

taleemzone.com

CHAPTER 17

REACTION KINETICS

Class 10 — Chemistry Notes

(Extracted & Compiled — Branded for taleemzone.com)

Contents

- i. Collision Theory of Reaction Rate
- ii. Change in Mass during a Chemical Reaction
- iii. Change in Temperature during a Chemical Reaction
- iv. Factors Affecting the Rates of Reactions
- v. Importance of Chemical Kinetics in Food Industry

DESCRIPTIVE QUESTIONS

REACTION KINETICS

Q.1 Define reaction kinetics. How the rate of reaction is related to it? [10217001]

Reaction Kinetics

It is branch of chemistry that deals with the rates of chemical reactions and the factors that affect rates of reactions.

COLLISION THEORY OF REACTION RATE

Q.2 What is collision theory? Describe the number of particles per unit volume and the frequency of collisions as the factors affecting the number of effective collision. [10217002]

Collision Theory of Reaction Rate

Collision theory states that a reaction takes place only when the participating particles (atoms, molecules or ions) collide with one another.

It has been observed that a very small fraction of collisions lead to the formation of products. In the majority of collisions, the reactant particles simply bounce back without any change.

Factors Affecting the Number of Effective Collisions

The rate of a reaction depends upon the number of effective collisions which, in turn, depends upon the factors like number of particles per unit volume and frequency of collisions etc.

1. The Number of Particles Per Unit Volume

The larger the number of particles per unit volume, larger is the possibility of effective collisions. In other words, higher the concentration of the reactants, more the number of molecules and hence more will be the number of collisions between them.

2. The Frequency of Collisions

A greater number of collisions per second will also result in the increase in the number of effective collisions.

Q.3 Describe the kinetic energy of the particles and activation energy as the factors affecting the number of effective collision. [10217003]

Factors Affecting the Number of Effective Collision

The rate of reaction depends upon the number of effective collisions, which in turn depends upon the factors like kinetic energy of the particles and activation energy etc.

1. The Kinetic Energy of the Particles

- The kinetic theory of particles says that all matter is composed of tiny constant moving particles.
- The motion of particles is due to kinetic energy they possess. As the temperature increases, the kinetic energy of the particles also increases. As a result, the particles start moving fast leading to more vigorous motion.
- The fast moving particles will have more chances to collide with each other.
- Effective collisions are increased in this way. Hence rate of reaction is also increased.

2. Activation Energy

According to collision theory, the colliding particles will lead to effective collisions only when they possess sufficient energy to break the bonds present in the reactant molecules. This minimum energy required to start a chemical reaction is called its activation energy.

Explanation:

- Generally, at a particular temperature, most of the molecules of the reactant possess average energy.
- A fraction of total molecules will, however have more than the average energy.
- Particles will react only when average energy of this small fraction of molecules exceeds the energy needed to activate molecules so that they can undergo a chemical reaction.
- When the reactant particles come close to each other at the time of collision, they slow down and the kinetic energy they possess, is converted to increase their potential energy. This process can be understood with the help of a graph drawn between the path of reaction and the potential energy of the system as shown in figure 17.1.

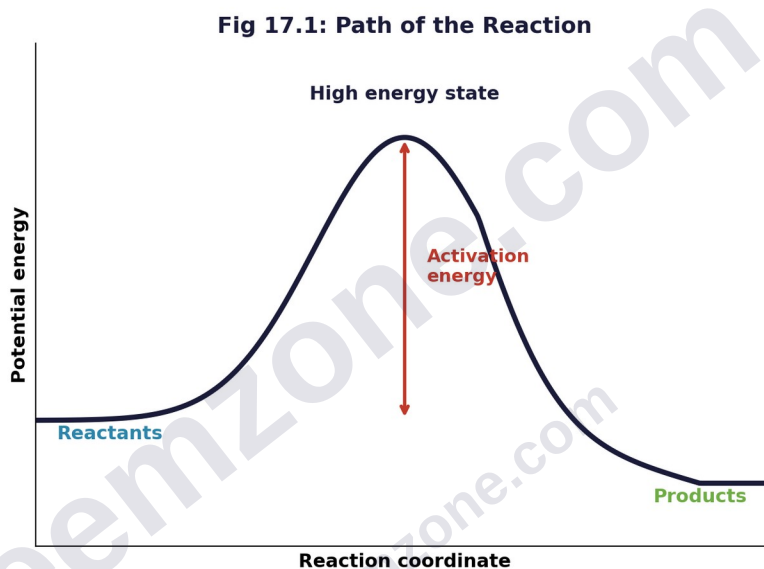


Fig 17.1: Path of the Reaction

- When the reactant particles possessing activation energy collide to form high energy state with the corresponding increase in the potential energy of the system. After this stage the reactants are converted into stable products and the potential energy of the system falls down.
- The information provided by the energy of activation is very important in understanding the mechanism of the reaction.

17.1 Quick Check

1. How will you increase the frequency of collisions? [10217004]

Ans. We can increase the frequency of collision by the following ways:

- By increasing the temperature. Kinetic energy of molecules is increased which results in increase of frequency of collision to overcome activation energy.
- We can also increase the frequency of collision by increasing concentration of reactant.
- It can be increased by increasing the pressure if reactants are present in gaseous state.
- Frequency of collision can also be increased by increasing the surface area of a solid.

2. What happens to the reactant particles after collision? [10217005]

Ans. Every collision does not cause a chemical reaction. Only effective collision leads to product formation. When the reactant particles come close to each other at the time of such collision, they slow down and the kinetic energy they possess is converted to increase their potential energy. When reactants particles possessing activation energy collide to form high energy state with corresponding increase in the potential energy. After this stage the reactants are converted into the stable products and the potential energy of the system falls down.

