

Chapter	7 Reaction Kinetics	Class	1 st Year	Subject	Chemistry
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Give Short Answers of the Following Questions

1. What do you understand by the rate of a reaction?

Ans. The rate of a reaction refers to how fast or slow a chemical reaction occurs. It is defined as the change in concentration of a reactant or product per unit time.

Mathematically, the rate of reaction can be expressed as:

$$\text{Rate of reaction} = \frac{\text{Change in concentration of the substance}}{\text{Time taken for the change}}$$

$$\text{Rate of reaction} = \frac{\Delta x}{\Delta t}$$

2. Give the difference between enthalpy change of reaction and energy of activation of reaction.

Ans. Difference between Enthalpy Change of Reaction and Energy of Activation of Reaction:

Property	Enthalpy of Reaction (ΔH)	Activation Energy (E_a)
Definition	The total heat change during a chemical reaction at constant pressure.	The minimum energy required for a reaction to occur.
Significance	It indicates whether a reaction is exothermic ($\Delta H < 0$) or endothermic ($\Delta H > 0$).	It represents the energy barrier that must be overcome for a reaction to proceed.
Effect on Reaction	Reflects the overall energy change between products and reactants.	Affects the rate of the reaction; higher E_a means slower reaction.
Energy Direction	ΔH can be positive (endothermic) or negative (exothermic).	E_a is always positive, indicating an energy input is needed.
Measurement	It is the difference in the enthalpy between reactants and products.	It is determined experimentally by studying reaction rates.
Example	In the combustion of methane: $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$ ΔH is negative (exothermic).	For a reaction to occur, molecules must first overcome the activation energy, which can be lowered by a catalyst.

3. Differentiate clearly between order and molecularity of a reaction.

Ans. Difference between Order and Molecularity

Property	Order and a Reaction	Molecularity of a Reaction
Definition	The power to which the concentration of a reactant is raised in the rate law expression.	The number of reacting species (atoms, molecules, or ions) involved in the elementary step of a reaction.
Dependence on Concentration	Order depends on the experimental observation of how reaction rate changes with concentration of	Molecularity is based on the stoichiometric coefficients in the elementary reaction step.

Chapter	7 Reaction Kinetics	Class	1 st Year	Subject	Chemistry
----------------	---------------------	--------------	----------------------	----------------	-----------

Nature	Experimental: Determined by experimental data, can be fractional or zero.	Theoretical: Based on the nature of the reaction mechanism and the elementary steps.
Units	Depends on the rate law and overall reaction rate, and can vary with different reactions.	Always an integer (1, 2, 3, etc.) indicating the number of molecules or ions reacting in an elementary steps.
Example	For $A \rightarrow \text{products}$, if $\text{rate} = k[A]^2$, the order is 2.	For $A + B \rightarrow \text{products}$, the molecularity is 2 (because two molecules are involved).
Can It Be Fractional?	Yes, order can be fractional, zero, or a whole number.	No, molecularity must always be a whole number (1, 2, 3, ...).
Reactions	The order applies to overall reactions and depends on how concentration affects the rate.	Molecularity applies to the elementary step of a reaction mechanism.

4. Why the instantaneous rate changes during a reaction?

Ans. The instantaneous rate of a reaction changes during the course of the reaction because:

1. Concentration of Reactants Changes:

- As the reaction proceeds, reactant molecules are consumed to form products. This causes a decrease in the concentration of the reactants over time.
- According to the rate law, the rate of reaction depends on the concentration of reactants. As the concentration decreases, the rate of the reaction generally slows down (in the case of most reactions).

2. Effect on Rate Law:

- The rate of the reaction is often directly proportional to the concentration of reactants raised to some power (the order of the reaction).
- For example, if the rate law is $\text{rate} = k[A]^n$, as $[A]$ decreases, the rate will decrease accordingly. This change in concentration over time causes the instantaneous rate to change as well.

3. Transition from Fast to Slow Reactions:

- In initial stages, when reactants are present in higher concentrations, the reaction proceeds faster.
- As reactants are consumed and their concentrations drop, the rate of reaction decreases.

