

DR. MANOJ KUMAR

ASSOCIATE PROFESSOR

DEPARTMENT OF CHEMISTRY

RAJA SINGH COLLEGE, SIWAN

TDC PART - 2 CHEMISTRY HONOURS

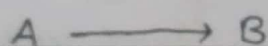
## CHEMICAL KINETICS

Chemical kinetics is the study of the rate at which a chemical process occurs. It is also used to study about order, rate and molecularity of the reaction. The word 'kinetics' is derived from the Greek word 'kinetic' which means 'the movement'. The product is formed due to the collision between the reactant during the chemical reaction.

The study of chemical kinetics includes -

1. The rate of reaction and rate laws.
2. The factors as temp., pressure, concentration and catalyst that affect the rate of reaction.
3. The mechanism or the sequence of steps by which reaction occurs.

**RATE OF REACTION :** It tells at what speed does the reaction occur.



Here the concentration of the reaction i.e. reactant A decreases and that of B increases as time passes. It is defined as; "the change in concentration of any reactant or product per unit time.

Rate of reaction = rate of disappearance of A

$$\text{rate} = - \frac{d[A]}{dt}$$

Rate of reaction = rate of appearance of B

$$\text{rate} = + \frac{d[B]}{dt}$$

[A], [B] represents the concentration in moles per litre.

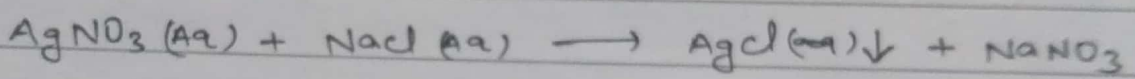
The unit of rate of reaction is measured in

- (a) mole / litre sec
- (b) mole / litre min
- (c) mole / litre hour

Rate of reaction are mainly three types —

- 1. Instantaneous Reaction
- 2. Extremely slow Reaction
- 3. Measurable Reaction

**Instantaneous Rate of Reaction**; The reaction in which the product is formed very fast when the reactant takes places, is called instantaneous reaction. This occurs between ionic compound and water solution. It occurs extremely fast reaction, so we cannot determine the rate of this type of reaction.



**Extremely slow Reaction**: Some reaction occurs extremely slow, due to this determination of rate of this type reaction, is impossible. formation alcohol in presence of yeast with help of Carbohydrate.

**Measurable Reaction**: Some reaction occurs not very fast neither extremely slow. So, determination of this type reaction is possible and can be determined easily. Decomposition of  $\text{H}_2\text{O}_2$ , esterification, or Hydrolysis of Carbohydrate (sugar).

**RATE LAW**: we know that the rate of a given reaction depends on the concentration of reaction. It is defined as; "the rate of a reaction is directly proportional to the reactant concentrations and each concentration being raised to some power".

for a substance A undergoing reaction

$$\text{Rate} \propto [\text{A}]^n$$

$$\text{Rate} \propto k[\text{A}]^n$$



for a reaction  $aA + bB \rightarrow \text{PRODUCT}$

The rate of the reaction,  $\text{Rate} = k[A]^m[B]^n$

"An expression which shows how the reaction rate is related to the concentration is called the rate law or rate equation."

The proportionality constant  $k$  is called rate constant.

where,  $m$  and  $n$  are reaction order

$$m \neq a, n \neq b$$

Example of Rate law

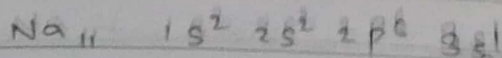
Reaction	Rate law
1. $2\text{N}_2\text{O}_5 \rightarrow 4\text{NO}_2 + \text{O}_2$	$\text{Rate} = k[\text{N}_2\text{O}_5]$
2. $\text{H}_2 + \text{I}_2 \rightarrow 2\text{HI}$	$\text{Rate} = k[\text{H}_2][\text{I}_2]$
3. $2\text{NO}_2 \rightarrow 2\text{NO} + \text{O}_2$	$\text{Rate} = k[\text{NO}_2]^2$
4. $2\text{NO} + 2\text{H}_2 \rightarrow \text{N}_2 + 2\text{H}_2\text{O}$	$\text{Rate} = k[\text{H}_2][\text{NO}]^2$

### FACTOR AFFECTING RATE OF REACTION

The following factors which affect the rate of reaction —

1. Nature of Reactant
2. Concentration
3. Temperature
4. Radiation
5. Physical state of reactant and product
6. Catalyst

Nature of Reactant; when  $\text{Na}$  reacts with water it gives  $\text{NaOH}$  and  $\text{H}_2$  gas (evolution) because  $\text{Na}$  has one unpaired electron in  $3s$  due to which it becomes more reactive.



