Order of Reaction Chemistry Questions with Solutions

Q1. The reaction rate is defined as the rate at which the concentration of the reactants ___with time or the concentration of products ___ with time.

a.) Increase, increase
b.) Decrease, decrease
c.) Decrease, increase
d.) Increase, decrease

Correct Answer– (c.) Decrease, increase

Q2. Which of the following option is the correct unit of rate of reaction–

a.) Mol L^{-1} s^{-1}
b.) Mol L s^{-1}
c.) Mol L^{-1} s
d.) Mol L s

Correct Answer– (a.) Mol L^{-1} s^{-1}
Explanation– The rate at which the concentration of reactants decreases with time or the concentration of products increases with time is defined as the reaction rate.

Q3. For a reaction 2A + B 2C, with the rate equation: Rate = $k[A]^2[B]$
a.) the order with respect to A is 1 and the overall order is 1.
b.) the order with respect to A is 2 and the overall order is 2.
c.) the order with respect to A is 2 and the overall order is 3.
d.) the order with respect to B is 2 and the overall order is 2.

Correct Answer– (c.) the order with respect to A is 2 and the overall order is 3.

Q4. Which of the following statement is true for the reaction, $2H_2S(g) + O_2(g) \rightarrow 2S(s) + 2H_2O(l)$?

a.) The reaction is first order with respect to H_2S and second order with respect to O2.
b.) The reaction is fourth-order overall.
c.) The rate law is: rate = $k[H_2S]^2[O_2]$.
d.) The rate law cannot be determined from the information given.

Correct Answer– (d) The rate law cannot be determined from the information given.

Q5. A zero-order reaction is one in which-

a.) reactants do not react.
b.) one of the reactants is in large excess.
c.) whose rate does not change with time.
d.) whose rate increases with time.

Correct Answer– (c.) whose rate does not change with time.

Q6. State True or False.
The order of the reaction can be zero, fractional, or integer, and it can always be determined experimentally.

Answer. True.
The order of the reaction can be zero, fractional, or integer, and it can always be determined experimentally. The order of reaction with respect to a given substance is defined as the index, or exponent, to which its concentration term in the rate equation is brought up.

Q7. Decay of $_{92}U^{235}$ is which order reaction?

Answer. The decay of $_{92}U^{235}$ is a first-order reaction.
This is because the rate of disintegration, in this case, is entirely determined by the concentration of radioactive material.

Q8. Identify the order of a reaction if the units of its rate constant are:
(i) L^{-1} mol s^{-1}
(ii) L mol^{-1} s^{-1}

Answer. The order of the reaction is as follows-
(i) Unit = L^{-1} mol s^{-1} = It is a zero-order reaction.
(ii) Unit = L mol^{-1} s^{-1} = It is a second-order reaction.

Q9. Differentiate between the order of reaction and molecularity of a reaction.

Answer. The order of the reaction is the sum of the entire concentration terms on which the reaction rate is actually dependent. It can be both fractional and zero, as well as it can be determined experimentally.

The Molecularity of a reaction is the number of atoms, ions, or molecules that must collide with one another simultaneously in order for a chemical reaction to occur. It is always a whole number, and can only be determined theoretically.

Q10. State the characteristics of the order of a reaction?

Answer. The characteristics of the order of a reaction are as follows-

- A reaction's magnitude of order can be zero, fractional, or integral. For elementary reactions, the order is never fractional.
- It is an experimentally determined quantity. It illustrates the dependence of observed reaction rate on reactant concentration.
- Simple reactions have low order values, such as n = 0, 1, 2; complex reactions have orders greater than or equal to 3.0.
- Depending on the rate, some reactions exhibit fractional order.
- Experimental conditions can vary in reaction order.
- Using excess concentrations of one or more reactants, higher-order reactions can be experimentally converted into simpler order (Pseudo) reactions.

Q11. How long will it take for the initial concentration of A to fall from 0.10 M to 0.075, if the rate constant for a reaction of zero-order in A is 0.0030 mol L^{-1} s^{-1}.

Answer. For a zero-order reaction, time t will be-

$$t = \frac{1}{K}[(A)_0 - (A)]$$

$$t = \frac{1}{0.003}[(0.10) - (0.075)]$$

$$t = \frac{1}{0.003} \times 0.025 = \frac{25}{3} = 8.3 seconds$$

Q12. **A reaction is of second order with respect to a reactant. How will the rate of reaction be affected if the concentration of this reactant is–**
(i) doubled,
(ii) reduced to half?

Answer. Since, Rate = $K[A]^2$
For second-order reaction Let [A] = a then Rate = Ka^2
(i) If [A] = 2a then Rate = $K \times (2a)^2 = 4Ka^2$
∴Rate of reaction becomes 4 times.

(ii) If [A] = a/2 the Rate $= K\left(\frac{a}{2}\right)^2 = \frac{Ka^2}{4}$
Therefore, rate of the reaction will be one-fourth.

Q13. Write the expression of half-life for
(i) zero-order reaction.
(ii) first-order reaction.

