CHEMISTRY

BOOKS - IIT-JEE PREVIOUS YEAR (CHEMISTRY)

SOLUTIONS AND COLLIGATIVE PROPERTIES

Jee Main And Advanced

1. 18g of glucose $(C_6H_{12}O_6)$is added to 178.2 g of water. The vapour pressure of water for this aqueous solution at $100^\circ C$is :

A. 76.0

B. 752.4

C. 759.0

D. 7.6

Answer: B::C::D

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2. The vapour pressure of acetone at $20^{\circ}C$ is 185 torr. When $1.2g$ of non-volatile substance was dissolved in $100g$ of acetone at $20^{\circ}C$ its vapour pressure was 183 torr. The moalr mass $\left(gmol^{-1}\right)$ of the substance is:

A. 32

B. 64

C. 128

D. 488

Answer: B::C::D

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3. For a dilute solution containing $2.5g$ of a non-volatile non-electrolyte solution in $100g$ of water, the elevation in boiling point at 1 atm pressure is $2^{\circ}C$. Assuming concentration of solute is much lower than the concentration of solvent, the vapour pressure (mm of

Hg) of the solution is:

(take $k_b = 0.76 K kg mol^{-1}$)

A. 724

B. 740

C. 736

D. 718

Answer: A

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4. The Henry's law constant for the solubility of N_2 gas in water at $298K$ is 1.0×10^5 atm. The mole fraction of N_2 in air is 0.8. The number of moles of N_2 from air

dissolved in 10 moles of water at 298K and 5 atm pressure is

A. 4.0×10^{-4}

B. 4.0×10^{-5}

C. 5.0×10^{-4}

D. 4.0×10^{-6}

Answer: A

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5. A molal solution is one that contains 1 mol of a solute in

A. $1000g$ of the solvent

B. $1L$ of the solvent

C. $1L$ of the solution

D. $22.4L$ of the solution

Answer: B::C::D

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6. For a dilute solution, Raoult's law states that

A. the lowering of vapour pressure is equal to the mole fraction of solute

B. the relative lowering of vapour pressure is equal to the mole fraction of solute

C. the relative lowering of vapour pressure is proportional to the amount of solute in solution

D. the vapour pressure of the solution is equal to the mole fraction of solvent

Answer: B::C::D

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7. An azeotropic solution of two liquid has boiling point lower than either of them when it

A. shows negative deviation from Raoult's law

B. shows no deviation from Raoult's law

C. shows positive deviation from Raoult's law

D. is saturated

Answer: C

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8. Mixture (s) showing positive deviation from Raoult's law at $35^{\circ} C$ is (are)

A. carbon tetrachloride + methanol

B. carbon disulphide + acetone

C. benzene +toluene

D. phenol + aniline

Answer: A::B

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9. The following statements is true only under some specific conditions. Write the condition for it "Two volatile and miscible liquids can be separated by fractional distillation into pure components."

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10. The vapour pressure of two miscible liquids (A) and (B) are 300 and $500mm$ of Hg respectively. In a flask 10 mole of (A) is mixed with 12 mole of (B). However, as soon as (B) is added, (A) starts polymerising into a completely insoluble solid. The polymerisation follows first-order kinetics. After 100 minute, 0.525 mole of a solute is dissolved whivh arrests the polymerisation completely. The final vapour pressure of the solution is $400mm$ of Hg. Estimate the rate constant of the polymerisation reaction. Assume negligible volume change on mixing and polymerisation and ideal behaviour for the final solution.

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11. The molar volume of liquid benzene (density $0.877 gmL^{-1}$) increases by a factor of 2750 as it vapourises at $20^{\circ}C$ and that of liquid toluene(density $0.867 gmL$) increases by a factor of 7720at $20^{\circ}C$. A solution of benzene and toluene at $20^{\circ}C$ has a vapour pressure of 46.0 torr. Find the mole fraction of benzene in the vapour above the solution.

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12. What weight of the non-volatile solute urea' $(NH_2 - CO - NH_2)$ needs to be dissolved in $100g$ of water in order to decrease the vapour pressure of water by $25\ \%$? What will be the molality of the solution?

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13. The degree of dissociation of $Ca(NO_3)_2$ in a dilute aqueous solution, containing $7.0g$ of the salt per $100g$ of water at $100^\circ C$ is $70\,\%$. If the vapour pressure of water at $100^\circ C$ is $760mm$, calculate the vapour pressure of the solution.

