(1) Show that $dH < TdS + VdP$, for an isothermal spontaneous expansion. (10 %)

(2) Calculate $\Delta U, \Delta H, \text{and } \Delta S$ in the gas after the following step (a) and (b), if one mole of an ideal gas is subjected to the sequence of steps:

(a) Starting at 25 °C, 1 atm, the gas expands freely into vacuum to triple its volume. (10 %)

(b) The gas is next heated to 125 °C, at constant volume. (10 %)

U, H, and S are the internal energy, the enthpy, and the entropy, respectively. R = 8.3144 joules/degree-mole = 82.06 cm^3-atm/degree-mole.

(3) A supercooled liquid tin (Sn) is adiabatically contained at 495 K. Calculate the fraction of tin which spontaneously freezes. Given: (10 %)
ΔH_m (Sn) = 1690 calories/mole at T_m = 505 K
C_p, $Sn_{(l)} = 8.29 - 2.2\times10^{-3}T$ calories/degree-mole
C_p, $Sn_{(s)} = 4.42 + 6.3\times10^{-3}T$ calories/degree-mole.

(4) Calculate the CO/CO_2 ratio in equilibrium with carbon at 727 °C, assuming that the total pressure to be 2 atm. Given: (10 %)
$2\,C + O_2 \rightarrow 2\,CO$; $\Delta G^0_{1000\,k} = -95.3$ Kcal.
$C + O_2 \rightarrow CO_2$; $\Delta G^0_{1000\,k} = -94.0$ Kcal.

(5) Please use the Helmholtz energy (A) to derive the expression (P=nRT/V) for the pressure of a gas of independent particles. (25%)

(6) A container is divided into two equal compartments. One contains 3 mol $H_2(g)$ at 3 atm/25 °C; the other contains 1 mol $N_2(g)$ at 1 atm/25 °C. Claculate the Gibbs energy of mixing when the partition is removed. Assume perfect behavior. (25%)