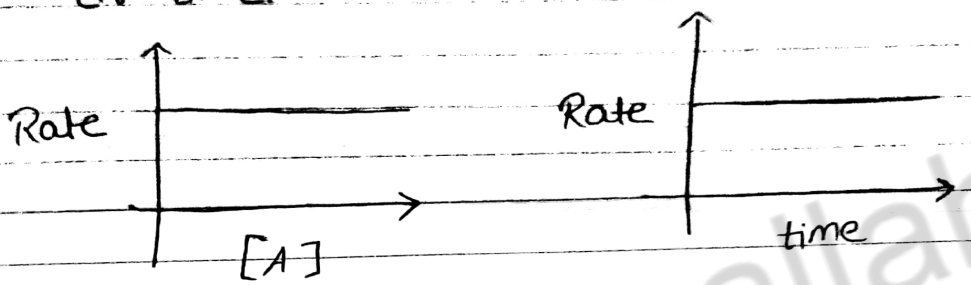
Zero Order Kinetics

$A \longrightarrow$ Products

Rate of Reaction (ROR) $= r = K[A]^0 = K$

$r = K$

Rate of Zero Order Reaction is constant & do not change with Concentration of reactant or time.



Integrated Rate Law

$A \longrightarrow$ Products (99% questions)

$r = K[A]^0$ & $r = -\frac{1}{1}\frac{dA}{dt}$

$\Rightarrow \quad -\frac{1}{1}\frac{dA}{dt} = K[A]^0$

$$\frac{dA}{dt} = -K$$

$$\int_{A_0}^{A} dA = \int_{0}^{t} -K\,dt$$

Let, at
$t = 0 \quad [A] = A_0$

$t = t \quad [A] = A$

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$$A - A_0 = -K(t-0)$$

$$\boxed{A = A_0 - Kt}$$ Integrated Rate Law

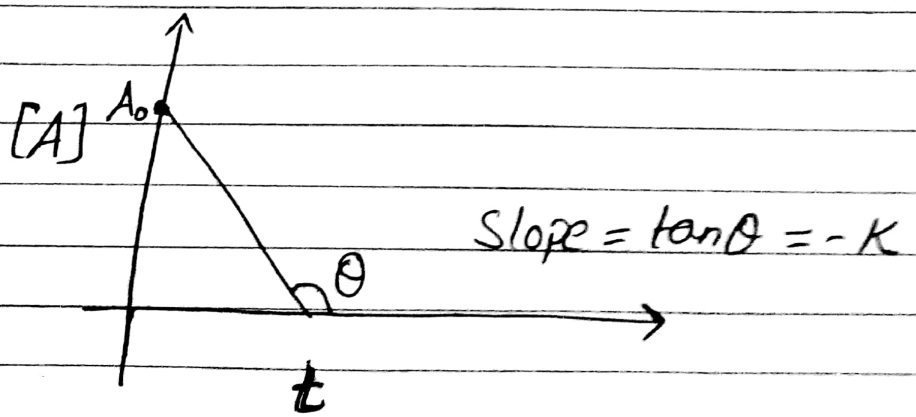
$A_0 \rightarrow$ Concentration of A at $t=0$ (initial)

$A \rightarrow$ " " " " $t=t$ (remaining)

$K \rightarrow$ Rate Constant

$t \rightarrow$ time in which conc changes from A_0 to A

$$A = -Kt + A_0$$
$$y = mx + C$$



Remember

If the plot of conc of reactant v/s time is a straight line $\Longrightarrow$ Zero Order Reaction

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$\boxed{A = A_0 - Kt}$ 99% Questions

Half Life of Reaction ($t_{1/2}$)

The time in which concentration of reactant reduces to half of it's initial value

at $t = t_{1/2}$ $\quad A = \frac{A_0}{2}$

$$A = A_0 - Kt$$

$$\frac{A_0}{2} = A_0 - K t_{1/2}$$

$$\boxed{t_{1/2} = \frac{A_0}{2K}}$$

Life Time of Reaction (t_{lf})

