Class- IX

Normality, Molality and Mole Fraction

Teaching Task

Q1) Ans:- D.

Solution:-

A) 8.0g of KOH /100ml of solution.

$$N = \frac{8}{56} \times \frac{1000}{100} = \frac{80}{56} = 1.4N.$$

B) 0.5 molar H_2SO_4. → N = Molarity x Basicity.

$$N = M \times 2.$$

$$= 0.5 \times 2 = 1N.$$

c) 1N H_3PO_4

D) 6g of NaOH /100g of water.

$$N = \frac{6}{23+16+1} \times \frac{1000}{100}$$

$$= \frac{60}{40} = 1.5N$$

Q2) Ans:- B.

Solution:- No. of moles of H_2O, $n = 4M \times 0.05L = 0.2$ moles.

$$Fe + 2HCl \rightarrow Fe^{+2} + H_2 + 2Cl^-$$

2 moles of HCl is required to convert Fe to Fe^{+2}.

No. of moles of

$$Fe^{+2} = \frac{1}{2} \times 0.2 = 0.1 \text{ moles.}$$

Q3) Ans:- B.

Solution:-

A) 0.3 % H_3PO_4

Molar mass = 3+31+16×4. = 98.

0.3% in 98gms = 0.294 gms.

B) 0.3M H_3PO_4. for 1 litre

$$M = \frac{w}{GMW} \times \frac{1000}{V_{mL}}$$

$$0.3 = \frac{w}{98} \times \frac{1}{1}.$$

w = 29.4 gms/in 1 litre

c) 0.3 m H_3PO_4

$$m = \frac{w}{GMW} \times \frac{1}{w(kg)}$$

$$0.3 = \frac{w}{98} \times \frac{1}{1}.$$

w = 29.4 gms present in 1kg

d). 0.3 N H_3PO_4

$$N = \frac{w}{G.EW} \times \frac{1000}{V_{mL}} = \frac{w}{49} \times \frac{1000}{1000}$$

0.3×49 = w

w = 14.7 gms in 1000 ml.

0.3M is more concentrated because 29.4gms present in 1000 mL

Q4) Ans:- D.

Solution:- Given

5ml of N HCl.

$M_1 = 1 \times 5 = 5M.$

20ml of N/2 H_2SO_4.

$M_2 = \frac{1}{2} \times 20 = 10M.$

30ml of N/3 HNO_3.

$M_3 = \frac{1}{3} \times 30 = 10M.$

$Meq = M_1 + M_2 + M_3 = 5 + 10 + 10 = 25M.$

Volume = 1000mL.

$Meq = N \times V.$

$25 = N \times 1000$

$N = \frac{25}{1000} = \frac{1}{40}.$

Normality of solution would be $\frac{N}{40}$.

Q5) Ans:- B.

Solution:- $H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$.

For 1 mole of H_2SO_4, 2 moles of KOH required.

Given 100 ml of 0.1M H_2SO_4.

$n = \text{Molarity} \times V_{lit} = 0.1 \times 0.1 = 0.01$ moles.

100 ml of of 0.1M KOH

$n = 0.1 \times 0.1 = 0.01$ moles.

For 0.01 moles of H_2SO_4 0.02 moles of KOH required, but we have only 0.01 moles of KOH. So KOH is limiting reagent, For 0.01 moles of KOH 0.005 moles of H_2SO_4 is used.

Remaining $H_2SO_4 = 0.01 - 0.005 = 0.005$ moles.

$$N = \frac{w}{GEW} \times \frac{1000}{V_{mL}}$$

$$GEW = \frac{GMW}{n} \Rightarrow N = \frac{nw}{GMW} \times \frac{1000}{V_{mL}}$$

Given V = 2 litres = 2000 mL.

$$N = \frac{0.005 \times 2 \text{ equivalents 1mole}}{2L}$$

$= 0.005 = 5 \times 10^{-3}$ N.

Q6). Ans:- D

Solution:- $Cr_2O_7^{2-} + 6Fe^{2+} + 14H^+ \rightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$

n=1 (Mohr's salt), Equivalent of Fe^{2+} = Equivalent of $K_2Cr_2O_7$.

