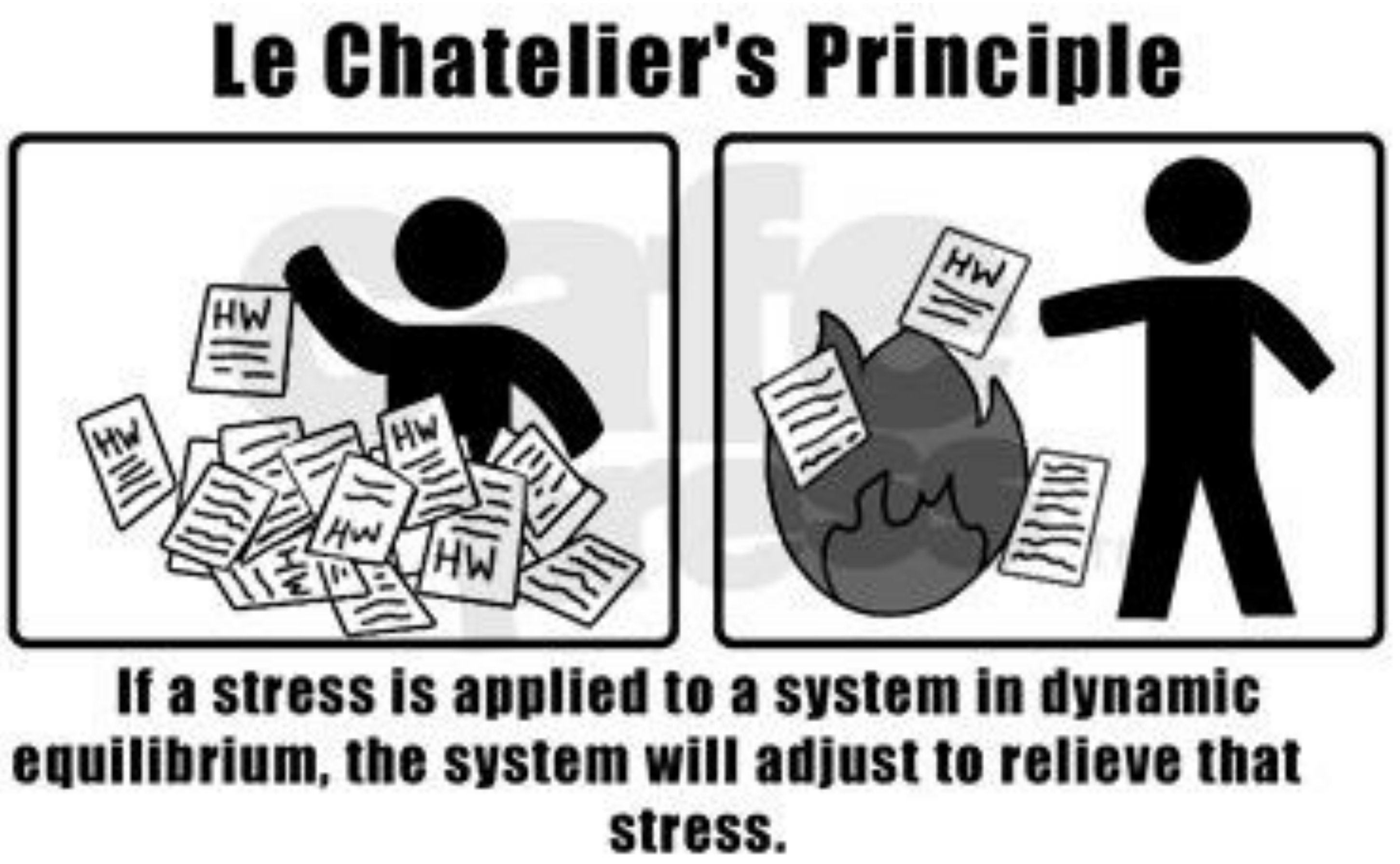
# LeChatelier's Principle

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**Outcome:**

Use Le Chatelier's Principle to predict shifts in equilibrium.

# Le Chatelier's Principle :

***"If a stress is imposed on a system at equilibrium, the position of the equilibrium will shift in a direction that tends to reduce the stress"***

In other words…

- **Whatever you do to a system at equilibrium, the system will do the opposite to reduce the stress.**

This statement is attributed to the French chemist **HENRI LE CHATELIER**

This idea has very **PRACTICAL APPLICATIONS** in the **PRODUCTION** of chemicals

- **CONDITIONS** are chosen so as to favor the
- **PRODUCT** as much as possible

ex) The Haber process

Remember: Most changes subjected to a system in equilibrium may **ALTER** the equilibrium **POSITION** but it will **NOT ALTER** the equilibrium **CONSTANT**!

