[Chapter 14 Worksheet 2]

Name: | UGA myID:

Instructions:

- Please enter your first and last name as it appears on the eLC roster (do not use a nickname).
- Your UGA myID is a combination of letters and numbers (example: mine is aw00285). **Do not use your 81x number.**
- If you do not have a printer, type your answers in the boxes then upload the worksheet template to Gradescope by **Friday, February 26th at 11:59 p.m.** Write your work on separate sheets of paper, convert to a PDF and upload to the dropbox on eLC.
- If you have a printer download the worksheet, write your answers and show your work on the worksheet template, convert it to a PDF and upload to Gradescope by **Friday, February 26th at 11:59 pm.**

Chapter 14-Part 2

Question 1: What are the ideal van't Hoff factors for these compounds: $Ba(OH)_2$, $C_6H_{12}O_6$, K_3PO_4, HNO_3 ?

C

A. 1, 1, 1, 1
B. 2, 1, 2, 2
C. 3, 1, 4, 2
D. 6, 3, 5, 5
E. none of the above

D. $\frac{0.20\ mol\ Na_2SO_4}{1\ kg\ H_2O} \times \frac{3\ mol\ ions}{1\ mol\ Na_2SO_4} = 0.60\ mol\ particles$

Question 2: Rank the following solutions from *lowest* boiling point to *highest* boiling point.

A, B, C, D

A. 0.35 *m* Ethylene Glycol ($C_2H_6O_2$) $\frac{0.35\ mol\ EG}{1\ kg\ H_2O} \times \frac{1\ particle}{1\ mol} = 0.35\ mol\ solute\ particles$
B. 0.20 *m* KBr
C. 0.50 *m* Glucose ($C_6H_{12}O_6$)
D. 0.20 *m* Na_2SO_4

B. $\frac{0.20\ mol\ KBr}{1\ kg\ H_2O} \times \frac{2\ mol\ ions}{1\ mol\ KBr} = 0.40\ mol\ solute\ particles$

0.50 mol particles

Question 3: Choose the aqueous solution with the **lowest** vapor pressure. These are all solutions of nonvolatile solutes and you should assume ideal van't Hoff factors where applicable.

C

A. 0.120 *m* $C_2H_6O_2$
B. 0.040 *m* $(NH_4)_2SO_4$
C. 0.060 *m* Li_2CO_3
D. 0.030 *m* $RbC_2H_3O_2$
E. They all have the same vapor pressure.

The higher the number of dissolved solute particles, the lower the vapor pressure.

A. $\frac{0.120\ mol\ molecules}{1\ kg\ H_2O}$ B. $\frac{0.120\ mol\ ions}{1\ kg\ H_2O}$ C. $\frac{0.180\ mol\ ions}{1\ kg\ H_2O}$

(0.060 mol ions/1 kg H_2O)

Question 4: Which of the following should have the largest Henry's law constant (k_H) in water?

B

A. Ne
B. CO
C. Br_2
D. CH_3CH_3
E. CO_2

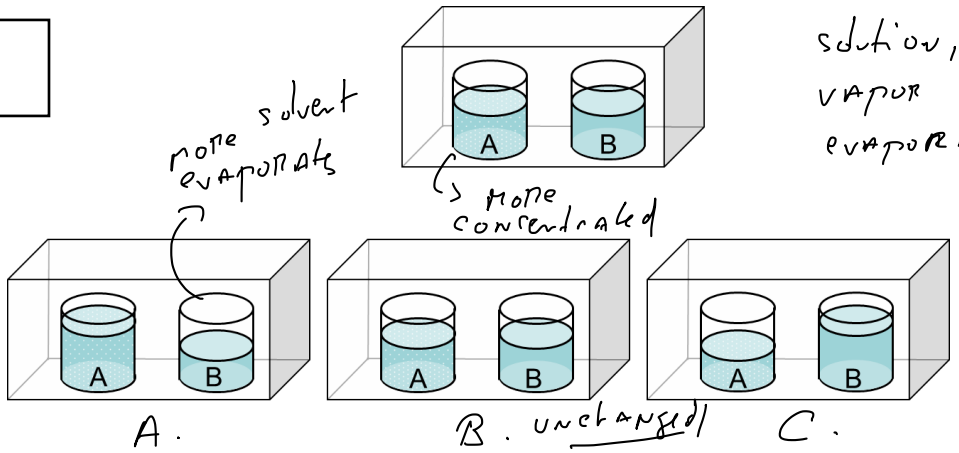
$S = k_H \cdot P$

CO: polar, strongest IMFs with water molecules.

