Chemical Kinetics – 04

Initial Rate Method to find Rate Law & Order of Reaction

we have studied that, for a Reaction

$$2A + 3B \longrightarrow 4C$$

$$\text{Rate of Reaction} = ROR = r = K[A]^x[B]^y$$

$K \rightarrow$ Rate Constant
$[A] \rightarrow$ Concentration of A
$[B] \rightarrow$ " " B
$x \rightarrow$ order of Reaction w.r.t A
$y \rightarrow$ " " " " B
$x + y = n =$ overall order of reaction

Rate Law expression $r = K[A]^x[B]^y$ & order (n) can be obtained <u>experimentally only</u>

For a Reaction $2A + B \longrightarrow$ Products following data is available, write Rate Law expression & find order of Reaction & rate Constant

Initial [A] (in mol/L)	Initial [B] (in mol/L)	Initial (r) Rate of Reaction (in mol/L/s)
0.1	0.1	2×10^{-3}
0.1	0.2	1×10^{-3}
0.2	0.1	4×10^{-3}

Solution Let $ROR = K[A]^x[B]^y$

put the values available

$$2\times10^{-3} = K[0.1]^x[0.1]^y \quad -(i)$$

$$4\times10^{-3} = K[0.1]^x[0.2]^y \quad -(ii)$$

$$4\times10^{-3} = K[0.2]^x[0.1]^y \quad -(iii)$$

(ii) ÷ (i)

$$\frac{1}{2} = 2^y \Rightarrow 2^{-1} = 2^y \quad \boxed{y = -1}$$

(iii) ÷ (i)

$$2 = 2^x \Rightarrow \boxed{x = 1}$$

$$ROR = K[A]^1[B]^{-1}$$

order of reaction = 1 − 1 = 0 Zero ord

from (i)

$$2\times10^{-3} = K[0.1]^1[0.1]^{-1}$$

$$2\times10^{-3} = K(0.1)^0$$

$$\boxed{K = 2\times10^{-3} \text{ mol } l^{-1} s^{-1}}$$

Rate constant

So, $ROR = 2\times10^{-3}[A]^1[B]^{-1}$

Q2) Find Order of Reaction, Rate constant, write Rate Law expression

Initial [A] (mol/L)	Initial [B] (mol/L)	Initial ROR (Mol/Ls)
0.2	0.1	1×10^{-3}
0.2	0.2	4×10^{-3}
0.4	0.2	0.25×10^{-3}

Solution: Let $ROR = K[A]^x[B]^y$

put values;

$$1\times10^{-3} = K[0.2]^x[0.1]^y \quad \text{(i)}$$

$$4\times10^{-3} = K[0.2]^x[0.2]^y \quad \text{(ii)}$$

$$0.25\times10^{-3} = K[0.4]^x[0.2]^y \quad \text{(iii)}$$

(ii) ÷ (i)

$$4 = 2^y \Rightarrow y = 2$$

(iii) ÷ (ii) $\quad \frac{1}{16} = 2^x \Rightarrow 2^{-4} = 2^x \Rightarrow x = -4$

$$ROR = K[A]^{-4}[B]^2$$

using (i)

$$1\times10^{-3} = K[0.2]^{-4}[0.1]^2$$

$$K = \frac{10^{-3}}{\left(\frac{2}{10}\right)^{-4}\times\left(\frac{1}{10}\right)^2} = \frac{10^{-3}\times\left(\frac{2}{10}\right)^4\times10^2}{} = 16\times10^{-5}$$

$$ROR = 16 \times 10^{-5} [A]^{-4} [B]^{2}$$

Short cut:

Q1)

	[A]	[B]	ROR
Constant	0.1	0.1	2×10^{-3}
double	0.1	0.2 (double)	1×10^{-3} (halved)
double	0.2	0.1 (Constant)	4×10^{-3} (doubled)

$ROR \propto [B]^{-1}$

$ROR \propto [A]^{1}$

$\Rightarrow ROR = K [A]^{1} [B]^{-1}$

Q2)

	[A]	[B]	ROR
Constant	0.2	0.1	1×10^{-3}
double	0.2	0.2 (double)	4×10^{-3} (4 times increases)
double	0.4	0.2 (Constant)	0.25×10^{-3} (16 times decreases)

