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Review On Study Of Different Order Of Reaction

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Abstract:-

Chemical kinetics is the study of the rates of chemical reactions, the factors that affect these rates, and the reaction mechanisms by which reactions occur. Reaction rates vary greatly – some are very fast (burning) and some are very slow (disintegration of a plastic bottle in sunlight).

A reaction mechanism is the step by step sequence of elementary reactions by which overall chemical process occurs. A mechanism describes in detail exactly what takes place at each stage of an overall transformation. It also describes each reactive intermediate, activated complex, and transition state, and which bonds are broken (and in what order), and which bonds are formed (and in what order).

A complete mechanism must also account for all reactants used, the function of a catalyst, stereo chemistry, all products formed and the amount of each. It must also describe the relative rates of the reaction steps and the rate equation for the overall reaction. Mechanisms describe in a step-wise manner the exact collisions and events that are required for the conversion of reactants into product.

Keywords: kinetics, Order ,Reaction rate

INTRODCTION:-

1)KINETICS:

Kinetics is the study of the rate at which process occur it is useful in providing information that: gives an insight into the mechanism of changes involved , and allows a prediction of the degree of the changes that will occur after a given time has elapsed.

2)Rate constant:

A rate constant is a proprationlity constant that appears in rate law .for example , k is the rate constant in the rate law d[A]/dt=k[A]. Rate constants are independent of concentration but depend on other factors ,most notably temperature.

3)Order of reaction:

This is the number of concentration terms that determine the rate .

Consider the reaction :

$$A+B \longrightarrow C+D$$

The rate of reaction is proportional to the concentration of A to the power of x,[A]x And aslo the rate may be proportional to the concentration of B to the power of y, [B]y. The overall reaction is ,

Rate =k[A]x [B]y The overall order of reaction is x+y.

4) Reaction Rate and Order:

Reaction rate is the velocity of reaction to convert the reactants into its products. Reactions may be classified according to the order of reaction which is the number of reacting species whose concentration determines the rate at which the reaction.

The most important orders of reaction are; zero order(breakdown rate is independent of the any of the reactants) first order (reaction rate is determined by one concentration term) and second order (rate is determined by the concentrations of two reacting species.) the decomposition of many drugs can occur simultaneously by two or more Pathways ,which complicates the determination of rate constants.

TYPES ORDER OF REACTION:-

1. **zero order reaction**
2. **first order reaction**
3. **Second order reaction**
4. **Third order reaction and higher**
5. **pseudo order reaction**
6. **Complex reactions**

1. zero order reaction:-

"when the reaction rate is independent of concentration of the reacting substance, it depends on the zero power of the reactant and therefore is zero order reaction" .In this type of reaction the limiting factor is something other than concentration ,for example, Solubility or absorption of light in a certain photochemical reactions.

Example :

Loss of colour of multi -sulfa durgs .

Rate of decomposition can be described mathematically as;

Rate of concentration decrease ;

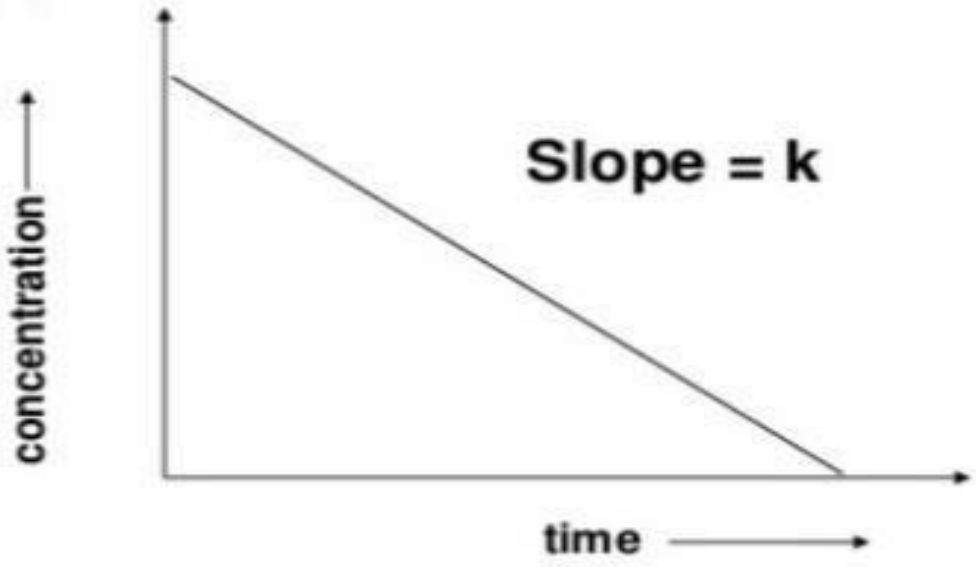
$$\frac{-dCx}{dt} = K \quad \text{.....(1)}$$

