gram-equivalent weight, gram-equivalent or simply 1 equivalent which means equivalent of given substance weight in grams. Gram-equivalent is also abbreviated as gm-equiv.

(c) For example,

1 equivalent of chlorine = 35.5 gm

1 equivalent of oxygen = 8 gm

∴ 71 gm chlorine = 2 equivalent of chlorine

∴ 32 gm oxygen = 4 equivalent of oxygen.

(d) The no. of equiv. of any substance

$$= \frac{\text{wt. of the substance in grams.}}{\text{Equiv. wt. of the substance in grams}}$$

$= \frac{w}{E}$ [where w and E represent the weight and equiv. wt. of the substance]

(e) Equiv. wt. of any oxidant and reductant is

$$\text{Equiv. wt. of oxidant} = \frac{\text{Mol. wt. of oxidant}}{\text{x factor}}$$

$$\text{Equiv. wt of reductant} = \frac{\text{Mol. wt. of reductant}}{\text{x factor}}$$

Do, remember the given formula not at all applicable in disproportionation reaction.

(f) Equiv. wt. of acid or base in a acid-base reaction (not the redox reaction) is

$$\text{Equiv. wt of acid} = \frac{\text{Mol. wt. of acid}}{\text{Basicity of the acid}}$$

$$\text{The equiv. wt. of acid} = \frac{\text{Mol. wt. of acid}}{x}$$

$$\text{The equiv. wt of base} = \frac{\text{Mol. wt. of base}}{\text{acidity of base}}$$

$$\text{The equiv. wt. of base} = \frac{\text{Mol. wt. of base}}{x}$$

The basicity or x for acid in a acid base reaction is equal to the total number of replacable H-atoms present in the acid. Replacable H-atoms are such type of H-atoms which are attached with the atoms of group VI or group VII elements, viz, O, S, Se, Te and F, Cl, Br, I.

The acidity or x for base in a acid-base reaction is equal to the number of replacable OH groups present in the formula unit of base.

Thus, acidity of Al $(OH)_3$ = 3. The acidity of NH_4OH = 1.

3. DETERMINATION OF EQUIVALENT WEIGHT OF ELEMENT, ACIDIC AND BASIC OXIDES AND SALT

(a) The oxidation state of the elements in the pure state = 0. The equivalent wt of the element

$$E = \frac{\text{Atomic wt of the element}}{x}$$

(b) The equivalent wt of any compound = sum of the equivalent wt of component elements or ions.

By using this relation we can calculate the equivalent wt. of any acidic and basic oxide.

It is already known to us equiv wt of O = 8

Equiv. wt. of the other element

$$= \frac{\text{Atomic wt of the element}}{\text{x or valency of that element}}$$

For example,

Equiv. wt. of Fe_2O_3 = $\frac{\text{atomic wt of Fe}}{3}$ + 8

$$= \frac{56}{3} + 8 = 26.5$$

For example,

equiv. wt of As_2O_3 = $\frac{75}{3}$ + 8 = 33

(c) Let us illustrate another problem :

The molecular wt. of R_2O_3 is 326. What is the equivalent wt of R ?

Let. the at. wt. of R is A_r.

$\therefore$ $2A_r + 48 = 326$

or $A_r = \frac{326-48}{2} = 139$

$\therefore$ 3 × 16 gm O combines with 2×139 gm of A_r

$\therefore$ 8 gm O combines with $\frac{2\times139}{3\times16}$ × 8 gm of A_r

$$= \frac{139}{3} \text{ gm of } A_r = 46.34 \text{ gm of } A_r$$

$\therefore$ the equivalent wt of R = 46.34 **Ans.**

Now you can also calculate the equiv. wt. of R_2O_3 = 46.34+8 = 54.34

Again you may calculate the equivalent wt. of R in otherway by applying the given concept as the valency of R = 3

$\therefore$ The equiv. wt of R = $\frac{1}{3}\left(\frac{326-48}{2}\right)$

$$= \frac{139}{3} = 46.34$$

But this method is not convenient one to calculate the equivalent wt. of the metal in mixed oxides. There we are to use oxidation state instead of valency.

