* Parallel or side or simultaneous reaction

$$A \xrightarrow{k_1} B \qquad \text{or,} \qquad A \xrightarrow{k_1} B$$
$$A \xrightarrow{k_2} C \qquad\qquad\qquad A \xrightarrow{k_2} C$$

Let initial concentration of A is $[A]_0 = a$ and that of B and C are zero. At an arbitrary time t, concentration of A is $[A] = a - x$, and that of B and C are $[B]$ and $[C]$ respectively.

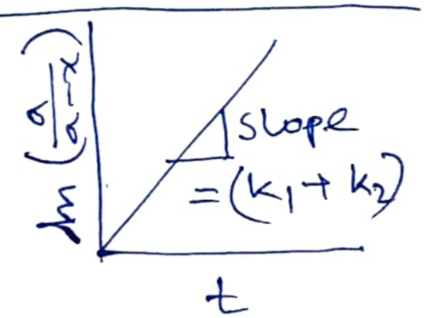
$$-\frac{d[A]}{dt} = \frac{d[B]}{dt} + \frac{d[C]}{dt}$$

$$\text{or,} \quad -\frac{d(a-x)}{dt} = k_1(a-x) + k_2(a-x)$$

$$\text{or,} \quad \frac{dx}{dt} = (k_1 + k_2)(a-x) = -\frac{d(a-x)}{dt}$$

$$\int_0^x \frac{dx}{a-x} = (k_1 + k_2)\int_0^t dt$$

$$\text{or,} \quad \ln\left(\frac{a}{a-x}\right) = (k_1 + k_2)t$$



$\ln\left(\frac{a}{a-x}\right)$ vs t

$$[A] = (a-x) = a e^{-(k_1+k_2)t}$$

$$\frac{d[B]}{dt} = k_1[A] = k_1 a e^{-(k_1+k_2)t}$$

$$\int_0^{[B]} d[B] = k_1 a \int_0^t e^{-(k_1+k_2)t}\,dt$$

$$[B] = C_B = k_1 a \left[\frac{e^{-(k_1+k_2)t}}{-(k_1+k_2)} \right]_0^t$$

$$[B] = C_B = \frac{k_1 a}{k_1 + k_2} \left[1 - e^{-(k_1+k_2)t} \right] \quad \text{—— (B)}$$

Note: from this expression, it is clear that starting from zero, [B] increases with time and it finally becomes $\frac{k_1 a}{k_1 + k_2}$ as $t \to \infty$. The rate of formation of C is

$$\frac{d[C]}{dt} = k_2[A] = k_2 a e^{-(k_1+k_2)t}$$

$$\int_0^{[C]} d[C] = k_2 a \int_0^t e^{-(k_1+k_2)t} dt$$

$$[C] = C_C = \frac{k_2 a}{k_1 + k_2} \left[1 - e^{-(k_1+k_2)t} \right] \quad \text{—— (C)}$$

Similar to [B], concentration of C increases from zero and finally it becomes $\left(\frac{k_2 a}{k_1 + k_2}\right)$ when $t \to \infty$.

From equations (B) & (C), we get

$$\frac{[B]}{[C]} = \frac{C_B}{C_C} = \frac{k_1}{k_2}$$

Using the slop of ([A] vs t plot) $= k_1 + k_2$ and $\frac{[B]}{[C]} = \frac{k_1}{k_2}$, one can determine the individual rate constants, k_1 & k_2.