Characteristics of first order reaction

The integrated rate equation of a first order reaction is given by,

$$K = \frac{2.303}{t} \log \frac{a}{a-x} \longrightarrow (1)$$

(a) The unit of K (specific rate const.) for a first order reaction is independent of the conc. unit. So, the unit of K is $time^{-1}$.

(b) The half life period of first order reaction is independent of the initial conc. of reactants.

Proof: The half life period, $t_{\frac{1}{2}}$ of a reactⁿ. is the time required for the reactant to become half of its initial conc. At $t_{\frac{1}{2}}$, $x = 0.5a$, hence the equⁿ (1) $\Rightarrow$

$$K = \frac{2.303}{t_{\frac{1}{2}}} \log \frac{a}{a - 0.5a}$$

$$t_{\frac{1}{2}} = \frac{2.303}{K} \log 2$$

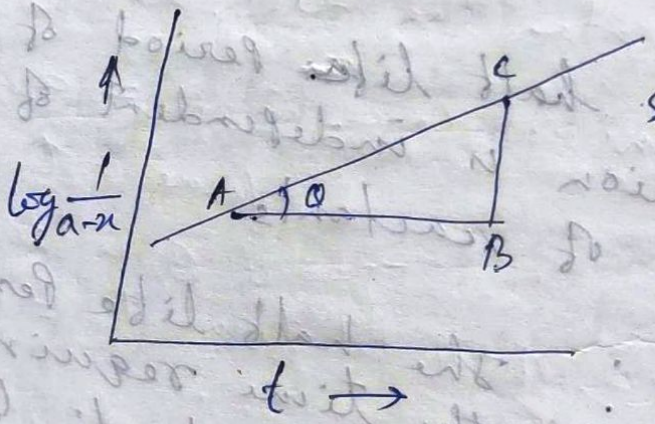
$$t_{\frac{1}{2}} = \frac{0.693}{K}$$

(c) The Plot of $\log \frac{1}{a-x}$ Vs t is a straight line

Proof: Rearranging the equⁿ. (1) ⇒

$$-\log(a-x) = +\left(\frac{k}{2.303}\right)t - \log a$$

This equⁿ is of the form of $Y = mx + c$ so the Plot of $\log \frac{1}{a-x}$ Vs t will be a straight line.



slope = $\tan\theta$

$= \frac{BC}{AB}$

$= \frac{k}{2.303}$

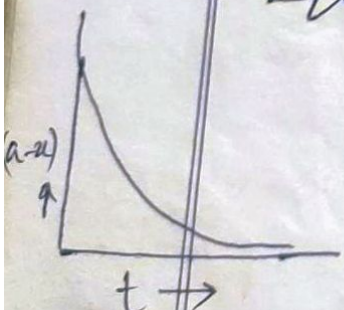
(d) A first order reaction never completed.

Equⁿ. (1) ⇒ $\ln \frac{a}{a-x} = kt$

$\Rightarrow \ln \frac{a-x}{a} = -kt$

$\Rightarrow \frac{a-x}{a} = e^{-kt}$

$\Rightarrow a - x = a e^{-kt}$



To complete the reaction $a - x = 0$ is must where as it is possible only when $t = \infty$, which not possible