

6.4 and 6.5 FACTORS AFFECTING REACTION RATES continued

2. Concentration of Reactants

The rate of a reaction is directly proportional to the **concentration of the reactants**.

As the concentration of the reactants increases **there will be more "effective collisions" between reactant molecules per unit of time**.

Consider the Chemical reaction: **A + B → C**

$v \propto [A]^x$ $[A]$ = concentration of A in moles per litre
where v = velocity or rate of a reaction measured in moles / L / s

i.e. v is $\frac{\text{concentration}}{\text{time}} = \frac{\text{moles}}{\text{L s}}$

also $v \propto [B]^y$

x and y are exponents which must be found experimentally

therefore $v \propto [A]^x[B]^y$

$v = k [A]^x[B]^y$ this is the rate equation for the reaction $A + B \rightarrow C$

The concentration of the reactants can be increased by
either adding more of the reactants per unit volume

(i.e. you can't just put more reactants in; you must put proportionally more moles of the reactant in the total volume of the reaction).

or decreasing the size of the container

- which applies to reactions in the gaseous phase.

For gases, pressure is the same as **concentration**:

$$PV = nRT$$

$$\frac{n}{V} = \frac{\text{moles}}{\text{L}} = \text{concentration}$$

$$\frac{n}{V} = \frac{P}{RT} \quad \text{at constant temperature, } R \text{ and } T \text{ are constant}$$

$$\text{therefore } \frac{n}{V} \propto P \text{ (at constant } T \text{)}$$

This is a GOOD TIME TO DO the IODINE CLOCK REACTION

3. Nature of Reactants

i.e. the chemical properties of the substance

(not the physical properties such as solid, liquid or gas)

for example, the bonding (double vs. single vs. triple - or in other words saturated vs. unsaturated), the molecule geometry, the available electrons, etc.

In general the greater the number of bonds which must be broken in a collision between two molecules, the higher is the activation energy barrier.

Recall the breaking of bonds requires energy. The larger and more complex the reactant molecules are, the slower the reaction because few molecules will possess sufficient KE to overcome E_a .

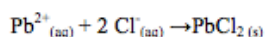
Monatomic species usually react much more rapidly than polyatomic species. (polyatomic reacts slower because many more bonds to break)

Eg.

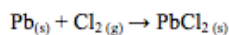
Factors Influencing Reaction Rate - Nature of Reactants

1. Which one of the following reactions would you expect to be fastest at room temperature and why?

SOLUTION



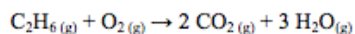
fastest - ions in aqueous solution react very quickly; all are in the same phase



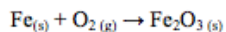
slower - one of the reactants is a solid

2. Consider the following reactions. Which do you predict will occur most rapidly at room conditions? Slowest?

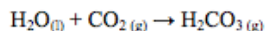
SOLUTION



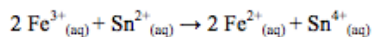
slow due to covalent bonding (unless the reaction is highly exothermic)



slowest - solid reactant (Fe); this reaction describes the rusting of iron



slow due to covalent bonding



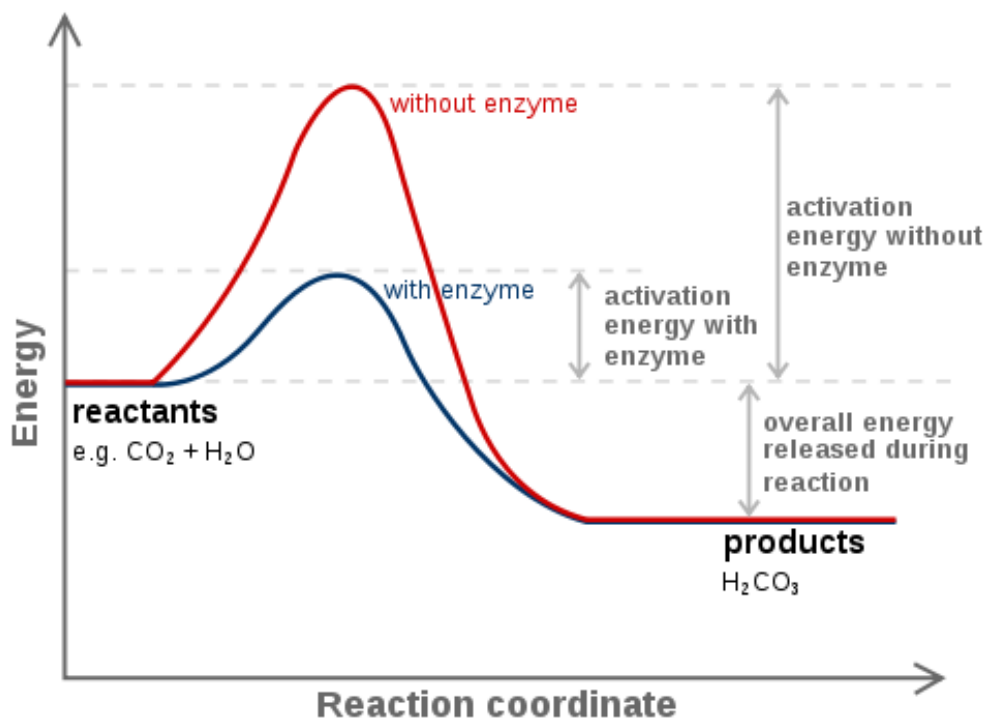
fastest - ions in solution react very quickly

4. Catalyst

A substance which: speeds up a chemical reaction but remains unchanged at the end of the reaction.

