Chapter -2

SOLUTIONS

Solved Example

Ex.1 The molarity of 20% (W/W) solution of sulphuric acid is 2.55 M. The density of the solution is :
(A) 1.25 g cm^{-3} (B) 0.125 g L^{-1} (C) 2.55 g cm^{-3} (D) unpredictable

(Ans. A)

Sol. Volume of 100 g of solution = $\frac{100}{d}$ ml

$$M = \frac{20 \times d \times 1000}{100 \times 98}$$

$$\text{or } d = \frac{2.55 \times 100 \times 98}{20 \times 1000} = 1.249 » 1.25$$

Ex.2 The density of a solution containing 13% by mass of sulphuric acid is 1.09 g/mL. Calculate the molarity and normality of the solution-
(A) 1.445 M (B) 14.45 M (C) 144.5 M (D) 0.1445 M

(Ans. A)

Sol. Volume of 100 gram of the solution = $\frac{100}{d}$

$$= \frac{100}{1.09} \text{ mL} = \frac{100}{1.09 \times 1000} \text{ litre}$$

$$= \frac{1}{1.09 \times 10} \text{ litre}$$

Number of moles of H_2SO_4 in 100 gram of the solution = $\frac{13}{98}$

$$\text{Molarity} = \frac{\text{No. of moles of } H_2SO_4}{\text{Volume of solution in litre}}$$

$$= \frac{13}{98} \times \frac{1.09 \times 10}{1} = \mathbf{1.445\ M}$$

Ex.3 Calculate the molarity of pure water (d = 1g/L)
(A) 555 M (B) 5.55 M (C) 55.5 M (D) None
(Ans. C)

Sol. Consider 1000 mL of water
Mass of 1000 mL of water

$$= 1000 \times 1 = 1000 \text{ gram}$$

Number of moles of water = $\frac{1000}{18}$ = 55.5

$$\text{Molarity} = \frac{\text{No. of moles of water}}{\text{Volume in litre}}$$

$$= \frac{55.5}{1} = \mathbf{55.5\ M}$$

Ex.4 Calculate the quantity of sodium carbonate (anhydrous) required to prepare 250 ml of
0.1 M solution-
(A) 2.65 gram (B) 4.95 gram (C) 6.25 gram (D) None
(Ans. A)

Sol. We know that

$$\text{Molarity} = \frac{W}{M \times V}$$

where;
W = Mass of Na_2CO_3 in gram
M = Molecular mass of Na_2CO_3 in grams =106
V =Volume of solution in litres = $\frac{250}{1000}$ = 0.25

$$\text{Molarity} = \frac{1}{10}$$

$$\text{Hence} , = \frac{1}{10} = \frac{W}{106 \times 0.25}$$

$$\text{or } W = \frac{106 \times 0.25}{10} = \mathbf{2.65\ gram}$$

Ex.5 Find the molality of H_2SO_4 solution whose specific gravity is 1.98 g ml^{-1} and 95% by volume H_2SO_4
(A) 7.412 (B) 8.412 (C) 9.412 (D) 10.412

(Ans. C)

Sol. H_2SO_4 is 95% by volume
wt. of H_2SO_4 = 95g
Vol of solution = 100ml
Moles of H_2SO_4 = , and weight of solution = 100 × 1.98 = 198 g
Weight of water = 198 _ 95 = 103 g
Molality = $\frac{95 \times 1000}{98 \times 103}$ = 9.412
Hence molality of H_2SO_4 solution is **9.412**

Ex.6. Calculate **molality of 1 litre solution of 93% H_2SO_4 by volume. The density of solution is 1.84 gm ml^{-1}**
(A) 9.42 (B) 10.42 (C) 11.42 (D) 12.42

(Ans. B)
Sol. Given H_2SO_4 is 93% by volume
wt. of H_2SO_4 = 93g
Volume of solution = 100ml
weight of solution = 100 × 1.84

= 184 gm

wt. of water = 184 _ 93 = 91 gm

Molality = $\frac{\text{Moles}}{\text{wt. of water in kg}}$

= $\frac{93 \times 1000}{98 \times 91}$ = 10.42

Ex.7 Suppose 5gm of CH_3COOH is dissolved in one litre of Ethanol. Assume no reaction between them. Calculate molality of resulting solution if density of Ethanol is 0.789 gm/ml.
(A) 0.0856 (B) 0.0956 (C) 0.1056 (D) 0.1156

(Ans. C)

Sol. Wt .of CH_3COOH dissolved = 5g

Eq. of CH_3COOH dissolved = $\frac{5}{60}$

Volume of ethanol = 1 litre = 1000ml.

