1. SOLUTIONS

TYPES OF SOLUTIONS

1. ***What is a solution?***

   A solution is a homogeneous mixture of two or more components (substances).

2. ***What is solvent?***

   The component which is present in larger quantity in the solution is called solvent.

3. ***What is solute?***

   The component which is present in smaller quantity in the solution is called solute.

4. ***Name the component of the solution which determines the physical state of the solution.***

   Solvent.

5. ***What is binary* solution*? Give an example.***

   A solution containing only two components is called binary solution.
   Example: Glucose dissolved in water or Glucose + water.

6. ***Name the types of binary solutions? Give an example.***

   Binary solutions are three types.

Sl.no	Type of solution	solute	solvent	Examples.
1	Solid solutions	Solid	Solid	Copper dissolved in gold
		Liquid	Solid	Amalgam of mercury with sodium (Na/Hg)
		Gas	Solid	Solution of H_2 in Pd
2	Liquid solution	Solid	Liquid	Glucose in water, $NaCl$ in water
		Liquid	Liquid	Ethanol in water
		Gas	Liquid	Oxygen in water, CO_2 in water.
3	Gaseous solution	Solid	Gas	Camphor in nitrogen gas
		Liquid	Gas	Chloroform in nitrogen gas
		Gas	Gas	Mixture of O_2 and N_2.

7. ***Give an example for a solid-solid solution.***

   Copper dissolved in gold

8. ***Give an example for a gas-gas solution.***

Mixture of oxygen and nitrogen gases.

9. ***Give an example for a gas-solid solution.***

Solution of hydrogen in palladium

10. ***Give an example for a liquid –solid solution.***

Amalgam of mercury with sodium

11. ***Give an example for a liquid –liquid solution.***

Ethanol dissolved in water.

12. ***Give an example for a solid-gas solution***

Camphor in nitrogen gas.

13. ***Give an example for liquid solution in which solute is gas.*** ***[J -15]***

CO_2 dissolved in water (soda water)

Methods of expressing concentration of a solution

14. ***What is concentration of a solution?***

The amount of solute present in the given quantity of the solution is called its concentration.

Molarity

15. ***Define molarity (M)*** ***[A-22]***

- The number of moles of solute dissolved in 1 litre (1 dm^3) or 1000 cm^3 of a solution is called molarity.
- It is denoted by 'M'.

$$\text{Molarity} = \frac{Number\ of\ moles\ of\ solute}{Volume\ of\ the\ solution\ in\ litres} \text{ or } \frac{n}{V(Lit)}$$

$$\text{Molarity} = \frac{W_B \times 1000\,cm^3}{M_B \times V(ml)} \text{ or}$$

$$\text{Molarity} = \frac{W_B \times 1L}{M_B \times V}$$

Where W_B = mass of solute, M_B = Molar mass of solute, V=Volume of the solution.

16. ***What is the effect of temperature on molarity?***

Molarity depends on temperature. As the temperature increases, molarity of solution decreases because volume of the solution increases.

17. ***Why molarity of solution varies inversely with temperature?***

It is due to increase in volume of the solution by increasing temperature.

18. ***Write the unit of molarity of solutions.***

Mol/ Lit or Mol/ dm^3

19. ***Define molality (m).*** ***[M-18, J-18]***

- The number of moles of solute dissolved in one Kg or 1000 g of a solvent is called molality.
- It is denoted by 'm'.

$$\text{Molality (m)} = \frac{Number\ of\ moles\ of\ solute}{Mass\ of\ the\ solvent\ in\ kg} = \frac{n}{W_A(kg)}$$

$$\text{Molality} = \frac{W_B \times 1}{M_B \times W_A kg}$$

$$\text{Molality} = \frac{W_B \times 1000g}{M_B \times W_A\, g}$$

Where W_B = mass of solute, M_B = Molar mass of solute,

W_A = mass of solvent

20. *Write the unit of molarity of solution.*

Mol/kg

21. *What is the effect of temperature on molality?*

Molality is independent on temperature because the mass is independent of temperature

22. *Among molarity and molality which is independent of temperature* ***[M-16]***

Molality.

Mole fraction

23. *What is mole fraction?*

- It is the ratio of number of moles of a particular component to the total number of moles of all the components in the solution.

  $$\text{Mole fraction of a component} = \frac{\textit{Number of moles of component}}{\textit{Total number of moles of all components}}$$

- Let the binary solution containg two component A and B, n_A, n_B are the number of moles X_A *and* X_B are the mole fractions of A, B respectively.

  $$\text{Mole fraction of solute, } (x_B) = \frac{n_B}{n_A + n_B}$$

  $$\text{Mole fraction of solvent, } (x_A) = \frac{n_A}{n_A + n_B}$$

24. *What is the unit of mole fraction?*

No units.

Mass Percentage, Volume Percentage, Mass by Volume Percentage and PPM

25. *Define mass percentage (w/w). For which type of solutions this unit is useful?*

Mass percentage of a solution is defined as the mass of the solute dissolved in 100g of the solution.

$$\text{Mass percentage of a component } \left(\frac{w}{w}\right)\% = \frac{\textit{Mass of a component in the solution}}{\textit{Total mass of the solution}} \times 100$$

Note: This unit is useful when both the solute and solvents are solid state.

26. *Define volume percentage. For which type of solutions this unit is useful?*

Volume percentage of a solution is defined as the volume of the solute dissolved in 100mL of the solution.

$$\text{Volume percentage (V/V) of a component} = \frac{\textit{Volume of the component in the solution}}{\textit{Total volume of the solution}} \times 100$$

Note: This unit is useful when both the solute and solvents are liquids.

27. *Define mass by volume percentage. Give an expression to calculate the volume percentage for the given mass and volume of solute and solvent.*

Mass by volume percentage of a solution is defined as mass of the solute dissolved in 100mL of the solution.

$$\left(\frac{w}{v}\right)\%\ \text{Mass by volume percentage} = \frac{\textit{Mass of the solute}}{\textit{Volume of the solution}} \times 100$$

Note: This unit is useful when solute is solid and solution is liquid. This unit is commonly used in medicine and pharmacy.

28. *Define parts per million.*

It is defined as **the number of parts of solute dissolved in one million parts of the solution.**

$$\text{Parts per million(ppm)} = \frac{\textit{Number of parts of the solute}}{\textit{Number of parts of all components of the solution}} \times 10^6$$

Parts per million are also expressed in w/w, v/v, w/v.

Note: This unit is suitable when solutes are present in trace quantities. (or) for a very dilute solution .

29. *What is ment by 15% glucose in water by mass?*

It means 15g of glucose is dissolved in 85g of water or in 100g of a solution.

30. *What is ment by 15% ethanol solution in water by volume?*

It means 15ml ethanol is dissolved in 85 ml of water or 100 ml solution.

31. *What is ment by 35% $\left(\frac{w}{v}\right)$ ethylene glycol?*

It means 35g ethylene glycol in 100ml solution.

32. *Identify the following into temperature dependent and temperature independent and give the reason.*

(i) Molarity (M) (ii) Molality (m) (iii) Mole fraction (x) (iv) Mass percent (w/w)

(v) Volume percent (v/v) (vi) Mass by volume percent (m/V)

(vii) Parts per million (ppm)

(i)Mass percent, ppm, mole fraction and molality are independent of temperature because mass is independent on temperature.

(ii) Molarity, volume percent and mass by volume percent depends on temperature because volume depends on temperature.

Solubility

33. *Define the following*

a) solubility.

The maximum amount of a substance that can be dissolved in a specific amount of solvent at a specified temperature is called solubility.

$$\text{Solubility} = \frac{\textit{Mass of solute}}{\textit{Mass of solvent}} \times 100$$

b) Saturated solution.

A solution in which no more solute can be dissolved at the same temperature and pressure is called saturated solution.

c) Unsaturated solution.

A solution in which some more solute can be dissolved under the same temperature and pressure is called unsaturated solution.

d) Dissolution.

When a solute is added to the solvent, some solute dissolves and its concentration increase in solution. This process is called dissolution.

e) Crystallization

Some solute particles in solution collide with the solute particles and get separated out the solution. This process is called crystallization.

Solubility of solid in liquid

34. ***Give reason:***

sugar is dissolved in water but not in benzene.

Sugar can form hydrogen bond with water. Therefore, sugar is dissolved in water. But benzene is non polar solvent and hence sugar is not soluble in benzene.

35. ***What is the effect of temperature on solubility of a solid in liquid?*** ***[M-17, J-19]***

(i) Solubility of a solid in liquid increases as temperature increases if the dissolution process is endothermic $(\Delta H = +ve)$. **Ex:** $NaNO_3\ NH_4Cl, KCl$

(ii) Solubility of a solid in liquid decreases as temperature increases if the dissolution process is exothermic $(\Delta H = -ve)$ **Ex:** $Li_2(SO_4)_3, Ce_2(SO_4)_3$

36. ***What is the effect of pressure on solubility of solid in liquid?*** ***[M-17]***

Pressure does not have any significant effect on solubility of solids in liquids.

37. ***Why the solubility of*** $NaNO_3, NH_4Cl\ KCl$ ***increases with increases temperature?***

Because solubility of these salts is endothermic process.

38. ***Why the solubility of*** $Li_2SO_4, Ce_2(SO_4)_3$ ***decreases with increases temperature?***

Because solubility of these salts is exothermic process.

Solubility of the gas in liquid.

39. ***What is the effect of temperature on the solubility of a gas in liquid?***

Solubility of a gas in liquid decreases when temperature is increases.

40. ***Solubility of a gas in liquid decreases as temperature increases. Why?***

Because dissolution of a gas in liquid is exothermic process.

41. ***What are the factors affecting the solubility of a substance?***

Generally the following factors affect the solubility of a substance,

(1) Nature of solute (2) Nature of solvent (3) Temperature (4) Pressure

42. ***State Henry's law and write it mathematical expression*** ***[J-16, M-18, J-18, J-19]***

It states that, at constant temperature, the solubility of a gas in a liquid is directly proportional to the partial pressure of a gas present above the surface of liquid or solution. Or

The partial pressure of the gas in vapour phase (p) is proportional to the mole fraction (x) of the gas in the solution.

i.e., $p = K_H x$

Where K_H = Henery's law constant, $x =$ mole fraction of the gas in liquid solution.

$p =$ Partial pressure of the gas in vapour phase.

43. ***What is the significance of Henry's law constant?***

The higher the value of K_H lower is the solubility.

44. ***Name the law behind the dissolution of CO_2 gas in soft drinks under pressure.*** ***[M-16]***

Henry's law

45. K_H ***values for the gases argon and methane in water at 298 K are 40.3 /k bar and 0.413/k bar respectively. Which gas is more soluble at this temperature?***

Methane $\left[Solubility\ \alpha \frac{1}{K_H value} \right] \alpha \frac{1}{temperature}$

46. *"As the temperature increases, the Henry's law constant for a particular gas in liquid solvent increases". What is the interference of this statement?*

Solubility of gas in particular solvent decreases.

47. *Soda water bottles are sealed under high pressure. Give reason.* *[J-16]*

To increase the solubility of a gas in liquid. (Henry's law)

48. *At constant temperature, different gases have different K_H value. What does this statement suggest? (or) K_H is α function o the nature of the gas* *[A-22]*

At constant temperature, different gases have different solubility in a particular solvent.

49. *At a given temperature O_2 gas is more soluble in water than N_2 gas. Which one of them has higher value of K_H?* *[J-19]*

Nitrogen

50. *Give any three applications of Henry's law.*

(i) It is used in the preparation of carbonated beverages (To increase the solubility of CO_2 in soda water, soft drinks and in beer, the bottle is sealed under high pressure).

(ii) It is used by scuba divers or deep sea divers for respiration (To avoid bends and toxic effects of nitrogen under deep sea).

(iii) It is used by mountain climbers for respiration. (At high altitudes the partial pressure of oxygen is less. The low concentration of oxygen in the blood and tissues causes climbers to become unable to think clearly which causes **anoxia).**

51. *At a given temperature and pressure nitrogen gas is more soluble in water than Helium gas. Which one of them has higher K_H value?* *[M-15, J-20]*

Helium

52. *Aquatic species are more comfortable in cold water rather than in warm water. Give reason.*

Solubility of oxygen (O_2) in cold water is more than warm water. Because solubility of the gas in liquid exothermic process.

53. *How to control the disease bends and toxic effects of high concentration of nitrogen in the blood in scuba divers during deep sea diving?*

To avoid the bends the tanks used by scuba divers are filled with air diluted with helium (11.7%), nitrogen (56.2% and oxygen (32%) because of the low solubility of helium in the blood than nitrogen.

54. *What is the diseases caused to the sea divers if they carry atmospheric air?*

Bends

55. *What is the disease caused to the people living at high altitudes or mountain climbers?*

Anoxia

56. *Why Henry's law is not applicable for solubility of gases like CO_2, SO_2, HCl, NH_3, ... in water?*

Only those gases which do not react with water or do not show H-bonding obey Henry's law. CO_2, SO_2, HCl react with water. NH_3 forms H-bonding. Hence they do not obey Henry's law.

