

# SOLUTION & COLLIGATIVE PROPERTIES

# EXERCISE-I

- The boiling point of  $C_6H_6$ ,  $CH_3OH$ ,  $C_6H_5NH_2$  and  $C_6H_5NO_2$  are  $80^\circ C$ ,  $65^\circ C$ ,  $184^\circ C$  and  $212^\circ C$  respectively which will show highest vapour pressure at room temperature :  
 (1)  $C_6H_6$  (2)  $CH_3OH$   
 (3)  $C_6H_5NH_2$  (4)  $C_6H_5NO_2$
- Mole fraction of A vapours above the solution in mixture of A and B ( $X_A = 0.4$ ) will be  
 [Given :  $P_A^\circ = 100$  mm Hg and  $P_B^\circ = 200$  mm Hg]  
 (1) 0.4 (2) 0.8  
 (3) 0.25 (4) none of these
- At a given temperature, total vapour pressure in Torr of a mixture of volatile components A and B is given by  

$$P_{\text{Total}} = 120 - 75 X_B$$
 hence, vapour pressure of pure A and B respectively (in Torr) are  
 (1) 120, 75 (2) 120, 195  
 (3) 120, 45 (4) 75, 45
- Two liquids A & B form an ideal solution. What is the vapour pressure of solution containing 2 moles of A and 3 moles of B at 300 K? [Given : At 300 K, Vapour pr. of pure liquid A ( $P_A^\circ$ ) = 100 torr, Vapour pr. of pure liquid B ( $P_B^\circ$ ) = 300 torr ]  
 (1) 200 torr (2) 140 torr  
 (3) 180 torr (4) None of these
- If Raoult's law is obeyed, the vapour pressure of the solvent in a solution is directly proportional to  
 (1) Mole fraction of the solvent  
 (2) Mole fraction of the solute  
 (3) Mole fraction of the solvent and solute  
 (4) The volume of the solution
- 1 mole of heptane (V. P. = 92 mm of Hg) was mixed with 4 moles of octane (V. P. = 31mm of Hg). The vapour pressure of resulting ideal solution is :  
 (1) 46.2 mm of Hg (2) 40.0 mm of Hg  
 (3) 43.2 mm of Hg (4) 38.4 mm of Hg
- Mole fraction of A vapours above solution in mixture of A and B ( $X_A = 0.4$ ) will be :-  
 ( $P_A^\circ = 100$ mm,  $P_B^\circ = 200$ mm)  
 (1) 0.4 (2) 0.8  
 (3) 0.25 (4) None
- The vapour pressure of a pure liquid 'A' is 70 torr at  $27^\circ C$ . It forms an ideal solution with another liquid B. The mole fraction of B is 0.2 and total vapour pressure of the solution is 84 torr at  $27^\circ C$ . The vapour pressure of pure liquid B at  $27^\circ C$  is  
 (1) 14 (2) 56 (3) 140 (4) 70
- At  $88^\circ C$  benzene has a vapour pressure of 900 torr and toluene has a vapour pressure of 360 torr. What is the mole fraction of benzene in the mixture with toluene that will boil at  $88^\circ C$  at 1 atm. pressure, benzene - toluene form an ideal solution:  
 (1) 0.416 (2) 0.588 (3) 0.688 (4) 0.740
- The exact mathematical expression of Raoult's law is ( $n$  = moles of solute ;  $N$  = moles of solvent)  
 (1)  $\frac{P^0 - P_s}{P^0} = \frac{n}{N}$  (2)  $\frac{P^0 - P_s}{P^0} = \frac{N}{n}$   
 (3)  $\frac{P^0 - P_s}{P_s} = \frac{n}{N}$  (4)  $\frac{P^0 - P_s}{P^0} = n \times N$
- The vapour pressure of a solvent decreased by 10 mm of Hg when a non-volatile solute was added to the solvent. The mole fraction of solute in solution is 0.2, what would be mole fraction of the solvent if decrease in vapour pressure is 20 mm of Hg  
 (1) 0.2 (2) 0.4 (3) 0.6 (4) 0.8
- The vapour pressure of a solution having solid as solute and liquid as solvent is :  
 (1) Directly proportional to mole fraction of the solvent  
 (2) Inversely proportional to mole fraction of the solvent  
 (3) Directly proportional to mole fraction of the solute  
 (4) Inversely proportional to mole fraction of the solute
- One mole of non volatile solute is dissolved in two moles of water. The vapour pressure of the solution relative to that of water is  
 (1)  $\frac{2}{3}$  (2)  $\frac{1}{3}$  (3)  $\frac{1}{2}$  (4)  $\frac{3}{2}$
- The vapour pressure of pure A is 10 torr and at the same temperature when 1 g of B is dissolved in 20 gm of A, its vapour pressure is reduced to 9.0 torr. If the molecular mass of A is 200 amu, then the molecular mass of B is :  
 (1) 100 amu (2) 90 amu  
 (3) 75 amu (4) 120 amu

