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States of Matter

# Physical Chemistry

**States of Matter**

**Single-Answer MCQ**

1. The density of neon will be highest at :

(1) STP (2) 0oC, 2atm

(3) 273o, 1atm (4) 273o, 2atm **[1990]**

2. The rate of diffusion of methane at a given temperature is twice that of a gas X. The molecular weight of X is

(1) 64 (2) 32

(3) 4.0 (4) 8.0 **[1990]**

3. At constant volume, for a fixed number of mole of a gas, the pressure of the gas increases with rise of temperature due to :

(1) increase in average molecular speed

(2) increase in number of moles

(3) increase in molecular attraction

(4) decrease in mean free path **[1992]**

4. A gas behaves most like an ideal gas under conditions of :

(1) high pressure and low temperature

(2) high temperature and high pressure

(3) low pressure and high temperature

(4) low pressure and low temperature **[1993]**

5. If C1, C2, C3, …. Represent the speeds of n1, n2, n3, …. Molecules, then the root mean square speed is:

(1) 

(2) 

(3) 

(4)  **[1993]**

6. The compressibility factor of a gas is defined as Z = PV/nRT. The compressibility factor of an ideal gas is :

(1) Zero (2) infinite

(3) 1 (4) -1 **[1996]**

7. A gas will approach ideal behaviour at :

(1) low T and high P (2) low T and low P

(3) high T and low P (4) high T and high P **[1999]**

8. At 100o and 1 atm, if the density of liquid water is 1.0 g cm-3 and that of water vapour is 0.0006 gcm-3, then the volume occupied by water molecules in one litre of stream at that temperature is :

(1) 6 cm3 (2) 60 cm3

(3) 0.6 cm3 (4) 0.06 cm3 **[2000]**

9. The rms speed of hydrogen is  times the rms speed of nitrogen. If T is the temperature of the gas, then :

(1)  (2) 

(3)  (4)  **[2000]**

10. The root mean square velocity of an ideal gas at constant pressure varies with density (d) as :

(1) d2 (2) d

(3)  (4)  **[2001]**

11. When the temperature is increased, surface tension of water :

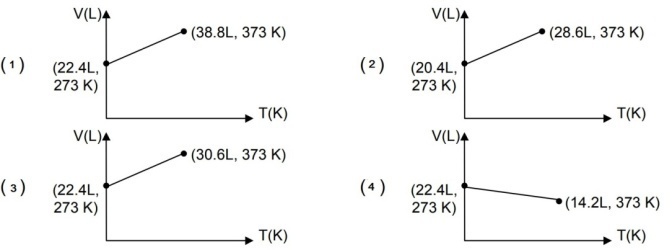
(1) increases

(2) decreases

(3) remains constant

(4) shows irregular behaviour **[2002]**

12. Which of the following volume (V), temperature (T) plots represents the behaviour of one mole of an ideal gas at one atmosphere ?

**** **[2002]**

13. Positive deviation from ideal behaviour takes place because of :

(1) molecular interaction between atoms and PV/nRT> 1

(2) molecular interaction between atoms and PV/nRT< 1

(3) finite size of atoms and PV/nRT> 1

(4) finite size of atoms and PV/nRT< 1 **[2003]**

14. For 1 mole of gas, the average kinetic energy is given as E. The urms of gas is :

(1)  (2) 

(3)  (4)  **[2004]**

15. The ratio of rate of diffusion of helium and methane under identical conditions of pressure and temperature is :

(1) 4 (2) 2

(3) 1 (4) 0.5 **[2005]**

16. A monoatomic ideal gas undergoes a process in which the ratio of P to V at any instant is constant and equal to unity. The molar heat capacity of the gas is :

(1) 4R/2 (2) 3R/2

(3) 5R/2 (4) zero **[2006]**

**Multiple Answer MCQ**

1. At constant volume, for a fixed number of mole of a gas, the pressure of the gas increases with rise of temperature due to :

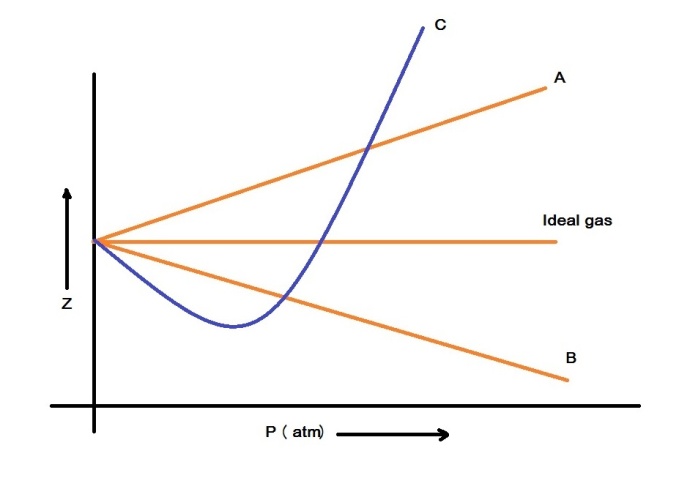
(1) increase in average molecular speed

(2) increased rate of collisions amongst molecules

(3) increase in molecular attraction

(4) decrease in mean free path **[1992]**

2. The given graph represents the variation of Z (compressibility factor) v.s. P for three real gases A, B and C. Identify the correct statements.



