Reaction Rates and Equilibrium

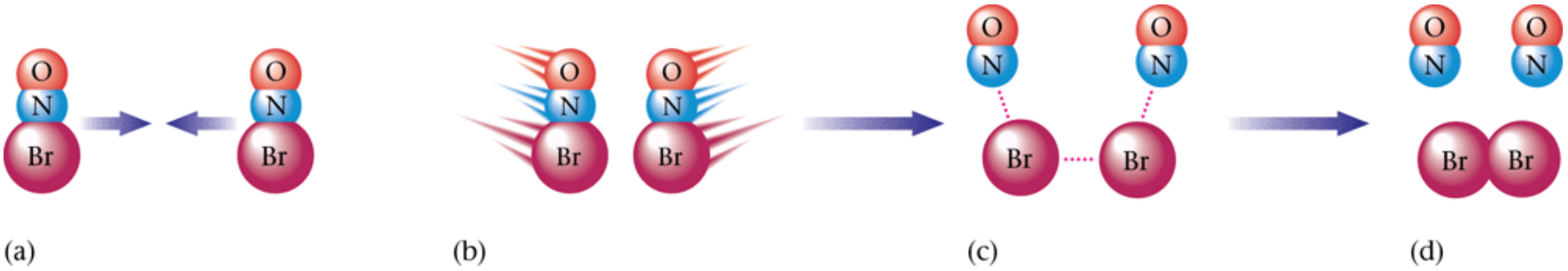
Objectives

1. To understand the collision model of chemical reactions
2. To understand activation energy
3. To understand how a catalyst speeds up a chemical reaction
4. To explore reactions with reactants or products in different phases
5. To learn how equilibrium is established
6. To learn about the characteristics of chemical equilibrium

Reaction Rates and Equilibrium

A. How Chemical Reactions Occur

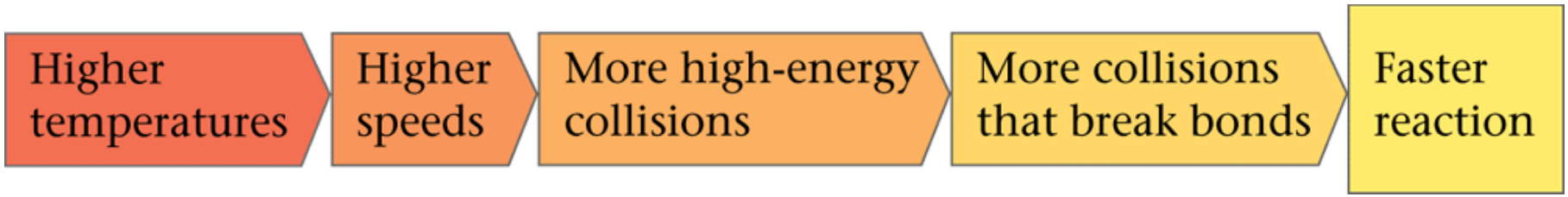
- Collision model – molecules must collide in order for a reaction to occur
  - Rate depends on concentrations of reactants and temperature.