CHANGE IN MASS DURING A CHEMICAL REACTION

Q.4 Explain by the help of examples, how reactions process with loss and gain in mass? [10217006]

Change in Mass during a Chemical Reaction

- **Law of conservation of mass:** The total mass during a chemical reaction always remains the same. This is the requirement of the law of conservation of mass which is always obeyed. However, some reactions may appear to proceed with a change in mass which can usually be explained because a reactant or a product is a gas in such reactions.
- **Evolution and absorption of gases:** If a reaction is carried out in an open container where gases can escape or enter, the apparent mass change can occur if a gas is either absorbed or evolved.

Example: If a gas is evolved, we shall observe a decrease in mass and if a gas is absorbed the apparent mass will increase.

Formation of a Gas during Chemical Reaction

This apparent decrease in mass is due to evolution of CO_2 gas during the reaction which escapes into the atmosphere.

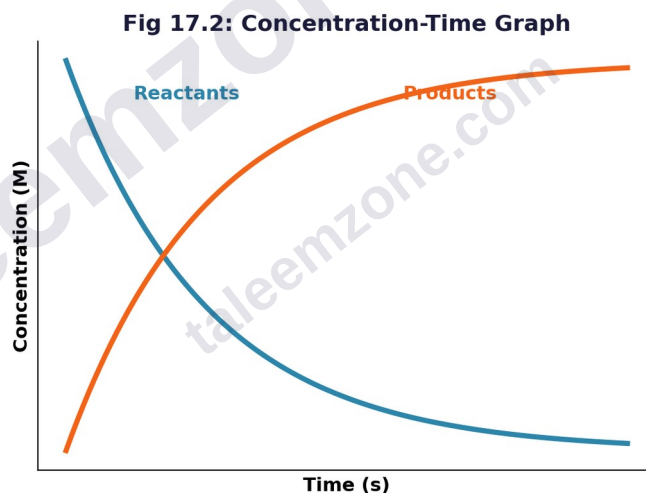
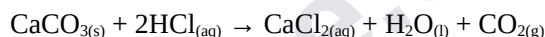


Fig 17.2: Concentration Time Graph

CHANGE IN TEMPERATURE DURING A CHEMICAL REACTION

Q.5 Explain temperature changes during a chemical reaction. [10217007]

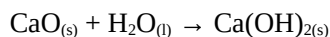
Change in Temperature during a Chemical Reaction

Chemical reactions are quite often accompanied by the changes in the temperature indicating whether they are exothermic or endothermic.

1. Exothermic Reactions

In exothermic reactions heat energy is released which is absorbed by the surrounding causing their temperature to increase.

Example: When quick lime (CaO) reacts with water, slaked lime $\text{Ca}(\text{OH})_2$ is formed and a lot of heat energy is released.



2. Endothermic Reactions

In endothermic reactions heat energy is absorbed causing the surrounding to cool down.

Example: When ammonium chloride or ammonium nitrate is dissolved in water, heat energy is absorbed causing the container to cool down.

- For many reactions, the rate doubles with every 10°C rise in temperature.
- **Cooking food:** Cooking food uses high temperature to speed up chemical reactions that break down the components of food making it edible.

FACTORS AFFECTING THE RATES OF REACTIONS

Q.6 Enlist the factors which affect the rate of reactions. [10217008]

List of Factors Affecting the Rates of Reactions

According to the collision theory all those factors which change the number of successful collisions per second affect the rates of chemical reactions.

Some of the important factors are in the following:

- (i) Effect of Concentrations of the Reactants
- (ii) Reactants present in gas phase
- (iii) Effect of Surface Area of Solids
- (iv) Effect of Temperature
- (v) Effect of Catalyst
- (vi) Enzymes as Catalysts

Q.7 Explain the effect of concentrations of reactants on rates of reaction. [10217009]

Effect of Concentrations of the Reactants

In order for the reaction to occur, the reactants must come in contact with each other. For this reason, the reactions are most often carried out in one phase.

Example: In liquid solutions or in gas phase.

Explanation

- When the reactants are present in the same phase, their particles are able to meet on the molecular level and thus are able to collide with each other easily.
- The higher the number of particles of the reactants per unit volume, higher will be chances of effective collisions and hence higher will be the rate of reaction.
- An increase or decrease in concentrations of the reactants will result in increase or decrease in the rate of reaction respectively.

Examples

- **(i) Combustion of coal:** Combustion of coal in air (21% oxygen) proceeds relatively slowly as compared to the reaction in pure oxygen.
- **(ii) Limestone and HCl:** Limestone reacts with different concentrations of hydrochloric acid at different rates.

Volume – Time Graph

The change in the rate of reaction is then seen when a graph is drawn between the time in seconds or minutes against the volume of gas evolved as shown in figure 17.4.

Graph in the Form of a Curve

The graph obtained is in the form of a curve. We can measure the rate of reaction during a time interval by drawing a tangent on this curve. The results show that the reaction starts with a very fast rate which then progressively slows down as the concentration of hydrochloric acid decreases. After a while the reaction stops because the whole of hydrochloric acid has been utilized.

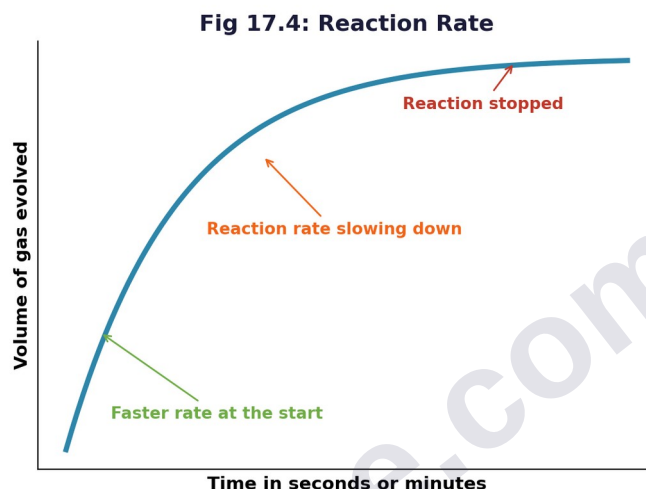


Fig 17.4: Reaction Rate

Curves A and B (At Different Concentrations of HCl)

The two curves A and B shown in figure 17.5 represent two separate experiments done with one and two molar concentrations of HCl respectively.