integrating the equation respect to time from t=0 to t=t ,we get;

X= Kt +constant..... (2)

comparing this equation with y= mx+c ,and

a plot of X Vs time results in a straight line with slope equal to K the value of k .indicate the amount of drug that is the grade per unit time, and intercept of a line at times zero is equal to constant in equation.



the unit of K is concentration time^{-1} with typical units of mole L^{-1}s^{-1}.

Half life is given by equation :

$$t_{1/2} = C0_{/2k}$$

Examples :-

- Vitamin E Acetate anhydrous vitamin A
- photo licence of Cefotaxime.
- loss in colour of multi sulphur product.
- intravenous infusion drug released from TDDS.

2. First order reaction:-

"When the reaction rate depends on the first power of concentration of a single reactant, "it considered to be first order.

Example:

- Absorption, distribution elimination rates
- Microbial death kinetics.

Thus the rate of reaction is directly proportional to the concentration of reacting substance and can be expressed as follows :

rate of concentration decrease ;

$$\frac{dCx}{dt} = \mathbf{KCx} \text{ ..... } (1)$$

- When the reaction rate depends on the first power of concentration of a single reactant, it is considered to be first order.
- If concentration of reactant X is 'a' at beginning of reaction when t=0,&if amount that has reacted after time t is denoted by x then amount of X remaining at time t will be (a-x)

Therefore ,

$$\frac{dCx}{dt} = \mathbf{k(a-x)} \text{ ..... } (2)$$

$$\frac{dCx}{(a-x)} = \mathbf{-k\ dt} \text{.....} (3)$$

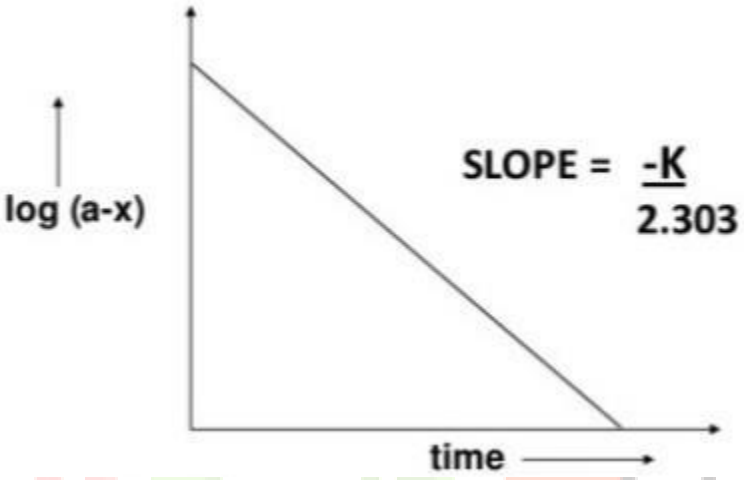
Integrating equation between time limit 0 to t

$$\int_{a}^{a-x} \frac{dc}{dt} x = -K \int_{0}^{t} dt$$

In (a-x) -In a=-kt

Log (a-x) -log a=-kt /2.303

Log (a-x) =log a-kt /2.303 ..... (4)



Equation (4)is like y=mx+c(linear relationship)