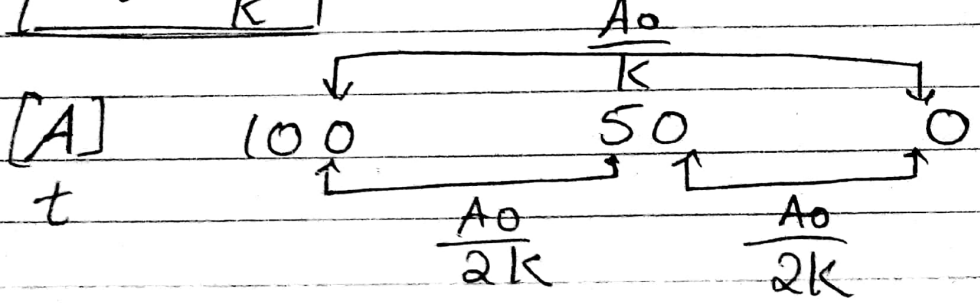
In which reaction completes

at $t = t_{lf}$ $\quad A = 0$

$$A = A_0 - Kt$$
$$0 = A_0 - K t_{lf}$$

$$\boxed{t_{lf} = \frac{A_0}{K}}$$

Observe →



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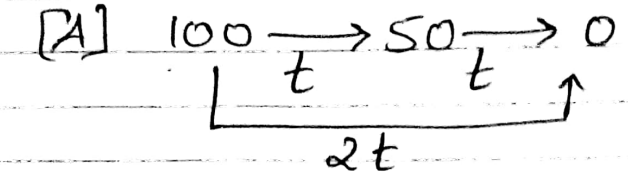
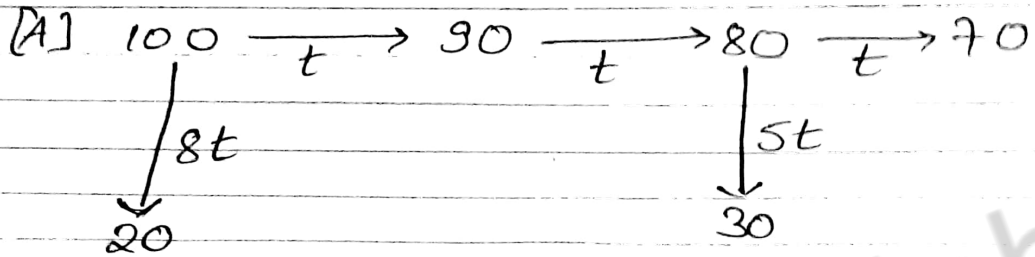
⇒ Unitary method applicable in Zero Order Kinetics





Q1) A zero order reaction is 50% complete in 2 minutes. Find the time taken for 75% completion.

Method 1: Using Integrated Rate Law

$$A = A_0 - kt$$

$$t = \frac{A_0 - A}{k}$$

50% completion $A_0 = 100$ $A = 50$

$$t = \frac{100 - 50}{k} = \frac{50}{k}$$

$$2\ \text{min} = \frac{50}{k} \quad (i)$$

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75% Completion $A_0 = 100$ $A = 25$

$$t = \frac{100-25}{K} = \frac{75}{K} \quad \text{(ii)}$$

$$\text{(ii)} \div \text{(i)} \quad \frac{t}{2\,min} = \frac{\frac{75}{K}}{\frac{50}{K}} = \frac{3}{2}$$

$$\boxed{t = 3\,mins}$$

Method 2: Unitary Method

[A] 100 $\xrightarrow{2min}$ 50 (50% completion)

100 $\xrightarrow{1min}$ 75 (25% completion)

75 $\xrightarrow{1min}$ 50 (50% completion) $\xrightarrow{1min}$ 25 (75% completion)

$$t = 3min$$

H.W. Q2) A Zero order Reaction is 50% complete in 2 min. Find the time taken for 33.33% completion of reaction:

a) 0.33 min b) 0.66 min c) 1.33 min d) 1.66 min

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Q3) A particular reaction that's completed 20% in 20 min & 40% in 40 min. Determine Order of Reaction & Rate Constant of Reaction

