

Le Chatelier's Principle

AP Chemistry

Le Chatelier's Principle

If a stress is applied to a system at equilibrium, the system will change to relieve that stress and re-establish equilibrium

It is like the “undo” button on your computer!

Factors that Affect Equilibrium

- **Concentration**
- **Temperature**
- **Pressure**
 - **For gaseous systems only!**
- **The presence of a catalyst**

Concentration Changes

- Add more reactant → *Shift to products*
 - Remove reactants → *Shift to reactants*
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- Add more product → *Shift to reactants*
- Remove products → *Shift to products*

Reaction Quotient

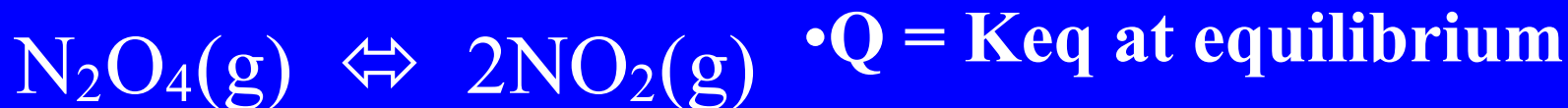
- The reaction quotient for an equilibrium system is the same as the equilibrium expression, but the concentrations are NOT at equilibrium!



$$Q = \frac{[\text{NO}_2]^2}{[\text{N}_2\text{O}_4]}$$

Changes in Concentration

Changes in concentration are best understood in terms of what would happen to “Q” if the concentrations were changed.



$$Q = \frac{[\text{NO}_2]^2}{[\text{N}_2\text{O}_4]}$$

• **Q = K_{eq} at equilibrium**

• **If Q < K then there are too many reactants, the reaction will shift in the forward direction (the products)**

• **If Q > K then there are too many products, the reaction will shift to the reactants.**

Temperature Changes Exothermic Reactions

- Consider heat as a product in exothermic reactions. $A + B = AB + \text{Heat}$

–Add **heat** →

Shift to reactants

–Remove **heat** →

Shift to products

Temperature Changes

Endothermic Reactions

- Consider heat as a reactant in endothermic reactions. $A + B + \text{heat} = AB$

–Add **heat** →

Shift to products

–Remove **heat** →

Shift to reactants

Pressure Changes

- Only affects equilibrium systems with unequal moles of gaseous reactants and products.



- Increase Pressure
 - Stress of pressure is reduced by reducing the number of gas molecules in the container



- There are 4 molecules of reactants vs. 2 molecules of products.
- Thus, the reaction *shifts to the product* ammonia.



- Decrease Pressure
 - Stress of decreased pressure is reduced by increasing the number of gas molecules in the container.



- There are two product gas molecules vs. one reactant gas molecule.
- Thus, the reaction *shifts to the products.*

Presence of a Catalyst

- A Catalyst lowers the activation energy and increases the reaction rate.
- It will lower the forward and reverse reaction rates,
- Therefore, a catalyst has NO EFFECT on a system at equilibrium!
- It just gets you to equilibrium faster!

Presence of an Inert Substance

- An inert substance is a substance that is not-reactive with any species in the equilibrium system.
- These will not affect the equilibrium system.
- If the substance does react with a species at equilibrium, then there will be a shift!

- Given:
- $\text{S}_8(\text{g}) + 12\text{O}_2(\text{g}) \rightleftharpoons 8 \text{SO}_3(\text{g}) + 808 \text{ kcal}$
- What will happen when
- Oxygen gas is added?
 Shifts to products →
- The reaction vessel is cooled?
 Shifts to Products – to replace heat

V increases, Pressure decreases, shifts to more particles? – to reactants!
 The size of the container is increased?

- Sulfur trioxide is removed?
 Shift to products to replace it!

No change!

- A catalyst is added to make it faster?

Given



- What will happen when

- Carbon dioxide was removed?

Shift to products – to replace it

- Sodium carbonate was added?

No Change – solids do not affect equilibrium

- Sodium bicarbonate was removed?

No Change

- Given



- What will happen when.
- Calcium ions are added?

Shift to the reactants

- NaOH is added?

Adding OH^- , shifts to reactants

- 1 M HCl is added?



- $\text{Na}_3\text{PO}_4(\text{aq})$ is added?

Adds PO_4^{3-} ions, shifts to reactants