Pair-Post-Score – Thermo FRQ #1

Answer the following questions about glucose, $C_6H_{12}O_6$, an important biochemical energy source.

(a) Write the empirical formula of glucose.

In many organisms, glucose is oxidized to carbon dioxide and water, as represented by the following equation.

$$C_6H_{12}O_6(s) + 6\ O_2(g) \rightarrow 6\ CO_2(g) + 6\ H_2O(l)$$

A 2.50 g sample of glucose and an excess of $O_2(g)$ were placed in a calorimeter. After the reaction was initiated and proceeded to completion, the total heat released by the reaction was calculated to be 39.0 kJ.

(b) Calculate the value of $\Delta H°$, in kJ/mol_{rxn}, for the combustion of glucose.

(c) When oxygen is not available, glucose can be oxidized by fermentation. In that process, ethanol and carbon dioxide are produced, as represented by the following equation.

$$C_6H_{12}O_6(s) \rightarrow 2\ C_2H_5OH(l) + 2\ CO_2(g) \qquad \Delta H° = -68.0\ kJ\ mol^{-1} \text{ at } 298\ K$$

The value of the equilibrium constant, K_p, for the reaction at 298 K is 8.9×10^{39}.

(i) Calculate the value of the standard free-energy change, $\Delta G°$, for the reaction at 298 K. Include units with your answer.

(ii) Calculate the value of the standard entropy change, $\Delta S°$, in $J\ K^{-1}\ mol^{-1}$, for the reaction at 298 K.

(iii) Indicate whether the total bond dissociation energy of the reactants is greater than, less than, or equal to the total bond dissociation energy of the products.

(d) Using your answer for part (b) and the information provided in part (c), calculate the value of $\Delta H°$ for the following reaction.

$$C_2H_5OH(l) + 3\ O_2(g) \rightarrow 2\ CO_2(g) + 3\ H_2O(l)$$

Pair-Post-Score – Thermo FRQ #2

Answer the following questions about nitrogen, hydrogen, and ammonia.

(e) Draw the complete Lewis electron-dot diagrams for N_2 and NH_3.

(f) Calculate the standard free-energy change, $\Delta G°$, that occurs when 12.0 g of $H_2(g)$ reacts with excess $N_2(g)$ at 298 K according to the reaction represented below.

$$N_2(g) + 3\ H_2(g) \leftrightarrow 2\ NH_3(g) \qquad \Delta G° = -34\ \text{kJ mol}^{-1}$$

(g) Given that $\Delta H°$ for the reaction is -92.2 kJ mol^{-1}, which is larger, the total bond dissociation energy of the reactants or the total bond dissociation energy of the products? Explain.

(h) The value of the standard entropy change, $\Delta S°$, for the reaction is -199 J mol^{-1}K^{-1}. Explain why the value of $\Delta S°$ is negative.

(i) Assume that $\Delta H°$ and $\Delta S°$ for the reaction are independent of temperature.

(i) Explain why there is a temperature above 298 K at which the algebraic sign of the value of $\Delta G°$ changes.

(ii) Calculate the temperature at which the reaction becomes thermodynamically favorable. Is the reaction enthalpy or entropy driven at this temperature?