THERMODYNAMICS FRQS #1

1. Liquid heptane, $C_7H_{16}(l)$, is completely combusted to produce $CO_2(g)$ and $H_2O(l)$. The heat of combustion, ΔH°_{comb}, for heptane is -4.85×10^3 kJ.

A. Write a balanced equation for the reaction.

B. Using the information in the table below, calculate the value of ΔH°_f for heptane in kJ/mole.

Compound	ΔH°_f (kJ/mole)
$CO_2(g)$	-393.5
$H_2O(l)$	-285.8

C. A 0.0108 mol sample of $C_7H_{16}(l)$ is combusted in a bomb calorimeter.

(i) Calculate the amount of heat released to the calorimeter.

(ii) Given that the total heat capacity of the calorimeter is 9.273 kJ/°C, calculate the temperature change of the calorimeter.

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

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 $FeO(s)$.

$$CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$$

3. The combustion of carbon monoxide is represented by the equation above.

(a) Determine the value of the standard enthalpy change, ΔH°_{rxn}, for the combustion of $CO(g)$ at 298 K using the following information.

$$C(s) + \frac{1}{2}O_2(g) \rightarrow CO(g) \qquad \Delta H^\circ_{298} = -110.5 \text{ kJ mol}^{-1}$$

$$C(s) + O_2(g) \rightarrow CO_2(g) \qquad \Delta H^\circ_{298} = -393.5 \text{ kJ mol}^{-1}$$

(b) Determine the value of the standard entropy change, ΔS°_{rxn}, for the combustion of $CO(g)$ at 298 K using the information in the following table.

Substance	S°_{298} (J mol^{-1} K^{-1})
$CO(g)$	197.7
$CO_2(g)$	213.7
$O_2(g)$	205.1

(c) Determine the standard free energy change, ΔG°_{rxn}, for the reaction at 298 K. Include units with your answer.

(d) Is the reaction spontaneous under standard conditions at 298 K ? Justify your answer.

(e) Calculate the value of the equilibrium constant, K_{eq}, for the reaction at 298 K.