(1) For the gas A, a = 0 and its dependence on P is linear at all pressure.

(2) For the gas B, b = 0 and its dependence on P is linear at all pressure

(3) For the gas C, which is typical real gas for which a≠0, b≠0. By knowing the minima and the point of intersection with Z = 1, a and b can be calculated

(4) At high pressure, the slope is positive for all real gases. **[2008]**

3. A gas described by van der walls’ equation : **[2008]**

(1) behaves similar to an ideal gas in the limit of large molar volumes

(2) behaves similar to an ideal gas in the limit of large pressure

(3) is characterised by van der walls’ coefficients that are dependent on the identity of gas but are independent of the temperature

(4) has the pressure that is lower than the pressure exerted by the same gas behaves ideally

**Atomic Structure**

**Single-Answer MCQ**

1. A 3p-orbital has :

(1) two non-spherical nodes

(2) two spherical nodes

(3) one spherical and one non-spherical node

(4) one spherical and two non-spherical nodes **[1995]**

2. The number of nodal planes in a px-orbital is :

(1) 1 (2) 2

(3) 3 (4) zero **[2000]**

3. The electronic configuration of an element is 1s2, 2s22p6, 3s23p63d5, 4s1. This represents its :

(1) excited state (2) ground state

(3) cationic form (4) anionic form **[2000]**

## Solutions

**Solution :** A solution is a homogeneous mixture of two or more chemically non-reacting substances whose composition can be varied within certain limits.

**Mass percentage (w/w) =**  X 100

**Volume percentage (v/v) =**  X 100

**Mass by Volume percentage (w/v) =**  X 100

**Parts per million (ppm) =**  X 106

**Mole fraction xA =**

**Molarity** M =

In case of ionic compounds it is called **Formality**

**Normality** N =

**Molality** *m* =

Mass % , ppm , mole fraction and molality are independent of temperature , whereas molarity is a function of temperature. This is because volume depends on temperature and the mass does not.

Q. Calculate the mole fraction of ethylene glycol (C2H6O2) in a solution containing 20% of C2H6O2 by mass.

Q. Calculate the molarity of a solution containing 5 g of NaOH in 450 mL solution. Q. Calculate molality of 2.5g of ethanoic acid (CH3COOH) in 75 g of benzene.

Q. Find the molarity and molality of a 15% solution of H2SO4 (density of H2SO4 = 1.020 g cm-1 )

Q. A sugar syrup of weight 214.2g contains 34.2g of sugar (C12H22O11). Calculate i)molal concentration II)mole fraction of sugar in the syrup.

***Solubility of a Solid in a Liquid******at any temperature is defined as the maximum amount of the solute in grams which can dissolve in 100 g of the solvent to form the saturated solution at that temperature.***

**Solubility of Solids in Liquids** depends on

i)**Nature of the solute and solvent** : Like dissolves like. Polar dissolves polar. Non polar dissolves non polar.

ii) **Temperature :**  a) for endothermic dissolution solubity increases with temperature

b) for exothermic dissolution solubility decreases with temperature

iiI) **Pressure :** No Effect.

***The solubility of any gas in a Liquid is the volume of gas in cc’s (converted to S.T.P) that can dissolve in 1 cc of the liquid to form the saturated solution******at the temperature of the experiment and under a pressure of one atmosphere.***

**Solubility of Gases in Liquids** depends on

**i) Nature of the gas and solvent :** Gases like H2S and NH3 are more soluble in polar solvents like water while gases like oxygen, nitrogen and carbon dioxide are more soluble in non polar solvents like ethyl alcohol.

II) **Temperature :** Solubility decreases with increase of temperature.

III) **Pressure :** On increasing the pressure, the solubility increases.

**Henry’s Law** : ***The partial pressure of a gas in vapour phase (p) is directly proportional to the mole fraction (x) of the gas in the solution.***

**pA = kHxA**

Applications of Henry’s Law

1) In the production of carbonated beverages.

2) In the deep sea diving.

3) In the function of lungs.

Q. The Henry’s law constant for oxygen dissolved in water is 4.34 X 104 atm at 25o C . If the partial pressure of oxygen in air is 0.2 atm under atmospheric conditions , calculate the concentration ( in moles per litre ) of dissolved oxygen in water in equilibrium with air at 25oC.

Q. If N2 gas is bubbled through water at 293 K , how many millimoles of N2 gas would dissolve in 1 litre of water. Assume that N2 exerts a partial pressure of 0.987 bar. Given that Henry’ s law constant for N2 at 293 K is 76.48 kbar.

Q. H2S , a toxic gas with rotten egg like smell , is used for the qualitative analysis. If the solubility of H2S in water at STP is 0.195m, calculate Henry’s Law Constant.