(d) The equivalent weight of salt E, which is not behave as oxidizing or reducing agent is given by,

$$E = \frac{\text{formula wt of the salt}}{\text{total valence of designated ion}}$$

For example, the equivalent wt E of $Ca_3(PO_4)_2$

$$= \frac{\text{formula wt of } Ca_3(PO_4)_2}{3\times2} = \frac{310}{6}$$

= 51.6 **Ans.**

(e) Equivalent wt of an ion

$$= \frac{\text{formula wt (or At. wt.) of ion}}{\text{its valency}}$$

4. LAW OF EQUIVALENTS AND ITS APPLICATION IN THE DETERMINATION OF EQUIVALENT WEIGHTS OF ELEMENTS

4.1 Law of Equivalents

(a) It is in accord with the law of equivalent proportion which states,

"Substances (elements or compounds) combine in the ratio of their gram equivalent weights or equivalents".

(b) Let g_1 and g_2 be the weights of the two reacting substances and E_1 and E_2 their equiv wts.

From the law of equivalent we can write,

$$\frac{\text{wt of the Ist substance in grams}}{\text{Equiv. wt of the Ist substance in grams}} = \frac{\text{wt of the IInd substance in grams}}{\text{Equiv. wt of the IInd substance in grams}}$$

or $\frac{g_1}{E_1} = \frac{g_2}{E_2}$ or $\frac{g_1}{g_2} = \frac{E_1}{E_2}$

(c) In general we can write for the two reacting substances X and Y as,

$$\frac{\text{wt. of X}}{\text{wt. of Y}} = \frac{\text{Equiv wt. of X}}{\text{Equiv wt. of Y}}$$

4.2 Determination of equiv. wt. of metals by hydrogen displacement method

(a) The equiv wt of metals viz, K, Na, Ca, Fe, Zn, Mg, Al and Sn,
which can displace hydrogen from any acid or from H containing compound, can only be determined by this method.

(b) For example, w_1 gm. of any metal displaces w_2 gm of H from an dilute acid. The,

$$\frac{w_1}{w_2} = \frac{\text{Equiv. wt. of metal}}{1}$$ [the equiv. wt. of H = 1]

$\therefore$ Equiv. wt. of metal = $\frac{w_1}{w_2}$

(c) 0.224 gm of a metal when dissolved in dilute acid liberates 285 c.c. of hydrogen, measured at 17 ºC and 78 cm of mercury pressure. Find the equiv. wt. of the metal.

$w_1 = 0.224$

wt. of hydrogen, $w_2 = \frac{PVM}{RT} = \frac{78}{76} \times \frac{0.285 \times 2}{0.082 \times 290}$

= 0.0246 gm.

$\therefore$ Equiv wt of metal = $\frac{w_1}{w_2} = \frac{0.224}{0.0246} = 9.105$

4.3 Determination of equivalent wt. of element from the oxide formation method

(a) From the formation of oxide the equiv. wt of the element can be easily determined.

(b) Let w_1 gm of element X, combines with w_2 gm of O.

$\therefore$ w_2 gm. O combines with w_1 gm of X.

$\therefore$ 8 gm. O combines with $\frac{w_1}{w_2} \times 8$ gm of X

[Equiv. wt. of O = 8]

$\therefore$ equiv. wt of X = $\frac{w_1}{w_2} \times 8$.

(c) From 3.36 gm of Fe, 4.80 gm of iron oxide is obtained. What is the equivalent wt of Fe ?

In iron oxide, the amount of Fe = 3.36 gm

In iron oxide, the amount of O = 4.8 – 3.36 = 1.44 gm.

$\therefore$ 1.44 gm oxygen combines with 3.36 gm of Fe

$\therefore$ 8 gm oxygen combines with $\frac{3.36}{1.44} \times 8$ gm of Fe = 18.67 gm of Fe

$\therefore$ equiv. wt of Fe in iron oxide = 18.67

(d) Some times the information about the composition of the oxides of the element is given indirectly. To find the equiv. wt of the element we are to proceed logically.

