The Richard Stockton College of New Jersey
Chemistry Program, School of Natural Sciences and Mathematics
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CHEM 3410: Physical Chemistry I — Fall 2008

Homework 3

Due in Class: September 17, 2008

1. A chemical reaction occurs isothermally a 300 K in a gas mixture that behaves ideally, and the total amount of gas increases by 0.27 moles. If $\Delta U = 9.4$ kJ what is ΔH?

2. The molar heat capacity, $C_{p,m}$ of SO_2 gas is described by the follwoing equation over the range 300–1700 K:

$$C_{P,m} = R\left[3.093 + 6.967 \times 10^{-3}\frac{T}{K} - 45.81 \times 10^{-7}\frac{T^2}{K^2} + 1.035 \times 10^{-9}\frac{T^3}{K^3}\right]$$

   where T is the absolute temperature in Kelvin and the ratios $\frac{T^n}{K^n}$ ensure that $C_{p,m}$ has the correct units. Assuming ideal gas behavior, calculate q, w, ΔU, and ΔH if 1 mole of SO_2 gas is heated from 75°C to 1350°C at a constant pressure of 1 atm. Does the sign you calculate for w make sense?

   HINT: It is useful to remember the definition of enthalpy and that you are dealing with an ideal gas, much like Problem 1.

3. Ammonia gas (NH_3) in a pressure cylinder is quickly brought to a temperature of 1200K by rapidly compressing it to 10 atm. At the end of the compression the piston is fixed so that the system remains at constant volume.

   At 1200K NH_3 will start to decompose according to the reaction:

$$2NH_3 -> N_2 + 3H_2$$

   Assume that no NH_3 has decomposed during the rapid compression.

   (a) What is the pressure inside the system when all the NH_3 has decomposed at a constant temperature of 1200K?
   (b) Compute the heat one needs to supply/extract from the cylinder to keep the temperature at 1200K during the decomposition of the ammonia in the cylinder?
   (c) If the decomposition reaction occurred adiabatically, what would be the temperature of the system after complete decomposition

   DATA:

   ΔH for the decomposition reaction at 1200 K: 87 kJ/mol (per mole of N_2 formed)

   C_p,N_2 = 33 J/mol-k

   C_p,H_2 = 33 J/mol-k

   C_p,NH_3 = 36 J/mol-k

   Assume that all gasses behave ideally.

   Some properties of ideal gasses:

$$C_p - C_v = R$$

$$\left(\frac{\partial U}{\partial V}\right)_T = 0$$