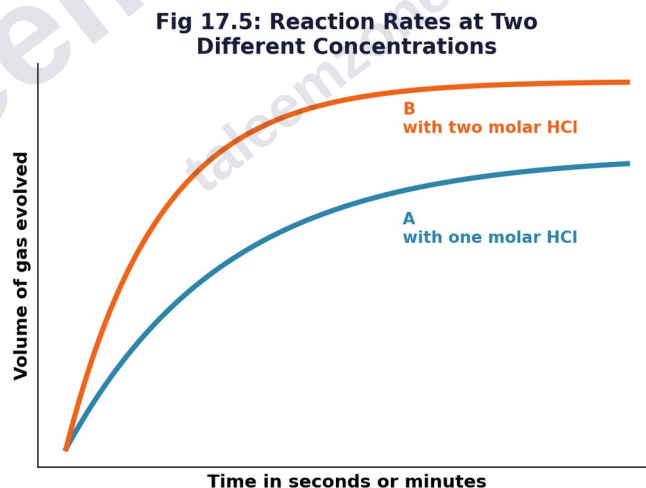


Fig 17.5: Reaction Rates at Two Different Concentrations

Conclusion

- The greater the concentration, the steeper is the curve at the start of the experiment which means faster rate of reaction.
- The more concentrated is the acid, the more are the chances of effective collisions.

Q.8 Discuss an experiment to show the effect of increase in concentration of reactant on the rate of reaction. [10217010]

Experiment to Show the Effect of Increase in Concentration of Reactant on the Rate of Reaction

An experiment can be performed to show the increase in the rate of reaction with the increase in the concentration of hydrochloric acid.

Working

Take a flat-bottomed conical flask fitted with a delivery tube which is connected to a syringe as shown in the figure 17.3.

- The flask contains granules of lime stone taken in excess and a fixed volume of one molar hydrochloric acid.
- When reaction starts, carbon dioxide gas is generated which is collected in the syringe by the following reaction.



- The scale present on the syringe directly measures the volume of carbon dioxide gas evolved.
- It is essential to keep all the variables constant in this experiment. Example: The volume of one molar hydrochloric acid, the temperature at which the experiment is being carried out, the mass and size of lime stone granules, and the rate of stirring.
- The reaction is followed by measuring the volume of carbon dioxide gas evolved.
- The same experiment is then repeated taking the same volume of two molar hydrochloric acid. It results in increases in value of more carbon dioxide produced.

Result

The experiment shows that by increasing the concentration of HCl from 1M to 2M the rate of reaction is also doubled. It is experimentally shown by the increase in evolution of carbon dioxide:

Fig 17.3: Reaction of Hydrochloric Acid with Limestone

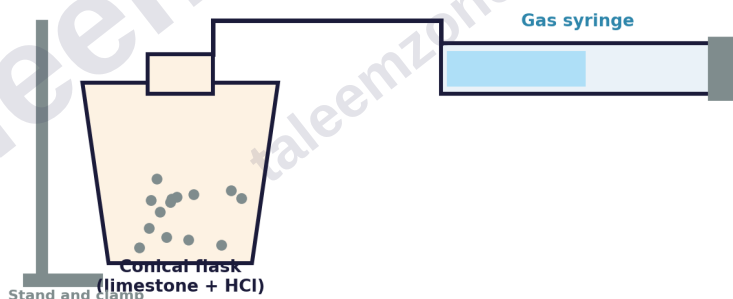


Fig 17.3: Reaction of Hydrochloric Acid with Limestone

Things to Know — S.Q. Give benefits of understanding the reaction kinetics. [10217011]

Ans. Understanding kinetics helps us to control the reaction conditions in order to speed up or slow down reactions as needed.

Q.9 How does gaseous phase of reactants affect the rate of reaction? What is the effect of surface area of solids on reaction rate? [10217012]

1. Reactants Present in Gas Phase

If reactants in a reaction are present in gas phase, their concentrations can be changed by changing their pressure.

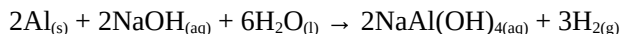
Example: The rate of reaction between hydrogen and chlorine can be doubled if the pressure of chlorine gas is doubled provided the other component hydrogen is present in excess.

2. Effect of Surface Area of Solids

Reactions involving solids take place on their surfaces and the rates of their reactions depend to a great extent on the area of the surface contact between them.

- The larger the surface area of the solids, the more is possibility of their particles to come in contact with each other and the higher is the rate of reaction.
- Finely divided solids, because of the greater surface area available, react more rapidly than do large pieces of the same substances.

Examples: Aluminium foil reacts slowly with warm sodium hydroxide but in finely divided state it reacts rapidly with even cold aqueous solution of sodium hydroxide evolving hydrogen gas.



Similarly, a large piece of wood will burn slowly while small pieces burn rapidly.

Q.10 Explain the effect of temperature on rate of reaction. [10217013]

Effect of Temperature

It is an everyday observation that the rates of chemical reactions increase with increase in temperature.

- **(i) Cooking of food:** Food cooks faster at higher temperatures than at lower ones.
- **(ii) Oxidation of iron:** Similarly, the oxidation of iron is very slow at room temperature but proceeds very fast at high temperature. In many cases the rate of reaction is nearly doubled when the temperature is increased by 10°C. The graph shown in the figure 17.6 explains this rapid increase in the rate of reaction with the rise in temperature.