15. The vapour pressure of a pure liquid solvent (X) is decreased to 0.60 atm. from 0.80 atm on addition of a non volatile substance (Y). The mole fraction of (Y) in the solution is:-  
 (1) 0.20 (2) 0.25 (3) 0.5 (4) 0.75
16. Among the following, that does not form an ideal solution is :  
 (1)  $C_6H_6$  and  $C_6H_5CH_3$  (2)  $C_2H_5Cl$  and  $C_6H_5OH$   
 (3)  $C_6H_5Cl$  and  $C_6H_5Br$  (4)  $C_2H_5Br$  and  $C_2H_5I$
17. Colligative properties of the solution depend upon  
 (1) Nature of the solution  
 (2) Nature of the solvent  
 (3) Number of solute particles  
 (4) Number of moles of solvent
18. When common salt is dissolved in water  
 (1) Melting point of the solution increases  
 (2) Boiling point of the solution increases  
 (3) Boiling point of the solution decreases  
 (4) Both Melting point and Boiling point is decreases
19. What should be the freezing point of aqueous solution containing 17 gm of  $C_2H_5OH$  in 1000 gm of water (water  $K_f = 1.86 \text{ deg} - \text{kg mol}^{-1}$ )  
 (1)  $-0.69^\circ\text{C}$  (2)  $-0.34^\circ\text{C}$   
 (3)  $0.0^\circ\text{C}$  (4)  $0.34^\circ\text{C}$
20. 5% solution of sucrose is isotonic with 1% solution of a compound 'A' then the molecular weight of compound 'A' is -  
 (1) 32.4 (2) 68.4 (3) 121.6 (4) 34.2
21. Osmotic pressure of a sugar solution at  $24^\circ\text{C}$  is 2.5 atmosphere. The concentration of the solution in mole per litre is :  
 (1) 10.25 (2) 1.025  
 (3) 1025 (4) 0.1025
22. A solution containing 4 g of a non volatile organic solute per 100 ml was found to have an osmotic pressure equal to 500 cm of mercury at  $27^\circ\text{C}$ . The molecular weight of solute is :  
 (1) 14.97 (2) 149.7 (3) 1697 (4) 1.497
23. Which of the following aqueous solution will show maximum vapour pressure at 300 K?  
 (1) 1 M NaCl (2) 1 M  $CaCl_2$   
 (3) 1 M  $AlCl_3$  (4) 1 M  $C_{12}H_{22}O_{11}$
24. 1.0 molal aqueous solution of an electrolyte  $A_2B_3$  is 60% ionised. The boiling point of the solution at 1 atm is ( $K_{b(H_2O)} = 0.52 \text{ K kg mol}^{-1}$ )  
 (1) 274.76 K (2) 377 K  
 (3) 376.4 K (4) 374.76 K
25. The Vant Hoff factor (i) for a dilute solution of  $K_3[Fe(CN)_6]$  is (Assuming 100% ionisation) :  
 (1) 10 (2) 4 (3) 5 (4) 0.25
26. The substance A when dissolved in solvent B shows the molecular mass corresponding to  $A_3$ . The vant Hoff's factor will be -  
 (1) 1 (2) 2 (3) 3 (4)  $1/3$
27. The freezing point of 1 molal NaCl solution assuming NaCl to be 100% dissociated in water is : ( $K_f = 1.86 \text{ K Molality}^{-1}$ )  
 (1)  $-1.86^\circ\text{C}$  (2)  $-3.72^\circ\text{C}$   
 (3)  $+1.86^\circ\text{C}$  (4)  $+3.72^\circ\text{C}$
28. What is the freezing point of a solution containing 8.1 gm. of HBr in 100gm. water assuming the acid to be 90% ionised ( $K_f$  for water =  $1.86 \text{ K molality}^{-1}$ ):-  
 (1)  $0.85^\circ\text{C}$  (2)  $-3.53^\circ\text{C}$   
 (3)  $0^\circ\text{C}$  (4)  $-0.35^\circ\text{C}$
29. If a ground water contains  $H_2S$  at concentration of 2 mg/l, determine the pressure of  $H_2S$  in head space of a closed tank containing the ground water at  $20^\circ\text{C}$ . Given that for  $H_2S$ , Henry's constant is equal to  $6.8 \times 10^3 \text{ bar}$  at  $20^\circ\text{C}$ .  
 (1) 720 Pa (2)  $77 \times 10^2 \text{ Pa}$   
 (3) 553 Pa (4)  $55 \times 10^2 \text{ Pa}$
30. A pressure cooker reduces cooking time for food because -  
 (1) The higher pressure inside the cooker crushes the food material  
 (2) Cooking involves chemical changes helped by a rise in temperature  
 (3) Heat is more evenly distributed in the cooking space  
 (4) Boiling point of water involved in cooking is increased

