1 Mark Questions

1. For the reaction $A \longrightarrow B$, the rate of reaction becomes three times when the concentration of A is increased by nine times. What is the order of reaction?
2. For a reaction $A + B \longrightarrow P$, the rate law is given by, $r = k[A]^{1/2}[B]^2$. What is the order of this reaction?
3. Express the rate of the following in terms of ammonia.
   $N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$
4. Define order of a reaction.
5. Identify the reaction order from the following rate constant,
   $k = 2.3 \times 10^{-5} L\ mol^{-1}\ s^{-1}$.
6. Why does the rate of a reaction not remain constant throughout the reaction process?
7. Define rate of a reaction.

2 Marks Questions

8. For a reaction,
   $$2H_2O_2 \xrightarrow[\text{Alkaline medium}]{I^-} 2H_2O + O_2$$
   the proposed mechanism is as given below
   (1) $H_2O_2 + I^- \longrightarrow H_2O + IO^-$ (slow)
   (2) $H_2O_2 + IO^- \longrightarrow H_2O + I^- + O_2$ (fast)
   (i) Write rate law for the reaction.
   (ii) Write the overall order of reaction.
   (iii) Out of steps (1) and (2), which one is rate determining step?
9. For the reaction,
   $$2N_2O_5(g) \longrightarrow 4NO_2(g) + O_2(g)$$
   the rate of formation of $NO_2(g)$ is $2.8 \times 10^{-3} Ms^{-1}$. Calculate the rate of disappearance of $N_2O_5(g)$.
10. For a reaction : $H_2 + Cl_2 \xrightarrow{h\nu} 2HCl$
    Rate = k
    (i) Write the order and molecularity of this reaction.
    (ii) Write the unit of k.
11. For a reaction,
    $$2NH_3(g) \xrightarrow{Pt} N_2(g) + 3H_2(g)$$
    Rate = k
    (i) Write the order and molecularity of this reaction.
    (ii) Write the unit of k.
12. Define rate of reaction. Write two factors that affect the rate of reaction.
13. Write units of rate constants for zero order and for the second order reactions if the concentration is expressed in mol L^{-1} and time in seconds.
14. Write two differences between 'order of reaction' and 'molecularity of reaction'.

    Or List two main differences between order of a reaction and molecularity of a reaction.

    Or Distinguish between molecularity and order of a reaction.
15. (i) For a reaction, $A + B \longrightarrow$ Product. The rate law is given by, Rate = $k[A]^1[B]^2$. What is the order of the reaction?
    (ii) Write the unit of rate constant 'k' for the first order reaction.
16. A reaction is of second order with respect to a reactant. How is its rate affected if the concentration of the reactant is
    (i) doubled?
    (ii) reduced to half?

17. What do you understand by the rate law and rate constant of a reaction? Identify the order of a reaction, if the units of its rate constant are

(i) $L^{-1} mol\, s^{-1}$. (ii) $L\, mol^{-1} s^{-1}$.

Or Distinguish between rate expression and rate constant of a reaction.

Or Express clearly, what do you understand by rate expression and rate constant of a reaction?

18. A reaction is of second order with respect to a reactant. How is the rate of reaction affected, if the concentration of the reactant is reduced to half? What is the unit of rate constant for such a reaction?

19. Define

(i) Order of reaction

(ii) Elementary step in a reaction.

20. Identify giving reasons, the reaction order from each of the following rate constants.

(i) $k = 2.3 \times 10^{-5}\ L\, mol^{-1}\, s^{-1}$

(ii) $k = 3.0 \times 10^{-4}\ s^{-1}$

21. Explain the following terms.

(i) Rate determining step of a reaction.

(ii) Molecularity of a reaction.

22. 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?

23. Discuss any four factors which affect the rate of a chemical reaction.

24. Explain the difference between the average rate and instantaneous rate of a chemical reaction.

3 Marks Questions

25. A reaction is first order in *A* and second order in *B*.

(i) Write the differential rate equation.

