Thermodynamics and Equilibrium

Consider the following reaction:

$$PCl_3(g) + Cl_2(g) \leftrightarrows PCl_5(g)$$

Do you expect this reaction to be favorable at all temperatures, favorable only at higher temperatures, favorable only at lower temperatures, or is the reaction unfavorable at all temperature? Clearly explain your reasoning.

Assuming that each species is present in its standard states, what is the standard state free energy for each of the following temperatures: 298 K, 400 K and 600 K. Are your results consistent with your answer to the first question. Explain.

Conclusions based on standard state conditions usually are not of much interest since a reaction seldom is in its standard state. Assuming that each species is present with a partial pressure of 0.5 atm, what is the free energy for each of the following temperatures: 298 K, 400 K and 600 K?

What is the equilibrium constant for the reaction at each of the following temperatures: 298 K, 400 K and 600 K? Do your results make sense given your answers to the first three questions? Explain.

Comparing Q and K provides an alternative way to evaluate the direction a reaction must move to reach its equilibrium position. For the temperatures 298 K, 400 K and 600 K, use this method to determine the direction the system must move to reach equilibrium. Be sure to justify your decisions. Are your answers consistent with the conclusions you would reach using ΔG? Explain.

Construct a graph of $\ln K_{eq}$ vs. $1/T$ and verify that the slope is equivalent to $-\Delta H^o/R$ and that the y-intercept is equivalent to $\Delta S^o/R$.