Collision Theory

How do reactions occur?

Getting Started

- You are playing pool. You line up your cue, pull back, and shoot.
- What must the cue ball do after you shoot in order for you NOT to lose a point?

It must hit another pool ball.

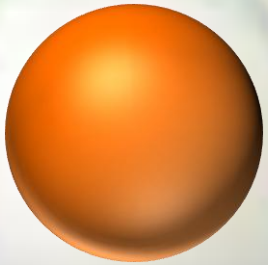
- Particles of matter interact much like pool balls.

They collide!

Minimum Requirements

Collision Theory

- In order for a reaction to occur, particles of the reactant must collide.



Effective Collisions

Consider a pool game:

- What must the collision be like in order for the cue ball to knock another ball into the pocket?

  It must be at the proper angle and the proper speed.

- The same is true for reacting particles.
- **Effective collision** - A collision in which the colliding particles approach each other at the proper angle and with the proper amount of energy for a reaction to occur.
- The greater the rate of effective collisions is, the greater the reaction rate is.

Probability and Reaction Mechanisms

- Probability
  - In a coin toss, what is the probability of tossing a "heads"? $^1/_2$
  - What is the probability of tossing another "heads"? $^1/_2$
  - What is the probability of tossing two "heads" together? $^1/_4$
- The probability of two independent events both occurring is the product of their individual probabilities. $^1/_2 \times {}^1/_2 = {}^1/_4$

Reaction Mechanisms

- Collisions are independent events. As the number of collisions needed for a reaction to occur increases, the probability that they will all occur simultaneously decreases.
- If all the particles shown on the reactant side of a balanced equation had to collide in order for a reaction to occur, the reaction probably would not take place.
- As a result:

A chemical reaction occurs through a **reaction mechanism**, a series of intermediate steps between the initial reactants and final products, each of which probably involves a collision of only two particles.

Rate Determining Step: Analogy

- Imagine you are in a race. You need to:
  1. Pick up a basketball
  2. Climb up a rope, and
  3. Drop the basketball in a waste basket on a shelf at the top of the rope.

- Which step would go slowest? **Climbing the rope.**
  - Exchanging the rope for a ladder would speed the whole thing up.
  - Climbing the rope is the **rate determining step**.

Rate Determining Step

- The slowest step of the reaction mechanism is called the **rate determining step**.
- Speeding up the rate determining step speeds up the reaction.
  - Increasing the concentration of the reactants in the rate determining step increases the frequency of effective collisions.
  - As a result:

Increasing the concentration of the reactants in the rate determining step increases the rate of the reaction.