Fig 17.6: Rise in Rate of Reaction with Temperature

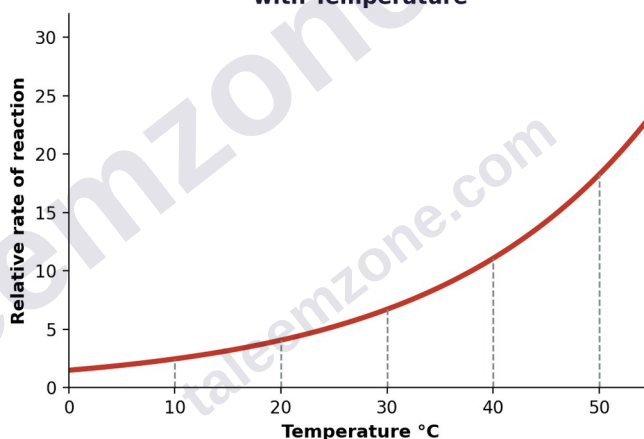


Fig 17.6: Rise in Rate of Reaction with Temperature

Increase in Successful Collisions

According to the collision theory:

- The rate of reaction depends upon the frequency of successful collisions between reactant molecules.
- As the temperature of a reaction is increased, the kinetic energy of the participating reacting particles also increases. This, in turn increases the velocities of their movements. As a result, the collisions which lead to the occurrence of reactions also increase, enhancing the rate of reaction.

Interesting Information — MCQ: Kinetics helps us to increase the ____ of a reaction and minimize the waste. [10217014]
 (a) Yield (b) Volume (c) Time (d) Density

Q.11 Define a catalyst. What role does a catalyst play to increase the rate of reaction? [10217015]

Catalyst

A catalyst is a substance which alters the rate of the reaction but it is not consumed during the course of reaction.

Effect of Catalyst

The role of catalyst is to alter the way the reaction takes place by substantially lowering its activation energy. When the activation energy is lowered, more and more particles of the reactants will start forming the high energy state and the rate of reaction will increase.

Example: Platinum metal serves as a catalyst during the addition of hydrogen in ethene. Both hydrogen and ethene are known to adsorb on the surface of platinum metal and the bonds, present in them, get weakened. Thus, the surface of metal helps the reactant molecule to react together. This is shown in the figure 17.7.

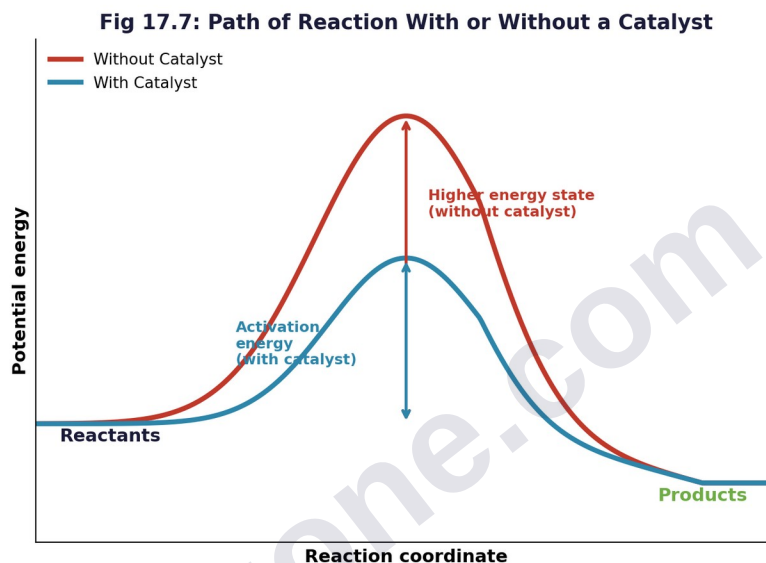


Fig 17.7: Path of Reaction With or Without the Presence of a Catalyst

Q.12 Explain how enzymes as catalyst alter the rate of a reaction? / Explain catalytic action of enzyme.

[10217016]

Enzymes as Catalysts

Enzymes are biological catalysts. These are basically proteins which help to speed up specific chemical reactions taking place in our body.

Catalytic Action of Enzyme

They react with the reactant molecules using the active sites present in them. Once bound with the reactant molecule the particular bonds in the reactant molecule are sufficiently weakened for the reaction to take place. The product formed then dissociates itself from enzyme which is then free to bind another reactant molecule.

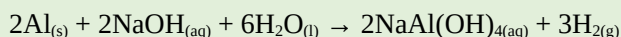
17.2 Quick Check

1. Why a catalyst is mostly used in finely divided form? [10217017]

Ans. A catalyst is mostly used in finely divided form because it increases the rate of reaction due to:

Large surface area – more active sites: Finely divided catalysts (powdered, porous solids) react rapidly than do large pieces of the same substances.

Example: Aluminium foil react slowly with warm sodium hydroxide but in finely divided state it reacts rapidly with even cold aqueous solution of sodium hydroxide evolving hydrogen gas.



2. How do you increase the number of successful collisions? [10217018]

Ans. Increase in number of successful collisions: We can increase the number of successful collisions.

By increasing temperature: According to collision theory, rate of reaction depends upon the frequency of successful collisions of reactants. As the temperature of reaction increases, the kinetic energy of the reactants also increases. This increase in velocities of molecules results in increase in number of successful collisions.

By increasing surface area: Similarly, we can increase the number of successful collisions by increasing surface area of solids and by the use of catalyst.

3. How does the concentrations of the products change during reaction? Explain with the help of a graph. [10217019]

Ans. When a reaction moves ahead the concentration of the reactants decrease until all the reactants are used up. At the same time, the concentrations of the products increase and reach the maximum value at the end of the reaction. This is shown in a graph in figure (17.2)

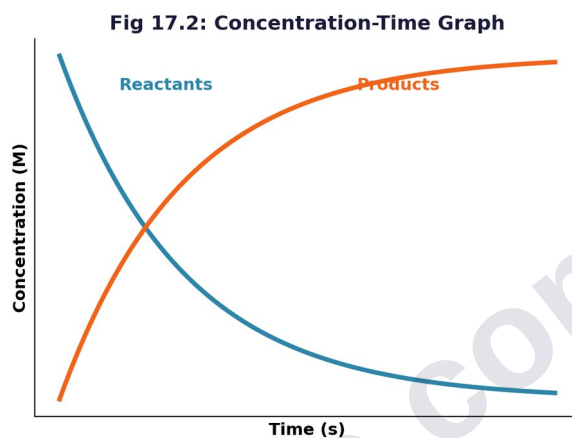


Fig 17.2: Concentration Time Graph

IMPORTANCE OF CHEMICAL KINETICS IN FOOD INDUSTRY

Q.13 How does chemical kinetics play an important role in food industry? [10217020]

Importance of Chemical Kinetics in Food Industry

The study of reaction rates and the factors which affect these rates play an important role in food industry.

