Chapter 5: Properties of Solutions

1. Wax is a solid mixture of hydrocarbon compounds consisting of molecules with long chains of carbon atoms. Which solvent would you expect to be most capable of dissolving wax?

Non-polar solute will dissolve in non polar solvet

a. H—O—H
b. CH_3—O—H
c. CF_3—O—H
d. H—O—CH_2—CH_2—O—H
* e. CH_3—CH_2—CH_2—CH_2—CH_2—CH_2—CH_2—CH_3

2. Which of the following will always cause an increase in the solubility of a gas in a solvent in which the gas does not react with the solvent to form a new substance?

a. increasing the temperature of the solvent and simultaneously decreasing the pressure of the gas in the space above the solvent.
* b. decreasing the temperature of the solvent and simultaneously increasing the pressure of the gas in the space above the solvent.
c. increasing the temperature of the solvent and simultaneously increasing the pressure of the gas in the space above the solvent.
d. decreasing the temperature of the solvent and simultaneously decreasing the pressure of the gas in the space above the solvent.
e. increasing the temperature of the solvent while maintaining the pressure of the gas in the space above the solvent at a set value.

3. During osmosis:

* a. pure solvent passes through a membrane but solutes do not.
b. pure solute passes through a membrane but solvent does not.
c. pure solvent moves in one direction through the membrane while the solution moves through the membrane in the other direction.
d. pure solvent moves in one direction through the membrane while the solute moves through the membrane in the other direction.
e. pure solute moves in one direction through the membrane while the solution moves through the membrane in the other direction.

4. The solubility of O_2 in water is approximately 0.00380 g L^{-1} when the temperature is 25.0 $^{\circ}$C and the partial pressure of gaseous oxygen is 760 torr. What will the solubility of oxygen be if the oxygen pressure is adjusted to 1000 torr?

a. 0.00289 g L^{-1} b. 0.00500 g L^{-1} c. 1.49 g L^{-1} d. 2.89 x 10^3 g L^{-1} e. 3.46 x 10^3 g L^{-1}	C_1= 0.00380 g L^{-1}, P_1= 760 torr C_2= ? g L^{-1}, P_2= 1000 torr $\frac{C_1}{C_2} = \frac{P_1}{P_2}$ $C_2 = \frac{P_2 C_1}{P_2} = \frac{1000x0.00380}{760}$ =0.00500 g L^{-1}

5. When a solute such as sugar is dissolved in a solvent like water, one of the observed effects is:

   * a. a decrease in the vapor pressure of the solvent.
   b. an increase in the vapor pressure of the solute.
   c. an increase in the freezing point of the liquid.
   d. a decrease in the boiling point of the liquid.

6. At 23.0 °C, the vapor pressure of acetonitrile, CH_3CN, is 81.0 torr while that of acetone, C_3H_6O, is 184.5 torr. What is the vapor pressure of a solution which contains 0.550 moles of acetonitrile and 0.350 moles of acetone? (Assume the mixture behaves as an ideal solution.)

a. 109 torr b. 121 torr c. 130 torr d. 144 torr e. 239 torr	Acetonitrile=A, acetone=B both are volatile P^o_A = 81 torr, P^o_B = 184.5 torr, n_A = 0.550 mole, n_B = 0.350 mole P_t = ?= P_A + P_B $P_t = X_A P^o_A + X_B P^o_B = \frac{n_A}{n_A + n_B} P^o_A + \frac{n_B}{n_A + n_B} P^o_B$ $(\frac{0.550}{0.55+0.35} x81) + (\frac{0.35}{0.55+0.35} x184.5) = 121 \quad torr$

7. A very dilute solution contains 116 mg of fructose (molar mass = 180.16 g mol^{-1}) in 1.000 liter of solution. It is placed in an osmotic membrane bladder, which is then suspended in pure water. What osmotic pressure would develop across the membrane if the temperature is 26.0 °C?

a. 3.36 torr b. 12.0 torr c. 151 torr d. 475 torr e. 1217 torr	m = 116 mg = 0.116 g MM = 180.16 g mol^{-1} V=1 L T= 26 °C +273 =299 K Π = M R T = $\frac{n}{V} RT = \frac{m.R.T}{MM.V} = \frac{0.116x0.082x299}{180.16x1} = 0.0158 atm x760 = 12.0 torr$