If First order law is obyed then a graph of log (a-x) v/s time t will give straight line with slope of -k/2.303 and an intercept of log a at t=0

Rearranging equation (4) we have

$$K = \frac{2.303}{t} \log (a/a-x). \ldots\ldots\ldots\ldots (5)$$

- Unit of K for first order is time -1. i.e SI unit is (sec)- because k Is inversely proportional
- The half life t1/2 of a drug is the time required for 50%o of drug to degrade and can be calculated as follows :

$$t_{1/2}=\frac{2.303}{k}\log C_0=\frac{2.303}{k}\log 100/50=\frac{2.303}{k}\log 2=\frac{0.693}{k}$$

Therefore,

$$t_{1/2}=\frac{0.693}{k} \quad \text{.....(7)}$$

- In pharmacutical field, the time required for 10% of the drug to degrade is an important value to know, since it represents a reasonable limit of degradation of active ingredients.
- The t10% value can be calculated as

$t_{10\%}$ **=0.104/k**

Or $t_{10\%}$ **=0.152**

t1/2

Example :

- Decomposition rate of hydrogen peroxide, catalysed by 0.02 molar KI.

3. Second order reaction :-

"Rate of change in concentration of product and reactant is dependent of second power of concentration of single reactant or to first powers of the concentration of two reactants."

dCx/dt =k [x] [y]. ..... (1)

Or

dCx/dt=K[x]². ..... (2)

Let us discuss; dCx/dt=k[x][y)] in detail

Here discuss in concentration of Y is similar to X. If concentration of X and Y at time t=0 are a and b respectively, and concentration of each substance that has reacted after time t is equal to X then concentration of X and Y remaining will be (a-x) and (b-x) respectively.

a) In case when (a≠b)

$$\frac{dx}{dt} = k(a-x)(b-x) \quad \text{.....(3)}$$

Where -dx /dt =rate of decrease in concentration of X and Y

Integrating equation(3) we get

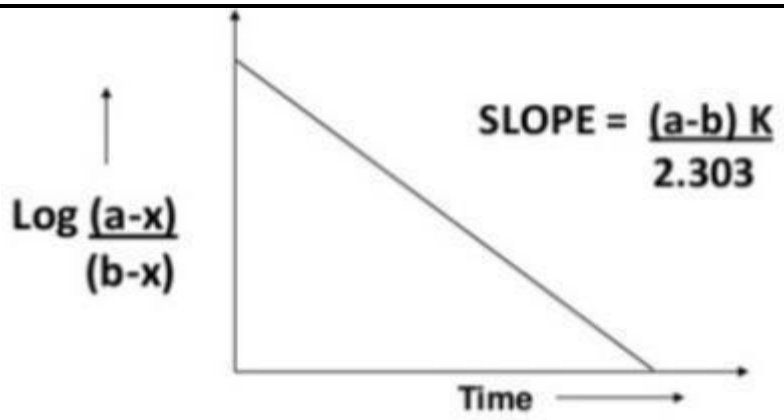
$$K = \frac{2.303}{(a-b)} \log \frac{b(a-x)}{(b\quad)} \quad \text{.....(4)}$$

Rearranging equation (4)we get

$$(b-x) \log \frac{(a-x)}{a} = (a-b)\,Kt/2.303 + \log a/b. \quad \text{..... (5)}$$

So, if second order reaction is observed then graph of

log (a-x) /(b-x) vs t



In case When (a=b)

$$\frac{Cx}{dt}=K(X)^2$$

Integrating gives,

$$Kt=\frac{x}{a}(a-x). \text{.....(6)}$$

Rearranging of equation(6) gives us

$$Kt=1/(a-x) - 1/a \text{ ..... (7)}$$

- So if second order reaction is observed then graph of 1/a-x Vs t gives straightline with slope K and intercept 1/a at t=0.

- Unit of second order reaction is concentration $^{-1}$ time^{-1} and unit is mol^{-1} sec^{-1}
- Half- life In this case is t1/2=1/ak.