- **(i) Rate of reactions in minimizing the food spoilage:** The rates of chemical reactions which are involved during food ripening and food spoilage are studied for different types of fruits and vegetables. The information thus obtained is used to minimize the losses due to spoilage.
- **(ii) Determination of optimum conditions:** Food scientists can determine the optimum conditions for harvesting, storage and transportation of food products by studying the rates of enzymatic reactions, oxidation or microbial growth.

Interesting Information — MCQ: Enzyme based biosensors are used to detect glucose in ____ [10217021]

(a) Kidney (b) Blood (c) Lungs (d) Hairs

- **(iii) Prediction of food ripening and harvesting:** Fruits and vegetables ripen owing to the reactions which involve enzymes. These reactions convert starches into sugars, soften tissues and develop characteristics flavour and colours. With the help of rates of these enzymatic reactions, farmers can predict when the product will reach at its peak quality and ready for harvesting.

Example: The rate of production of ethene during ripening can be monitored to determine the best time to harvest the fruits.

- **(iv) Enzymes in food cause of spoilage:** Some enzymes which are naturally present in foods can spoil the foods which then undergo changes in texture, flavour and nutritional value. Again understanding the rates of these enzymatic reactions will allow us to plan how to stop this spoilage.

Example: If a fruit is known to degrade rapidly during transportation or storage owing to high temperature, refrigeration can be employed to prevent rapid spoilage.

Interesting Information — MCQ: Understanding the kinetics of oxidation reactions of fats helps to prevent spoilage of ____ [10217022]

(a) Milk (b) Butter (c) Yogourt (d) Honey

17.3 Quick Check

1. How would you determine the best time of fruit harvesting? [10217023]

Ans. Determination of best time of fruit harvesting: We can determine the optimum conditions for harvesting, storage and transportation of food products by studying the rates of enzymatic reactions, oxidation or microbial growth.

Prediction of time of food ripening: Fruits and vegetables ripen owing to the reactions which involve enzymes. These reactions convert starches into sugars, soften tissues and develop characteristics flavour and colours. With the help of rates of these enzymatic reactions, we can predict when the product will reach at its peak quality and ready for harvesting.

2. Why some fruits and vegetables get destroyed early during summer than during winter? [10217024]

Ans. Some fruits and vegetables get destroyed early during summer than during winter mainly because higher temperature speeds up chemical and biological reactions taking place due to presence of natural enzymes which are present inside them.

MULTIPLE CHOICE QUESTIONS (EXERCISE)

A. Choose and tick the correct answer from the given choices.

- The number of collisions per unit volume of the reaction mixture is called: [10217025] (a) Collision energy (b) Activation energy (c) Collision frequency (d) Collision force
- If the reactants possess an energy higher than the activation energy, then the reaction will be: [10217026] (a) Slow (b) Fast (c) Not affected (d) Instantaneous
- Which of the following explains the increase in rate of reaction in the presence of a catalyst? [10217027] (a) Catalyst provides extra energy to the reactant molecules (b) Catalyst provides an alternative pathway which lowers the activation energy. (c) Catalyst increases the collision frequency (d) Catalyst decreases the collision frequency
- Which of the following statements is correct? [10217028] (a) Collisions with energy equal to or greater than the activation energy lead to reaction. (b) Collision frequency is not related to the reaction rate (c) All collisions lead to a reaction. (d) Collisions with energy less than the activation energy lead to the reaction.
- When a reaction proceeds ahead, how the concentrations of reactants and products change? [10217029] (a) Concentration of reactants increases and that of the products decreases. (b) Concentration of reactants decreases and that of the products increases. (c) Concentration of both reactants and products decreases. (d) Concentration of both reactants and products increases.

SLO Based Multiple Choice Questions

Collision Theory of Reaction Rate

- A reaction takes place only when the participating particles _____ with one another: [10217030] (a) React (b) Mix (c) Repel (d) Collide
- Majority of the molecules of the reactants: [10217031] (a) React with one another (b) Bounced back without any change (c) Undergo effective collisions (d) Cannot move
- Rate of reaction depends upon number of: [10217032] (a) Ineffective collisions (b) Molecules (c) Effective collisions (d) Ions
- A large number of collision per second will also result in the increase in: [10217033] (a) Volume (b) Pressure (c) Number of vibrations (d) Number of effective collisions
- Decrease in temperature will result the decrease in: [10217034] (a) Kinetic energy (b) Density (c) Frequency (d) All of these
- The minimum energy required to start a chemical reaction: [10217035] (a) Potential energy (b) Activation energy (c) Kinetic energy (d) Rotational energy
- In path of reaction diagram, reactant before converting into products passes through: [10217036] (a) Low energy state (b) Middle energy state (c) High energy state (d) Minimum energy state
- After higher energy state, the reactants are converted into stable products and potential energy of the system: [10217037] (a) Falls down (b) Increases (c) Remain same (d) Become maximum

Change in Mass during Chemical Reaction

- Which law should be obeyed in a chemical reaction? [10217038] (a) Law of momentum (b) Law of active mass (c) Law of matter (d) Law of conservation of mass

