Chs 11-13 Student's Choice Difficult Q's

13.39 *Analyze/Plan.* Follow the logic in Sample Exercise 13.3. *Solve.*

(a) $$\text{mass \%} = \frac{\text{mass solute}}{\text{total mass solution}} \times 100 = \frac{10.6\text{ g } Na_2SO_4}{10.6\text{ g } Na_2SO_4 + 483\text{ g } H_2O} \times 100 = 2.15\%$$

(b) $$\text{ppm} = \frac{\text{mass solute}}{\text{total mass solution}} \times 10^6; \frac{2.86\text{ g Ag}}{1\text{ ton ore}} \times \frac{1\text{ ton}}{2000\text{ lb}} \times \frac{1\text{ lb}}{453.6\text{ g}} \times 10^6 = 3.15\text{ ppm}$$

11.43 *Analyze.* The heat required to vaporize 60 g of H_2O equals the heat lost by the cooled water.

Plan. Using the enthalpy of vaporization, calculate the heat required to vaporize 60 g of H_2O in this temperature range. Using the specific heat capacity of water, calculate the mass of water than can be cooled 15 °C if this much heat is lost.

Solve. Evaporation of 60 g of water requires:

$$60\text{ g } H_2O \times \frac{2.4\text{ kJ}}{1\text{ g } H_2O} = 1.44 \times 10^2\text{ kJ} = 1.4 \times 10^5\text{ J}$$

Cooling a certain amount of water by 15 °C:

$$1.44 \times 10^5\text{ J} \times \frac{1\text{ g-K}}{4.184\text{ J}} \times \frac{1}{15\text{ °C}} = 2294 = 2.3 \times 10^3\text{ g } H_2O$$

Check. The units are correct. A surprisingly large mass of water (2300 g ≈ 2.3 L) can be cooled by this method.

11.45 *Analyze/Plan.* Follow the logic in Sample Exercise 11.3. *Solve.* Physical data for ethanol, C_2H_5OH, is: mp = -114°C; ΔH_{fus} = 5.02 kJ/mol; $C_{s(solid)}$ = 0.97 J/g-K; bp = 78°C; ΔH_{vap} = 38.56 kJ/mol; $C_{s(liquid)}$ = 2.3 J/g-K. *Solve.*

(a) Heat the liquid from 35 °C to 78 °C, ΔT = 43 °C = 43 K.

$$42.0\text{ g } C_2H_5OH \times \frac{2.3\text{ J}}{\text{g-K}} \times 43\text{ K} \times \frac{1\text{ kJ}}{1000\text{ J}} = 4.1538 = 4.2\text{ kJ}$$

(b) The density of H_2O = 0.997 g/mL = 0.997 kg/L.

$$\frac{4.80\text{ g NaCl}}{0.350\text{ L } H_2O} \times \frac{1\text{ mol NaCl}}{58.44\text{ g NaCl}} \times \frac{1\text{ L } H_2O}{0.997\text{ kg } H_2O} = 0.235\ m\text{ NaCl}$$

13.47 *Analyze/Plan.* Assume 1 L of solution. Density gives the total mass of 1 L of solution. The g H_2SO_4/L are also given in the problem. Mass % = (mass solute/total mass solution) × 100. Calculate mass solvent from mass solution and mass solute. Calculate moles solute and solvent and use the appropriate definitions to calculate mole fraction, molality, and molarity. *Solve.*

(a) $$\frac{571.6\text{ g } H_2SO_4}{1\text{ L soln}} \times \frac{1\text{ L soln}}{1329\text{ g soln}} = 0.430098\text{ g } H_2SO_4/\text{g soln}$$

mass percent is thus 0.4301 × 100 = 43.01% H_2SO_4

(b) In a liter of solution there are 1329 – 571.6 = 757.4 = 757 g H_2O.

$$\frac{571.6\text{ g } H_2SO_4}{98.09\text{ g/mol}} = 5.827\text{ mol } H_2SO_4; \frac{757.4\text{ g } H_2O}{18.02\text{ g/mol}} = 42.03 = 42.0\text{ mol } H_2O$$

$$\chi_{H_2SO_4} = \frac{5.827}{42.03 + 5.827} = 0.122$$

(The result has 3 sig figs because (g H_2O) resulting from subtraction is limited to 3 sig figs.)