4. THIRD ORDER REACTION AND HIGHER:-

Rate of change in concentration is proportional to three concentration terms However such reactions are there and their analysis is complex reaction of even higher order is unlikely to occur.

Rate equation of third order reaction is as follows

$$K=1/2t[1/(a-x)^2-1/a^2]$$

Half life equation is

$$t_{\frac{1}{2}} = \frac{3}{2}\ \frac{1}{a^2k}$$

5. PSEUDO ORDER REACTION:-

A) PSEUDO -ZERO ORDER REACTION:

In solid state May drug decomposers by pseudo zero order that is reaction between drug and moisture in a solid dosage form the system behaves like Suspension and because of the presence of excess Solid drug; the first order rate actually become pseudo zero order. equation for it is similar to zero order accept k is represented by k'.

How suspension degradation follows pseudo zero order reaction suspension is the case of zero order kinetics in which the concentration in a solution depends on the drug solubility as the drug decomposes in a solution ,more drug release from the suspended particles so that the concentration remains constant.

This concentration is of course that drugs equilibrium salubility in a particular solvent at a particular temperature the important point is that the amount of the drug in the solution remains constant despite its decomposition with time.

The reservoir of a solid drug in a suspension is responsible for this constancy. it follows zero order kinetics because the suspended drug reservoir that ensures constant concentration.once all the suspended particles have been converted into drug in a solution the system changes to a first- order reaction.

B) PSEUDO-FIRST ORDER REACTION

A second order or biomolecular reaction is made to behave like first order. this is found in the case in which one reacting material is present in great excess or is maintained at constant concentration as compared with other substance .Here reaction rate is determined by one reactant even throw two are present.

EXAMPLES:

- decomposition of ascorbic acid tablet.
- Aspirin hydrolysis.

6. COMPLEX REACTION:-

These are reaction involving simultaneous breakdown by more than one routerus or by a sequence of reaction steps.

although most degradative reactions in pharmaceutical systems can be treated by simple zero-order, first order and pseudo first order kinetics, there are certain Pharmaceutical formulations that exhibit more complicated reactions.

Three types of reaction :

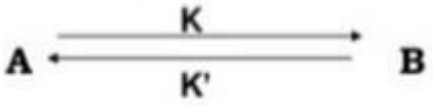
a) opposing reaction (reversible)

b) side reactions (parallel)

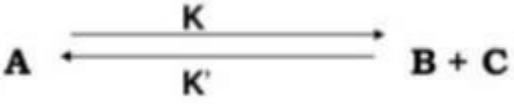
c) Consecutive reactions

a) OPPOSING REACTION(REVERSIBE):

The simplest case is ,in which both reactions are of first order



A some what more complicated reaction is when forward is a first order type and reverse reaction is second order type

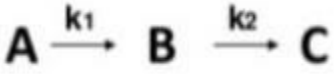


Example :

- Epimerization of tetracycline.

b) CONSECUTIVE REACTIONS:

simplest is one where both the reaction is of first order. if k2> k1 then B can be considered as unstable intermediate and rate determining step for overall reaction would be conversion of A to B.

