Application of Equilibria

Objectives

1. To learn to predict the changes that occur when a system at equilibrium is disturbed
2. To learn to calculate equilibrium concentrations
3. To learn to calculate the solubility product of a salt
4. To learn to calculate solubility from the solubility product

Application of Equilibria

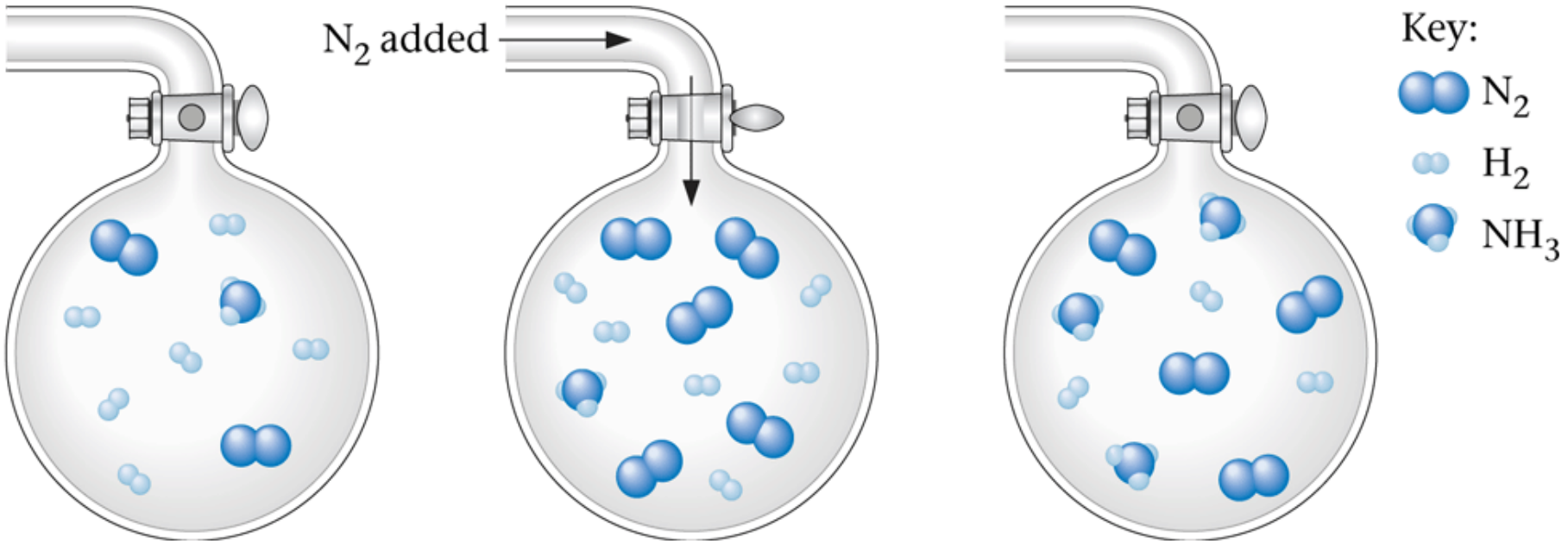
A. Le Chatelier's Principle

- Le Chatelier's Principle – when a change is imposed on a system at equilibrium the position of the equilibrium shifts in a direction that tends to reduce the effect of that change

Application of Equilibria

A. Le Chatelier's Principle

- Effect of a Change in Concentration



Application of Equilibria

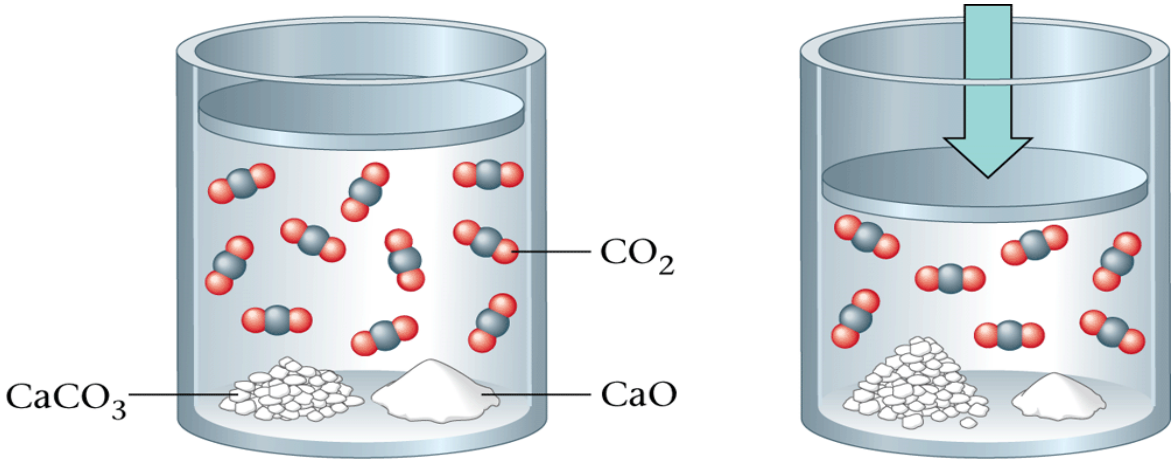
A. Le Chatelier's Principle

- Effect of a Change in Concentration
  - When a reactant or product is added the system shifts away from that added component.
  - If a reactant or product is removed, the system shifts toward the removed component.