$= 500 \times 10^{-3} \times 6 \times 1 = 3.0$.

Mole percent of Mohr's salt of 5 moles $= \frac{3}{5} \times 100$

$= 60$.

Q7) Ans:- A.

Solution:- The valency factor for $K_2Cr_2O_7$ is 6.

$N_1V_1 = N_2V_2$

$0.2 \times 5\cancel{0} = N_2 \times 4\cancel{0}$

$N_2 = \frac{1}{4}$

$N_2 = \frac{w}{M.wt} \times eq.factor \times \frac{1}{V\,lit.}$

$\frac{1}{4} = \frac{w}{56} \times 1 \times 1.$

$w = \frac{56}{4} = 14g.$

Q8) Ans:- D.

Solution:- Mole fraction of water $= 1 - 0.6 = 0.4.$

No. of moles of water in solution $= n.$

Moles of alcohol $= \frac{\text{Given mass}}{\text{Molecular mass}} = \frac{69}{46} = \frac{3}{2}$

Mole fraction of water $= \frac{n}{n + \frac{3}{2}}$

$\frac{n}{n+\frac{3}{2}} = 0.4.$

$\frac{2n}{2n+3} = 0.4 \Rightarrow 2n = 0.4(2n+3)$

$2n = 0.8n + 1.2$

$2n - 0.8n = 1.2$

$\cancel{1.2}n = \cancel{1.2} \Rightarrow n = 1.$

For 1 mole water, GMW = 18 gms.

Q9) Ans: B

Solution:- $M = \frac{n}{V \text{ in litres}}$.

Given volume = 500mL = $\frac{500}{1000}$

$$M = \frac{n}{\frac{500}{1000_2}} = 2n \rightarrow \text{Molarity} = 2 \times \text{moles of solute}$$

$$\text{No. of moles} = \frac{\text{weight}}{\text{molar mass}} = \frac{\text{Molarity}}{2}$$

$$\text{weight} = \frac{\text{Molarity}}{2} \times \text{molar mass}.$$

$$\text{Equivalent weight} = \frac{\text{molar mass}}{\text{basicity}} = \frac{\text{Molar mass}}{2}$$

Weight of acid present in solution =

$$\text{Molarity} \times \frac{\text{molar mass of dibasic acid}}{2}$$

Amount of acid = Molarity × Equivalent weight

= M × E.

Q10) Ans:- B.

Solution:- Moles of solute present in 500ml of solution = $\frac{6}{60}$ = 0.1.

Weight of solution = 500 × 1.05 = 525 gm.

weight of solvent = 525 − 6 = 519 gms.

$$m = \underset{(\text{moles of solute})}{0.1} \times \frac{1000}{\underset{(\text{weight of solvent})}{519.}} = 0.19$$

Q11) **Ans:-** B.

Solution:- No. of moles of solute (n) = $\frac{16}{32}$ = $\frac{1}{2}$ = 0.5 moles

Weight of solution = d × V

= 0.96 × 100 = 96.

Molality = no. of moles of solute × $\frac{1000}{\text{weight of solvent}}$

weight of solvent = W. Solution − W. of Solute

= 96 − 16 = 80

$m = 0.5 \times \frac{1000}{80} = \frac{50}{8} = 6.25\,m.$

Q12) **Ans:-** A.

Solution:- $3C_2H_2 \xrightarrow{\text{red hot tubes}} X.$

$2Na_2S_2O_3 + Y \rightarrow Na_2S_4O_6 + 2NaI.$

$Y = I_2$, $X = C_6H_6$.

Mole fraction of Y = 0.2.

Total mole fraction of X & Y = 1.

mole fraction of X = 1 − Y = 1 − 0.2 = 0.8.

Molality = $\frac{0.2}{0.8 \times 78} \times 1000 = \frac{200}{62.4} = 3.2\,m.$

Q13) **Ans:-** C, D.

Solution:- Mole fraction, molality & % wt are independent of temperatures.

Q14) Ans:- B, C.

