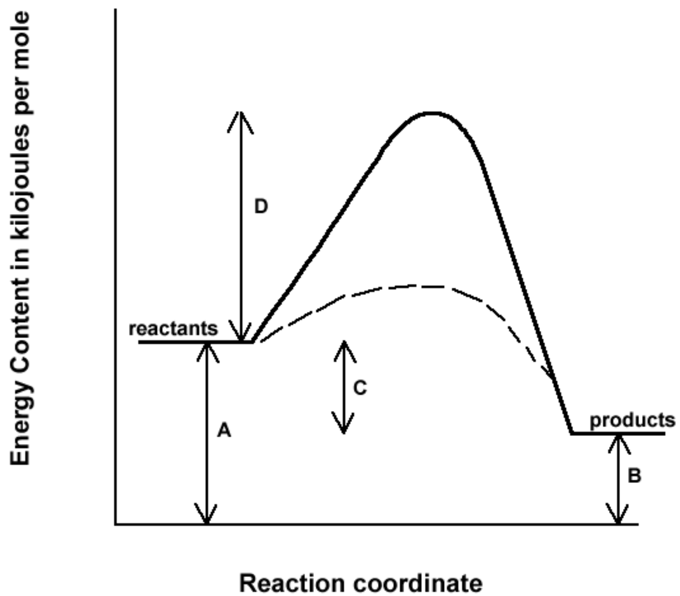
Kinetics and Thermodynamics Organizer

I. Energy Diagrams



Line A — The energy content (enthalpy) of the reactants

Line B — The energy content (enthalpy) of the products

Line C — Heat of reaction (ΔH). The energy released or absorbed as a reaction takes place. Also called ΔE. ΔH is positive for endothermic reactions, and negative for exothermic reactions.

Line D — Activation Energy (E_a). The energy required to convert reactants into the activated complex.

Catalyst — A substance that speeds up the rate of a chemical reaction without itself being permanently changed. The effect of a catalyst is represented on the diagram by the ----- line.

II. Collision Theory - Molecules must collide in order to react

1. Collisions must be properly oriented
   a. Catalysts improve collision orientation
2. Collisions must have sufficient energy
   a. Heating increases collision energy and collision frequency
   b. Heating <u>does not</u> improve orientation

III. Reaction Rates

1. Reactions proceed by a series of simple steps
2. The rate of the reaction is determined by the <u>slowest</u> step
3. The rate of a reaction can be expressed in several ways:
   a. The rate of disappearance of reactants
   b. The rate of formation of products
4. The rate of appearance of products is stoichiometrically related to the rate of disappearance of reactants
5. Increasing reaction rate
   a. Catalysts lower the activation energy by providing an alternate reaction pathway
   b. Heating – Increases the frequency and energy of collisions
   c. Increasing surface area increases reaction rate for solids
   d. Vaporization may increase reaction rate for some liquids, particularly in combustion reactions
   e. Increasing concentration increases the likelihood of a collision

Le Chatelier’s Principle

Many chemical reactions do not go to completion. In these reactions there will be measurable amounts of reactants and products even after a considerable period of time. An equilibrium is established and the ratio of products to reactants will remain constant if temperature is kept constant. It is possible to shift the equilibrium in a desired direction by applying a stress to the system. This process is explained by Le Chatelier's Principle which states that, "When a system at equilibrium is subjected to a stress, the system will react so as to relieve the stress." Some examples of stresses that can be applied to a system are changes in concentration (both increasing and decreasing), pressure (for systems involving gases), and temperature.

Stresses and responses include:

- **Adding more of a reactant or product.** In this case, the system restores equilbrium by a shift AWAY from the side to which the substance has been added. This restores equilibrium by using up some of the added substance, and increases the quantities on the other side.
- **Removing a reactant or product.** In this case, the system restores equilbrium by a shift TOWARD the side to which the substance has been removed. This restores equilibrium by adding to the quantity of the removed substance, and decreasing the quantities on the other side.
- **Heating a reaction.** The system shifts AWAY from the side where "heat" is present.
    - In an endothermic reaction, "heat" appears on the reactant side, so increasing temperature produces more product.
    - For an exothermic reaction, "heat" is on the product side, so increasing temperature results in a shift toward the reactant side.
- **Cooling a reaction.** Lowering the temperature pushes the reaction toward the side on which "heat" appears.
    - In an endothermic reaction, "heat" appears on the reactant side, so decreasing temperature produces more reactant.
    - For an exothermic reaction, "heat" is on the product side, so decreasing temperature results in more product being made.
- **Increasing pressure.** The system shifts toward whichever side has fewer moles of GAS phase molecules.
- **Decreasing pressure.** The system shifts toward whichever side has more moles of GAS phase molecules.