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14. The vapour pressure of pure benzene at a certain temperature is $640mm$ of Hg. A non-volatile non-electrolyte solid weighing $2.175g$ added $39.0g$ of

benzene. The vapour pressure of the solution is $600mm$ of Hg. What is the molecular weight of solid substance?

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15. The vapour pressure of a dilute aqueous solution of glucosse $(C_6H_{12}O_6)$ is $750mmHg$ at $273K$. Calculate (a) molality and (b) mole fraction of the solute.

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16. The vapour pressures of ethanol and methanol are 44.5 and $88.7mmHg$, respectively. An ideal solution is formed at the same temperature by mixing $60g$ of

ethanol with $40g$ of $methanol$. Calculate the total vapour pressure of the solution and mole fraction of methanol in the vapour.

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17. An organic compound $\left(C_xH_{2y}O_y\right)$ was burnt with twice the amount of oxygen needed for complete combustion to CO_2 and H_2O. The hot gases, when cooled to $0^\circ C$ and $1atm$ pressure, measured $2.24L$. The water collected during cooling weighed $0.9g$. The vapour pressure of pure water at $20^\circ C$ is $17.5mmHg$ and is lowered by $0.104mm$ when $50g$ of the organic compound is dissolved in $1000g$ of water. Give the molecular formula of the organic compound.

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18. Two liquids A and B form ideal solution. At $300K$, the vapour pressure of a solution containing 1 mole of A and 3 moles of B is $550mm$ of Hg. At the same temperature, if one more mole of B is added to this solution, the vapour pressure of the solution increases by $10mm$ of Hg. Determine the vapour pressure of a and B in their pure states.

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19. The vapour pressure of pure benzene is $639.7mmHg$ and the vapour pressure of solution of a solute in

benzene at the temperature is $631.9 mmHg$. Calculate the molality of the solution.

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20. What is the molarityk and molality of a 13% solution (by weight) of sulphric acid with a density of $1.02 mL^{-1}$? To what volume should $100 mL$ of this acid be diluted in order to preapre a $1.5 N$ solution?

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21. The freezing point of benzene decreases by $0.45^{\circ} C$ 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 $\left(K_f \text{for benzene} = 5.12 K kg mol^{-1}\right)$

A. $64.6\ \%$

B. $\frac{80}{4}\ \%$

C. $74.6\ \%$

D. $94.6\ \%$

Answer: D

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22. Consider separate solutions of $0.500 M C_2H_5OH(aq)$,$0.100 M Mg_3(PO_4)(aq)$,$0.250 M KBr(aq)$, and

$0.125 M Na_3PO_4(aq)$ at $25^\circ C$. Which statement is true about these solutions, assuming all salts to be strong electrolytes?

A. They all have the same osmotic pressure

B. $0.100 M Mg_3(PO_4)_2(aq)$ has the highest osmotic pressure

C. $0.125 M Na_2PO_4(aq)$ has the highest osmotic pressure

D. $0.500 M C_2H_5OH(aq)$ has the highest osmotic pressure

Answer: A

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23. The freezing point (in $.^{\circ} C$) of a solution containing $0.1g$ of $K_3\left[Fe(CN)_6\right]$ (Mol.wt. 329) in 100 g of water $\left(K_f = 1.86 K kg mol^{-1}\right)$ is

A. -2.3×10^{-2}

B. -5.7×10^{-2}

C. -5.7×10^{-3}

D. -1.2×10^{-2}

Answer: A

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24. When $20g$ of naphthoic acid $(C_{11}H_8O_2)$ is dissolved in $50g$ of benzene $\left(K_f = 1.72Kkgmol^{-1}\right)$, a freezing point depression of $2K$ is observed. The Van't Hoff factor (i) is

A. 0.5

B. 1

C. 2

D. 3

Answer: A

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25. The elevation in boiling point, when $13.44g$ of freshly prepared $CuCI_2$ are added to one kilogram of water, is [Some useful data, $K_b(H_2O) = 0.52kgKmol^{-1}$, mol.wt of$CuCI_2 = 134.4gm$]

A. 0.05

B. 0.1

C. 0.16

D. 0.21

Answer: C

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26. When $0.004MNa_2SO_4$ is an isotonic acid with $0.01M$glucose, the degree of dissociation of Na_2SO_4 is