Solution:-

$$M_{Na_2CO_3} = \frac{5.3}{106} \times \frac{1000}{100} = \frac{1}{2} = 0.5M$$

$$N_{Na_2CO_3} = 0.5 \times 2 = 1.0\ N.$$

$$M_{H_2C_2O_4 \cdot 2H_2O} = \frac{6.3}{126} \times \frac{1000}{100} = \frac{1}{2} = 0.5\ M$$

$$N_{H_2C_2O_4 \cdot 2H_2O} = 0.5 \times 2 = 1\ N.$$

For Both solutions Molarity & Normality are same.

Q15) Ans:- A.

Solution:- The quantities of the solute & solvent are expressed in weights, the molality does not change with the change in temperature.

Q16) Ans:- D

Solution:- Equivalent weight $= \frac{\text{Molar mass}}{\text{valency factor}}$.

$$2KMnO_4 + 3H_2SO_4 + 5H_2C_2O_4 \rightarrow K_2SO_4 + 2MnSO_4 + 8H_2O.$$

Oxidation number of Mn in $KMnO_4$.

$$1 + Mn + 4(-2) = 0$$
$$Mn = 7$$

In $MnSO_4 \rightarrow$ $Mn + 6 + 4(-2) = 0$

$$Mn = 2$$

Oxidation state of Mn changes from 7 to 2,

So valency factor = 5.

Equivalent weight $= \frac{M}{5}$.

Q17) Ans:- C.

Solution:- Relation b/w molarity & molality

$$m = \frac{1000 \times M}{(1000 \times d) - (M \times GMW)}$$

$$= \frac{1000M}{1000d - MM'}$$

Q18) Ans:- B

Solution:- Molecular weight of $H_2O_2 = 2+32 = 34$.

20% aqueous H_2O_2 means 20gms of H_2O_2 in 100gm of solution.

Mass of water = 100 − 20 = 80.

$$\text{Mole fraction of water} = \frac{n_{water}}{n_{water} + n_{H_2O_2}}$$

$$n_{water} = \frac{80}{18}, \quad n_{H_2O_2} = \frac{20}{34}$$

$$X_{water} = \frac{\frac{80}{18}}{\frac{80}{18} + \frac{20}{34}} = \frac{\frac{80}{18}}{\frac{(34 \times 80) + 18(20)}{18 \times 34}}$$

$$= \frac{80 \times 34}{2720 + 360}$$

$$= \frac{2720}{3080} = \frac{68}{77} = 0.883$$

$$= \frac{68}{77} = 0.883$$

Matrix Matching

Q19) Ans:- A) A – 4, B – 1, C – 2, D – 3

Solution:-

A) Molality → 4) $g\,mol.\,Kg^{-1}$.

B) Mole fraction → 1) No units.

c) Normality → 2) $g.\,eq.\,dm^{-3}$.

D) Molarity → 3) $mol.\,dm^{-3}$.

Q20). Ans:- A) P B) P c) q, s D) q, R, S.

Solution:-

A) Normality → p) Vary with temperature.

B) Mdarity → p) Vary with temperature.

c) Molality → q) Independent of temperature variation.
s) Involves weight

D) Mole fraction → q) Independent of temperature.
R) Involves ratio.
S) Involves weight.

Learner's Task

Q1) Ans:- C.

Solution:- Units of Normality are Gramequivalents/litre.

Q2) Ans:- C

Solution:- Units of molality are moles/kg.

Q3) Ans:- C.

Solution:- Relation b/w molarity & molality

$$m = \frac{1000 \times M}{(1000 \times d) - (M \times GMW)}$$

$$GMW = M'$$

$$m = \frac{1000 \times M}{1000 \times d - MM'}.$$

Q4) Ans:- A.

No. of moles of urea $(n) = 0.1$ gram mol.

$W_{solvent} = 100g.$

Mass of solvent $= 0.1 kg.$

$$\text{Molality} = \frac{\text{Moles (solute)}}{\text{Mass (solvent in kg)}}$$

$$= \frac{0.1}{0.1} = 1 \text{ molal.}$$

Q5) Ans:- C

Solution:- Urea $CH_4N_2O = 12+4+28+16 = 60.$

Given 6 gm of urea $\rightarrow n = \frac{6}{60} = 0.1.$

90 gms. of water $\rightarrow n = \frac{90}{18} = 5$ moles.

$$X_{urea} = \frac{0.1}{0.1+5} = \frac{0.1}{5.1} = 0.019$$

$$= \frac{1}{51}$$

Q6) Ans:- B.