Answer. The half-life of a reaction is defined as the time in which 50% of the reaction is completed, that is half of the reactants changes into products.
(i) For a zero-order reaction,

$$t_{1/2} = \frac{[R]_0}{2k}$$

Here, $[R]_0$ is the initial concentration and k is the rate constant.

(ii) For a first-order reaction,

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

Q14. Rate constant is equal to the rate of reaction when molar conc. of reactants is unity. Its unit depends upon order of reaction.
A reactant has a half-life of 10 minutes. Then, calculate the rate constant for the first-order reaction.

Answer. $t_{1/2}$ = 10 minutes = 10 × 60 = 600 seconds.

$$k = \frac{0.693}{t_{1/2}} = \frac{0.693}{600 seconds}$$

$$k = 1.155 \times 10^{-3} s^{-1}.$$

Q15. (a) A reaction is second order in A and first order in B.
(i) Write the differential rate equation.
(ii) How is the rate affected by increasing the concentration of A three times?
(iii) How is the rate affected when the concentrations of both A and B are doubled?
(b) A first-order reaction takes 40 minutes for 30% decomposition. Calculate t1/2 for this reaction.
(Given: log 1.428 = 0.1548)

Answer. (a) A reaction is second order in A and first order in B.
(i) The differential rate equation is given by-

$$\frac{dx}{dt} = k\,[A]^2\,[B]^1$$

(ii) If the concentration of A is increased three times–

$$\frac{dx}{dt} = k\,[3A]^2\,[B]^1 = 9k\,[A]^2\,[B]^1$$

Hence, the rate will increase 9 times.

(iii) When the concentrations of both A and B are doubled–

$$\frac{dx}{dt} = k\,[2A]^2\,[2B]^1 = 8k\,[A]^2\,[B]^1$$

Hence, the rate will increase 8 times.

(b) $k = \frac{2.303}{t} log\frac{[R]_0}{[R]} = \frac{2.303}{40} log\frac{[R]_0}{\frac{70}{100}[R]_0}$

$$k = \frac{2.303}{40}(log10 - log7) = \frac{2.303}{40}(1 - 0.08451)$$

$$k = \frac{2.303}{40} \times 0.1549 min^{-1}$$

$$t_{1/2} = \frac{0.693}{k} = \frac{0.693 \times 40}{2.303 \times 0.1549} = 77.7 minutes$$

Practise Questions on Order of Reaction

Q1. Given: A + 3B → 2C + D
This reaction is first order with respect to reactant A and second-order with respect to reactant B. If the concentration of A is doubled and the concentration of B is reduced to half, the rate of the reaction would ____by a factor of _____.

a.) increase, 2
b.) decrease, 2
c.) increase, 4
d.) decrease, 4

Correct Answer– (b.) decrease, 2

Q2. Decomposition of dimethyl ether at 504℃ **is first order having a half-life of 1570 seconds. What fraction of an initial amount of it remains after 4710 seconds?**

a.) ⅓.
b.) ⅙.
c.) ⅛.
d.) 1/16.

Correct Answer– (.c) ⅛.

Q3. A reaction is of first-order in reactant A and of second order in reactant B. How is the rate of this reaction affected when–
(i) the concentration of B alone is increased to three times?
(ii) the concentrations of A as well as B are doubled?

Answer. $r = K[A]^1 [B]^2$
(i) When concentration of B increases to 3 times, the rate becomes–

$r = KA(3B)^2$
$r = 9KAB^2$
Hence, the rate of reaction becomes 9 times.

(ii) When the concentrations of A as well as B are doubled
$r = K(2A)\ (2B)^2$
$r = 8KAB^2$
Hence, the rate of reaction becomes 8 times.

Q4. What are pseudo first-order reactions? Give one example of such reactions.

Answer. Pseudo first-order reactions are reactions that are not truly first order but become first order under certain conditions.
For example- In the hydrolysis of ester-
$CH_3COOCH_3 + H_2O \rightarrow CH_3COOH + CH_3OH$
Rate = k' $[CH_3COOCH_3]\ [H_2O]$
Water as solvent is present in such a large excess that its concentration remains constant. Thus, $[H_2O]$ = constant = k"
Rate = k' $[CH_3COOCH_3]$ k"
Rate = k' k" $[CH_3COOCH_3]$
Rate = k $[CH_3COOCH_3]$, where k' k" = k = constant

This indicates that the second-order true rate law is forced into first-order rate law. Hence, this bimolecular reaction which appears of second order is actually a pseudo first-order reaction.

Q5. Show that the time required for half the change (half-life period) in a first-order reaction is independent of initial concentration.

Answer. Half-life is the time in which 50% of the reaction is complete.
At $t_{1/2}$ $[A] = [A_0]/2$

$$k = \frac{2.303}{t_{1/2}} log \frac{[A]_0}{[A]_0/2} = \frac{2.303}{t_{1/2}} log2$$

$$k = \frac{2.303}{t_{1/2}} \times 0.3010 = \frac{0.693}{t_{1/2}}$$

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