Class:- IX

IIT Advanced

Order of Reaction

Teaching Task

Q1) Ans:- C.

Solution:- Molecularity of a reaction is the no. of reacting species taking part in elementary reaction. So, the molecularity of a reaction is always a positive integer, it can not be negative or a fraction.

Q2) Ans:- B

Solution:- Molecularity is not the sum of stoichiometric coefficients of the reactants. It is equal to the no. of molecules that actually collide to bring about the reaction.

Q3) Ans:- D.

Solution:- Molecularity always positive whole number and it can't be zero & fractional.

Q4) Ans:- B.

Solution:- Molecularity → no. of molecules take part

Order → Sum of powers to which the reactant concentrations.

For Elementary reaction only,

Molecularity = order.

Q5) Ans:- B

Solution:- The integrated rate law for the 1st order reaction is $K = \frac{2.303}{t} \log \frac{a}{a-x}$.

$$\log \frac{a-x}{a} = \frac{kt}{2.303} + 0$$

It is the form of straight line $y = mx + c$

∴ In a 1st order reaction, when $\log\left[\frac{a}{a-x}\right]$ is plotted against time, the graph obtained is a straight line having the slope $\frac{K}{2.303}$.

Q6) Ans:- A

Solution:- $K = \frac{1}{t} \times \ln\left(\frac{a}{a-x}\right)$.

1st order reaction, $a - x = ae^{-kt}$

where $(a-x)$ is the concentration of reactant A at any time, t.

when the reaction goes to completion.

$a - x = 0$ then

$ae^{-kt} = 0 \Rightarrow t = \infty$.

Q7) Ans:- C

Solution: $\log\left(\frac{a}{a-x}\right) = \frac{kt}{2.303}$.

$\log(a-x) = \frac{-kt}{2.303} + \log a. \Rightarrow y = mx + c$

The plot of 't' against $\log(a-x)$ gives a straight line with slope equal to $\frac{-K}{2.303}$.

Q8) Ans:- B.

Solution:-

Time require for 75% completion $(A \rightarrow A/4) = 2\, t_{1/2}$

99.9% Completion $= 10 \times t_{1/2}$

$t_{99.9\%} = 10 \times t_{50\%} = 10 \times 1 = 10$ hours

Q9) Ans:- B

Solution:- $t_{1/2} = \frac{2.303}{k} \log(2) = \frac{0.693}{k}$.

Half life of a 1st order reaction is given by $0.693/k$.

Q10) Ans:- B.

Solution:- 1st order half-life $= \frac{0.693}{k}$.

93.75% of reaction completed in 50 minutes.

Remaining is : $1 - 0.9375 = 0.0625$

1st order formula:- $0.0625 = e^{-k(50)}$

$\ln(0.0625) = -k\,50.$

$-2.772 = -50k.$

$k = \frac{2.772}{50} = 0.05544\ \text{min}^{-1}.$

Calculate Half life

$t_{1/2} = \frac{0.693}{k} = \frac{0.693}{0.05544}$

$= 12.5$ min

Q11) Ans:- A, B, D

Solution:-

A). zero order reaction, $t_{1/2} = \frac{[A]_0}{2K}$.

Half life is directly proportional to initial Concentration $[A]_0$.

B) Average life of first order

$$t_{1/2} = \frac{0.693}{K}.$$

$$T = \frac{1}{0.693} \times t_{1/2} \simeq 1.44 \times t_{1/2}$$

C) For 2nd order reaction, 75% completion can be derived, but it not exactly three times $t_{1/2}$.

D) First order reaction:-

$$1 - 0.999 = 0.001$$

$$0.001 = e^{-0.0693 \times 100}.$$

$$\ln(0.001) = 0.0693 \times 100$$

$$-6.907 \equiv -6.93$$

Q12) Ans:- A, B, D.

Solution:-

A) For elementary reactions, order = molecularity.

B) Order can be fraction, negative or positive.

D) Molecularity is always a whole number.

Q13) Ans:- A.

Solution:- $A + B \rightarrow$ products

$Rate = K[A]^2 \rightarrow$ No effect of $[B]$

$Rate = K[A][B]$

$Rate = K[B]^2 \rightarrow$ No effect of $[A]$.

So, some times $[A]$ or $[B]$ may or may not influence the rate.

Q14) Ans:- B.

