

**Chemistry 230**  
**Problem Set # 11 — 11/10/99**

Recommended Problems: Chapt. 9: 1-5, 8-12, 14-16, 19, 20, 29, 35, 39, 53, 63-65

1. 4.45 g of 100% sulfuric acid is added to 82.20 g of water, and the density of the solution is found to be 1.029 g/cm<sup>3</sup> at 25°C and 1 atm. Treating the acid as solute, calculate (a) the weight per cent; (b) the mole fraction; (c) the mole per cent; (d) the molality; and (e) the molarity of the solution.

2. The partial molar volume  $V_B$  of K<sub>2</sub>SO<sub>4</sub> in aqueous solutions at 25°C is given by

$$V_B \text{ (cm}^3\text{/mol)} = 32.280 + 18.216 m^{1/2} + 0.0222 m,$$

where  $m$  is the molality of the solution. For water at this temperature,  $V_m = 18.068 \text{ cm}^3\text{/mol}$ .

- (a) Obtain an equation for the total volume  $V$  of a solution containing 1.000 kg of H<sub>2</sub>O.  
(b) Obtain an equation for the partial molar volume  $V_A$  of water. [**Hint:** See Problem 9.22 in Levine.]

3. The molar enthalpy of mixing for forming solid solutions of NaCl and NaBr at 25°C as a function of the mole fraction  $x$  of NaBr is given by

$$H_{\text{mix,m}} \text{ (kJ/mol)} = 5.996 x - 6.761 x^2 + 0.765 x^3.$$

- (a) Calculate  $H$  for mixing 1.000 mol of each component to form 2.000 mol of solution.  
(b) Calculate the differential heats of solution for each component in the 50.0 mole per cent solution.
4. Benzene and hexane form nearly ideal solutions. At 300.0 K the vapor pressure of pure benzene is 0.1355 atm and that of pure hexane is 0.2128 atm. 50.00 g of benzene is mixed with 50.00 g of hexane at 300.0 K to form 100.00 g of solution.
- (a) Calculate the mole fraction of benzene in the solution and the vapor pressures of both components.  
(b) Calculate the total vapor pressure of the solution and the mole fraction of benzene in the vapor present in equilibrium with the solution.  
(c) The densities of benzene and hexane are 0.8787 and 0.6603 g/cm<sup>3</sup>, respectively. Calculate the volume of the solution.  
(d) Calculate  $G_{\text{mix}}$ ,  $S_{\text{mix}}$ , and  $H_{\text{mix}}$  for this solution.
5. Pure liquids A and B form ideal solutions at  $T = 300.0 \text{ K}$  &  $P = 1.00 \text{ atm}$ . Calculate the minimum work needed to remove 1.00 mole of A from (a) a mixture of 2.00 mol A and 2.00 mol B; (b) a mixture of 10.00 mol A and 10.00 mol B; (c) a mixture of 10000.0 mol A and 10000.0 mol B.

6. Two 10.0-L bulbs are connected by a stopcock. One bulb contains 100.0 g of water, and the other contains a gas at 2.00 atm pressure. Both bulbs are at 25°C. The solubility of the gas in water at this  $T$  and  $P = 1.00 \text{ atm}$  is 2.00 mol/kg. The vapor pressure of water is 23.76 torr. Calculate the total pressure in the system if the stopcock is opened and equilibrium is established at 25°C. (Assume the gas neither dissociates nor associates in solution, and treat it as ideal in the gas phase.)

7. The CRC Handbook lists the following "relative apparent molal enthalpies" ( $\Delta_L$ ) for aqueous solutions of HBr at 25°C: (These are relative to infinite dilution;  $H^\circ = -20.35 \text{ kcal/mol}$ .)

$m$ (mol/kg)	1.000	6.000	15.000	20.000	27.753	37.004	55.506
$\Delta_L$ (cal/mol)	314	1196	3415	4760	6650	8530	11670

- (a) Calculate the mole fractions of HBr corresponding to each of these molalities.  
(b) Calculate integral heats of solution for HBr in water for each of these concentrations.  
(c) Further, convert these integral heats to  $H_{\text{mix}}$  values. Then plot  $H_{\text{mix}}/n$  as a function of  $x_{\text{HBr}}$ , and use the method of intercepts to estimate  $H_{\text{diff}}$  for both components at  $x_{\text{HBr}} = 0.25$ . [**Hint:** See problem 9.27 in Levine.]