A. $75\ \%$

B. $50\ \%$

C. $25\ \%$

D. $85\ \%$

Answer: A

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27. During depression of freezing point in a solution, the following are in equilibrium:

A. liquid solvent, solid solvent

B. liquid solvent, solid solute

C. liquid solute, solid solute

D. liquid solute, solid solvent

Answer: A

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28. The molecular weight of benzoic acid in benzene as determined by depression in the freezing point method corresponds to

A. ionisation of benzoic acid

B. dimerisation of benzoic acid

C. trimerisation of benzoic acid

D. solvation of benzoic acid

Answer: B

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29. The freezing point among the following equimolal aqueous solutions will be highest for

A. $C_6H_5NH_3Cl$ (aniline hydrochloride)

B. $Ca(NO_3)_2$

C. $La(NO_3)_3$

D. $C_6H_{12}O_6$ (glucose)

Answer: D

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30. Which of the following $0.1M$ aqueous solutions will have the lowest freezing point?

A. Potassium sulphate

B. Sodium chloride

C. Urea

D. Glucose

Answer: A

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31. When mercuric iodide is added to the aqueous solution of potassium iodide, then:

A. freezing point is raised

B. freezing point is lowered

C. freezing point does not change

D. boiling point does not change

Answer: A

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32. In the depression of freezing point experiment, it is found that the:

A. vapour pressure of the solution is less than that of pure solvent

B. vapour pressure of the solution is more than that of pure solvent

C. only solute molecules solidify at the freezing point

D. only solvent molecules solidify at the freezing point

Answer: A::D

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33. $75.2g$ of C_6H_5OH (phenol) is dissolved in a solvent of $K_f = 14$. If the depression in freezing point is $7K$, then find the percentage of phenol that dimerises.

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34. When $1.22gC_6H_5COOH$ is added into two solvents, the following data of ΔT_b and K_b are obtained:

i. In $100gCH_3COCH_3$,$\Delta T_b = 0.17$,$K_b = 1.7kgKmol^{-1}$.

ii. In $100g$ benzene,$\Delta T_b = 0.13$ and $K_b = 2.6kgKmol^{-1}$

.

Find out the molecular weight of C_6H_5COOH in both cases and interpret the results.

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35. Consider the three solvents of identical molar masses. Match their boiling point with their K_b values

Solvents	Boiling point	$K_b$values
X	$100^\circ C$	0.92
Y	$27^\circ C$	0.63
Z	$283^\circ C$	0.53

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36. To $500cm^3$ of water, $3.0 \times 10^{-3}kg$ acetic acid is added. If $23\ \%$ of acetic acid is dissociated, what will be the depression in freezing point? K_f and density of water are $1.86Kkgmol^{-1}$ and $0.997gcm^{-3}$ respectively.

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37. Nirtobenzene is formed as the major product along with a minor product in the reaction of benzene with a hot mixture of nitric acid and sulphuric acid. The minor product consists of carbon 42.86%, hydrogen 2.40%, nitrogen 16.67% and oxygen 38.07%.

a. Calculate the empirical formula of the minor product.

b. When $5.5g$ of the minor product is dissolved in $45g$ of benzene, the boiling point of the solution is $1.84C$ higher than that of pure benzen. Calculate the molar mass of the minor product and determine its molecular and structural formulae. (Molar elevation constant of benzene is $2.53Kkgmol^{-1}$)

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38. A solution of a non-volatile solute in water freezes at $-0.30^{\circ}C$. The vapour pressure of pure water at $298K$ is $23.51mmHg$ and K_f for water is $1.86degree/molal$. Calculate the vapour pressure of this solution at $298K$.

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39. The addition of $0.643g$ of a compound to $50mL$ of benzene (density 0.879 g mL^{-1}) lowers the freezing point from 5.51 to $5.03^{\circ}C$. If K_f for benzene is 5.12, calculate the molecular weight of the compound.