Solution:- Order of reaction is experimentally determined and can be fractional.

For an elementary reaction, partial orders are determined by reaction stoichiometry.

Q15) Ans:- B

Solution:- When A is taken in excess, its concentration will become constant, the rate law may..

$Rate = K[B]^2$

order $= 2$.

Q16) Ans:- B.

Solution:- Rate depends on slow step.

$$NO_2 + O_3 \rightarrow NO_3 + O_2$$

$$R = K[NO_2][O_3]$$

Molecularity $= 2$

Integer Type

Q17) Ans:- 2.

Solution:- $t_{1/2} = \frac{1}{Ka}$ for 2nd order reaction.

Q18) Ans:- 0.001 sec^{-1}.

Solution:- $t_{1/2} = \frac{0.693}{K}$.

$t_{1/2} = 693$ sec.

$693 = \frac{0.693}{K}$, $K = \frac{0.693}{693} = \frac{\cancel{693} \times 10^{-3}}{\cancel{693}}$

$K = 10^{-3} = 0.001\ sec^{-1}$.

Matrix Matching

Q19) Ans:- A) 3 B) 1 C) 4 D) 2

Solution:-

A) Formation of H_2 → 3) 2nd order reaction because the rate depends on the concentration of Hydrogen atoms squared.

B) Depletion of O_3 → 1) First order.

C) Elementary process → 4) Reaction mechanism

D) Order of reaction → 2) Depends on slow step.

Learner's Task

Q1) Ans:- D

Solution:- $t_{1/2} \propto (CO)^0$ i.e, half life for 1st order is independent of initial concentration.

Q2) Ans:- D.

Solution:- Order of reaction is decided by,

1) Mechanism of reaction.

2) Relative Concentration of reactants.

Q3) Ans:- C

Solution:- Rate $= K[C_{12}H_{22}O_{11}]$.

Inversion of cane sugar in dilute acid is a pseudo - 1st order because in this reaction it is assumed that con. of water does not change very drastically.

Q4) Ans:- A

Solution:- $CH_3COOC_2H_5 + H_2O \xrightarrow{H^+} CH_3COOH + C_2H_5OH$

Rate $= K[CH_3COO\,C_2H_5]$

1st order reaction

Q5) Ans:- C

Solution:- Rate of zero order reaction is independent of the con. of reactants and remains constant throughout the reaction.

Q6) Ans:- D.

Solution:- Half life for nth order reaction to inital concentration.

$$t_{1/2} \propto \frac{1}{a^{n-1}}.$$

Q7) Ans:- B.

Solution:- $CH_3COO\ C_2H_5 + NaOH \rightarrow CH_3COONa + C_2H_5OH$.

$$\frac{dx}{dt} = k[CH_3COOC_2H_5]^1[NaOH]^1$$

Order = 2

Molecularity = 2

Q8) Ans:- A.

Solution:- The rate will be given by slowest step.

$$r = k[A][B_2].$$

$$A + B_2 \rightarrow AB + B \rightarrow (slow).$$

$$K_c = \frac{[AB][B]}{[A][B_2]} \quad \text{or}$$

$$K_c = \frac{[A][A]}{[A_2]}$$

$$r = K \times [K_c]^{1/2}[A_2]^{1/2}[B_2] = k[A_2]^{1/2}[B_2].$$

Order = 0.5 + 1 = 1.5

Q9) Ans:- D

Solution:- Units of first order rate constants are sec^{-1} i.e, $time^{-1}$.

Q10) Ans:- D.

Solution:- Bimolecular reactions that follow first order kinetics are called pseudo-unimolecular reactions. This can happen when one reactant is present in excess.

JEE Mains

Q1) Ans:- C

Solution:- $2NO + O_2 \rightarrow 2NO_2$

$$Rate = k[NO]^2[O_2]$$

$$Order = 2+1 = 3$$

Q2) Ans:- C

Solution:- 1st order reaction

$$K = \frac{2.303}{t} \log \frac{a}{a-x} \qquad \left[\because K = \frac{t_{1/2}}{0.93}\right]$$

$$t = \frac{2.303}{0.693} t_{1/2} \log\left(\frac{100}{100-90}\right)$$

$$= \frac{2.303 \times t_{1/2}}{0.693} \log 10 = 3.3 t_{1/2}$$

= 3.3 times that of half-life.