ANSWER KEY						Exercise-I				
Que.	1	2	3	4	5	6	7	8	9	10
Ans.	2	3	3	4	1	3	3	3	4	3
Que.	11	12	13	14	15	16	17	18	19	20
Ans.	3	1	1	2	2	2	3	2	1	2
Que.	21	22	23	24	25	26	27	28	29	30
Ans.	4	2	4	4	2	4	2	2	1	4

## PREVIOUS YEARS' QUESTIONS

## EXERCISE-II

1. A 0.004 M solution of  $\text{Na}_2\text{SO}_4$  is isotonic with a 0.010 M solution of glucose at same temperature. The apparent degree of dissociation of  $\text{Na}_2\text{SO}_4$  is [JEE 2004]  
(1) 25% (2) 50% (3) 75% (4) 85%
2. The elevation in boiling point, when 13.44 g of freshly prepared  $\text{CuCl}_2$  are added to one kilogram of water, is [Some useful data,  $K_b(\text{H}_2\text{O}) = 0.52 \text{ K kg mol}^{-1}$ , mol. wt. of  $\text{CuCl}_2 = 134.4 \text{ gm}$ ] [JEE 2005]  
(1) 0.05 (2) 0.1 (3) 0.16 (4) 0.21
3. 72.5 g of phenol is dissolved in 1 kg of a solvent ( $k_f = 14$ ) which leads to dimerization of phenol and freezing point is lowered by 7 kelvin. What percent of total phenol is present in dimeric form? [JEE 2006]  
(1) 20 (2) 30 (3) 35 (4) 40
4. When 20 g of naphtholic acid ( $\text{C}_{11}\text{H}_8\text{O}_2$ ) is dissolved in 50 g of benzene ( $K_f = 1.72 \text{ K kg mol}^{-1}$ ), a freezing point depression of 2 K is observed. The van't Hoff factor ( $i$ ) is [JEE 2007]  
(1) 0.5 (2) 1 (3) 2 (4) 3
5. The degree of dissociation ( $\alpha$ ) of a weak electrolyte,  $\text{A}_x\text{B}_y$  is related to van't Hoff factor ( $i$ ) by the expression :- [AIEEE-2011]  
(1)  $\alpha = \frac{x+y-1}{i-1}$  (2)  $\alpha = \frac{x+y+1}{i-1}$   
(3)  $\alpha = \frac{i-1}{(x+y-1)}$  (4)  $\alpha = \frac{i-1}{x+y+1}$
6.  $K_f$  for water is  $1.86 \text{ K kg mol}^{-1}$ . If your automobile radiator holds 1.0 kg of water, how many grams of ethylene glycol ( $\text{C}_2\text{H}_6\text{O}_2$ ) must you add to get the freezing point of the solution lowered to  $-2.8^\circ\text{C}$ ? [AIEEE-2012]  
(1) 27 g (2) 72 g (3) 93 g (4) 39 g
7. A solution containing 0.85 g of  $\text{ZnCl}_2$  in 125.0 g of water freezes at  $-0.23^\circ\text{C}$ . The apparent degree of dissociation of the salt is : [JEE (MAIN)-2012 ONLINE]  
( $k_f$  for water =  $1.86 \text{ K kg mol}^{-1}$ , atomic mass ;  $\text{Zn} = 65.3$  and  $\text{Cl} = 35.5$ )  
(1) 1.36% (2) 2.47% (3) 73.5% (4) 7.35%
8. Liquids A and B form an ideal solution. At  $30^\circ\text{C}$ , the total vapour pressure of a solution containing 1 mol of A and 2 moles of B is 250 mm Hg. The total vapour pressure becomes 300 mm Hg when 1 more mol of A is added to the first solution. The vapour pressures of pure A and B at the same temperature are [JEE (MAIN)-2012 ONLINE]  
(1) 450, 150 mm Hg (2) 250, 300 mm Hg  
(3) 125, 150 mm Hg (4) 150, 450 mm Hg
9. The freezing point of a 1.00 m aqueous solution of HF is found to be  $-1.91^\circ\text{C}$ . The freezing point constant of water,  $K_f$ , is  $1.86 \text{ K kg mol}^{-1}$ . The percentage dissociation of HF at this concentration is [JEE (MAIN)-2012 ONLINE]  