Reaction Rates and Equilibrium

B. Conditions That Affect Reaction Rates

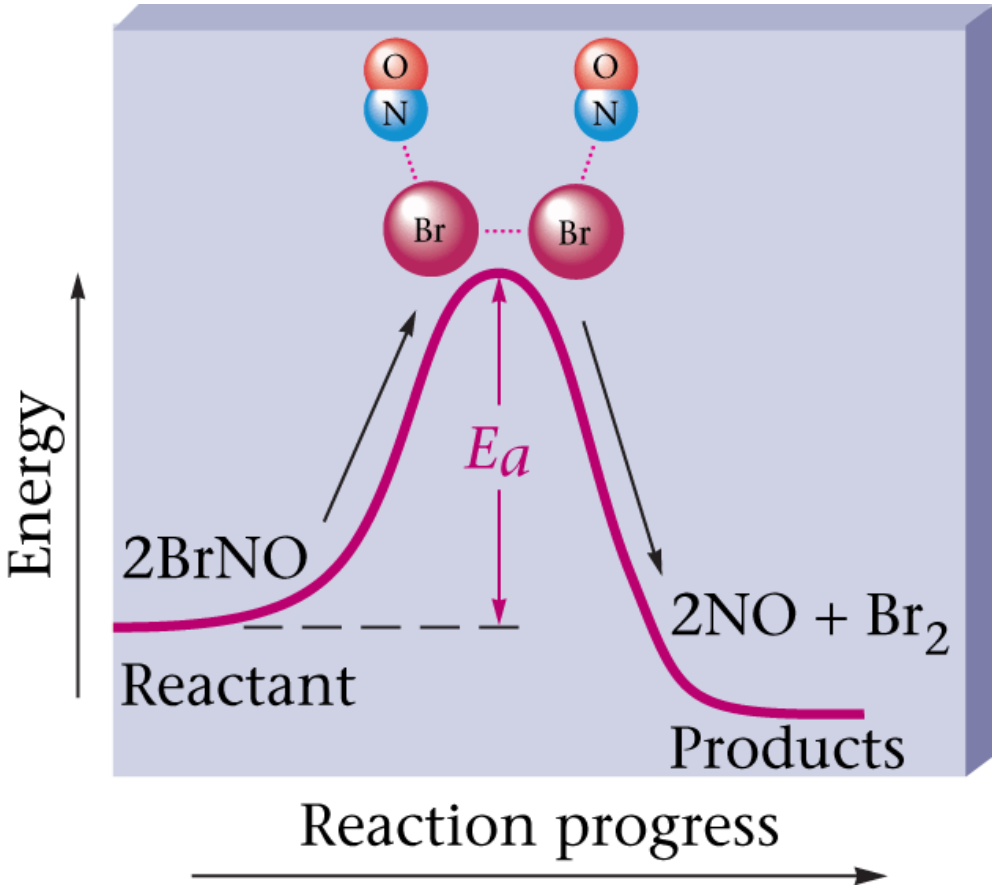
- Concentration – increases rate because more molecules lead to more collisions
- Temperature – increases rate
  - Why?



Reaction Rates and Equilibrium

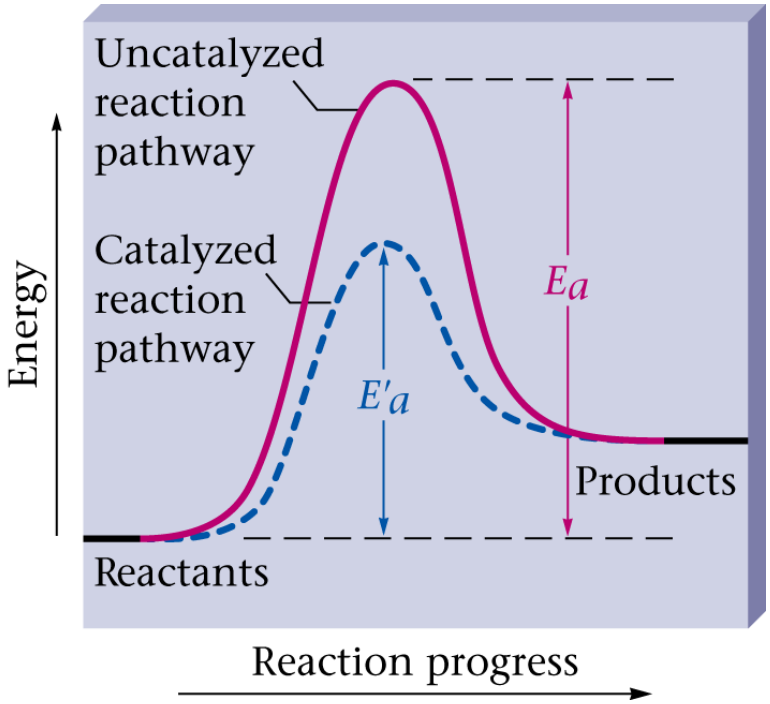
B. Conditions That Affect Reaction Rates

- Activation energy – minimum energy required for a reaction to occur



B. Conditions That Affect Reaction Rates

- Catalyst – a substance that speeds up a reaction without being consumed
  - Enzyme – catalyst in a biological system