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40. A solution M is prepared by mixing ethanol and water. The mole fraction of ethanol in the mixture is 0.9

Given: Freezing point depression constant of water

$\left(K_f^{water} = 1.86Kkgmol^{-1}\right)$

Freezing point depression constant to ethanol

$\left(K_f^{ethanol}\right) = 2.0Kkgmol^{-1}\right)$

Boiling point elevation constant of water

$\left(K_b^{water}\right) = 0.52Kkgmol^{-1}\right)$

Boiling point elevation constant of ethanol

$\left(K_b^{ethanol}\right) = 1.2Kkgmol^{-1}\right)$

Standard freezing point of water = $273K$

Standard freezing point of ethanol = $155.7K$

Standard boiling point of water = $373K$

Standard boiling point of ethanol = $351.5K$

Vapour pressure of pure water =$32.8mmHg$

Vapour pressure of pure ethanol =$40mmHg$

Molecular weight of water =$18gmol^{-1}$

Molecular weight of ethanol =$46gmol^{-1}$

In anwering the following questions consider the solutions to be ideal dilute solutions and solutes to be non-volatile and non-dissociative.

The freezing point of the solution M is

A. $268.7K$

B. $268.5K$

C. $234.2K$

D. $150.9K$

Answer: B

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41. A solution M is prepared by mixing ethanol and water. The mole fraction of ethanol in the mixture is 0.9

Given: Freezing point depression constant of water

$\left(K_f^{water} = 1.86 K kgmol^{-1}\right)$

Freezing point depression constant to ethanol

$\left(K_f^{ethanol}\right) = 2.0 K kgmol^{-1}\right)$

Boiling point elevation constant of water

$\left(K_b^{water}\right) = 0.52 K kgmol^{-1}\right)$

Boiling point elevation constant of ethanol

$\left(K_b^{ethanol}\right) = 1.2 K kgmol^{-1}\right)$

Standard freezing point of water = $273 K$

Standard freezing point of ethanol = $155.7 K$

Standard boiling point of water = $373K$

Standard boiling point of ethanol = $351.5K$

Vapour pressure of pure water =$32.8mmHg$

Vapour pressure of pure ethanol =$40mmHg$

Molecular weight of water =$18gmol^{-1}$

Molecular weight of ethanol =$46gmol^{-1}$

In anwering the following questions consider the solutions to be ideal dilute solutions and solutes to be non-volatile and non-dissociative.

The vapour pressure of the solution M is

A. $39.3mmHg$

B. $36.0mmHg$

C. $29.5mmHg$

D. $28.8mmHg$

Answer: A

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42. A solution M is prepared by mixing ethanol and water. The mole fraction of ethanol in the mixture is 0.9

Given: Freezing point depression constant of water

$\left(K_f^{water} = 1.86 K kgmol^{-1}\right)$

Freezing point depression constant to ethanol

$\left(K_f^{ethanol}\right) = 2.0 K kgmol^{-1}\right)$

Boiling point elevation constant of water

$\left(K_b^{water}\right) = 0.52 K kgmol^{-1}\right)$

Boiling point elevation constant of ethanol

$\left(K_b^{ethanol}\right) = 1.2 K kgmol^{-1}\right)$

Standard freezing point of water = $273K$

Standard freezing point of ethanol = $155.7K$

Standard boiling point of water = $373K$

Standard boiling point of ethanol = $351.5K$

Vapour pressure of pure water =$32.8mmHg$

Vapour pressure of pure ethanol =$40mmHg$

Molecular weight of water =$18gmol^{-1}$

Molecular weight of ethanol =$46gmol^{-1}$

In anwering the following questions consider the solutions to be ideal dilute solutions and solutes to be non-volatile and non-dissociative.

Water is added to the solution M such that the mole fraction of water in the solution becomes 0.9. The boiling point of this solution is

A. $380.4K$

B. $376.2K$

C. $375.5K$

D. $354.7K$

Answer: B

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43. Given that ΔT_f is the depression in freezing point of the solvent in a solution of a non-volatile solute of molarity m,the quantity $\underset{m \to 0}{Lt} \left(\Delta T_f / m \right)$ is equal to ..... .

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44. If the freezing point of a 0.01 molal aqueous solution of a cobalt (III) chloride-ammonia complex (which behaves as a strong electrolyte) is $-0.0558^{\circ}C$, the number of chloride (s) in the coordination sphere of the complex if $\left[K_f \text{ of water } = 1.86Kkgmol^{-1}\right]$

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45. A compound is known to be a salt of potassium (KX). If $4.00g$ of the salt is dissolved in $100g$ of water, the solution freezes at $-1.24^{\circ}C$. What is the identify of X ? k_f of water is $1.86KKg/mol$. M are : $K = 39, F = 19, Cl = 35, Br = 80$ and $I = 127$.