Solution:- $X_A + X_B + X_C + X_D = 1.$

$X_B = 0.5$

$X_A + X_C + X_D = 1 - 0.5 = 0.5$

X_A is less than 0.5.

Q7) Ans:- A.

Solution:-

$$m = \frac{X_A \times 1000}{(1 - X_A)\,(GMW)_B}.$$

$$X_S = \frac{m}{m + \frac{1000}{\text{MW of Solvent}}}.$$

Given $m = 0.1$, For water MW = 18.

$$X_S = \frac{0.1}{0.1 + \frac{1000}{18}} = \frac{0.1}{\frac{1.8 + 1000}{18}}$$

$$= \frac{0.1 \times 18}{1001.8} = 0.00179.$$

Molefraction of Solvent $= 1 - X_S$

$= 1 - 0.00179 = 0.99821$

Q8) Ans:- D.

Solution:- Given, $m = 1$, $M' = 40$, $d = 1.02\,g/ml$.

$$m = \frac{1000 \times M}{1000d - MM'} \Rightarrow 1 = \frac{1000\,M}{1000(1.02) - 40M}$$

$1000M = 1020 - 40M.$

$1000M + 40M = 1020.$

$1040\,M = 1020$

$$M = \frac{102\cancel{0}}{104\cancel{0}} \Rightarrow M = 0.98$$

Q9) Ans:- B.

Solution:- Concentration of NaOH = 10% w/w.

Let 100gms of solution, mass of NaOH = 10 gms.

$$n_{NaOH} = \frac{10}{40} = 0.25 \text{ moles.}$$

$$\text{Mass of water} = 100 - 10 = 90.$$

$$n_{water} = \frac{90}{18} = 5 \text{ moles.}$$

$$X_{NaOH} = \frac{n_{NaOH}}{n_{NaOH} + n_{water}}$$

$$= \frac{0.25}{0.25+5} = \frac{0.25}{5.25} = 0.0476$$

Q10). Ans:- C.

Solution:- Specific gravity = 1.54.

$$H_3PO_4 = 3 + 31 + 64 = 98.$$

weight % = 70%.

$$N = \frac{10 \times \text{specific gravity} \times \text{weight \%}}{GEW}$$

$$= \frac{10 \times 1.54 \times 70}{\frac{98}{3}} = \frac{1078 \times 3}{98} = 33N.$$

JEE Main Level Questions

Q1) Ans:- D.

Solution:- 1 Mole of acid dissolved in on litre water will giv 1N solution only if the acids having basicity 1.

→ HCl, $HClO_4$ & HNO_3 are all mono basic.

→ H_3PO_4 has basicity value 3, so it won't give 1N solution.

Q3) Ans:- D.

Solution:- $N = \frac{w}{GEW} \times \frac{1000}{V in.}$

I) 1000mL of 0.3N

$0.3 = \frac{w}{GEW} \times \frac{1000}{1000}$

$\frac{w}{GEW} = 0.3.$

II) 2000mL of 0.15N.

$0.15 = \frac{w}{GEW} \times \frac{1000}{2000}$ 2

$\frac{w}{GEW} = 2 \times 0.15 = 0.3.$

III) 2500mL of 0.2N solution.

$\frac{w}{GEW} = 0.2 \times \frac{2500}{1000} = \frac{5}{10} = 0.5.$

IV). 3000ml of 0.1N solution.

$0.1 = \frac{w}{GEW} \times \frac{1000}{3000}$
3

$\frac{w}{GEW} = 0.1 \times 3 = 0.3.$

I, II & III are same.

Q4) Ans:- B.

Solution:- $N_{HCl} = \frac{weight \times 1000}{GEW \times V} = \frac{0.04 \times 1000}{36.5 \times 1} = 1.095.$

$N_{NaOH} = N_{HCl}$

$N_{NaOH} = \frac{w_B \times 1000}{40 \times 1} \Rightarrow \frac{1.095 \times 40}{1000} = w.$

$w_B = 0.0438 g/mL.$

Q5) Ans:- B.