8. At 28.0 °C, the vapor pressure of *n*-propyl mercaptan, C_3H_7SH, is 175 torr, while that of acetonitrile, CH_3CN, is 102 torr. What is the vapor pressure, at 28.0 °C, of a solution made by mixing 100.0 g of C_3H_7SH and 100.0 g CH_3CN, if Raoult's Law is obeyed?

a. 35.7 torr b. 128 torr c. 139 torr d. 149 torr e. 277 torr	Acetonitrile=A (MM=41 g/mol), *n*-propyl mercaptan =B (MM =76 g/mol) both are volatile P^o_A = 102 torr, P^o_B = 175 torr, m_A = 100 g, m_B = 100 g $P_t = ?= P_A + P_B$ $P_t = X_A P^o_A + X_B P^o_B =$ $\frac{n_A}{n_A + n_B} P_A^o + \frac{n_B}{n_A + n_B} P_B^o = \frac{(\frac{m}{MM})_A}{(\frac{m}{MM})_A + (\frac{m}{MM})_B} P_A^o + \frac{(\frac{m}{MM})_B}{(\frac{m}{MM})_A + (\frac{m}{MM})_B} P_B^o$ $(\frac{\frac{100}{41}}{\frac{100}{41} + \frac{100}{76}} x102) + (\frac{\frac{100}{76}}{\frac{100}{41} + \frac{100}{76}} x175) = 128 \text{ torr}$

9. A molecular solute with a molar mass of 50.0 g mol^{-1} is dissolved in 500 g of water and the resulting solution has a boiling point of 101.53 $^\circ$C. How many grams of solute were in the solution? K_b = 0.51 $^\circ$C m^{-1}

a. 30. grams b. 75. grams c. 100 grams d. 125 grams e. 150 grams	MM= 50 g/mol, $m_{(solvent)}$ = 500 g, T_b= 101.53°C , m = ? g, K_b = 0.51 $^\circ$C m^{-1} $\Delta T_b = T_b - T^o_b$ $\Delta T_b = K_b \frac{n_{solute}}{m_{solvet(kg)}} = \frac{(\frac{m}{MM})_{solute}}{m_{solvent(kg)}} K_b = \frac{m_{solute}}{MM_{solute}.m_{solvent(kg)}} K_b =$ $\frac{m}{50x0.5} x0.51 = 101.53 - 100 = 1.53$ $m = \frac{1.53x50x0.5}{0.51} = 75g$

10. A solution contains 221 g of glycerol ($C_3H_8O_3$) in 600 grams of water. The K_f is 1.86 $^\circ$C m^{-1} and K_b is 0.51 $^\circ$C m^{-1}. What should the boiling point of the solution be?

a. 100.02 $^\circ$C b. 100.73 $^\circ$C c. 101.65 $^\circ$C d. 102.04 $^\circ$C e. 103.62 $^\circ$C	MM= 92 g/mol, $m_{(solvent)}$ = 600 g, m_{solute} = 221 g, $m_{solvent}$= 600 g K_f = 1.86 $^\circ$C m^{-1}, K_b = 0.51 $^\circ$C m^{-1}, T^o_b = 100 ^{o}C $T_b = T^o_b + \Delta T_b$ $\Delta T_b = K_b \frac{n_{solute}}{m_{solvet(kg)}} = \frac{(\frac{m}{MM})_{solute}}{m_{solute(kg)}} K_b = \frac{m_{solute}}{MM_{solute}.m_{solvent(kg)}} K_b =$ $\frac{221}{92x0.6} x0.51 = 2.04^0 C$ $T_b = T^o_b + \Delta T_b$ =100 + 2.04 = 102.04 ^{o}C

11. A solution, which was made by dissolving 62.07 g of a nonelectrolyte in 500 g of water, exhibits a freezing point of -1.86 °C. What is the molecular weight of this nonelectrolyte compound? For water, K_f is 1.86 °C m^{-1} and K_b is 0.51 °C m^{-1}.

