FREE NOTES · NCERT + JEE/NEET LEVEL

Chemical Kinetics

Reaction ka rate, use badalne wale factors, rate law, order aur molecularity, zero aur first order ke integrated equations, half-life, pseudo first order, Arrhenius equation, activation energy aur collision theory.

01 Reaction ka rate
02 Rate ko badalne wale factors
03 Rate law & order
04 Molecularity
05 Zero order reactions
06 First order reactions & half-life
07 Arrhenius equation & activation energy
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01 Reaction ka rate

Rate = per unit time concentration me badlav. Unit: mol L^{-1} s^{-1}.

$$\text{Average rate} = -\Delta[R]/\Delta t = +\Delta[P]/\Delta t$$

$$\text{Instantaneous rate} = -d[R]/dt \text{ ([R]–t curve pe tangent ka slope)}$$

$$aA + bB \rightarrow cC + dD \text{ ke liye: } \text{rate} = -(1/a)d[A]/dt = -(1/b)d[B]/dt = (1/c)d[C]/dt = (1/d)d[D]/dt$$

Example: $2N_2O_5 \rightarrow 4NO_2 + O_2$ ⇒ rate = -½ $d[N_2O_5]/dt$ = ¼ $d[NO_2]/dt$ = $d[O_2]/dt$.

02 Rate ko badalne wale factors

- **Concentration:** zyada reactant ⇒ zyada collisions ⇒ tez (zero order chhod ke).
- **Temperature:** har 10°C badhne pe rate lagbhag double (temperature coefficient ≈ 2–3).
- **Catalyst:** kam E_a wala naya raasta deta. ΔH, ΔG ya equilibrium constant nahi badalta, bas equilibrium jaldi aata hai.
- **Surface area:** powder, tukde se tez react karta.
- **Reactants ka nature** aur **light** (photochemical reactions).

03 Rate law & order

$$\text{Rate} = k\,[A]^x\,[B]^y$$

x aur y **experiment se** milte hain, balanced equation se nahi. Order = x + y. Order 0, fraction, ya negative bhi ho sakta. k = rate constant (sirf temperature pe depend).

Order	k ki unit	Example
0	mol L^{-1} s^{-1}	Garam Pt pe $2NH_3 \rightarrow N_2 + 3H_2$; gold pe 2HI
1	s^{-1}	Radioactive decay, N_2O_5 ka tootna
2	L mol^{-1} s^{-1}	$2NO_2 \rightarrow 2NO + O_2$
n	$(\text{mol } L^{-1})^{1-n}$ s^{-1}	General

INITIAL RATE METHOD

[B] fix rakho, [A] double karo. Rate double ⇒ A me order 1; 4 guna ⇒ order 2; koi badlav nahi ⇒ order 0.

04 Molecularity

Order	Molecularity
Experimental	Theoretical: ek **elementary step** me takrane wale species ki ginti
0 ya fraction ho sakta	Hamesha poora number 1, 2 ya 3 (kabhi 0 nahi)
Poore reaction ke liye	Sirf elementary step ke liye

Complex reaction me **sabse slow step rate decide karta** hai (rate-determining step). Overall order = slowest step ki molecularity (jab koi fast pre-equilibrium na ho).

PSEUDO FIRST ORDER

Ek reactant bahut zyada matra me hai, to uska concentration lagbhag nahi badalta. Paani me ethyl acetate ka hydrolysis: $CH_3COOC_2H_5 + H_2O \rightarrow CH_3COOH + C_2H_5OH$, rate = k′[ester]. Cane sugar ka inversion bhi example hai.

05 Zero order reactions

Rate $= k[R]^0 = k$

$$[R] = [R]_0 - kt$$

$t_{1/2} = [R]_0/2k$ (shuruaati concentration pe depend)

[R] vs t ka graph seedhi line, slope -k. Tab hota jab catalyst ki surface poori bhari (saturated) ho.

06 First order reactions & half-life

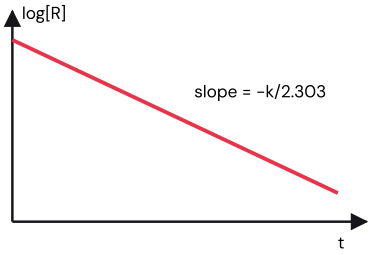
$$k = (2.303/t)\log([R]_0/[R])$$

$[R] = [R]_0\, e^{-kt}$

$\mathbf{t_{1/2} = 0.693/k}$ (concentration pe depend nahi)

$t_{99.9\%} \approx 10\ t_{1/2}$, n half-lives ke baad $[R] = [R]_0/2^n$

Gas phase A(g) → B(g) + C(g): $k = (2.303/t)\log[p_o/(2p_o - p_t)]$.



First order: log[R] vs t seedhi line

JALDI PEHCHANO

Baar baar same half-life ⇒ first order. Saara radioactive decay first order hai.

