CHE152 Freezing Point Depression Key

1. Predict the effect of each of the following on the molar mass calculated for this experiment. Select the number that indicates the effect AND briefly explain your reasoning.

   1) the molar mass calculated would be **greater** than it should be
   2) the molar mass calculated would be **less** than it should be
   3) there would be **no effect** on the calculated molar mass
   4) there would be an **unpredictable effect** on the calculated molar mass.

Equation: $MW = \dfrac{K_f \cdot mass_{solute}}{\Delta T_f \cdot kg_{solvent}}$

a) Some of the solute fell on the lab bench, after massing, rather than into the test tube.

Effect__**1**__

) T_f will be lower. Since MW " 1/) T_f, MW will be higher.

b) Some of the solvent was lost after massing the test tube and solvent.

Effect__**2**__

) T_f will be greater therefore, MW will be lower.

c) The thermometer is systematically high by 1.3 ^{0}C for all of the readings.

Effect__**3**__

Since) T_fs are determined and not absolute Ts, there will be no effect.

d) The thermometer touched the walls of the test tube during the runs with the solute dissolved.

Effect__**2**__

The walls of the test tube are cooler than the solution therefore, the thermometer will record a lower temperature for the T_f of the solution causing) T_f to be larger causing MW to be lower.

e) The thermometer touched the walls of the test tube only during the runs with the solvent.

Effect__**1**__

Here $T_{solvent}$ will be lower and) T_f will be lower therefore, MW will be higher.

f) The liquid was not well stirred during the runs with the solute dissolved.

Effect__**4**__

The temperature in the solution will not be uniform and the effect is hard to predict.

2. In this determination of the molar mass, which of the measured quantities is the largest source of error? Explain. **Temperature.**

Temperature is measured to the nearest 0.1 ^{0}C while mass is measured to the nearest 0.001 g.

3. To improve the accuracy of this experiment, would you be better off with a solvent with a larger or a smaller cryoscopic constant, Kf? Explain.

Larger K_f will yield a larger) T_f for a give mass of solute. The larger) T_f will minimize the errors in the temperature readings.

4. The molar mass of an unknown material was determined by the freezing point depression method. 0.351 g of unknown was added to 9.476 g of ethylene dibromide, $C_2H_4Br_2$. The resulting solution was found to have a melting point of 4.18 ^{0}C. Pure ethylene dibromide has a melting point of 9.79 ^{0}C, and a cryoscopic constant of 11.8 ^{0}C/molal. Calculate the molar mass of the unknown. Show your work with units.

$$MW = \frac{K_f \cdot g_{solute}}{\Delta T_f \cdot kg_{solvent}} = \frac{11.8\ ^oC/m \cdot 0.351\ g}{(9.79 - 4.18)\ ^oC \cdot 0.009476\ kg} = 77.9\ g/mol$$

5. The melting point of pure camphor, $C_{10}H_{16}O_2$, is 179.8 ^{0}C. When 1.235 g of toluene, C_7H_8, is added to29.142 g of camphor, the melting point is decreased to 162.5 ^{0}C.Calculate the cryoscopic constant for camphor. Show your work with units.

$$K_f = \frac{\Delta T_f}{m} = \frac{\Delta T_f \cdot kg_{camphor}}{mol_{toluene}} = \frac{(179.8 - 162.5)^oC \cdot 0.029142\ kg}{1.235\ g / 92.0\ g} = 37.6\ ^oC/m$$

6. 3.00 quarts of ethylene glycol, $C_2H_6O_2$, (Density 1.109 g/mL), is added to 5.50 liters of water, H_2O (Density 0.997 g/mL) . If the cryoscopic constant for water is 1.86 ^{0}C/molal calculate the freezing point of this solution in ^{0}C <u>AND</u> ^{0}F. Show your work with units.

$$3.00\ qts \cdot \frac{0.9464\ L}{qt} \cdot \frac{1\ mL}{10^{-3}\ L} \cdot \frac{1.109\ g}{mL} \cdot \frac{1\ mol\ C_2H_6O_2}{62.0\ g\ C_2H_6O_2} = 50.7_9\ mol\ C_2H_6O_2$$

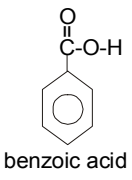
$$5.50\ L \cdot \frac{1\ mL}{10^{-3}\ L} \cdot \frac{0.997\ g}{mL} \cdot \frac{1\ kg}{10^3\ g} = 5.48\ kg\ H_2O$$

$$\Delta T_f = K_f \cdot m = \frac{1.86\ ^oC}{mol/kg} \cdot \frac{50.7_9\ mol}{5.48\ kg} = 17.2\ ^oC;\ T_f = -17.2\ ^oC$$

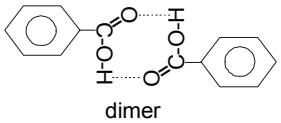
$$^oF = 1.8 \cdot ^oC + 32 = 1.8 \cdot (-17.2) + 32 = 1.0_4\ ^oF$$

7. In a freezing point experiment, the molar mass of benzoic acid, $C_7H_6O_2$ was found to be 245 g/mole. If the experiment was done correctly, what does this result suggest about the benzoic acid molecule and its behavior in this solvent?

   The molecular weight of benzoic acid is 1225. g/mol. This is one half of the experimentally determined weight of 245 g/mol. this is due to the dimerization of benzoic acid, that is it forms ($C_7H_6O_2$).



benzoic acid


dimer