Warm-Up | Reaction Rate

Lesson Objectives

By the end of this lesson, you should be able to:

- Explain the concept of reaction rate.
- Describe collision theory and how it is related to reactions.
- Explain how various factors, including concentration, temperature, and pressure, affect the rate of a chemical reaction.

Science Practice: Use the collision theory model to explain how reactions happen.

Words to Know

Fill in this table as you work through the lesson. You may also use the glossary to help you.

activation energy	the minimum amount of energy needed to initiate a chemical reaction
collision theory	a model for chemical reactions that requires particles to collide in order to react
reaction rate	the rate at which reactants are converted into products

Instruction | Reaction Rate

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Lesson Question

What factors affect how fast a chemical reaction can occur?

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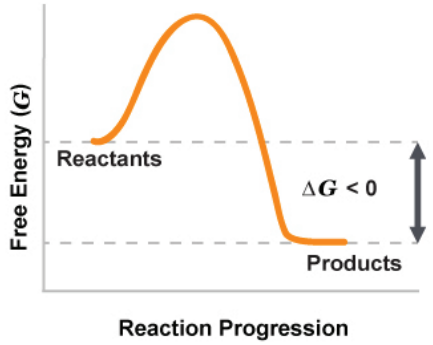
Energy Diagrams and ΔG

Spontaneous reaction

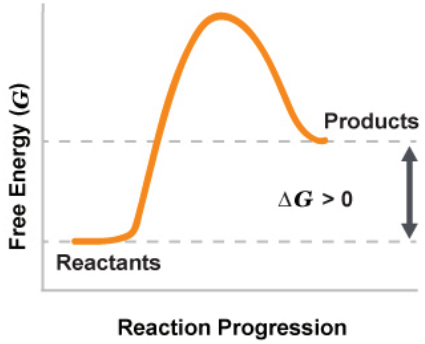
- $\Delta G_{rxn} <$ 0
- Reactants have more free energy than products.



Energy Diagrams and ΔG

Nonspontaneous reaction

- $\Delta G_{rxn} > 0$
- Products have more free energy than reactants.



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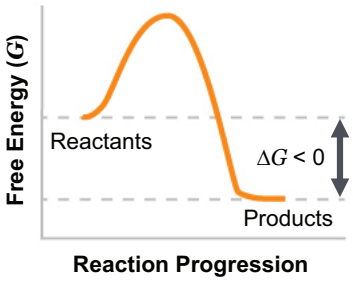
Activation Energy

Activation energy (E_A): the minimum amount of energy needed to initiate a chemical reaction

- Is a barrier to reaction
- Must be overcome before reaction will proceed



The greater the activation energy for a reaction, the less likely the reaction is to proceed, even if it is spontaneous.

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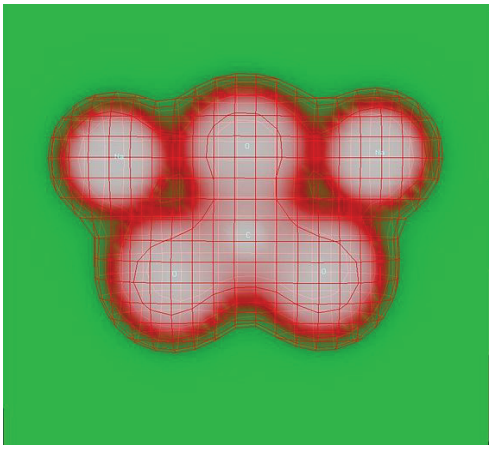
Chemical Bonds

Chemical reactions rearrange the atoms in molecules by making and/or breaking bonds.

- Bonds are stable configurations of electrons.
- Electrons need enough energy to leave their current bonds to form new or different bonds.



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Spontaneous Reactions and Activation Energy

Spontaneous reactions are self-sustaining.

- Energy released during the reaction provides energy to additional reactant molecules to [overcome] their activation energy.
- [Initial] energy input may be required to overcome activation energy.

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Reaction Rate

Reaction rate: the rate at which reactants are converted into products

- Reaction rates depend on [activation] energy.
  - High activation energy barriers result in [low] rates.
  - Low activation energy barriers result in [high] rates.

Reaction rate is not determined by ΔG_{rxn}.

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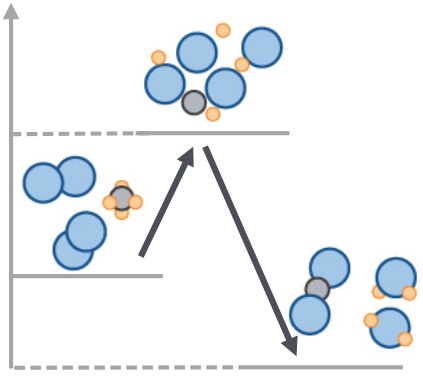
Collision Theory

Collision theory: a model for [chemical] reactions that requires particles to collide in order to react

- Every reaction begins with collision of [molecules] or particles.



