Answer to question 1 on page 2 of Tutorial 3.

\[ N_2O_4(g) + \text{heat} \rightleftharpoons 2NO_2(g) \]

1. Now, consider the forward reaction and the reverse reaction. Which reaction do you think would be most affected by an increase in temperature? ___ the forward reaction ___

Explanation:

In an endothermic reaction like this, the **forward reaction** has the higher activation energy (see the graph above). If the activation energy is high, it means only a few molecules have enough energy for a successful reaction. When the temperature is increased, the number of molecules with sufficient energy will increase and the rate of reaction will increase.

For a reaction with a low activation energy (like the reverse reaction here), most molecules already have sufficient energy to react and increasing the temperature will not have as much affect.
So, to summarize:

*Temperature will always have more effect on the reaction with the higher activation energy.*

**Answer to question 2 on page 7 of Tutorial 3**

2. Given the equilibrium: \( CO_2(g) + NO(g) \rightleftharpoons CO(g) + NO_2(g) \)

   Some \( NO_2 \) is added to the system.

   The _______reverse_________ reaction will speed up.

\[
CO_2(g) + NO(g) \rightleftharpoons CO(g) + NO_2(g)
\]

This will cause the \([CO_2]\) and the \([NO]\) to ______________increase______

\[
CO_2(g) + NO(g) \rightleftharpoons CO(g) + NO_2(g)
\]

Therefore, after awhile, the rate of the ______forward_______ reaction will speed up, and there will be a new equilibrium.

Because the rate of the _______reverse_________ reaction was higher for awhile, in the new equilibrium mixture, the \([CO_2]\) and the \([NO]\) will be _____higher___

than they were before and the \([CO]\) and the \([NO_2]\) will be _____lower_____ than after we added the NO_2.

We can say that adding the \( NO_2 \) **shifted** the equilibrium to the _________left_______

**Answers to question 3 on page 10 of Tutorial 3**

3. Given the equilibrium: \( 2C_2H_6(g) + 7O_2(g) \rightleftharpoons 4CO_2(g) + 6H_2O(g) \)

   \[ 2 + 7 = 9 \text{ moles of gas} \quad 4 + 6 = 10 \text{ moles of gas} \]

   a) **Increasing** the total pressure on this system, will cause a shift to the side with ___less___ moles of gas, which in this case is the _____left_________ side.
b) Decreasing the total pressure on this system, will cause a shift to the side with more moles of gas, which in this case is the right side.

c) Increasing the total volume on this system (the same as decreasing the total pressure) will cause a shift to the side with more moles of gas, which in this case is the right side.

d) Decreasing the total volume on this system (the same as increasing the total pressure) will cause a shift to the side with less moles of gas, which in this case is the left side.

Answers to Self-Test starting on page 12 of Tutorial 3

1. When a chemical system is at equilibrium, when the temperature is increased, the endothermic reaction speeds up the most.

2. In the reaction: \( A + B \rightleftharpoons C + 43.3 \text{ kJ} \)

   a) When the temperature is increased the (forward/reverse) reverse reaction speeds up more.

   b) During this time, the [A] and [B] will increase and the [C] will decrease.

   c) Because [A] and [B] are increasing, the rate of the forward reaction will increase.

   d) Sooner or later, the forward rate and the reverse rate will again become equal.

      At this point a new equilibrium is established.

   e) In the new equilibrium, [A] and [B] will be higher than they were before the temperature is increased.

      In the new equilibrium, [C] will be lower than it was before.

   f) In this example, we say that the equilibrium has shifted to the left.
3. Given the reaction: \( A + B \rightleftharpoons C + 43.3 \text{ kJ} \)

a) When the temperature is decreased, the (forward/reverse) _______ forward reaction will be the faster one. (the endothermic reverse reaction slows down)

b) During this time, the \([A]\) and \([B]\) will ___decrease and the \([C]\) will ___increase.

c) Because \([C]\) is ______ increasing, the rate of the ______ reverse reaction will increase.

d) Sooner or later, the forward rate and the reverse rate will again become ___equal__.

At this point a new ________equilibrium______ is established.

e) In the new equilibrium, \([A]\) and \([B]\) will be __________lower than they were before the temperature is increased.

In the new equilibrium, \([C]\) will be ___________higher than it was before.

f) In this example, we say that the equilibrium has shifted to the ________right______

4. In the reaction: \( A + B + 324 \text{ kJ} \rightleftharpoons C \)

a) When the temperature is increased, the (forward/reverse) _______forward reaction speeds up more.

b) During this time, the \([A]\) and \([B]\) will ___decrease and the \([C]\) will ___increase.

c) Because \([C]\) is ___increasing, the rate of the _______reverse reaction will increase.

d) Sooner or later, the forward rate and the reverse rate will again become ___equal__.

