Chemical Kinetics Chemistry Questions with Solutions

Q1: Define Reaction Rate.

Answer:

The reaction rate is determined by how rapidly the products are created and the reactants are consumed. It is usual to deal with substance concentrations in chemical systems, which are defined as the amount of substance per unit volume. The concentration of a material consumed or produced in unit time can thus be described as the rate. It's sometimes easier to express rates as the number of molecules generated or consumed per unit of time.

Q2: What is meant by the Half-Life?

Answer:

The half-life of a reactant, which is defined as the time it takes for half of the initial amount to undergo reaction, is a useful rate metric. The half-life is independent of the initial amount for a certain form of kinetic behaviour (first order kinetics).

Radioactive substances are a simple and typical example of a half-life that is independent of the initial amount. Uranium-238, for example, has a half-life of 4.5 billion years, meaning that half of an initial amount of uranium will have decayed in that time. Many chemical reactions exhibit the same behaviour.

Q3: Write the rate equation for the reaction 2A + B → C if the order of the reaction is zero.

Answer:

The rate equation for the reaction 2A + B → C in the zero order reaction is,

Rate = $k [A]^0 [B]^0 = k$.

Q4: Although the reaction between $H_2(g)$ and $O_2(g)$ is highly feasible, leaving the gases in the same vessel at room temperature does not result in the creation of water. Explain.

Answer:

Although the reaction between $H_2(g)$ and $O_2(g)$ is very feasible, leaving the gases to remain at room temperature in the same vessel does not result in the creation of water because the reactants' activation energy is very high at room temperature and not readily available.

Q5: Match the statements given in Column I and Column II

Column I	Column II
(a) Catalyst alters the rate of reaction	(i) cannot be fraction or zero
(b) Molecularity	(ii) proper orientation is not there always
(c) Second half-life of first order reaction	(iii) By lowering the activation energy
(d) $e^{-Ea/RT}$	(iv) is same as the first
(e) Energetically favourable reactions are sometimes slow	(v) total probability is one
(f) Area under the Maxwell Boltzman curve is constant	(vi) refers to the fraction of molecules with energy equal to or greater than activation energy

Answer:

a) – (iii); (b) – (i); (c) – (iv); (d) – (vi); (e) – (ii); (f) – (v)

Q6: Match the items of Column I and Column II.

Column I	Column II
(a) Mathematical expression for rate of reaction	(i) rate constant
(b) Rate of reaction for zero order reaction is equal to	(ii) rate law
(c) Units of rate constant for zero order reaction is same as	(iii) order of slowest step
(d) Order of a complex reaction is determined by	(iv) rate of a reaction

Answer:

(a) – (ii); (b) – (i); (c) – (iv); (d) – (iii)

Q7: Define each of the following:
i) Specific rate of a reaction
ii) Activation energy of a reaction

Answer:

i) Specific rate of a reaction: When the molar concentration of each of the reactants is equal, the rate of reaction is called the specific rate of reaction.

ii) Activation energy of a reaction: The activation energy is the minimum extra amount of energy absorbed by the reactant molecules in need of their energy to equal the threshold value. The addition of a catalyst reduces the reaction's activation energy.

Q8: Which among the following is a false statement?
(i) Rate of zero order reaction is independent of initial concentration of reactant.
(ii) Half-life of a third order reaction is inversely proportional to the square of initial concentration of the reactant.
(iii) Molecularity of a reaction may be zero or fraction.
(iv) For a first order reaction, $t_{1/2}$ = 0.693/K

Answer: (iii) Molecularity of a reaction may be zero or fraction.

Q9: The average rate and instantaneous rate of a reaction are equal
(i) at the start
(ii) at the end
(iii) in the middle
(iv) when two rates have a time interval equal to zero

Answer: (iv) when two rates have a time interval equal to zero

Q10: For a chemical reaction A→B, it is found that the rate of reaction doubles when the concentration of A is increased four times. The order of the reaction is
(i) Two
(ii) One
(iii) Zero
(iv) Half

Answer: (iv) Half

Q11: Differentiate between the Order and Molecularity of a reaction.