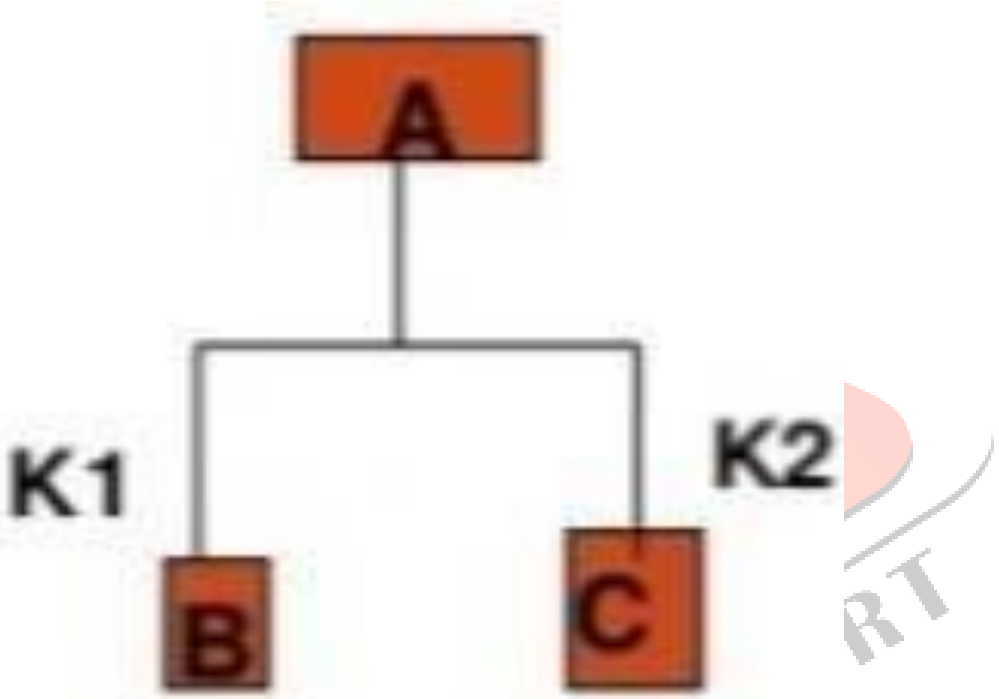


Examples :-

- radioactive series isotope decay that follows first order, but it is a consecutive reaction.
- degradation of chlorobenzene by hydrolysis To lactam from and further to benzophenone.

C) SIDE REACTIONS(PARALLEL):

Here the reacting substance can be removed by two or more reactions occurring simultaneously ,as depicted.



Example :

- purified insulin the grades by two mechanisms the deamidation and polymerization.
- the relative rates of deamidation and polymerization are PH and temperature dependent.

KNOWN FACTS:-

1. There is no detectable difference between first order and zero order at less than 15% decomposition.
2. Many companies take the attitude of plotting by first order in situation where the order is unknown.
3. Establishing the true order of reaction can often be difficult due to the fact that strength changes at 25 dgree Celsius are small and that you need to units and a assay variation make a such a distinction difficult.

METHODS TO DETERMINE ORDER OF REACTION:-

1. Substitution Method
2. Data Plotting Method
3. Intial Rate Method
4. Half Life Determination Method
5. Software Tools for Second Order Reaction

1) SUBSTITION METHOD:-

The data accumulated in kinetic study may be substituted in the integrated form of the equations which describes the various orders. when The equation is found in which the calculated k values remain constant the reaction is considered to be of the order.

2) GRAPICAL (DATA PLOTTING) METHOD:

- If a straight line results when concentration is plotted against time the reaction is zero order. H
- If plot of 1/c against time is linear then it is second order .
- If plot of log 1/c against Time is linear then it is second order .
- If plot of log c against time is linear then it is second order reaction.

3) INITIAL RATE METHOD:-

- Graps are plotted of rate of reaction against concentrations and the initial rate determined from the gradient at time t=0.
- If it is a straight line the reaction is first order .
- A line which is independent of concentration is zero order .
- If a curve is obtained then it is second orde