At this point a new ________equilibrium______ is established.

e) In the new equilibrium, \([A]\) and \([B]\) will be __________lower than they were before the temperature is increased.

In the new equilibrium, \([C]\) will be ___________higher than it was before.

f) In this example, we say that the equilibrium has shifted to the ________right______
5. Given the equilibrium: \[ \text{B} (g) + \text{C} (g) \rightleftharpoons \text{D} (g) + \text{E} (g) + \text{heat} \]

   a) Some B is added to the mixture at equilibrium. The rate of the ________forward____ reaction will increase due to the increase in the [B].

   b) While this is happening, the [D] and [E] will gradually ______increase.

   c) The ______increase in the [D] and [E] will cause the rate of the ______reverse____ reaction to increase.

   d) When the rates of the forward and reverse reactions are equal, we have a new ___________________________equilibrium___________________________

   e) Due to the addition of B, the equilibrium will shift to the ________right_____

       [B] and [C] will ______decrease and [D] and [E] will _________________increase

6. Given the equilibrium: \[ \text{B} (g) + \text{C} (g) \rightleftharpoons \text{D} (g) + \text{E} (g) + \text{heat} \]

   a) Some D is added to the mixture at equilibrium. The rate of the ________reverse____ reaction will increase due to the increase in the [D].

   b) While this is happening, the [B] and [C] will gradually ______increase.

   c) The ______increase in the [B] and [C] will cause the rate of the ______forward____ reaction to increase.

   d) When the rates of the forward and reverse reactions are equal, we have a new ___________________________equilibrium___________________________

   e) Due to the addition of D, the equilibrium will shift to the ________left_____

       [B] and [C] will ______increase and [D] and [E] will _________________decrease.

7. Given the equilibrium: \[ 2\text{A} (g) + \text{B} (g) \rightleftharpoons 2\text{C} (g) \]

   a) If the total pressure on the system is increased, the ________forward____ reaction will speed up the most. to compensate for the increased pressure.

   b) While this is happening, the [C] will ______increase.
c) This _____ increase in [C] will cause the _____ reverse _____ reaction to speed up.

d) When the new equilibrium is reached, the [A] and [B] will be ___________ lower

than before and the [C] will be ___________ higher ___________ than before.

e) We say that the increase in total pressure has caused the equilibrium to shift to the

_ right (the side with the least moles of gas.) ____________________________.

8. Given the equilibrium: 2A\(_{(g)}\) + B\(_{(g)}\) \rightleftharpoons 2C\(_{(g)}\)

a) If the total pressure on the system is decreased, the ___________ reverse _____

reaction will be the faster one.

b) While this is happening, the [A] and the [B] will ________ increase.

c) This _____ increase in [A] and the [B] will cause the _____ forward _____ reaction

to speed up.

d) When the new equilibrium is reached, the [A] and [B] will be ___________ higher

than before and the [C] will be ___________ lower ___________ than before.

e) We say that the decrease in total pressure has caused the equilibrium to shift to the

________________ left ____________.

9. Given the equilibrium: NO\(_{(g)}\) + CO\(_2(g)\) \rightleftharpoons NO\(_2(g)\) + CO\(_(g)\)

a) Will an increase in total pressure have an affect on the equilibrium? _____ no _____

b) Explain your answer to question (a) ____ the same number of moles on both sides. __

It could not compensate for the increased pressure by shifting either way.__

10. Given the equilibrium: 2A\(_{(g)}\) + B\(_{(g)}\) \rightleftharpoons 2C\(_{(g)}\)

a) If the total volume of the system is decreased, the ___________ pressure ___________

will increase, and the _____ forward _____ reaction will be the faster one.

b) While this is happening, the [C] will ___________ increase.
c) This ___increase in [C] ___ will cause the ___reverse___ reaction to speed up.

d) When the new equilibrium is reached, the [A] and [B] will be _______lower
   than before and the [C] will be _______higher_____ than before.

e) We say that the decrease in total volume has caused the equilibrium to shift to the
   _______________right________________.

11. Given the equilibrium: \[ 2A(g) + B(g) \rightleftharpoons 2C(g) + \text{heat} \]

   a) How will this equilibrium be affected if a catalyst is added to the mixture? it won't

   b) Explain your answer to "a" in terms of forward and reverse reaction rates

      a catalyst speeds up the forward rate and the reverse rate by the same amount,
      so the rates are still equal and the equilibrium is not affected.

      A catalyst will cause a reaction which is not at equilibrium to reach
      equilibrium faster.

You have now finished Tutorial 3. If you have any questions, check with the teacher
before going on.