(ii) How is the rate affected on increasing the concentration of *B* three times?

(iii) How is the rate affected when the concentration of both *A* and *B* are doubled?

26. A reaction is second order w.r.t. *A* and first order w.r.t. *B*.

(i) Write the differential rate equation.

(ii) How is the rate affected on increasing the concentration of *A* three times?

(iii) How is the rate affected when the concentrations of both *A* and *B* are doubled?

27. For the reaction,

$$2NO(g) + Cl_2(g) \longrightarrow 2NOCl(g)$$

The following data were collected. All the measurements were taken at 263 K.

Exp. No.	Initial [NO] (M)	Initial $[Cl_2]$ (M)	Initial rate of disappearance of Cl_2 (M/min)
1.	0.15	0.15	0.60
2.	0.15	0.30	1.20
3.	0.30	0.15	2.40
4.	0.25	0.25	?

(i) Write the expression for rate law.

(ii) Calculate the value of rate constant and specify its unit.

(iii) What is the initial rate of disappearance of Cl_2 in experiment 4?

28. Consider the reaction,

$$2A + B \longrightarrow C + D$$

Following results were obtained from experiments designed to study the rate of reactions.

Exp. No.	Initial concentration (mol L^{-1})		Initial rate of formation
	$[A]$	$[B]$	$[D]$ (M/min)
1.	0.10	0.10	1.5×10^{-3}
2.	0.20	0.20	3.0×10^{-3}
3.	0.20	0.40	6.0×10^{-3}

(i) Write the rate law for the reaction.

(ii) Calculate the value of rate constant for the reaction.

(iii) Which of the following possible reaction mechanisms is consistent with the rate law?

I. $A + B \longrightarrow C + E$ (slow)

$A + E \longrightarrow D$ (fast)

II. $B \longrightarrow C + E$ (slow)

$A + E \longrightarrow F$ (fast)

$A + F \longrightarrow D$ (fast)

29. The following results have been obtained during kinetic studies of the reaction:

$$2A + B \longrightarrow C + D$$

Exp. No.	$[A]$	$[B]$	Initial rate of formation of D
1.	0.1 M	0.1 M	6.0×10^{-3} M min^{-1}
2.	0.3 M	0.2 M	7.2×10^{-3} M min^{-1}
3.	0.3 M	0.4 M	2.88×10^{-2} M min^{-1}
4.	0.4 M	0.1 M	2.40×10^{-2} M min^{-1}

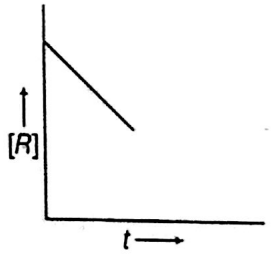
Determine rate law and the rate constant for the reaction.

1 Mark Questions

1. For a reaction $R \rightarrow P$, half-life ($t_{1/2}$) is observed to be independent of the initial concentration of reactants. What is the order of reaction?
2. A first order reaction is found to have a rate constant, $k = 5.5 \times 10^{-14} s^{-1}$. Find the half-life of the reaction.
3. If half-life period of a first order reaction is x and 3/4th life period of the same reaction is y, how are x and y related to each other?

2 Marks Questions

4. Define the following terms.
   (i) Half-life of a reaction ($t_{1/2}$)
   (ii) Rate constant (k)
5. For a chemical reaction, $R \longrightarrow P$, the variation in the concentration of R *versus* time (t) plot is given as



   (i) Predict the order of the reaction.
   (ii) What is the slope of the curve?

6. Hydrogen peroxide, $H_2O_2(aq)$ decomposes to $H_2O(l)$ and $O_2(g)$ in a reaction that is first order in H_2O_2 and has a rate constant $k = 1.06 \times 10^{-3}$ min^{-1}.

(i) How long will it take for 15% of a sample of H_2O_2 to decompose?

