Problem Set No. 7

Due: Wednesday, February 23, 2011

Objective: To understand and perform calculations involving the entropy and the second law of thermodynamics for closed, open, and cyclical processes.

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

Problem 32 (*thought problem)*

A well-insulated container consists of two halves of equal volumes separated by a partition. On one half there an ideal gas. On the other, there is a vacuum. The partition is suddenly removed, and the gas expands. Your friend suggests that the entropy change is zero since this is an adiabatic process for which $\delta Q = 0$. What is wrong with his assessment? What is the actual entropy change per mol?

Problem 33 (*Smith, van Ness, Abbott, 5.2, page 190)*

A Carnot engine receives $250\ kJ/s$ of heat from a heat-source reservoir at $525\ ℃$ and rejects heat to a heat sink reservoir at $50\ ℃$. What are the power developed and the heat rejected?

Problem 34 (*Smith, van Ness, Abbott, 5.9, page 191)*

A rigid vessel of $0.06\ m^3$ volume contains an ideal gas, $C_V = (5/2)R$, at $500\ K$ and $1\ bar$.

(a) If heat in the amount of $15\ kJ$ is transferred to the gas, determine its entropy change.

(b) If the vessel is fitted with a stirrer that is rotated by a shaft so that work in the amount of $15\ kJ$ is done on the gas, what is the entropy change of the gas if the process is adiabatic?

Problem 35 (*Smith, van Ness, Abbot, 5.18e, page 193)*

An ideal gas with constant heat capacities undergoes a change of state from conditions T_1, P_1 to conditions T_2, P_2. Determine ΔH (J/mol) and ΔS (J/mol/K) for the following conditions: $T_1 = 500\ \mathrm{K},\ P_1 = 6.0\ \mathrm{bar},\ T_2 = 300\ \mathrm{K},\ P_2 = 1.2\ \mathrm{bar},\ C_P/R = 4$.

Problem 36 (*Smith, van Ness, Abbott, 5.22, page 194)*

A mass m of liquid water at temperature T_1 is mixed adiabatically and isobarically with an equal mass of liquid water at temperature T_2. Assuming constant C_P, show that the total entropy change for this process is given by

$$\Delta S^t = 2mC_P \ln\left[\frac{(T_1 + T_2)/2}{(T_1T_2)^{1/2}}\right]$$

and prove that this is positive. What would be the result if the masses of the water were difference, say, m_1 and m_2?

Problem 37 (*Smith, van Ness, Abbott, 5.26, page 194)*

One mole of an ideal gas is compressed isothermally but irreversibly at $130\ ^\circ\mathrm{C}$ from 2.5 to 6.5 bar in a piston/cylinder device. The work required is 30% greater than the work of reversible, isothermal compression. The heat transferred from the gas during compression flows to a heat reservoir at $25\ ^\circ\mathrm{C}$. Calculate the entropy changes of the gas, the heat reservoir, and $\Delta S_{\mathrm{total}}$.

Problem 38 (*Smith, van Ness, Abbott, 5.28, page 194)*

For a steady-flow process at approximately atmospheric pressure, what is the entropy change when:

(a) 40 $lbmol$ of ethylene is heated from 500 to 1200 °F?

(b) 10^6 Btu is added to 40 $lbmol$ of ethylene initially at 500 °F?

Assume ethylene can be modeled as an ideal gas with T-dependent C_P.