LeChatelier's Principle

(If you have your book, this is on pages 633-639)

Definition:
If a change (stress) is imposed on a system in equilibrium, the position of the equilibrium will shift in the direction to reduce (relieve) the change (stress).

There are three different changes or stresses put on a system in equilibrium that will cause an effect on the direction of the shift.

1) Addition or removal of a reactant or product in the reaction will cause an effect in the direction of the shift.
   Note: Substances that are **solid** or **liquid** appear in the equilibrium expression as "1" and will have **no effect** on the equilibrium of the reaction.

2) Changes in pressure on a system due to a change in the volume of the container of the reaction will have an effect on the **gas** reactants or products in the system.

3) Changes in the temperature of a system will change the K_C or K_P of the system and will have
   an effect on the equilibrium of the system depending on whether it is an endothermic or exothermic reaction.

LeChatelier's Principle (1)

In the following reaction system

$$\mathbf{3\ H_2(g) + N_2(g) \leftrightarrow 2\ NH_3(g)}$$

The equilibrium concentrations of each gas is as follows:
$[N_2] = 0.399$ M, $[H_2] = 1.197$ M, $[NH_3] = 0.202$ M.

The equilibrium expression is

$$K_C = (0.202)^2 / (0.399)(1.197)^3$$
$$K_C = 1.70 \times 10^{-2}$$

If I increase the concentration of NH_3 (the product) to 0.494 M,

$$Q = (0.404)^2 / (0.399)(1.97)^3$$
$$Q = 5.35 \times 10^{-2}$$

Now Q > K so the reaction shifts toward the **reactants (left)** to relieve the stress.
Likewise, if Q < K. the reaction would have shifted to the **products (right)** to relieve the stress.

***Adding** a substance (aq or g, not s or l) to one side of a system in equilibrium shifts it to the **opposite** side.
Removing a substance from one side of a system in equilibrium shifts it to the **same** side.
[(See Interactive Example 13.13 p.635)]

LeChatelier's Principle (2)

Effects of Pressure on a System—pressure only has an effect on the gases in a system.

*The addition of an "inert" gas or noble gas to a system that increases the total pressure of the system has **No Effect** on the concentrations or partial pressures of the system an therefore, no effect on the equilibrium.

*When the **Volume** of the container holding a gaseous system is **reduced** and therefore, the **Partial Pressures** of the gases **increase**, the system responds by reducing its own volume. This Is done by **decreasing the number of gaseous molecules** (The system shifts to the side with **fewer**
Gas molecules).
The same is true if the volume of the container is increased (decreases partial pressures). The System reacts by **increasing the number of gaseous molecules** (The system shifts to the side with
more Gas molecules).

Example: $3\ H_2(g) + N_2(g) \leftrightarrow 2\ NH_3(g)$
(4 gas molec) (2 gas molec)

Increased pressure due to volume decrease—shifts **left (products)**
Decreased pressure due to volume increase—shifts **right (reactants)**
(See Interactive Example 13.14 p.637)

LeChatelier's Principle (3)

Effects of Temperature on a System—Temperature changes K_C or K_P and causes a stress on the system.

*If a system is **endothermic (+ΔH)** for a reaction, it means that the **product (right)** side of the reaction
is endothermic (+). Therefore, the reactant side (or the reverse side of the reaction) is exothermic (-).
If the system is **exothermic (-ΔH)** for a reaction, it means that the **product (left)** side of the reaction is
exothermic (-). Therefore, the reactant side (or the reverse side of the reaction) is endothermic (+).

If heat is **added** (+) to the system, the reaction will shift toward the **endothermic or +** side of the reaction.
If heat is **removing** (-) or **cooling** a system, the reaction will shift to the **exothermic** or **–** side of the rxn.

Example: $3\ H_2(g) + N_2(g) \leftrightarrow 2\ NH_3(g)$ $\Delta H = +92$ kJ

(-) (+)

Endothermic Reaction above.

Product side is (+), Reactant side is (-).

Adding heat shifts **right** toward the endothermic (+) side.

Removing heat or cooling shifts **left** toward the exothermic (-) side.

(See Interactive Example 13.15 p. 639)

Also see Summary of LeChatelier's Principle under 13.15 on the same page.

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