(ii) How long will it take for 85% of the sample to decompose?

7. Define half-life of a reaction. Write the expression of half-life for

(i) zero order reaction

(ii) first order reaction

8. A first order reaction takes 40 min for 30% decomposition. Calculate $t_{1/2}$ for this reaction. (Given, log 1.428 = 0.1548)

9. A reactant has a half-life of 10 min.

(i) Calculate the rate constant for the first order reaction.

(ii) What fraction of the reactant will be left after an hour of the reaction has occurred?

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

11. In a first order reaction, the concentration of the reactant is reduced from 0.6 mol L^{-1} to 0.2 mol L^{-1} in 5 min. Calculate the rate constant of the reaction.

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

3 Marks Questions

13. The decomposition of NH_3 on platinum surface is zero order reaction. If rate constant (k) is 4×10^{-3} Ms^{-1}, how long will it take to reduce the initial concentration of NH_3 from 0.1 M to 0.064 M.

14. A first order reaction takes 20 minutes for 25% decomposition. Calculate the time when 75% of the reaction will be completed.

Given : log 2 = 0.3010, log 3 = 0.4771,
log 4 = 0.6021

15. Following data are obtained for the reaction

$$N_2O_5 \longrightarrow 2NO_2 + \frac{1}{2}O_2$$

t/s	0	300	600
$[N_2O_5]$/mol L^{-1}	1.6×10^{-2}	0.8×10^{-2}	0.4×10^{-2}

(i) Show that it follows first order reaction.

(ii) Calculate the half-life.

(Given: log 2 = 0.3010 , log 4 = 0.6021)

16. For the first order thermal decomposition reaction, the following data obtained:

$$C_2H_5Cl(g) \longrightarrow C_2H_4(g) + HCl(g)$$

Time/s	Total pressure/atm
0	0.30
300	0.50

Calculate the rate constant.

(Given: log 2 = 0.3010, log 3 = 0.4771, log 4 = 0.6021)

17. The rate constant for a first order reaction is 60 s^{-1}. How much time will it take to reduce the initial concentration of the reactant to its 1/10th value?

18. The following data were obtained during the first order thermal decomposition of SO_2Cl_2 at a constant volume:

$$SO_2Cl_2(g) \longrightarrow SO_2(g) + Cl_2(g)$$

Experiment	Time	Total pressure/atm
1	0	0.4
2	100	0.7

Calculate the rate constant.

(Given, log 4 = 0 . 6021, log 2 = 0.3010)

19. A first order reaction takes 100 min for completion of 60% of the reaction. Find the time when 90% of the reaction will be completed.

20. Nitrogen pentoxide decomposes according to the equation

$$2N_2O_5(g) \longrightarrow 4NO_2(g) + O_2(g)$$

This first order reaction was allowed to proceed at 40°C and the data below were collected.

$[N_2O_5]$ M	Time (min)
0.400	0.00
0.289	20.0
0.209	40.0
0.151	60.0
0.109	80.0

(i) Calculate the rate constant. Include units with your answer.

(ii) What will be the concentration of N_2O_5 after 100 min?

(iii) Calculate the initial rate of reaction.

21. The thermal decomposition of HCOOH is a first order reaction with a rate constant of $2.4\times10^{-3}\ s^{-1}$ at a certain temperature. How long will it take for three fourth of initial quantity of HCOOH to decompose? (log 0.25 = –0.6021)

22. Nitrogen pentoxide decomposes according to equation, $2N_2O_5(g) \longrightarrow 4NO_2(g)+O_2(g)$

This first order reaction was allowed to proceed at 40°C and the data below were collected.

$[N_2O_5]$ M	Time (min)
0.400	0.00
0.289	20.0
0.209	40.0
0.151	60.0
0.109	80.0

(i) Calculate the rate constant. Include units with your answer.

(ii) Calculate the initial rate of reaction.

