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30-07-20

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

Topics - Numerical - problem based upon various Topics.

(A) Rates of Reaction

Example - (1) In a reaction, the Conc^{n} 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:- $A \longrightarrow$ Product

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

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

Time = 10 minutes

$\Delta[A] = [A]_{final} - [A]_{initial}$

$= 0.150 - 0.200$

$= -0.050$ mol/lit

Now average Rate

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

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

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

Example (2) Ammonia & Oxygen react at high temp^{r} as.

$$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$$
$$(g) \quad (g) \quad (g) \quad (g/l)$$

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

Solution:-

$$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$$
$$(g) \quad (g) \quad (g) \quad (g/l)$$

Rate-expression is expressed as

$$Rate = -\frac{1}{4}\frac{d[NH_3]}{dt} = -\frac{1}{5}\frac{d[O_2]}{dt} = +\frac{1}{4}\frac{[NO]}{dt} = \frac{1}{6}\frac{d[H_2O]}{dt}$$

(a) Rate of disappearance of NH_3

$$-\frac{1}{4}\frac{d[NH_3]}{dt} = \frac{1}{4}\frac{[NO]}{dt}$$
$$= 3.6 \times 10^{-3}\ mol\,L^{-1}s^{-1}$$

(b) Rate of appearance of H_2O.

$$\frac{1}{6}\frac{d[H_2O]}{dt} = \frac{1}{4}\frac{d[NO]}{dt}$$

or, $\frac{d[H_2O]}{dt} = \frac{6}{4}\frac{d[NO]}{dt} = \frac{6}{4} \times 3.6 \times 10^{-3}$

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

(B) Rate-expression & order of Reaction

Example - (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 mol $L^{-1} s^{-1}$
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.

(a) Rate expression
(b) Order of Reaction
(c) Rate-Constant.

Solution:- from given data,

(a) If Conc^n of A is doubled keeping B & C constant rate is also doubled

Thus rate $\propto [A]$

Similiarly for reactant B, rate increases four times, rate $\propto [B]^2$

But for C, No effect upon Rate

Thus rate $\propto [C]^0$

The Overall rate is expressed as

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

Rate expressed, Rate $= K[A][B]$

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

$= 3$

So, Third order Reaction.

(c) Determination of Rate Constant

By taking any one step in given data, putting the value of rate & various concns 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, $K = \frac{10}{0.001} = 10^4$

Example (4) For a Reaction

$A + B \longrightarrow$ Products

its rate expressed as

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

Calculate (a) order of Reaction

(b) Unit of Rate Constant

Solution:— $\text{rate} = K[A]^{1/3}[B]^2$

(a) order of Rxn $= 1/3 + 2 = 7/3$
$= 2.33$

(b) Unit of K. $= \frac{\text{Rate}}{(\text{mol}/\text{lit})^{1/3}\cdot(\text{mol}/\text{lit})^2}$

$= \frac{\text{mol lit}^{-1}\,\text{s}^{-1}}{(\text{mol}/\text{lit})^{1/3}\cdot(\text{mol}/\text{lit})^2}$

$= \text{mol}^{-4/3}\,L^{4/3}\,s^{-1}$

Example-(5).

For the Reaction $2A \longrightarrow X_2$ the rate of Reaction becomes 27-times when the Conc^n of A is increased three-times. What is the order of Reaction.

Solution:- Let the order of Rxn is n.

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

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

Divide-(2) by (1)

$$\frac{27 \times \text{rate}}{\text{rate}} = \frac{K[3A]^n}{K[A]^n}$$

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

$\therefore 3^n = 27 = (3)^3 \quad \therefore \boxed{n = 3}$