57. *When sealed soda water bottle is opened CO_2 gas is evolved with effervescene. Why?*

Soda water is manufactured by dissolving CO_2 gas in water at high pressure. When the bottle is opened, pressure becomes equal to atmospheric pressure and the dissolved CO_2 escapes with effervescene because solubility of CO_2 gas decreases with decrease in pressure.

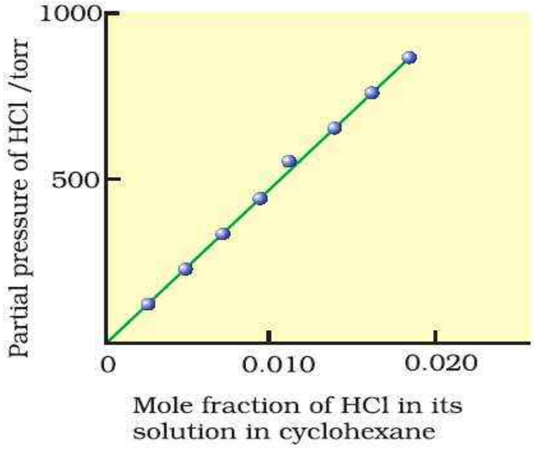
58. *Why carbonated drink bottles are kept under water during summer?*

Carbonated drinks contain, CO_2 dissolved in water at high pressure. The solubility of CO_2 on water during summer decrease due to high temperature. Hence high pressure is developed inside the bottle that causes explosion. To avoid this the bottles are placed in water during summer.

59. *The K_H values of $H_2; N_2O_2$ at 293 K is 69.16, K bar, 76.48 K bar and 34.86 K bar respectly which gas readily soluble?*

O_2 is more soluble because it has least K_H value.

60. *Draw the graph it shows relation between partial pressure of a gas v/s its mole fraction.*



61. *Write the limitations of Henry's law.*

(i) Pressure is not very high
(ii) Temperature is not very low
(iii) Gas not highly soluble
(iv) Gas do not form any compound with solvent
(v) Gas does not undergo dissociation

Vapour pressure of liquid solutions

62. *What is vapour pressure?*

The pressure exerted by the vapours above the liquid surface at constant temperature when they are in equilibrium with the liquid is called vapour pressure or saturated pressure or equilibrium vapour pressure.

63. *State and explain Raoult's law of liquid solutions.* *[J-17]*

It states that in a solution of volatile liquids, the partial vapour pressure of each component of the solution is directly ***p***roportional to its mole fraction.
Consider a solution containing two volatile components 1 and 2.
According to Raoult's law, $p_1 \ \alpha \ x_1$

Or $p_1 = p_1^0 x_1$

Similarly $p_2 = p_2^0 x_2$

$p_1^0 =$ vapour pressure of the component 1 in the pure state.
$x_1 =$ mole fraction of the component 1,
$p_1 =$ partial pressure of the component 1 from the solution
$p_2 =$ partial vapour of component 2 from the solution
$p_2^0 =$ vapour pressure of component 2 in pure state
$x_2 =$ mole fraction of component 2 in the solution.
$\therefore$ Total vapour pressure of solution $= p_{total} = p_1 + p_2$, $p_{total} = p_1^0 x_1 + p_1^0 x_2$

64. *Write the mathematical form of Raoult's law for solution containing two liquids.*

$p_{total} = p_1^0 x_1 + p_2^0 x_2$

65. *What are the limitations of Raoult'slaw?*

The law holds good

1) for dilute solutions only

2) when the solute is non volatile

3) when the solute neither associates nor dissociates in the solution.

66. *Why hot liquids are sipped from a saucer?*

The surface area for evaporation is larger in a saucer. Hence temperature of the liquid decreases quickly.

67. *Vapour pressures of chloroform and dichloromethane are 200mm of Hg and 415 mm of Hg at 298K respectively. Which one is more volatile?*

Dichloromethane because Higher the vapour pressure, more the volatile.

68. *Vapour pressure of liquid increases with increase in temperature. Why?*

With the increase in temperature, kinetic energy of solvent molecules increases and hence their tendency to escape increases and rate of evaporation becomes more. This results in increases in vapour pressure.

69. *A person cutting onion cooled in refrigerator cries less than a person cutting onion at room temperature. Why?*

This is because onions kept in the refrigerator have low vapour pressure of their contents at low temperature than onions at room temperature.

70. *How do you determine the composition of components in the vapour phase in equilibrium with the solution?*

The composition of vapour phase in equilibrium with the solution is determined by the partial pressures of the components.

If y_1 *and* y_2 are the mole fractions of the components 1 and 2 respectively in the vapour phase, then using Dalton's law of partial pressures,

$$p_1 = y_1 \times P_{total}$$

$$p_2 = y_2 \times P_{total}$$

$$y_1 = \frac{p_1}{p_{total}}$$

$$y_2 = \frac{p_2}{p_{total}}$$

Ideal and non ideal solutions

71. *What are ideal solutions? Give an example.* ***[J-16]***

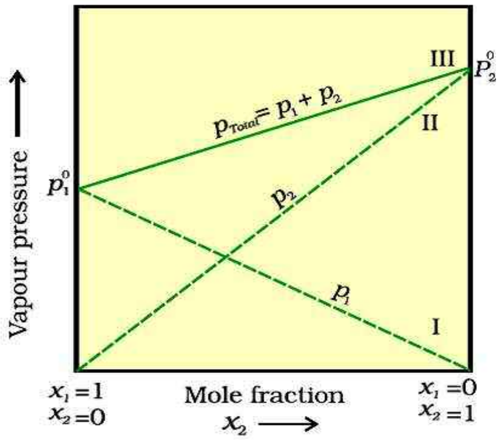
The solutions which obey Raoult's law at all concentrations are called ideal solutions.

Examples:
- Benzene and Toluene
- Bromoethane and chloroethane
- N-hexane and n-heptane

72. *Give any four conditions to form ideal solutions.*

- They should obey Raoult's law
- $\Delta V_{mix} = 0$, i.e., there should be no change in volume on mixing
- $\Delta H_{mix} = 0$, i.e., there should be no change in enthalpy (heat) on mixing.
- The forces of attraction betaeen A and B (solvent and solute)molecules will be same as that of A-A (solvent-solvent) and B-B (solute-solute) molecules.
- It does not form azeotropic mixture.

73. *Draw the graph of vapour pressure against mole fraction of an ideal solution.*



74. *What happens to the heat when chlorobenzene and bromobenzene are mixed?*

Heat is neither absorbed nor liberated. Because it is ideal solution.

75. *What kind of deviation is observed when heptanes and octane are mixed?*

The solution obeys Raoult's law at all conditions of temperature and concentration, hence no deviation.

76. *How does the (i) volume change [M-19] (ii) enthalpy change on mixing two volatile liquids to form an ideal solution*

(i) No change in volume OR $\Delta Vmix = 0$

(ii) No change in enthalpy OR $\Delta Hmix = 0$

77. *Mention the enthalpy of mixing* $(\Delta_{mix}H)$ ***value to form an ideal solution*** ***[M-14]***

Zero or 0 or $\Delta_{mix}H = 0$

78. *What are non-ideal solutions give an example*

The solutions which do not obey Raoult's law at all concentrations are called non-ideal solutions.
Examples: (i) HCl and water (ii) Ethyl alcohol and water, (iiii) Etahnol and acetone (iv) CS_2 and acetone.

79. *Give any four conditions to form non-ideal solutions.*

- They should not obey Raoult's law.
- $\Delta V_{mix} \neq 0$
- $\Delta H_{mix} \neq 0$
- The forces of attraction between A and B molecules will be greater or lesser than that of A-A and B-B molecules.
- They form azeotropic mixture.

80. *Give differences between ideal an non ideal solutions.* ***[J-15, M-16, J-18]***

Sl.no	Ideal solution	Non-ideal solution
1	They obey Raoult's law	They donot obey Raoult's law
2	$\Delta V_{mix} = 0$	$\Delta V_{mix} \neq 0$
3	$\Delta V_{mix} = 0$	$\Delta H_{mix} \neq 0$
4	The forces of attraction between A and B molecules will be same as that A-A and B-B molecules.	The forces of attraction between A and B molecules will be greater or lesser than that of A-A and B-B molecules.
5	They do not form azeotropic mixture	They form azeotropic mixture

81. ***Name the types of non-ideal solutions.***

Non ideal solutions are of two types

- Non ideal solution showing positive deviation from Raoult's law
- Non ideal solution showing negative deviation from Raoult's law.
- They form azeotropic mixture.

82. ***Which type of solutions show positive deviation? Give an example.***

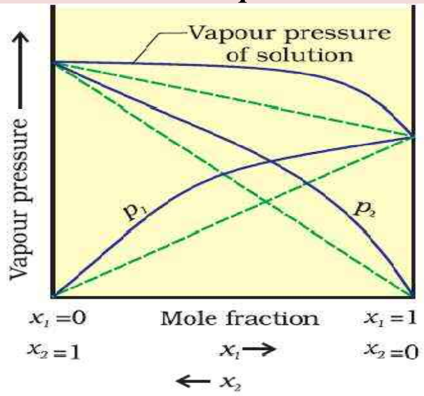
If the vapour pressure of the solution is higher than the vapour pressure calculated from Raoult's law shows positive deviation.

Example: (i) Mixture of ethanol and acetone (ii) Mixture of carbon disulphide and acetone.

83. ***Mixture of acetone and ethanol shows positive deviations from Raoult's law. Give reason.***

In pure ethanol, molecules are hydrogen bonded. On adding acetone, its molecules get in between the ethanol molecules and break hydrogen bond between them. Due to weakening of interactions, the solution shows positive deviations from Raoult's law.

84. ***Draw the graph to show non ideal solutions with positive deviation from ideal behaviour.***



(a)

85. ***What happens to the total volume when ethanol and water are mixed?***

The total volume increases. Because it show positive deviation from Raoult's law.

86. ***What would be the enthalpy change when benzene and acetone are mixed?***

Heat absorbed. ($\Delta H = +ve$, endothermic process)

87. ***What type of deviation from Raoult's law is observed when equal volume of ethanol and acetone are mixed? Mention the reason for it.*** ***[A-22]***

Positive deviation because acetone breaks some of the hydrogen bonds of ethanol thereby decreasing the ethanol – ethanol interaction.

88. ***Which type of solutions show negative deviation from Raoult's law?***

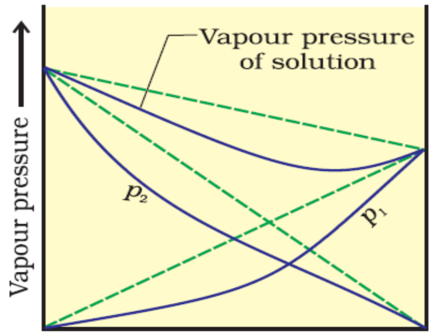
If the vapour pressure of the solution is lower than the vapour pressure calculated by Raoult's law shows negative deviation from Raoult's law.

Examples: Phenol and aniline. Chloroform and acetone.

89. ***Solution of phenol and aniline show negative deviation from Raoult's law. Give reason.***

This is because the intermolecular hydrogen bonding between phenolic proton and lone pair on nitrogen atom of aniline is stronger than the respective intermolecular hydrogen bonding between similar molecules. So, vapour pressure of the solution becomes less than the expected.

90. *Draw the graph to show non ideal solutions with negative deviations.*



(b)

91. *What happens to the total volume when benzene and toluene are mixed?*

The total volume decreases. Because it show negative deviation from Raoult's law.

92. *What would be the enthalpy change when acetone and aniline are mixed?*

Heat is liberated ($\Delta H = -ve$, exothermic process)

93. *What kind of deviation is observed when hydrochloric acid and water are mixed?*

The solution will show a negative deviation from Raoult's law.

94. *Give differences between solutions showing positive deviation and negative deviation from Raoult' slaw*

S.N	Non ideal solution with positive deviation	Non ideal solution with negative deviation
1	$\Delta V_{mix} = +ve$ (i.e., volume increases on mixing two componenets)	$\Delta V_{mix} = -ve$ (volume decrease on mixing two components)
2	$\Delta H_{mix} = +ve$ (heat is absorbed on mixing)	$\Delta H_{mix} = -ve$ (heat is liberated on mixing)
3	The vapour pressure is higher than that calculated from Raoult's law	the vapour pressure is lower than that calculated from Raoult's law
4	Forces of attraction between A and B molecules will be less than that of A-A and B-B molecules.	Forces of attraction between A and B molecules will be greater than that of A-A and B-B molecuoles.
5	They form minimum boiling azeotrope	They form maximum boiling azeotrope

95. *10 mol of liquid A is mixed with 10 ml of liquid B. The volume of the resultant solution is*
(i) 19.9 ml ***(M-17, M-20]***
(ii) 20.1 ml
What type of deviation is expected from Raoult's law?
(i) Negative deviation. (ii) Positive deviation

96. *What are azeotropes or azeotropic mixtures?*

Binary liquid mixtures having the same composition in liquid and vapour phase and boil at a constant temperature are called azeotropic mixtures.

Example: (i) 95% ethyl alcohol and 5% water by volume (ii) 68% nitric acid and 32% water by mass.

Note: In azeotropic mixture the components cannot be separated by fractional distillation.

97. ***Name the types of azeotropes or azeotropic mixtures.***
Azeotropic mixtures of two types:
(i) Minimum boiling azeotropes
(ii) Maximum boiling azeotropes.

98. ***What are minimum boiling azeotropes? Give an example.***
The solutions which show large positive deviation from Raoult's law are called minimum boiling azeotrops. They boil at lower temperature than the boiling point of the components.
Example: 95% Ethylalcohol and 5% water by volume (rectified spirit). This mixture boils at 78.15^0C is which is lower than that of pure ethyl alcohol (78.5^0C pure water (100^0C).

99. ***What are maximum boiling azeotropes? Give an example.***
Solutions which shows the large negative deviations from Raoult's law are called maximum boilin azeotropes.
Example: 68%nitric acid and 32% water by mass with a boiling point of 393.5K .

100. ***Components of a non ideal binary solution cannot be completely separated by fractional distillation why?***
Due to the formation of azeotropic mixture.

Colligative properties of dilute solutions

101. ***What are colligative properties?***
The properties of dilute solutions depend only on the number of solute particles present in the dilute solution. But not on their nature are called colligative properties.

102. ***On what factor does the colligative property value depends.*** ***[J-15]***
It depends on the number of solute particles but not their nature.

103. ***Name the four colligative properties.***
- Relative lowering of vapour pressure
- Elevation in boiling point or Ebullioscope or increasing in boiling point
- Depression in freezing point or Cryoscope or decrease in freezing point
- Osmotic pressure.

Relative lowering of vapour pressure (RLVP)

104. ***What happens to the vapour pressure of the pure liquid when a non volatile solute is dissolved in it?***
Vapour pressure of liquid decreases.

105. ***Define lowering of vapour pressure.***
When a non volatile solute is added into the pure solvent, the vapour pressure of the solution decreases.
Let p^0 be the vapour pressure of the pure solvent and p be the vapour pressure of the solution, then,
Lowering of vapour pressure $= p^0 - p.$
So, lowering of vapour pressure is the difference between the vapour pressure of the pure solvent and that of the solution containing non volatile solute.

106. ***Define relative lowering of vapour pressure.***
It is the ratio of lowering of vapour pressure to the vapour pressure of solvent.

Relative lowering of vapour pressure $= \dfrac{P_A^0 - P_A}{P_A^0} = X_B$

It states that in a solution containing non volatile solute the relative lowering of vapour pressure is equal to the mole fraction of the solute in dilute solutions.

i.e., $\dfrac{P_A^0 - P_A}{P_A^0} = \dfrac{n_B}{n_A + n_B}$

107. ***State Raoult's law of relative lowering of vapour pressure. Write its mathematical form.*** ***[M- 23]***

It states that in a solution containing non volatile solute the relative lowering of vapour pressure is equal to the mole fraction of the solute in dilute solution.

108. ***Among pure water and sea water which has highest vapour pressure.***

Pure water

109. ***Arrange the following aqueous solutions in decreasing order of their relative lowering of vapour pressure: i) 0.1 M sucrose ii) 0.1 M NaCl iii) 0.05 M glucose iv) 0.1 M acetic acid***

0.1 M NaCl > 0.1 M sucrose > 0.05 glucose > 0.1 M acetic acid.

110. ***The mole fraction of a solvent is 0.95. What is the relative lowering of vapour pressure?***

$\frac{P_A^0 - P_A}{P_A^0} = X_B, X_B = 1 - X_A$

0.05

111. ***What is the trend in boiling point temperatures of equimolar solutions of glucose, sodium chloride, sodium sulphate and $AlCl_3$.***

Elevation in boiling point is proportional to the number of solute particles.

$\therefore$ The trend in boiling point is glucose $< NaCl < Na_2SO_4 < AlCl_3$

112. ***Derive the relation to calculate the molar mass or molecular mass OR molecular weight using relative lowering of vapour pressure.***

We know that from Raoult's law $\frac{p_A^o - p_A}{p_A^o} = \frac{n_B}{n_A + n_B}$

Where n_A and n_B are the number of moles of solvent and solute respectively present in the solutions.

For dilute solutions $n_B << n_A, \therefore n_A + n_B \approx n_A.$

$$\frac{p_A^0 - p_A}{p_A^0} = \frac{n_B}{n_A}$$

But, $n_A = \frac{w_A}{M_B}, n_B = \frac{w_B}{M_B}$

$$\frac{p_A^0 - p_A}{p_A^0} = \frac{w_B / M_B}{w_A / M_A} \quad or \quad \frac{p_A^0 - p_A}{p_A^0} = \frac{w_B \times M_A}{w_A \times M_B}$$

$$M_B = \frac{w_B \times M_A \times p_A^0}{w_A \times \left(p_A^0 - p_A\right)}$$

Elevation of boiling point (Ebulliscopy)

113. ***What is boiling point***

The temperature at which liquid is converted into vapours is called boiling point

114. ***When does liquid boils?***

Liquid boils when vapour pressure of the liquid becomes equal to the atmospheric pressure.

115. ***What happens to the boiling point of a liquid when a non volatile solute is dissolved in a pure solvent?***

Boiling point of solvent increases.

116. *Define elevation in boiling point.*

It is the difference between the boiling point of the solution and that of the pure solvent.

i.e., $\Delta T_b = T_b - T_b^0$

Where ΔT_b = elevation in boiling point, T_b = boiling point of solution, T_b^0 = boiling point of the pure solvent.

117. *Give the relation between elevation in boiling point and molality.*

$$\Delta T_b \ \alpha \ m$$

$$\Delta T_b = k_b m$$

Where ΔT_b = elevation in boiling point, m=molality, k_b = molal elevation constant or ebulliscopic constant.

118. *Define Ebulliscopic constant or molal elevation constant and write its units.*

- It is the increase in the boiling point produced when one mole of non volatile solute is dissolved in 1 kg of a pure solvent.
- K kg mol^{-1}.

119. *What is the value of k_b for water?*

$0.52\, K\, kg\, mol^{-1}$

120. *Molecular mass of proteins cannot be determined by elevation in boiling point method. Why?*

This because proteins on heating undergo denaturation.

121. *How is the molecular mass of a solute calculated by ebulliscopic method (elevation in boiling point).*

We know that $\Delta T_b = K_b m$

Let w_B be the mass of the solute of molecular mass M_B dissolved in w_A gram of the solvent, then molality (m) of the solution is given by the equation:

$$m = \frac{w_B \times 1000}{M_B \times w_A}$$

Substituting the value of m in equation 1, we get,

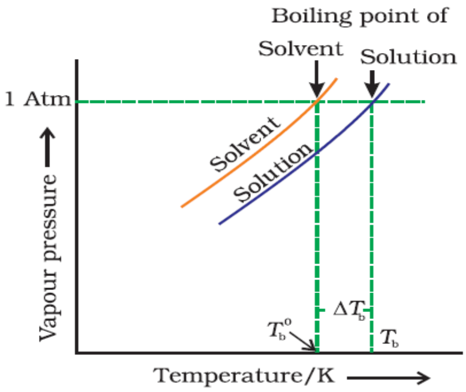
$$\Delta T_b = K_b \times \frac{w_B \times 1000}{M_B \times w_A}$$

The molar mass of the solute (M_B) is calculated using the equation,

$$M_B = \frac{K_b \times w_B \times 1000}{\Delta T_b \times w_A}$$

Thus, in order to determine M_B, molar mass of the solute, known mass of solute in a known mass of the solvent is taken and ΔT_b is determined experimentally for a known solvent whose K_b value is known.

122. *Draw the graph of vapour pressure with temperature to show elevation in boiling point of solvent and solution.*



123. ***Give the relation between K_b and ΔH_V***

$$K_b = \frac{R \times M_1 \times T_b^2}{1000 \times \Delta_{vap} H}$$

Depression in freezing point (Cryoscopy)

124. ***What is freezing point of liquid?***

Freezing point is the temperature at which the solid form of liquid begins to separate out from the liquid. At this temperature solid and liquid will be in equilibrium.

125. ***Define depression in freezing point.***

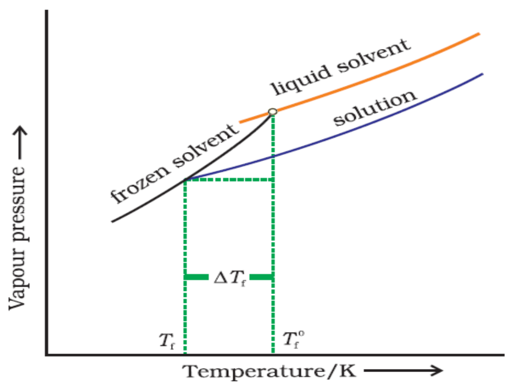
It is the differences between the freezing point of the pure solvent and that of the solution.

i.e., $\Delta T_f - T_f^0 - T_f$

where ΔT_f depression in freezing point, T_f^0 = freezing point of the pure solvent,

T_f = freezing point of the solution.

126. ***Draw the graph of vapour pressure with temperature to show depression in freezing point if solvent and solution.***



127. ***Give the relation between depression in freezing point and molality.***

$\Delta T_f \, \alpha \, m \, (or) \, \Delta T_f = K_f . m$

Where K_f is called molal depression constant or cryoscopic constant.

128. ***Define cryoscopic constant or molal depression constant.***

It is the decrease in the freezing point produced when one mole of non volatile solute is dissolved in one Kg or 1000g of pure solvent.

129. ***What is the value of K_f for water?***

$K_f = 1.86 \, K \, kg \, mol^{-1}$ for water.

130. ***What is the SI unit of K_f ?***

$K\,kg\,mol^{-1}$

131. ***Derive the relation between depression in freezing point and the molecular mass of a solute.***

We know that

$$\Delta T_f = K_f m$$

Where m is the molality of the solution and K_f is the molal depression constant or freezing point depression constant or cryoscopic constant.

But for the given mass of solute, molality is given by $m = \frac{w_B \times 1000}{M_B \times w_A}$

$$\therefore \Delta T_f = K_f \left[\frac{w_B \times 1000}{M_B \times w_A}\right]$$

$$M_B = \frac{K_f \times w_B \times 1000}{\Delta T_f \times w_A}$$

132. ***Why freezing and boiling points are not considered as colligative properties?***

Because these are dependent on the type of salt. (or) number of solute particles.

133. ***Give the relation to calculate molar depression constant with respect to enthalpy of fusion.***

$$K_f = \frac{R \times M_A \times T_f^2}{1000 \times \Delta H_{fus}}$$

Where R=universal gas constant M_A = molecular mass of solvent T_f = freezing point of solvent, ΔH_{fus} = Enthalpy of fusion.

134. ***Give reason:***

a) The freezing point of a sea water is less than $0^0 C(273K)$

Due to dissolved salts.

b) The osmotic pressure of NaCl solution is more than glucose solution.

NaCl solution contains more particles (2) than the glucose solution (1).

135. ***Give the relationship between depression in freezing point and molecular mass of the solute.***

$$\Delta T_f = \frac{1000 \times K_f \times w_2}{w_1 \times M_2}$$

136. ***Why the mixture of ethylene glycol and water are used in car radiators in cold countries?***

This is because glycol lowers the freezing point of water. Hence the coolant in radiator will not freeze.

137. ***Sea water does not freeze at*** $0^0 C$***. Why?***

Sea water contains a number of non-volatile solute particles and as a result there is depression in freezing point of water.

138. ***Of 1 M sugar solution and 1 M NaCl solution, which has higher freezing point?***

Sugar is a non-electrolyte. NaCl is an electrolyte. Hence 1 M solution of sugar has higher freezing point since lowering in freezing point temperature is less compared to 1 M NaCl solution.

139. *How are ΔT_b and ΔT_f related to the molecular mass of the solute?*

Both ΔT_b *and* ΔT_f are inversely proportional to the molecular mass of the solute.

140. *Why is freezing point depression of 1.0 M NaCl is twice that of 0.1 M glucose solution?*

Freezing point depression is a colligative property. NaCl is a strong electrolyte and in water it dissociates into ions $\left(Na^+ \text{ and } Cl^-\right)$. On the other hand glucose being a molecular solid does not dissociate into ions. Therefore freezing point depression for NaCl is twice that of glucose solution.

141. *What is the trend in freezing point temperature of equimolar solutions of urea, potassium chloride and sodium sulphate?*

Depression in freezing point is a colligative property. Hence the trend in freezing point is

Urea > KCl > Na_2SO_4

142. *Why in cold countries $CaCl_2$ is used to clear snow?*

When $CaCl_2$ is added to snow, the freezing point of snow (ice) decreases due to the impurities. Present in ice. As a result ice melts and ice gets cleared.

Osmosis and osmotic pressure

143. *What is osmosis?*

The flow of solvent molecules from lower concentrated solution to higher concentrated solution through a semipermeable membrane is called osmosis.

144. *What is semipermeable membrane?*

A membrane which allows the movement of only solvent molecules through it but not the solute particles is called semipermeable membrane.

145. *Give two examples for natural semi permeable membrane.*

Pig's bladder and cell membranes of the plants.

146. *Give two examples for artificial semi permeable membrane.*

Gelatinous copper ferrocyanide and gelatinous calcium phosphate.