(c) $$\text{molality} = \frac{5.827\text{ mol } H_2SO_4}{0.7574\text{ kg } H_2O} = 7.693 = 7.69\ m\ H_2SO_4$$

(d) $$\text{molarity} = \frac{5.827\text{ mol } H_2SO_4}{1\text{ L soln}} = 5.827\ M\ H_2SO_4$$

13.65 (a) *Analyze/Plan.* H_2O vapor pressure will be determined by the mole fraction of H_2O in the solution. The vapor pressure of pure H_2O at 338 K (65°C) = 187.5 torr. *Solve.*

$$\frac{22.5\,g\,C_{12}H_{22}O_{11}}{342.3\,g/mol} = 0.06573 = 0.0657\ mol;\ \frac{200.0\,g\,H_2O}{18.02\,g/mol} = 11.09878 = 11.10\ mol$$

$$P_{H_2O} = \chi_{H_2O}\,P^{\circ}_{H_2O} = \frac{11.09878\ mol\ H_2O}{11.09878 + 0.06573} \times 187.5\ torr = 186.4\ torr$$

(b) *Analyze/Plan.* For this problem, it will be convenient to express Raoult's law in terms of the lowering of the vapor pressure of the solvent, ΔP_A.

$\Delta P_A = P_A^\circ - \chi_A P_A^\circ = P_A^\circ\,(1 - \chi_A)$. $1 - \chi_A = \chi_B$, the mole fraction of the *solute* particles

$\Delta P_A = \chi_B P_A^\circ$; the vapor pressure of the solvent (A) is lowered according to the mole fraction of solute (B) particles present. *Solve.*

$$P_{H_2O}\ \text{at}\ 40^\circ C = 55.3\ torr;\quad \frac{340\,g\,H_2O}{18.02\,g/mol} = 18.868 = 18.9\ mol\ H_2O$$

$$\chi_{C_3H_8O_2} = \frac{2.88\ torr}{55.3\ torr} = \frac{y\ mol\ C_3H_8O_2}{y\ mol\ C_3H_8O_2 + 18.868\ mol\ H_2O} = 0.05208 = 0.0521$$

$$0.05208 = \frac{y}{y + 18.868};\ 0.05208\,y + 0.98263 = y;\ 0.94792\,y = 0.98263,$$

$y = 1.0366 = 1.04\ mol\ C_3H_8O_2$

This result has 3 sig figs because (0.340 kg water) has 3 sig figs.

$$1.0366\ mol\ C_3H_8O_2 \times \frac{76.09\,g\,C_3H_8O_2}{mol\,C_3H_8O_2} = 78.88 = 78.9\,g\,C_3H_8O_2$$

13.67 *Analyze/Plan.* At 63.5°C, $P^{\circ}_{H_2O} = 175$ torr, $P^{\circ}_{Eth} = 400$ torr. Let G = the mass of H_2O and/or C_2H_5OH. *Solve.*

(a) $$\chi_{Eth} = \frac{\dfrac{G}{46.07\,g\,C_2H_5OH}}{\dfrac{G}{46.07\,g\,C_2H_5OH} + \dfrac{G}{18.02\,g\,H_2O}}$$

Multiplying top and bottom of the right side of the equation by 1/G gives:

$$\chi_{Eth} = \frac{1/46.07}{1/46.07 + 1/18.02} = \frac{0.02171}{0.02171 + 0.05549} = 0.2812$$

(b) $P_t = P_{Eth} + P_{H_2O}$; $P_{Eth} = \chi_{Eth} \times P^{\circ}_{Eth}$; $P_{H_2O} = \chi_{H_2O}\,P^{\circ}_{H_2O}$

$\chi_{Eth} = 0.2812$, $P_{Eth} = 0.2812\ (400\ torr) = 112.48 = 112\ torr$

$\chi_{H_2O} = 1 - 0.2812 = 0.7188$; $P_{H_2O} = 0.7188(175\ torr) = 125.8 = 126\ torr$

$P_t = 112.5\ torr + 125.8\ torr = 238.3 = 238\ torr$

(c) $$\chi_{Eth}\ \text{in vapor} = \frac{P_{Eth}}{P_{total}} = \frac{112.5\ torr}{238.3\ torr} = 0.4721 = 0.472$$