A. freezing point is raised

B. Cl

C. Br

D. I

Answer: C

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46. At a given temperature, the vapour pressure in mm of Hg. of a solution of two volatile liquids A and B is given by the equation :

$\rho = 120 - 80X_B, X_B =$ mole fraction of B.

Vapour pressures of pure A and B at the same temperature are respectively

A. 120,80

B. 120, 200

C. 120, 40

D. 80, 40

Answer: C

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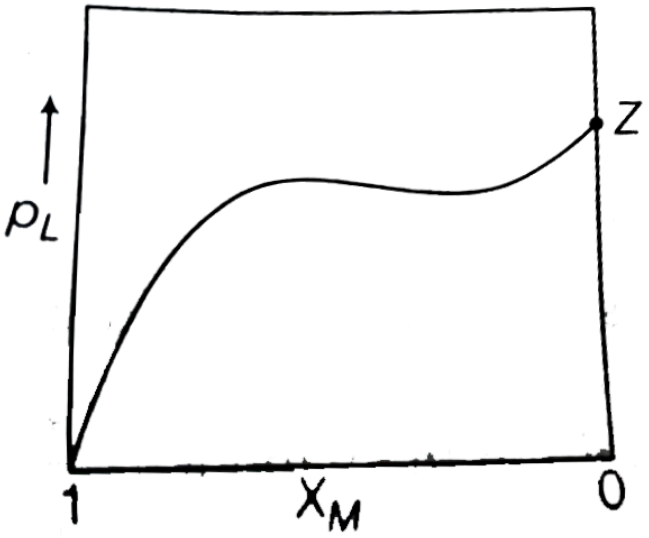
Objective Questions Ii

1. For a solution formed by mixing liquids L and M, the vapour pressure of L plotted against the mole fraction of M in solution is shown is the following figure. Here x_L

and x_M represent mole fractions of L and M, respectively, in the solution. The correct statement (s) applicable to this system is (are)



A. The point Z represents vapour pressure of pure liquid M and Raoult's law is obeyed from $x_L = 0$ to $x_L = 1$

B. Attractive intermolecular interaction between $L - L$ in pure liquid L and $M - M$ in pure liquid M are stronger than those between L-M when mixed in solution

C. The point Z represents vapour of pure liquid M and Raoult's law is obeyed when $x_L \to 0$

D. The point Z represents vapour of pure liquid L and Raoult's law is obeyed when $x_L \to 1$

Answer: B::C

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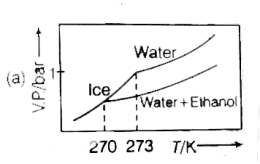
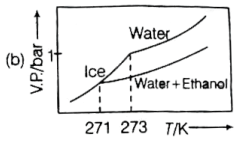
Topic 2 Objective Questions I

1. Pure water freezes at $273K$ and 1 bar. The addition of $34.5g$ of ethanol to $500g$ of water changes the freezing point of the solution. Use the freezing point depression contant of water as $2Kkgmol^{-1}$. The figures shown below represent polts of vapour (V.P.) versus temperature (T). [Molecular weight of ethanol is $46gmol^{-1}$]

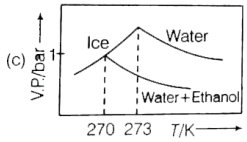
Among the following, the option representing change in the freezing point is

A. 

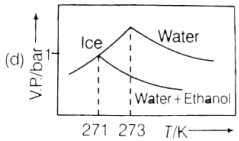
B.



C.



D.



Answer: A

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Test

1. An open beaker containing a pure solvent and a seconf beaker containing a solution in the same solvent with a

non-volatile solute are sealed in a container. Over the period of time

A. the volume of solution increases and the volume of solvent decreases

B. the volume of both solution and solvent increases

C. the volume of solution decreases while volume of solvent increases

D. the volume of both solution and solvent decreases

Answer: A

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2. A beaker containing 2.0 moles of octane and another beaker containing 3.0 moles of nonane are enclosed in chamber-1. Another 2.0 moles of octane is mixed with 3.0 moles of nonane in a beaker, which is then enclosed in chamber-II. At equilibrium, the vapour in chamber-I is

A. greater than the vapour pressure in chamber-II

B. less than the vapour pressure in chamber-II

C. equal to the vapour pressure ib chamber-II

D. can be either less than or greater than the vapour pressure of chamber-II and it depends on the vapour pressure of pure components

Answer: C

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3. When solid, insoluble $Hgl_2(s)$ is added gradually to a solution of Kl, following equilibrium is established :

$2Kl(aq) + Hgl_2(s) \Leftrightarrow K_2[Hgl_4](aq)$

Which of the following applies appropriately at the above equilibrium?