***Raoult’s Law states that for a solution of volatile liquids, the partial vapor pressure of each component in the solution is directly proportional to its mole fraction.***

**P1 = p1o x1**

**According to Dalton’s Law of partial pressures, the total pressure (ptotal) over the solution phase in the container will be the sum of the partial pressures of the components of the solution .**

**ptotal = p1o x1  + p2o x2 = p1o  + (p2o- p1o) x2**

**­pi = yi p total**

Q. Vapour pressure of chloroform (CHCl3) and dichloromethane (CH2Cl2) at 298 K are 200 mm Hg and 415 mm Hg respectively. (i) Calculate the vapour pressure of the solution prepared by mixing 25.5 g of CHCl3 and 40 g of CH2Cl2 at 298 K and , (ii) mole fractions of each component in vapour phase.

Q. The vapour pressure of pure liquids A and B are 450 and 700 mm Hg respectively, at 350 K. Find out the composition of the liquid mixture if total vapour pressure is 600 mm Hg. Also find the composition of the vapour phase.

The properties

(1) relative lowering of vapour pressure of the solvent

(2) depression of freezing point of the solvent

(3) elevation of boiling point of the solvent

(4) osmotic pressure of the solution.

***All these properties depend on the number of solute particles irrespective of their nature relative to the total number of particles present in the solution. Such properties are called colligative properties.***

**Relative lowering of vapour pressure**

**=**

Q. The vapour pressure of pure benzene at a 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 g mol-1 ) . Vapour pressure of the solution ,then, is 0.845 bar. What is the molar mass of the solid substance?

Q. Vapour pressure of pure water at 298 K is 23.8 mm Hg. 50 g of urea (NH2CONH2) is dissolved in 850 g of water. Calculate the vapour pressure of water for this solution and its relative lowering.

**Elevation of boiling point**

***Kb  is called boiling point elevation constant or Molal Elevation Constant ( Ebullioscopic Constant)***

**ΔTb = Kb *m***

**Kb =**

Q. 18 g of glucose , C6H12O6, is dissolved in 1 kg of water in a saucepan. At what temperature will water boil at 1.013 bar? Kb for water is 0.52 K kg mol -1

Q. The boiling point of benzene is 353.23 K. When 1.80 g of a non-volatile solute was dissolved in 90 g of benzene, the boiling point is raised to 354.11 K . Calculate the molar mass of the solute. Kb for benzene is 2.53 K Kg mol-1

Q. Boiling point of water at 750 mm Hg is 99.63°C. How much sucrose is to be added to 500 g of water such that it boils at 100°C. Kb for water is 0.52 K kg mol -1

**Depression of freezing point**

***Kf is called Freezing Point Depression Constant or Molal Depression Constant or Cryoscopic Constant.***

**ΔTf = Kf *m***

**Kf =**

Q. 45 g of ethylene glycol C2H6O2 is mixed with 600 g of water . Calculate (a) the freezing point depression and (b) the freezing point of the solution. Kf for water is 1.86 K kg mol -1

Q. 1.00 g of a non-electrolyte solute dissolved in 50 g of benzene lowered the freezing point of benzene by 0.40 K . The freezing point depression constant of benzene is 5.12 K kg mol-1 . Find the molar mass of the solute.

Q. Calculate the mass of ascorbic acid (Vitamin C, C6H8O6) to be dissolved in 75 g of acetic acid to lower its melting point by 1.5°C. Kf = 3.9 K kg mol-1

**Osmotic pressure**

**Π = (n2/V) R T**

Q. 200 cm3 of an aqueous solution of a protein contains 1.26g of the protein. The osmotic pressure of such a solution at 300 K is found to be 2.57 x 10 -3 bar . Calculate the molar mass of the protein. (R=0.083Lbar mol-1 K-1 )

Q Calculate the osmotic pressure in pascals exerted by a solution prepared by dissolving 1.0 g of polymer of molar mass 185,000 in 450 ml of water at 37°C.

**Abnormal molar mass**

*i* =

*i* =

*i* =

**=*i***

**ΔTb = *i* Kb *m***

**ΔTf = *i* Kf *m***

**Π =*i* (n2/V) R T**

Q. 2 g of benzoic acid (C6H5COOH) dissolved in 25 g of benzene shows a depression in freezing point equal to 1.62 K. Molal depression constant for benzene is 4.9 K kg mol-1 .What is the percentage association of acid if it forms dimer in solution?

Q. 0.6 mL of acetic acid (CH3COOH), Having density 1.06 g mL -1 , is dissolved in 1 Litre of water. The depression in freezing point observed for this strength of acid was 0.205oC . Calculate the van’t hoff factor and the dissociation constant of acid.

## NCERT Exercise

**2.1** Define the term solution. How many types of solutions are formed? Write briefly about each type with an example.

**2.2** Suppose a solid solution is formed between two substances, one whose particles are very large and the other whose particles are very small. What kind of solid solution is this likely to be?