a. 57.7 g mol^{-1} b. 62.07 g mol^{-1} c. 115 g mol^{-1} d. 124 g mol^{-1} e. 231 g mol^{-1}	MM= ? g/mol, $m_{(solvent)}$ = 500 g, m_{solute} = 62.07 g, K_f = 1.86 °C m^{-1}, K_b = 0.51 °C m^{-1}, T_f = -1.86 °C $\Delta T_f = T^o_f - T_f = 0-(-1.86) = 1.86\ ^oC$ $\Delta T_f = K_f \frac{n_{solute}}{m_{solvet(kg)}} = \frac{(\frac{m}{MM})_{solute}}{m_{solute(kg)}} K_f = \frac{m_{solute}}{MM_{solute}.m_{solvent(kg)}} K_f =$ $MM = \frac{m_{solute}}{m_{solvent(kg)} x \Delta T_f} K_f = \frac{62.07 x 1.86}{0.5 x 1.86}$ = 124 g/mol

12. How many moles of the nonelectrolyte, propylene glycol ($C_3H_8O_2$) should be dissolved in 800.0 g of water to prepare a solution whose freezing point is -3.72 °C? For water, K_f is 1.86 °C m^{-1} and K_b is 0.51 °C m^{-1}.

a. 1.60 moles b. 2.00 moles c. 2.50 moles d. 2.98 moles e. 4.65 moles	MM = 92 g/mol, $m_{(solvent)}$ = 800 g, n_{solute} = ? mol, K_f = 1.86 °C m^{-1}, K_b = 0.51 °C m^{-1}, T_f = -3.72 °C $\Delta T_f = T^o_f - T_f = 0 - (-3.72) = 3.72\ ^oC$ $\Delta T_f = K_f \frac{n_{solute}}{m_{solvet(kg)}}$ $n_{solute} = \frac{m_{solvent}(kg)\ x\ \Delta T_f}{K_f} = \frac{0.8 X 3.72}{1.86} = 1.60^o C$

13. How many grams of glycerol ($C_3H_8O_3$, a nonelectrolyte) should be dissolved in 600 g of water to prepare a solution whose freezing point is -4.65 °C? For water, K_f is 1.86 °C m^{-1} and K_b is 0.51 °C m^{-1}.

a. 22.1 grams b. 93.6 grams c. 138 grams d. 384 grams e. 478 grams	MM = 92 g/mol, m_{solute} = ?g, $m_{solvent}$= 600 g K_f = 1.86 °C m^{-1}, K_b = 0.51 °C m^{-1}, T_f = -4.65 °C $\Delta T_f = T^o_f - T_f = 0 - (- 4.65) = 4.65\ ^oC$

	$\Delta T_f = K_f \frac{n_{solute}}{m_{solvet(kg)}} = \frac{(\frac{m}{MM})_{solute}}{m_{solute(kg)}} K_f = \frac{m_{solute}}{MM_{solute}.m_{solvent(kg)}} K_f =$ $\frac{m}{92x0.6} x1.86 = 4.65$ $m = \frac{4.65x92x0.6}{1.86} = 138g$

14. At 28.0 °C, the vapor pressure of *n*-propyl mercaptan, C_3H_7SH, is 175 torr, while that of acetonitrile, CH_3CN, is 102 torr. What is the vapor pressure, at 28.0 °C, of a solution made by mixing 80.0 g of C_3H_7SH and 120.0 g CH_3CN, if Raoult's Law is obeyed?

a. 121 torr b. 131 torr c. 139 torr d. 146 torr e. 156 torr	Acetonitrile=A (MM = 41 g/mol), *n*-propyl mercaptan = B (MM =76 g/mol) both are volatile P^o_A = 102 torr, P^o_B = 175 torr, m_A = 120 g, m_B = 80 g $P_t = ? = P_A + P_B$ $P_t = X_A P^o_A + X_B P^o_B =$ $\frac{n_A}{n_A + n_B} P^o_A + \frac{n_B}{n_A + n_B} P^o_B = \frac{(\frac{m}{MM})_A}{(\frac{m}{MM})_A + (\frac{m}{MM})_B} P^o_A + \frac{(\frac{m}{MM})_B}{(\frac{m}{MM})_A + (\frac{m}{MM})_B} P^o_B$ $(\frac{\frac{120}{41}}{\frac{120}{41} + \frac{80}{76}} x102) + (\frac{\frac{80}{76}}{\frac{120}{41} + \frac{80}{76}} x175) = 46.3 + 75 = 121$ torr