4. Reverse Reaction (if applicable):

- In reversible reactions, as products form, they can also react to regenerate reactants. This can affect the overall rate, especially as the reaction approaches equilibrium.

5. Briefly summarize the effects of temperature and surface area on the rates of reaction.

Ans. 1. Effect of Temperature on Reaction Rate:

- Increase in Temperature $\Rightarrow$ Increase in Rate of reaction.
- At higher temperatures, molecules have more kinetic energy, leading to:
 - More frequent collisions between reactant molecules.
 - More energetic collisions, increasing the chances of successful reactions (i.e., Collisions with enough energy to overcome the activation energy barrier).

Chapter	7 Reaction Kinetics	Class	1 st Year	Subject	Chemistry
---------	---------------------	-------	----------------------	---------	-----------

- **Arrhenius Equation:** The rate constant (k) increases with temperature, generally leading to a faster reaction.

2. Effect of Surface Area on Reaction Rate:

- Increase in Surface Area $\Rightarrow$ Increase in Rate of reaction.
- Smaller particles or larger surface area of reactants result in:
 - o More surface contact between reactants, leading to more collisions.
 - o Faster reaction rate as more reactant particles are exposed to react with the other reactant molecules.
- **Example:** Powdered solid reactants react faster than large chunks of the same substance because of the greater surface area available for collisions.

6. Justify that the radioactive decay is always a first order reaction.

Ans. Radioactive decay is always a first order reaction due to the nature of the process, which can be justified as follows:

First Order Reaction:

- A first order reaction is one where the rate reaction depends on the concentration of a single reactant raised to the power of 1.
- Mathematically: rate = $k[A]$, where $[A]$ is the concentration of the reactant, and k is the rate constant.

Dependence on the Number of Radioactive Nuclei:

- In radioactive decay, the rate at substance decays depends on the number of radioactive nuclei present at any given time.
- The probability that a single nucleus will decay within a given time interval is constant and independent of the number of decays that have already occurred.
- The rate of decay is proportional to the number of radioactive atoms that are still intact at any moment, i.e., the concentration of the substance.
- The half life remains constant regardless of how much material is left, further proving that radioactive decay is a first order process.

7. A reaction is second order with respect to a reactant. How is the rate of reaction affected if the square of the concentration is doubled and reduced to half?

Ans. For a second order reaction with respect to a reactant, the rate of the reaction is proportional to the square of the concentration of that reactant. This means that the rate law can be expressed as:

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

Where:

- k is the rate constant,
- $[A]$ is the concentration of the reactant.

8. What is meant by half- life and what is it used for?

Ans. Half -Life ($T_{1/2}$):

The half-life of a reaction is the time required for the concentration of a reactant to decrease to half of its initial value. It is a measure of how quickly a reaction occurs or how long it takes for a substance to undergo a certain amount of decay or transformation.

Uses:

Chapter	7 Reaction Kinetics	Class	1 st Year	Subject	Chemistry
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It is used in various fields like radioactive decay, chemical reactions, and pharmacokinetics to measure the rate of processes or determine safe and effective dosages in medicine.

9. Why does wood burn more rapidly in pure oxygen than in air?

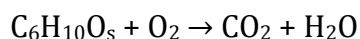
Ans. 1. Increased Oxygen Concentration:

- In air, oxygen makes up about 21% of the atmosphere, with the rest primarily consisting of nitrogen and trace gases.
- In pure oxygen, the oxygen concentration is 100%, meaning there is a much higher availability of oxygen molecules to react with the wood during combustion.
- More oxygen molecules allow the combustion reaction to proceed more quickly and at a higher rate, as there are more molecules available to support the chemical reaction.

2. Increased Rate of Combustion:

- Combustion is a chemical reaction between the fuel (in this case, wood) and oxygen. The reaction rate increases when the concentration of oxygen is higher.
- Since the combustion of wood involves breaking bonds in the wood's cellulose structure, more oxygen molecules allow the reaction to happen more efficiently and rapidly.

The general combustion reaction of wood (which primarily consists of cellulose) is:



In pure oxygen, this reaction can proceed much faster than in air.