Question 5: The diagram shows a closed system containing two salt water solutions. The solution labeled A is more concentrated than the one labeled B. Which of the diagrams below best represents the system at an infinite time after preparation?

A.

The more concentrated a solution, the lower the vapor pressure (less will evaporate)



Question 6: What is the vapor pressure of a solution that is 30.3% w/w ethylene glycol (MW = 62.07 g/mol) in water at 90 °C. The vapor pressure of pure water is 525.8 torr at 90 °C.

467 mm Hg

Assume 100 g solution: 30.3 g EG + 69.7 g H_2O

$$X_{solvent} = X_{H_2O} = \frac{69.7/18.02}{69.7/18.02 + 30.3/62.07} = \frac{3.868\ mol}{3.868\ mol + 0.488\ mol}$$

$X_{solvent} = 0.888$

$i = 1$

$$P_{soln} = X_{solvent} \cdot P^{o}_{solvent} = (0.888)(525.8\ mm\ Hg) = 466.9\ mm\ Hg$$

Question 7: What is the vapor pressure of a solution that is 30.3% w/w ethylene glycol (MW = 62.07g/mol) in water at 100 °C.

675 Torr

$$P_{soln} = X_{solvent} \cdot P^{o}_{solvent} \cdot i$$

$$P_{soln} = (0.888) \cdot (760\ torr) \cdot (1) = 674.9\ torr$$

(0.888: previous problem; 760 torr: BP pressure)

Question 8: As the water evaporates from this saturated solution

C

A. the vapor pressure above the solution increases.
B. the vapor pressure above the solution decreases.
C. the vapor pressure above the solution remains constant.

Vapor pressure is independent of quantity.

(40 % v/v) 40 mL EtOH + 60 mL H_2O = V_{soln}

Question 9: The concentration of alcohol in adult beverages is typically expressed as proof. Proof is simply double the % by volume (% v/v). Assuming that vodka is a solution of only water and ethanol, what is the *total* vapor pressure above an 80 proof vodka at 25 °C?

=> two volatile solutes example

Water: density = 1.00 g/mL; VP @ 25 °C = 23.8 mm Hg; MW = 18 g/mol

Ethanol: density = 0.789 g/mL; VP @ 25 °C = 58.7 mm Hg; MW = 46 g/mol

$$(40\ mL\ EtOH) \times \left(\frac{0.789\ g}{mL\ EtOH}\right)\left(\frac{1\ mol}{46\ g}\right) = 0.686\ mol\ EtOH$$

$$(60\ mL\ H_2O) \times \left(\frac{1.00\ g}{mL\ H_2O}\right)\left(\frac{1\ mol}{18\ g}\right) = 3.33\ mol\ H_2O$$

$P_{sol} = P_{H_2O} + P_{EtOH}$, $P_{H_2O} = (23.8\ mm\ Hg)\left(\frac{3.33\ mol\ H_2O}{3.33\ mol\ H_2O + 0.686\ mol\ EtOH}\right)$

$P_{H_2O} = 19.73\ mm\ Hg$

$P_{EtOH} = (58.7\ mm\ Hg)\left(\frac{0.686\ mol}{0.686\ mol + 3.33\ mol}\right) = 10.03\ mm\ Hg.$

$P_{sol} = (19.73\ mm\ Hg) + (10.03\ mm\ Hg) = 30.00\ mm\ Hg$

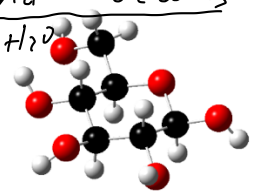
30.0	mm Hg

Question 10: 6. A 2.0 molal aqueous solution of glucose ($C_6O_6H_{12}$) is found to boil at 101 °C. What would the boiling point of a 2.0 molal solution of sucrose be?

