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Deg - I(H/S) - Chemical - Kinetics

Topics - Numerical - Problem based
upon various Topics.

(A) Rates of Reaction

Example - (1) In a reaction, the
Concⁿ of reactant (A) change
from 0.200 mol/lit to 0.150 mol/lit
in 10 minutes. What is the average
rate of reaction during this interval?

Solution: - $A \longrightarrow \text{Product}$

$$[A]_{\text{initial}} = 0.200 \text{ mol/lit}$$

$$[A]_{\text{final}} = 0.150 \text{ mol/lit}$$

$$\Delta \text{ Time} = 10 \text{ minutes}$$

$$\begin{aligned}\Delta [A] &= [A]_{\text{final}} - [A]_{\text{initial}} \\ &= 0.150 - 0.200 \\ &= -0.050 \text{ mol/lit}\end{aligned}$$

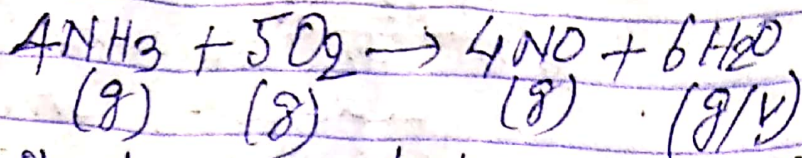
Now average Rate

$$= \frac{-\Delta [A]}{\Delta t}$$

$$= \frac{0.050}{10}$$

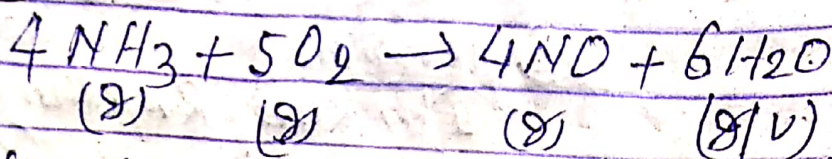
$$= 0.005 \text{ mol lit}^{-1} \text{ min}^{-1}$$

Example (2) Ammonia & oxygen react at high temp^r as.



If rate of formation (appearance) of NO is $3.6 \times 10^{-3} \text{ mol/lit/second}$ ($\text{mol L}^{-1} \text{s}^{-1}$). Calculate (a) rate of disappearance of NH_3 (b) rate of appearance of water.

Solution:—



Rate-expression is expressed as

$$\text{Rate} = -\frac{1}{4} \frac{d[\text{NH}_3]}{dt} = -\frac{1}{5} \frac{d[\text{O}_2]}{dt} = +\frac{1}{4} \frac{d[\text{NO}]}{dt} = \frac{1}{6} \frac{d[\text{H}_2\text{O}]}{dt}$$

(a) Rate of disappearance of NH_3

$$-\frac{1}{4} \frac{d[\text{NH}_3]}{dt} = \frac{1}{4} \frac{d[\text{NO}]}{dt}$$

$$= 3.6 \times 10^{-3} \text{ mol L}^{-1} \text{s}^{-1}$$

(b) Rate of appearance of H_2O

$$\frac{1}{6} \frac{d[\text{H}_2\text{O}]}{dt} = \frac{1}{4} \frac{d[\text{NO}]}{dt}$$

$$\text{or, } \frac{d[\text{H}_2\text{O}]}{dt} = \frac{6}{4} \frac{d[\text{NO}]}{dt} = \frac{6}{4} \times 3.6 \times 10^{-3}$$

$$= 5.4 \times 10^{-3} \text{ mol L}^{-1} \text{s}^{-1}$$

③ Rate - expression & order of Reaction

Exaple - ③
From the following data given for three
Reactant $A+B+C \rightarrow$ Product

	[A]	[B]	[C]	Rate
I -	0.1	0.1	0.1	$10 \text{ mol L}^{-1} \text{ s}^{-1}$
II -	0.2	0.1	0.1	20 " " "
III -	0.1	0.2	0.1	40 " " "
IV -	0.1	0.1	0.3	10 " " "

Determine.

- Rate expression
- Order of Reaction
- Rate - Constant.

Solution: - From given data.

- (a) If concn of A is doubled keeping B & C constant rate is also double.

Thus $\text{rate} \propto [A]$

Anilinary for reactant B, rate even four times, $\text{rate} \propto [B]^2$

But for C, No effect upon rate

Thus $\text{rate} \propto [C]^0$

The Overall rate is expressed as

$$\text{rate} = K \cdot [A]^1 [B]^2 [C]^0$$

Rate expressed, $\text{Rate} = K [A] [B]$

(b) Order of Reaction = $1 + 2 + 0$
 $= 3$

∴ Third order Reaction.

(c) Determination of Rate Constant.
By taking any one expression step
in given data, putting the value
of rate & various concs of A, B
& C.

$$\text{Rate} = K [A]^1 [B]^2 [C]^0$$

$$10 = K \times 0.1 \times (0.1)^2 \times (1)^0$$

or

$$10 = K \times 0.1 \times 0.01 \times 1$$

or

$$10 = K \times 0.001$$

or

$$K = \frac{10}{0.001} = 10^4$$

Examp 6 (4) For a Reaction
 $A + B \rightarrow \text{Products}$

its rate expressed as

$$\text{rate} = K \cdot [A]^{\frac{1}{3}} [B]^2$$

Calculate (a) order of Reaction
(b) unit of Rate Constant

Solution:- $\text{Rate} = k[A]^{\frac{1}{3}}[B]^2$

(a) order of Rxn

$$= \frac{1}{3} + 2 = \frac{7}{3}$$

$$= 2.33$$

(b) unit of k

$$= \frac{\text{Rate}}{(\text{mol/l})^{\frac{1}{3}} (\text{mol/l})^2}$$

$$= \frac{\text{mol/l} \cdot \text{s}^{-1}}{(\text{mol/l})^{\frac{7}{3}}}$$

$$= \text{mol}^{-\frac{4}{3}} \text{l}^{\frac{4}{3}} \text{s}^{-1}$$

Examp-5

For the Reaction $2A \rightarrow X_2$
 the rate of Reaction becomes 27 times
 when the conc of A is increased
 three-times. What is the order of Reaction.

Solution:- let the order of Rxn
 is n .

In Case-I $\text{Rate} = k[A]^n$ — (1)

In Case-II $27 \times \text{Rate} = k[3A]^n$ — (2)

Divide - (2) by (1)

$$\frac{27 \times \text{Rate}}{\text{Rate}} = \frac{k[3A]^n}{k[A]^n}$$

$$27 = \frac{[3A]^n}{[A]^n} = \frac{3^n A^n}{A^n}$$

$\therefore 3^n = 27 = (3)^3 \therefore n = 3$