Application of Equilibria

A. Le Chatelier's Principle

- Effect of a Change in Volume



(a)

The system is initially at equilibrium.

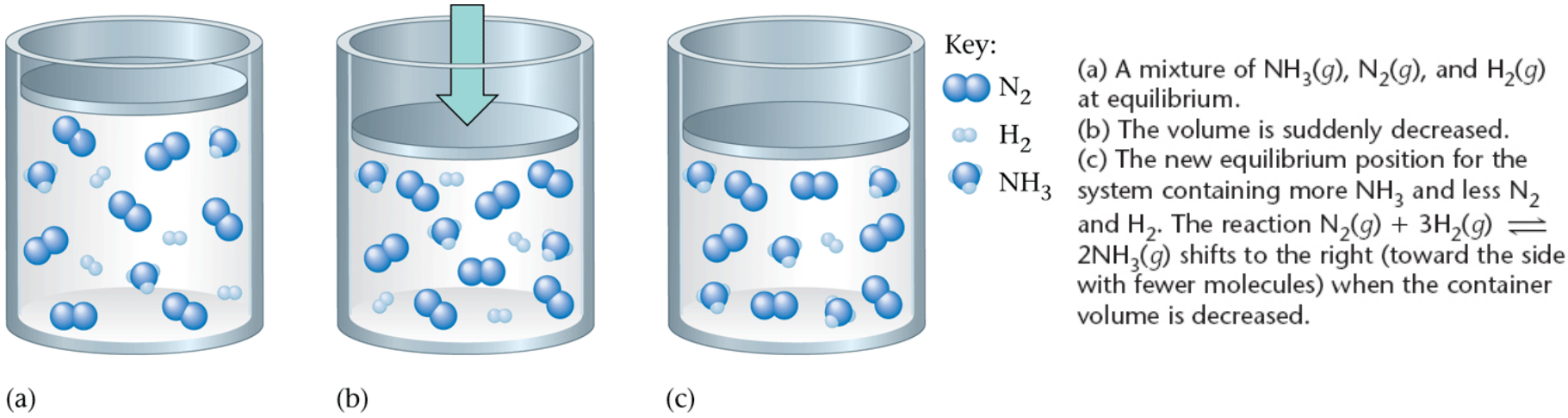
(b)

The piston is pushed in, decreasing the volume and increasing the pressure. The system shifts in the direction that consumes CO_2 molecules, lowering the pressure again.

Application of Equilibria

A. Le Chatelier's Principle

- Effect of a Change in Volume
  - Decreasing the volume



(a) A mixture of $NH_3(g)$, $N_2(g)$, and $H_2(g)$ at equilibrium.
(b) The volume is suddenly decreased.
(c) The new equilibrium position for the system containing more NH_3 and less N_2 and H_2. The reaction $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ shifts to the right (toward the side with fewer molecules) when the container volume is decreased.

  - The system shifts in the direction that gives the fewest number of gas molecules.

Application of Equilibria

A. Le Chatelier's Principle

- Effect of a Change in Volume
  - Increasing the volume
    - The system shifts in the direction that increases its pressure.

Application of Equilibria

A. Le Chatelier's Principle

- Effect of a Change in Temperature
  - The value of K changes with temperature. We can use this to predict the direction of this change.
  - Exothermic reaction – produces heat (heat is a product)
    - Adding energy shifts the equilibrium to the left (away from the heat term).
  - Endothermic reaction – absorbs energy (heat is a reactant)
    - Adding energy shifts the equilibrium to the right (away from the heat term).

Application of Equilibria

B. Applications Involving the Equilibrium Constant

The Meaning of K

- $K > 1 \Rightarrow$ the equilibrium position is far to the right
- $K < 1 \Rightarrow$ the equilibrium position is far to the left

Application of Equilibria

B. Applications Involving the Equilibrium Constant

- The value of K for a system can be calculated from a known set of equilibrium concentrations.
- Unknown equilibrium concentrations can be calculated if the value of K and the remaining equilibrium concentrations are known.

Application of Equilibria

C. Solubility Equilibria

- The equilibrium conditions also applies to a saturated solution containing excess solid, MX*(s)*.
  - $K_{sp} = [M^+][X^-]$ = solubility product constant
  - The value of the K_{sp} can be calculated from the measured solubility of MX*(s)*.