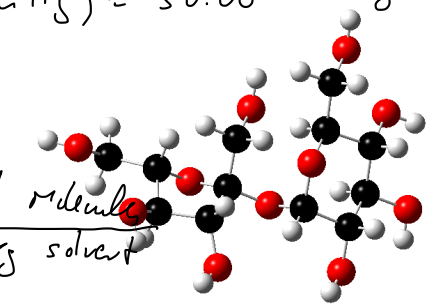
2.0 molal glucose = $\frac{2.0\ mol\ molecule}{1\ kg\ H_2O}$ } $\frac{2.0\ mol\ molecule}{1\ kg\ solvent}$

C

A. 102 °C
B. 100.5 °C
C. 101 °C (same)
D. Slightly higher than 100.5 °C
E. Cannot determine without K_b



glucose ($C_6O_6H_{12}$)



sucrose ($C_{12}O_{11}H_{22}$)

Question 11: Last year the lowest temperature in Athens was 12 °F (-11 °C). What is the minimum concentration for the radiator fluid in your car so that the solution doesn't freeze? Radiator fluid is ethylene glycol (MW 62.07 g/mol) dissolved in water. The K_{fp} for water is -1.86 °C/*m*.

5.91

$\Delta T = K_f \cdot m \cdot i \Rightarrow m = \frac{(-11)}{(-1.86)(1)} = 5.91\ m$ ($i = 1$)

Question 12: A 0.100 *M* acetic acid solution has an osmotic pressure of 2.47 atm at 25 °C. Calculate the van't Hoff factor.

$\Pi = M \cdot R \cdot T \cdot i$

A. | 1.011 | atm

$i = \frac{(2.47\ atm)}{(0.1\ \frac{mol}{L})(0.082\ \frac{L \cdot atm}{mol \cdot K})(298)} = 1.011$

B. What is the percent ionization of acetic acid in the solution?

1.1	%

$\alpha = \frac{(i-1)}{(n-1)} \times 100\% = \frac{(1.011-1)}{(2-1)} \times 100\% = 1.1\%$

↳ theoretical

Question 13: An isotonic solution will produce an osmotic pressure of 7.84 atm measured against pure water at human body temperature (37.0 °C). How many *grams* of sodium chloride must be dissolved in a liter of water to produce an isotonic solution?

9.00	g

$\Pi = \frac{mol}{L} \cdot R \cdot T \cdot i$ ($i = 2$)

$mol = \frac{(\Pi)(L)}{(R)(T)(i)} = \frac{(7.84)(1)}{(0.082)(310)(2)} = 0.1542\ mol\ NaCl$

$8.99\ g = (0.1542\ mol\ NaCl)\left(\frac{58.35\ g}{1\ mol\ NaCl}\right)$

82 g/mol

Question 14: The smell of ripe raspberries is due to 4-(*p*-hydroxyphenyl)-2-butanone, which has the empirical formula C_5H_6O. To find its molecular formula, you dissolve 0.135 g in 25.0 g of chloroform, $CHCl_3$. The boiling point of the solution is 61.82 °C. What is the molecular formula of the solute?

$CHCl_3$: BP = 61.70 °C; K_{bp} = +3.63 °C/*m*

$\Delta T = 61.82 - 61.70 = 0.12\ °C$

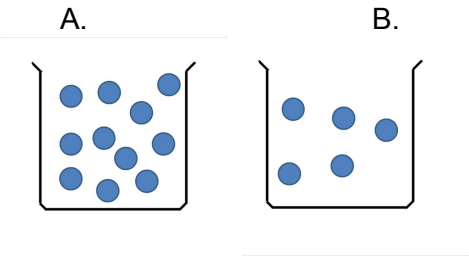
$\Delta T_{bp} = (m)(K_B)(i)$, $m = \frac{(0.12)}{(3.63)(1)}$

$m = 0.03305\ \frac{mol}{kg}$, $mol\ solute = (0.03305)(0.025\ kg) = 8.28 \times 10^{-4}\ mol$

$C_{10}H_{12}O_2$

$MM = \frac{g\ solute}{mol\ solute} = \frac{0.135\ g}{8.28 \times 10^{-4}\ mol} = 163\ g/mol \Rightarrow 2 \times (C_5H_6O)$ (82 g/mol)

Question 15: Only the solutes are shown in the following solutions. Which lettered beaker has the lowest vapor pressure?