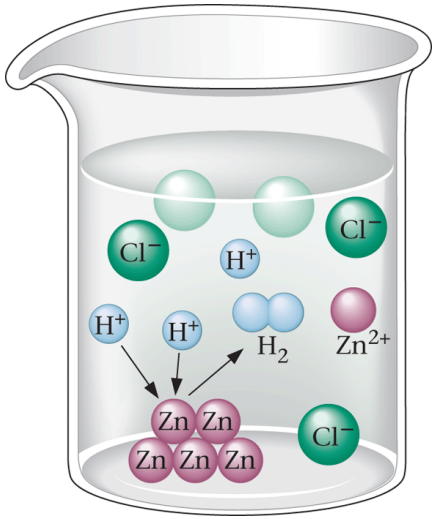


Reaction Rates and Equilibrium

C. Heterogeneous Reactions

- Homogeneous reaction – all reactants and products are in one phase
  - Gas
  - Solution
- Heterogeneous reaction – reactants in two phases

$$Zn(s) + 2HCl(aq) \rightarrow H_2(g) + ZnCl_2(aq)$$



Reaction Rates and Equilibrium

C. Heterogeneous Reactions

Let's Review

Factors That Affect Reaction Rates

Nature of Reactants: Substances vary greatly in their tendency to react depending on their bond strengths and structures.

Concentration (Pressure): The rate of a homogeneous reaction depends on the number of collisions that occur between reactants. Reaction rates typically increase as concentration (solution reactions) or pressure (gaseous reactions) increases.

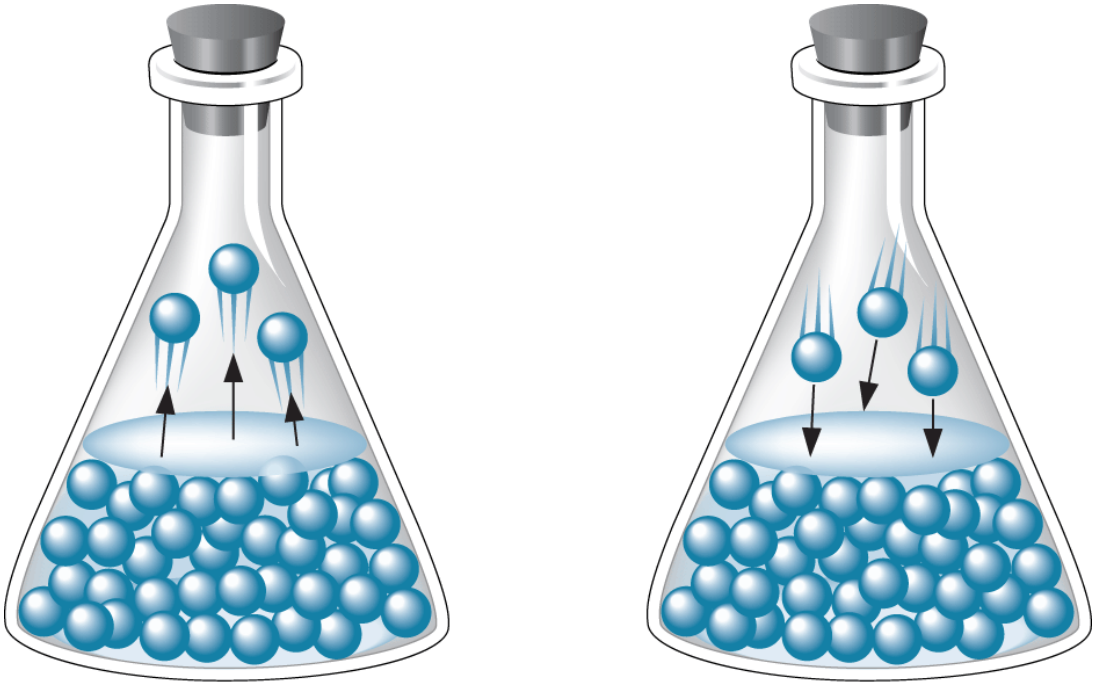
Temperature: Because increased temperature accelerates reactant speeds, and thus increases the number of high-energy collisions, reaction rates increase with an increase in temperature.

Surface Area: For heterogeneous reactions, reaction rates increase with increased surface area.