147. *Give reason for the following*

a. Raw mangoes shrivel when pickled in brine (salt + water) solution
b. Blood cells collapse when suspended in saline water
c. Wilted flowers revive when placed in fresh water.

a. Due to exosmosis, water molecules of blood cells enter into the saline
b. Due to endosmosis, water molecules enter into the flowers
c. Due to exosmosis, water molecules of mango enters into brine solution.

148. *What are isotonic solutions? Give an example.* ***[M-15, M-18]***

Two solutions having the same osmotic pressure at a given temperature are called isotonic solution.

Example: RBC (Red blood cells) is isotonic with 0.9% $\left(\frac{w}{v}\right)$ NaCl solution which is called normal saline. IT is used in injections instead of distilled water.

149. *What is osmotic pressure?*

The external pressure applied on the concentrated solution to stop osmosis is called osmotic pressure. It is denoted by π.

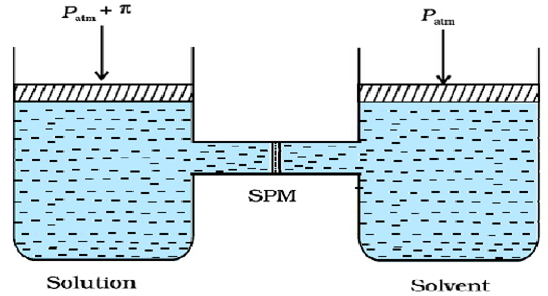


Fig. 2.10: *The excess pressure equal to the osmotic pressure must be applied on the solution side to prevent osmosis.*

150. *Derive an expression to calculate the molar mass of solute by osmotic pressure experiment.*

$$\pi \, \alpha \, C \ \ and \ \ \pi \, \alpha \, C$$

$$\therefore \pi \, CRT \ \ or \, \pi - n_B \, CRT$$

But $$C = \frac{1}{V} \ \ and \ \ n_B = \frac{w_B}{M_B}$$

$$\therefore \ \ \pi = \frac{w_B}{M_B} \times \frac{1}{V} RT \qquad \therefore M_B = \frac{w_B RT}{\pi V}$$

Where R = solution constant whose value is same as that of gas constant.
The above equation is used to calculate the molecular mass of a solute like polymers, proteins and other macromolecules.

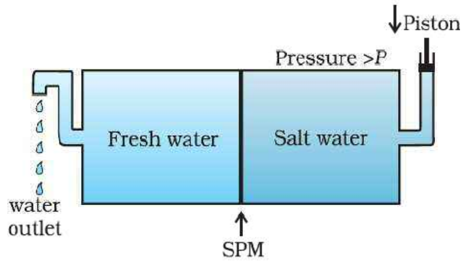
151. *Which of the following has high osmotic pressure?*
(i) Pure water (ii) 1 M glucose (iii) 1 M NaCl (iv) 1 M $CaCl_2$.

$1 \, MCaCl_2$ due to 3 particles $\left(1Ca^{2+} \ and \ 2Cl^-\right)$ in the solution.

152. *What are hypertonic solutions?*
The solutions whose osmotic pressure is higher than that of the given solution is called hypertonic solution.
Example: When RBC is placed in sea water, water passes out of the cell due to osmosis and the cell shrinks.

153. *What are hypotonic solutions?*
The solutions whose osmotic pressure is lower than that of give solution are called hypotonic solutions.
Example: When RBC is placed in hypotonic solution they swell and even burst due to the inflow of water due to osmosis.

154. *Explain the desalination of sea water (purification of water) by reverse osmosis.*
(Or) Write a note on reverse osmosis
The process of reversing the direction of osmosis by applying the pressure higher than the osmotic pressure to the solution of higher concentration is called **reverse osmosis.** During reverse osmosis, the pure solvent flows out of the solution through the semi permeable membrane. Reverse osmosis is used in desalination of sea water. When pressure, more than osmotic pressure (30 atm at 25^0C) is applied to the sea water, pure water is squeezed out of the sea water through the semipermiable membrane as shown in figure.



155. *Name the semi permeable membrane used in reverse osmosis.*
Cellulose acetate.

156. ***How does the size of blood cells change when placed in an aqueous solution containing.***
(i) more than 0.9% sodium chloride1% NaCl ***[M-15, M-19]***
(ii) less than 0.9% sodium chloride /0.5% NaCl /pure water?

(i) Size of the blood cells decrease

(ii) Size of the blood cells increase.

157. ***After removing the outer shell to two eggs in dilute HCl, one is placed in distilled water and the other is placed in saturated solution of NaCl. What will you observe and why?***

Egg in water swell and egg in NaCl solution shrinks because in water the solvent molecules enters into the egg cell (hypotonic). In NaCl solution egg shrinks because water flows out of the egg cell (hypertonic).

158. ***Name the only colligative property by which any of proteins and polymers can be measured precisely***

Osmotic pressure.

159. ***Why do dried fruits and vegetables swell when placed in water?***

Dry fruits and vegetables absorb water due to endo-osmosis and swell up.

160. ***Will osmosis take place when 0.05 M urea solution and 0.05 M glucose solution are separated by semi-permeable membrane?***

No, because the two solutions are isotonic in nature.

161. ***What happens when human RBC is kept in 0.9% saline solutions?***

It neither swells nor shrinks.

162. ***Give the relationship between osmotic pressure and temperature.***

$\pi =$ CRT, where π is the osmotic pressure, C is the concentration, R = gas constant and T = Absolute Temperature.

163. ***Are equimolar solutions of potassium chloride and sucrose isotonic?***

No. Potassium chloride is an electrolyte and gives $K^{+}ion$ and $Cl^{-}\,ion$ in water. While sucrose is a molecular solid and it does not dissociate into ions in water.

164. ***State van't Hoff-Boyle's law.***

The osmotic pressure π of a dilute solution is directly proportional to its concentration, provided the temperature is kept constant.

i.e. $\pi \alpha C$, at constant temperature.

165. ***State van't Hoff-Charle's law.***

The osmotic pressure of a dilute solution is directly proportional to the Absolute temperature, provided the concentration is kept constant.

i.e. $\pi \alpha \, C$, at constant temperature.

Abnormal molar mass

166. ***What is abnormal molar mass?***

The molar mass determined by colligative properties is found to be lower or higher than the expected or normal molecular mass. Such a molecular mass is called abnormal molecular mass. **OR**

A molar mass that is either lower or higher than the expected or normal value is called has abnormal molar mass.

167. *What is van't Hoff's factor?*

It is the ratio of normal molar mass to the abnormal molecular mass.

$$i = \frac{normal\ molar\ mass}{abnormal\ mass} \quad or \quad i = \frac{\text{observed colligativeProperty}}{\text{calculated colligative property}}$$

168. *Give the significance of van't Hoff's factor* ***[M-17, M-18]***

- If $i = 1$, the solute doesn't undergo either dissociation or association
- If $i > 1$, solute undergo dissociation
- If $i < 1$ solute undergo association

169. *Write the colligative properties for solutes undergo dissociation or association.*

- Elevation in boiling point, $\Delta T_b = iK_b m$
- Depression in freezing point, $\Delta T_f = iK_f m$
- Osmotic pressure $\pi = iCRT$
- Relative lowering of vapour pressure, $\frac{p^0 - p}{p^0} = ix_2$.

170. *What is the value of Van't Hoff factor (i) for the following compounds*

a) NaCl ***b) K_2SO_4*** ***[M-20]*** ***c) Sugar*** ***d) Glucose***

ans: a) 2 b) 3 c) 1 d) 1.

171. *Define the following:*

a) Exo-osmosis

The outward flow of water from a cell containing an aqueous solution through semi-permeable membrane is called Exo-osmosis

Example: Grape is in NaCl solution (Grape shrinks).

b) Endo-osmosis

The inward flow of water in to cell containing an aqueous solution through semi-permeable membrane is called Endo-osmosis.

Example: Grape is in water (Grape swell out)

172. *Normal molar mass of a solute is 246 g mol^{-1} and molar mass of the same in a solvent is 346 g mol^{-1}. What is the value of I ? comment on the state of the solute in the solvent.*

Vant off factor (i) $= \frac{observed\ molar\ mass}{Normal\ molar\ mass} = \frac{346}{246}$

$i = 1.4$. This indicates that some of the solute molecules are associated in the solvent.

173. *When is the value of Van't Hoff factor more than one?*

When solute in the solution undergoes dissociation.

174. *Define Van't Hoff factor (i) Give the value of 'i' for complete dimerisation of all the molecules of ethanoic acid in benzene.* ***[M-23]***

It is ratio of normal molar mass to the abnormal molar mass (or) it is ratio of number of particles formed after dissociation (or) association to the number of particles present before dissociation (or) association

$$i = \frac{Particles\ present\ after\ associaiton}{Particles\ present\ before\ associaiton}$$

Van't Hoff factor $(i) = \frac{1}{2} = 0.5$

PART – E NUMERICAL QUESTIONS

Molarity

175. ***Calculate the molarity of a solution containing 5g of $NaOH$ in $450\,mL$ solution.***

[NCERT solved problem]

Molar mass of $NaOH = M_B = 23+16+1 = 40\,g\,mol^{-1}$.

$$\text{Molarity} = \frac{W_B \times 1000}{M_B \times V}$$

$$\text{Molarity} = \frac{5\times 1000}{40\times 450} = 0.278\,M$$

176. ***Calculate the amount of benzoic acid $\left[C_6H_5COOH\right]$ required for preparing 250 mL of 0.15M solution in methanol.*** **[NCERT exercise problem]**

$$\text{Molarity} = \frac{W_B \times 1000}{M_B \times V}$$

$$0.15 = \frac{W_B \times 1000}{122\times 250}$$

$$W_B = \frac{0.15\times 122\times 250}{1000} = 4.578g$$

Molality

177. ***Calculate molality of 2.5 g ethanoic acid $\left(CH_3COOH\right)$ in 75 g of benzene.***

[NCERT exercise problem]

Given $W_B = 2.5g, W_A = 75g, M_B = 2\times 12 + 4\times 1 + 2\times 16 = 60g\,mol^{-1}$

$$\text{Molality} = \frac{W_B \times 1000}{M_B \times W_A} = \frac{W_B\times 1000}{M_B\times W_A}$$

$$\text{Molality} = \frac{2.5\times 1000}{60\times 75} = 0.5556m.$$

178. ***Calculate the mass of urea $\left(NH_2CONH_2\right)$ required in making 2.5 kg of 0.25 molal aqueous solution.*** **[NCERT intext problem]**

Given $W_B = ?, M_B = 2\times 14 + 4\times 1 + 12 + 15 = 60g\,mol^{-1}$,

mass of solution $= 2.5\,kg = 2500\,g, m = 0.25\ molal$

Mass of solute = number of moles of solute x molecular mass.

$= 0.25\times 60 = 15\,g$

Mass of solvent, $W_A = 2500 - 15 = 2485\,g$

$$\text{Molality} = \frac{W_B \times 1000}{M_B \times W_A}$$

$$0.25 = \frac{W_B \times 1000}{60\times 2485}$$

$$W_B = \frac{0.25\times 6\times 2485}{1000} = 37.275\,g$$

Mole fraction

179. ***Calculate the mole fraction of ethylene glycol $\left(C_2H_6O_2\right)$ in a solution containing 20% of $C_2H_6O_2$ by mass.*** ***[HOTS]*** **[NCERT example problem]**

20% ethylene glycol means 20g ethylene glycol present in 100 g solution (80g solvent).

$\therefore W_B = 20g, \therefore W_A = 100 - 20 = 80g,\ M_{C_6H_4O_2} = 62g\,mol^{-1}, M_{H_2o} = 18g\,mol^{-1}$.

Number of moles of $C_2H_6O_2 = n_B = \frac{W_B}{M_B} = \frac{20}{62} = 0.322\,mol$

Number of moles of $H_2O = n_A = \frac{W_A}{M_A} = \frac{80}{18} = 4.444\,mol.$

Mole fraction of ethylene glycol $= x_B = \frac{n_B}{n_A + n_B} = \frac{0.322}{4.444 + 0.322} = 0.0675$

180. ***Calculate (a) molality (b) molarity and (c) mole fraction of KI if the density of 20% (mass / mass) aqueous KI is*** $1.202\,mgL^{-1}$. **[HOTS]** **[NCERT intext problem]**

20% (w/w) aqueous KI solution means 20g KI is present in 100g of the solution.