A. Freezing point increases and then becomes constant

B. Freezing point decreases and then becomes constant

C. Boiling point increases and then becomes constant

D. Vapour pressure increases to a constant value

Answer: A::D

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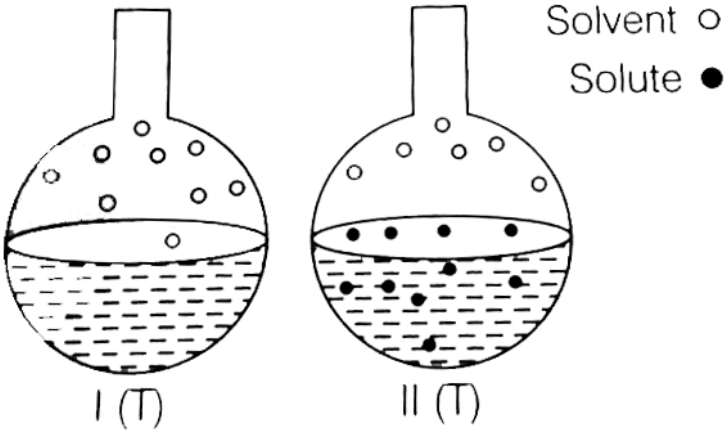
4. Consider the following two diagram :



Suppose that the solute molecules on the surface of solution occupy $10\,\%$ of the surface area. The correct statement is (are)

A. If the water in the vessel-I was transferred to a container with $10\,\%$ less surface area, the vapour pressure would be lowered to same value as the vapour pressure in vessel-II.

B. Mole fraction of solute in container-II is $1/3$.

C. Boiling point solution II is $114.44^{\circ}C$ (k_b of water is $0.52KKg/mol$)

D. If the cross sectional area of surface of solution in container-II is increased by $10\,\%$, the number of

molecules in the phase will increase by $10\ \%$

Answer: B::C::D

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Passage

1. At $300K$, vapour pressure of pure benzene and pure toluene are $100mm$ and $30mm$ of Hg respectively. Also benzene and toluene is prepared by mixing 3.0 moles of toluene in 2.0 moles of benzene at $300K$. Anser the following questions:

If vapours which is in equilibrium with the solution is

condensed, mole fraction of benzene in the first drop of liquid formed will be

A. $\frac{9}{29}$

B. $\frac{20}{29}$

C. $\frac{11}{29}$

D. $\frac{18}{29}$

Answer: B::C::D

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2. At $300K$, vapour pressure of pure benzene and pure toluene are $100mm$ and $30mm$ of Hg respectively. Also benzene and toluene is prepared by mixing 3.0 moles of

toluene in 2.0 moles of benzene at $300K$. Anser the following questions:

If the given solution is distilled by lowering the external pressure at constant $300K$, what will be the mole fraction of benzene in the last drop of liquid condensed ?

A. $\frac{3}{5}$

B. $\frac{6}{5}$

C. $\frac{1}{3}$

D. $\frac{1}{6}$

Answer: D

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Assertion Reason Type

1. Assertion Increasing temperature of a volatile liquid increases its vapour pressure.

Reason Increase in temperature increases the average kinetic energy of molecules in the vapour phase hence they collide to the surface of liquid with greater force.

A. Both assertion and reason are correct and reason is the correct explanation of the assertion,

B. Both assertion and reason are correct but reason is not the correct explanation of assertion.

C. Assertion is correct but reason is wrong.

D. Assertion is wrong but reason is correct.

Answer: B::C::D

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2. Assertion When a solution of non-volatile solute in volatile solvent is distilled, boiling point of the left-over solution increases gradually.

Reason Distillationincrease the molality of the left-over solution.

A. Both assertion and reason are correct and reason is the correct explanation of the assertion,

B. Both assertion and reason are correct but reason is not the correct explanation of assertion.

C. Assertion is correct but reason is wrong.

D. Assertion is wrong but reason is correct.

Answer: A

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