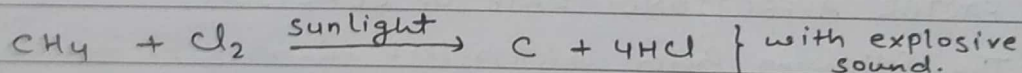
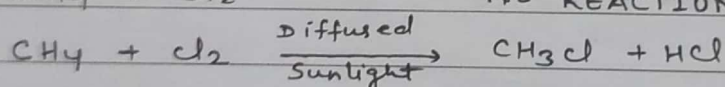
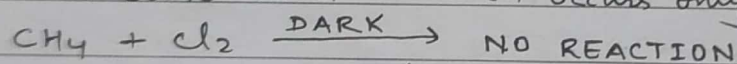
Unpaired electron:  $\uparrow$ ,  $\boxed{\uparrow}$

while Mg reacts with water, it does not occur, because Mg has no unpaired electrons. It reacts when with hot water and gives magnesium hydroxide and  $H_2$ -gas evolution. This is because electron in 3s get excited and one electron goes in 3p due to effect of hot water and reaction occurs.

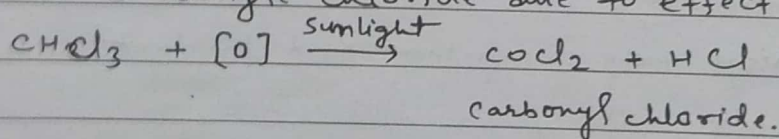
**Concentration:** Rate of reaction is directly proportional to the concentration. It means that on increasing reaction concentration rate increases while decreasing it decreases. Increasing concentration, number of molecules increases, thus number of collision per sec increases and so rate of reaction increases.

**Temperature:** Rate of reaction is directly proportional to the temp.

**Radiation:** Some reaction which occurs only in presence of radiation.



When chloroform gets oxidised in presence of sunlight, then it converts into carbonyl chloride due to effect of radiation.



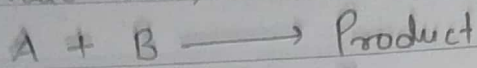
**Physical state of the reactant and product:** It also affects the rate of reaction. If physical state of reactant changes then rate of reaction also changes.

**Catalyst:** Some reaction occurs a special type of substance which does not take part in reaction but affects the rate of reaction, known as catalyst.



## ORDER AND MOLECULARITY

**ORDER OF REACTION:** It is defined as "the sum of the power of concentration in the rate law," of the reactant taking part in reaction."



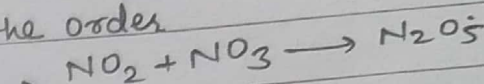
$$\text{rate} = k[A]^m[B]^n$$

The order of such a reaction is  $(m+n)$ . It may be 0 to  $n^{\text{th}}$  term.

It also be fraction.

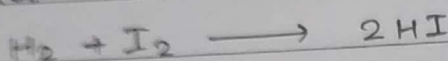
Reactions may be classified according to the order

① first Order reaction,  $(m+n) = 1$



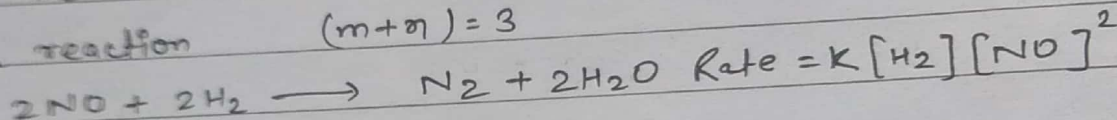
$$\text{Rate} = k[\text{N}_2\text{O}_5]$$

② Second Order reaction  $(m+n) = 2$



$$\text{Rate} = k[\text{H}_2][\text{I}_2]$$

③ Third Order reaction  $(m+n) = 3$



$$\text{Rate} = k[\text{H}_2][\text{NO}]^2$$

**MOLECULARITY:** The total number of molecules or atoms which take part in reaction as represented by the chemical equation is called molecularity of reaction

\* Unimolecular      molecularity = 1

\* Bimolecular      "      " = 2

\* Termolecular      "      " = 3

### ORDER

1. Sum of power of concentration.
2. Experimentally determined
3. fractional value
4. zero value
5. change with condition

### MOLECULARITY

1. Number of reacting species
2. Theoretical concept.
3. whole number
4. cannot be zero value
5. Invariant for chemical eqn.