15. Some reactions may proceed with change in mass because reactant or product is: [10217039] (a) Gas (b) Liquid (c) Solid (d) Solution
16. If a ribbon of Mg is burnt in an open container, the mass of product (MgO) formed will be: [10217040] (a) Lesser than reactant (b) Equal to reactant (c) Greater than reactant (d) Minimum
17. If calcium carbonate reacts with dilute HCl in open container, the mass of product will be: [10217041] (a) less than reactant (b) More than reactant (c) Equal to reactant (d) Less than catalyst
18. In concentration time graph, the concentration of product reach _____ at the end of reaction: [10217042] (a) Minimum (b) Maximum (c) Average (d) Below average

Change in Temperature during Chemical Reaction

19. In exothermic reactions, the temperature of surrounding: [10217043] (a) Decreases (b) Minimum (c) Remains same (d) Increases
20. Quick lime reacts with water to give: [10217044] (a) Slaked lime (b) Normal lime (c) Limestone (d) Gypsum
21. When ammonium chloride is dissolved in water, the heat: [10217045] (a) Released (b) Remains same (c) Absorbed (d) Become energy

Factors Affecting the Rates of Reactions

22. According to collision theory, all those factors which change the _____ per second affect the rates of chemical reactions: [10217046] (a) Number of molecules (b) Translation motion (c) Number of successful collisions (d) Number of vibrations
23. The reactions are most often carried out in: [10217047] (a) Two phases (b) Three phases (c) Four phases (d) One phase
24. The higher the number of particles of the reactants per unit volume, higher will be the chances of: [10217048] (a) Stopping reaction (b) Ineffective collision (c) Effective collisions (d) Attaining equilibrium
25. Combustion of coal in air is relatively _____ as compared to the reaction in pure oxygen. [10217049] (a) Slow (b) Moderate (c) Fast (d) Quick
26. Limestone reacts with different concentrations of HCl at _____ rate: [10217050] (a) Slow (b) Different (c) Fast (d) Moderate
27. The graph of reaction rate obtained is in the form of: [10217051] (a) Curve (b) Parallel line (c) Straight line (d) Horizontal line
28. Rate of reaction of hydrogen and chlorine is doubled, when the pressure on chlorine is: [10217052] (a) Four times (b) Three times (c) Halved (d) Doubled
29. The larger the surface area of solids, the rate of reaction will be: [10217053] (a) Higher (b) Lower (c) Doubled (d) Moderate
30. Food cooks _____ at higher temperatures than at lower ones: [10217054] (a) Slower (b) Faster (c) Moderate (d) Never
31. In the addition of hydrogen and ethene, the catalyst used is: [10217055] (a) Mg (b) Cl (c) Na (d) Pt
32. In the presence of catalyst, which of the following is lowered? [10217056] (a) Activation energy (b) Internal Energy (c) Pressure (d) Volume
33. Enzymes are specific for a specific reaction because of their part: [10217057] (a) Co-enzyme (b) Apo enzyme (c) Active sites (d) Prosthetic group

Importance of Chemical Kinetics in Food Industry

34. The information of rate of reaction involved in ripening is used to minimize the losses due to: [10217058] (a) Spoilage (b) Preservation (c) Combustion (d) Substitution
35. The reactions that convert starch into sugar in ripening of fruits involves: [10217059] (a) Activators (b) Poisons (c) Deactivators (d) Enzymes
36. Rate of production of ethene during ripening can be monitored to determine the best time to: [10217060] (a) Cutting of fruits (b) Harvest the fruits (c) Mixing of fruits (d) All of these
37. Some enzymes are naturally present in foods can spoil the foods which undergo changes in: [10217061] (a) Texture (b) Flavour (c) Nutritional value (d) All of these

38. If a fruit is known to degrade rapidly during transportation owing to high temperature _____ can be employed to prevent rapid spoilage. [10217062] (a) Substitution (b) Combustion (c) Heating (d) Refrigeration

Answer Key

1	2	3	4	5	6	7
c	b	b	a	b	d	b
8	9	10	11	12	13	14
c	d	a	b	c	a	d
15	16	17	18	19	20	21
a	c	a	b	d	a	c
22	23	24	25	26	27	28
c	d	c	a	b	a	d
29	30	31	32	33	34	35
a	b	d	a	c	a	d
36	37	38				
b	d	d				

SHORT ANSWER QUESTIONS (EXERCISE)

B. Short Answers Questions.

1. What is a successful collision? [10217063]

Ans. Successful collision: A successful collision is a collision between reactant particles that actually leads to the formation of products. Conditions for successful collision: A collision is successful only when: (i) The colliding particles have energy equal to or greater than activation energy. (ii) Secondly the particles collide with the proper orientation.

2. How does increase in the temperature increase the rate of a reaction? [10217064]

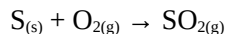
Ans. The increase in temperature increase the reaction rate because as the temperature increases, the kinetic energy of the particles also increases. As a result, the particles start moving fast leading to more vigorous motion. The fast moving particles will have more chances to collide with each other. Effective collisions are increased in this way. Hence rate of reaction is also increased.

3. Define activation energy. [10217065]

Ans. Activation energy: According to collision theory, the colliding particles will lead to effective collisions only when they possess sufficient energy to break the bonds present in the reactant molecules. This minimum energy required to start a chemical reaction is called its activation energy.

4. Why does the burning of sulphur proceed slower in air than in pure oxygen? [10217066]

Ans. Burning of sulphur in pure oxygen: It has been observed that burning of sulphur proceed slower in air than in pure oxygen.



In the presence of air it slows down because air is a mixture of different gases. It has 21% of oxygen the rest is mostly nitrogen which does not support combustion. In pure oxygen, more frequent collisions between sulphur and oxygen molecules result in more successful collisions and increase in rate of reaction.

5. Why a catalyst used in a reaction is preferably taken in the powdered form? [10217067]

Ans. A catalyst is mostly used in finely divided form because it increases the rate of reaction due to: Large surface area – more active sites. Finely divided catalysts (powdered, porous solids) react rapidly than do large pieces of the same substances. Example: Aluminium foil reacts slowly with hot sodium hydroxide but in finely divided state it reacts rapidly with even cold aqueous solution of sodium hydroxide evolving hydrogen gas.