Mass of KI $(W_B) = 20g, \therefore Mass\ of\ water = 100 - 20 = 80g$

Volume of solution $= \frac{mass\ of\ solution}{density\ of\ solution} = \frac{100g}{1.202g} = 83.1947\,mL.$

Molar mass of KI $(M_B) = 166\,g\,mol^{-1}, Molar\ mass\ of\ H_2O = M_A = 18\,gmol^{-1}$

Number of moles of $KI(n_B) = \frac{20}{166} = 0.12048\ mol$

Number of moles of water $(n_A) = \frac{80}{18} = 4.444\ mol$

(a) **Calculation of molality of KI**

$$Molality = \frac{w_B \times 1000}{M_B \times w_A} = \frac{20 \times 1000}{166 \times 80} = 1.506\,m$$

(b) **Calculation of molarity of KI**

$$Molality = \frac{w_B \times 1000}{M_B \times V} = \frac{20 \times 1000}{166 \times 83.1947} = 1.448\,M$$

(c) **Calculation of mole fraction of KI**

$$x_{KI} = \frac{n_B}{n_A + n_B} = \frac{0.12048}{4.444 + 0.12048} = \frac{0.12048}{4.56448} = 0.02639$$

181. ***In a binary solution, mole fraction of one component is 0.068. What is the mole fraction of another component?*** ***[J-18]***

1 – 0.068 = 0.932

Henry's Law

182. ***The solubility of*** CO_2 ***in water is*** $3.4 \times 10^{-2}\,M\ at\ 25^0C$ ***and 1 atm pressure. What is the Henry' law constant in M*** atm^{-1}***?***

$$S = K_H p$$

$$K_H = \frac{S}{P} = \frac{3.4 \times 10^{-2} M}{1\,atm} = 3.4 \times 10^{-2} M\ atm^{-1}$$

183. ***What pressure of CO_2 is required to keep the CO_2 concentration in a bottle of club soda bottle at 0.12M at $25^0 C\left(K_H = 3.4\times10^{-2} M\ atm^{-1}\right)$***

$$S = K_h p$$

$$K_H = \frac{S}{K_B} = \frac{0.12M}{3.4\times10^{-2} M\ \ atm^{-1}} = 3.529 atm.$$

184. ***If nitrogen gas is bubbled through water at 293K, how many millimole of $\mathbf{N_2}$ gas dissolve in 1 litre of water? Assume that $\mathbf{N_2}$ exerts a partial pressure of 0.987 bar. Given that Henry's law constant for N_2 at $293K$ is $76.48K\ bar$.*** ***[HOTS]*** ***[NCERT example]***

According to Henry's law.

$$p = K_H x$$

$$x_{N_2} = \frac{p}{K_H} = \frac{0.987\ bar}{76.48\times10^3\ bar} = 1.27\times10^{-5}$$

$$n_{H_2O} = \frac{Mass\ of\ 1L\ water}{Molecular\ mass} = \frac{1000g}{18} = 55.55\ mol$$

$$x_{N_2} = \frac{n_{N_2}}{n_{H_2O} + n_{N_2}}$$

$$1.29\times10^{-5} = \frac{n_{N_2}}{55.55 + n_{N_2}}$$

n_{N_2} in denominator is neglected as $n_{N_2} << 55.55$

$$\therefore\ 1.29\times10^{-5} = \frac{n_{N_2}}{55.5}$$

$$n_{N_2} = 55.55\times1.29\times10^{-5} = 71.66\times10^{-5}\ moles$$

$$\therefore n_{N_2} = 0.716\ m\ \ mol$$

185. ***$\mathbf{H_2S}$, a toxic gas with rotten egg smell, is used for qualitative analysis. If the solubility of $\mathbf{H_2S}$, in water at STP is 0.195 m, calculate Henry's law constant.***

[HOTS] [NCERT intext problem]

Solubility of $H_2S = 0.195\,m = 0.195$ mole in 1000g water.

$\therefore$ Mass of water = 1000g

Number of moles of water $= n_{H_2o} = \frac{1000}{18} = 55.55\ moles.$

Mole fraction of $H_2S = x_{H_2S} = \frac{n_{H_2S}}{n_{H_2}o + n_{H_2}s}$

$$= \frac{0.195}{55.55 + 0.195} = 0.003498$$

Pressure at STP = 0.987 bar

According to Henry's law

$$p = K_H x$$

$$K_H = \frac{p}{x_{H_2}s} = \frac{0.987}{0.003498} = 282.16\ bar$$

Raoult's law

186. *Heptane and octane form an ideal solution. At 373K, the vapour pressures of the two liquid components are 105.2 kpa and 46.8 kpa respectively. What will be the vapour pressure of a mixture of 26g heptanes and 35g of octane? [HOTS] [NCERT exercise equation]*

According to Raoult's law.

$$p_{octane} = x_{octane} \times p^{o}_{octane}$$

$$p_{heptane} \times x_{heptane} \times p^{0}_{heptane}$$

Molar mass of octane $(C_8H_{18}) = 8\times12+18\times1 = 114\,g\,mol^{-1}$

Molar mass of heptanes $(C_7H_{16}) = 7\times12+1\times16 = 100\,g\,mol^{-1}$

Number moles of octane $= \dfrac{w}{M} = \dfrac{35}{114} = 0.31\,mol$ '

Number of moles of heptanes $= \dfrac{w}{M} = \dfrac{26}{100} = 0.26\,mol$

Mole fraction of octane $= x_{octane} = \dfrac{n_{octane}}{n_{octane}+n_{heptane}} = \dfrac{0.31}{0.31+0.26} = 0.544$

$$x_{heptane} = 1 - x_{octane} = 1 - 0.544 = 0.456$$

$$p_{octane} = 0.544 \times 46.8\,kpa = 25.46\,kpa$$

$$P_{heptane} = 0.456 \times 105.2\,kpa = 47.97\,kpa$$

Total vapour pressure, $P_{total} = P_{octane} + P_{heptane}$

$$= 25.46 + 47.97 = 73.43\,kpa$$

Relative lowering of vapour pressure

187. *3 moles of urea is dissolved in 15 mol of a water. Calculate the relative lowering of vapour pressure.*

Relative lowering of vapour pressure $= \dfrac{n_B}{n_A + n_B} = \dfrac{3}{15+3} = 0.166$

188. *The vapour pressure of pure benzene at a certain temperature is 0.850 bar. When 0.5g of a non-volatile solute is added to 39.0g of benzene [molar mass of benzene 78g mol^{-1}] , vapour pressure of the solution is 0.845 bar. What is the molar mass of a non volatile solute?*

[MQP, J-17]

$$p_1^0 = 0.850\,bar,\ w_2 = 0.5g, w_1 = 39g$$

$$p_1 = 0.845\,bar, M_1 = 78g/mol, M_2 = ?$$

$$\frac{p_1^0 - p_1}{p_1^0} = \frac{w_2 \times M_1}{M_2 \times w_1}$$

$$\frac{0.85 - 0.845}{0.85} = \frac{0.5\times78}{M_2\times39}$$

$$M_2 = 170\,g\,mol^{-1}$$

189. *5.8g of a non volatile solute was dissolved in 100g of carbon disulphide (CS_2). The vapour pressure of the solution was found to be 190 mm of Hg. Calculate the molar mass of the solute. [Given the vapour pressure of pure CS_2 is 195 mm of Hg, Molar mass of CS_2=76 mol^{-1}] [M-16, J-18]*

$w_2 = 5.8, w_1 = 100g, p_1 = 190\,mm\ of\ Hg$

$p_1^0 = 195mm\ of\ Hg,\ M_1 = 76g/mol$

$M_2 = 2$

$$\frac{p_1^0 - p_1}{p_1^0} = \frac{w_2 \times M_1}{M_2 \times w_1}$$

$$\frac{195-190}{195} = \frac{5.8\times 76}{M_2 \times 100}$$

$$M_2 = \frac{5.8\times 76\times 195}{100\times 5}$$

$M_2 = 171.91g\,mol^{-1}$

190. ***Vapour pressure of benzene is 200mm of Hg. When 2g of non volatile solute is dissolved in 78g of benzene, benzene has a vapour pressure of 195 mm Hg. Calculate the molar mass of solute. (molecular mass of benzene =78 g/mol)*** ***[M-20]***

$P_1^0 = 200\,mm\ of\ Hg,\ w_2 = 2g,\ w_1 = 78g$

$p_1 = 195\,mm\ of\ Hg,\ M_1 = 78g/mol$

$M_2 = ?$

$$\frac{p_1^0 - p_1}{p_1^0} = \frac{w_2 \times M_1}{M_2 \times w_1}$$

$$\frac{200-195}{200} = \frac{2\times 78}{M_2 \times 78}$$

$$M_2 = \frac{2\times 200}{5} = 80g\,mol^{-1}$$

191. ***The vapour pressure of pure benzene at certain temperature is 0.850 bar. A non-volatile, non electrolyte solid weighing 0.5 g when added to 39.0 g of benzene (molar mass $78\,gmol^{-1}$). Vapour pressure of the solution then is 0.845 bar. What is the molar mass of the solid substance?***

Given, $w_B = 0.5g,\ p_A^0 = 0.850\ bar,\ p_A = 0.845\,bar, w_A = 39\,g,\ M_A = 78\,g\,mol^{-1}$

$$M_B = \frac{w_B \times M_A \times p_A^0}{w_A \times (p_A^0 - p_A)}$$

$$M_B = \frac{0.5\times 78\times 0.850}{39\times(0.850-0.845)} = 170\,g\,mol^{-1}$$

192. ***Vapour pressure of a water at 293K is 17.535 mmHg. Calculate the vapour pressure of water at 293 K when 25g of glucose is dissolved 450 g water.***
[HOTS] [NCERT exercise question]

Give, $w_B = 25g, p_A^0 = 17.535\,mm\,Hg, p_A = ?, w_A = 450g, M_A = 18\,g\,mol^{-1}$

Molar mass of glucose $(C_6H_{12}O_6) = M_B = 6\times 12.12\times 1 + 6\times 16 = 180g\,mol^{-1}$

Number of moles of glucose $= \dfrac{25\,g}{180\,g\,mol^{-1}} = 0.139\,mol$

Number of moles of water $= \dfrac{450g}{18\,g\,mol^{-1}} = 25\,mol$

According to Raoult's law $\frac{p_A^0 - p_A}{p_A^0} = \frac{n_B}{n_B + n_A}$

$$\frac{17.535 - p_A}{17.535} = \frac{0.139}{0.139 + 25}$$

$p_A =$ vapour pressure of solution

$$17.53 - p_A = \frac{0.139 \times 17.535}{25.139}$$

$$17.535 - p_A = 0.097$$

$$p_A = 17.535 - 0.097 = 17.44\,mm\,Hg$$

193. ***Calculate the mass of a non-volatile solute (molar mass 40g mol^{-1}) which should be dissolved in g octane to reduce its vapour pressure to 80%.***

[HOTS] [NCERT exercise question]

Molecular mass of octane $\left(C_8H_{18}\right) = M_A = 8 \times 12 + 18 \times 1 = 114 g\,mol^{-1}$

Vapour pressure of octane after dissolving solute $= \frac{80 p_A^0}{100} = 0.8 p_A^0$

$$\frac{p_A^0 - p_A}{p_A^0} = \frac{n_A}{n_A + n_B}$$

$$n_B = \frac{w_B}{40} mol, n_A = \frac{114}{114} = 1 mol$$

$$\therefore \frac{p_A^0 - 0.8 p_A^0}{p_A^0} = \frac{\frac{w_B}{40}}{\left[\frac{w_B}{40} + 1\right]} \Rightarrow \frac{p_A^0 - 0.8 p_A^0}{p_A^0} = \frac{w_B}{w_B + 40}$$

$$0.2 = \frac{w_B}{w_B + 40} \quad \therefore \quad w_B = 10g$$

Elevation in boiling point

194. ***18 g of glucose is dissolved in 1Kg of water in a saucepan. At what temperature will water boil at 1.013 bar? K_b for water is 0 .52 K $kg\,mol^{-1}$. [NCERT solved problem]***

$$\Delta T_b = \frac{K_b \times w_b \times 1000}{M_B \times w_A}$$

Given,

$w_A = 1Kg = 1000g, K_b = 0.52\,K\,kgmol^{-1}, w_B = 18g, T_b^0 = 373.15K.$

$$T_b - T_b^0 = \frac{0.52 \times 18 \times 1000}{180 \times 1000} = 0.052K$$

$$T_b = 0.052 + T_b^0 = 0.052 + 372.15 = 373.202K$$

195. ***The boiling point of benzene is 353. 23K. When 1.80g of a non volatile solute was dissolved in 90g of benzene, the boiling point is raised to 354.11K. Calculate the molar mass of the solute. (K_b for benzene =2.53 K kg mol^{-1}) [NCERT solved problem] [M-18]***

$$w_2 = 1.80g, w_1 = 90g, M_2 = ?$$

$$\Delta T_b = T_b - T_b^0 = 354.11K - 353.23K = 0.88K$$

$$M_2 = \frac{K_b \times w_2 \times 1000}{\Delta T_b \times w_1} = \frac{2.53 \times 18 \times 1000}{0.88 \times 90}$$

$$M_2 = 57.5 g\, mol^{-1}$$

196. Boiling point of water at 750 mm Hg is 99.63^{0}C. How much sucrose is to be added to 500g of water such that it boils at 1000C, Molal elevation constant for water is 0.52 K kg mol^{-1}. **[NCERT intext question]**

Elevation of boiling point $\Delta T_b = (100+273)-(99.63+273) = 0.37K$

Molar mass of sucrose $(C_{12}H_{22}O_{11}), M_B = 12\times12 + 22\times1 + 11\times16 = 342\, g\, mol^{-1}$

$$w_B = \frac{\Delta T_b \times M_B \times w_A}{K_b \times 1000}$$

$$w_B = \frac{0.37 \times 342 \times 500}{0.52 \times 1000} 121.67\, g$$

197. The boiling point of a solution of 0.1050g of a substance in 15.84 g of ether was found to be 0.1 K higher than that of ether. What is the molecular weight of the substance. $(K_b = 2.02\, K\, kg\, mol^{-1})$

$$M_B = \frac{K_b \times w_B \times 1000}{\Delta T_b \times w_A}$$

$$M_B = \frac{2.02 \times 0.1050 \times 1000}{0.1 \times 15.84} = 133.9\, g\, mol^{-1}$$

Depression in freezing point

198. ***(a) 1.00g of non-electrolyte solute dissolved in 50g of benzene lowered the freezing point of benzene by 0.40K. Find the molar mass of the solute. [Give: Freezing point depression constant of benzene = 5.12Kk mol^{-1}]*** ***[M-17, M-23]***

$w_2 = 1.0g, w_1 = 50g, \Delta T_f = 0.40K,\ M_2 = ?$

$$M_2 = \frac{K_f \times w_2 \times 1000}{\Delta T_f \times w_1} = \frac{5.12 \times 1.0 \times 1000}{0.40 \times 50}$$

$$M_2 = 256\, g\, mol^{-1}$$

199. ***1.00g of non-electrolyte solute dissolved in 50g of benzene lowered the freezing point of benzene by 0.40K. The freezing point depression constant of benzene is 5.12 K kg mol^{-1}. Find the molecular mass of the solute.*** ***[NCERT solvent problem]***

$$M_B = \frac{K_f \times w_B \times 1000}{\Delta T_f \times w_A}$$

$$M_B = \frac{5.12 \times 1.00 \times 1000}{0.4 \times 50} = 256\, g\, mol^{-1}$$

200. Calculate the mass of ascorbic acid (Vitamin C, $C_6H_8O_6$) to be dissolved in 75 g acetic acid to lower its melting point by 1.50^{0}C. $K_f = 3.9\, K\, kg\, mol^{-1}$.

