Review PROBLEMS: Entropy and Gibbs Free Energy

1. Write a balanced equation that depicts the formation of 1 mol of $Fe_2O_{3(s)}$ from its elements. What is the standard free energy of formation of 1.00 mol of $Fe_2O_{3(s)}$? What is the value of ΔG°_{rxn} when 454g (1 lb) of $Fe_2O_{3(s)}$ is formed from the elements.

2. Hydrazine is used to remove dissolved oxygen from the water in hot-water heating systems.

$$N_2H_{4(l)} + O_{2(g)} \rightarrow 2H_2O_{(l)} + N_{2(g)}$$

What is the value of ΔG°_{rxn} when 1.00 mol of N_2H_4 is oxidized?
What is the value of ΔG°_{rxn} for the oxidation of 1.00 kg of hydrazine?

3. Synthesis gas, a mixture of H_2 and CO, can be converted to methane, CH_4:

$$3H_{2(g)} + CO_{(g)} \rightarrow CH_{4(g)} + H_2O_{(g)}$$

Calculate ΔH°, ΔS°, and ΔG° at 25° for the reaction. Is it predicted to be product or reactant favored under standard conditions?

4. Methanol, CH_3OH, is now widely used as a fuel in race cars such as those that compete in the Indianapolis 500. The liquid fuel can be formed using the reaction…

$$C_{(graphite)} + \tfrac{1}{2}\, O_{2(g)} + 2H_{2(g)} \rightarrow CH_3OH_{(l)}$$

a) What is ΔH° for the above reaction
b) Calculate ΔS° for the above reaction
c) Identify a thermodynamic function that can be used to predict reaction spontaneity.
d) Use the values obatined in (a) and (b) above to determine if the above reaction is spontaneous or non spontaneous at 25°C.

5. For each of the following processes, gove the algebraic sign of ΔH°, ΔS°, and ΔG° at 25°C for the following reactions. No calculations are necessary; use your common sense.

a) the splitting of liquid water to give the gaseous oxygen and hydrogen, a process that requires a considerable amount of energy.
b) The explosion of dynamite, a mixture of nitroglycerin, $C_3H_5N_3O_9$, and diatomaceous earth, gives gaseous products, such as water, CO_2, and others; much heat is evolved.
c) The combustion of gasoline in the engine of your car, as exemplified by the combustion of octane.
$2C_8H_{18(g)} + 25O_{2(g)} \rightarrow 16CO\,(g) + 18H_2O_{(l)}$

Answers:

1. $\Delta G^0_f\,(Fe_2O_3)$ = - 742.2 kJmol^{-1}, ΔG^0 released by 454 g Fe_2O_3 = - 2.111x10^3 kJ

2. $\Delta G^0_f\,(1.00\text{ mol } N_2H_4)$ = - 623.5 kJ, ΔG^0 for1 kg N_2H_4 = - 19.48 kJ

3. ΔH^0_{rxn} = - 206.1 kJ, ΔS^0_{rxn} = - 214.7 J/K, ΔG^0_{rxn} = - 142.1 kJ, Product-favoured

4. ΔH^0_{rxn} = - 238.7 kJ, ΔS^0_{rxn} = - 242.87 J/K, ΔG^0_{rxn} = - 166.3 kJ, Yes, Spontaneous

5.	ΔH°	ΔS°	ΔG°
a)	+	+	+
b)	-	+	-
c)	-	+	-