6. Why is the rate of a reaction often very fast at the beginning of the reaction? [10217068]

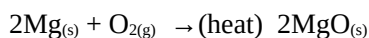
Ans. Rate of reaction at the beginning of reaction: The rate of reaction is very fast at the beginning because. Maximum concentration of reactants: At the start, the concentrations of reactants are highest so more frequent collisions results in increase the rate of reaction.

7. Magnesium does not react with air at room temperature but it reacts very fast at high temperature giving intense white light. Explain. [10217069]

Ans. Magnesium requires high energy to react with oxygen, which it does not get at room temperature. At room temperature, oxygen molecules in air do not have enough energy to overcome the activation energy.

At higher temperature

Magnesium atom gains enough kinetic energy at higher temperature and the collision between magnesium and oxygen become more effective which results in fast reaction releasing lot of energy and giving intense white light.



8. What happens to the reactants after they climb the energy hill during a reaction? [10217070]

Ans. When reactant particles possessing activation energy climbs the energy hill, after this stage the reactants are converted into stable products and potential energy of the system falls down.

9. How does a catalyst lower the activation energy of a reaction? [10217071]

Ans. A catalyst lowers the activation energy by providing an alternative reaction pathway that requires less energy for the reactants to be converted into products. When the activation energy is lowered, more and more particles of the reactants start forming the high energy state and the rate of reaction will increase.

10. Give any two features of the catalytic action of an enzyme. [10217072]

Ans. Features of the catalytic action of enzymes: The reactions catalysed by enzymes have following characteristics. (i) Specific in nature: Each enzyme acts on a specific type of reaction. (ii) Lowers activation energy: Enzymes provide an alternative pathway for the reaction by lowering activation energy. (iii) Not consumed in reaction: Enzymes increase the rate of reaction without being consumed chemically in the reaction.

SLO BASED SHORT ANSWER QUESTIONS

Reaction Kinetics

11. What is reaction kinetics? [10217073]

Ans. Reaction kinetics: The branch of chemistry that tells the rates of chemical reactions and factors affecting the rates of chemical reactions is called reaction kinetics.

Collision Theory of Reaction Rate

12. What is collision theory? [10217074]

Ans. Collision Theory: According to collision theory, a reaction take place only when the participating particles (atoms, molecules or ions) collide with one another. A very small fraction of molecule lead to products because they have collisions which are effective collisions.

13. What is the frequency of collisions? [10217075]

Ans. Frequency of collisions: The number of collisions per second is called frequency of collisions. A greater number of collision per second will also result in the increase in the number of effective collision. The frequency of collision increases at higher temperatures.

14. Give the importance of activation energy. [10217076]

Ans. Importance of activation energy: The information provided by the energy of activation is very important in understanding the mechanism of the reaction. It tells that the reaction is either feasible or not.

15. How number of particles per unit volume affects the successful collisions? [10217077]

Ans. The larger the number of particles per unit volume, larger is the possibility of effective collisions. In other words, higher the concentration of the reactants, more the number of molecules and hence more will be the number of collisions between them.

Change in Mass during a Chemical Reaction

16. Why do some reactions appear to proceed with a change in mass? [10217078]

Ans. Some reactions appear to proceed with a change in mass because a reactant or a product is a gas in such reactions. So gas can leave or enter the system, in this way change in mass can occur.

17. Discuss a reaction which proceeds by change in mass. [10217079]

Ans. If a reaction is carried out in an open container where gases can escape or enter, the apparent mass change can occur, if a gas is either evolved or absorbed. Example: If a gas is evolved, we shall observe a decrease in mass and if a gas is absorbed, the apparent mass will increase.

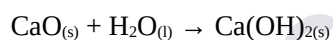
18. What is concentration time graph? [10217080]

Ans. The graph of time against concentration is called concentration-time graph. When a reaction moves ahead the concentrations of the reactants decrease until all the reactants are used up. At the same time, concentration of the products increase and reach the maximum value at the end of reaction. This is shown in graph.

Change in Temperature during a Chemical Reaction

19. What are exothermic reactions? Give example. [10217081]

Ans. Exothermic reactions: In these reactions heat energy is released which is absorbed by the surrounding causing its temperature to increase. Example: When quick lime (CaO) reacts with water, slaked lime Ca(OH)₂ is formed and a lot of heat energy is released.



20. What are endothermic reactions? Give example. [10217082]

Ans. Endothermic reactions: In these reactions, heat energy is absorbed causing surrounding to cool down. Example: When ammonium chloride is dissolved in water, heat energy is absorbed causing container to cool down.

Factors Affecting the Rates of Reactions

21. What is the effect of concentration of reactants on reaction rates? [10217083]

Ans. An increase or decrease in concentration of reactants will result in increase or decrease in the rate of reaction respectively. Example: Combustion of coal in air (21% oxygen) proceeds relatively slowly as compared to the reaction in pure oxygen.

22. What is the graph obtained of volume of gas evolved against time in seconds? [10217084]

Ans. Ans. When a graph is drawn between the time in seconds or minutes against the volume of gas evolved as shown in figure. The graph obtained is in the form of curve.

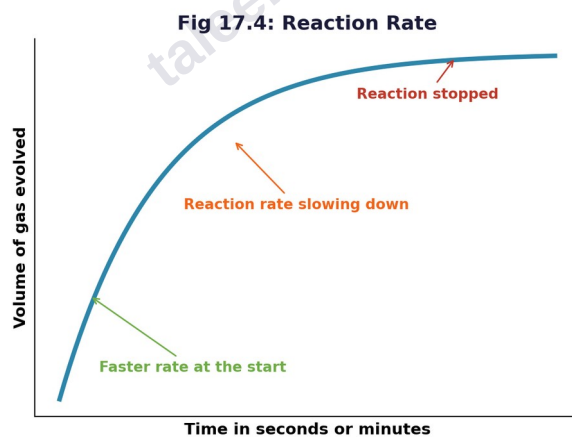


Fig 17.4: Reaction Rate

23. How rate of reaction is measured from volume time graph? [10217085]

Ans. The graph of volume of gas against time is obtained in the form of curve. The rate of reaction is measured during a time interval by drawing a tangent on this curve.

