

CHEM 3410: Physical Chemistry I — Fall 2009

Homework 4

Due in Class: September 28, 2009

1. One mole of an ideal gas at 298 K expands isothermally from 1.0 L to 2.0 L in two different manners:

- (a) reversibly
(b) irreversibly against a constant pressure of 12.2 atm

Calculate the values of ΔS_{sys} , ΔS_{surr} , and $\Delta S_{universe}$ in both cases. Are your results consistent with the nature of the processes?

HINT: Remember that ΔS_{system} is a state function.

2. A sheet of manganese (2 moles) at room temperature (298 K) is placed in thermal contact with a heat supply that slowly transfers 100,698 J of heat into the sample at constant pressure. Use the following thermodynamic data for Mn to answer the questions below:

Mn has four solid phases, α , β , γ , and δ :

$$C_p^\alpha = 21.6159 \text{ J/mole-K} \quad T_{trans}^{\alpha \rightarrow \beta} = 993 \text{ K} \quad \Delta H_{trans}^{\alpha \rightarrow \beta} = 2010 \text{ J/mole}$$

$$C_p^\beta = 34.9028 \text{ J/mole-K} \quad T_{trans}^{\beta \rightarrow \gamma} = 1373 \text{ K} \quad \Delta H_{trans}^{\beta \rightarrow \gamma} = 2300 \text{ J/mole}$$

$$C_p^\gamma = 44.8 \text{ J/mole-K} \quad T_{trans}^{\gamma \rightarrow \delta} = 1409 \text{ K} \quad \Delta H_{trans}^{\gamma \rightarrow \delta} = 1800 \text{ J/mole}$$

$$C_p^\delta = 47.3 \text{ J/mole-K}$$

- (a) Calculate the final temperature of the sample.
(b) Determine the total enthalpy change for this process.
(c) Calculate the total entropy change for this process.
(d) What phase (or phases) are present at equilibrium at the end of this process?
3. In the reversible adiabatic expansion of an ideal gas, there are two contributions to entropy changes: the expansion of the gas and the cooling of the gas. Show that these two contributions are equal in magnitude but opposite in sign. (Hint: try to break up the expansion into two processes: an isothermal expansion and a constant volume cooling.)

Remember that for an adiabatic expansion:

$$\frac{T_2}{T_1} = \left(\frac{V_2}{V_1} \right)^{1-\gamma}$$

where $\gamma = \frac{C_p}{C_v}$