**2.3** Define the following terms:

(i) Mole fraction (ii) Molality (iii) Molarity (iv) Mass percentage.

**2.4** Concentrated nitric acid used in laboratory work is 68% nitric acid by mass in aqueous solution. What should be the molarity of such a sample of the acid if the density of the solution is 1.504 g mL-1?

**2.5** A solution of glucose in water is labelled as 10% w/w, what would be the molality and mole fraction of each component in the solution? If the density of solution is 1.2 g mL–1, then what shall be the molarity of the solution?

**2.6** How many mL of 0.1 M HCl are required to react completely with 1 g mixture of Na2CO3 and NaHCO3 containing equimolar amounts of both?

**2.7** A solution is obtained by mixing 300 g of 25% solution and 400 g of 40% solution by mass. Calculate the mass percentage of the resulting solution.

**2.8** An antifreeze solution is prepared from 222.6 g of ethylene glycol (C2H6O2) and 200 g of water. Calculate the molality of the solution. If the density of the solution is 1.072 g mL–1, then what shall be the molarity of the solution?

**2.9** A sample of drinking water was found to be severely contaminated with chloroform (CHCl3) supposed to be a carcinogen. The level of contamination was 15 ppm (by mass):

(i) express this in percent by mass

(ii) determine the molality of chloroform in the water sample.

**2.10** What role does the molecular interaction play in a solution of alcohol and water?

**2.11** Why do gases always tend to be less soluble in liquids as the temperature is raised?

**2.12** State Henry’s law and mention some important applications?

**2.13** The partial pressure of ethane over a solution containing 6.56 × 10–3 g of ethane is 1 bar. If the solution contains 5.00 × 10-2 g of ethane, then what shall be the partial pressure of the gas?

**2.14** What is meant by positive and negative deviations from Raoult's law and how is the sign of ΔmixH related to positive and negative deviations from Raoult's law?

**2.15** An aqueous solution of 2% non-volatile solute exerts a pressure of 1.004 bar at the normal boiling point of the solvent. What is the molar mass of the solute?

**2.16** Heptane and octane form an ideal solution. At 373 *K*, 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 26.0 g of heptane and 35 g of octane?

**2.17** The vapour pressure of water is 12.3 kPa at 300 *K*. Calculate vapour pressure of 1 molal solution of a non-volatile solute in it.

**2.18** Calculate the mass of a non-volatile solute (molar mass 40 g mol–1) which should be dissolved in 114 g octane to reduce its vapour pressure to 80%.

**2.19** A solution containing 30 g of non-volatile solute exactly in 90 g of water has a vapour pressure of 2.8 kPa at 298 *K*. Further, 18 g of water is then added to the solution and the new vapour pressure becomes 2.9 kPa at 298 *K*. Calculate:

(i) molar mass of the solute (ii) vapour pressure of water at 298 *K*.

**2.20** A 5% solution (by mass) of cane sugar in water has freezing point of 271*K*. Calculate the freezing point of 5% glucose in water if freezing point of pure water is 273.15 *K*.

**2.21** Two elements A and B form compounds having formula AB2 and AB4. When dissolved in 20 g of benzene (C6H6), 1 g of AB2 lowers the freezing point by 2.3 *K* whereas 1.0 g of AB4 lowers it by 1.3 *K*. The molar depression constant for benzene is 5.1 *K* kg mol-1. Calculate atomic masses of A and B.

**2.22** At 300 K, 36 g of glucose present in a litre of its solution has an osmotic pressure of 4.98 bar. If the osmotic pressure of the solution is 1.52 bars at the same temperature, what would be its concentration?

**2.23** Suggest the most important type of intermolecular attractive interaction in the following pairs.

(i) n-hexane and n-octane

(ii) I2 and CCl4

(iii) NaClO4 and water

(iv) methanol and acetone

(v) acetonitrile (CH3CN) and acetone (C3H6O).

**2.24** Based on solute-solvent interactions, arrange the following in order of increasing solubility in n-octane and explain. Cyclohexane, KCl, CH3OH, CH3CN.

**2.25** Amongst the following compounds, identify which are insoluble, partially soluble and highly soluble in water?

(i) phenol (ii) toluene (iii) formic acid (iv) ethylene glycol (v) chloroform (vi) pentanol.

**2.26** If the density of some lake water is 1.25g mL-1 and contains 92 g of Na+ ions per kg of water, calculate the molality of Na+ ions in the lake.

**2.27** If the solubility product of CuS is 6 × 10-16, calculate the maximum molarity of CuS in aqueous solution.

**2.28** Calculate the mass percentage of aspirin (C9H8O4) in acetonitrile (CH3CN) when 6.5 g of C9H8O4 is dissolved in 450 g of CH3CN.

**2.29** Nalorphene (C19H21NO3), similar to morphine, is used to combat withdrawal symptoms in narcotic users. Dose of nalorphene generally given is 1.5 mg. Calculate the mass of 1.5X10–3 m aqueous solution required for the above dose.