10. A catalyst lowers the activation energy of a chemical reaction. Illustrate it.

Ans. A catalyst is a substance that lowers the activation energy of a chemical reaction, thereby increasing the reaction rate without being consumed in the process.

11. The rate constant for a certain reaction is $3.5 \times 10^{-4} \text{ s}^{-1}$ at 25°C . What is the order of the reaction? Explain based on the units of the rate constant.

Ans. It seems to a reaction with a given rate constant ($k = 3.5 \times 10^{-4} \text{ s}^{-1}$) at a specific temperature (25°C). This rate constant suggests that the reaction may follow first-order kinetics, where the rate of reaction depends linearly on the concentration of the reactant.

Here are some key points about rate constants and their interpretation:

First Order Kinetics:

For a reaction with first-order kinetics, the rate law is given by:

$$\text{rate} = k[\text{A}]$$

Where:

- k is the rate constant (in this case, $3.5 \times 10^{-4} \text{ s}^{-1}$)
- $[\text{A}]$ is the concentration of the reactant.

The units of k for a first-order reaction are s^{-1} seconds inverse, which is consistent with the given rate constant.

“The number of reacting molecules whose concentration alters as a result of the chemical change is called order of reaction.”

OR

“The sum of all the exponents to which the concentrations in the rate equation are raised is called order of reaction.”

Order of a reaction decides the units of rate constant a reaction.

Explanation:

Chapter	7 Reaction Kinetics	Class	1 st Year	Subject	Chemistry
---------	---------------------	-------	----------------------	---------	-----------

The units of the rate constant (k) reveal the reaction order:

- **First-Order (s^{-1}):** Rate depends linearly on concentration (Rate = $k[A]$).
- **Second-Order ($dm^3 mol^{-1} s^{-1}$):** Rate depends on concentration squared (Rate = $k[A]^2$).
- **Zero-Order ($k = mol.dm^3 s^{-1}$):** Rate independent of concentration.

12. If the initial concentration of the reactant is 0.50 mol dm^{-3} , calculate the initial rate of the reaction.

Ans. For a first-order reaction, the rate law is:

$$\text{rate} = k[A]$$

Where:

- Rate is the initial rate of the reaction,
- k is the rate constant (given as $3.5 \times 10^{-4} s^{-1}$)
- [A] is the initial concentration of the reactant (given as 0.50 mol/dm^3).

Substitute the Given Values:

$$\text{Rate} = (3.5 \times 10^{-4} s^{-1}) \times 0.50 \text{ mol/dm}^3$$

$$\text{Rate} = 1.75 \times 10^{-4} \text{ mol/dm}^3 s$$

13. How would the rate of this reaction change if the concentration of the reactant were double

Ans. The reaction is first-order the rate is directly proportional to the concentration of the reactant.

Rate law:

$$\text{rate} = k[A]$$

If the initial concentration is doubled, say from [A] to $2[A]$, then:

$$\text{New rate} = k(2[A]) = 2. (k [A]) = 2 \times \text{original rate}$$

14. A certain first order reaction has a rate constant of $3.5 \times 10^{-4} s^{-1}$. Calculate the half- life of the reaction in minutes.

Ans. Half- life formula (for first-order reaction):

$$t_{1/2} = \ln 2/k$$

Where:

$$t_{1/2} = \text{half-life}$$

$$\ln 2 \approx 0.693$$

$$k = 2.5 \times 10^{-3} s^{-1}$$

Calculate in seconds:

$$t_{1/2} = 0.693/2.5 \times 10^{-3} = 277.2 \text{ seconds}$$

Convert seconds to minute:

$$t_{1/2} = 277.2/60 \approx 4.62 \text{ minute}$$

15. A radioactive isotope decays by a first order process with a half -life of 12 hours. Calculate the rate constant for the decay in s^{-1} .

Ans.

$$k = \ln 2/t_{1/2}$$

Given:

$$t_{1/2} = 12 \text{ hours}$$

Convert to seconds: $12 \text{ hours} = 12 \times 60 \times 60 = 43,200 \text{ s}$

$$k = 0.693/43,200 \approx 1.60 \times 10^{-5} s^{-1}$$

The rate constant k is approximately $1.60 \times 10^{-5} s^{-1}$