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MME 2010 Metallurgical Thermodynamics II

Review Problems II

1. How much water must be added to 1000 ml of NiSO4-water solution containing 96% NiSO4.6H2O by volume in order to make a plating solution containing 64% NiSO4.6H2O by volume?

Partial molar volume of NiSO4.6H2O = 98.1 ml for 96% solution, 96.6 ml for 64% solution

Partial molar volume of H2O = 14.5 ml for 96% solution, 17.1 ml for 64% solution

2. Partial molar entropies of components in an A-B solution are given as So-RlnX where X is the mole fraction of component A or B. Determine the entropy change of process involving addition of 1 mole of B into A-B solution with XB= 0.33 initial composition if the addition is made to

a) 3 moles of solution, b)large quantity of solution.

Standard entropies of A and B are 10 J/mol K and 20J/mol K respectively

3. One mole of Pb at 25 C is added to a 7 moles of Si liquid metal at 473 K. Calculate the activity of lead in the solution at 473 K if the partial enthalpy and entropy of Pb at this composition are -1142.5 J/mole and 2.5 J/mole K respectively. Hint: find S^o of Pb and compare it with its partial entropy.

4. Total molar enthalpy of mixing for Bi-Cd alloys at 200 C is given as 5000XbiXcd J/mole. Calculate enthalpy change of the system when 1 mole of Cd is added to a solution with XBi=0.7 if the solution is a) 2 moles.

5. The binary system acetonitrile/nitromethane conforms closely to Raoult's law. Vapor pressures for the pure species are given by the following Antoine equations:

$\ln P_1^{sa} = 14.2724 - 2945.47/(T(C)+224)$ kPa

$\ln P_2^{sat} = 14.2043 - 2972.64/(T(C)+209)$ kPa

Calculate the total pressure for 0.6 weight % acetonitrile containing liquid phase in equilibrium with vapor at room temperature.

6. For the system n-pentane/n-heptane, the vapor pressures of the pure species are given by

$\ln P_1^{sa} = 13.8183 - 2477.07/(T(C)+233.21)$ kPa

$\ln P_2^{sat} = 13.8587 - 2911.32/(T(C)+216.64)$ kPa

Assuming Raoult's law to describe the vapor/liquid equilibrium states of this system, determine the fraction of the system that is liquid and y1 at 60 C and 115 kPa, when the composition of the liquid is equimolar

7. *The Gibbs free energy of a binary liquid mixture at a given T and P is given by*

$$G/RT = (-1.2x_1 - 1.5x_2)\, x_1x_2$$

a) *Find an expression for $\ln a_1$ and $\ln a_2$ and show that the above equation is recovered from $G/RT= \sum x_i \ln a_i$*

b) *Show that these equations satisty the Gibbs/Duhem equation ($\sum x_i d\ln a_i = 0$)*

8. *The molar volume of a binary liquid mixture at T and P is given by*

$$V= 90x_1 + 50x_2 + (6x_1 + 9x_2)x_1x_2$$

a) *Find expressions for the partial molar volumes of species 1 and 2*

b) *Show that the above equation is recovered when these expressions are combined*

c) *Show that these expressions satisfy the Gibbs/Duhem equation*

9. The following equations have been proposed to represent activity data for a system at fixed T and P:

$$\ln a_1= Ax_2^2 + Bx_2^2(3x_1 - x_2)$$

$$\ln a_2= Ax_1^2 + Bx_1^2(x_1 - 3x_2)$$

a) Do these equations satisfy the Gibbs/Duhem equation?

b) Determine an expression for G/RT for the system

10. For a particular binary system at constant T and P, total enthalpy is given as

$$H = \sum x_iA (1-x_i)$$

Derive expressions for partial enthalpies of the components. Combine the two equations to show that the original equation is recovered.

11. *For a particular binary system at constant T and P, the molar enthalpies of mixtures are represented by the following equation:*

$$H= x_1(a_1 + b_1 x_1) + x_2 (a_2 + b_2 x_2)$$

Determine an expression for the partial molar enthalpy of component 1. Hint: it is not equal to $(a_1 + b_1 x_1)$

12. *The volume of a binary liquid mixture of species 1 and 2 at 25 C and atmospheric pressure is given by the following equation:*

$$V = x_1x_2 (30x_1 + 50x_2)\ cm^3/mol$$

Determine the partial molar volumes of species 1 and 2 for an equimolar mixture of species.

13. Total molar volumes for the system ethanol/methyl butyl ether at 25 C are given by the following equation:

$$V = x_1x_2 (30x_1 + 50x_2)\ cm^3/mol$$

What is the volume of the mixture formed when 1000 cm^3 of each pure component are mixed at 25 C if V_1= 58.63 and V_2= 118.46 cm^3/mol ?