(e) When 31.6 gm of pure copper oxide are completely reduced by dry hydrogen, 7.2 gm of water are produced. Calculate the equiv. wt of copper.

wt of oxygen, w_2 present in given copper oxide

$= 7.2 \times \frac{16}{18}$ gm = 6.4 gm

$\therefore$ wt of copper w_1 = 31.6 – 6.4 = 25.2 gm

Hence, equiv wt of copper

$= \frac{w_1}{w_2} \times 8 = \frac{25.2}{6.4} \times 8 = 31.5$

4.4 Determination of equivalent wt. of the elements from their chloride formation

(a) The equiv. wt of the element is that weight which combines with 35.5 gm of Cl.

(b) Let, w_1 gm of the element 'x' combines with w_2 gm of Cl.

$\therefore$ w_2 gm Cl combines with w_1 gm of X

$\therefore$ 35.5 gm Cl combines with $\frac{w_1}{w_2} \times 35.5$ gm of X

$\therefore$ The equiv. wt. of X = $\frac{w_1}{w_2} \times 35.5$

(c) Sometimes composition of the chlorides are given indirectly.

(d) The equivalent wt. of a metal is 30. What volume of chlorine would be liberated at 27 ºC and 750 mm pressure by 0.6 gm of the metal ? (Aq. tension at 27 ºC = 26.6 mm)

Here weight of metal = W_1 = 0.6gm

Here, wt of chlorine = w_2 gm.

$\therefore$ $\frac{0.6}{w_2} = \frac{30}{35.5}$ or $w_2 = \frac{0.6 \times 35.5}{30} = 0.71$ gm.

The volume of chlorine liberated = $\left(\frac{w_2}{M}\right) \frac{RT}{P}$

$$= \frac{0.71}{71} \times \frac{\frac{0.082 \times 300}{(750-26.6)}}{760} = 0.2584 \text{ lit.}$$

4.5 Determination of equivalent wt. of metal from the displacement/substitution reactions

(a) When one metal displaces another from a solution of one of its compounds, the equivalent weight of one metal displaces the equivalent weight of the other, so that of the other can be found.

(b) For instance, if metallic zinc or iron be added to a solution of silver nitrate or copper sulphate, finely divided silver or copper is precipitated : so, we can write

$$= \frac{\text{wt. of zn / or /Fe}}{\text{wt of Ag}}$$

$$= \frac{\text{Equiv. wt. of zn / or /Equiv. wt. of Fe}}{\text{Equiv. wt of Ag}}$$

(c) 0.13 gm of copper displaces 0.432 gm of silver from silver nitrate solution. 0.13 gm of aluminium displaces 0.47 gm of copper from copper sulphate solution. While 0.13 gm of hydrogen is displaced by 1.17 gm of aluminium calculate from this data the equivalent weight of silver.

$$\frac{\text{wt of cu}}{\text{wt of Ag}} = \frac{\text{Equiv. wt.of Cu}}{\text{Equiv.wt. of Ag}} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

$$\frac{\text{wt of Al}}{\text{wt of Cu}} = \frac{\text{Equiv. wt.of Al}}{\text{Equiv. wt. of Cu}} \quad \ldots\ldots\ldots\ldots\ldots (2)$$

$$\frac{\text{wt of Al}}{\text{wt of H}} = \frac{\text{Equiv. wt.of Al}}{\text{Equiv. wt. of H}} \quad \ldots\ldots\ldots\ldots\ldots (3)$$

Now, introducing the informations in relation (3)

$$\text{Equiv. wt. of Al} = \frac{\text{wt of Al}}{\text{wt of H}} \times 1 = \frac{1.17}{0.13} = 9$$

Now, introducing equiv. wt of Al = 9 in relation (2) we get

$$\text{Equiv. wt of Cu} = \frac{\text{wt of Cu}}{\text{wt of Al}} \times \text{Equiv. wt of Al}$$

$$= \frac{0.47}{0.13} \times 9 = 32.54$$

Now putting the equiv. wt. of Cu = 32.54 in relation (1)

$$\text{Equiv. wt of Ag} = \frac{\text{wt of Ag}}{\text{wt of Cu}} \times \text{Equiv. wt. of Cu}$$

$$= \frac{0.432}{0.13} \times 32.54 = 108.1$$

4.6 Determination of equivalent weight of metal by double decomposition method

(a) Double decomposition method is based on the law of equivalent. As per this law, substances react in the proportion of their equivalent amount. This procedure is also applicable for nonmetallic reactants.