**2.30** Calculate the amount of benzoic acid (C6H5COOH) required for preparing 250 mL of 0.15 M solution in methanol.

**2.31** The depression in freezing point of water observed for the same amount of acetic acid, trichloroacetic acid and trifluoroacetic acid increases in the order given above. Explain briefly.

**2.32** Calculate the depression in the freezing point of water when 10 g of CH3CH2CHClCOOH is added to 250 g of water. *K*a = 1.4 × 10-3, *K*f = 1.86 K kg mol-1.

**2.33** 19.5 g of CH2FCOOH is dissolved in 500 g of water. The depression in the freezing point of water observed is 1.0o C. Calculate the van’t Hoff factor and dissociation constant of fluoroacetic acid.

**2.34** Vapour pressure of water at 293 *K* is 17.535 mm Hg. Calculate the vapour pressure of water at 293 *K* when 25 g of glucose is dissolved in 450 g of water.

**2.35** Henry’s law constant for the molality of methane in benzene at 298 *K* is 4.27 × 105 mm Hg. Calculate the solubility of methane in benzene at 298 *K* under 760 mm Hg.

**2.36** 100 g of liquid A (molar mass 140 g mol-1) was dissolved in 1000 g of liquid B (molar mass 180 g mol-1). The vapour pressure of pure liquid B was found to be 500 torr. Calculate the vapour pressure of pure liquid A and its vapour pressure

in the solution if the total vapour pressure of the solution is 475 Torr.

**2.38** Benzene and toluene form ideal solution over the entire range of composition. The vapour pressure of pure benzene and naphthalene at 300 *K* are 50.71 mm Hg and 32.06 mm Hg respectively. Calculate the mole fraction of benzene in vapour phase if 80 g of benzene is mixed with 100 g of naphthalene.

**2.39** The air is a mixture of a number of gases. The major components are oxygen and nitrogen with approximate proportion of 20% is to 79% by volume at 298 *K*. The water is in equilibrium with air at a pressure of 10 atm. At 298 *K* if theHenry’s law constants for oxygen and nitrogen at 298 *K* are 3.30 × 107 mm and 6.51 × 107 mm respectively, calculate the composition of these gases in water.

**2.40** Determine the amount of CaCl2 (*i* = 2.47) dissolved in 2.5 litre of water such that its osmotic pressure is 0.75 atm at 27° C.

**2.41** Determine the osmotic pressure of a solution prepared by dissolving 25 mg of K2SO4 in 2 litre of water at 25° C, assuming that it is completely dissociated.

# Assignment

Problem 1. Calculate the osmotic pressure at 17°C of an aqueous solution containing 1.75 g of sucrose per 150 mL solution. [IITR 1985]

Problem 2. At 27oC*,* 36 g of glucose per litre has an O.P. of 4.92 atm. If the osmotic pressure of solution is 1.5 atm at the same temperature, what should be its concentration? [IITR 1985]

Problem 3. (a) 10 g of a certain non-volatile solute were dissolved in 100 g water at 20°C. The vapour

pressure was lowered from 17.3555 mm to 17.2350 mm, calculate m. wt. of solute.

(b) The vapour pressure of pure water at 25°C is 23.62 mm. What will be the vapour pressure of a solution of 1.5 g of urea in 50 g of water? [IITR 2001]

Problem 4. The vapour pressure of pure benzene at a certain temperature is 640 mm of Hg. A non-volatile non-electrolyte solid weighing 2.175 g is added 39.0 g of benzene. The vapour pressure of

the solution is 600 mm of Hg. What is the molecular weight of solid substance. [IIT 1990]

Problem 5. The vapour pressure of an aqueous solution of glucose is 750 mm of Hg at 373 K. Calculate

molality and mole fraction of solute. [lIT 1989]

Problem 6. The molar volume of liquid benzene (density = 0.877 g mL-1) increases by a factor of 2750 as it vaporises at 20°C and that of liquid toluene (density 0.867 g mL-1) increases by a factor of 7720 at 20°C. A solution of benzene and toluene at 20°C has a vapour pressure of 46.0 torr. Find the mole fraction of benzene in the vapour above the solution [IIT 1996]

Problem 7. A very small amount of a non-volatile solute (that does not dissociate) is dissolved in 56.8 cm3 of benzene (density 0.889 g cm-3). At room temperature, vapour pressure of this solution is 98.88 mm Hg while that of benzene is 100 mm Hg. Find the molality of this solution. If the freezing temperature of this solution is 0.73 degree lower than that of benzene, what is the value of molal freezing point depression constant of benzene? [lIT May 1997]

Problem 8. The vapour pressure of two miscible liquids *(A)* and *(B)* are 300 and 500 mm of Hg respectively. In a flask 10 mole of *(A)* is mixed with 12 mole of *(B).* However, as soon as *(B)* is added, *(A)* starts polymerising into a completely insoluble solid. The polymerization follows first-order kinetics. After 100 minute, 0.525 mole of a solute is dissolved which arrests the polymerisation completely. The final vapour pressure of the solution is 400 mm of Hg. Estimate the rate constant of the polymerisation reaction. Assume negligible volume change on mixing and polymerisation and ideal behaviour for the final solution. [IIT 2001]

