Factors that affect reaction rates

- Chemical nature of the reactants,
- Ability of the reactants to come in contact with each other,
- Concentrations of the reactants,
- Temperature,
- Availability of catalysts.

Chemical nature of the reactants

- The fundemental differences among reaction rates are due to the reactants themselves. For example, some reaction lose electrons so easily that these reactions are fast.
- In acidic solution, permanganate ion (MnO_4^-), is reduced by ferro (Fe^{++}) ion very fast.

$$\underset{\text{violet color}}{MnO_4^-} + FeSO_4 \xrightarrow{H^+} \text{Once } FeSO_4 \text{ added, violet color is lost. immediately.}$$

- The rate of this reaction depends on the rate of mixing.

- Contrary to $FeSO_4$ reduction, the reduction of permangante ion in acidic solution by oxalic acid occurs very slow.

$$MnO_4^- + C_2H_2O_4 \xrightarrow{H^+}$$ Violoet color stays unchanged for a long time.

- In both reactions, all the conditions are the same, except the reductive reactants, but the rate of the reactions are very different.

Ability of the reactants to come in contact with each other

- In order for a chemical reaction to occur, two or more reactants whose particles (atoms, ions or molecules) must collide with each other.

- This is why reactions often carried out in liquid solutions or in the gas phase in which the particles collide each other easily.

- For example, liquid gasoline burns rapidly, but gasoline vapor explodes when mixed with air.

Homogenous reactions

- These reactions take place in the same phase.
- For example, the combustion of gasoline vapor is a typical homogenous reaction because all of the reactants are in the same phase.
- Another example is the neutralization of aqueous sodium hydroxide by aqueous hydrochloric acid.

Heterogeneous reactions

- When the reactants are present in different phases, the reaction is called a heterogeneous reaction. For example, one reactant is a gas, the other is a liquid or a solid.
- In heterogeneous reactions, the reactants are able to meet only at the interface. (between the phases).
- The area of contact at the interface determines the rate of the reaction.

- This area is controlled by the sizes of the particles of the reactants.
  - **Pulverizing a solid:** Total surface area can be increased tremendously. This maximizes contacts between the molecules in solid state and the molecles in a different state. **Examples:**
    - Rusting of iron bar and iron dusts
    - Burning camp fire with a log and with a log finely divided.
    - Explosion of grain dust particles during transportation.
    - Burning coal or coal dust in coal-operated plants.

- **Example 8:** Find out how much the surface area is increases when the cubes of 1 cm of its edges is divided into cubes of 0.01 cm on an edge.

Concentrations of the reactants

- Rates of both homogeneous and heterogeneous reactions are affected by the concentrations of reactants.

Examples:

- Burning of wood: Wood burns relatively quickly in air (21% O_2) but extremely rapidly in pure oxygen (100% O_2) .

Concentration of foods:

- During concentration of fruit juices, reactant concentration are increased.
- Therefore, the reactants come close to each other and collide much more easily.
- As a result, the rate of chemical reactions, such as browning, will increase considerably in concentared products.

- Chemical shelf-lives of **fruit juices** packaged in laminated carton packages are 4 to 18 months.

- Chemical shelf-lives of **fruit juice concentrates** are much shorter (2 to 6 months).

- Chemical shelf-life in fruit juice and its concentrates implies the **brown colored pigment formation**.

Temperature

- Almost all chemical reactions occur faster at higher temperature.

- For example, insects move slowly when the air is cool. An insect is cold-blooded creature, which means that its body temp. is regulated by the temp. of its surroundings. As the air cools, insects cool, so the rate of their metabolism slows down, making insects motions' slows down.

- Changes in temp. affect the reaction rate by affecting the **reaction rate constant (k).**

- In general, **increase in temp will increase the *k* value.**

- In general, every 10°C increase in temp will increase the reaction rate by 2 to 3 times (Q_{10}). (exception browning reactions)

- However, we need to find experimentally how the increase in temp. will affect the rate of reaction. (how can this be done?)

Presence of catalysts

- Catalysts are substances that increase the rates of chemical reactions without being used up.

- Catalysts decreases the activation energy of the chemical reactions.

Activation energy is the barrier needs to be passed for the occurence of chemical reaction.

- The following reaction is catalyzed by the Fe^{+3} ions.

$$H_2O_2 \rightarrow H_2O + \frac{1}{2} O_2$$

- On the contrary, phosphate ions (PO_4^{-3}) reduce this reaction’s rate.
- If both Fe^{+3} and phosphate are present, then Fe^{+3} and phosphate intreract with each other, and then the catalyst effect of Fe^{+3} diminishes.

- The most important catalysts in foods: enzymes and metal ions (copper, iron and nickel).

- Copper and iron ions, and the enyzme lipoxygenase catalyze the oxidation of fats.

- The enzyme lipase catalyzes the hydrolysis of fats (triglycerides).

- Nickel is used for solidification of oils (hydrogenation process).

Rate law

- Rate law tells us how the rate of reaction changes with the conc. of the reactants or the products.

$$A + B \rightarrow C + D$$

$$Rate = -k\,[A]^{n}\,[B]^{m}$$

$$Rate = +k\,[C]^{x}\,[D]^{y}$$

Concentration and time

However, we may need to know the conc. of a compound during processing or storage at a given time. For instance;

- **Producing a chemical compound**: We need to know the conc. of the compound (eg. soap) at a specified time during processing.
- **Preserving a quality parameter**: We need to know the conc. of the compound (eg, anthocyanin) at a specified time during processing or storage.

Example

We may need to know the amount af anthocyanins in sour cherry juice stored at 10^{o}C for 6 months

- To obtain such data, expression about the conc. with time is needed.

- This expression is derived from rate law.

- **Rate law** is actually a differential equation between concentration and time and is obtained by integration.

$$v\ (\text{rate}) = -\frac{dA}{dt} = k\ [A]^n$$

- "–" sign, showing the reduction in the conc. of A with time.

$\frac{dA}{dt}$: Differential of A conc. to *t*. It shows the change in the conc. of A to time in small time increments,

k: reaction rate constant,

[A]: concentration of A at any (*t*) time,

n: order of reaction.