Weight of ethanol = 1000 × 0.789 = 789g

Molality of solution = $\frac{\text{Moles of solute}}{\text{wt of solvent in kg}}$

= $\frac{\frac{5}{60 \times 789}}{1000}$ = 0.1056

Ex.8 Calculate the molarity and normality of a solution containing 0.5 gm of NaOH dissolved in 500 ml. solution-
(A) 0.0025 M, 0.025 N (B) 0.025 M, 0.025 N
(C) 0.25 M, 0.25 N (D) 0.025 M, 0.0025 N

(Ans. B)

Sol. Wt. of NaOH dissolved = 0.5 gm

Vol. of NaOH solution = 500 ml

Calculation of molarity

0.5 g of NaOH = $\frac{0.5}{40}$ moles of NaOH

[Q Mol. wt of NaOH = 40]

= 0.0125 moles

Thus 500 ml of the solution contain NaOH = 0.0125 moles

1000 ml of the solution contain

= $\frac{0.0125}{500}$ × 1000

= 0.025 M

Hence molarity of the solution = **0.025 M**

Calculation of normality

Since NaOH is monoacidic ;
Eq. wt. of NaOH = Mol. wt. of NaOH = 40

0.5 gm of NaOH = $\frac{0.5}{40}$ gm equivalents = 0.0125 gm equivalents
Thus 500 ml of the solution contain NaOH = 0.0125 gmequ.
1000 ml of the solution contain

= $\frac{0.0125}{500}$ × 1000 = 0.025
Hence normality of the solution = **0.025 N**

Ex.9 Calculate the molality and mole fraction of the solute in aqueous solution containing 3.0 gm of urea per 250 gm of water (Mol. wt. of urea = 60).
(A) 0.2 m, 0.00357 (B) 0.4 m, 0.00357 (C) 0.5 m, 0.00357 (D) 0.7m, 0.00357

(Ans. A)

Sol. Wt. of solute (urea) dissolved = 3.0 gm
Wt. of the solvent (water) = 250 gm
Mol. wt. of the solute = 60

3.0 gm of the solute = $\frac{3.0}{60}$ moles = 0.05 moles
Thus 250 gm of the solvent contain = 0.05 moles of solute

1000 gm of the solvent contain = $\frac{0.05 \times 1000}{250}$ = 0.2 moles
Hence molality of the solution = 0.2 m

In short,
Molality = No. of moles of solute/1000 g of solvent

Molality = $\frac{3/60}{250}$ × 1000 = **0.2 m**
Calculation of mole fraction
3.0 gm of solute = 3/60 moles = 0.05 moles

250 gm of water = $\frac{250}{18}$ moles = 13.94 moles
Mole fraction of the solute

= $\frac{0.05}{0.05 + 13.94}$ = $\frac{0.05}{13.99}$ = **0.00357**

Ex.10 A solution has 25% of water, 25% ethanol and 50% acetic acid by mass. Calculate the mole fraction of each component.
(A) 0.50, 0.3, 0.19 (B) 0.19, 0.3, 0.50 (C) 0.3, 0.19, 0.50 (D) 0.50, 0.19, 0.3

(Ans. D)

Sol.
Since 18 g of water = 1 mole

25 g of water = $\frac{25}{18}$ = 1.38 mole
Similarly, 46 g of ethanol = 1 mole

25 g of ethanol = $\frac{25}{46}$ = 0.55 moles
Again, 60 g of acetic acid = 1 mole

50 g of acetic acid = $\frac{50}{60}$ = 0.83 mole
Mole fraction of water

= $\frac{1.38}{1.38 + 0.55 + 0.83}$ = **0.50**
Similarly, Mole fraction of ethanol

= $\frac{0.55}{1.38 + 0.55 + 0.83}$ = **0.19**
Mole fraction of acetic acid

= $\frac{0.83}{1.38 + 0.55 + 0.83}$ = **0.3**

Ex.11. 15 gram of methyl alcohol is dissolved in 35 gram of water. What is the mass percentage of methyl alcohol in solution?
(A) 30% (B) 50% (C) 70% (D) 75%

(Ans. A)

Sol. Total mass of solution = (15 35) gram = 50 gram
mass percentage of methyl alcohol

= $\frac{\text{Mass of methyl alcohol}}{\text{Mass of solution}}$ × 100

= $\frac{15}{50}$ × 100 = **30%**

Ex.12 Calculate the masses of cane sugar and water required to prepare 250 gram of 25% cane sugar solution-
(A) 187.5 gram, 62.5 gram (B) 62.5 gram, 187.5 gram
(C) 162.5 gram, 87.5 gram (D) None of these
(Ans. B)
Sol. Mass percentage of sugar = 25
We know that

