Chemistry 2720 Fall 2003 Quiz 5 Solutions

1. We get the maximum amount of product when a reaction reaches equilibrium. In this case, $\Delta\bar{G}^\circ$ is relatively large and positive. This means that the equilibrium constant

$$K = e^{-\Delta\bar{G}^\circ/(RT)}$$

will be very small. Since

$$K = \frac{(a_\mathrm{B})(a_\mathrm{C})}{a_\mathrm{A}},$$

we wouldn't expect to get much of the product C unless the activity of the reactant A were extremely large.

2. (A) consumes the desired product C, so it won't be much help.

(B) has a negative standard free energy change, and it consumes the undesired product B, so it would increase the yield.

(C) has a negative free energy change and generates the reactant A. This will tend to shift the equilibrium toward the products of reaction (0), so it will increase the yield.

(D) produces one more unit of C than it consumes. Furthermore, it has a negative free energy change, so it should also increase the yield from reaction (0).

3. We can immediately rule out reaction (B) since it has such a small standard free energy change. The choice is then one between reactions (C) and (D).

To eliminate A from reactions (0) and (C), we multiply the former by 2:

$$2\mathrm{A} \rightarrow 2\mathrm{B} + 2\mathrm{C}, \qquad \Delta\bar{G}^\circ = 408\,\mathrm{kJ/mol}.$$

If we combine this reaction with (C), we have

$$\mathrm{W} + \mathrm{Z} \rightarrow 2\mathrm{B} + 2\mathrm{C}, \qquad \Delta\bar{G}^\circ = -142\,\mathrm{kJ/mol}.$$

Reactions (0) and (D) can be added directly:

$$\mathrm{V} + \mathrm{A} \rightarrow 2\mathrm{C} + \mathrm{B}, \qquad \Delta\bar{G}^\circ = -246\,\mathrm{kJ/mol}.$$

Both reactions will have extremely large, positive equilibrium constants (7.5×10^{24} and 1.3×10^{43}). These are so large that, for all intents and purposes, we should get 100% yield from both reactions. One would therefore choose one reaction over the other based on practical issues (kinetics, cost of reactants, etc.) and not on the thermodynamics, which are extremely favorable for both reactions.