Answer EITHER Question 2 OR Question 3 below. Only one of these two questions will be graded. If you start both questions, be sure to cross out the question you do not want graded. The Section II score weighting for the question you choose is 20 percent.

2. Answer the following questions about voltaic cells.

    (a) A voltaic cell is set up using Al/Al^{3+} as one half-cell and Sn/Sn^{2+} as the other half-cell. The half-cells contain equal volumes of solutions and are at standard conditions.

        (i) Write the balanced net-ionic equation for the spontaneous cell reaction.

        (ii) Determine the value, in volts, of the standard potential, $E°$, for the spontaneous cell reaction.

        (iii) Calculate the value of the standard free-energy change, $\Delta G°$, for the spontaneous cell reaction. Include units with your answer.

        (iv) If the cell operates until $[Al^{3+}]$ is $1.08\ M$ in the Al/Al^{3+} half-cell, what is $[Sn^{2+}]$ in the Sn/Sn^{2+} half-cell?

    (b) In another voltaic cell with Al/Al^{3+} and Sn/Sn^{2+} half-cells, $[Sn^{2+}]$ is $0.010\ M$ and $[Al^{3+}]$ is $1.00\ M$. Calculate the value, in volts, of the cell potential, E_{cell}, at $25°C$.

3. Answer the following questions about the thermodynamics of the reactions represented below.

    Reaction X: $\frac{1}{2}I_2(s) + \frac{1}{2}Cl_2(g) \rightleftarrows ICl(g)$ $\Delta H_f° = 18\ kJ\ mol^{-1},\ \Delta S_{298}° = 78\ J\ K^{-1}\ mol^{-1}$

    Reaction Y: $\frac{1}{2}I_2(s) + \frac{1}{2}Br_2(l) \rightleftarrows IBr(g)$ $\Delta H_f° = 41\ kJ\ mol^{-1},\ \Delta S_{298}° = 124\ J\ K^{-1}\ mol^{-1}$

    (a) Is reaction X, represented above, spontaneous under standard conditions? Justify your answer with a calculation.

    (b) Calculate the value of the equilibrium constant, K_{eq}, for reaction X at $25°C$.

    (c) What effect will an increase in temperature have on the equilibrium constant for reaction X? Explain your answer.

    (d) Explain why the standard entropy change is greater for reaction Y than for reaction X.

    (e) Above what temperature will the value of the equilibrium constant for reaction Y be greater than 1.0? Justify your answer with calculations.

    (f) For the vaporization of solid iodine, $I_2(s) \rightarrow I_2(g)$, the value of $\Delta H_{298}°$ is $62\ kJ\ mol^{-1}$. Using this information, calculate the value of $\Delta H_{298}°$ for the reaction represented below.

$$I_2(g) + Cl_2(g) \rightleftarrows 2\ ICl(g)$$
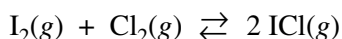
S T O P
If you finish before time is called, you may check your work on this part only.
Do not turn to the other part of the test until you are told to do so.