Mass percentage = $\frac{\text{Mass of solute}}{\text{Mass of solution}}$ × 100

So, 25 = $\frac{\text{Mass of cane sugar}}{250}$ × 100

or Mass of cane sugar = $\frac{25 \times 250}{100}$
= **62.5 gram**
Mass of water = (250 - 62.5) = **187.5 gram**

Ex.13 Calculate normality of the mixture obtained by mixing 100ml of 0.1N HCl and 50ml of 0.25N NaOH solution.
(A) 0.0467 N (B) 0.0367 N (C) 0.0267 N (D) 0.0167 N

(Ans. D)
Sol. Meq. ofHCl =100 × 0.1 = 10
Meq.ofNaOH = 50 × 0.25 = 12.5
Q HCl and NaOH neutralize each other with equal eq.
Meq.ofNaOH left = 12.5 _ 10 = 2.5
Volume of new solution = 100 50 = 150 ml.

N_{NaOH} left = $\frac{2.5}{150}$ = 0.0167 N
Hence normality of the mixture obtained is **0.0167 N**

Ex.14. 300 ml 0.1 M HCl and 200 ml of 0.03M H_2SO_4 are mixed. Calculate the normality of the resulting mixture-
(A) 0.084 N (B) 0.84 N (C) 2.04 N (D) 2.84 N

(Ans.A)
Sol. For HClFor H_2SO_4
V_1 = 300 ml V_2 = 200 ml
N_1 = M x Basicity N_2 = M x Basicity
= 0.1 x 1 = 0.1 = 0.03 × 2 = 0.06
Normality of the mixture,

N = $\frac{V_1N_1+V_2N_2}{V_1+V_2}$
= $\frac{300 \times 0.1+200 \times 0.06}{500}$ = $\frac{30+12}{500}$ = **0.084 N**

Ex.15 Calculate the amount of each in the following solutions –

B.. **150 ml of $\frac{N}{7}$ H_2SO_4 (ii) 250 ml of 0.2M $NaHCO_3$**

(iii) 400 ml of $\frac{N}{10}$ Na_2CO_3 (iv) 1052 g of 1 m KOH.
(A) 52g, 2.12g, 4.2g, 1.05g (B) 1.05g, 4.2g, 2.12g, 52g
© 1.05g, 2.12g, 52g, 4.2g (D) 4.2g, 2.12g, 1.05g, 52g

(Ans. B)

Sol. (i) Eq. wt. of H_2SO_4 = $\frac{\text{Mol. wt}}{\text{Basicity}}$ = $\frac{98}{2}$ = 49
Amount of H_2SO_4 per litre (strength) = Normality × Eq. wt. = × 49 = 7 g/litre

Amount in 150 ml = $\frac{7 \times 150}{1000}$ = 1.05 g
(ii) Molecular wt. of

$NaHCO_3$ = 23 1 12 48 = 84
Amount of $NaHCO_3$ required to produce 1000 c.c. of one molar solution = 84 g
Amount present per litre in 0.2 M solution = 84 × 0.2 = 16.8 g
Amount present in 250 c.c.
$= \frac{16.8 \times 250}{1000} = 4.2$ g

B.. Equivalent weight of
$Na_2CO_3 = \frac{\text{Mol.wt}}{\text{No. of positive valencies}}$
= = 53
Amount of Na_2CO_3 = Normality × Eq. wt. = × 53 = 5.3 g/litre
Amountpresent in 400 c.c. = $\frac{5.3 \times 400}{1000}$ = 2.12 g

B.. We know that 1 molal solution of a substance contains 1000 g of solvent.
Wt. of KOH in 1052 g of 1 m KOH solution = 1052 _ 1000 = 52 g

Ex.16 How many kilograms of wet NaOH containing 12% water are required to prepare 60 litres of 0.50 N solution ?
B.. **1.36 kg (B) 1.50 kg (C) 2.40 gm (D) 3.16 kg**

(Ans. A)
Sol. One litre of 0.50 N NaOH contains = 0.50 × 40g = 20 g = 0.020 kg
60 litres of 0.50 N NaOH contain
= 0.020 × 60 kg = 1.20 kg NaOH
Since the given NaOH contains 12% water, the amount of pure NaOH in 100 kg of the given NaOH = 100 _ 12 = 88 kg
Thus 88 kg of pure NaOH is present in 100 kg wet NaOH
B.P. kg of pure NaOH is present in
$= \frac{100}{88}$ × 1.20 = **1.36 kg wet NaOH**

Ex. 17 Calculate the vapour pressure of a solution at 100^0C containing 3g of cane sugar in 33g of water. (At wt. C = 12 , H = 1 , O = 16)
B.. **760 mm (B) 756.90 mm (C) 758.30 mm (D) None**