A catalyst is thought to: lower the activation energy barrier by providing an alternative reaction pathway or a more favourable collision geometry.
(more favourable collisions = faster rate)

In Biology, it is called an enzyme. In Chemistry, it is called a catalyst.



If E_a is lowered then: the number of molecules present of A and B with sufficient KE to collide effectively and overcome the activation energy barrier is increased. Therefore the rate of the reaction increases.

INHIBITORS: Chemicals which slow or retard the reaction rate without being consumed themselves

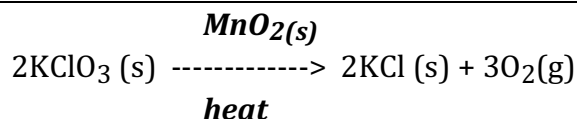
eg. food preservatives
medicine
fire retardants on clothing

Many different types of catalysts:

a) IONS eg. Mn^{+2} in the reaction of MnO_4^- with Fe^{+2}

The $\text{Mn}^{+2}(\text{aq})$ ion makes this reaction go faster

b) MOLECULES eg. MnO_2 in making $\text{O}_2(\text{g})$ out of $\text{KClO}_3(\text{s})$



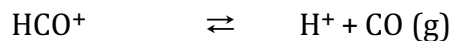
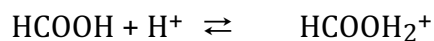
c) ACIDS (H^+ or H_3O^+)

Acid decomposition of formic acid

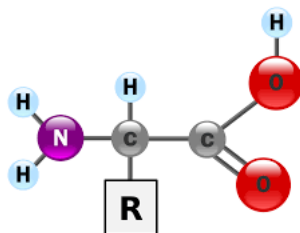
$\text{HCOOH}(\text{l}) \rightleftharpoons \text{CO}(\text{g}) + \text{H}_2\text{O}(\text{l})$ this is a slow reaction

Adding an acid (i.e. a hydrogen ion) speeds up the reaction

Proposal mechanism: (3 step mechanism)



d) ENZYMES (proteins) large protein molecules found in all living organisms
-proteins are long chains of amino acids



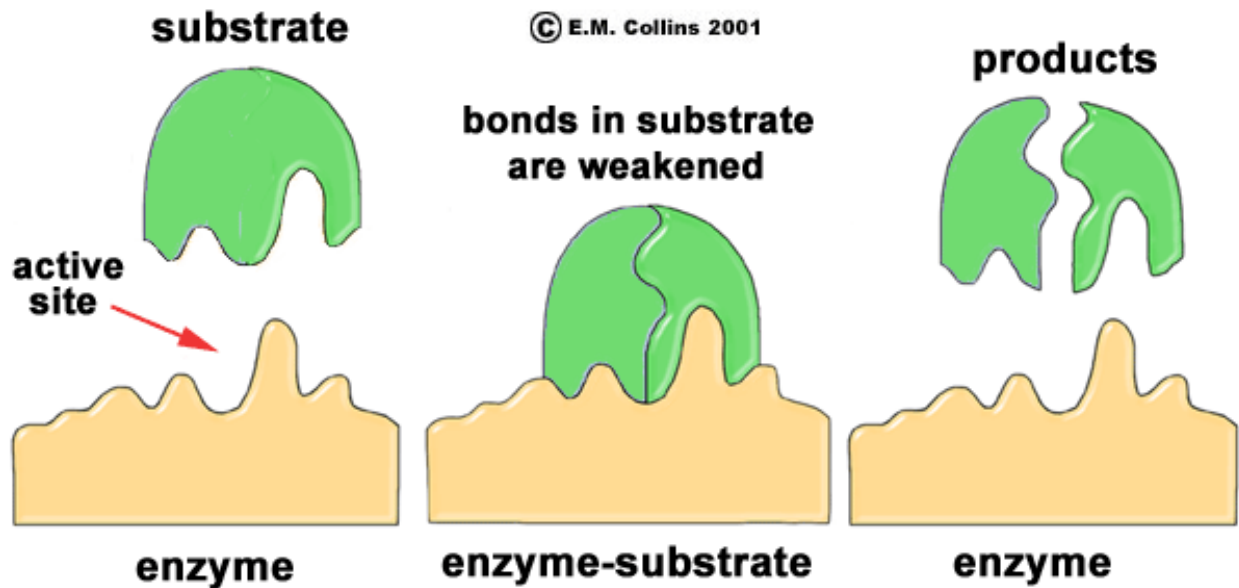
NH₂ amino group

COOH carboxyl group

R changes from one amino acid to another

Your body needs 20 **different amino acids** to grow and function properly.
Though all 20 of these are important for your health, only nine **amino acids** are classified as essential. These are histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine.

Enzymes have an active site:



An enzyme speeds up a reaction by lowering the E_a for both the forward and reverse reactions.

Each enzyme has a specific active site, therefore only one substrate molecule can fit into the active site, therefore each different reaction will have a different specific enzyme.

FACTORS AFFECTING REACTION RATES continued

for Heterogeneous reactions, add :

5. Surface Area



Therefore more collisions per unit of time between the reacting molecules.

FASTEST ----->SLOWEST

Aqueous Ions in solution	>	gas or liquids	>	solids
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6. Agitation (stirring)

increased KE = more particles = increased possibility = increased rate
(eg. ultrasound stirring device) brought into contact of reaction