Problem 9. 1.4 g of acetone dissolved in 100 g of benzene gave a solution which freezes at 277.12 K. Pure benzene freezes at 278.4 K. 2.8 g of a solid *(A)* dissolved in 100 g of benzene gave a solution which froze at 277.76 K. Calculate the molecular weight of *(A).* [IITR 2000]

Problem 10. The molal freezing point constant of C6H6 is 4.90 and its melting point is 5.51oC. A solution of 0.816 g of a compound *A* dissolved in 7.5 g of benzene freezes at 1.59°C. Calculate molecular weight of compound *A.* [IITR 1989]

Problem11. A solution of 0.643 g of an organic compound in 50 mL of benzene (density 0.879 g/mL) lowered its freezing point from 5.51 °C to 5.03°C. Calculate the molecular weight of solid. *Kf* for benzene is 5.12 K mol-1 kg. [lIT 1992]

Problem 12. A solution of a non-volatile solute in water freezes at - 0.30°C. The vapour pressure of pure water at 298 K is 23.51 mm Hg and Kf for water is 1.86 degree/molal. Calculate the vapour pressure of this solution at 298 K. [lIT 1998]

Problem 13. To 500 cm3 of water, 3.0 x 10-3 kg of acetic acid is added. If 23% of acetic acid is dissociated, what will be the depression in freezing point? *Kf* and density of water are 1.86 K kg mol-1 and 0.997 gcm-3 respectively. [lIT 2000]

Problem14. The degree of dissociation of Ca(NO3)2 in a dilute aqueous solution containing 7 g of salt

Per 100 g of water at 100°C is 70%. Calculate the vapour pressure of solution. [lIT 1991]

Problem 15**.** 1.22 g of benzoic acid is dissolved in acetone and benzene separately. Boiling point of

mixture with acetone increase by 0.17oCand boiling point of mixture with benzene increases by 0.13°C. .

*Kb* (acetone) =1.7 K kg mol-1, Mass of acetone =100 g ;

*Kb* (benzene) =2.6 K kg mol ; Mass of benzene =100 g.

Find molecular weight of benzoic acid in acetone and in benzene solution. Justify your answer with structure. [lIT 2004]

Problem 16**.** 75.2 g of C6H5OH (phenol) is dissolved in 1 kg of solvent of *Kf=* 14 K molality-1. If depression in freezing point is 7K, Calculate % of phenol that dimerises. [lIT 2006]

# Objective

1. Freezing point of an aqueous solution is-0.186°C. Elevation of boiling point of the same solution is……………. If *Kb* = 0.512 K molality-1 and *Kf =* 1.86 K molality-1:

(a) 0.186 °C (b) 0.0512 °C (c) 0.092 °C (d) 0.237 °C

2. In mixture *A* and *B,* components show –ve deviations as:

(a) ΔVmix is +ve (b) *A-B* interaction is weaker than *A-A* and *B-B* interaction.

(c) Hmix is + ve (d) *A-B* interaction is stronger than *A-A* and *B-B* interaction.

3. If liquid *A* and *B* form ideal solution, than:

(a) ΔGmix = 0 (b) Δ Hmixing = 0 (c) ΔGmix = 0, ΔSmix = 0 (d) ΔSmix = 0

4. In a 0.2 molal aqueous solution of weak acid HX (the degree of dissociation 0.3) the freezing point is

(given *Kf =* 1.85 K molality-1):

(a) -0.26°C (b) +48°C (c) -0.48°C (d) -0.36°C

5. A pressure cooker reduces cooking time for food because:

(a) the higher pressure inside the cooker crushes the food material

(b) cooking involves chemical changes helped by rise in temperature

(c) heat is more evenly distributed in the cooking space

(d) boiling point of water involved in cooking increases

6. The elevation in boiling point of a solution of 13.44 g of CuCl2 (molecular weight = 134.4, *Kb* = 0.52 K molality-1) in 1kg water using the following information will be

(a) 0.16 (b) 0.05

(c) 0.1 (d) 0.2

7. Which aqueous solution exhibits highest boiling point:

(a) *0.015M* glucose (b) 0.01*M* KNO3 (c) *0.015M* urea (d) 0.01*M* Na2SO4

8. Which liquid pair shows a positive deviation from Raoult's law:

(a) Acetone –chloroform (b) Benzene-methanol

(c) Water-nitric acid (d) Water-hydrochloric acid

9. Which statement is false:

(a) Two sucrose solutions of same molality prepared in different solvents have same Δ*Tf*

(b) Osmotic pressure, π = *MRT*

(c) Osmotic pressure for 0.01*M* aqueous solution: BaCl2 > KCl > CH3COOH > Sucrose

(d) The vapour pressure of a component over a solution is proportional to its mole fraction

10. If α is the degree of dissociation of Na2SO4 - the van't Hoff factor (i) used for calculating molecular mass is :

(a) 1+ α (b) 1- α (c) 1 + 2 α (d) 1 - 2 α

11. Benzene and toluene form nearly ideal solutions. At 20°C, the vapour pressure of benzene is 75 torr and that of toluene is 22 torr. The partial vapour pressure of benzene at 20°C for a solution containing 78 g benzene and 46 g toluene in torr is:

(a) 50 (b) 25 (c) 375

(d) 53.5

12**.** Equimolar solutions of two non-electrolytes in the same solvent have:

(a) Same b.pt. but different f.pt.