(b) Let us consider a reaction as

$$P_mQ_n + R_OS_P \longrightarrow \text{products}$$

Let, amount of $P_m Q_n$ reacted = w_1 gm
Let, amount of R_oS_p reacted = w_2 gm

$$\therefore \frac{w_1}{w_2} = \frac{\text{Equivalent wt of } P_mQ_n}{\text{Equivalent wt of } R_oS_p}$$

$$\therefore \frac{w_1}{w_2} = \frac{\text{Equivalent wt of P+Equivalent wt of Q}}{\text{Equivalent wt of R+Equivalent wt of S}}$$

If w_1, w_2 and Equiv wt of Q, R and S are known to us, we can calculate the equiv wt of P.

(c) Chloride of metal 'M' contains 47.23% of the metal. 1 gm of this metal displaced from a compound 0.88 gm of another metal 'N'. Find the equivalent weight of 'M' and 'N' respectively.

Let, the equiv wts of M and N are E_M and E_N respectively.

$$\therefore \frac{E_M}{35.5} = \frac{47.23}{52.77} \quad \text{or } E_M = \frac{35.5 \times 47.23}{52.77}$$

or $E_M = 31.77$

$$\therefore \frac{E_M}{E_N} = \frac{1}{0.88}$$

or $E_N = 0.88\ E_M = 0.88 \times 31.77 = 27.96$

SOLVED PROBLEMS

Ex.1 In the reaction
$Br_2 + Na_2CO_3 \longrightarrow NaBr + NaBrO_3 + CO_2$ The equiv. wt. of $NaBrO_3$ is

(A) $\frac{\text{Mol. wt}}{1}$ ***(B)*** $\frac{\text{Mol. wt}}{10}$ ***(C)*** $\frac{\text{Mol. wt}}{5}$ ***(D)*** $\frac{\text{Mol. wt}}{4}$

Sol. Per mole of the formation $NaBrO_3$ the x factor = + 5

$\therefore$ equiv. wt. of $NaBrO_3 = \frac{\text{Mol. wt}}{5}$ **(Ans. C)**

Ex.2 The equiv. wt. of hypo in the reaction
$Na_2S_2O_3 + Cl_2 + H_2O \longrightarrow Na_2SO_4 + H_2SO_4 + HCl$ is –

(A) $\frac{\text{Mol. wt}}{2}$ ***(B)*** $\frac{\text{Mol. wt}}{4}$ ***(C)*** $\frac{\text{Mol. wt}}{1}$ ***(D)*** $\frac{\text{Mol. wt}}{8}$

Sol. $Na_2\overset{+2}{S_2}O_3 + Cl_2 + H_2O \longrightarrow Na_2\overset{+6}{S}O_4 + H_2\overset{+6}{S}O_4 + HCl$

$\therefore$ x factor for $Na_2S_2O_3 = 2|(2 - 6)| = 8$

$\therefore$ equiv. wt. of $Na_2S_2O_3 = \frac{\text{Mol. wt}}{8}$ **(Ans.D)**

Ex.3 In acting as a reducing agent, a piece of metal M weighing 16 grams gives up 2.25×10^{23} electrons, what is the equiv.alent weight of the metal
(A) 42.83 (B) 21.33 (C) 83.32 (D) 32

Sol. N_A no of electron will be removed by

$\frac{6.023 \times 10^{23}}{2.25 \times 10^{23}} \times 16$ gm of metal M

= 42.83 gm of metal M

$\therefore$ equiv. wt. of metal is 42.83 **(Ans.A)**

Ex.4 The equiv. wt. of the salt KHC_2O_4, $H_2C_2O_4$, $4H_2O$ (to be used as a reducing agent) is -