Solution:- $N = \frac{N_1V_1 + N_2V_2}{V_1+V_2}$

Valency factor of HCl is 1.

$N = 5$

$5 = \frac{N \times 1.5 + 2 \times 2.5}{1.5+2.5}$

$5 = \frac{1.5N + 5}{4}$

$1.5N + 5 = 20$

$1.5N = 20 - 5$

$N = \frac{15}{1.5} = 10$

Q6). Ans:- B.

Solution:- Equivalent mass of $KMnO_4 = \frac{\text{Molecular weight}}{\text{No. of Electrons gained by } MnO_4}$

In $KMnO_4$, Mn = 7, In $MnO_4 \Rightarrow$ Mn = 8.

Electrons gained = 1.

E.M of $KMnO_4 = \frac{158}{1} = 158$.

Q7) Ans:- B.

Solution:- Solvay process, 'X' is $CaCO_3$ & Y is HCl.

Let V be the volume of HCl that neutralise 25 gms of $CaCO_3$.

$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O$.

Equivalent of X = Equivalent of Y.

$2 \times \frac{25}{100} = V \times 1 \Rightarrow V = \frac{50}{100_2} = 0.5 l$ or 500 ml.

Q9) Ans:- C

Solution:- 0.25 mole of urea are present in 1Kg of water

Moles of urea = 0.25 moles.

Mass of solvent (water) = 1kg = 1000g

Molar mass of urea (NH_2CONH_2) = 60g mol.

0.25 moles of urea = 0.25 × 60g
= 15 g.

Total mass of solution = 1000 + 15 = 1015g
= 1.015 Kg.

1.015 Kg of solution contains urea =

15g × 2.5 kg of solution will require urea

$$\text{Mass of urea} = \frac{15g \times 2.5\,kg}{1.015\,kg} = 37g.$$

Q10) Ans:- A.

Solution:- Mass of sugar = 34.2g.

$$\text{No. of moles of sugar} = \frac{34.2}{\text{Mol. mass}} = \frac{34.2}{342} = 0.1.$$

Mass of water = 214.2 − 34.2 = 180g = 0.18 Kg.

$$\text{No. of moles of water} = \frac{180}{18} = 10 \text{ moles.}$$

→ $$\text{Molality} = \frac{\text{No. of moles of sugar}}{\text{Mass of water in kg}} = \frac{0.1}{0.18} = 0.555M$$

→ Total no. of moles = 10 + 0.1 = 10.1.

$$\text{Mole fraction of Sugar} = \frac{0.1}{10.1} = 0.0099$$

Q11) Ans:- B.

Solution:- 10% means 10g of glucose in 100gms solution.

water = 100 − 10 = 90 gms.

Molar mass

$C_6H_{12}O_6 = 6\times12 + 12\times1 + 6\times16 = 180$ g/mol.

no. of moles of glucose $= \frac{10}{180} = 0.056$ mol.

X_w = molefraction of A.

Molality of solution $= \frac{0.056}{0.09 \text{ kg}} = 0.62$ m

No. of moles of water $= \frac{90}{18} = 5$ moles.

$X_g = \frac{0.056}{0.05+5} = \underline{0.011}$.

mole fraction of water $X_w = 1 - X_g = 1 - 0.011$
$= 0.989$.

Q12) Ans:- C.

Solution:- A → Solute , B → Solvent

$$m = \frac{X_A}{(1-X_A)\,m_B} \times 1000$$

$$= \frac{1-0.849}{0.849\times18} \times 1000$$

$$= \frac{0.151}{15.282} \times 1000$$

$$= \frac{151}{15.282} = \underline{9.8809}$$

Q13). Ans:- A, B, C.

Solution:- Molality $m = \frac{n_2}{w_2}$

$$n_2 = mw_1$$

$$X_2 = \frac{n_2}{n_1 + n_2} = \frac{mW_1}{\frac{W_1}{M_1} + mW_1} = \frac{mM_1}{1 + mM_1}$$

$$\rightarrow \quad m = \frac{1000 \cdot M}{1000\rho - (M \times GMW)}$$

$$m = \frac{M}{\rho - MM_2}$$

$$\rightarrow \quad X_2 = \frac{mM_1}{1 + mM_1}$$

Q14) Ans:- A

Solution:- 1 M solution means 1 mole solute in 1000 mL.

