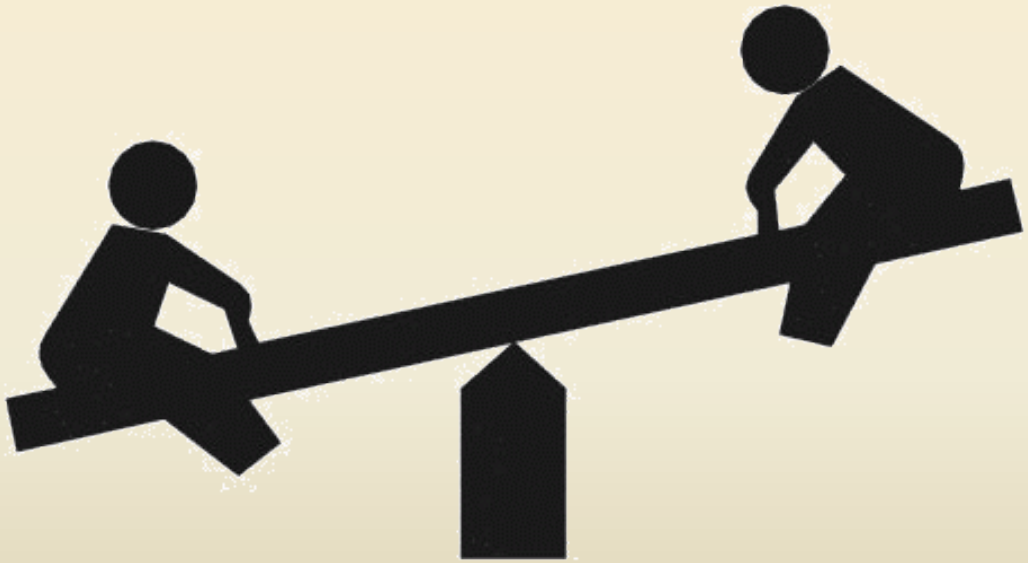
Equilibrium
and
Le Chatelier's Principle



MA Standards

Students know how to use LeChatelier's principle to predict the effect of changes in concentration, temperature, and pressure.

Students know equilibrium is established when forward and reverse reaction rates are equal.

Chemical Equilibrium

Reversible Reactions:

A chemical reaction in which the products can react to re-form the reactants

Chemical Equilibrium:

When the rate of the forward reaction equals the rate of the reverse reaction and the concentration of products and reactants remains unchanged

$$2HgO(s) \leftrightarrows 2Hg(l) + O_2(g)$$

Arrows going both directions ($\leftrightarrows$) indicates equilibrium in a chemical equation

LeChatelier's Principle

When a system at equilibrium is placed under stress, the system will undergo a change in such a way as to relieve that stress.

Henry Le Chatelier

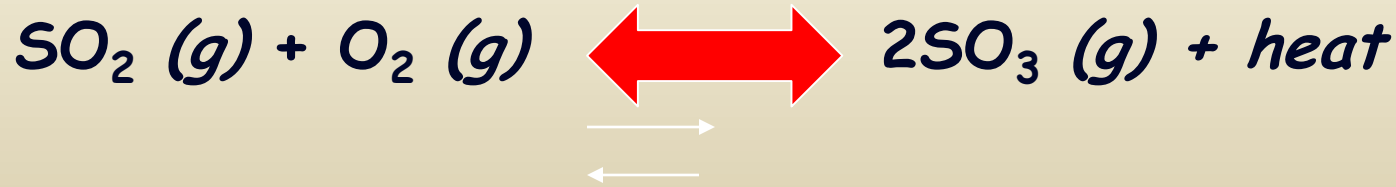
Le Chatelier Translated:

When you take something away from a system at equilibrium, the system shifts in such a way as to replace what you've taken away.

When you add something to a system at equilibrium, the system shifts in such a way as to use up what you've added.

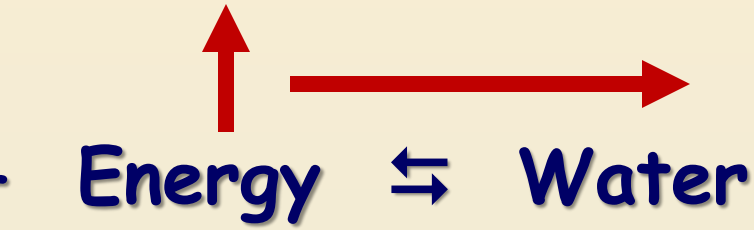
Effect of Temperature

- Increasing the temperature causes the equilibrium to shift in the direction that absorbs heat.
  Stress: Increase in Temp
- Relief: Decrease in Temp
- Shift: Towards the left



LeChatelier Example #1

A closed container of ice and water at equilibrium. The temperature is raised.



The equilibrium of the system shifts to the right to use up the added energy.

Effect of Concentration

- Adding reactant shifts the reaction toward the products. Why?
- Stress: Increasing reactants
- Relief: Decreasing reactants
- Shift: to the right (products)

$H_2O\ (l) + CO_2\ (g) \rightleftharpoons H_2CO_3\ (aq)$

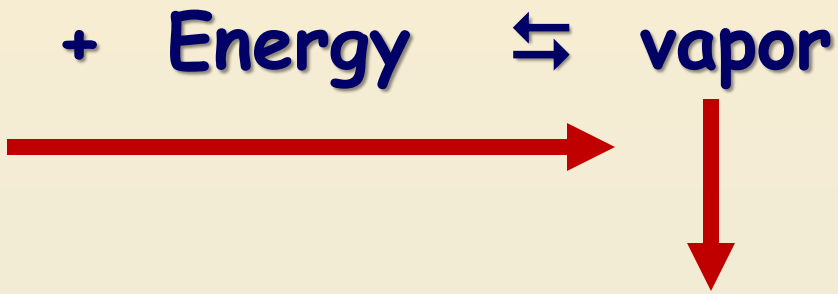
LeChatelier Example #2

A closed container of N_2O_4 and NO_2 at equilibrium. NO_2 is added to the container.

The equilibrium of the system shifts to the left to use up the added NO_2.

LeChatelier Example #3

A closed container of water and its vapor at equilibrium. Vapor is removed from the system.



The equilibrium of the system shifts to the ___right___ to replace the vapor.

Effect of Pressure

- Affects gases only.
- For unequal number of moles of reactants and products, if pressure is increased, the equilibrium will shift to reduce the number of particles.
- For equal number of moles of reactants and products, no shift occurs.

$$N_{2\,(g)} + 3\,O_{2\,(g)} \leftrightarrows 2\,NH_{3\,(g)}$$

LeChatelier Example #4

A closed container of N_2O_4 and NO_2 at equilibrium. The pressure is increased.

$$N_2O_4\,(g) + \text{Energy} \leftrightarrows 2\,NO_2\,(g)$$

The equilibrium of the system shifts to the left to lower the pressure, because there are fewer moles of gas on that side of the equation.