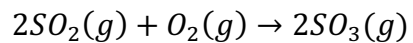General Chemistry II

1. One of the possible initial steps in the formation of acid rain is the oxidation of the pollutant SO_2 to SO_3 by the reaction:

$$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$$

Compound	$\Delta H_f°$ (kJ/mol)	$\Delta S°$(J/mol*K)
SO2 (g)	-296.8	248.2
O2 (g)	0	205.2
SO3 (g)	-395.8	256.8

a. Calculate $\Delta G°$ and determine whether the reaction is product-favored at equilibrium at 25˚C.

b. Estimate the temperature at which the reaction switches between product-favored and reactant-favored at equilibrium.
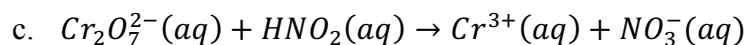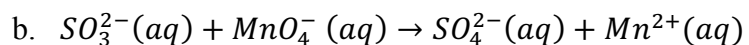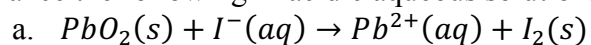
2. For a certain chemical reaction, $\Delta H° = -35.4$ kJ and $\Delta S° = -85.5$ J/K.
   a. Is the reaction exothermic or endothermic?

   b. Does the reaction lead to an increase or decrease in the randomness/disorder of the system?

   c. Calculate the $\Delta G°$ for the reaction at 298 K.

   d. Is the reaction spontaneous at 298 K under standard conditions?

3. Classify each of the following reactions as one of the four possible types: (i) spontaneous at all temperatures, (ii) not spontaneous at any temperature; (iii) spontaneous at low T but not spontaneous at high T; (iv) spontaneous at high T but not spontaneous at low T.
   a. $N_2(g) + 3\,F_2(g) \rightarrow 2\,NF_3(g)$
      $\Delta H° = -249$ kJ; $\Delta S° = -278$ J/K

   b. $N_2(g) + 3Cl_2(g) \rightarrow 2NFCl_3(g)$
      $\Delta H° = 460$ kJ; $\Delta S° = -275$ J/K

   c. $N_2F_4(g) \rightarrow 2NF_2(g)$
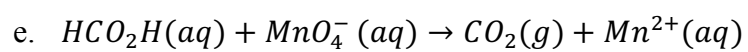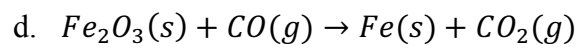 $\Delta H° = 85$ kJ; $\Delta S° = 198$ J/K

True or False

(T / F) For a process that occurs at constant temperature, the change in Gibbs free energy depends on changes in the enthalpy and entropy of the system.
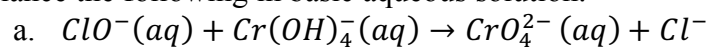
(T / F) If ΔG is large and negative for a certain reaction, the rate at which the reaction occurs is fast.

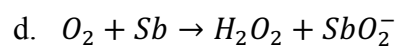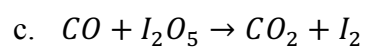4. Balance the following in acidic aqueous solution. I
   a. $PbO_2(s) + I^-(aq) \rightarrow Pb^{2+}(aq) + I_2(s)$

   b. $SO_3^{2-}(aq) + MnO_4^-(aq) \rightarrow SO_4^{2-}(aq) + Mn^{2+}(aq)$

   c. $Cr_2O_7^{2-}(aq) + HNO_2(aq) \rightarrow Cr^{3+}(aq) + NO_3^-(aq)$

d. $Fe_2O_3(s) + CO(g) \rightarrow Fe(s) + CO_2(g)$

e. $HCO_2H(aq) + MnO_4^-(aq) \rightarrow CO_2(g) + Mn^{2+}(aq)$

5. Balance the following in basic aqueous solution.
   a. $ClO^-(aq) + Cr(OH)_4^-(aq) \rightarrow CrO_4^{2-}(aq) + Cl^-$

b. $Ag(s) + Zn^{2+}(aq) \rightarrow Ag_2O\ (aq) + Zn\ (s)$

c. $CO + I_2O_5 \rightarrow CO_2 + I_2$

d. $O_2 + Sb \rightarrow H_2O_2 + SbO_2^-$
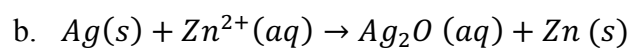
6. Consider a voltaic cell involving chromium (II) and gold (I)
   a. Balance the following reaction: $Au^+(aq) + Cr(s) \rightarrow Au(s) + Cr^{2+}(aq)$

   b. Sketch this cell, identifying the cathode and anode, the flow of electrons and the flow of cations and anions from the salt bridge (composed of $NaNO_3$).