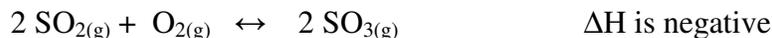


Unit 5, Lesson 07: Answers to Le Chatelier's Principle

1. Predict the direction of the equilibrium shift for the reaction below:



- | | |
|---|--|
| a) $[\text{SO}_2]$ is increased \rightarrow | d) $[\text{SO}_3]$ is decreased \rightarrow |
| b) temperature is raised \leftarrow | e) volume of the system is decreased ($P \uparrow$) so \rightarrow |
| c) $[\text{O}_2]$ is decreased \leftarrow | f) a catalyst is added: no change |

2. The system below is at equilibrium. What will happen to the amount of $\text{NO}_2(g)$ in the system if the following stresses are imposed? Explain briefly.



- | | |
|--|---|
| a) an increase in the amount of N_2O_3 | eq'm will shift right to use up N_2O_3 so $[\text{NO}_2]$ will increase |
| b) a decrease in temperature | eq'm will shift right to produce heat and $[\text{NO}_2]$ will increase |
| c) the addition of a catalyst | both fwd and reverse reactions increase, so no change in $[\text{NO}_2]$ |
| d) an increase in the amount of $\text{NO}_{(g)}$ | eq'm will shift left to use up NO so $[\text{NO}_2]$ will decrease |
| e) increase in the volume of the system | pressure will drop so eq'm will shift right & $[\text{NO}_2]$ will increase |
| f) an inert gas such as He is added | doesn't change the conc'ns of reactants or products; no change |

3. Suggest five ways to produce a maximum amount of product in this system. Explain briefly why each method should be effective.



Need to drive the reaction to the right, so;

- increase the pressure, there are fewer gas particles on the product side, so reaction will shift right
- decrease the volume, this will increase the pressure and reaction will shift right
- add I_2 or Cl_2 and reaction will shift right to use up the reactants
- remove ICl_2 as it forms and reaction shift right to make more product
- increase the temperature and the reaction will shift right to absorb the added heat (forward reaction is endothermic because ΔH is positive)

4. For the reaction: $\text{PCl}_{3(g)} + \text{Cl}_{2(g)} \leftrightarrow \text{PCl}_{5(g)} \quad \Delta H = -98 \text{ kJ}$

- a) Write the equilibrium constant expression for this system.
$$K_{eq} = \frac{[\text{PCl}_5]}{[\text{PCl}_3][\text{Cl}_2]}$$
- b) In which direction will this equilibrium shift if the temperature is increased? \leftarrow to absorb heat
- c) If temperature is increased, what will happen to the concentration of the product? $[\text{PCl}_5]$ will decrease
- d) If temperature is increased, what will happen to the concentration of the reactants? $[\text{PCl}_3]$ & $[\text{Cl}_2]$ go up
- e) If temperature is increased, what will happen to the value of K_{eq} ? Explain.

When temp. is increased, $[\text{PCl}_5]$ goes down and $[\text{PCl}_3]$ & $[\text{Cl}_2]$ go up so the value of K_{eq} will decrease.

- f) If temperature is decreased, what will happen to the value of K_{eq} ? Explain.

When temp. is decreased, $[\text{PCl}_5]$ goes up and $[\text{PCl}_3]$ & $[\text{Cl}_2]$ go down so the value of K_{eq} will increase.

- g) If a catalyst is added, what will happen to the value of K_{eq} ? Explain.

The value of K_{eq} will remain the same because the rates of both the forward and reverse reactions are both increased equally, so the concentrations of reactants and products will stay the same.



- a) Write the equilibrium constant expression for this system. $K_{eq} = \frac{[\text{H}_2\text{O}][\text{CO}]}{[\text{CO}_2][\text{H}_2]}$
- b) In which direction will this equilibrium shift if the temperature is increased? →
- c) If temperature is increased, what will happen to the concentration of the product? will increase
- d) If temperature is increased, what will happen to the concentration of the reactants? will decrease
- e) If temperature is increased, what will happen to the value of K_{eq} ? Explain.

When temp. is increased, [products] increases and [reactants] decreases, so K_{eq} will increase.

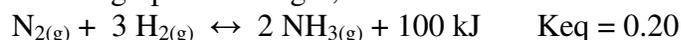
- f) If temperature is decreased, what will happen to the value of K_{eq} ? Explain.

When temp. is decreased, [products] decreases and [reactants] increases, so K_{eq} will decrease.