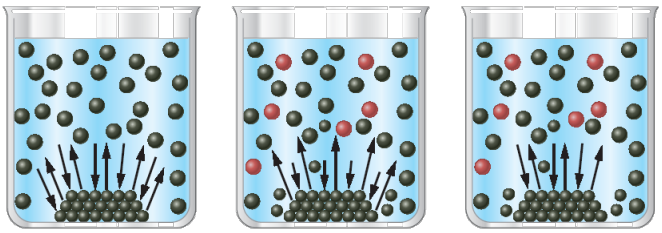
Correct answer is A, the higher the solute conc the lower the vapor pressure.

Question 16: The freezing point of a solution is lower than that of the pure solvent because

B

A. The addition of solute to the liquid increases the rate of escape of molecules from the solid phase to the liquid phase. At lower temperature these rates can again become equal.

B. The addition of solute to the liquid decreases the rate at which solvent molecules enter the solid phase. By lowering the temperature, the rate of escape of molecules from the solid to liquid phase is also lowered and become equal.



Equilibrium at freezing point of solvent | Equilibrium disrupted by solute added to solvent | Equilibrium restored at a lower temperature

For Questions 17-21, *match the following.*

A. solution with ΔT_b = 0.026 °C
B. solution of ionic compound with highest freezing point
C. highest boiling point
D. largest van't Hoff factor
E. solution that is most strongly dependent upon pressure

$\Delta T = K_f \cdot m \cdot i$, $K_f = 0.512$

$m = \frac{0.026}{0.512 \cdot i} = 0.050$

if $i = 1$

Question 17: 0.050 *m* NaCl $i = 2$, 0.100 mol ions / kg H_2O

C

Question 18: 0.050 *m* $C_6H_{12}O_6$ (aqueous) $i = 1$, 0.050 mol ions / kg H_2O

A

Question 19: 0.0050 *m* CO_2 $i = 1$, 0.0050 mol CO_2 molecules / kg H_2O

E

Question 20: 0.020 m NH_4Cl $i = 2$, 0.040 mol ions / kg H_2O

B

Question 21: 0.010 *m* $Al(NO_3)_3$ $i = 4$, 0.040 mol ions / kg H_2O

B, D

Question 22: 0.250 L solution

A dilute aqueous solution of an organic compound is formed by dissolving 2.35 g of the compound in water to form 250 mL solution. The resulting solution has an osmotic pressure of 0.605 atm at 25 °C. What is the molar mass of this compound?

$\Pi = i \cdot M \cdot R \cdot T$, $M = \frac{0.605\ atm}{(1)(0.08206\ \frac{L \cdot atm}{mol \cdot K})(298\ K)}$

$M = 0.02474\ mol/L$

$mol\ solute = (0.02474\ \frac{mol}{L})(0.250\ L) = 0.0062\ mol$

$MW = \frac{2.35\ g}{0.0062\ mol} = 379.944\ g/mol$

E

A. 7.97 g/mol
B. 31.9 g/mol
C. 57.5 g/mol
D. 230 g/mol
(E) 380 g/mol

Question 23:

The boiling point of ethanol, CH_3CH_2OH, is 78.500 °C at 1 atm. When 14.10 g of an unknown, non-electrolyte compound was dissolved in 282.0 g of ethanol, the solution was found to have a boiling point of 78.833 °C. What is the molar mass of the unknown compound? (K_{bp} for ethanol = 1.22 °C/*m*)

$i = 1$, $m = \frac{78.833 - 78.500}{1.22} = 0.2727$

$mol\ solute = (0.2727)/(0.282) = 0.07696\ mol$

$MW = \frac{14.10}{0.07696} = 183.17...$

E

A. 68.65 g/mol
B. 84.40 g/mol
C. 145.68 g/mol
D. 174.46 g/mol
(E) 183.18 g/mol

Question 24:

Two aqueous are prepared: 1.00 *m* Na_2CO_3 and 1.00 *m* LiCl. Which of the following statements is true?

B

A. The Na_2CO_3 solution has a higher osmotic pressure and ~~higher vapor pr~~ lower pressure than the LiCl solution. ($i = 3$, $i = 2$)
(B) The Na_2CO_3 solution has a higher osmotic pressure and higher boiling point than the LiCl solution.
C. The Na_2CO_3 solution has ~~a lower~~ higher osmotic pressure and lower vapor pressure than the LiCl solution.
D. The Na_2CO_3 solution has ~~a lower~~ higher osmotic pressure and higher boiling point than the LiCl solution.