Solution Hit & Trial Method

Apply Zero order Kinetics ⟶ Find two values of K

↓

If same or nearly same ⟵ NO ⟵ Apply First order Kinetics ⟵ Find two values of K

↓ yes

Zero Order Reaction

$A = A_0 - Kt$

20% complete $80 = 100 - K(20)$

$K = 1$

40% complete $60 = 100 - K(40)$

$K = 1$

Same value of K ⇒ Zero order Kinetics is followed

∴ Zero order Reaction

$$\boxed{K = 1\left(\frac{Mol}{l}\right) min^{-1}}$$

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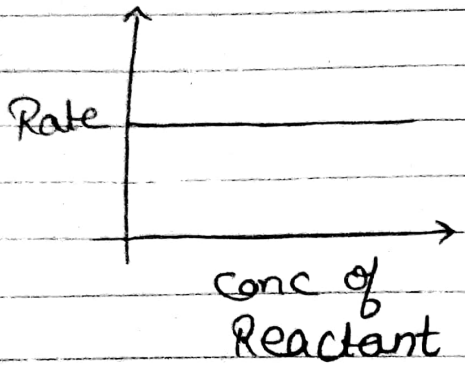
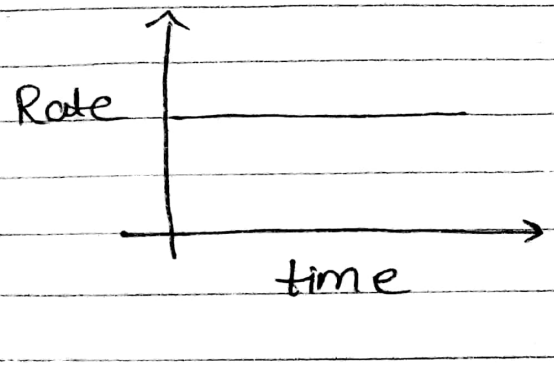
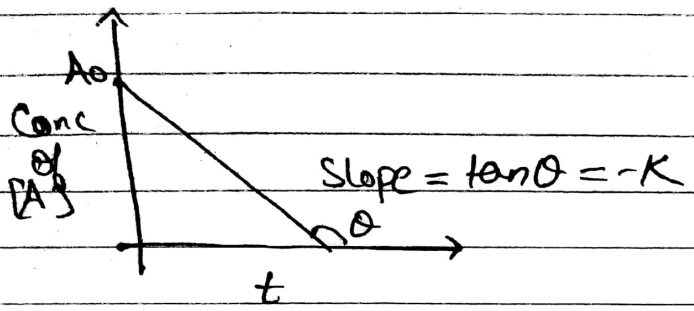
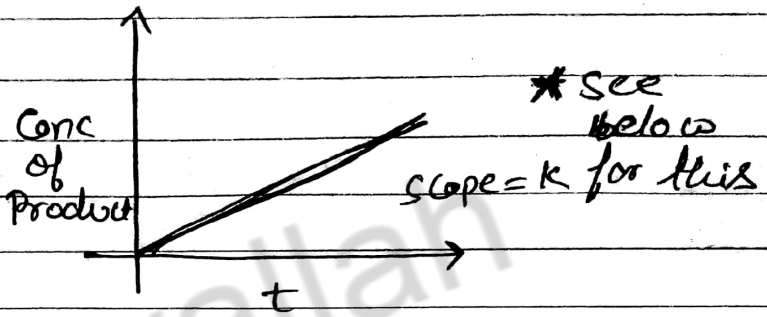
Graphs of Zero Order Kinetics

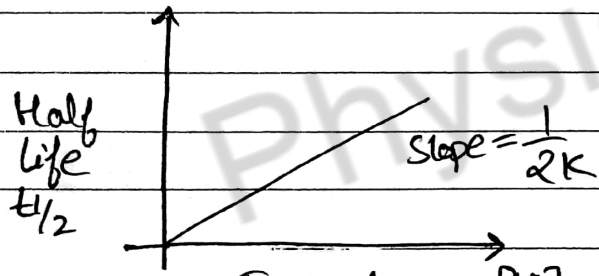








* See below for this



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* Conc of product v/s time

A ⟶	B
Ao	-
Ao - x	x

$$A = A_o - Kt$$

$$A_o - x = A_o - Kt$$

$$x = Kt$$

$$[B] = x = Kt$$

Examples of Zero Order Reaction

(i) Photochemical Reaction

$$H_2 + Cl_2 \xrightarrow{h\nu} 2HCl \qquad r = K[H_2]^0[Cl_2]^0$$

Rate depends on Intensity of light

(ii) Enzyme Catalysis Reaction

(iii) Dissociation of gases on solid surface at high Pressure

$$2NH_3 \longrightarrow N_2 + 3H_2$$

★★★ Special Cases of Zero Order Kinetics (1%)

Q) $3A \longrightarrow$ Products, where initial conc of $A = A_0$

$r = K[A]^0$

Find conc of A after time 't'

Find Half life

Solution:

Note → this is not regular $A \longrightarrow$ Product type reaction so don't use $A = A_0 - kt$

Apply concept.

$$r = K[A]^0 \quad \& \quad r = -\frac{1}{3}\frac{dA}{dt}$$

$$\frac{1}{-3}\frac{dA}{dt} = K$$

$$\int_{A_0}^{A} dA = -\int_0^t 3K\,dt$$

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$$A - A_0 = -3kt$$

$$\boxed{A = A_0 - 3kt}$$

Conc of A after time 't'

see in place of k we get 3k

Trick: $K_{reactant} = K_{reaction} \times$ Stochiometric coeffecient

$$t_{1/2} = \frac{A_0}{2k} \text{ (standard)}$$

Here $K_{reactant} = K \times 3 = 3k$

$$t_{1/2} = \frac{A_0}{2(3k)} = \frac{A_0}{6k}$$

Q2) $\frac{5}{2}A \longrightarrow$ Product . Find conc of A after time t & Half life if Initial conc of A is A_0

$r = K[A]^0$

Solution

$$K_{reactant} = K \times \frac{5}{2}$$

$A = A_0 - Kt$ standard

$$A = A_0 - \frac{5}{2}kt$$

$$t_{1/2} = \frac{A_0}{2\left(\frac{5}{2}k\right)} = \frac{A_0}{5k}$$

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Q8) $A + 2B \longrightarrow$ Products

$r = k[A]^{\circ}[B]^{\circ}$

Initial conc of A & B = A_0 & B_0 respectively

Find conc of A & B after time t
Find Half life of A & B.

A

$k_{reactant} = k \times 1$

$A = A_0 - kt$

$(t_{1/2})_A = \frac{A_0}{2(k)}$

B

$k_{reactant} = 1k \times 2$

$B = B_0 - 2kt$

$(t_{1/2})_B = \frac{B_0}{2(2k)}$

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