1m solution means 1 mole solute in 1000 gram of solvent.

So concentration of molar aqueous solution is more

Q15). Ans:- C

Solution:- $E = \frac{\text{Molecular weight}}{\text{change in oxidation state}}$

Oxidation number of Mn in $KMnO_4 = 7$

In $MnO_4 = 6$.

Change $= 7 - 6 = 1$.

$$E = \frac{M}{1} = M.$$

Q15) Ans: c.

Solution: $m = \frac{M \times 1000}{1000d - MM'}$

Integer Type

Q16) Ans: 3.

Solution: H_3PO_4 is tribasic.

$N = 3M$

$= 3 \times 1 = 3.$

Q17). Ans: 3.

Solution: n-factor of $H_3PO_4 = 3.$

mass of $H_3PO_4 = 4.9$ g/mol.

molar mass of $H_3PO_4 = 3 + 31 + 64 = 98.$

no. of moles $= \frac{4.9}{98} = 0.05$ mol.

Molarity $= \frac{\text{no. of moles of } H_3PO_4}{\text{volume of solution in Litre}} = \frac{0.05}{0.5}$

$= 0.1M.$

Normality $= n \times$ Molarity $= 3 \times 0.1$

$= 0.3 \Rightarrow 3 \times 10^{-1}$

$x = 3.$

Q18). Ans: 2.

Solution: $m = \frac{x}{GMW} \times \frac{1000}{100 - x}$

$= \frac{2}{58.5} \times \frac{1000}{100-2} = \frac{2000}{58.5 \times 98} = \frac{2000}{5733}$

$= 0.3488$

$\cong 0.35$

$= 35 \times 10^{-2}$

Q19) Ans:- 1.

Solution:-

$$2\overset{+2}{Cu}SO_4 \longrightarrow \overset{+1}{Cu_2}I_2$$

change in oxidation state = 1.

Equivalent weight of $CuSO_4 = \frac{M_{CuSO_4}}{n}$

$= \frac{M}{1}$

Q20) Ans:- 50.

Solution:- $n_{O_2} = \frac{0.8}{32} = 0.025$

$n_{N_2} = \frac{0.7}{28} = 0.025$

mole percent of $O_2 = \frac{0.025}{0.025 + 0.025} \times 100$

$= \frac{2.5}{0.05} = 50$

Additional Practise Questions

Q1) Ans:- A

Solution:- Equivalent weight equal to molecular weight divided by n-factor.

$E.W = \frac{M.W}{n\text{-factor}}$

n-factor in case of $H_3PO_2 = 1$.

$E.W = \frac{M.W}{1}$

Q2) Ans:- B.

Solution:- Mdality = No.of moles of solute.

Molality $\propto$ no. of moles of solute.

Molality $\propto \frac{1}{\text{weight of Solvent}}$.

To reduce molality one half, double the weight of solvent.

Q3). Ans:- B.

Solution:- $N = \frac{10y}{GEW}$.

$y = 0.98\%$. $\quad GEW_{(H_2SO_4)} = \frac{GMW}{2} = \frac{98}{2} = 46.$

$N = \frac{10 \times 0.98}{46} = \frac{9.8}{46} = 0.2\,N.$

Q4) Ans:- C

Solution:-

$FeSO_4$	$K_2Cr_2O_7$
0.1 N.	x gms
100 mL	GMW = 294.

no. of GEW of $FeSO_4$ = no. of GEW of $K_2Cr_2O_7$

$0.1 \times 100 \times 10^{-3} = \frac{w}{GEW}.$

$10^{-2} = \frac{w}{GMW/6} \Rightarrow \frac{6.w}{294}$

$Cr_2O_7^{2} \rightarrow Cr^{3+}.$
$\overline{6 \quad 3\times2=6 \quad 3}$
$n = 6.$

$w = \frac{10^{-2} \times 294}{6.}$

$= 0.49.$