THERMODYNAMICS PROBLEMS

1. Calculate ΔH°_{rxn} for the following reaction at 25 °C.

$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$

$\Delta H^\circ_f [NO(g)] = 90.4 \frac{kJ}{mol}$ $\Delta H^\circ_f [H_2O(g)] = -241.8 \frac{kJ}{mol}$ $\Delta H^\circ_f [NH_3(g)] = -46.3 \frac{kJ}{mol}$

2. Calculate the entropy change for $2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$

S° values: Na(s) = 51.05 J/mol•K, Cl_2(g) = 223.0 J/mol•K, NaCl(s) = 72.38 J/mol•K

3. a) Calculate ΔG, given ΔH = -227 kJ, ΔS = -309 J/K, T = 1450 K.

b) Is this process spontaneous at this temperature? If not, calculate the temperature (in ^oC) at which this reaction becomes spontaneous.

3. **ΔG_f^o in kJ/mol:**

CaO(s) -604.2 $Ca(OH)_2$(s) -896.8 H_2O(g) -228.6 H_2O(l) -237.2

Calculate ΔG^o for these reactions and predict whether they will be spontaneous or not.

a) $2H_2O(g) \leftrightarrows 2H_2(g) + O_2(g)$

b) $CaO(s) + H_2O(l) \leftrightarrows Ca(OH)_2(s)$

4. ΔG^o is -24.7 kJ/mol for the formation of methanol.

   $C(s) + ½\ O_2(g) + 2H_2(g) \leftrightarrows CH_3OH(g)$

   Calculate the equilibrium constant, K, at 25 ° C for this reaction.

5. a) At 25 °C, K_a for acetic acid is 1.8×10^{-5}. Predict the sign of ΔG^o at 25°C for $CH_3COOH(aq) + H_2O(l) \leftrightarrows H_3O^+(aq) + CH_3COO^-(aq)$. Calculate ΔG^o at 25 °C.

   b) Calculate ΔG at 25 °C for the acetic acid equilibrium reaction, when $[H_3O^+] = 0.020$ M, $[CH_3COO^-] = 0.010$ M, and $[CH_3COOH] = 0.10$ M. (Use ΔG^o from part a.)

6. ΔG° for the reaction $H_2(g) + I_2(g) \leftrightarrows 2\ HI(g)$ is 2.60 kJ/mol at 25°C.
   In one experiment, the initial pressures are $P_{H_2} = 4.3$ atm, $P_{I_2} = 0.34$ atm, and $P_{HI} = 0.23$ atm. Calculate ΔG and predict the direction that this reaction will proceed.