(b) Same f.pt. but different b.pt.

(c) Same b.pt. and same f.pt.

(d) Different b.pt. and different f.pt.

13**.** 18 g glucose (C6H12O6) is added to 178.2 g water. The vapour pressure of water for this aqueous solution at 100°C is:

(a) 759 torr (b) 7.60 torr (c) 76.0 torr (d) 752.40 torr

14**.** Equal masses of methane and oxygen are mixed in an empty container at 25°C. The fraction of the total pressure exerted by oxygen is:

(a) 2/3 (b)1/3 x 273/298 (c)1/3 (d)1/2

15**.** A 5.25% solution of a substance is isotonic with a 1.5% solution of urea (molar mass = 60 g mol-1) in the same solvent. If the densities of both the solutions are assumed to be equal to 1.0 g cm-3, molar mass of the substance will be :

(a) 90.0 g mol-1 (b) 115.0 g mol-1 (c) 105.0 g mol-1 (d) 210.0 g mol-1

16.A mixture of ethyl alcohol and propyl alcohol has a vapour pressure of 290 mm at 300 K. The vapour pressure of propyl alcohol is 200 mm. If the mole fraction of ethyl alcohol is 0.6, its vapour pressure (in mm) at the same temperature will be :

(a) 350 (b) 300 (c) 700

(d) 360

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

(a) liquid solvent, solid solvent (b) liquid solvent, solid solute

(c) liquid solute, solid solute (d) liquid solute, solid solvent

18.A 0.004*M* solution of Na2SO4 is isotonic with a 0.0*1M* solution of glucose at same temperature. The apparent degree of dissociation of Na2SO4 is:

(a) 25% (b) 50% (c) 75% \

(d) 85%

19.When 20 g of naphthoic acid (C11H8O2) is dissolved in 50g of benzene *(Kf =* 1.72 K kg mol-1), a freezing point depression of 2 K is observed. The van't Haff factor *(i)* is:

(a) 0.5 (b) 1.0 (c) 2.0

(d) 3.0

Solutions Test ( IIT)

Q. Vapour pressure of chloroform (CHCl3) and dichloromethane (CH2Cl2) at 298 K are 200 mm Hg and 415 mm Hg respectively. (i) Calculate the vapour pressure of the solution prepared by mixing 25.5 g of CHCl3 and 40 g of CH2Cl2 at 298 K and , (ii) mole fractions of each component in vapour phase.

20 Marks

Q. The vapour pressure of pure benzene at a 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 g mol-1 ) . Vapour pressure of the solution ,then, is 0.845 bar. What is the molar mass of the solid substance?

20 Marks

Q. The boiling point of benzene is 353.23 K. When 1.80 g of a non-volatile solute was dissolved in 90 g of benzene, the boiling point is raised to 354.11 K . Calculate the molar mass of the solute. Kb for benzene is 2.53 K Kg mol-1 20 Marks

Q Calculate the osmotic pressure in pascals exerted by a solution prepared by dissolving 1.0 g of polymer of molar mass 185,000 in 450 ml of water at 37°C. 20 Marks

Q. 2 g of benzoic acid (C6H5COOH) dissolved in 25 g of benzene shows a depression in freezing point equal to 1.62 K. Molal depression constant for benzene is 4.9 K kg mol-1 .What is the percentage association of acid if it forms dimer in solution? 20 Marks

Solid State Test ( CBSE )

**GENERAL INSTRUCTIONS**

*(i) All questions are compulsory.*

*(ii) Marks for each question are indicated against each.*

*(iii) Question nos. 1 to 8 are very short answer questions ,carrying 1 mark each. Answer these in one word or*

*about one sentence each.*

*(iv) Question nos. 9 to 18 are short answer questions, carrying 2 marks each. Answer these in about 30 words each.*

*(v) Question nos. 19 to 27 are short answer questions, carrying 3 marks each. Answer these in about 40 words each.*

*(vi) Question nos. 28 to 30 are long answer questions, carrying 5 marks each. Answer these in about 70 words each.*

*(vii) Use Log Tables, if necessary. Use of calculators is not permitted.*

Q. 1. Name one solid which has both Schottky and Frenkel defects. 1 Marks

Q. 2. Arrange the following according to their packing fractions: 1 Marks

Simple cubic, face-centred cubic, body centred cubic

Q. 3. Why is Common salt sometimes yellow instead of being pure white? 1 Marks

Q. 4. Why is Frenkel defect not found in pure alkali metal halides? 1 Marks

Q. 5. A solid is hard, electrical insulator in the solid as well as molten state and melts at extremely high temperature. What type of solid is it ? 1 Marks

