ME 119a - HW 4

Due November 1, 2004

Reading:

Sears & Salinger, review Chaps. 1-8; Fay, Chapter 5 (handed out in class).

Problems:

4.1 Melting point for ice.

a) Calculate the slope of the fusion curve of ice in $N/(m^2K)$ at the normal melting point. The heat of fusion at this temperature is 3.34 E+05 J/kg and the change in specific volume on melting is -9.05 E-05 m^3/kg.

b) Ice at -2 ^oC and atmospheric pressure is compressed isothermally. Find the pressure at which the ice starts to melt. Assume the fusion curve is linear.

c) Calculate $(\partial P / \partial T)_v$ for ice at -2 ^oC using β= 15.7 E-05 K^{-1} and κ= 120 E-12 m^2/N.

d) Ice at -2 ^oC and atmospheric pressure is kept in a container at constant volume, and the temperature is gradually increased. Find the temperature and pressure at which the ice starts to melt. Assume that the rate of change of pressure with temperature at a constant volume is constant.

4.2 Work to separate gases.

The atmospheric air that surrounds us can be viewed as an ideal gas mixture at temperature T_o =25 ^oC and pressure P_o = 0.1MPa. The composition of air varies with location and time, but assume that on a particular afternoon in Pasadena the surrounding air has the following composition in terms of mole fractions:

$X(N_2)=0.7657$
$X(O_2)=0.2037$
$X(H_2O)=0.0303$
$X(CO_2)=0.0003$

We want to extract pure O_2 from the air. Determine the minimum work required to extract 10 moles of pure O_2 at T_o and P_o from 1 kmol of air at the same temperature and pressure. The minimum work would occur when the process proceeded reversibly while exchanging heat with the environment.

4.3 Diamond and graphite

The following properties are for diamond and graphite at a temperature of 25^oC and a pressure of 0.1 MPa.

	Graphite	**Diamond**
$\bar{g}$	0	2867.8 kJ/kmol
***v* (m^3/kg)**	4.44 x 10^{-4}	2.84 x 10^{-4}
κ (MPa^{-1})	3.04 x 10^{-7}	1.6 x 10^{-8}

a) What is the pressure required to make diamond from graphite at a temperature of 25^{o}C? Assume that the specific volume is constant over a wide range of pressures.

b) Estimate the error in assuming that the specific volume is constant.

4.4 Spinoidal limits

Using the relations derived in class for the spinoidal limits, determine the maximum temperature at which water will vaporize at 1 atm pressure. Also calculate the minimum temperature at which water will condense at the same pressure. Using the experimental data shown in Figs. 5.11 and 5.16 from the handout in class and assuming that this data can be extrapolated to conditions for water at 1 atm, estimate the maximum and minimum temperatures (Figures are from V.P. Carey, Liquid-Vapor Phase Change Phenomena, 1992). How well do the theoretical spinoidal limits compare with estimates from the experimental data?