Collision Theory

Unit: Kinetics & Equilibrium

MA Curriculum Frameworks (2016): HS-PS1-4, HS-PS1-5

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

- Use collision theory to explain activation energy and when a reaction does or does not occur.

Success Criteria:

- Explanations refer to Kinetic Molecular Theory (KMT).
- Explanations account for the role of activation energy.

Tier 2 Vocabulary: collision

Language Objectives:

- Explain the process of reactants colliding with enough energy to react and form products.

Notes:

Recall that Kinetic Molecular Theory (KMT) states:

- Gases are made of very large numbers of molecules.
- Molecules are constantly moving (obeying Newton's laws of motion), and their speeds are constant.
- Molecules are very far apart compared with their diameter.
- Molecules collide with each other and walls of container in elastic collisions.
- Molecules behaving according to KMT are not reacting or exerting any other forces (attractive or repulsive) on each other.

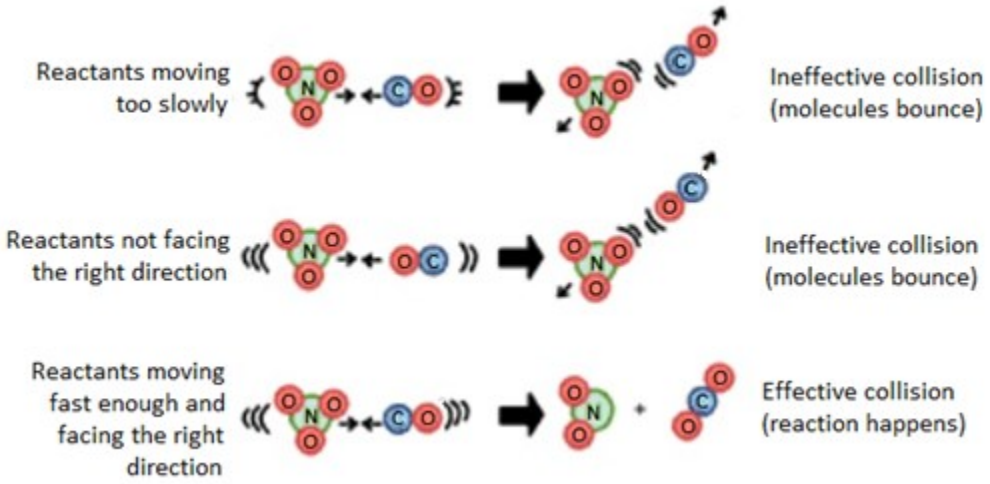
Use this space for summary and/or additional notes:

When we studied KMT earlier this year, we mentioned that the last bullet point did not mean that reactions did not occur, but that they were covered by collision theory, not KMT.

Collision theory states that:

- Molecules can be modeled as rigid spheres.
- Molecules move according to KMT.
- When molecules collide, kinetic energy (proportional to temperature) is transferred.
- If the molecules collide with enough energy to break existing chemical bonds, and if they are oriented in a way that allows the new bonds to form, a reaction occurs.
- If a reaction does not occur, the reactants "bounce" off each other as described by KMT.

For example, consider the reaction: $NO_3 + CO \rightarrow NO_2 + CO_2$



effective collision: a collision with enough energy that it leads to formation of products

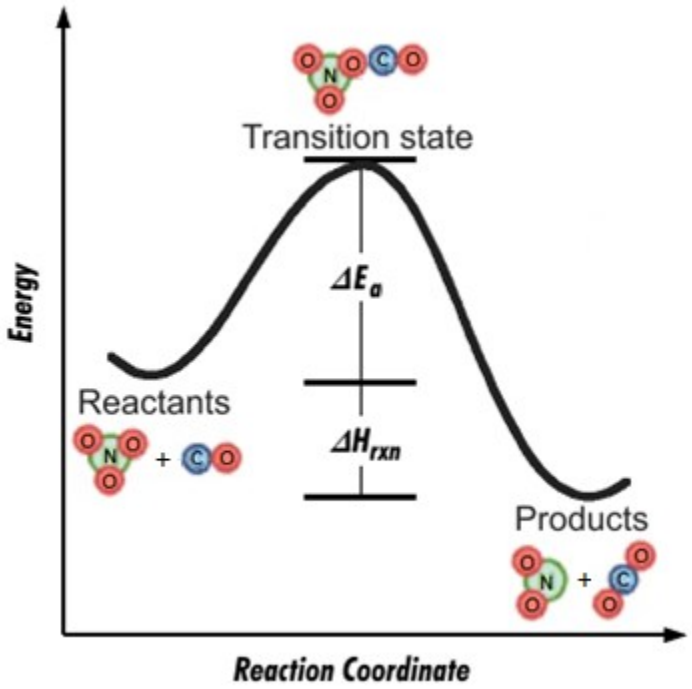
ineffective collision: a collision that does not have enough energy to lead to formation of products.

mechanism: the details of which molecules collide and in what order and orientation in order for the reaction to take place.

Use this space for summary and/or additional notes:

The progress of the reaction vs. energy can be graphed in a "reaction coördinate" diagram:

reaction coördinate diagram: a graph that shows energy *vs.* progress of a chemical reaction.



enthalpy of reaction (ΔH_{rxn}): the difference between the enthalpy of the products and the enthalpy of the reactants. The enthalpy change is the overall heat produced or consumed by the chemical reaction.

activation energy (ΔE_a): minimum kinetic energy needed for a collision to produce the transition state (and therefore proceed to form products).

transition state (or activated complex): the configuration of all molecules at the instant an effective collision happens. In the transition state, all of the energy needed by the reaction has been converted to enthalpy.

Use this space for summary and/or additional notes: