1. Calculate $\Delta H$ and $\Delta U$ for the transformation of 1 mol of an ideal gas from 27.0°C and 1.00 atm to 327°C and 17.0 atm if $C_{p,m} = 20.9 + 0.042\frac{T}{K}$ in units of J K$^{-1}$ mol$^{-1}$. (20%)

2. At 1000 K, $\Delta H^\circ_{\text{reaction}} = -123.77$ kJ mol$^{-1}$ for the reaction $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$, with $C_{p,m} = 3.502R$, 3.466$R$, and 4.217$R$ for $N_2(g)$, $H_2(g)$, and $NH_3(g)$, respectively. Calculate $\Delta H^\circ_f$ of $NH_3(g)$ at 300 K from this information. Assume that the heat capacities are independent of temperature. (10%)

3. Calculate $\Delta S$, $\Delta S_{\text{total}}$, and $\Delta S_{\text{surroundings}}$ when the volume of 85.0 g of CO initially at 298 K and 1.00 bar increases by a factor of three in (a) an adiabatic reversible expansion, (b) an expansion against $P_{\text{external}} = 0$, and (c) an isothermal reversible expansion. Take $C_{p,m}$ to be constant at the value 29.14 J mol$^{-1}$ K$^{-1}$ and assume ideal gas behavior. State whether each process is spontaneous. (30%)

4. An ideal solution is made from 5.00 mol of benzene and 3.25 mol of toluene. Calculate $\Delta G_{\text{mixing}}$ and $\Delta S_{\text{mixing}}$ at 298 K and 1 bar pressure. Is mixing a spontaneous process? (20%)

5. For the Daniell cell $E^\circ = 1.1$ V. Calculate K for the reaction $Zn(s) + Cu^{2+}_{(aq)} \rightarrow Zn^{2+}_{(aq)} + Cu(s)$. (10%)

6. A certain reaction is first order, and 540 s after initiation of the reaction, 32.5% of the reactant remains. What is the rate constant for this reaction? (10%)