

## 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,  $\Delta H^\circ_{comb}$ , for heptane is  $-4.85 \times 10^3$  kJ.

A. Write a balanced equation for the reaction.

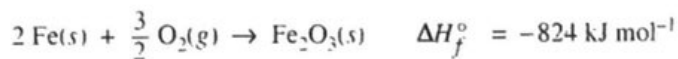
B. Using the information in the table below, calculate the value of  $\Delta H^\circ_f$  for heptane in kJ/mole.

Compound	$\Delta H^\circ_f$ (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.

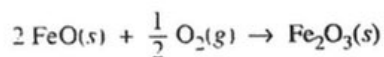
(ii) Given that the total heat capacity of the calorimeter is  $9.273 \text{ kJ}^\circ\text{C}$ , calculate the temperature change of the calorimeter.



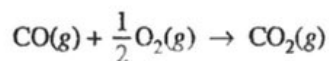
2. Iron reacts with oxygen to produce iron(III) oxide, as represented by the equation above. A 75.0 g sample of Fe(s) is mixed with 11.5 L of O<sub>2</sub>(g) at 2.66 atm and 298 K.

- (a) Calculate the number of moles of each of the following before the reaction begins.
  - (i) Fe(s)
  - (ii) O<sub>2</sub>(g)
- (b) Identify the limiting reactant when the mixture is heated to produce Fe<sub>2</sub>O<sub>3</sub>(s). Support your answer with calculations.
- (c) Calculate the number of moles of Fe<sub>2</sub>O<sub>3</sub>(s) produced when the reaction proceeds to completion.
- (d) The standard free energy of formation, ΔG<sub>f</sub><sup>∘</sup>, of Fe<sub>2</sub>O<sub>3</sub>(s) is -740. kJ mol<sup>-1</sup> at 298 K.
  - (i) Calculate the standard entropy of formation, ΔS<sub>f</sub><sup>∘</sup>, of Fe<sub>2</sub>O<sub>3</sub>(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<sub>f</sub><sup>∘</sup>, or the standard entropy of formation, ΔS<sub>f</sub><sup>∘</sup>? Justify your answer.

The reaction represented below also produces iron(III) oxide. The value of ΔH<sup>∘</sup> for the reaction is -280. kJ per mole of Fe<sub>2</sub>O<sub>3</sub>(s) formed.



- (e) Calculate the standard enthalpy of formation, ΔH<sub>f</sub><sup>∘</sup>, of FeO(s).



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

- (a) Determine the value of the standard enthalpy change,  $\Delta H_{\text{rxn}}^\circ$ , for the combustion of  $\text{CO}(g)$  at 298 K using the following information.



- (b) Determine the value of the standard entropy change,  $\Delta S_{\text{rxn}}^\circ$ , for the combustion of  $\text{CO}(g)$  at 298 K using the information in the following table.

Substance	$S_{298}^\circ$ ( $\text{J mol}^{-1} \text{K}^{-1}$ )
$\text{CO}(g)$	197.7
$\text{CO}_2(g)$	213.7
$\text{O}_2(g)$	205.1

- (c) Determine the standard free energy change,  $\Delta G_{\text{rxn}}^\circ$ , 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,  $K_{\text{eq}}$ , for the reaction at 298 K.