Chemistry 30 Unit 4 - Acid Base / Equilibrium

Equilibrium Shifts and Le Chatelier's Principle

Today, you will:

- predict, qualitatively, using Le Chatelier's principle, shifts in equilibrium caused by changes in temperature, pressure, volume, concentration or the addition of a catalyst and describe how these changes affect the equilibrium constant

Shifting Equilibrium

Chemical systems tend towards equilibrium, but can be taken out of equilibrium by a stress to the system.

Common stresses include:

-adding more reactants
-removing products
-changing temperature
-changing pressure

Systems taken out of equilibrium will shift or take measures to get back to equilibrium.

This shift can be examined using the theories set out in 1885 by Henri Louis Le Chatelier. He said:

Le Chatelier's Principle

"If a chemical system experiences a change in concentration, temperature or pressure, the system will shift in order to minimize that change."

Pour quoi?

Effect of [ ] change on a system

For example, consider a system containing nitrogen dioxide and water reacting to form nitric acid and nitrogen monoxide.

$$3\ NO_{2(g)} + H_2O_{(g)} \rightleftharpoons 2\ HNO_{3(aq)} + NO_{(g)}$$

1. When the reactants are first mixed, they will initially react to form some products and an equilibrium will be created.

$$3\ NO_{2(g)} + H_2O_{(g)} \overset{\text{shift right}}{\rightleftharpoons} 2\ HNO_{3(aq)} + NO_{(g)}$$

2. To stress the equilibrium, assume some of the $NO_{(g)}$ is removed. The equilibrium is now lost.

To rebalance the system, the equilibrium must shift to the right, or create more products.

Removing the $NO_{(g)}$ is a change in [ ]. The system will resist this change and try to reestablish the original [ ].

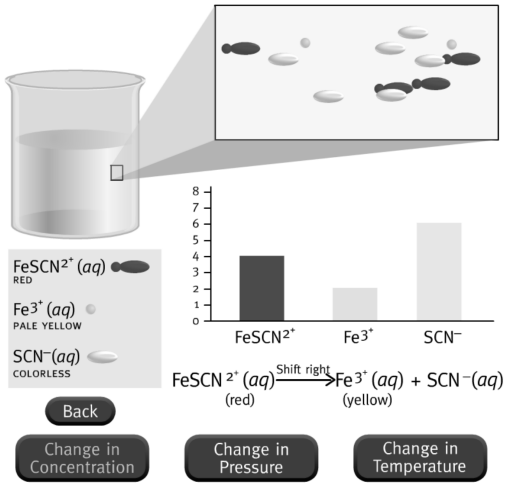
shift right

$$3\ NO_{2(g)} + H_2O_{(g)} \rightleftharpoons 2\ HNO_{3(aq)} + NO_{(g)}$$

The same shift would take place if we increased the [ ] of the $NO_{2(g)}$.

This would cause more forward reactions in an attempt to reset the balance.

Le Chatelier's Principle Animation



Effect of Temperature Change on a System

Some chemical reactions show changes in energy right in the reaction. In these reactions, energy is treated just like another product or reactant.

For example, consider the production of $SO_{3(g)}$ from $SO_{2(g)}$ and $O_{2(g)}$.

$$2\ SO_{2(g)} + O_{2(g)} \rightleftharpoons 2\ SO_{3(g)} + \text{energy}$$

shift right

$$2\ SO_{2(g)} + O_{2(g)} \rightleftharpoons 2\ SO_{3(g)} + \text{energy}$$

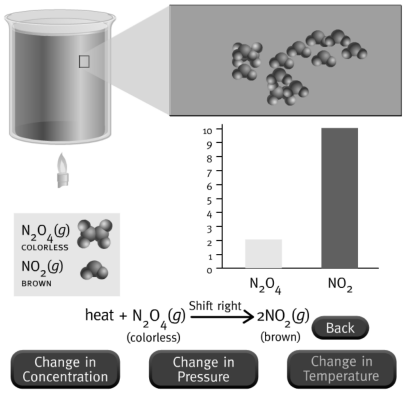
1. If the system is cooled down (i.e. energy is removed), the system shifts to the right to produce more energy to replace that which was lost.

shift left

$$2\ SO_{2(g)} + O_{2(g)} \rightleftharpoons 2\ SO_{3(g)} + \text{energy}$$

2. If the system is heated up (i.e. energy is put in), the equilibrium shifts left to produce more reactants.

Change in temperature animation



Changes in Pressure to a System

If we're talking a change in pressure, we're talking gases.

Remember: pressure is inversely proportional to volume: as volume goes up, pressure goes down, and visa versa.

To study pressure, again consider the reaction:

$$2\ SO_{2(g)} + O_{2(g)} \rightleftharpoons 2\ SO_{3(g)}$$

1. Let's say we increase pressure. Which way will the equilibrium shift? Pressure is not shown in the reaction.

To rewrite the equation with pressure, you need to determine what side pressure is on. Do this by comparing the number of moles of gas on either side. There is a total of 3 moles on the left

$$\text{pressure} + 2\,SO_{2(g)} + O_{2(g)} \rightleftharpoons 2\,SO_{3(g)}$$

Now the equilibrium works the same as before. Increasing pressure causes a shift to the right.

And increase in pressure will always cause a shift to the side with the least number of moles of gas.

2. If we were to reduce pressure, the equilibrium would shift to the left. Decreasing pressure causes a shift to the side with the greater number of moles of gas.

HW: