

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 $\rightarrow$ no. of molecules take part
Order $\rightarrow$ 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 $y = mx + c$

$\therefore$ 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 ($A \rightarrow A_{1/4}$) = $2 t_{1/2}$

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

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

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:- $0.0625 = e^{-k(50)}$

$$\ln(0.0625) = -k50.$$

$$-2.772 = -50k.$$

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

Calculate Half life

$$t_{1/2} = \frac{0.693}{k} = \frac{0.693}{0.05544} = 12.5 \text{ min}$$

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 ✓

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

$$\tau = \frac{1}{0.693} \times t_{1/2} \approx 1.44 \times t_{1/2}$$

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

D) First order reaction:-

$$1 - 0.999 = 0.001$$

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

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

$$-6.907 \approx -6.93 \quad \checkmark$$

Q12) Ans:- A, B, D.

Solution:-

A) For elementary reaction, order = molecularity.

B) Order can be fraction, negative or positive.

D) Molecularity is always a whole number.

Q13) Ans:- A.

Solution:- $A + B \rightarrow \text{products}$

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,

$$\text{Rate} = k[B]^2$$

$$\text{order} = 2.$$

Q16) Ans:- B.

Solution:- Rate depends on slow step.



$$R = k[\text{NO}_2][\text{O}_3]$$

$$\text{Molecularity} = 2$$

Integer Type

Q17) Ans:- 2.

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

Q18) Ans:- 0.001 sec⁻¹.

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

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

$$693 = \frac{0.693}{k}, \quad k = \frac{0.693}{693} = \frac{693 \times 10^{-3}}{693}$$

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

Matrix Matching

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

Solution:-

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

B) Depletion of $O_3 \rightarrow$ 1) First order.

C) Elementary process $\rightarrow$ 4) Reaction mechanism

D) Order of reaction $\rightarrow$ 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 = $k[CH_3COOC_2H_5]$

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 n^{th} order reaction is proportional to initial concentration.

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

Q7) Ans:- B.

Solution:- $\text{CH}_3\text{COO C}_2\text{H}_5 + \text{NaOH} \rightarrow \text{CH}_3\text{COONa} + \text{C}_2\text{H}_5\text{OH}$

$$\frac{dx}{dt} = k [\text{CH}_3\text{COO C}_2\text{H}_5] [\text{NaOH}]$$

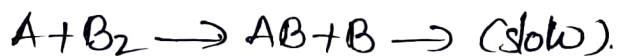
Order = 2

Molecularity = 2

Q8) Ans:- A.

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

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



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

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

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

$$\text{Order} = 0.5 + 1 = 1.5$$

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:- $2\text{NO} + \text{O}_2 \rightarrow 2\text{NO}_2$

$$\text{Rate} = k[\text{NO}]^2[\text{O}_2]$$

$$\text{Order} = 2 + 1 = 3$$

Q2) Ans:- C.

Solution:- 1st order reaction

$$k = \frac{2.303}{t} \log \frac{a}{a-x} \quad \left[\because k = \frac{t_{1/2}}{0.693} \right]$$

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

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

= 3.3 times that of half-life.

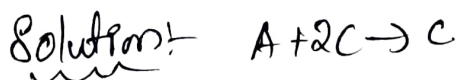
Q3) Ans:- C.

Solution:- $\text{C}_{12}\text{H}_{22}\text{O}_{11} + \text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + \text{C}_6\text{H}_{12}\text{O}_6$
(Excess)

$$\text{rate} \propto [\text{C}_{12}\text{H}_{22}\text{O}_{11}]$$

$$\text{Molecularity} = 1$$

Q4) Ans:- A

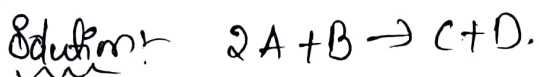


$$R = [A][B]^2$$

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

$$\text{Total order} = 1 + 2 = 3$$

Q5) Ans:- D.



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

$$\text{Molecularity} = 2 + 1 = 3$$

Q6) Ans:- B

Solution:- For a first-order,

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

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

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

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, $t_{75\%} = 2 t_{50\%}$.

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

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

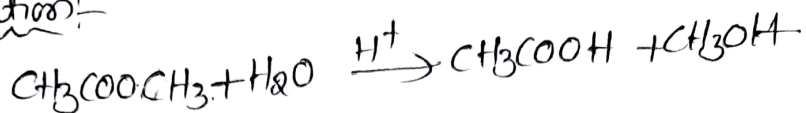
$$t_{50\%} = \frac{32}{2} = 16 \text{ min}.$$

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:



$$r \propto k [\text{CH}_3\text{COOCH}_3]$$

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

$$t_{1/2} = 138.6.$$

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

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

Matrix Matching

Q19) Ans: A) 4 B) 2 c) 1 D) 3.

Solution:

- a) Unit of k is always $\rightarrow$ 4) Unit of A equal to
b) Units of k in zero order $\rightarrow$ 2) M/time
c) Unit of k in 1st order $\rightarrow$ 1) $1/\text{time}$
d) Unit of k in second order $\rightarrow$ 3) $\text{Time}^{-1} M^{-1}$.

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

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

- | order | | Rate Constant k . |
|---------|-------------------|---|
| a) zero | $\rightarrow$ 2) | $\text{Lit}^{0-1} \text{mole}^1 \text{sec}^{-1}$
$\text{mole litre}^{-1} \text{sec}^{-1}$ |
| b) I | $\rightarrow$ 4) | $\text{Lit}^{1-1} \text{mole}^{1-1} \text{time}^{-1}$
Time^{-1} |
| c) II | $\rightarrow$ 1). | $\text{Lit}^{2-1} \text{mole}^{1-2} \text{Time}^{-1}$
$\text{litre mole}^{-1} \text{time}^{-1}$ |
| d) III | $\rightarrow$ 3) | $\text{Lit}^{3-1} \text{mole}^{1-3} \text{time}^{-1}$
$\text{litre}^2 \text{mole}^{-2} \text{time}^{-1}$ |