ASSIGNMENT SHEET #5 APQ ANSWERS

10 ace

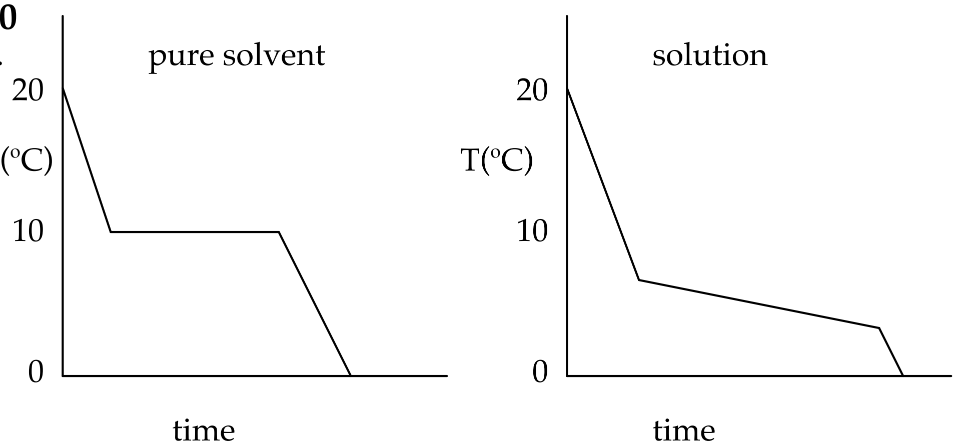
a. $Pb(NO_3)_2$ will have the highest B.P. This solution contains the highest concentration of solute particles (the *i* factor = 3), which will consequently have the greatest effect on the boiling point of the solvent (recall that colligative properties are based solely on the number of solute particles).

c. Referring to a solubility table (e.g. Table 4.2, page 109 of Chang), mixing $Pb(NO_3)_2$ and NaCl will produce the precipitate $PbCl_2$.

e. The least conductive solution will be the one containing the fewest ions. Ethanol, C_2H_5OH, does not ionize in water (*i* factor = 1), whereas all the other solutes will ionize in their respective solutions. Therefore, the ethanol solution will be the least conductive solution.

20

a.



b i. You need to measure the volume of the solvent and know its density (or know its mass), the mass of the solute, and the change in the freezing point (ΔT).

$\Delta T = m \cdot K_F$ $\quad\quad m = \dfrac{moles_{solute}}{kg_{solvent}}$ $\quad\quad$ moles solute = $\dfrac{mass_{solute}}{MM_{solute}}$

Therefore, $\Delta T = \dfrac{\dfrac{mass_{solute}}{MM_{solute}}}{kg_{solvent}} \cdot K_F$

b ii. Given: $MM_{solute} = \dfrac{mass_{solute}}{(\Delta T)(kg_{solvent})} \cdot K_F$

b iii. Measure the difference between the temperatures of the <u>starts</u> of the two plateaus (these are the FPs) [note: the solution doesn't have a horizontal plateau]; this value = ΔT.

c. If some of the solvent evaporated, your solution would be more concentrated (i.e., have a higher molality) than you suspect. This would result in a higher ΔT than you anticipated. Using the equation above, a high ΔT would make your calculated MM value be too low.

d. Percent error = $\dfrac{(126g/mol - 120g/mol)}{120g/mol}$ x 100

28 abc

a. (see APQ 10e) The least conductive solution will be the one containing the fewest ions. Ethanol, C_2H_5OH, does not ionize in water (*i* factor = 1), whereas all the other solutes will ionize in their respective solutions. Therefore, the ethanol solution will be least conductive.
b. $MgCl_2$ will have the lowest F.P. This solution contains the highest concentration of solute particles (the *i* factor = 3), which will consequently have the greatest effect on the freezing point of the solvent (recall that colligative properties are based solely on the number of solute particles).
c. The aqueous solution with the highest water vapor pressure above it will be the one containing the fewest solute particles. C_2H_5OH does not ionize in water (*i* factor = 1), whereas all the other solutes will ionize in their respective solutions. Therefore, the ethanol solution will have the least reduced solvent vapor pressure; hence it will have the highest water vapor pressure above it.

