2004 AP® CHEMISTRY FREE-RESPONSE QUESTIONS
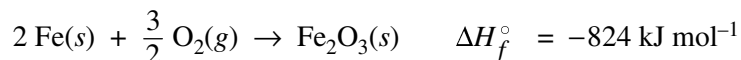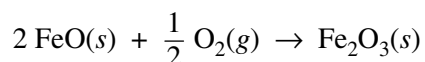
Answer EITHER Question 2 below OR Question 3 printed on page 8. Only one of these two questions will be graded. If you start both questions, be sure to cross out the question you do not want graded. The Section II score weighting for the question you choose is 20 percent.

$$2 \, Fe(s) \; + \; \frac{3}{2} \, O_2(g) \; \rightarrow \; Fe_2O_3(s) \qquad \Delta H_f^{\circ} \; = \; -824 \; kJ \; mol^{-1}$$

2. Iron reacts with oxygen to produce iron(III) oxide, as represented by the equation above. A 75.0 g sample of $Fe(s)$ is mixed with 11.5 L of $O_2(g)$ at 2.66 atm and 298 K.

   (a) Calculate the number of moles of each of the following before the reaction begins.

       (i) $Fe(s)$

       (ii) $O_2(g)$

   (b) Identify the limiting reactant when the mixture is heated to produce $Fe_2O_3(s)$. Support your answer with calculations.

   (c) Calculate the number of moles of $Fe_2O_3(s)$ produced when the reaction proceeds to completion.

   (d) The standard free energy of formation, ΔG_f°, of $Fe_2O_3(s)$ is $-740.$ kJ mol^{-1} at 298 K.

       (i) Calculate the standard entropy of formation, ΔS_f°, of $Fe_2O_3(s)$ at 298 K. Include units with your answer.

       (ii) Which is more responsible for the spontaneity of the formation reaction at 298 K, the standard enthalpy of formation, ΔH_f°, or the standard entropy of formation, ΔS_f°? Justify your answer.

   The reaction represented below also produces iron(III) oxide. The value of ΔH° for the reaction is $-280.$ kJ per mole of $Fe_2O_3(s)$ formed.

$$2 \, FeO(s) \; + \; \frac{1}{2} \, O_2(g) \; \rightarrow \; Fe_2O_3(s)$$

   (e) Calculate the standard enthalpy of formation, ΔH_f°, of $FeO(s)$.

GO ON TO THE NEXT PAGE.