Q.6. A group 14 element is to be converted into n-type semiconductor by doping it with a suitable impurity. To which group should this impurity belong? 1 Marks

Q. 7. How does quartz glass differ from quartz? 1 Marks

Q. 8. A metallic element crystallizes into a lattice containing a sequence of layers of ABABAB Any packing of spheres leaves out voids in the lattice. What percentage by volume of this lattice is empty space? 1 Marks

Q.9. Why is glass considered as a supercooled liquid? 2 Marks

Q.10. Comment on the electrical conductivity of metals and semiconductors with increase of temperature. 2 Marks

Q.1 1. Distinguish between hexagonal and monoclinic unit cells. 2 Marks

Q.12. What type of defect can arise when a solid is heated? Which physical property is affected by it and in what

way? 2 Marks

Q.13. Non-stoichiometric cuprous oxide, Cu20 can be prepared in the laboratory. In this oxide, copper to oxygen

ratio is slightly less than 2 : 1. Can you account for the fact that this substance is a p-type semiconductor? 2 Marks

Q.14. Gold (atomic radius = 0 ·144 nm) crystallizes in a face centered unit cell. What is the length of the side of the

cell? 2 Marks

Q.15. A compound forms hexagonal close-packed structure. What is the total number of voids in 0·5 mol of it ? How many of these are tetrahedral voids? 2 Marks

Q.16. Classify each of the following as being either a p-type or n-type semiconductor giving reason. 2 Marks

*(i)* Ge doped with In

*(ii)* B doped with Si.

Q.17. In terms of band theory, what is the difference 2 Marks

*(i)* between a conductor and an insulator.

*(ii)* between a conductor and a semiconductor?

Q.18. Niobium crystallizes in a body centered cubic structure. If density is 8·55 g cm-3, calculate atomic radius of

niobium, given that its atomic mass is 93u. 2 Marks

Q.19. An element with molar mass 2·7 x 10-2kg mol-1 forms a cubic unit cell with edge length 405 pm. If its density is 2,7 x 103 kg m-3, what is the nature of the cubic unit cell? 3 Marks

Q.20. If the radius of the octahedral void is r and the radius of the atoms in the close packing is R, derive relationsip

between rand R. 3 Marks

Q.21. Analysis shows that a metal oxide has the empirical formula of M0.96O1.00 . Calculate the percentage of M2+ and M3+ ions in this crystal. 3 Marks

Q.22. In an ionic compound, the anions (N) form cubic close type of packing while the cations (M) occupy one third

of the tetrahedral voids. Deduce the empirical formula of the compound and the coordination number of (M) ions. 3 Marks

Q.23. The mineral haematite, Fe2O3 consists of a cubic close packed array of oxide ions with Fe3+ ions occupying

interstitial positions. Predict whether the iron ions are in the octahedral or tetrahedral holes. Radius of Fe3+=0·65A and that of O2- = 1·45A. 3 Marks

Q.24. If NaCl is doped with 10-3 mol % SrCl­2 What is the concentration of cation vacancies? 3 Marks

Q.25. *(a)* 'Stability of a crystal is reflected in the magnitude of its melting point'. Comment.

*(b)* The melting points of some compounds are given below:

Water = 273 K, Ethyl alcohol = 155·7 K, Diethyl ether = 156,8 K, Methane = 90·5 K. 3 Marks

What can you say about the intermolecular forces between these molecules?

Q.26. Classify each of the following solids as ionic, metallic, molecular, network (covalent) or amorphous:

*(i)* Tetraphosphorus decoxide (P4O10)

*(ii)* Ammonium phosphate, (NH4)3PO4 *(iii)* SiC *(iv)*I2 *(v)* P4 *(vi)* Plastics *(vii)* Graphite *(viii)* Brass *(ix)* Rb

*(x)* LiBr *(xi)* Si 3 Marks

Q.27. How will you distinguish between the following pairs of terms? 3 Marks

*(iii)* Hexagonal close packing and cubic close packing

*(iii)* Crystal lattice and unit cell

*(iii)* Tetrahedral void and octahedral void.

Q.28. Account for the following: 5 Marks

*(i)* Silicon is an insulator but silicon doped with phosphorus acts as a semi-conductor.

*(ii)* Some of the glass objects recovered from ancient monuments look milky instead of being transparent.

*(iii)* FeO is non-stoichiometric with the formula Fe0.95O,

Q.29. Explain the difference between the following : 5 Marks

*(i)* Ferromagnetism and antiferromagnetism

*(ii)* n and p-type semiconductors.

Q.30. Derive the expressions for the following: 5 Marks

*(i)* Density of a cubic crystal of an element of edge 'a' and atomic mass M.

*(ii)* Packing efficiency of a body-centred cubic structure.