

# 8 • Thermochemistry, Kinetics, & Equilibrium

## LE CHATELIER'S PRINCIPLE

Match the change to the equilibrium system below with the letter of the appropriate response. Each letter can be used once, more than once, or not at all.



- |  |  |
|--|--|
| _____ 1. O <sub>2</sub> is added to the system.      | a. The equilibrium shifts to the right.            |
| _____ 2. SO <sub>3</sub> is added to the system.     | b. The equilibrium shifts to the left.             |
| _____ 3. The temperature of the system is increased. | c. There is no change in the equilibrium position. |
| _____ 4. A catalyst is added to the system.          |  |
| _____ 5. The volume is decreased.                    |  |

If the statement is true, write "true." If it is false, change the underlined word or words to make the statement true. Write your answer on the line provided.



- \_\_\_\_\_ 5. The above reaction is exothermic.
- \_\_\_\_\_ 6. The production of ammonia from ammonium chloride will increase at higher temperature.
- \_\_\_\_\_ 7. For the above reaction at equilibrium, an increase in the concentration of HCl causes a decrease in gaseous ammonia concentration.

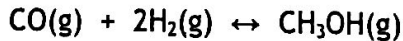
8. The following equilibrium may be established with carbon dioxide and steam.



Predict the direction of equilibrium shift (right, left, or no shift) if the following changes occur:

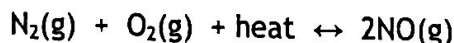
- a.) The addition of more H<sub>2</sub>O? \_\_\_\_\_
- b.) The removal of some H<sub>2</sub>? \_\_\_\_\_
- c.) Raising the temperature? \_\_\_\_\_
- d.) Addition of a catalyst? \_\_\_\_\_
- e.) Increasing the volume? \_\_\_\_\_

9. What would be the effect of each of the following on the concentration of CO (increase, decrease, or no effect) when the following stresses are placed on the equilibrium involving the synthesis of methanol?



- a.) The removal of CH<sub>3</sub>OH? \_\_\_\_\_
- b.) Lowering the concentration of H<sub>2</sub>? \_\_\_\_\_
- c.) The addition of a catalyst? \_\_\_\_\_
- d.) Decreasing the volume? \_\_\_\_\_

10. A small percentage of nitrogen gas and oxygen gas in the air combine at the high temperatures found in automobile engines to produce NO(g), an air pollutant.

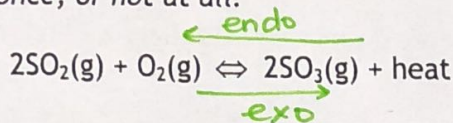


Higher engine temperatures are used to minimize carbon monoxide production. What effect do higher engine temperatures have on the production of NO? Why?

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Match the change to the equilibrium system below with the letter of the appropriate response. Each letter can be used once, more than once, or not at all.



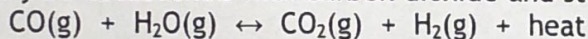
- |  |  |
|--|--|
| <p><u>a</u> 1. O<sub>2</sub> is added to the system.</p> <p><u>b</u> 2. SO<sub>3</sub> is added to the system.</p> <p><u>b</u> 3. The temperature of the system is increased.</p> <p><u>c</u> 4. A catalyst is added to the system.</p> <p><u>a</u> 5. The volume is decreased. <span style="color: green;">(less moles of gas)</span></p> | <p>a. The equilibrium shifts to the right.</p> <p>b. The equilibrium shifts to the left.</p> <p>c. There is no change in the equilibrium position.</p> |
|--|--|

If the statement is true, write "true." If it is false, change the underlined word or words to make the statement true. Write your answer on the line provided.



- F 5. The above reaction is exothermic. endothermic
- T 6. The production of ammonia from ammonium chloride will increase at higher temperature.
- T 7. For the above reaction at equilibrium, an increase in the concentration of HCl causes a decrease in gaseous ammonia concentration. (shifts reverse which uses NH<sub>3</sub>)

8. The following equilibrium may be established with carbon dioxide and steam.



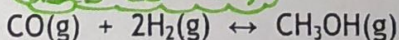
Predict the direction of equilibrium shift (right, left, or no shift) if the following changes occur:

- |  |                   |
|--|-------------------|
| a.) The addition of more H <sub>2</sub> O? | <u>Right</u>      |
| b.) The removal of some H <sub>2</sub> ?   | <u>Right</u>      |
| c.) Raising the temperature?               | <u>left</u>       |
| d.) Addition of a catalyst?                | <u>no shift *</u> |
| e.) Increasing the volume?                 | <u>no shift *</u> |

catalyst ↑ rate both forward and rev.

moles of gas are the same on both sides.

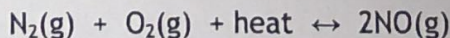
9. What would be the effect of each of the following on the concentration of CO (increase, decrease, or no effect) when the following stresses are placed on the equilibrium involving the synthesis of methanol?



- |  |                                  |
|--|----------------------------------|
| a.) The removal of CH <sub>3</sub> OH?             | <u>shift left - increases CO</u> |
| b.) Lowering the concentration of H <sub>2</sub> ? | <u>shift right - decrease CO</u> |
| c.) The addition of a catalyst?                    | <u>no shift</u>                  |
| d.) Decreasing the volume?                         | <u>shift right - decrease CO</u> |

(less moles)

10. A small percentage of nitrogen gas and oxygen gas in the air combine at the high temperatures found in automobile engines to produce NO(g), an air pollutant.



Higher engine temperatures are used to minimize carbon monoxide production. What effect do higher engine temperatures have on the production of NO? Why?

Higher temp increases production of NO b/c the endothermic forward reaction will be favored.