Q3) Ans:- C.

Solution:- $C_{12}H_{22}O_{11} + \underset{(Excess)}{H_2O} \rightarrow C_6H_{12}O_6 + C_6H_{12}O_6$

rate $\propto [C_{12}H_{22}O_{11}]$.

Molecularity = 1

Q4) Ans:- A

Solution:- $A + 2C \rightarrow C$

$$R = [A][B]^2$$

Order of $[A] = 1$, order of $[B] = 2$

Total order $= 1+2 = 3$

Q5) Ans:- D.

Solution:- $2A + B \rightarrow C + D$.

2 'A' molecules & one - B molecule involved.

Molecularity $= 2+1 = 3$

Q6) Ans:- B

Solution:- For a first-order,

$$t_{1/2} = \frac{0.693}{K}.$$

rate constant $K = 0.6932\ hr^{-1}$.

$$t_{1/2} = \frac{0.693}{0.6932} \approx 1\ hr.$$

Q7) Ans:- B.

Solution:- Half life period for 1st order reaction

$$t_{1/2} = \frac{0.693}{K}.$$

Q8) Ans:- A

Solution:- 1st order reaction, $t_{75\%} = 2\, t_{50\%}$

$t_{75\%} = 32$ min.

$32 = 2\, t_{50\%}$

$$t_{50\%} = \frac{32}{2} = 16 \text{ mins.}$$

Q9) Ans:- B.

Solution:- $t_{1/2} = \frac{0.693}{K} = \frac{0.693}{1.1 \times 10^{-9}} = 6.3 \times 10^{8}$

Q10) Ans:- B

Solution:-

$CH_3COOCH_3 + H_2O \xrightarrow{H^+} CH_3COOH + CH_3OH$

$r \propto K[CH_3COOCH_3]$

It is a pseudo unimolecular reaction

Advanced Level

Q11) Ans:- A, B, C, D

Solution:- Order may be equal to zero, positive, negative or fractional value

Q12) Ans:- A, B, C, D.

Statements

Q12) Ans:- B.

Solution:- The order of reaction = molecularity for simple reactions.

→ Molecularity can't be fractional.

Q13) Ans:- C

Solution:- A is incorrect, R is correct.

For simple reactions, order = molecularity.

→ Molecularity can't be fractional

Q14) Ans:- A

Solution:- Molecularity can not be greater than three because more than three molecules may not mutually collide with each other to have an effective collision.

Q15) Ans:- 0.693/5.7

Solution:- $t = 5.7$

$$K = \frac{0.693}{t_{1/2}} = \frac{0.693}{5.7}$$

Q16) Ans:- 0.005 min^{-1} (B)

Solution:- $K = \frac{0.693}{t_{1/2}}$

$t_{1/2} = 138.6.$

$$K = \frac{0.693}{138.6} = 0.005\ min^{-1}.$$

Integer.

Q17) Ans:- 0.693/5.7

Solution:- $K = \frac{0.693}{t_{1/2}} = \frac{0.693}{5.7}$

Q18) Ans:- 0.005 min^{-1}.

Solution:- $K = \frac{0.693}{t_{1/2}} = \frac{0.693}{138.6} = 0.005\ min^{-1}$

Matrix Matching

Q19) **Ans:-** A) 4   B) 2   C) 1   D) 3.

Solution:-

a) Unit of K is always equal to → 4) Unit of A

b) Units of K in zero order → 2) M / time

c). Unit of K in 1st order → 1) 1/time

D) Unit of k in second order → 3) $Time^{-1} M^{-1}$.

Q20) **Ans:-** a) 2   b) 4   c) 1   d) 3

Solution:- $K = Lit^{n-1}\ mole^{1-n}\ sec^{-1}$.

	Order		Rate Constant K.
a)	Zero	→	2) $Lit^{0-1} mole^{1} sec^{-1}$. $mole\ litre^{-1} sec^{-1}$.
b)	I	→	4) $Lit^{1-1}\ mole^{1-1}\ time^{-1}$. $Time^{-1}$
c)	II	→	1). $Lit^{2-1}\ mole^{1-2}\ Time^{-1}$. $litre\ mole^{-1}\ time^{-1}$
d)	III	→	3) $Lit^{3-1}\ mole^{1-3}\ time^{-1}$. $litre^{2}\ mole^{-2}\ time^{-1}$.