[NCERT exercise question]

Molar mass of ascorbic acid $(C_6H_8O_6), M_B = 6\times12 + 8\times1 + 6\times16 = 176\, g\, mol^{-1}$

Lowering of melting pint, $\Delta T_f = 1.5\, K$

$$\Delta T_f = \frac{K_f \times w_B \times 1000}{M_B w_A}$$

$$w_B = \frac{\Delta T_f \times M_B \times w_A}{K_f \times 1000} = \frac{1.5 \times 176 \times 75}{3.9 \times 1000} = 5.0769\, g$$

201. A solution containing 18g of non-volatile non-electrolyte solute dissolved in 200g of water, freezes at 272.07K. Calculate the molecular mass of solute. Given $K_f = 1.86\,K$ kg/mol, Freezing point of water = 273 K. **[M-15]**

$$w_2 = 18g, w_1 = 200g, M_2 = ?$$

$$\Delta T_f = T_f^0 - T_f = 273 - 272.07 = 0.93K$$

$$M_2 = \frac{K_f \times w_2 \times 1000}{\Delta T_f \times w_1}$$

$$M_2 = \frac{1.86 \times 18 \times 1000}{0.93 \times 200} = 180 g\, mol^{-1}$$

202. 31g of an unknown molecular material is dissolved in 500g of water. The resulting solution freezes at 271.14K. Calculate the molar mass of the material.
[Given: K_f for water =1.86K $kg\, mol^{-1}, T_f^0$ of water = 273K]. **[M-19]**

$$w_2 = 31g, w_1 = 500g, M_2 = ?$$

$$\Delta T_f = T_f^0 - T_f = 273 - 271.14 = 1.86K$$

$$M_2 = \frac{K_f \times w_2 \times 1000}{\Delta T_f \times w_1}$$

$$M_2 = \frac{1.86 \times 31 \times 1000}{1.86 \times 500} = 62\, g\, mol^{-1}$$

203. 45g of ethylene glycol $(C_2H_6O_2)$ is mixed with 600 g of water. Calculate (a) the freezing point depression and (b) the freezing point of the solution $(K_f = 1.86K\, kg\, mol^{-1})$

[HOTS] [NCERT solved problem]

Freezing point depression (ΔT_f) is given by $\Delta T_f = \frac{K_f \times w_B}{M_b \times w_A} \times 100$

Molecular mass of ethylene glycol $(C_2H_6O_2) = 212 + 6 \times 1 + 2 \times 16 = 62\, g\, mol^{-1}$

$$\Delta_f = \frac{1.86 \times 45 \times 1000}{62 \times 600}$$

$$\Delta T_f = 2.25K, \Delta T - f = T_f^0 - T_f$$

T_f^0 =freezing point of water $= 273.15\,K, T_f =$ freezing point of solution.

$$T_f = T_f^0 - \Delta T_f$$

$$T_f = 273.15 - 2.35 = 270\,K$$

204. 1.4 g acetone dissolved in 100g benzene gave a solution which freezes at 277.12K. Pure benzene freezes at 278.4K. 2.8g of a solute dissolved in 1000g of benzene gave a solution which froze at 277.76K.

$$K_f = \frac{\Delta T_f \times w_A \times M_B}{w_B \times 1000}$$

$$\Delta T_f = T_f^0 - T_f = 278.4 - 277.12 = 1.28K$$

$$= \frac{1.28 \times 100 \times 58}{1.4 \times 1000} = 5.3\,K\,kg\,mol^{-1}$$

$$M_B = \frac{K_f \times w_B \times 1000}{\Delta T_f \times w_A} = \frac{5.3 \times 2.8 \times 1000}{0.64 \times 100} = 231.87\ g\,mol^{-1}$$

Osmotic pressure

205. ***The osmotic pressure of blood is 7.65 atm at 37^{0}C. How much glucose should be used per litre for an intravenous injection that is to have the same osmotic pressure as blood? (Molar mass of glucose $= 180\,g\,mol^{-1}$)***

$$M_B = \frac{w_B RT}{\pi V} \ or \ w_B = \frac{M_B \pi V}{RT}$$

$$\therefore w_B = \frac{180\,g\,mol^{-1} \times 7.65\,atm \times 1L}{0.0821\,L\,atm\,mol^{-1}K^{-1}310\,K} = \frac{1377}{25.451} = 54.1\,g\,mol^{-1}$$

206. ***300 cm^3 of an aqueous solution of a protein contains 2.12g of the protein. The osmotic pressure of such a solution at 300 K is found to be 3.89×10^{-3} bar. Calculate the molar mass of the protein. [r=0.0823 l BAR $mol^{-1}K^{-1}$]*** **[J-16]**

$$V = 300\,cm^3 = 0.3L, w_2 = 2.12g, T = 300K$$

$$\pi = 3.89 \times 10^{-3} bar, M_2 = ?$$

$$M_2 = \frac{w_2 RT}{\pi V}$$

$$M_2 = \frac{2.12 \times 0.0823 \times 300}{3.89 \times 10^{-3} \times 0.3} = 44,852.44\,g\,mol^{-1}$$

207. ***450 cm^3 of an aqueous solution of a protein contains 1.0g of the protein. The osmotic pressure of such a solution at 300 K is found to be 3.1×10^{-4} bar. Calculate the molar mass of the protein. [r =0.083 L bar $mol^{-1}K^{-1}$]*** **[M-23]**

$$V = 450\,cm^3 = 0.450\,L$$

$$w = 1g, T = 310\,K$$

$$\pi = 3.1 \times 10^{-4}\ bar$$

$$M_2 = \frac{w_2 \times R \times T}{\pi V}$$

$$M_2 = \frac{1.0.083 \times 310}{3.1 \times 10^{-4} \times 0.450} = 184444\,g\,mol^{-1}$$

208. ***What is the osmotic pressure of 0.05% urea solution in water at 20^0C ?R = 0.821 lit atm $mol^{-1}K^{-1}$ molar mass of ureac $= 60g\,mol^{-1}$*** **[J-16]**

0.05% urea menas 0.05g urea present in 100 mL water.

$$\pi = \frac{w_B RT}{M_B V}$$

$$\pi = \frac{0.05 \times 0.0821 \times 293}{60 \times 0.1L} \qquad (\because 100\,mL = 0.1\,L)$$

$$\pi = 0.2\,amt$$

209. $200cm^3$ ***of an aqueous solution of a protein contains 1.26 g of the protein. The osmotic pressure of such a solution at 300 K is found to be*** $2.57\times10^{-3}\,bar$ ***bar. Calculate the molar mass of the protein.*** $\left(R=0.083\,L\,bar\,mol^{-1}K^{-1}\right)$

[NCERT solved]

$$M_B=\frac{w_B RT}{\pi V} \qquad V=200cm^3=0.2\,L$$

$$M_B=\frac{1.26\times0.083\times300}{2.57\times10^{-3}\times0.2} \quad 61039\,g\,mol^{-1}$$

210. ***Calculate the osmotic pressure in pascals exerted by a solution prepared by dissolving 1.0 g of polymer of molar mass 185000 in 450mL of water at*** $37^0C\left(R=0.0821\,atm\,K^{-1}\,mol^{-1}\right)$

$$\pi=\frac{w_B RT}{M_B V} \qquad V=450\,mL=0.45\,L$$

$$\pi=\frac{1\times0.0821\times310}{185000\times0.45}=0.00030572$$

$$\pi=0.00030572\times101325=30.9768\,Pa.$$

211. A 4% solution of a non-voltatile sooute is isotonic with 0.702% urea solution. Calculate the molar mass of the non-volatile solute. [Molar mass of urea = 60 g mol^{-1})

[NCERT Examples]

For isotonic solutions $\left(\frac{w_2}{M_2}\right)_{urea}=\left(\frac{w_2}{M_2}\right)_x$

$$(M_2)_x=\frac{4\times60}{0.702}=341.8g/mol$$

MCQ's

1. The term homogenous mixtures signify that:

a) Both composition and properties are uniform throughout the mixture.

b) Its properties are uniform throughout the mixture.

c) Its composition in uniform throughout the mixture.

d) Neither composition nor properties are uniform throughout the mixture.

Ans: (a) Explanation:

In homogeneous mixtures composition and properties both are uniform throughout the mixture.

2. Which of the following is not a gaseous solution?

(a) camphor in nitrogen gas

(b) chloroform mixed with nitrogen gas

(c) solution of hydrogen in palladium

(d) mixture of oxygen and nitrogen

Ans: (c) Explanation:

In gaseous solution solvent is a gas and solute may be the gas (or) liquid (or) solid.

3. Which one of the given below is the liquid solution

(a) amalgam of mercury and sodium

(b) chloroform mixed with nitrogen gas

(c) glucose dissolved in water

(d) copper dissolved in gold

Ans: (c) Explanation:

In liquid solution solvent is liquid and solute may be the gas (or) liquid (or) solid.

4. Which one of the following is not a solid solution

(a) camphor in nitrogen gas

(b) solution of hydrogen in palladium .

(c) amalgam of mercury and sodium

(d) Copper dissolved in gold

Ans: (a) Explanation:

In solid solution solvent is a solid and solute may be the solid (or) liquid (or) gas.

5. A beaker contains a solution of substance 'A' precipitation of substance 'A' takes place when small amount of 'A' is added to the solution. The solution is ______.

(a) saturated (b) supersaturated
(c) unsaturated (d) concentrated

Ans: (b) Explanation:

A supersaturated solution is one in which on adding small amount of solute at given temperature and pressure the solute molecules does not dissolved and precipitates.

6. Type of the solution obtained when copper dissolved in gold is

(a) Heterogeneous mixture
(b) Gaseous solution
(c)- Liquid solution
(d) Solid solution

Ans: (d) Explanation:

Copper is a solid dissolved in gold solid $\therefore$ It is a solid solution.

7. Molarity of the solution is number of moles of the solute dissolved in

(a) 1 kg of solvent (b) 1 kg of solution
(c) 1 L of the solvent (d) 1 L of the solution

Ans: (d) Explanation:

Number of moles of solute dissolved in 1 lit of solution called molarity

8. Molarity of a solution

(a) Increases with increase in temperature
(b) Decreases with increase in temperature
(c) Remains same at all temperature
(d) May increase or decrease with increase with temperature depending of the solvent

Ans: (b) Explanation:

$M = \frac{n}{v(Lit)}$ as the temperature increases,

volume of solution increases as a result molarity decreases.

