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***

- 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!

$$N_2O_4(g) \Leftrightarrow 2NO_2(g)$$

$$Q = \frac{[NO_2]^2}{[N_2O_4]}$$

Changes in Concentration

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

$N_2O_4(g) \Leftrightarrow 2NO_2(g)$

$$Q = \frac{[NO_2]^2}{[N_2O_4]}$$

- **Q = Keq 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 + 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 + 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.

$N_2(g) + 3H_2(g) = 2NH_3(g)$

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

$N_2(g) + 3H_2(g) = 2NH_3(g)$

- There are 4 molecules of reactants vs. 2 molecules of products.

– Thus, the reaction *shifts to the product* ammonia.

$PCl_5(g) = PCl_3(g) + Cl_2(g)$

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

$PCl_5(g) = PCl_3(g) + Cl_2(g)$

- 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:
- $S_8(g) + 12O_2(g) \Leftrightarrow 8\,SO_3(g) + 808$ kcals
- What will happen when ……
- Oxygen gas is added?

Shifts to products →

- The reaction vessel is cooled?

Shifts to Products – to replace heat

- The size of the container is increased?

V increases, Pressure decreases, shifts to more particles – to reactants!

- Sulfur trioxide is removed?

Shift to products to replace it!

No change!

- A catalyst is added to make it faster?

Given

$2NaHCO_3(s) \Leftrightarrow Na_2CO_3(s) + H_2O(g) + CO_2(g)$

- What will happen when . . . . . .
- Carbon dioxide was removed?

  Shift to products – to replace it

- Sodium carbonate was added?

  No Change – solids to not affect equilibrium

- Sodium bicarbonate was removed?

  No Change

- Given

$Ca_5(PO_4)_3OH(s) \Leftrightarrow 5Ca^{2+}(aq) + 3PO_4^{3-}(aq) + OH^-(aq)$

- 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?

H+ + OH- → H2O (removes OH-, shifts to products)

- $Na_3PO_4(aq)$ is added?

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