10.213 Chemical Engineering Thermodynamics
Spring 2002

Problem Set C

Due Wednesday, February 27, 2002

Problem 9

a) Calculate the theoretical flame temperature of propane mixed with a stoichiometric amount of air. Assume that the air and propane mixture is initially at 25°C.
b) Repeat the calculation of flame temperature if 10% excess of air is used.
c) Repeat the calculation for a 10% deficiency of air.
d) Assume that the combustion reaction is only 95% complete. Calculate the temperature for a stoichiometric mixture of propane and air.
e) Careful and accurate measurements of the stoichiometric flame temperature for propane and air are approximately 190°C lower than the calculated value. The reaction goes to completion. What do you think causes the discrepancies between measured and calculated values?

Problem 10

Calculate the molar volume of steam at 68 bar and 300°C, using a) the ideal gas law, b) the van der Waals equation, c) the Redlich/Kwong equation of state, d) the generalized compressibility correlation, e) the steam tables.

Problem 11

a) Calculate the heats of reaction ΔH at 298 K and at 750 K for the oxidation of sulfur dioxide at one atmosphere

$$SO_2(g) + O_2(g) = SO_3(g)$$

b) Calculate the heat of reaction for the hydration of CaO at one atmosphere and 298 K.

$$CaO(s) + H_2O(l) = Ca(OH)_2(s)$$

Calculate the heat of reaction at one atmosphere and 750^0 K for the similar reaction

$$CaO(s) + H_2O(g) = Ca(OH)_2(s)$$

c) Why is the percentage change in the heat of reaction between 298 and 750 K for the oxidation of sulfur dioxide smaller than that for the hydration reactions for calcium oxide?

Problem 12

Methane gas is stored in a 0.1 m^3 tank at 1500 kPa and 25°C. Some of the gas is allowed to flow from the tank through a partially opened valve into a gas holder, in which the pressure is maintained constant at 115 kPa. When the pressure in the tank has dropped to 750 kPa, calculate:

a) The mass of methane remaining in the gas holder if the process takes place slowly enough that the temperature remains constant.

b) The mass of methane remaining in the gas holder and its temperature if the process occurs so rapidly that there no heat transfer between parts of the system and between the system and its surroundings.

d) Repeat b) for the case if the pressure in the gas holder is held at 300 kPa.

Assume that methane is an ideal gas for which $\gamma = 1.31$.

Practice Problem P5 (not to be handed in)

For a reversible, adiabatic process involving an ideal gas with constant heat capacity we obtained the expression

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$$

Determine the relationship between temperatures and pressures for an ideal gas with

$$C_p(T) = A + BT + CT^2$$