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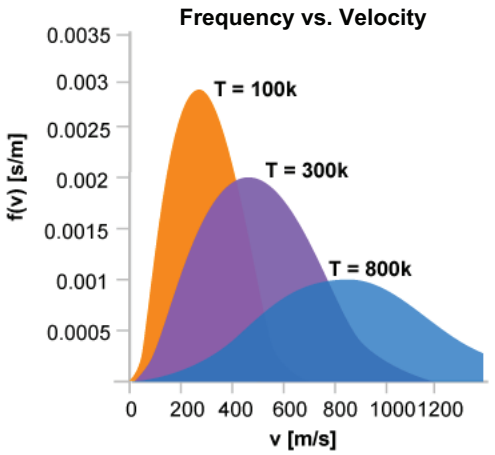
Velocity Distributions

Kinetic theory:

- Molecules at a given temperature have different [speeds].

Maxwell-Boltzmann distribution:

- Graph shows fraction of [particles] (vertical axis) and the particle's speed ([horizontal] axis).



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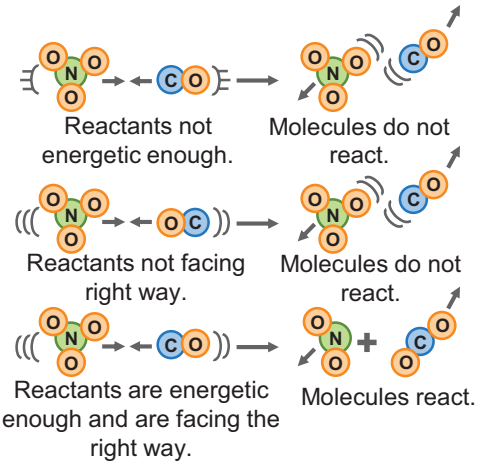
Effective Collisions

Conditions for a reaction to occur:

- Molecules or particles must collide.
- Collisions must be [effective].

Conditions for effective collisions:

- Collision must be [energetic] enough.
  - Energy comes from the kinetic energy of [random] collisions.
- Collision should be in the correct [orientation].



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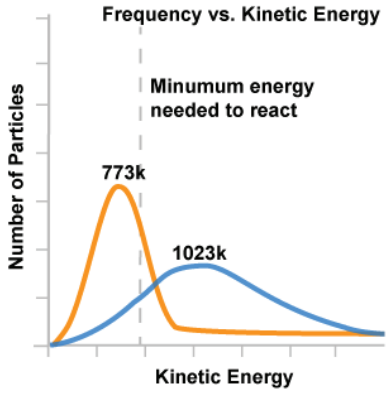
Factors Affecting Reaction Rate

Reactions require collisions.

- Factors that increase frequency or energy of [collisions] will increase reaction rate.
- Factors that decrease frequency or energy of collisions will decrease reaction rate.

Effect of Temperature on Reaction Rate

- Temperature represents a distribution of [kinetic] energies.
- Only a small fraction of molecules have sufficient [energy] to react.
- Increasing temperature [increases] the proportion of reacting molecules.



As temperature increases, reaction rate increases.

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Effect of Concentration on Reaction Rate

- Higher reactant concentration leads to more [frequent] collisions.
- [More] frequent collisions increases the rate of reaction.

As the concentration of [reactants] increases, reaction rate increases.

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Effect of Pressure on Reaction Rate

To make a [gas] reaction go faster:

- Add reactants.
- Decrease [volume].

For reactions involving [gases]:

- Increasing pressure increases concentration, which increases reaction rate.

Increasing pressure increases reaction rate if the reactants contain more [moles] of gas than the products.

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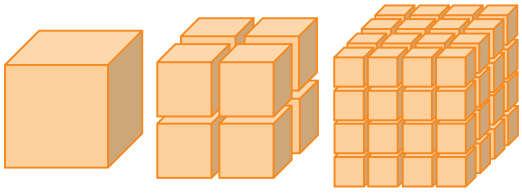
Effect of Surface Area on Reaction Rate

Reactions occur at the [surface].

- Increasing the surface area increases [particles] available for reaction.



- Decreasing the particle [size] increases the surface area.

As the surface area of a [solid] reactant increases, reaction rate increases.

Summary | Reaction Rate

Lesson Question

What factors affect how fast a chemical reaction can occur?

Answer

(Sample answer) The rate of reaction is the speed with which reactants are converted into products. Collision theory states that molecules must collide to react. Collisions must be energetic enough and properly oriented to be effective. The common ways to change reaction rate iare by changing the temperature, concentration, pressure, or surface area of molecules.

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Reaction Rate and Energy Diagrams

- Molecules can lose or gain energy during reactions.
- Energy changes are due to the rearrangement of [electrons] in bonds.
- Activation energy barriers prevent reactions from occurring without an input of energy.
- The rate of a reaction is the speed with which reactants are converted to [products].

Collision Theory

- Collision theory states that [molecules] must collide to react.
- Collisions must be energetic enough and properly oriented to be effective.

Summary | Reaction Rate

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Factors Affecting Reaction Rate

Reaction rates increase when:

- the [temperature] increases.
  - Particles collide more frequently and with more [force].
- the concentration of reactants increases.
  - Particles collide more frequently.
- pressure increases on systems containing more moles of gaseous reactants than gaseous products.
  - Particles collide more frequently.
- the surface area of solid reactants increases.
  - Particles collide more frequently.

Use this space to write any questions or thoughts about this lesson.