9. Unit for molarity is

(a) $g\,Lit^{-1}$ (b) $mol\,Lit^{-1}$
(c) $mol\,kg^{-1}$ (d) $g\,kg^{-1}$

Ans: (b) Explanation:

$M = \frac{n}{v(Lit)}$ units: $mol\,Lit^{-1}$

10. Molali1ty of a solution is number of moles of the solute dissolved in

(a) 1 kg of solvent
(b) 1 kg of the solution
(c) 1 Litre of the solvent
(d) 1 Litre of the solution

Ans: (a) Explanation:

Number of moles of solute dissolved in 1 kg of solvent is called molarity

11. Unit for molality is

(a) $mol\,L^{-1}$ (b) $mol\ kg^{-1}$
(c) mol kg (d) $g\,kg^{-1}$

Ans: (b) Explanation:

$m = \frac{n}{W_A(kg)}$ unit: $mol\,kg^{-1}$

12. If the solute is present in-trace quantities in a solution, its concentration is generally expressed as

(a) Molarity (b) Molality
(c) parts per million (d) Mole fraction

Ans: (c) Explanation:

parts per million

13. Solubility of a solid in a liquid does not depend on

(a) Nature of the solute
(b) Nature of the solvent
(c) pressure
(d) Temperature

Ans: (c) Explanation:

Solubility of solid in liquid independent of pressure

14. Solubility of a gas in a liquid

(a) Increases with increase in temperature
(b) Decrease with increase in temperature
(c) Unaffected on changing the temperature
(d) Decrease with increase in pressure

Ans: (b) Explanation:

Solubility $\alpha \frac{1}{temperatrure}$

because exothermic process

15. According to Henry's Law the partial pressure of the gas in the vapour phase is proportional to its

(a) Molarity (b) Molality
(c) mole fraction (d) mass percentage

Ans: (c) Explanation:

$P \alpha X$

$\boxed{p = K_H X}$

16. A solution in which no more solute can be dissolved at the same temperature and pressure is called

(a) Saturated solution
(b) Unsaturated solution

(c) Super saturated solution
(d) Dilute solution

Ans: (a) Explanation:

Saturated solution

17. An unsaturated solution in which

(a) Some more quantity of solute can be dissolved in it
(b) Precipitation takes place
(c) Dynamic equilibrium is attained between solute and solvent
(d) Solubility of this solution does not depends on temperature

Ans: (a) Explanation:

The solution in which some more quantity of solute can be dissolved called un saturated solution.

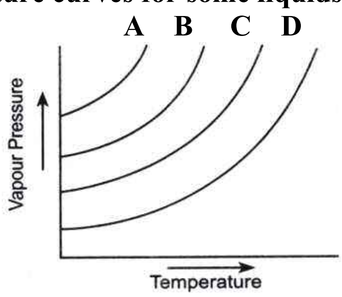
18. The name of the disease caused to the people living at high altitudes or mountain climbers due to low concentration of oxygen in blood is

(a) Anoxia (b) Bends
(d) Beri Beri (d) Goitre

Ans: (a) Explanation:

Anoxia

19. The given graph shows the vapour pressure, temperature curves for some liquids.



Liquids A, B C and D respectively are.

a) Ethyl alcohol, acetone, diethyl ether, water
b) Water, ethyl alcohol, acetone, diethyl ether
c) Acetone, ethyl alcohol, diethyl ether, water
d) Diethyl ether, acetone, ethyl alcohol, water

Ans: (d) Explanation:

The vapour pressure increase with decrease in intermolecular forces and increase in temperature. As when temperature increases the molecular forces are weak end the bonds are broken between molecules. When the forces are weak, the liquid has high volatility and maximum vapour pressure. Diethyl ether has highest vapour pressure while water has lowest vapour pressure.

20. To avoid the bends during scuba diving, the tanks used by scuba divers are filled with air diluted with

(a) 11.7% helium, 32.1% oxygen and 56.2% nitrogen
(b) 32.1% helium, l 1.7% oxygen and 56.2% nitrogen
(c) 11.7% nitrogen, 32.1% helium and 56.2% oxygen
(d) 11.7% helium, 56.2% oxygen and 32.1% nitrogen

Ans: (a) Explanation:

11.7% helium, 32.1% oxygen and 56.2% nitrogen

21. In a solution containing two volatile liquids, the partial vapour pressure of each component in the solution is directly proportional to its mole fraction present in the solution. This statement is called

(a) Henry's law
(b) Raoult's law of liquid solutions
(c) Dalton's law of pressure
(d) Boyle's law

Ans: (b) Explanation:

Raoult's law $P_A = X_A P_A^0$

22. Raoult's law as a special case

(a) Henry's law (b) Boyle's law
(c) Charle's law (d) Dalton's law

Ans: (a) Explanation:

Henry's law

23. When non volatile solute is added to volatile solvent, the vapour pressure of solvent at constant temperature.

(a) decreases
(b) increases
(c) may decrease or increase
(d) no change in the vapour pressure

Ans: (a) Explanation:

When non volatile solute is added to pure volatile solvent its vapour pressure is decreases.

24. The solutions which obey Raoult's law over the entire range of concentration are known as

(a) ideal solutions
(b) dilute solutions
(c) concentrated solutions
(d) non ideal solutions

Ans: (a) Explanation:

Ideal solutions obey the Raoult's law

25. K_H value is the function of the nature of gas. If the K_H value of the gas is more, the gas is

(a) more soluble
(b) less soluble
(c) No change in its solubility
(d) cannot be predicted

Ans: (b) Explanation:

$$P = K_H X,\ K_H = \frac{P}{X}$$

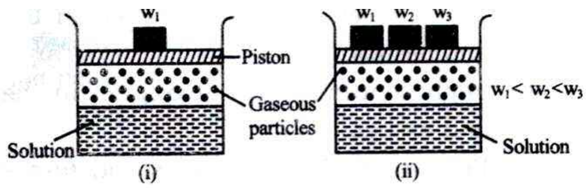
$$K_H\ \alpha \frac{1}{solubility}, K_H \times Temperate$$

26. Which is an example for ideal solution
(a) Acetone + chloroform
(b) Phenol + Aniline
(c) Ethanol + Acetone
(d) Benzene + Toluene

Ans: (d) Explanation:

Ideal solutions,
benzene + toluene
n – hexane + n-heptane
ethyl chloride + ethyl bromide
$CCl_4 + SiCl_4$

27. Consider the two figures given below,



Which one of the following statements regarding the experiment is true?
a) The solubility of a gas remains unaffected by change in weights.
b) The solubility of a gas is equal in both beakers.
c) The solubility of a gas in beaker (i) is less than that in beaker (ii).
d) The solubility of a gas in liquid in beaker (i) is greater than that in beaker (ii).

Ans: (c) Explanation:

The solubility of gas in a liquid increases with increase in pressure and is directly proportional to the pressure of the gas.

28. Which of the following is a non ideal solution
(a) n-hexane + n-heptane
(b) carbon disulphide + Acetone
(c) bromoethane + chloroethane
(d) Benzene + toluene

Ans: (b) Explanation:

$CS_2 + Acetone$

29. Which of the following is an example for non ideal solution with negative deviation
(a) Phenol + Aniline
(b) n-hexane + n-heptane
(c) Carbon disulphide + Acetone
(d) Ethanol + Acetone

Ans: (a) Explanation:

Phenol + Aniline

30. Azeotropes are binary mixtures having
(a) same composition in liquid and vapour phase and boil at constant temperature
(b) different composition in liquid and vapour phase and boil at constant temperature
(c) same composition in liquid and vapour phase and boil at different temperature
(d) different composition in liquid and vapour phase and boil at different temperature

Ans: (a) Explanation:

Azeotropic mixtures having same composition in both liquid and vapour phase and boils at constant temperature.

31. The solutions which show a large positive deviation from Raoult's law form
(a) Minimum boiling point azeotrope
(b) Maximum boiling point azeotrop
(c) Minimum or maximum boiling point azeotrope
(d) No azeotrope

Ans: (a) Explanation:

The solutions which shows large +ve deviation from Raoults law can form minimum boiling azeotrope

32. The solutions that show large negative deviation from Raoult's law form
(a) Minimum boiling point azeotrope
(b) Maximum boiling point azeotrope
(c) Minimum or maximum boiling point azeotrope
(d) No azeotrope

Ans: (b) Explanation:

Max boiling azeotrope

33. Example for maximum boiling point azeotrope is
(a) Nitric acid (68%) and Water (32%)
(b) Nitric acid (32%) and water (68%)
(c) Ethanol and water
(d) Bromoethane and chloroethane

Ans: (a) Explanation:

Nitric and (6.8%) and water (38%) by mass

34. Colligative properties depend on

(a) Nature of solvent
(b) Nature of solute
(c) Number of solute particles present in the solution
(d) Number of solvent particles present in the solution

Ans: (c) Explanation:

Colligative properties depends on number of solute particles present in the solution.

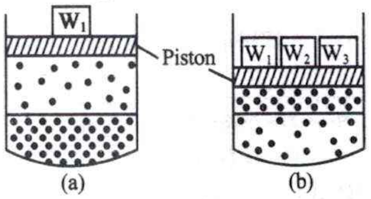
35. Which of the following is not the colligative property?

(a) Relative lowering of vapour pressure
(b) Elevation in the boiling point
(c) Freezing point
(d) Osmotic pressure

Ans: (c) Explanation:

Colligative properties RLVP. Eleviation in bp depression in freezing point osmatic pressure lowering of vapour pressure etc.,

36. On the basis of the figure given below which one of the following is not ture?



a) Rate at which gaseous particles are striking the solution to enter it, increases.
b) Rate at which gaseous particles are striking the solution to enter it, decreases.
c) In figure (b) on compressing the gas number of gaseous particles per unit volume over the solution increases.
d) In figure (a) assuming the state of dynamic equilibrium rate of gaseous particles entering and leaving the solution phase is same.

Ans: (b) Explanation:

On increasing the pressure over the solution phase by compressing the gas to a smaller volume (in fig. b) increases the number of gaseous particles per unit volume over the solution and also the rate at which the gaseous particles are striking the surface of solution to enter it. The solubility of the gas will also increase until a new equilibrium is reached resulting in an increase in the pressure of a gas above the solution and thus its solubility increases.

37. Relative lowering of vapour pressure of solution containing non volatile solute is equal to of solute

(a) mole fraction (b) molarity
(c) molality (d) parts per million

Ans: (a) Explanation:

$$\frac{P^0 - P}{P^0} = X_2$$

X_2 = mole fraction of solute.

38. When non volatile solute is added to volatile solvent, the boiling point of solvent

(a) Decreases
(b) Increases
(c) No change
(d) Either decreases or increases

Ans: (b) Explanation:

When non volatile solute is added to pure votalite solvent vapour pressure decreases and bp increases.

39. Elevation in boiling (ΔT_b) point is directly proportional to

(a) Molar concentration of the solute in the solution
(b) Mass percentage of the solute in the solution
(c) Volume percentage of the solute in the solution
(d) Molal concentration of the solute in the solution

Ans: (d) Explanation:

$\Delta T_b \alpha\, m$,

$\Delta T_b = K_b m$

40. The unit of molal elevation constant (K_b) is

(a) Mole per dm^3 (b) mole per kg
(c) $JK^{-1}1mol^{-1}$ (d) $K\ kg\ mol^{-1}$

Ans: (d) Explanation:

$$\Delta T_b = K_b m,\ K_b = \frac{\Delta T_b}{m}, K\ kg\ mol^{-1}$$

41. Depression in freezing (ΔT_f) point is directly proportional to

(a) Molar concentration of the solute in the solution
(b) Mass percentage of the solute in the solution
(c) Volume percentage of the solute in the solution
(d) Molal concentration of the solute in the solution

Ans: (d) Explanation:

$\Delta T_f = K_f m$

42. The unit of molal depression constant (K_b) is

(a) Mole per dm^3 (b) mole per kg

(c) $JK^{-1}\ mol^{-1}$ (d) $K\ kg\ mol^{-1}$

Ans: (d) Explanation:

$\Delta T_f = K_f m,$

$K_f = \frac{\Delta T_f}{m} \therefore K\ kg\ mol^{-1}$

43. During osmosis, solvent molecules are

(a) moving from lower concentrated solution to higher concentrated solution through semipermeable membrane

(b) moving from higher concentrated solution to lower concentrated solution through semipermeable membrane

(c) no movement of solvent molecules

(d) solute molecules are moving from higher concentrated solution to lower concentrated solution.

Ans: (a) Explanation:

Spontaneous flow of solvent molecule from lower concentration to higher concentrate (or) Dilute solution to concentrate solution called osmosis.

44. The movement of solvent molecules can be stopped during osmosis by applying extra pressure on

(a) lower concentrated solution

(b) higher concentrated solution

(c) on either side of the solution

(d) osmosis cannot be stopped

Ans: (b) Explanation:

The excess of pressure must be applied on solution to stop osmosis called osmatic pressure.

45. The extra pressure applied to higher concentrated solution to stop osmosis is called

(a) osmotic pressure

(b) vapour pressure

(c) dynamic pressure

(d) atmospheric pressure

Ans: (a) Explanation:

The excess of pressure must be applied on solution to stop osmosis called osmatic pressure.

46. Raw mangoes shrivel when pickled in brine (0.9% NaCl in water) due to

(a) Osmosis (b) diffusion

(c) vapourisation (d) condensation

Ans: (a) Explanation:

Osmosis.

47. Which of the following is naturally occurring semipermeable membrane

(a) pig's bladder (b) parchment

(c) cellophane (d) both (a) and (b)

Ans: (d) Explanation:

Pigblader , animal membrane, parchment

48. Two solutions having same osmotic pressure at given temperature are called

(a) Hypertonic solutions

(b) Hypotonic solutions

(c) Isotonic solutions

(d) Dilute solutions

Ans: (c) Explanation:

The solutions which are having same osmatic pressure called isotonic solution.

49. A solution having more osmotic pressure (more concentrated) with respect to other solution is called

(a) Hypertonic solutions

(b) (Hypotonic solutions

(c) Isotonic solution

(d) Dilute solutions.