$ROR \propto [B]^{2}$

$ROR \propto [A]^{-4}$

$$ROR = K [A]^{-4} [B]^{2}$$

Q3) 2014 IIT JEE Main

$$2A + B \longrightarrow C + D$$

Initial [A] (Mol/l)	Initial [B] (Mol/l)	Initial Rate of Formation of C (Mol/l
0.1	0.1	1.2×10^{-3}
0.1	0.2	1.2×10^{-3}
0.2	0.1	2.4×10^{-3}

The rate Law for formation of C

$\frac{dC}{dt}$ = a) $K[A][B]$ b) $K[A]^2[B]$
c) $K[A][B]^2$ d) $K[A]$

Solution

[A]	[B]	ROR	
0.1	0.1	1.2×10^{-3}	
Constant 0.1	double 0.2	$P.2 \times 10^{-3}$	No change
double 0.2	Const 0.1	2.4×10^{-3}	

ROR $\propto [B]^0$

double → ROR $\propto [A]^1$

(Note that $2A + B \longrightarrow C + D$

$ROR = -\frac{1}{2}\frac{dA}{dt} = -\frac{1}{1}\frac{dB}{dt} = +\frac{dC}{dt} = +\frac{dD}{dt}$)

So $\frac{dC}{dt} = ROR$

$\frac{dC}{dt} = ROR = K[A]^1[B]^0$

$= K[A]$

Q4) IIT Advance 2014 for $M \longrightarrow N$

the Rate of dissapearance of M increases by a factor of 8 upon doubling the concentration of M. The order of reaction w.r.t M is.

a) 4 b) 3 c) 2 d) 1

Solution) $ROR = -\frac{1}{1}\frac{dM}{dt} = +\frac{1}{1}\frac{dN}{dt}$

↓

ROR = Rate of dissapearance of M

M	ROR
1	x
2	$8x$

$ROR \propto [M]^3$

order w.r.t $M \longrightarrow 3$

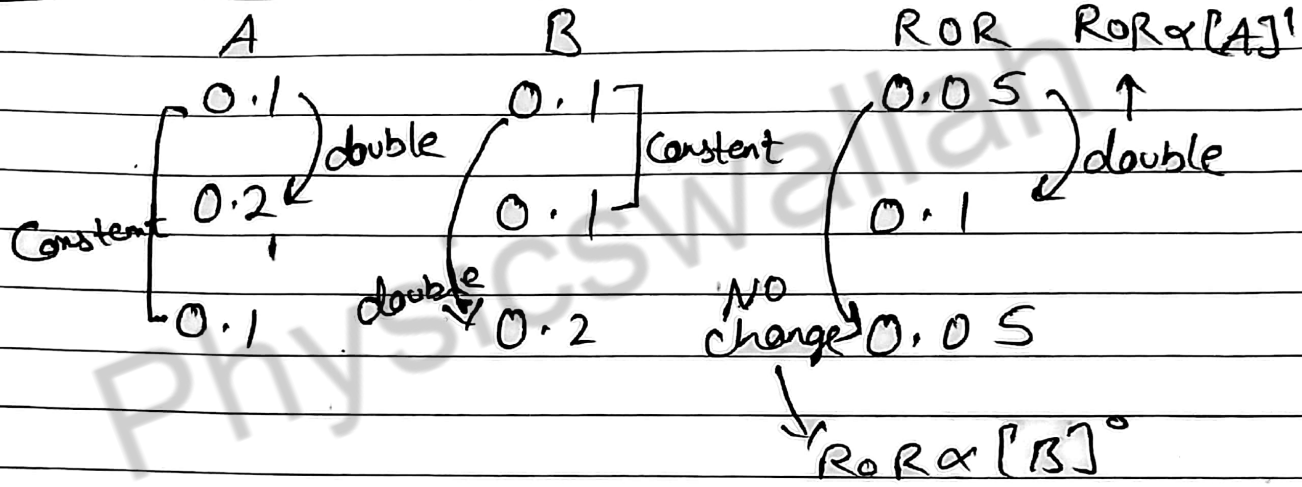
Home work

Q5) IIT 2004

Initial [A] (mol/L)	Initial [B] (mol/L)	Initial Rate
0.1	0.1	0.05
0.2	0.1	0.1
0.1	0.2	0.05

Write Rate equation & find rate constant

Solution:



$$ROR = K[A]^1[B]^0$$

$$0.05 = K[0.1]^1[0.1]^0$$

$$\boxed{K = 0.5}$$ Rate constant

$$ROR = 0.5[A]^1[B]^0$$