I. FIRST ORDER KINETICS

A ⟶ products (radioactive decay, decompositions)

average rate $= \frac{-\Delta[A]}{\Delta t}$ rate $= k[A]$

$$\frac{-\Delta[A]}{\Delta t} = k[A]$$

⇓

$$\ln\frac{[A]}{[A]_0} = -kt$$

[A] = @ time = "t"

$[A]_0$ = @ time = 0

$$\ln[A] = -kt + \ln[A]_0$$

$$y = mx + b$$

example

$$2N_2O_5 \longrightarrow 4NO + 3O_2$$

first order overall; at 45°C, $k = 4.8\times10^{-4}\,s^{-1}$

a) if $[N_2O_5]_0 = 1.65\times10^{-2}$ M, what is $[N_2O_5]$ after 13 minutes and 45 seconds? (825 s)

$$\ln[N_2O_5] = -(4.8\times10^{-4}\,s^{-1})(825\,s) + \ln[1.6\times10^{-2}\,M]$$

$$\ln[N_2O_5] = -4.53$$

$$[N_2O_5] = 0.011\,M$$

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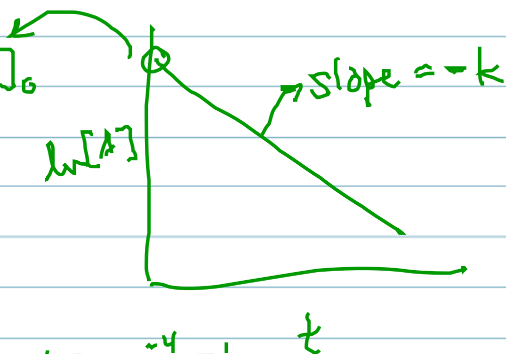

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$$\ln[N_2O_5] = -4.53$$

$$[N_2O_5] = 0.011\ M$$

b) How long (in minutes) will it take to get $[N_2O_5] = 1.0 \times 10^{-2} M$ starting with $[N_2O_5] = 1.65 \times 10^{-2} M$?

$$\ln \frac{[1.0 \times 10^{-2} M]}{[1.65 \times 10^{-2} M]} = -(4.8 \times 10^{-4} s^{-1})\, t$$

$t = 1043 s \Rightarrow$ **17.4 min**

c) How long will it take to convert 2/3 of the N_2O_5 ?

67% gone
33% there

$[N_2O_5]_0 = 100$

$[N_2O_5] = 33$

$$t = \frac{1}{k} \ln \frac{[N_2O_5]_0}{[N_2O_5]}$$

$$t = \frac{1}{(4.8 \times 10^{-4} s^{-1})} \ln \frac{100}{33}$$

$t = 2310 s \Rightarrow 38.5 min$

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with a gas.. $P = \frac{n}{V} RT = MRT \quad P \propto M$

$A \rightarrow$ products

$[A] = \frac{P}{RT}$ $\ln \frac{(P/RT)}{(P_0/RT)} = \boxed{\ln \frac{P}{P_0} = -kt}$

$\ln P = -kt + \ln P_0$

HALF LIFE ⇒ TIME for $[A] = \frac{1}{2}[A]_0$

FIRST ORDER

$$t_{\frac{1}{2}} = \frac{1}{k}\ln\left(\frac{[A]_0}{[A]}\right) \rightarrow \frac{2}{1}$$

$\ln 2 = 0.693$

$$\boxed{t_{\frac{1}{2}} = \frac{0.693}{k}}$$

INDEPENDENT OF [A]

the larger the k, the shorter the $t_{\frac{1}{2}}$
the faster the reaction

What is the $t_{\frac{1}{2}}$ for $N_2O_5 \longrightarrow$ products @ 45°C
$k = 4.8 \times 10^{-4} s^{-1}$

$$t_{\frac{1}{2}} = \frac{0.693}{4.8\times10^{-4} s^{-1}} = 1443 s \Rightarrow 24 \text{ minutes}$$

II. SECOND ORDER

~~rate = k [A][B]~~
rate = $k[A]^2$

A ⟶ products

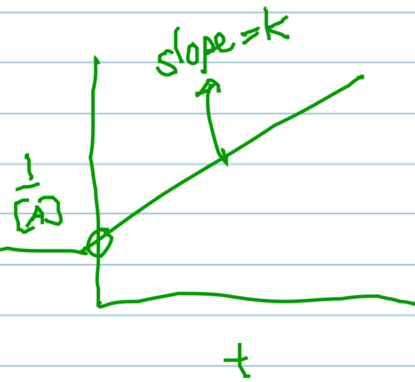
$$\text{average rate} = \frac{-\Delta[A]}{\Delta t}$$

rate = $k[A]^2$

$$\frac{-\Delta[A]}{\Delta t} = k[A]^2$$

⇓

$$\boxed{\frac{1}{[A]} = kt + \frac{1}{[A]_0}}$$



$$\boxed{t_{\frac{1}{2}} = \frac{1}{k[A]_0}}$$

$$t_{\frac{1}{2}} \propto \frac{1}{[A]_0}$$

as $[A]_0$ ↑ $t_{\frac{1}{2}}$ ↓

B → products second order kinetics

rate = k [B]^2 @ 22°C, $k = 1.0 \times 10^{-2}\ M^{-1} s^{-1}$

a) if $[B]_0 = 0.022M$, what is [B] after 15 minutes?
(900s)

$$\frac{1}{[B]} = (1.0 \times 10^{-2} M^{-1} s^{-1})(900s) + \frac{1}{(0.022M)}$$

$[B] = 0.018M$

b) what is $t_{\frac{1}{2}}$ in minutes? $[B]_0 = 0.022M$

$$t_{\frac{1}{2}} = \frac{1}{(1.0 \times 10^{-2} M^{-1} s^{-1})(0.022M)} = 4545s$$

↓

75.8 minutes