Answer:

ORDER OF A REACTION	MOLECULARITY OF A REACTION
It is the sum of the concentration terms on which the rate of reaction is based or the sum of the concentration exponents in the rate law equation.	It is the number of atoms, ions, or molecules that must collide at the same time in order for a chemical reaction to occur.
It does not have to be a whole number; it might be fractional or zero.	It is always a whole number.

It can only be determined through experiments and cannot be calculated.	It's easy to figure out by adding the molecules from the slowest step.
There are no separate steps written to obtain it because it is for the whole reaction.	A complex reaction's overall molecularity has no significance. Only the slowest step's molecularity has any impact on the overall reaction.
As the unbalance equation shows, even the order of a simple reaction might not be equal to the number of molecules of the reactants.	The molecularity of simple reactions can usually be deduced from the equation's Stoichiometry.

Q12: With the help of an example explain what is meant by pseudo first order reaction.

Answer:

Consider the reaction of ethyl acetate hydrolysis, which can be expressed as

$CH_3COOC_2H_5 + H_2O \rightarrow CH_3COOH + C_2H_5OH$

The rate equation can be given as $Rate = k\,[CH_3COOC_2H_5]\,[H_2O]$

The concentration of water is relatively high in this case and consequently does not change much during the process. As a result, the rate of the reaction is independent of the change in H_2O concentration. We might write the effective rate equation as if the term for a change in water concentration in the above reaction is set to zero.

$Rate = k\,[CH_3COOC_2H_5]$

The term here takes into account the value of the water's constant concentration.

where $K = K'\,[H_2O]$

The reaction is a first order reaction, as we can see. These reactions are termed **pseudo first order reactions**.

Q13: What is the use of the integrated rate equation?

Answer:

Uses of integrated rate equation are as follows:

(i) When the concentration of a reactant at different intervals is known, the value of the rate constant can be calculated.

(ii) The knowledge of reaction concentration at different intervals can be used to establish the order of a reaction.

Q14: How does collision theory explain the formation of products in a chemical reaction?

Answer:

The reactant molecules are considered to be hard spheres in Collision Theory, and the reaction occurs when these molecules collide. The production of a product is induced by collisions between molecules with sufficient kinetic energy (called threshold energy) and proper orientation. The conditions for effective collision, and hence the rate of a reaction, are determined by the activation energy and proper orientation of the molecules.

Q15: The time required to decompose SO_2Cl_2 to half of its initial amount is 60 minutes. If the decomposition is a first order reaction, calculate the rate constant of the reaction.

Answer:

We know that for a 1st order reaction,

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

It is already given that $t_{1/2}$ = 60mins

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

= 0.693/60 = 0.01155 min^{-1} = **1.155 min^{-1}**

Practise Questions on Chemical Kinetics

Q1: Mention the factors that affect the rate of a chemical reaction.

Answer:

The following are the factors that influence the rate of a reaction.
(i) Concentration of reactants (pressure in case of gases)
(ii) Temperature
(iii) Presence of a catalyst

Q2: For a reaction, A + B → Product; the rate law is given by, $R = k [A]^{1/2} [B]^2$. What is the order of the reaction?

Answer:

The order of the reaction = 1/2 + 2 = **2.5**

Q3: Define the following terms:
i) Pseudo first order reaction.
ii) Half-life period of reaction ($t_{1/2}$).

Answer:

i) Pseudo first order reactions are reactions that are not true first order reactions but become first order under certain conditions.

ii) The half-life period is the time it takes for half of a reaction to complete.

Q4: Distinguish between Rate Expression and Rate Constant of a reaction.

Answer:

A **Rate Expression** is a mathematical expression that expresses the rate of a reaction in terms of the reactant's molar concentration.

The **Rate Constant** is the rate of the reaction if the concentration of reactants is unity. The rate law has a proportionality constant that is independent of the reactant concentrations at the start.

Q5: Write the Arrhenius equation.

Answer:

Arrhenius equation is as follows:

$$k = Ae^{-Ea/RT}$$

where,

- *k* represents the rate constant of the reaction
- *A* indicates the pre-exponential factor which, in terms of the collision theory, is the frequency of correctly oriented collisions between reacting species
- "*e*" is the base of the natural log (Euler's number)
- *Ea* indicates the activation energy of the chemical reaction

- *R* signifies the universal gas constant
- *T* represents the absolute temperature related with the reaction (in Kelvin)