Reaction Rates and Equilibrium

D. The Equilibrium Condition

- Equilibrium – the exact balancing of two processes, one of which is the opposite of the other



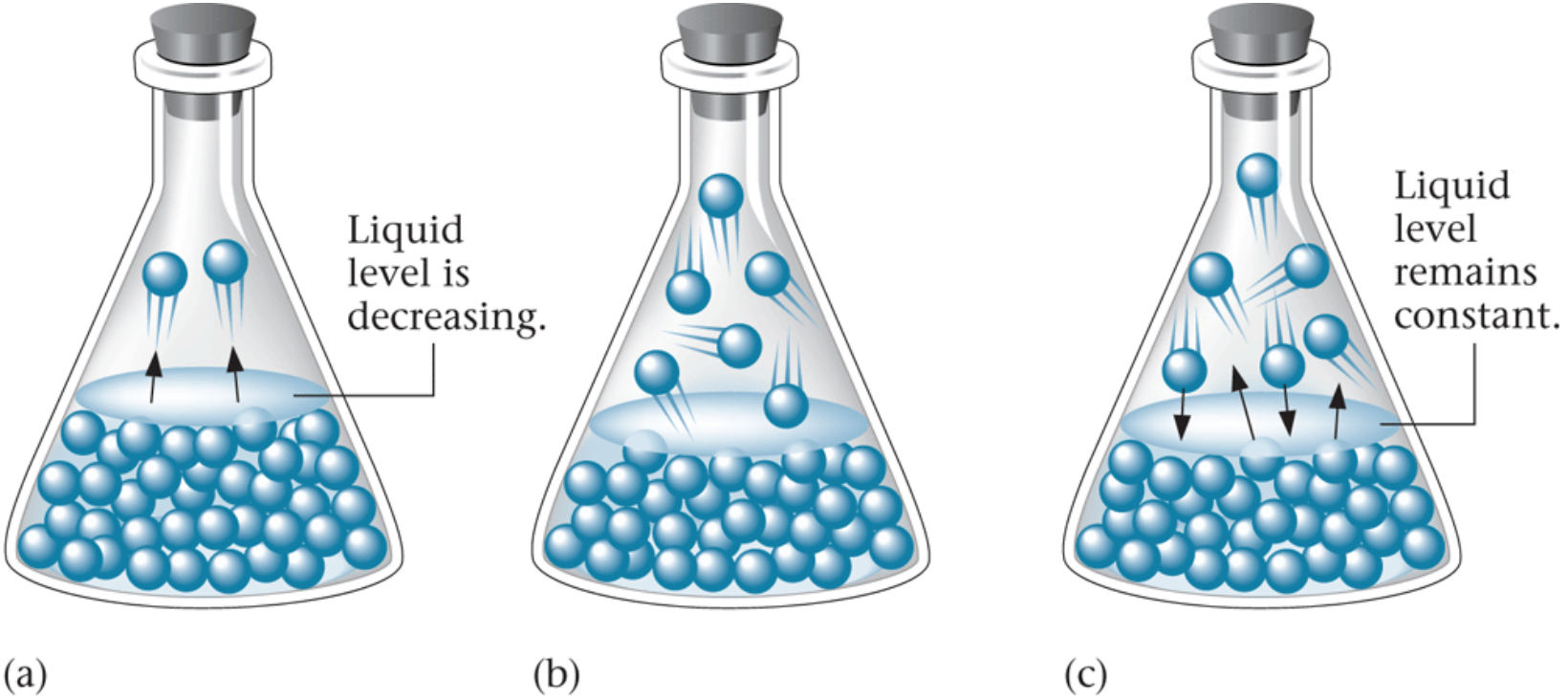
Evaporation

Condensation

Reaction Rates and Equilibrium

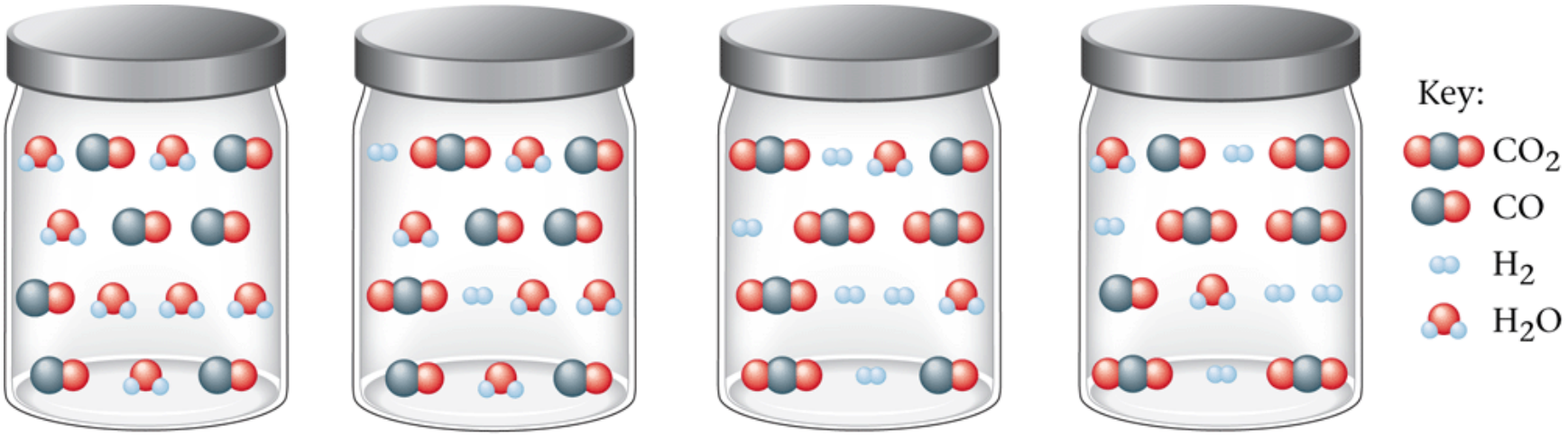
D. The Equilibrium Condition

- Chemical equilibrium – a dynamic state where the concentrations of all reactants and products remain constant



Reaction Rates and Equilibrium

E. Chemical Equilibrium: A Dynamic Condition



(a)

Equal numbers of moles of H_2O and CO are mixed in a closed container.

(b)

The reaction begins to occur, and some products (H_2 and CO_2) are formed.

(c)

The reaction continues as time passes and more reactants are changed to products.

