

Rate of Reaction (Kinetics)

Unit: Kinetics & Equilibrium

MA Curriculum Frameworks (2016): HS-PS1-5

Mastery Objective(s): (Students will be able to...)

- List and explain factors that affect the rate of a chemical reaction.

Success Criteria:

- Descriptions convey how each factor affects the rate of reaction.

Tier 2 Vocabulary: intermediate

Language Objectives:

- Explain what it means for a reaction to happen faster vs. slower, and how each factor affects the reaction rate.

Labs, Activities & Demonstrations:

- Drop of food coloring in hot vs. cold water.

Notes:

reactants: the compounds consumed in the chemical reaction; compounds that *react*.

products: the compounds created by the chemical reaction; compounds that are *produced*.

intermediates: compounds that are produced in one step of a multi-step reaction and consumed by a later step.

Use this space for summary and/or additional notes:

reaction rate (k): the rate at which products are formed in a chemical reaction,

usually expressed in units of: $\frac{\text{mol}}{\text{L}\cdot\text{s}}$ or $\frac{\text{M}}{\text{s}}$ (where M = molarity = $\frac{\text{mol}}{\text{L}}$)

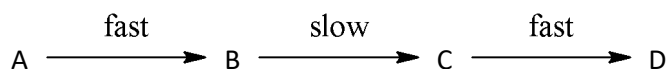
The reaction rate is related to the activation energy. A reaction with higher activation energy will happen more slowly, because fewer of the collisions will have enough energy to enable the molecules to react. Conversely, a reaction with lower activation energy will happen more quickly.

The equation for rate of reaction is: $\ln(k) = -\frac{RT}{E_a}$ or $k = e^{-RT/E_a}$

Quantitative rate calculations are studied in AP[®] Chemistry. In this course, you need to understand how the equation shows that a higher temperature will speed up the reaction (larger value of k), and a higher activation energy will slow down the reaction (smaller value of k).

rate-limiting step (or rate-determining step): the step that determines the overall rate of the reaction. In a multi-step reaction, the rate-limiting step is the slowest step.

For example, in the multi-step reaction:



- A → B will happen faster than B can get used up, so B will accumulate and the first reaction will not affect the overall rate.
- C → D will happen fast, which means as soon as C is produced, it will react to produce D.

Therefore, the rate of B → C, which happens slowly, is what determines the overall rate of the reaction A → D.

catalyst: a substance that speeds up a reaction by lowering the activation energy of (and therefore speeding up) the rate-limiting (slowest) step.

Use this space for summary and/or additional notes:

Factors that Affect Reaction Rates

- concentration of reactants: higher concentration means more frequent collisions = faster rate. (Only applies to molecules involved in the rate-determining step.) For gases, higher pressure = higher concentration.
- surface area of reactants: more surface area means higher probability of a collision = faster rate.
- temperature: higher temperature = faster because faster-moving molecules collide more often, and because faster-moving molecules have more kinetic energy to overcome the activation energy.
- nature of the reactants: weak bonds are easier to break than strong bonds. Reactions involving dissolved ions are very fast, because bonds are already broken.
- catalysts: catalysts *speed up reactions* in any of several ways:
 - bring molecules into the correct orientation for an effective collision (equivalent to increasing the concentration and/or surface area)
 - assist in breaking of bonds in the reactant(s) and/or formation of bonds in the products (equivalent to changing the nature of the reactants and/or lowering the activation energy)

Catalysts are not reactants; they are not consumed by the reaction.

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