15. What is the expected freezing point of a solution that contains 25.0 g of fructose, $C_6H_{12}O_6$, in 250.0 g of H_2O? For water, K_f = 1.86 °C m^{-1}.

a.-0.10 °C b.+0.10 °C c.-0.186 °C d.+0.186 °C e.-1.03 °C	MM= 180 g/mol, $m_{(solvent)}$ = 250 g, m_{solute} = 25 g, K_f = 1.86 °C m^{-1}, K_b = 0.51 °C m^{-1}, T^o_f = 0 °C $T_f = T^o_f + \Delta T_f$ $\Delta T_f = K_f \frac{n_{solute}}{m_{solvet(kg)}} = \frac{(\frac{m}{MM})_{solute}}{m_{solute(kg)}} K_f = \frac{m_{solute}}{MM_{solute}.m_{solvent(kg)}} K_f =$ $\frac{25}{180x0.250} x1.86 = 1.03^0 C$ $T_f = T^o_f - \Delta T_f = 0 - 1.03 = -1.03$ °C

16. Pure cyclohexane, C_6H_{12}, has a freezing point of 6.53 °C. Its freezing point depression constant is: K_f = 20.0 °C m^{-1}. A solution was made by taking 18.55 g of an unknown nonelectrolyte and dissolving it in 150.0 g of cyclohexane. The measured freezing point of the solution was -4.28 °C. Calculate the molecular weight of the unknown substance.

a.61.8 g mol^{-1} b.66.8 g mol^{-1} c.229 g mol^{-1} d.578 g mol^{-1} e.1099 g mol^{-1}	MM=? g/mol, $m_{(solvent)}$ = 150 g, m_{solute} = 18.55 g, K_f = 20.0 °C m^{-1}°C m^{-1}, T_f^0 = 6.53 °C, T_f = -4.28 °C $\Delta T_f = T^o_f - T_f = 6.53 - (-4.28) = 10.81$ °C $\Delta T_f = K_f \frac{n_{solute}}{m_{solvet(kg)}} = \frac{(\frac{m}{MM})_{solute}}{m_{solute(kg)}} K_f = \frac{m_{solute}}{MM_{solute}.m_{solvent(kg)}} K_f =$ $\frac{18.55}{MMx0.150} x20 = 10.81^0 C$ MM = (18.55 x 20) / (0.15 x 10.81) = 228.8 g/mol

17. Which property of a solution is not a colligative property?

* a. solubility of a solute
b. freezing point depression
c. boiling point elevation
d. osmotic pressure
e. vapor pressure lowering

18. Pure benzene, C_6H_6, has a freezing point of 5.45 °C. Its freezing point depression constant is: K_f = 5.07 °C m^{-1}. A solution was made by taking 24.20 g of an unknown nonelectrolyte and dissolving it in 125.0 g of benzene. The measured freezing point of the solution was -1.65 °C. Calculate the molecular weight of the unknown substance.

a. 138 g mol^{-1} b. 145 g mol^{-1} c. 258 g mol^{-1} d. 272 g mol^{-1} e. 595 g mol^{-1}	MM= ? g/mol, $m_{(solvent)}$ =125.0 g, m_{solute} = 24.20 g, K_f = 5.07 °C m^{-1}, T_f^o = 5.45 °C , T_f = -1.65 °C $\Delta T_f = T^o_f - T_f = 5.45 - (-1.65) = 7.1$ °C $\Delta T_f = K_f \frac{n_{solute}}{m_{solvet(kg)}} = \frac{(\frac{m}{MM})_{solute}}{m_{solute(kg)}} K_f = \frac{m_{solute}}{MM_{solute}.m_{solvent(kg)}} K_f =$ $MM = \frac{m_{solute}}{m_{solvent(kg)} x \Delta T_f} K_f = \frac{24.2x5.07}{0.125x7.1}$ = 138 g/mol