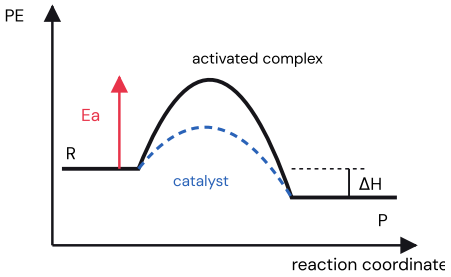
07 Arrhenius equation & activation energy

$$k = A\, e^{-E_a/RT}$$

$$\log k = \log A - E_a/(2.303RT)$$

$$\log(k_2/k_1) = [E_a/(2.303R)] \times [(T_2 - T_1)/(T_1T_2)]$$

A = frequency (pre-exponential) factor. ln k vs 1/T seedhi line, slope $-E_a/R$. $e^{-Ea/RT}$ = un molecules ka fraction jinki energy ≥ E_a.



Energy profile: catalyst Ea ghatata, ΔH same rehta

Activation energy: wo minimum extra energy jo reactants ko **activated complex** banane ke liye chahiye. E_a zyada ⇒ reaction slow. T badhane pe E_a se upar wale molecules badh jaate (Maxwell-Boltzmann curve right khisak ke chapti hoti).

08 Collision theory

Molecules ka **takrana** zaroori hai. Takkar tabhi kaam ki jab (1) energy ≥ threshold energy aur (2) **orientation sahi** ho.

$$\text{Rate} = P\, Z_{AB}\, e^{-E_a/RT}$$

Z_{AB} = collision frequency, P = orientation ka probability (steric) factor. Threshold energy = E_a + reactants ki average energy.

09 JEE Extra + Tricks

JEE LEVEL

- Half-life: zero order $t_{½} = [A]_o/2k$ ($\propto [A]_o$); first order $t_{½} = 0.693/k$ (independent); second order $1/(k[A]_o)$.
- First order: 75% ke liye 2 $t_{½}$, 87.5% ke liye 3 $t_{½}$, 99.9% ≈ 10 $t_{½}$.
- k ki units: $(\text{mol L}^{-1})^{1-n}\ \text{s}^{-1}$ ⇒ zero order mol L^{-1} s^{-1}, first s^{-1}, second L mol^{-1} s^{-1}.
- Arrhenius: $k = Ae^{-Ea/RT}$; $\log(k_2/k_1) = (Ea/2.303R)(1/T_1 - 1/T_2)$. Thumb rule: 10 °C pe rate double.
- Pseudo-first order: zyada paani me ester hydrolysis, cane sugar ka inversion.
- Catalyst forward aur backward dono ki Ea barabar ghataata; ΔH ya K nahi badalta.

10 Solved numericals

Q1. First order reaction ka $k = 1.15 \times 10^{-3}\ s^{-1}$. $t_{½}$ nikalo.

$t_{½} = 0.693/1.15 \times 10^{-3} =$ **≈ 602.6 s**.

Q2. First order reaction 32 min me 75% poora hota. 50% kab hoga?

75% = 2 half-lives ⇒ $t_{½}$ = **16 min**.

Q3. 300 K se 310 K pe rate constant double ho jaata. E_a nikalo. (R = 8.314)

$\log 2 = E_a/(2.303 \times 8.314) \times 10/(300 \times 310) \Rightarrow 0.301 = E_a \times 10/(19.147 \times 93000) \Rightarrow E_a \approx$ **53.6 kJ/mol**.

Q4. A + B → P me [A] double karne pe rate double, [B] double karne pe 4 guna. Rate law?

Rate = $k[A][B]^2$, overall order **3**.

11 Mistakes, formula sheet & practice

- Balanced equation ke coefficients se order le lena.
- Kehna ki molecularity zero ya fraction ho sakti hai.
- Sochna ki catalyst ΔH ya equilibrium constant badalta hai.
- Natural log ke saath 2.303 bhi laga dena (ya ln, ya 2.303 × log, dono nahi).

Zero order	$[R] = [R]_0 - kt$; $t_{1/2} = [R]_0/2k$
First order	$k = (2.303/t)\log([R]_0/[R])$; $t_{1/2} = 0.693/k$
Arrhenius	$k = Ae^{-Ea/RT}$
Do temperatures	$\log(k_2/k_1) = Ea(T_2-T_1)/(2.303RT_1T_2)$
k ki units	$(\text{mol L}^{-1})^{1-n}\ \text{s}^{-1}$

1. k ki unit L mol^{-1} s^{-1} hai. Order?
2. Samay ke saath rate kyun girta hai?
3. Zero order me $[R]_0$ double karne pe $t_{1/2}$?
4. Rate-determining step kya hai?

ANSWERS

1) Second · 2) Reactant ka concentration ghatta jaata · 3) Double · 4) Mechanism ka sabse slow step, jo poore reaction ka rate tay karta

12 Quick revision: exam se 5 minute pehle

BASICS

- Rate = -(1/a) d[A]/dt.
- Order: experimental, 0/fraction ho sakta.
- Molecularity: sirf 1, 2, 3.

EQUATIONS

- Zero: $[R] = [R]_0 - kt$.
- First: $t_{1/2} = 0.693/k$.
- $k = Ae^{-Ea/RT}$.

GRAPHS

- Zero: [R] vs t seedhi.
- First: log[R] vs t seedhi.
- ln k vs 1/T: slope -Ea/R.

CATALYST

- Sirf Ea ghatata.
- ΔH, ΔG, K same.
- Kaam ki takkar = energy + orientation.

Koi doubt? padhaiadda.netlify.app pe AI Doubt Solver se poocho, ya is chapter ka mock test do.