

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

(2) Calculate  $\Delta U, \Delta H$ , 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 enthalpy, and the entropy, respectively.  $R = 8.3144 \text{ joules/degree-mole} = 82.06 \text{ cm}^3\text{-atm/degree-mole}$ .

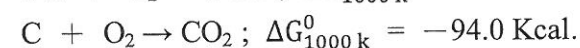
(3) A supercooled liquid tin (Sn) is adiabatically contained at 495 K. Calculate the fraction of tin which spontaneously freezes. Given: (10 %)

$$\Delta H_m (\text{Sn}) = 1690 \text{ calories/mole at } T_m = 505 \text{ K}$$

$$C_{p, \text{Sn}(l)} = 8.29 - 2.2 \times 10^{-3} T \text{ calories/degree-mole}$$

$$C_{p, \text{Sn}(s)} = 4.42 + 6.3 \times 10^{-3} T \text{ calories/degree-mole.}$$

(4) Calculate the CO/CO<sub>2</sub> ratio in equilibrium with carbon at 727 °C, assuming that the total pressure to be 2 atm. Given: (10 %)



(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<sub>2</sub>(g) at 3 atm/25 °C; the other contains 1 mol N<sub>2</sub>(g) at 1 atm/25 °C. Calculate the Gibbs energy of mixing when the partition is removed. Assume perfect behavior. (25%)