(1) 2.7% (2) 30% (3) 10% (4) 5.2%
10. How many grams of methyl alcohol should be added to 10 litre tank of water to prevent its freezing at 268 K ? [JEE (MAIN)-2013 ONLINE]  
( $K_f$  for water is  $1.86 \text{ K kg mol}^{-1}$ )  
(1) 899.04 g (2) 886.02 g  
(3) 868.06 g (4) 880.07 g
11. Vapour pressure of pure benzene is 119 torr and that of toluene is 37.0 torr at the same temperature. Mole fraction of toluene in vapour phase which is in equilibrium with a solution of benzene and toluene having a mole fraction of toluene 0.50, will be : [JEE (MAIN)-2013 ONLINE]  
(1) 0.137 (2) 0.205 (3) 0.237 (4) 0.435
12. A molecule M associates in a given solvent according to the equation  $\text{M} \rightleftharpoons (\text{M})_n$ . For a certain concentration of M, the van't Hoff factor was found to be 0.9 and the fraction of associated molecules was 0.2. The value of  $n$  is : [JEE (MAIN)-2013 ONLINE]  
(1) 2 (2) 4 (3) 5 (4) 3
13. 12g of a nonvolatile solute dissolved in 108g of water produces the relative lowering of vapour pressure of 0.1. The molecular mass of the solute is : [JEE (MAIN)-2013 ONLINE]  
(1) 60 (2) 80 (3) 40 (4) 20
14. The molarity of a solution obtained by mixing 750 mL of 0.5(M)HCl with 250 mL of 2(M)HCl will be :- [JEE (MAIN)-2013]  
(1) 0.875 M (2) 1.00 M (3) 1.75 M (4) 0.975 M
15. The observed osmotic pressure for a 0.10 M solution of  $\text{Fe}(\text{NH}_4)_2(\text{SO}_4)_2$  at  $25^\circ\text{C}$  is 10.8 atm. The expected and experimental (observed) values of Van't Hoff factor ( $i$ ) will be respectively : ( $R = 0.082 \text{ L atm K}^{-1} \text{ mol}^{-1}$ ) [JEE (MAIN)-2014 ONLINE]  
(1) 3 and 5.42 (2) 5 and 3.42  
(3) 4 and 4.00 (4) 5 and 4.42
16. For an ideal Solution of two components A and B, which of the following is true ? [JEE (MAIN)-2014 ONLINE]  
(1)  $\Delta H_{\text{mixing}} < 0$  (zero)  
(2) A – A, B – B and A – B interactions are identical  
(3) A – B interaction is stronger than A – A and B – B interactions  
(4)  $\Delta H_{\text{mixing}} > 0$  (zero)
17. Consider separate solution of 0.500 M  $\text{C}_2\text{H}_5\text{OH}(\text{aq})$ , 0.100 M  $\text{Mg}_3(\text{PO}_4)_2(\text{aq})$ , 0.250 M  $\text{KBr}(\text{aq})$  and 0.125 M  $\text{Na}_3\text{PO}_4(\text{aq})$  at  $25^\circ\text{C}$ . Which statement is true about these solutions, assuming all salts to be strong electrolytes ? [JEE (MAIN)-2014]  
(1) 0.125 M  $\text{Na}_3\text{PO}_4(\text{aq})$  has the highest osmotic pressure.  
(2) 0.500 M  $\text{C}_2\text{H}_5\text{OH}(\text{aq})$  has the highest osmotic pressure.  
(3) They all have the same osmotic pressure.  
(4) 0.100 M  $\text{Mg}_3(\text{PO}_4)_2(\text{aq})$  has the highest osmotic pressure.

