CHEN 320

Individual Homework

1. You need to copy-paste your MATLAB codes and results to the Word processing software, export it as PDF, and then upload the PDF file.
2. You also need to upload the MATLAB file (.m file)

Homework Problem

1. Determine the equilibrium conversion for

$$2CO + O_2 \rightarrow 2CO_2$$

If stoichiometric amounts of CO and air are reacted at 2000 K and 1 atmosphere pressure. At 2000 K the equilibrium constant for this reaction is 62.4×10^6 atm. As a basis, consider 2 gmoles of CO. Then there would be 1 gmole of O_2 and 3.76 gmoles of N_2. Performing a mole balance on each species and defining x as the amount of CO that reacts yields

$$N_{CO} = 2 - x \qquad N_{O_2} = 1 - 0.5x \qquad N_{CO_2} = x$$

Then the partial pressures are given as

$$P_{CO} = \frac{N_{CO}}{N_T} = \frac{2-x}{6.76-0.5x} \qquad P_{O_2} = \frac{N_{O_2}}{N_T} = \frac{1-0.5x}{6.76-0.5x} \qquad P_{CO_2} = \frac{N_{CO_2}}{N_T} = \frac{x}{6.76-0.5x}$$

Substituting these results into the equilibrium relationship yields

$$K_1 = \frac{P_{CO_2}^2}{P_{CO_2}^2 P_{O_2}} = \frac{x^2(6.76 - 0.5x)}{(1 - 0.5x)(2 - x)^2} = 62.4 \times 10^6$$

assuming the standard state fugacities of CO_2, CO and O_2 are unity. Rearranging into a normalized form gives

$$\frac{x^2(6.76 - 0.5x)}{62.4 \times 10^6(1 - 0.5x)(2 - x)^2} = 1$$

a. Solve for the equilibrium composition to three significant figures accuracy using Newton's method with a starting point of $x = 0.1\ g\ mole$
b. Solve this problem using the *Illinois* method
c. <u>Solve this problem using a built-in function from MATLAB.</u>

2. The volume of a liquid in a spherical tank is given by

$$V = \frac{\pi h^2(3R - h)}{3}$$

where *h* is the height of the liquid level in the tank and *R* is the radius of the spherical tank. Determine the liquid level in a spherical tank to three significant figures accuracy that is 15 ft in diameter if the tank is holding 500 ft^3 of liquid.

3. Consider a hot sheet of metal that is exposed air. It is desired that rate of heat flux removed from the hot sheet metal is 850 Btu/h-ft^2. For convective and radiation heat transfer, the rate of heat flux is

$$\frac{\dot{Q}}{A} = h(T_S - T_\infty) + \varepsilon\sigma(T_S^4 - T_\infty^4)$$

Where *h* is the convective heat transfer coefficient (1.0 Btu/h-ft^2-deg. F), T_∞ is surrounding temperature (100 °F), ε is the emissivity (0.9), σ is the Stefan-Boltzmann constant (1.174$\times$ 10^{-9} Btu/h-ft$_2$-R^4) and T_s is the average surface temperature. Determine the average surface temperature for this case to within 4 significant figures accuracy.