- g) If a catalyst is added, what will happen to the value of K_{eq} ? Explain.

The value of K_{eq} will remain the same because the rates of both the forward and reverse reactions are both increased equally, so the concentrations of reactants and products will stay the same.

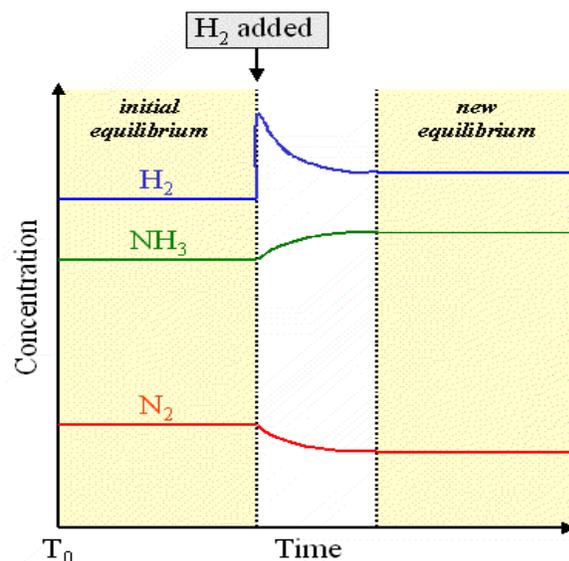
6. For the graph to the right, the reaction is:



H_2 is added to the system and a new equilibrium is established.

At the new equilibrium, the:

- a) concentration of H_2 (g) is **higher** (it isn't all used up)
- b) concentration of N_2 (g) is **lower**
- c) concentration of NH_3 (g) is **higher**
- d) value of K_{eq} is **unchanged or 0.20** (the only thing that changes K_{eq} is changing the temperature)



7. $4 \text{NO}_{(g)} + 6 \text{H}_{2(g)} + \text{heat} \leftrightarrow 4 \text{NH}_{3(g)} + 5 \text{O}_{2(g)}$

Which of the following sets of conditions will give the maximum yield of $\text{NH}_{3(g)}$?

- a) high temperature and low pressure
- b) high temperature and high pressure** (both drive the reaction to the right, producing NH_3)
- c) low temperature and low pressure
- d) low temperature and high pressure

8. For the equilibrium system: $\text{PCl}_{3(g)} + \text{Cl}_{2(g)} \leftrightarrow \text{PCl}_{5(g)} \quad \Delta H = -98 \text{ kJ}$

If the temperature is decreased, which of the following changes will occur?

- a) $[\text{PCl}_5]$ increased, $[\text{PCl}_3]$ decreased and $[\text{Cl}_2]$ decreased** (as temp goes down, rxn shifts right)
- b) $[\text{PCl}_5]$ decreased, $[\text{PCl}_3]$ increased and $[\text{Cl}_2]$ increased
- c) $[\text{PCl}_5]$ decreased, $[\text{PCl}_3]$ decreased and $[\text{Cl}_2]$ increased
- d) $[\text{PCl}_5]$ decreased, $[\text{PCl}_3]$ decreased and $[\text{Cl}_2]$ decreased

9. Which will **increase** the eq'm concentration of ammonia? $\text{N}_{2(g)} + 3 \text{H}_{2(g)} \leftrightarrow 2 \text{NH}_{3(g)} + 100 \text{ kJ}$
- a decrease in the total pressure at constant volume
 - a decrease in the concentration of hydrogen
 - a decrease in temperature***
 - an increase in the volume of the container
10. What is the effect of adding oxygen gas to the system: $2 \text{NO}_{(g)} + \text{O}_{2(g)} \leftrightarrow 2 \text{NO}_{2(g)}$
- no change in the concentration of $\text{NO}_{(g)}$ or $\text{NO}_{2(g)}$
 - decrease in the concentration of $\text{NO}_{2(g)}$
 - increase in the concentration of $\text{NO}_{(g)}$
 - increase in the concentration of $\text{NO}_{2(g)}$***
11. When hydrogen gas is added to the equilibrium system: $\text{H}_{2(g)} + \text{I}_{2(g)} \leftrightarrow 2 \text{HI}_{(g)}$
- $[\text{I}_2]$ will decrease and $[\text{HI}]$ will increase***
 - $[\text{I}_2]$ will decrease and $[\text{HI}]$ will decrease
 - $[\text{I}_2]$ will increase and $[\text{HI}]$ will increase
 - $[\text{I}_2]$ will increase and $[\text{HI}]$ will decrease