Useful Information: 
\[ R = 0.08206 \text{ L-atm/mol-K} = 8.314 \text{ J/mol-K} \]
\[ 1 \text{ atm} = 760 \text{ torr} = 760 \text{ mm Hg} \]

\[ P_{\text{soln}} = (P_{\text{solv}})(X_{\text{solv}}) \]

\[ \pi = MRT \ (R = 0.0821 \text{ Latm/mol K}) \]

\[ \Delta T_f = \Delta K_f \text{ or } \Delta T_b \]

\[ \Delta P_{\text{soln}} = (P_{\text{solv}})(X_{\text{solute}}) \]

\[ P_{\text{total}} = P_aX_a + P_bX_b \text{ (two volatile liquids)} \]

Intermolecular Attractions: Likes dissolve Likes

1. What is the strongest intermolecular force in each (a) H₂O  (b) CH₄  (c) NaF  (d) HCl  (e) Xe

2. Which solute below is expected to be more soluble in CH₄ than in H₂O  
(a) NH₄Cl  (b) HCl  (c) KCl  (d) CH₃CH₂CH₂CH₃  (f) HF

3. What is the interaction between CCl₄ and KCl?  
(a) ion-ion  (b) ion-dipole (c) London Dispersion-ion (d) Hydrogen Bonding-dipole

Molality

4. 45 g of NaOH is dissolved in 100 ml of water. (a) What is the m of the solution. The density of water is 1g/ml. (b) If the density of the NaOH solution is 1.5 g/ml, what is the M of the solution?

5. A certain aqueous solution is 50% HCl by mass. The density of the solution is 1.2 g/cm³. What is the concentration of HCl expressed in molality?

Colligative Properties van’t Hoff factor, i. How an ionizing compound works.

6. Which of the solutions below, at the same concentration of 0.1 m in an aqueous solution, would have the highest van’t Hoff factor, i.  
(a) NaCl  (b) CH₃CH₂CH₃  (c) CaCl₂  (d) KBr
7. Which of the following would have the lowest boiling point?
(a) 0.08 m glucose (a non-electrolyte) (b) 0.05 m CaCl₂ (c) 0.02 m K₃PO₄ (d) 0.007 m AlCl₃

**Colligative Properties and Raoult’s Law: Determining Molar Mass**

8. A solution of 0.5 g of an unknown is dissolved in 30 ml of benzene. The solution exhibits an osmotic pressure of 8.92 torr at 27°C. What is its molecular mass?

9. A solution is prepared by dissolving 31.4 g of a nonvolatile, nonelectrolyte solute in 85.0 g of water. The vapor pressure of the solution at 60°C is 142 torr. What is the molar mass of the solute? (Given: the vapor pressure of water at 60°C is 150 torr.)

**Mole Fraction, X**

10. A solution is made by mixing ethyl alcohol and water. If the mole fraction of water is .7, what is the mole fraction of ethyl alcohol?

11. A solution of benzene and toluene obey Raoult’s Law. The vapor pressures at 20°C are: benzene = 76 torr, toluene = 21 torr. What is the mole fraction of benzene in a solution whose total vapor pressure is 50 torr at 20°C?

**Freezing Point Depression and Boiling Point Elevation**

12. The freezing point of ethanol (C₂H₅OH) is −114.6°C. The molal freezing point depression constant for ethanol is 2.00°C/m. What is the freezing point (in °C) of a solution prepared by dissolving 50.0 g of glycerine (C₃H₈O₃), a nonelectrolyte, in 200 g of ethanol?

13. 20.7 g of magnesium chloride were dissolved in 100 g of water. What is the boiling point of this solution, assuming complete dissociation?

(Kₘ for water is 0.51 °C/m)

**Henry’s Law: Solubility of gases in liquids**

14. The partial pressure of CO₂ in air is approximately 4.0 X 10⁻⁴ atm. The solubility of CO₂ in water under these conditions is 1.3 X 10⁻⁵ M. What is CO₂ solubility at 1 atm?
Raoult’s Law: Vapor Pressure of a solution

15. The vapor pressure of pure water at 25°C is 23.8 mm Hg. Determine the vapor pressure of water at 25°C above a solution containing 35 g of urea (a non-volatile, nonelectrolyte, molecular mass = 60) dissolved in 75 g of water.

16. A solution was prepared by mixing 0.300 mole of acetone, C_3H_6O, with 0.50 mol of ethyl acetate, C_4H_8O_2. At 30°C, the vapor pressure of pure acetone is 285 torr and the vapor pressure of pure ethyl acetate is 118 torr. What is the vapor pressure of the solution?

More notes on Intermolecular Attractions:

I. Intermolecular attractions from strongest to weakest
   A. Ion-Ion- Ionic compounds (metal/non-metal)
   B. Hydrogen Bonding- Compounds containing H attached to N, O, or F
   C. Dipole-Dipole- polar compounds
   D. London Dispersion Forces- All compounds exhibit these, however they are most important with non-polar compounds.

II. Questions pertaining to intermolecular attractions:
   A. Which compound has the highest boiling point, melting point, and highest heat of vaporization corresponds to the compound with the strongest intermolecular attractions.
   B. Which compound has the highest vapor pressure corresponds to lowest intermolecular attractions.

III. If two compounds are both non-polar, the compound with the greatest molecular mass has the greater London Dispersion Forces and will have the greater boiling point, melting point. .

IV. If two compounds are both ionic, the compound which contains the ions with the greatest charge has the greater intermolecular attraction. If ions have the same charge, the smallest ions have the greatest intermolecular attractions.

Example Problem:

Arrange in order from highest to lowest melting point: NaCl, CO_2, Ne, CaCl_2, H_2O, H_2S.

Go back to number I on this page and decide what attraction is in each:

NaCl (ion/ion), CO_2 (London), Ne (London), CaCl_2(ion/ion), H_2O (H-Bonding), H_2S( dipole/dipole)
If two contain the same attraction, use III and IV to delineate between them:
Answer: CaCl₂, NaCl, H₂O, H₂S, CO₂, Ne