30

a. $C_7H_{12}O_2$
b. (Note: look at APQ 20b for the equation to use for this calculation)
MM = 256.9 g/mole. The empirical formula weight = 128 g/empirical formula. Therefore, the molecular formula is $(C_7H_{12}O_2)_2 = C_{14}H_{24}O_4$
c. Use $PV = \frac{mass}{MM} RT$ for this calculation. MM = 128 g/mole

d. Apparently, when in solution, pairs of the organic solute particles became hydrogen bonded to one another (the technical term is *dimerization*), essentially cutting the number of solute particles in half. In other words, this solute had an *i* factor of 0.5.
An *i* factor of 0.5 will reduce the ΔT_F by half, thus doubling the molar mass calculated using the equation $\Delta T_F = m \cdot K_F$. Hence, the molar mass calculated from the solution data was twice as high as the molar mass calculated from the gas data.
Dimerization is unique to organic solutes capable of H-bonding. It is the opposite of the dissociation that ionic compounds undergo, and it has the opposite effect on calculated molar masses. *i* factors >1 cause the calculated molar masses to be proportionately less than actual.

41

[Note: This question is exactly like the gravimetric analysis lab we did.]
a. Look at the procedure for the lab to answer this question.
b. Again, look at your lab procedure.
c. Again, look at your lab report.
d. According to the solubility table (Table 4.2, page 109 of Chang), $MgSO_4$ is soluble. Therefore, $MgCl_2$ is not an acceptable substitute for $BaCl_2$.

49

a. ? L · $\frac{18.4\,mole}{L}$ = 5.20 moles ? L = 0.283 L = 283 mL

b. mass % = $\frac{mass\ solute\ (H_2SO_4)}{mass\ of\ 1.0L\ solution}$ x 100

mass of solute = 18.4 moles · $\frac{98\,g}{mole\ H_2SO_4}$ = 1,803 grams

mass of 1.0 L solution = 1000 mL · $\frac{1.84\,g}{mL}$ = 1,840 grams

mass % = $\frac{1{,}803g\ solute}{1{,}840g\ solution}$ · 100 = 98 %

d. 5.2 M = $\frac{5.2\ moles\ solute}{1000mL\ solution}$

mass of solution = 1000 mL · $\frac{1.38\,g}{mL}$ = 1380 grams

mass of solvent = 1380 grams – (5.2 moles solute · $\frac{98\ g\ H_2SO_4}{mole}$) = 870 g = 0.87 kg solvent

molality = $\frac{5.2\ moles\ H_2SO_4}{0.87\ kg}$ = 5.98 m

54 abc

a. The sucrose solution contains no appreciable number of ions due to the molecular nature of the sucrose, so the sucrose solution is not a conductor of electricity. Since the ionic solute silver nitrate is completely soluble in water, there are many free moving ions in that solution; hence, it is a good conductor.
b. Solid silver nitrate has no free moving charged particles – the ions are locked in a rigid lattice. As such, it cannot conduct electricity. The sodium metal has loose valence electrons in a "sea of electrons" which are free moving, allowing the metal to readily conduct electricity.
c. Sucrose is a molecule – there are no ions – so even in the fused state, there are no free moving charged particles to enable the material to conduct electricity. The molten silver nitrate does have free moving charged particles – ions – so it can conduct electricity.

65 a

Each $CaCl_2$ unit forms 3 particles in aqueous solution, whereas each NaCl unit forms two particles in aqueous solution. The higher *i* factor causes a lower freezing point depression, which makes $CaCl_2$ more efficient at de-icing roads.

67 a

The vapor pressures above the beakers are unequal. The pressure above beaker A is greater than that above beaker B because A contains pure solvent, whereas B contains a solution. Recall that a solute reduces the solvent vapor pressure of a solvent. This will lead to a net transfer of solvent (water in this case) from beaker A to beaker B. As the beakers in the bell jar approach equilibrium, you will see the volume of beaker A decrease and eventually disappear. The water in beaker A will vaporize and then condense in beaker B in an attempt to reduce the concentration gradient (a la osmosis). This will increase the volume in beaker B and consequently decrease the concentration of the sugar solution in beaker B.