(A) $\frac{\text{Mol. wt}}{1}$ ***(B)*** $\frac{\text{Mol. wt}}{2}$ ***(C)*** $\frac{\text{Mol. wt}}{3}$ ***(D)*** $\frac{\text{Mol. wt}}{4}$

Sol. Per moles of this salt moles of $C_2O_4^{2-} = 2$
$\therefore$ no of electrons transferred per moles of this salt is
$2C_2O_4^{2-} \longrightarrow 2 \times 2e = 2CO_2 \times 2$
$\therefore$ 'x' factor (as a reducing) of the given salt = 4

$\therefore$ equiv. wt. of the given salt = $\frac{\text{Mol. wt}}{4}$ **(Ans. D)**

Ex.5 What weight of HNO_3 is needed to convert 62 gm of P_4 in H_3PO_4 in the reaction ?
$P_4 + HNO_3 \longrightarrow H_3PO_4 + NO_2 + H_2O$
(A) 63 gm (B) 630 gm
(C) 315 gm (D) 126 gm

Sol. The equiv. wt. of $P_4 = \frac{31 \times 4}{5 \times 4} = \frac{31}{5}$

$\therefore$ 62 gm $P_4 = \frac{62 \times 5}{31}$ equiv. of P_4

= 10 equiv. of P_4

The equiv. wt. of $HNO_3 = \frac{\text{Mol. wt}}{1} = \frac{63}{1}$

$\therefore$ the wt. of HNO_3 required
= 10 × 63 = 630 gm **(Ans. B)**

Ex.6 The equiv. wt. of an element is 9. If it forms volatile chloride of vapour density 58.5. What is the approximate at wt. of the element ?
(A) 9 (B) 18 (C) 27 (D) 54

Sol. Let, the molecular formula of the chloride is MCl_x and at wt. of the element is a
$\therefore$ $9x + x \times 35.5 = 58.5 \times 2$

$x = \frac{58.5 \times 2}{44.5} = 2.63$

The nearest whole no. of 2.63 = 3
$\therefore$ approximate at wt. of the element
= 9 × 3 = 27 **(Ans. C)**

Ex.7 6.90 gm of a metal carbonate were dissolved in 60 ml of 2(N) HCl. The excess acid was neutralized by 20 ml of 1(N) NaOH. What is the equiv.alent wt. of metal ?
(A) 40 (B) 20 (C) 19 (D) 39

Sol. Equiv. of HCl taken = $60 \times 2 \times 10^{-3}$
Equiv. of HCl present after the reaction
= $20 \times 1 \times 10^{-3}$
$\therefore$ Equiv. of HCl utilized = 100×10^{-3}
$\therefore$ 100×10^{-3} equiv. of metal carbonate
= 6.90 gm
$\therefore$ 1 equiv. of metal carbonate

$= \frac{6.90}{10^{-1}} = 69$ gm

$\therefore$ equiv. wt. of metal = 69 – 30 = 39
[becuase equiv. wt. of carbonate = 30]
(Ans. D)

Ex.8 10 ml of $\left(\frac{N}{2}\right)$ HCl, 30 ml of $\left(\frac{N}{10}\right)$ HNO_3 and 75 ml of $\left(\frac{N}{5}\right)$ HNO_3 are mixed, the normality of H^+ in the resulting solution is-
(A) 0.2 (B) 0.1 (C) 0.5 (D) 0.25

Sol. The equiv. of H^+ in 10 ml of $\left(\frac{N}{2}\right)$ HCl

$= \frac{10}{2} \times 10^{-3}$

The equiv. of H^+ in 30 ml of $\left(\frac{N}{10}\right)$ HNO_3

$= \frac{30}{10} \times 10^{-3}$

The equiv. of H^+ in 75 ml of $\left(\frac{N}{5}\right)$ HNO_3

$= \frac{75}{5} \times 10^{-3}$

Hence, total equiv. of H^+

$= (5 + 3 + 15) \times 10^{-3} = 23 \times 10^{-3}$

total volume of solution = 115 ml

Hence, normality of H^+ in the resulting mixture

$= \frac{23 \times 10^{-3} \times 10^3}{115} (N)$

$= \left(\frac{N}{5}\right) = 0.2\ (N)$ **(Ans. A)**

Ex.9 500 ml of 0.2 (M) H_2SO_4 are mixed with 250 ml of 0.1 (M) $Ba(OH)_2$, the normality of resulting solution is -

