

## Post-Laboratory Questions

(Use the spaces provided for answers and additional paper if necessary.)

1. If you wanted to do this experiment more accurately, you could cool the liquid more slowly and measure the temperature more accurately. Suggest how you could modify the equipment to accomplish these changes.

To measure the temperature more accurately we could utilize temperature probes or electronic thermometers as well as the computer program in which the probe records the data.

2. The freezing point of camphor is  $178.4\text{ }^\circ\text{C}$  and its molal freezing point depression constant ( $K_f$ ) is  $37.7\text{ }^\circ\text{C}\cdot\text{kg/mol}$ . How many grams of naphthalene ( $\text{C}_{10}\text{H}_8$ ; molar mass =  $128.17\text{ g/mol}$ ; a solute, not the solvent, in this question) should be mixed with  $12.0\text{ g}$  of camphor to lower the freezing point to  $170.0\text{ }^\circ\text{C}$ ?

$$178.4\text{ }^\circ\text{C} - 170.0\text{ }^\circ\text{C} = 8.4\text{ }^\circ\text{C}$$

$$8.4\text{ }^\circ\text{C} / 37.7\text{ }^\circ\text{C}\cdot\text{kg/mol} = 0.223\text{ mol/kg}$$

$$12.0\text{ g} \times 1\text{ kg} / 1000\text{ g} \times 0.223\text{ mol/kg} \times 128.17\text{ g/mol} = 0.343\text{ grams naphthalene.}$$

3. Pure biphenyl freezes at  $71.0\text{ }^\circ\text{C}$ . A solution of  $1.44\text{ g}$  of anthracene ( $\text{C}_{14}\text{H}_{10}$ ; molar mass =  $178.2\text{ g/mol}$ ) and  $12.87\text{ g}$  of biphenyl froze at  $21.1\text{ }^\circ\text{C}$ . Calculate  $K_f$  of biphenyl.

49.9

$$21.1\text{ }^\circ\text{C} - 71.0\text{ }^\circ\text{C} = 49.9\text{ }^\circ\text{C}$$

Moles of anthracene =  $1.44\text{ g} / 178.2\text{ g/mol} = 0.00808\text{ moles}$

$$0.00808\text{ moles} / 0.01287\text{ kg} = 0.6279\text{ mol/kg}$$

$$49.9\text{ }^\circ\text{C} / 0.6279\text{ mol/kg} = 79.8\text{ }^\circ\text{C}\cdot\text{kg/mol}$$

SLIGHTLY OFF

4. Suppose that a student calculated  $K_f$  of biphenyl to be  $81.2\text{ }^\circ\text{C}\cdot\text{kg/mol}$ . Calculate the molar mass of an unknown if a solution containing  $1.64\text{ g}$  of unknown in  $18.22\text{ g}$  of biphenyl froze at  $39.9\text{ }^\circ\text{C}$ .

$$\Delta T = K_f \times m \quad \Delta T = 71.0\text{ }^\circ\text{C}$$

$$39.9\text{ }^\circ\text{C} = 31.1\text{ }^\circ\text{C} \cdot m$$

$$31.1\text{ }^\circ\text{C} / 81.2\text{ }^\circ\text{C}\cdot\text{kg/mol} = 0.383\text{ molal}$$

moles of solute =  $0.383 \times 0.01822\text{ kg biphenyl} = 0.0069\text{ moles}$

$$1.64\text{ g} / 0.0069\text{ moles} = 237.68\text{ g/mol MM} = 237.68\text{ g/mol}$$