(Ans. B)
Sol. Vapour pressure of pure water (solvent) at 100^0C, p^0 = 760 mm.
Vapour pressure of solution, p = ?
Wt. of solvent , W = 33g
Wt. of solute , w = 3g
Mol. Wt. of water (H_2O), M = 18
Mol. Wt. of sugar ($C_{12}H_{22}O_{11}$),
m = 12 x 12 22 x 1 11 x 16 = 342
According to Raoult's law ,

$$\frac{p^\circ - p}{p^\circ} = \frac{wM}{Wm}$$

$$p = p^0 - \frac{w \times M}{m \times W} \times p^0$$

$$p = 760 - \frac{3 \times 18}{342 \times 33} \times 760$$

(p^0 for H_2O = 760 mm)

= 760 – 3.19 = 756.90 mm

Ex.18 Osmotic pressure of a sugar solution at 24°C is 2.5 atmospheres. Determine the concentration of the solution in gm mole per litre.
(A) 0.0821 moles/litre (B) 1.082 moles/litre
© 0.1025 moles/litre (D) 0.0827moles/litre
Ans.C)
Sol. Here it is given that, p = 2.5 atm, T = 24 273 = 297K, S = 0.0821 lit. atm. Deg^{-1} mol^{-1}, C = ?

We know that p = CST

$$\text{or } C = \frac{\pi}{ST} = \frac{2.5}{0.0821 \times 297}$$

= 0.1025 moles/litre

Ex.19 Twenty grams of a substance were dissolved in 500 ml. of water and the osmotic pressure of the solution was found to be 600 mm of mercury at 15^0C. Determine the molecular weight of the substance-
B.. **1120 (B) 1198 (C) 1200 (D) None of these**

Sol. Here it is given that
w = 20 gm ; V = 500 ml .

$$= \frac{500}{1000} = 0.5 \text{ litre}$$

$$p = 600 \text{ mm} = \frac{600}{760} \text{ atm ;}$$

T = 15 273 = 288^0A
m = ?
According to Van't Hoff equation ,

$$Pv = nSTpV = \frac{w}{m} ST$$

$$m = \frac{wST}{\pi V} = \frac{20 \times 0.0821 \times 288 \times 760}{600 \times 0.5} = 1198$$

Ex.20. 0.15g of a substance dissolved in 15g of solvent boiled at a temperature higher by 0.216^0C than that of the pure solvent. Calculate the molecular weight of the substance. Molal elevation constant for the solvent is 2.16^0C.
B.. **216 (B) 100 (C) 178 (D) None of these**

(Ans. B)

w = 0.15 g, ΔT_b = = 0.216^0C
W = 15g $K_b = 2.16^0C$
m =?
Substituting values in the expression,

$$m = \frac{1000 \times K_b \times w}{\Delta T_b \times W}$$

$$m = \frac{1000 \times 2.16 \times 0.15}{0.216 \times 15} = 100$$

Ex.21 A solution of 0.450 gm of urea (mol. Wt 60) in 22.5 g of water showed 0.170^{0}C of elevation in boiling point. Calculate the molal elevation constant of water-

B.. **0.17ºC (B) 0.45ºC (C) 0.51ºC (D) 0.30ºC**

(Ans. C)
Sol. Wt. of solute, w = 0.450 g
Wt. of solvent , W = 22.5 g
Mol. Wt of solute, m = 60
Molal elevation constant K_b = ?
Boiling point elevation ,$DT_b = 0.170^0C$
Substituting these values in the equation-

$$K_b = \frac{m \times W \times \Delta T_b}{1000 \times w}$$

$$= \frac{60 \times 22.5 \times 0.170}{1000 \times 0.450} = 0.51^0C$$

Ex.22 Calculate the boiling point of a solution containing 0.45g of camphor (mol. Wt. 152) dissolved in 35.4g of acetone (b.p. 56.3^{0}C); K_b per 100 gm of acetone is 17.2^{0}C.

B.. **56.446ºC (B) 52.401ºC (C) 56.146ºC (D) 50.464ºC**

Sol. Here it is given that
w = 0.45 g , W = 35.4 , m = 152 ,
Kb = 17.2 per 100gm

Now we know that $\Delta T_b = \frac{100 \times K_b \times w}{m \times W}$
(Note that this is expression when K_b is given per 100g of the solvent)
Substituting the values in the above expression.

$$\Delta T_b = \frac{100 \times 17.2 \times 0.45}{152 \times 35.4} = 0.146^0C$$

Now we know that
B.P. of solution (T) – B.P. of solvent (T^0) = ΔT
B.P. of solution (T) = B.P. of solvent(T^0)=ΔT
Hence B.P. of solution = 56.3 0.146
= 56.446^0C

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