

Problem Set No. 6

Due: Wednesday, February 16, 2011

Objective: To understand and perform thermodynamic calculations involving sensible heats, latent heats, and heats of chemical reaction.

Note: Numerical values for some problems have been changed from those in the book.

Problem 25 (*thought problem*)

A dense, nonideal gas passes through a heat exchanger. Can you use the expression $\Delta H = \int (A + BT + CT^2 + DT^{-2})RdT$ for this process if (a) the pressure drops substantially, and (b) the pressure stays the same? Explain your answer.

Problem 26 (*Smith, van Ness, Abbott, 4.1b, page 150*)

For steady flow in a heat exchanger at approximately atmospheric pressure, what is the heat transferred when 14 mol propane is heated from 250 to 1200 °C?

Problem 27 (*Smith, van Ness, Abbot, 4.2c, page 150*)

For steady flow through a heat exchanger at approximately atmospheric pressure, what is the final temperature when heat in the amount of 10^6 Btu is added to 40 lbmol of ethylene initially at 500 °F?

Problem 28 (*Smith, van Ness, Abbot, 4.11, page 152*)

For methanol, estimate the latent heat of vaporization in J/g at 25 °C using each of the following methods. Compute the percent error with respect to the tabulated value $\Delta H^{\text{vap}}(T = 0 \text{ °C}) = 1189.5 \text{ J/g}$.

- (a) The Antoine Equation with the Clausius-Clapeyron Equation.
- (b) The Riedel Equation with the Watson correlation.
- (c) The Watson correlation using the tabulated normal heat of vaporization (Table B.2).

Problem 29 (Smith, van Ness, Abbott, 4.10e, page 151)

Table 9.1 lists the thermodynamic properties of saturated liquid and saturated vapor tetrafluoroethane. Making use of the vapor pressures as a function of temperature and of the saturated-liquid and saturated-vapor volumes, calculate the latent heat of vaporization using the Clapeyron equation at 105 °F and compute a percent error with respect to the value calculated from the enthalpies given in Table 9.1

Problem 30 (Smith, van Ness, Abbott, 4.14b, page 152)

One hundred kmol per hour of a subcooled liquid toluene at 300 K and 3 bar is superheated to 500 K in a steady-flow heat exchanger. Estimate the exchanger duty in kW. For toluene $T^{sat} = 426.9$ at 3 bar. Hint: you will need to find a suitable estimation of the vaporization enthalpy.

Problem 31 (Smith, van Ness, Abbott, 4.33, page 155)

A fuel consisting of 75 mol-% methane and 25 mol-% ethane enters a furnace with 80% excess air at 30 °C. Heat in the amount of 8×10^5 kJ per kg mole of fuel is transferred from the combustion chamber to boiler tubes. For the following two cases, calculate the temperature at which the flue gas leave the furnace.

- (a) Complete combustion of the fuel.
- (b) 75% conversion of the fuel.