There are two type's of rate:

① **Average Rate**

The rate of reaction over a certain measurable period of time during the course of reaction is called Avg. rate. it is denoted by $\bar{r}$.

ex: $A \longrightarrow B$

$$\bar{r}_A = -\frac{\Delta[A]}{\Delta t}; \quad \bar{r}_B = \frac{\Delta[B]}{\Delta t}$$

(2) **Instantaneous Rate**

The rate of reaction over a certain at any particular instant of time during the course of reaction. it is denoted by r_{inst}.

$r_{inst} = (r_{avg.})_{\Delta t \to 0}$

$A \longrightarrow B$

$$(r_{inst})_A = (\bar{r}_A)_{\Delta t \to 0}$$

$$(r_{inst})_A = \left(-\frac{\Delta[A]}{\Delta t}\right)_{\Delta t \to 0}$$

$$(r_{inst})_A = -\frac{d[A]}{dt}$$

As it is-

$$(r_{inst})_B = \frac{d}{dt}[B]$$

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ex:- (ii) $2A \longrightarrow 3B$

r_A & r_B = ?

$r_A = -\frac{1}{2}\frac{d}{dt}[A] = -2\frac{d}{dt}[A]$ ~~xx~~

$r_A = -\frac{d}{dt}[A]$; $r_B = \frac{d}{dt}[B]$

Rate of reaction in terms of Stoichimetry Coefficients :-

$m_1A + m_2B \longrightarrow n_1C + n_2D$; Here:- m_1, m_2, n_1 & n_2 are Stoichiometry Coefficients

⇒ Rate of A / Rate of disapperance of A $= -\frac{d}{dt}[A]$

— " — B / — " — " — B $= -\frac{d}{dt}[B]$

Rate of C / Rate of appearance of C $= \frac{d}{dt}[C]$

— " — D / — " — of D $= \frac{d}{dt}[D]$

Rate of Reaction (r. o. r.)

$= -\frac{1}{m_1}\frac{d}{dt}[A] = -\frac{1}{m_2}\frac{d}{dt}[B] = \frac{1}{n_1}\frac{d}{dt}[C]$

$= \frac{1}{n_2}\frac{d}{dt}[D]$

Rate of reaction always a positive quantity; But +ve/−ve sign represent increase/decrease concentration of product/reactant.

For rate of reaction to determine always required a balanced chemical reaction.

Q.1. Express rate of reaction in following changes.

(a) $N_2 + 3H_2 \longrightarrow 2NH_3$; $R.o.r. = -\frac{d}{dt}[N_2] = -\frac{1}{3}\frac{d}{dt}[H_2] = \frac{1}{2}\frac{d}{dt}[NH_3]$

(b) $2SO_2 + O_2 \longrightarrow 2SO_3$; $r.o.r. = -\frac{1}{2}\frac{d}{dt}[SO_2] = -\frac{d}{dt}[O_2] = \frac{1}{2}\frac{d}{dt}[SO_3]$

(c) $H_2 + \frac{1}{2}O_2 \longrightarrow H_2O$; $r.o.r. = -\frac{d}{dt}[H_2] = -\frac{1}{1/2}\frac{d}{dt}[O_2] = \frac{d}{dt}[H_2O]$

$\Rightarrow -\frac{d}{dt}[H_2] = -2\frac{d}{dt}[O_2] = \frac{d}{dt}[H_2O]$

Q.2. In a rexn; $N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$, the rate of apperance of NH_3 is 2.5×10^{-4} mol ltr^{-1} sec^{-1}. The rate of reaction & rate of disapperance of H_2 will be.

Sol. given $\frac{d}{dt}[NH_3] = 2.5 \times 10^{-4}$ — (1)

(i) $r.o.r. = \frac{1}{2}\frac{d}{dt}[NH_3] \Rightarrow r.o.r. = \frac{1}{2} \times 2.5 \times 10^{-4}$ (1.25)

$r.o.r. = 1.25 \times 10^{-4}$ mol. ltr^{-1} sec^{-1} Ans.

(ii) $r_{H_2} = -\frac{d}{dt}[H_2] \Rightarrow ?$

We know that:- $r.o.r = -\frac{1}{3}\frac{d}{dt}[H_2] = \frac{1}{2}\frac{d}{dt}[NH_3]$

$\Rightarrow -\frac{1}{3}\frac{d}{dt}[H_2] = \frac{1}{2}\frac{d}{dt}[NH_3]$

$\Rightarrow -\frac{d}{dt}[H_2] = \frac{3}{2}\frac{d}{dt}[NH_3] \Rightarrow -\frac{d}{dt}[H_2] = \frac{3}{2} \times 2.5 \times 10^{-4}$ (1.25)

$-\frac{d}{dt}[H_2] = 3.75 \times 10^{-4}$ Ans.

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Q.3. For a general Chemical rexn -
$2A + 3B \longrightarrow P$; the rate of disapperance of A is r_1
& B is r_2. The rate r_1 & r_2 are related as -

(a) $3r_1 = 2r_2$ (b) $r_1 = r_2$ (c) $2r_1 = 3r_2$ (d) $r_1^2 = 2r_2^2$

Sol. given :- $-\frac{d}{dt}[A] = r_1$; $-\frac{d}{dt}[B] = r_2$

we know :- $-\frac{1}{2}\frac{d}{dt}[A] = -\frac{1}{3}\frac{d}{dt}[B]$

$\Rightarrow \frac{1}{2}\cdot r_1 = \frac{1}{3}\cdot r_2 \Rightarrow$ $\boxed{3r_1 = 2r_2}$