(iii) After how many minutes will $[N_2O_5]$ be equal to 0.350 M?

23. A first order reaction has a rate constant value of $0.00510\ min^{-1}$. If we begin with 0.10 M concentration of the reactant, how much of the reactant will remain after 8.0 h?

24. The decomposition of phosphine, PH_3 proceeds according to the following equation:

$$4PH_3(g) \longrightarrow P_4(g) + 6H_2(g)$$

It is found that the reaction follows the following rate equation

$$\text{Rate} = k[PH_3]$$

The half-life of PH_3 is 37.9 s at 120°C.

(i) How much time is required for 3/4th of PH_3 to decompose?

(ii) What fraction of the original sample of PH_3 remains behind after 1 min?

25. The decomposition of a compound is found to follow a first order rate law. If it takes 15 min for 20% of original material to react, calculate

(i) the rate constant.

(ii) the time at which 10% of the original material remains unreacted.

26. In a pseudo first order hydrolysis of ester in water, the following results are obtained

t (in s)	0	30	60	90
[Ester] M	0.55	0.31	0.17	0.085

(i) Calculate the average rate of reaction between the time interval 30 to 60 s.

(ii) Calculate the pseudo first order rate constant for the hydrolysis of ester.

5 Marks Questions

27. For the hydrolysis of methyl acetate in aqueous solution, the following results were obtained.

t/s	0	10	20
$[CH_3COOCH_3]$ / mol L^{-1}	0.10	0.05	0.025

(i) Show that it follows pseudo first order reaction, as the concentration of water remains constant.

(ii) Calculate the average rate of reaction between the time interval 10 to 20 s.
(Given: log 2 = 0.3010, log 4 = 0.6021)

28. (i) For a reaction, $A + B \rightarrow P$, the rate is given by Rate $= k[A]\ [B]^2$

(a) How is the rate of reaction affected if the concentration of B is doubled?

(b) What is the overall order of reaction if A is present in large excess?

(ii) A first order reaction takes 30 min for 50% completion. Calculate the time required for 90% completion of this reaction.
(log 2 = 0.3010)

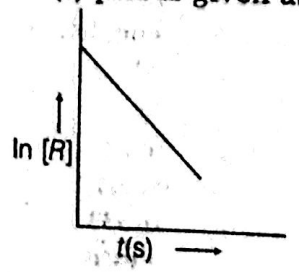
29. For the hydrolysis of methyl acetate in aqueous solution, the following results were obtained.

t/s	0	30	60
$[CH_3COOCH_3]$ / mol L^{-1}	0.60	0.30	0.15

(i) Show that it follows pseudo first order reaction, as the concentration of water remains constant.

(ii) Calculate the average rate of reaction between the time interval 30 to 60 s.
(Given: log 2 = 0.3010, log 4 = 0.6021)

30. (i) For a chemical reaction $R \rightarrow P$, the variation in the concentration, ln $[R]$ *vs* time(s) plot is given as



(a) Predict the order of the reaction.

(b) What is the slope of curve?

(c) Write the unit of rate constant for this reaction.

(ii) Show that the time required for 99% completion is double of the time required for the completion of 90% reaction.

1 Mark Questions

1. What is the effect of adding a catalyst on
   (i) Activation energy (E_a) and
   (ii) Gibbs energy (ΔG) of a reaction?
2. In some cases, it is found that a large number of colliding molecules have energy more than threshold energy, yet the reaction is slow. Why?
3. Define activation energy.

2 Marks Questions

4. Define the following terms.
   (i) Rate constant (k)
   (ii) Activation energy (E_a)
5. Define each of the following.
   (i) Specific rate of a reaction
   (ii) Energy of activation of a reaction
6. How does a change in temperature affect the rate of a reaction? How can this effect on the rate constant of a reaction be represented quantitatively?

