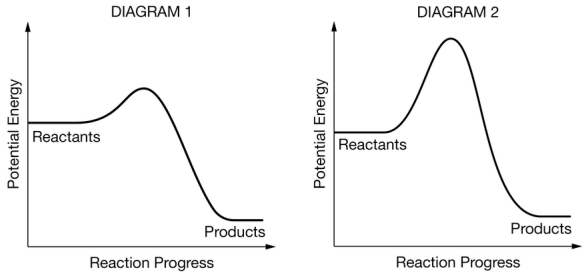
Thermodynamics and Electrochemistry

Wake Up Exercise

Thermodynamics versus Kinetics

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

$\Delta S^\circ = +217.7\ \mathrm{J/(mol_{rxn} \cdot K)}$
$\Delta H^\circ = -1235\ \mathrm{kJ/mol_{rxn}}$



The combustion of $\mathrm{C_2H_5OH}$ is represented by the equation above and the standard entropy and enthalpy changes for the reaction are provided. When the reactants are combined at $25^\circ\mathrm{C}$, essentially no $\mathrm{CO_2}(g)$ or $\mathrm{H_2O}(g)$ is produced after a few hours. Which of the diagrams above could best help explain the low yield of the reaction under these conditions, and why?

(A) Diagram 1, because it represents a reaction that is not thermodynamically favorable with $\Delta G^\circ > 0$, regardless of its reaction rate.

(B) Diagram 1, because it represents a reaction that reaches equilibrium quickly after a very small amount of the reactants is consumed.

(C) Diagram 2, because it represents a reaction with a high activation energy barrier for molecules to overcome and a very slow reaction rate, even if it is thermodynamically favorable with $\Delta G^\circ < 0$.

(D) Diagram 2, because it represents a reaction that is thermodynamically favorable with $\Delta H^\circ < 0$, but the products formed are unstable and quickly revert to form reactants.