(A) 0.2 (B) 0.1 (C) 0.5 (D) 0.25

Sol. 500 ml of 0.2 (M) H_2SO_4

$= 500 \times 0.2 \times 10^{-3}$ moles of H_2SO_4

$= 0.5 \times 0.2 \times 2$ equiv. of H_2SO_4

$= 0.2$ equiv. of H_2SO_4

250 ml of 0.1 (M) $Ba(OH)_2$

$= 250 \times 0.1 \times 10^{-3}$ moles of $Ba(OH)_2$

$= 250 \times 0.1 \times 10^{-3} \times 2$

$= 0.05$ equiv. of $Ba(OH)_2$

$\therefore$ Excess $H_2SO_4 = 0.2 - 0.05 = 0.15$ equiv.

Hence normality of H_2SO_4 in resulting solution

$= \frac{0.15}{750} \times 1000 = 0.2\ (N)$ **(Ans. A)**

Ex.10 What weight of $H_2C_2O_4$, $2H_2O$ (mol. wt. = 126) should be dissolved to prepare 250 ml of centinormal to be used as a reducing agent ?

(A) 0.63 gm (B) 0.1575 gm

(C) 0.126 gm (D) 0.875 gm

Sol. Per mole of given acid $C_2O_4^{2-}$ present

= 1 mole

$\therefore C_2O_4^{2-} \longrightarrow CO_2 + 2e$

$\therefore$ x factor for $H_2C_2O_4$, $2H_2O$ as a reducing agent = 2

$\therefore$ equiv. wt. $= \frac{126}{2} = 63$

250 ml of seminormal solution

$= \frac{250}{100} \times 10^{-3}$ equiv.

$\therefore$ wt. of $H_2C_2O_4$, $2H_2O$ required

$= \frac{250}{100} \times 10^{-3} \times 63$ gm = 0.1575 gm

(Ans. B)

Ex.11 Which of the following has the highest normality ? (consider each of the acid is 100% ionised.)

(A) 1 (M) H_2SO_4 (B) 1 (M) H_3PO_3

(C) 1 (M) H_3PO_4 (D) 1 (M) HNO_3

Sol. The normality of 1(M) H_2SO_4 = 2(N)

The normality of 1(M) H_3PO_3 = 2(N)

The normality of 1(M) H_3PO_4 = 3(N)

The normality of 1(M) HNO_3 = 1(N)

(Ans. C)

Ex.12 0.45 gm of an acid of mol. wt. 90 was neutralised by 20 ml of 0.5 (N) caustic potash. The basicity of acid is-

(A) 1 (B) 2 (C) 3 (D) 4

Sol. 20 ml of 0.5 (N) caustic potash

$= 20 \times 0.5 \times 10^{-3}$ equiv. of caustic potash

$\therefore 20 \times 0.5 \times 10^{-3}$ equiv. of acid = 0.45 gm

$\therefore$ 1 equiv. of acid $= \frac{0.45}{10 \times 10^{-3}} = 45$ gm

$\therefore$ x for acid $= \frac{90}{45} = 2$

Hence, basicity of acid = 2

(Ans. B)

Ex.13 The equivalent wt. of a metal is double that of oxygen. How many times is weight of its oxide greater than the wt. of metal ?

(A) 2 (B) 3 (C) 1.5 (D) 0.25

Sol. The equiv. wt. of the metal = 16

The equiv. wt. of the metal oxide

= 16 + 8 = 24

$\therefore$ oxide is $\frac{24}{16}$

= 1.5 times greater than the wt. of metal

(Ans. C)