   Or What is the effect of temperature on the rate constant of a reaction? How can this temperature effect on rate constant be expressed quantitatively?
7. With the help of diagram, explain the role of activated complex in a reaction.
8. The rate of most reactions become double when their temperature is raised from 298 K to 308 K. Calculate their activation energy.
   (Given, $R = 8.314\ \text{J mol}^{-1}\ \text{K}^{-1}$)
9. The rate of a reaction becomes four times when the temperature changes from 300 K to 320 K . Calculate the energy of activation of the reaction, assuming that it does not change with temperature.
   ($R = 8.314\ \text{J K}^{-1}\text{mol}^{-1}$)

3 Marks Questions

10. A first order reaction is 50% completed in 40 minutes at 300 K and in 20 minutes at 320 K. Calculate the activation energy of the reaction. (Given : log 2 = 0.3010, log 4 = 0.6021, $R = 8.314\ \text{JK}^{-1}\ \text{mol}^{-1}$)

11. The rate constant for the first order decomposition of H_2O_2 is given by the following equation:

$$\log k = 14.2 - \frac{1.0 \times 10^4}{T} K$$

Calculate E_a for this reaction and rate constant k if its half-life period be 200 min. (Given, $R = 8.314\ JK^{-1}mol^{-1}$)

12. The rate constants of a reaction at 500 K and 700 K are 0.02 s^{-1} and 0.07 s^{-1} respectively. Calculate the value of activation energy, E_a. ($R = 8.314\ J\ K^{-1}mol^{-1}$).

13. For a decomposition reaction, the values of k at two different temperatures are given below.

$k_1 = 2.15 \times 10^{-8}$ L/(mol·s) at 650 K

$k_2 = 2.39 \times 10^{-7}$ L/(mol·s) at 700 K

Calculate the value of E_a for the reaction.

(Given, log11.11 = 1.046
$R = 8.314\ J\ K^{-1}\ mol^{-1}$)

14. The decomposition of A into products has a value of k as $4.5 \times 10^3\ s^{-1}$ at 10°C and energy of activation 60 kJ mol^{-1}. At what temperature would k be $1.5 \times 10^4\ s^{-1}$?

15. Rate constant 'k' of a reaction varies with temperature 'T' according to the equation

$$\log k = \log A - \frac{E_a}{2.303R}\left(\frac{1}{T}\right)$$

where E_a is the activation energy. When a graph is plotted for log k vs $\frac{1}{T}$, a straight line with a slope of –4250 K is obtained. Calculate 'E_a' for the reaction.
($R = 8.314\ K^{-1}mol^{-1}$)

16. The rate of a reaction becomes four times when the temperature changes from 293 K to 313 K. Calculate the energy of the activation (E_a) of the reaction assuming that it does not change with temperature.
($R = 8.314\ JK^{-1}mol^{-1}$, log 4 = 0.6021)

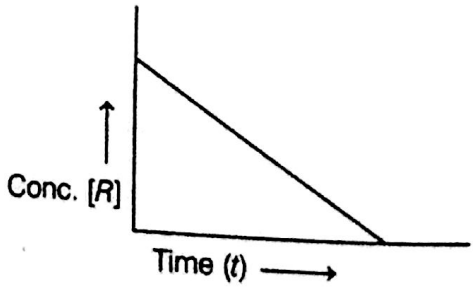
17. The activation energy for the reaction $2HI(g) \longrightarrow H_2(g) + I_2(g)$ is 209.5 kJ mol^{-1} at 581 K. Calculate the fraction of molecules having energy equal to or greater than activation energy.
($R = 8.31\ JK^{-1}mol^{-1}$)

5 Marks Questions

18. (i) Define the following terms.
(a) Activation energy
(b) Rate constant

(ii) A first order reaction takes 10 min for 25% decomposition. Calculate $t_{1/2}$ for the reaction.
(Given, log 2 = 0.3010, log 3 = 0.4771, log 4 = 0.6021)

19. (a) Consider the reaction $R \rightarrow P$ for which the change in concentration of R with time is shown by the following graph :



(i) Predict the order of reaction.
(ii) What does the slope of the curve indicate?

