

#### <물리화학 Homework #4>

1. The standard enthalpy of combustion of solid phenol ( $\text{C}_6\text{H}_5\text{OH}$ ) is  $-3054 \text{ kJ mol}^{-1}$  at 298 K and its standard molar entropy is  $144.0 \text{ J K}^{-1}\text{mol}^{-1}$ . Calculate the standard Gibbs energy of formation of phenol at 298 K.
  
2. A Carnot cycle uses 1.00 mol of a monatomic perfect gas as the working substance from an initial state of 10.0 atm and 600 K. It expands isothermally to a pressure of 1.00 atm (step 1), and then adiabatically to a temperature of 300 K (step 2). This expansion is followed by an isothermal compression (step 3), and then an adiabatic compression (step 4) back to the initial state. Determine the values of  $q$ ,  $w$ ,  $\Delta U$ ,  $\Delta H$ ,  $\Delta S$ ,  $\Delta S_{\text{tot}}$  and  $\Delta G$  for each stage of the cycle and for the cycle as a whole. Express your answer as a table of values.
  
3. Suppose that (a) the attractive interactions between gas particles can be neglected, (b) the attractive interaction is dominant in a van der Waals gas, and the pressure is low enough to make the approximation  $4ap/(RT)^2 \ll 1$ . Find expressions for the fugacity of a van der Waals gas in terms of the pressure and estimate its value for ammonia at 10.00 atm and 298.15 K in each case.
  
4. 1.00 mol of perfect gas molecules at  $27^\circ\text{C}$  is expanded isothermally from an initial pressure of 3.00 atm to a final pressure of 1.00 atm in two ways: (a) reversibly, and (b) against a constant external pressure of 1.00 atm. Determine the values of  $q$ ,  $w$ ,  $\Delta U$ ,  $\Delta H$ ,  $\Delta S$ ,  $\Delta S_{\text{sur}}$ ,  $\Delta S_{\text{tot}}$  for each path.
  
5. A particular power plant operates with a heat-source reservoir at  $350^\circ\text{C}$  and a heat-sink reservoir at  $30^\circ\text{C}$ . It has a thermal efficiency equal to 55% of the Carnot-engine thermal efficiency for the same temperatures.
  - (a) Derive the equation (5-8) ('Introduction to Chemical Engineering Thermodynamics' 참조)
  - (b) What is the thermal efficiency of the plant?
  - (c) To what temperature must the heat-source reservoir be raised to increase the thermal efficiency of the plant to 35%? Again  $\eta$  is 55% of the Carnot-engine value.
  
6. For ideal gas prove that:

$$\frac{\Delta S}{R} = \int_{T_0}^T \frac{C_V^{ig}}{R} \frac{dT}{T} + \ln \frac{V}{V_0}$$