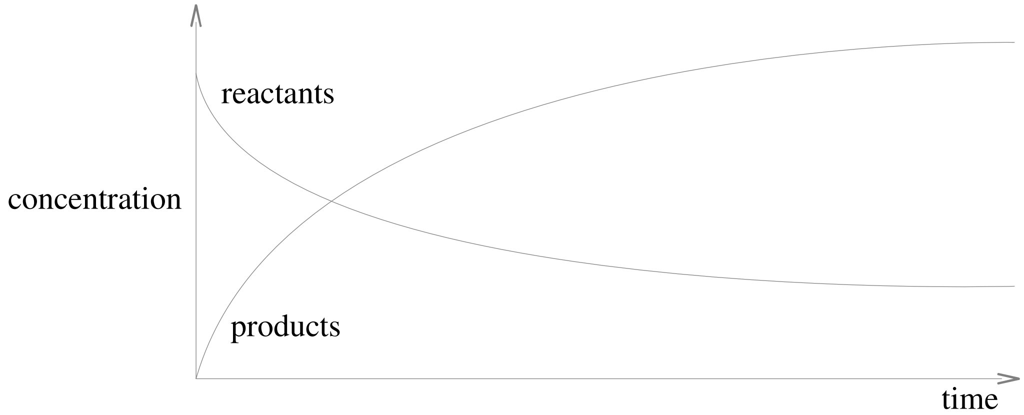
Rate of Reaction

The time taken for a reaction to reach a specified point is an indication of the *rate* of the reaction.

Example: reactants → products



The rates of a reaction at different times can be compared by considering the slope of a graph of quantity (or molar concentration) of reactant or product against time. Steeper slope indicates faster rate of reaction.

Collision theory can be used to predict and explain rate of reaction. According to collision theory, chemical reactions involves collisions between reacting particles. Particles are constantly moving around and colliding. The minimum energy for the collision to be productive is called the *activation energy*.

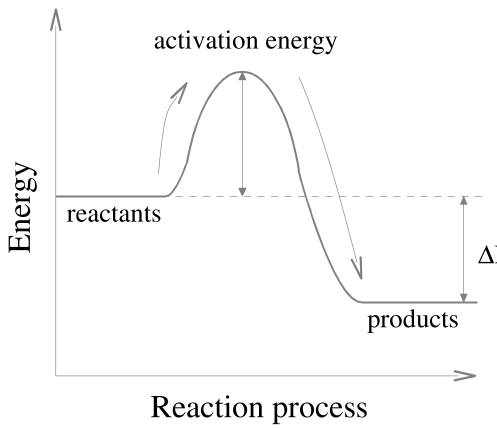
When reactant particles collide with sufficient energy and the correct orientation *reaction* occurs:

1. Bonds in the reactants are broken, absorbing energy.
   - This energy is shown as the upward arrows on the diagrams below.
2. New bonds form, making the products, releasing energy.
   - This energy is shown as the downward arrows on the diagrams below.

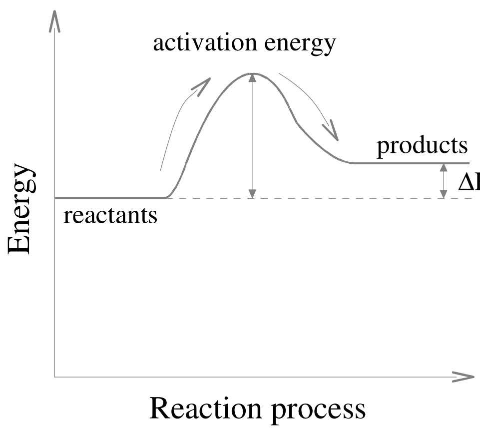
Anything that increases the rate of collision, the energy available, or the chance of correct orientation will increase the rate of reaction.

The reaction process for a productive collision can be shown on an *energy profile diagram*, shown below. The horizontal line on the left shows the energy of reactants, the peak in the centre shows the activation energy, and the horizontal line on the right shows energy of products.

Exothermic Reaction ($\Delta H < 0$)



Endothermic Reaction ($\Delta H > 0$)



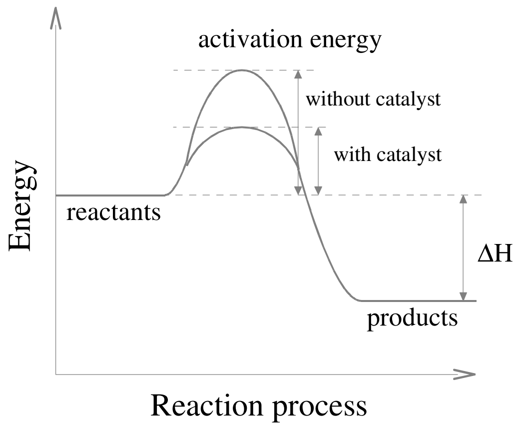
Note: these are diagrams of the process, *not* graphs against time. Slopes on the diagrams are meaningless, and *not* related to the rate of reaction. Rate of reaction depends on how often per time this process occurs.

The rates of a reaction are affected by changes in the:

- concentration of reactants
  - higher concentration → more chance of collision → more chance of reaction → faster rate of reaction
- temperature of the reaction mixture
  - higher temperature → faster movement of particles → more chance of collision + more energy for reaction → more chance of reaction → faster rate of reaction
- pressure of the reaction mixture (for systems involving gases)
  - particles closer together → more chance of collision → more chance of reaction → faster rate of reaction
- state of subdivision of reactants
  - more subdivided reactants → more surface area available → more chance of collision → more chance of reaction → faster rate of reaction
- presence of catalysts (including enzymes which are effectively biological catalysts)
  - presence of catalyst → alternate pathway with lower activation energy → more chance of reaction → faster rate of reaction
- intensity of light (for photochemical reactions)
  - more light → more energy → more chance of reaction → faster rate of reaction

A catalyst provides an alternate reaction pathway with lower activation energy. This can be represented on an energy profile diagram, as shown below. Notice ΔH is unchanged by the presence of a catalyst.

Exothermic Reaction



Endothermic Reaction