18. Consider separate solution of 0.500 M  $C_2H_5OH(aq)$ , 0.100 M  $Mg_3(PO_4)_2(aq)$ , 0.250 M  $KBr(aq)$  and 0.125 M  $Na_3PO_4(aq)$  at 25°C. Which statement is true about these solutions, assuming all salts to be strong electrolytes ? [JEE-MAIN-2014]  
 (1) 0.125 M  $Na_3PO_4(aq)$  has the highest osmotic pressure.  
 (2) 0.500 M  $C_2H_5OH(aq)$  has the highest osmotic pressure.  
 (3) They all have the same osmotic pressure.  
 (4) 0.100 M  $Mg_3(PO_4)_2(aq)$  has the highest osmotic pressure.
19. Determination of the molar mass of acetic acid in benzene using freezing point depression is affected by : [JEE (MAIN)-2015 ONLINE]  
 (1) association (2) dissociation  
 (3) complex formation (4) partial ionization
20. A solution at 20°C is composed of 1.5 mol of benzene and 3.5 mol of toluene. If the vapour pressure of pure benzene and pure toluene at this temperature are 74.7 torr and 22.3 torr, respectively, then the total vapour pressure of the solution and the benzene mole fraction in equilibrium with it will be, respectively : [JEE (MAIN)-2015 ONLINE]  
 (1) 38.0 torr and 0.589  
 (2) 30.5 torr and 0.389  
 (3) 35.8 torr and 0.280  
 (4) 35.0 torr and 0.480
21. The vapour pressure of acetone at 20°C is 185 torr. When 1.2 g of non-volatile substance was dissolved in 100 g of acetone at 20°C, its vapour pressure was 183 torr. The molar mass ( $g\ mol^{-1}$ ) of the substance is : [JEE (MAIN)-2015]  
 (1) 128 (2) 488 (3) 32 (4) 64
22. An aqueous solution of a salt  $MX_2$  at certain temperature has a van't Hoff factor of 2. The degree of dissociation for this solution of the salt is : [JEE (MAIN)-2016-ONLINE]  
 (1) 0.50 (2) 0.80 (3) 0.67 (4) 0.33
23. The solubility of  $N_2$  in water at 300 K and 500 torr partial pressure is 0.01  $g\ L^{-1}$ . The solubility (in  $g\ L^{-1}$ ) at 750 torr partial pressure is : [JEE (MAIN)-2016-ONLINE]  
 (1) 0.02 (2) 0.005  
 (3) 0.015 (4) 0.0075
24. 18 g glucose ( $C_6H_{12}O_6$ ) is added to 178.2 g water. The vapour pressure of water (in torr) for this aqueous solution is : [JEE (MAIN)-2016]  
 (1) 759.0 (2) 7.6 (3) 76.0 (4) 752.4
25. The freezing point of benzene decreases by 0.45°C when 0.2 g of acetic acid is added to 20 g of benzene. If acetic acid associates to form a dimer in benzene, percentage association of acetic acid in benzene will be :- ( $K_f$  for benzene = 5.12  $K\ kg\ mol^{-1}$ ) [JEE (MAIN)-2017]  
 (1) 64.6% (2) 80.4% (3) 74.6% (4) 94.6%
26. 5 g of  $Na_2SO_4$  was dissolved in x g of  $H_2O$ . The change in freezing point was found to be 3.82°C. If  $Na_2SO_4$  is 81.5% ionised, the value of x ( $K_f$  for water = 1.86°C  $kg\ mol^{-1}$ ) is approximately. (Molar mass of S = 32  $g\ mol^{-1}$  and that of Na = 23  $g\ mol^{-1}$ ) [JEE (MAIN)-2017-ONLINE]  
 (1) 45 g (2) 65 g (3) 15 g (4) 25 g
27. A solution is prepared by mixing 8.5 g of  $CH_2Cl_2$  and 11.95 g of  $CHCl_3$ . If vapour pressure of  $CH_2Cl_2$  and  $CHCl_3$  at 298 K are 415 and 200 mmHg respectively, the mole fraction of  $CHCl_3$  in vapour form is: (Molar mass of Cl = 35.5  $g\ mol^{-1}$ ) [JEE (MAIN)-2017-ONLINE]  
 (1) 0.486 (2) 0.325 (3) 0.162 (4) 0.675
28. For 1 molal aqueous solution of the following compounds, which one will show the highest freezing point ? [JEE (MAIN)-2018]  
 (1)  $[Co(H_2O)_5Cl]Cl_2 \cdot H_2O$   
 (2)  $[Co(H_2O)_4Cl_2]Cl \cdot 2H_2O$   
 (3)  $[Co(H_2O)_3Cl_3] \cdot 3H_2O$   
 (4)  $[Co(H_2O)_6]Cl_3$
29. Two 5 molal solutions are prepared by dissolving a non-electrolyte non-volatile solute separately in the solvents X and Y. The molecular weights of the solvents are  $M_x$  and  $M_y$ , respectively where  $M_x = \frac{3}{4} M_y$ . The relative lowering of vapour pressure of the solution in X is "m" times that of the solution in Y. Given that the number of moles of solute is very small in comparison to that of solvent, the value of "m" is - [JEE (MAIN)-2018-ONLINE]  
 (1)  $\frac{3}{4}$  (2)  $\frac{4}{3}$  (3)  $\frac{1}{2}$  (4)  $\frac{1}{4}$
30. The mass of a non-volatile, non-electrolyte solute (molar mass = 50  $g\ mol^{-1}$ ) needed to be dissolved in 114 g octane to reduce its vapour pressure to 75%, is :- [JEE (MAIN)-2018-ONLINE]  
 (1) 50 g (2) 37.5 g (3) 75 g (4) 150 g

PREVIOUS YEARS QUESTIONS				ANSWER KEY			Exercise-II			
Que.	1	2	3	4	5	6	7	8	9	10
Ans.	3	3	3	1	3	3	3	1	1	3
Que.	11	12	13	14	15	16	17	18	19	20
Ans.	3	1	4	1	4	2	3	3	1	1
Que.	21	22	23	24	25	26	27	28	29	30
Ans.	4	1	3	4	4	1	2	3	1	4