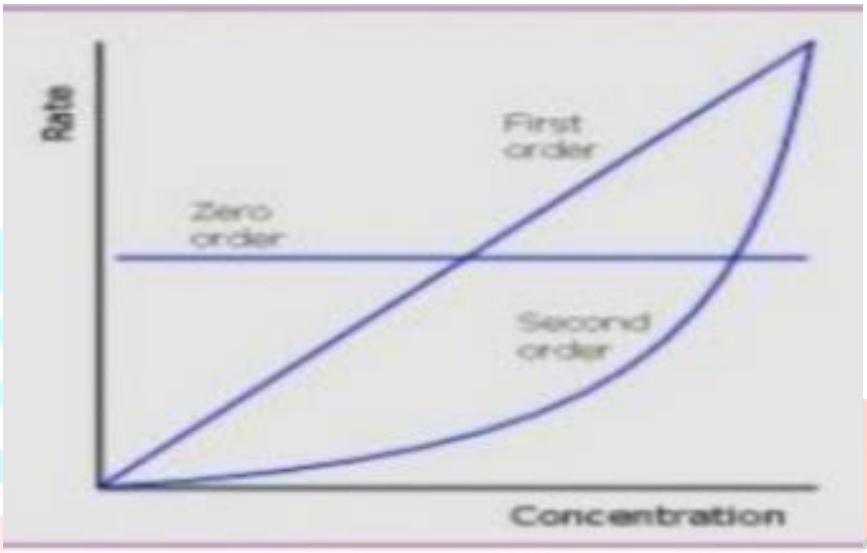


Fig. Curves for different types of order

4) HALF LIFE DETERMINATION METHOD:

In general the half life of reaction in which the concentration of all reactants are identical ,the relationship is,

$$t1/2 \propto 1/a\ n^{-1}$$

Where n is the order of reaction .

Thus if two reactions are run at different initial concentrations, a1 & a2 with there respective half- lives and putting them in above equation in logarithmic from we finally get

$$n = \frac{log\,(t1/2(1)/\,t1/2(2))}{log(a2/a1)} + 1$$

EXPIRSTION PEROID:

- Prime goal of stability testing is to be established an expiry date .
- The terms defined in lines 82- 90 of guidlines as

- " the date placed on the intermediate container label of drug product that designates the date through which the product is expected to remain within specification.

CONCLUSION:-

We began with a consideration of chemical reactions and the mechanisms that illustrate the individual steps necessary to transform reactants into products. We demonstrated the way to derive a reaction's rate law through the analysis of experimental data, and we looked at the factors that can affect the rates of chemical reactions.

After such an overview, you should begin to appreciate that many chemical principles in the human body rely on the principles of chemical kinetics. Why does the body maintain a certain temperature? Primarily to stabilize the enzymes that catalyze the metabolic reactions necessary for life.

Why does the body maintain a pH buffer? Altering the concentration of protons affects not only the ability of an enzyme to maintain its secondary, tertiary, and quaternary structure, but can also directly affect the collisions between reactants. You will begin to appreciate these and many other questions from a clinical perspective throughout your medical career. In the next chapter, we will investigate chemical equilibria, which although related to kineticsare distinct (and commonly confused!) topics. determines whether or not a reaction is spontaneous.

Chemical mechanisms propose a series of steps that make up the overall reaction. Intermediates are molecules that exist within the course of a reaction, but are neither reactants nor products overall.The slowest step, also known as the rate-determining step, limits the maximum rate at which the reaction can proceed.

The collision theory states that a reaction rate is proportional to the number of effective collisions between the reacting molecules. For a collision to be effective, molecules must be in the proper orientation and have sufficient kinetic energy to exceed the activation energy.

The Arrhenius equation is a mathematical way of representing collision theory.

Order	Integrate rate equation	$t_{1/2}$	Linear Graph			
			Ordinate	Abscissa	Slope	Intercept
0	X = Kt	= a/2K	X	t	K	0
1	log (a/a-x) = Kt/2.303	= 0.693/K	log(a-x)	t	-K/2.303	log a
2 (a = b)	X/a(a-x) = Kt	= 1/aK	1/a-x	t	K	1/a

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The transition state theory states that molecules form a transition state or activated complex during a reaction in which the old bonds are partially dissociated and the new bonds are partially formed.From the transition state, the reaction can proceed toward products or revert back to reactants. The transition state is the highest point on a free energy reaction diagram.

Reaction rates can be affected by a number of factors. Increasing the concentration of reactant will increase reaction rate (except for zero-order reactions) because there are more effective collisions per time. Increasing the temperature will increase reaction rate because the particles' kinetic energy is increased.Changing the medium can increase or decrease reaction rate, depending on how the reactants interact with the medium.

Conditions	Zero-Order	First-Order	Second-Order
Temperature lowered	rate decreased	rate decreased	rate decreased
All reactants' concentrations doubled	rate unaffected	rate doubled	rate multiplied by 4
Catalyst added	rate increased	rate increased	rate increased

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