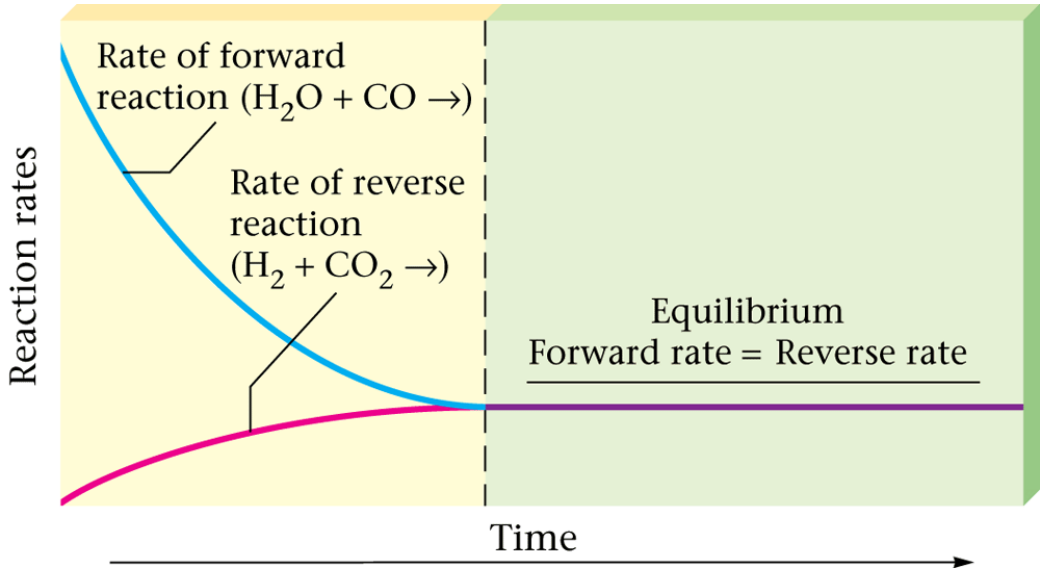
(d)

Although time continues to pass, the numbers of reactant and product molecules are the same as in (c). No further changes are seen as time continues to pass. The system has reached equilibrium.

Reaction Rates and Equilibrium

E. Chemical Equilibrium: A Dynamic Condition

- Why does equilibrium occur?



The changes with time in the rates of the forward and reverse reactions for $H_2O(g) + CO(g) \rightleftharpoons H_2(g) + CO_2(g)$ when equal numbers of moles of $H_2O(g)$ and $CO(g)$ are mixed. At first, the rate of the forward reaction decreases and the rate of the reverse reaction increases. Equilibrium is reached when the forward rate and the reverse rate become the same.