24. How changing pressure can affect reaction rate in gas phase reactions? [10217086]

Ans. If reactants in a reaction are present in gas phase, their concentration can be changed by changing pressure. Example: The rate of reaction between hydrogen and chlorine is doubled if the pressure of chlorine gas is doubled.

25. Why finely divided solids react more rapidly? [10217087]

Ans. Finely divided solids reacts more rapidly because of greater surface area available than do large pieces of the same substances. Example: Finely divided aluminium reacts rapidly with sodium hydroxide as compared to aluminium foil.

26. How rate of reaction can be doubled by changing temperature? [10217088]

Ans. In many cases, the rate of reaction is nearly doubled when the temperature is increased by 10°C.

27. How temperature change affects the reaction rate according to collision theory? [10217089]

Ans. According to collision theory, the rate of reaction depends upon the frequency of successful collisions between reactants. As the temperature is increased, the kinetic energy of the reacting particles also increases. As a result, successful collisions increases, enhancing the reaction rate.

28. What is the role of catalyst on reaction rate? [10217090]

Ans. The role of catalyst is to alter the way the reaction takes place by substantially lowering its activation energy. When the activation energy is lowered, the rate of reaction will increase.

29. What are enzymes? [10217091]

Ans. Enzymes are biological catalyst. These are basically proteins which help to speed up specific chemical reactions taking place in living organisms.

30. What are active sites of the enzymes? [10217092]

Ans. The active sites present in enzymes binds with the reactant molecules. They convert the reactants into products, then free to bind other reactants. Active sites are highly specific such that a particular enzyme can catalyse a specific reaction only.

Importance of Chemical Kinetics in Food Industry

31. How is reaction kinetics is used to minimize food spoilage? [10217093]

Ans. The rate of chemical reactions which are involved during food ripening and food spoilage are studied for different types of fruits and vegetables. The information thus obtained is used to minimize the loses due to spoilage.

32. How food ripening and harvesting can be predicted? [10217094]

Ans. Fruits and vegetables ripen owing the reactions which involve enzymes. These reactions convert starches into sugars, soften tissues and develop characteristics flavour and colours. With the help of rates of these enzymatic reactions, farmers can predict when the product will reach at its peak quality and ready for harvesting.

CONSTRUCTED RESPONSE QUESTIONS

1. In what different ways you can increase the successful collisions between the particles of the reactants? [10217095]

Ans. We can increase the frequency of collision by different ways:

- (i) By increasing the temperature. Kinetic energy of molecules is increased which results is increase of frequency of collision to overcome activation energy.
- (ii) We can also increase the frequency of collision by increasing concentration of reactant.
- (iii) It can be increased by increasing the pressure if reactants are present in gaseous state.
- (iv) Frequency of collision can also be increased by increasing the surface area of a solid.

2. Give an example of a reaction which proceeds with the gain in mass. [10217096]

Ans. Example of reaction with increase in mass: If a ribbon of magnesium is burnt in an open crucible, the mass of the product (MgO) formed will be greater than the reactant (Mg). This increase in mass has occurred due to the reaction of magnesium with oxygen present in air.

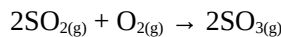
However, if the two reactants (Mg and O₂) are allowed to react in a closed container, the total mass will remain the same before and after the reaction.

3. From where do molecules get energy to attain higher energy state? [10217097]

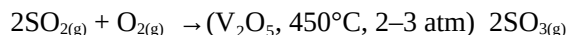
Ans. Higher energy state (Transition state of molecules): Molecules get the energy to attain a higher energy state from their surroundings usually in the form of:

- Heat
- Light
- Chemical energy (released by bond formation) after this state the reactants are converted into stable products and the potential energy of the system falls down.

4. How does the presence of V_2O_5 catalyst lower the activation energy of the following reaction? [10217098]



Ans.



Vanadium pentoxide as a catalyst: V_2O_5 (vanadium pentoxide) acts as a catalyst in this reaction and lowers the activation energy by providing an alternative pathway in which SO_2 is oxidized to SO_3 in intermediate steps and requires less energy than uncatalyzed reaction.

Under the conditions $450^\circ C$ and 2–3 atm pressure, 98% SO_2 gas is converted to SO_3 , which is regarded a major role of a catalyst.

5. Explain the catalytic action of an enzyme.

Ans. See Q.12 from theory.

6. If you desire to stop a reaction going on at $60^\circ C$, what action you will take? [10217100]

Ans. As we know temperature increases the rate of reaction by increasing the number of successful collisions. If you desire to stop a reaction going on at $60^\circ C$ we can do it.

By cooling the reaction mixture

To stop a reaction at $60^\circ C$, the reaction mixture should be cooled quickly. Lowering the temperature reduces the kinetic energy of the molecules, decreasing the number of successful collision which results in cease of the reaction. We can also stop the reaction

- by removing one of the reactant
- by removing a catalyst (If present)

DESCRIPTIVE QUESTIONS (EXERCISE)

1. Explain the effect of surface area on the rate of a reaction. [10217101]

Ans. See Q.9 from theory.

2. Describe the main points of the collision theory of reaction rate. [10217102]

Ans. See Q.2 from theory.

3. Discuss the following factors affecting the rate of a reaction: [10217103]

(a) Effect of concentrations of the reactants.

Ans. See Q.7 from theory.

(b) Effect of temperature at which a reaction is carried out.

Ans. See Q.10 from theory.

4. How does chemical kinetics play an important role in the food industry? [10217104]

Ans. See Q.13 from theory.

5. Write briefly about the role enzymes play in our body as biological catalysts. [10217105]

Ans. See Q.12 from theory.

End of Chapter Notes