Ans: (a) Explanation:

Hypertonic solution.

50. Hypotonic solution has osmotic pressure with respect to other solution.

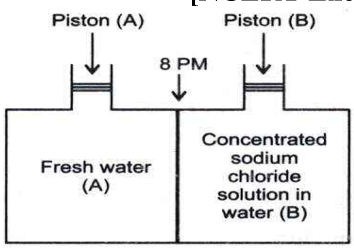
(a) less (b) more

(c) same (d) either less or more

Ans: (a) Explanation:

Solution having less asmatic pressure than given solution called hypotonic solution.

51. Consider the Fig. and mark the correct options [NCERT Exemplar]



a) Water will move from side (A) to side (B) if a pressure lower than osmotic pressure is applied on piston (B).

b) Water will move from side (B) to side (A) if a pressure greater than osmotic pressure is applied on piston (B).

c) Water will move from side (B) to side (A) if a pressure equal to osmotic pressure is applied on piston (B).
d) Water will move from side (A) to side (B) if pressure equal to osmotic pressure is applied on piston (A).

Ans: (b) Explanation:

Water will move from side B(concentrated sodium chloride solution) to side A (fresh water) if a pressure greater than osmotic pressure is applied on piston B.

52. Wilted flowers revive when placed in fresh water due to
(a) osmosis (b) osmotic pressure
(c) diffusion (d) vapourisation

Ans: (a) Explanation:

Osmosis

53. Water movement from soil into plant root and into upper portion of the plant is partly due to
(a) osmosis (b) diffusion
(c) high pressure (d) low pressure

Ans: (a) Explanation:

Osmosis.

54. The direction of osmosis can be reversed (reverse osmosis) by
(a) applying pressure larger than the osmotic pressure to the higher concentrated solution.
(b) applying pressure lesser than the osmotic pressure to the higher concentrated solution.
(c) by increasing temperature of the solution
(d) by decreasing temperature of the solution

Ans: (a) Explanation:

Reverse osmosis is due to applying pressure higher than the osmotic pressure on lighten concentration solution.

55. Example for reverse osmosis is
(a) Desalination of sea water
(b) Raw mangoes shrivel when pickled in brine
(c) blood cells collapse when suspended in saline water
(d) wilted flowers revive when placed in fresh water

Ans: (a) Explanation:

Desalination of sea water

56. Which of the following is not the reason for the abnormal molar mass measured by its colligative properties?
(a) Association of the solute
(b) dissociation of the solute
(c) Either association or dissociation
(d) No association or dissociation

Ans: (d) Explanation:

Abnormal molar mass of solute is measured when solute dissolute (or) associate.

57. If the solute dissociates in the solution vant Hoff factor is
(a) > 1 (b) < 1
(c) $= 0$ (d) $= 1$

Ans: (a) Explanation:

For dissociation Vant' Hoff factor $i > 1$.

58. When blood cells are put in 0.9% (mass volume) sodium chloride solution then
(a) shrink (b) swell
(c) remains same in size (d) they burst

Ans: (c) Explanation:

In isotonic solution RBC neither swell nor shrink.

59. When blood cells are put in hypotonic solution (con of NaCl < 0.9% mass by vol.) they
(a) swell (b) shrink
(c) remains same in size (d) none

Ans: (a) Explanation:

In hypotonic solution RBC will swell

60. The colligative property generally used for measuring the molar mass of polymers, proteins and biomolecules is
(a) Osmotic pressure
(b) Elevation of boiling point
(c) Relative lowering of vapour pressure
(d) Depression of freezing point

Ans: (a) Explanation:

Molar mass of polymers like protein, biomoleucle by osmatic pressure.

61. In which of the following case $i \neq 1$ in their solution
(a) Glucose (b) Urea
(c) Sucrose (d) NaCl

Ans: (d) Explanation:

For electrolyte $i \neq 1$.

62. Which of the following concentration terms is / are independent of temperature?
a) Molality only
b) Molality and mole fraction
c) Molarity and mole fraction
d) Molality and normality.

Ans: (b) Explanation:

Molality and mole fraction indepent of temperature of temperature.

63. Which of the following statements is wrong concerning ideal solutions? Ideal solutions can be formed when their components

a) have zero heat of mixing

b) have zero volume change on mixing

c) obey Raoult's law

d) can be converted into ideal gases.

Ans: (c) Explanation:

Ideal solutions don't converted in to ideal gases.

64. At higher altitudes, the boiling point of Water lowers because:

a) Atmospheric pressure is low

b) Temperature is low

c) Atmospheric pressure is high

d) None of these.

Ans: (a) Explanation:

At higher altitude boiling point is less due to less atmospheric pressure.

65. The osmotic pressure of equimolar solutions of glucose, sodium chloride and barium chloride will be in the order:

a) $BaCl_2$ > NaCl > glucose

b) $BaCl_2$ > glucose > NaCl

c) Glucose > $BaCl_2$ > NaCl

d) NaCl > $BaCl_2$ > glucose

Ans: (a) Explanation:

$\pi \, \alpha \, iC, BaCl_2 \; i=3, NaCl \; i=2, \; glucose \; i=1$

66. The ratio of the value of any colligative property for KCl solution to that for sugar solution is nearly.

a) 1 .0 b) 0.5

c) 2.0 d) 2.5

Ans: (c) Explanation:

Colligative property $\alpha \; iC, \therefore \frac{2}{1} = 2$

67. Equal amounts in grams of following substances were dissolved in equal amount of water. Which of these will have the highest boiling point?

a) Urea (NH_2CONH_2)

b) Glucose ($C_6H_{12}O_6$)

c) Sodium chloride (NaCl)

d) Calcium chloride ($CaCl_2$)

Ans: (c) Explanation:

$T_b \; \alpha \; iC$

Urea $= 1 \times \frac{1}{60} = 0.0166$

Glucose $1 \times \frac{1}{80} = 0.0055$

$NaCl \; 2 \times \frac{1}{58.5} = 0.0341$

$CaCl_2 \; 3 \times \frac{1}{111} = 0.027$

68. What is the effect of the addition of sugar on the boiling and freezing points of water?

a) Both boiling point and freezing point increases

b) Both boiling point and freezing point decreases

c) Boiling point decreases and freezing point increases

d) Boiling point increases and freezing point decreases

Ans: (d) Explanation:

When non volatile solute is added to volatile solvent. bp increases, F.p decreases

69. During osmosis, flow of water through at semi permeable membrane is

a) from both sides of semi permeable membrane with equal flow rates

b) from both sides of the semi permeable membrane with unequal flow rates

c) from solution having lower concenration only

d) from solution having higher concentration only.

Ans: (b) Explanation:

$\Delta T_f \; \alpha \; iC$

$for \; Al_2(SO_4)_3, \; i = 5$

70. Of the following 0.10 m aqueous solutions, which one will exhibit the largest fi'eezing point depression?

a) KCl b) $C_6H_{12}O_6$

c) $Al_2(SO_4)_3$ d) K_2SO_4

Ans: (c) Explanation:

Entropy of ideal solution not equal to zero

71. Which one is not equal to zero for an ideal solution?

a) ΔS_{mix} b) ΔV_{mix}

c) $\Delta P = P_{observed} - P_{Raoult}$ d) ΔH_{mix}

Ans: (a) Explanation:

$\Delta S_{mix} \neq O$

72. If molality of the dilute solution is doubled, mix the value of molal depression constant (K_f) will be:

a) doubled b) halved

c) tripled d) unchanged

Ans: (a) Explanation:

K_f is independent of nature of solute

73. Scuba divers may experience a condition called _______. To avoids this, the tanks used by scuba divers are filled with air diluted with ______.

a) Migrains, Hydrogen b) Cramps, Nitrogen
c) Nausea, Oxygen d) Bends, Helium

Ans: (d) Explanation:

Bends and He

74. Which one of the following gases has the lowest value of Henry's law constant?

a) N_2 b) He c) H_2 d) CO_2

Ans: (d) Explanation:

CO_2

75. A mixture of components A and B will show – ve deviation when

a) $\Delta V_{mix} > 0$
b) $\Delta H_{mix} > 0$
c) A-B interaction is weaker than A-A and B-B interactions
d) A-B interaction is stronger than A-A and B-B interactions.

Ans: (d) Explanation:

A – B interactions stronger than A – A and B – B interaction.

76. The value of van't Hoff factors for KCl, NaCl and K_2SO_4 respectively are ….

a) 2, 2 and 2 b) 2, 2 and 3
c) 1,1and 2 d) 1,1 and 1

Ans: (b) Explanation:

$KCl \rightarrow 2,\ NaCl \rightarrow 2, K_2SO_4 \rightarrow 3$

77. If 0.1 M solution of glucose and 0.1 M solution of urea are placed on two sides of the semipermeable membrane to equal heights, then it will be correct to say that

a) There will be no net movement across the membrane
b) **Glucose will flow towards urea solution**
c) **Urea will flow towards glucose solution**
d) **Water will flow from urea solution to glucose**

Ans: (a) Explanation:

Since they are isotonic solutions there will be no net movement across the semi-permeable membrane.

78. If α is the degree of dissociation of Na_2SO_4, the van't Hoffs factor (i) used for calculating the molecular mass is

a) $1+\alpha$ b) $1-\alpha$
c) $1+2\alpha$ d) $1-2\alpha$

Ans: (c) Explanation:

$$\alpha = \frac{i-1}{n-1} = \frac{i-1}{3-1}$$

$2 = i-1, i = 1+2\alpha$

79. At given temperature, osmotic pressure of a concentrated solution of a substance …..,

a) Is higher than that of a dilute solution
b) Is lower than that of a dilute solution
c) It gains water due to reverse osmosis
d) It loses water due to osmosis

Ans: (a) Explanation:

$\pi = CRT,\ \pi\, \alpha\, C$

80. A binary liquid mixture that forms maximum boiling azeotrope at a specific composition is [M-23]

a) Ethanol + Water
b) n-Hexane +n-Heptane
c) Benzene+ Toluene
d) Nitric acid + water

Ans: (d) Explanation:

$-ve$ deviations from Raoult's law can form maximum boiling azeotrope

81. The value of Vant' Hoff factor (i) for ethanoic acid in benzene is nearly. [M-23]

a) 2 b) 1
c) 0.5 d) 0

Ans: (c) Explanation:

Ethanoic acid in benzene undergo association (dimerisation) $\therefore i = 0.5$

82. Which of the following is a colligative property? [MAY-23]

a) Osomsis b) Osmotic pressure
c) Optical activity d) Boiling point

Ans: (b) Explanation:

Osmotic pressure is a colligative property

83. Which of the following term is dependent on temperature ? [MAY-23]

a) Molarity b) Mole traction
c) Molality d) Mass percentage (w/w)

Ans: (a) Explanation:

Molarity depends on temperature

FILL IN THE BLANKS:

SET – 1

1. According to Henry's law, the value of K_H, is ________ proportional to the solubility of solute in solution.
2. _________ in nitrogen gas is the example for gaseous solution.
3. Maximum amount of a solid solute that can be dissolved in a specified amount of a given liquid solvent does not depend upon _________.
4. A solution of acetone in ethanol shows _______ deviation from Raoult's law.
5. During depression of freezing point in a solution, an equilibrium exists between ________ solvent and solid solvent.

SET – 2

(inversely, Henry's, anoxia, lower, liquid)

1. Oxygen dissolved in water is an example for ________solution.
2. Molarity varies ________ with temperature.
3. Higher the value of Henry's law constant (K_H) _____________ is the solubility.
4. The disease caused to the people living at high altitudes or maintain climbers to ________.
5. _________ law explain the dissolution of CO_2 gas in soft drinks under high pressure.

SET - 3

(K kg mol^{-1}, non ideal, $\Delta V > 0$ and $\Delta H > 0$, decreases, increases)

1. Ethyl alcohol and water is an example for _________ solution.
2. __________ is the condition for non ideal solutions with positive deviation.
3. The boiling point of a liquid ________ when a non volatile solute is dissolved in it
4. _________ is the SI unit of ebullioscopic constant (K_b).
5. When non volatile solute is added to the pure solvent, the freezing point of pure solvent__________.

SET - 4

(one, shrink, osmosis, cellulose acetate, association)

1. Sum of mole fractions of all components in the solution is equal to _________ .
2. ________ is the semipermeable membrane used in reverse osmosis.
3. When RBC is placed in 1% NaCl solution, the cell will ________.
4. When van't Hoff factor of a solution is less than one, the solute in the solution will undergoes ___________.
5. Raw mangoes shrivel when pickeled in brine solution due to __________.

SET – 5

($p=K_H x$ two, maximum boiling point, solute, more)

1. Solution which shows the large negative diviation from Raoult's law is called __________ azeotrope
2. Colligative properties depend on number of __________ particles in the solution.
3. Aquatic species are _________comfortable in cold water rather than in warm water
4. The mathematical form of Henry's law is __________ .
5. Binary solution contains ________ components.
6. Because of low concentration of O_2 in the blood and tissues of people living at high altitudes, suffer from a disease called _____. **[M-23]**
7. Low blood oxygen causes climbers to become weak and unable to think clearly, symptoms of a condition is known as _____. **[MAY-23]**