(b) The rate of reaction quadruples when temperature changes from 293 K to 313 K. Calculate E_a assuming that it does not change with time.
[$R = 8.314\ JK^{-1}mol^{-1}$]

20. (a) Draw the plot of ln k vs $1/T$ for a chemical reaction. What does the intercept represent? What is the relation between slope and E_a?

(b) A first order reaction takes 30 minutes for 20% decomposition. Calculate $t_{1/2}$.
[log 2 = 0.3010]

Objective Questions

(For Complete Chapter)

1 Mark Questions

1. Rate law for the reaction, $A + 2B \rightarrow C$ is found to be, rate = $k[A][B]$.

Concentration of reactant 'B' is doubled, keeping the concentration of 'A' constant, the value of rate constant will be

(a) same

(b) doubled

(c) quadrupled

(d) halved

2. For the reaction, $N_2 + 3H_2 \longrightarrow 2NH_3$, if $\frac{d[NH_3]}{dt} = 2 \times 10^{-4}$ mol L^{-1} s^{-1}, the value of $\frac{-d[H_2]}{dt}$ would be

(a) 3×10^{-4} mol L^{-1} s^{-1}

(b) 4×10^{-4} mol L^{-1} s^{-1}

(c) 6×10^{-4} mol L^{-1} s^{-1}

(d) 1×10^{-4} mol L^{-1} s^{-1}

3. On increasing the pressure three fold, the rate of reaction of $2H_2S + O_2 \longrightarrow$ products, would increase

(a) 3 times

(b) 9 times

(c) 12 times

(d) 27 times

4. Which of these does not influence the rate of reaction?

(a) Nature of the reactants

(b) Concentration of the reactants

(c) Temperature of the reaction

(d) Molecularity of the reaction

5. The unit of rate constant depends upon

(a) rate of reaction

(b) order of reaction

(c) molecularity of reaction

(d) All of the above

6. The value of rate constant for a first order reaction is $2.303 \times 10^{-2} s^{-1}$. What will be the time required to reduce the concentration to $\frac{1}{10}$th of its initial concentration?

(a) 100 s (b) 10 s (c) 2303 s (d) 23.03 s

7. The first order integrated rate equation is

(a) $k = \frac{x}{t}$

(b) $k = -\frac{2.303}{t} \log \frac{a}{a-x}$

(c) $k = \frac{1}{t} \ln \frac{a}{a-x}$

(d) $k = \frac{1}{t} \frac{x}{a(a-x)}$

8. The unit of rate constant for first order reaction is

(a) mol L^{-1} s^{-1} (b) s^{-1}

(c) L mol^{-1} s^{-1} (d) L^2 mol^{-2} s^{-1}

9. When plotted a graph of concentration *versus* time for zero order reaction, then the value of slope is

(a) $-\frac{k}{2.303}$ (b) $-2.303\,xk$

(c) $-k$ (d) $-\frac{E_a}{2.303R}$

10. For which order half-life period is independent of initial concentration?

(a) Zero (b) First (c) Second (d) Third

11. For a given reaction, $t_{1/2} = \frac{1}{ka}$, the order of the reaction is

(a) 1 (b) 0 (c) 3 (d) 2

12. According to Arrhenius equation, the slope of $\log k$ *versus* $\frac{1}{T}$ plot is

(a) $\frac{-E_a}{2.303R}$ (b) $\frac{-E_a}{2.303}$

(c) $\frac{-E_a}{2.303RT}$ (d) $\frac{E_a}{2.303RT}$

13. The activation energy of a reaction at a given temperature is found to be $2.303\ RT\ \text{J mol}^{-1}$. The ratio of rate constant to the Arrhenius factor is

(a) 0.01 (b) 0.1

(c) 0.02 (d) 0.001