# Consequences of LeChatelier:

Allows us to make **QUALITATIVE** predictions about what will happen when the conditions of a reaction existing in equilibrium are changed

This '**CHANGE** of **CONDITIONS'** is commonly referred to as a **STRESS**

Several different kinds of stresses can effect a chemical system:

- Change in **TEMPERATURE**
- Change in **PRESSURE**/change in **VOLUME**
- Change in **CONCENTRATION**
- Addition/removal of a **CATALYST**

# Consequences of LeChatelier:

When any one of the stresses effects a system, the system will try to **ACCOMMODATE** the new conditions

One of three things will happen:

- More **PRODUCTS** will form (shift **RIGHT**)
- More **REACTANTS** will form (shift **LEFT**)
- The equilibrium **POSITION** will **NOT** be **AFFECTED** (no **SHIFT**)

# Changes in Concentration:

"*For a system to resist an action that* ***INCREASES*** *the equilibrium* ***CONCENTRATION*** *of one of the reacting* ***SPECIES****, it must do so by* ***FAVORING*** *the* ***REACTION*** *in which that species is* ***CONSUMED***"

Consider:

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

- If more **$SO_{3(g)}$** is added to the reaction flask, the system will react by forming more of the **REACTANTS** (the reaction will proceed to the **LEFT** or the **REVERSE REACTION** will occur until a **NEW EQUILIBRIUM** is established)
- In the new equilibrium there will be **DIFFERENT** (**NEW**) **AMOUNTS** of the substances than in the original equilibrium

# Changes in Concentration:

**Example 1:**

$$CO_{(g)} + H_2O_{(g)} \longleftrightarrow CO_{2(g)} + H_{2(g)}$$

Predict the effect of adding more $CO_{(g)}$ to a constant volume equilibrium mixture of the above gases.

***The equilibrium will shift 'to the right'***

**Example 2:**

$$N_{2(g)} + 3\,H_{2(g)} \longleftrightarrow 2\,NH_{3(g)}$$

Predict the effect of removing $H_{2(g)}$ from an equilibrium mixture in a sealed flask.

***The equilibrium will shift 'to the left'***

# Changes in Pressure:

There are 3 ways we can change pressure of a constant equilibrium mixture:

- Change the **VOLUME** of the container
- **ADD** or **REMOVE** a **GASEOUS** product or reactant
- Add an **INERT GAS**
    - like increasing the total **PRESSURE** in the flask but doesn't affect the **CONCENTRATIONS** of the products or reactants

"***When the VOLUME of on equilibrium mixture of gases is REDUCED, a net reaction occurs in the direction producing a SMALLER number of MOLES of GAS. When the volume is INCREASED, a net reaction occurs in the direction producing a LARGER number of MOLES of GASES***"

# Changes in Pressure:

**Example 1:**

$$N_{2(g)} + 3\,H_{2(g)} \longleftrightarrow 2\,NH_{3(g)}$$

An equilibrium mixture the above is transferred from a 1.5L flask to a 5.0L flask. In which direction does a net reaction occur to restore equilibrium?

***The reaction shifts to the left***

**Example 2:**

$$PCl_{3(g)} + Cl_{2(g)} \longleftrightarrow PCl_{5(g)}$$

Predict the shift in equilibrium position when the volume is reduced.

***The reaction will shift to the right***

# Changes in Temperature:

The value of **K** changes with **TEMPERATURE**

*"To describe the effect of temperature change on a system at equilibrium, treat energy as a* ***REACTANT*** *(in an* ***ENDOTHERMIC*** *process) or as a* ***PRODUCT*** *(in an* ***EXOTHERMIC*** *process). Now consider the problem as one of* ***CONCENTRATION****"*

**Example 1:**

$$556kJ + CaCO_{3(s)} \longleftrightarrow CaO_{(s)} + CO_{2(g)}$$

If the temperature of a closed system containing the given compounds is increased predict what will happen.

***The reaction will shift to the right***

# Changes in Temperature:

**Example 2:**

$$2\ SO_{2(g)} + O_{2(g)} \longleftrightarrow 2SO_{3(g)} \quad \Delta H° = -198kJ$$

ie: $$2\ SO_{2(g)} + O_{2(g)} \longleftrightarrow 2SO_{3(g)} + 198kJ$$

If heat were added to the above system, predict the direction that the equilibrium position would move.

***The reaction will shift to the left***

# Effect of a Catalyst:

A catalyst **SPEEDS** up **BOTH** the **FORWARD** and **REVERSE** reactions

- it lowers the **ACTIVATION** **ENERGY** for each
- **EQUILIBRIUM** is achieved more **RAPIDLY**
- the equilibrium amounts are **UNCHANGED**
- the presence of a catalyst **DOES** **NOT** **CHANGE** the numerical value of the **EQUILIBRIUM CONSTANT**

***** The addition or removal of a catalyst has no effect on the position of equilibrium *****