

## Previous Years' CBSE Board Questions

### 4.1 Rate of a Chemical Reaction

#### VSA (1 mark)

- Express the rate of the following reaction in terms of the formation of ammonia.  

$$\text{N}_{2(g)} + 3\text{H}_{2(g)} \longrightarrow 2\text{NH}_{3(g)} \quad (\text{Delhi 2013C})$$
- Define elementary step in a reaction.  
*(1/5, Foreign 2011)*
- Why does the rate of a reaction not remain constant throughout the reaction process?  
*(AI 2009C)*

#### SA I (2 marks)

- What is meant by rate of reaction? Differentiate between average rate and instantaneous rate of reaction.  
*(AI 2012C)*
- Explain the difference between the average rate and instantaneous rate of chemical reaction.  
*(2/5, AI 2010C)*

### 4.2 Factors Influencing Rate of a Reaction

#### VSA (1 mark)

- Define the rate constant.  
*(1/5, Foreign 2015, Delhi 2015C)*
- Define the specific rate of reaction.  
*(AI 2014C)*
- For a reaction  $A + B \rightarrow P$ , the rate law is given by,  

$$r = k[A]^{1/2} [B]^2$$
 What is the order of this reaction? *(AI 2013)*
- If the rate constant of reaction is  $k = 3 \times 10^{-4} \text{s}^{-1}$ , then identify the order of the reaction.  
*(Delhi 2013C, 2011C)*
- Define 'order of a reaction'. *(AI 2011)*
- Identify the reaction order from the following rate constant :  
 $k = 2.3 \times 10^{-5} \text{L mol}^{-1} \text{s}^{-1}$  *(Delhi, AI 2011C)*
- Distinguish between molecularity and order of a reaction.  
*(1/5, AI 2010C)*

- Define the term 'order of reaction' for chemical reactions.  
*(Delhi, AI 2008)*
- For the reaction,  $\text{Cl}_{2(g)} + 2\text{NO}_{(g)} \rightarrow 2\text{NOCl}_{(g)}$  the rate law is expressed as  

$$\text{Rate} = k[\text{Cl}_2] [\text{NO}]^2$$
 What is the overall order of this reaction?  
*(Delhi 2007)*
- Express the rate of the following reaction in terms of disappearance of hydrogen in the reaction :  

$$3\text{H}_{2(g)} + \text{N}_{2(g)} \rightarrow 2\text{NH}_{3(g)} \quad (\text{AI 2007})$$

#### SA I (2 marks)

- For a reaction :  $2\text{NH}_{3(g)} \xrightarrow{\text{Pt}} \text{N}_{2(g)} + 3\text{H}_{2(g)}$   

$$\text{Rate} = k$$
  - Write the order and molecularity of this reaction.
  - Write the unit of  $k$ . *(Delhi 2016)*
- For a reaction :  $\text{H}_2 + \text{Cl}_2 \xrightarrow{h\nu} 2\text{HCl}$   

$$\text{Rate} = k$$
  - Write the order and molecularity of this reaction
  - Write the unit of  $k$ . *(AI 2016)*
- For a reaction  $A + B \rightarrow P$ , the rate is given by  

$$\text{Rate} = k[A][B]^2$$
  - How is the rate of reaction affected if the concentration of  $B$  is doubled?
  - What is the overall order of reaction if  $A$  is present in large excess? *(2/5, Delhi 2015)*
- Define rate of reaction. Write two factors that affect the rate of reaction. *(AI 2015)*
- Write units of rate constants for zero order and for the second order reactions if the concentration is expressed in  $\text{mol L}^{-1}$  and time in second. *(AI 2015C)*
- Write two differences between 'order of reaction' and 'molecularity of reaction'.  
*(Delhi 2014, 2011C)*
- (i) For a reaction,  $A + B \rightarrow \text{Product}$ , the rate law is given by,  $\text{Rate} = k[A]^1[B]^2$ . What is the order of the reaction ?

- (ii) Write the unit of rate constant ' $k$ ' for the first order reaction. (Delhi 2014C)
23. A reaction is of second order with respect to its reactant. How will its reaction rate be affected if the concentration of the reactant is (i) doubled (ii) reduced to half?  
(AI 2014C, 2012, Delhi 2009)
24. What do you understand by the 'order of a reaction'? Identify the reaction order from each of the following units of reaction rate constant.  
(i)  $L^{-1} mol s^{-1}$  (ii)  $L mol^{-1} s^{-1}$  (Delhi 2012)
25. Distinguish between 'rate expression' and 'rate constant' of a reaction. (Delhi 2011)
26. 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)  $L mol^{-1} s^{-1}$  (AI 2011)
27. Express clearly what do you understand by 'rate expression' and 'rate constant' of a reaction  
(2/5, Foreign 2011)
28. Explain the term 'order of reaction'. Derive the unit for first order rate constant. (Delhi 2009C)
29. What is meant by the 'rate constant,  $k$ ' of a reaction? If the concentration be expressed in  $mol L^{-1}$  units and time in seconds. What would be the units for  $k$  (i) for a zero order reaction and (ii) for a first order reaction? (Delhi 2008)
30. List the factors on which the rate of a chemical reaction depends. (2/5, Delhi, AI 2008)
31. Distinguish between order and molecularity of a reaction. When could order and molecularity of a reaction be the same? (Delhi 2008C)

**SA II (3 marks)**

32. A reaction is second order in  $A$  and first order in  $B$ .  
(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 concentration of both  $A$  and  $B$  are doubled?  
(3/5, Delhi 2013)
33. The reaction,  $N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)}$  contributes to air pollution whenever a fuel is burnt in air

at a high temperature. At 1500 K, equilibrium constant  $K$  for it is  $1.0 \times 10^{-5}$ . Suppose in a case  $[N_2] = 0.80 mol L^{-1}$  and  $[O_2] = 0.20 mol L^{-1}$  before any reaction occurs. Calculate the equilibrium concentrations of the reactants and the product after the mixture has been heated to 1500 K.

(AI 2012)

34. (i) A reaction is first order in  $A$  and second order in  $B$ .  
(a) Write differential rate equation.  
(b) How is rate affected when concentration of  $B$  is tripled?  
(c) How is rate affected when concentration of both  $A$  and  $B$  is doubled?  
(ii) What is molecularity of a reaction?  
(AI 2012C)
35.  $A + 2B \rightarrow 3C + 2D$ . The rate of disappearance of  $B$  is  $1 \times 10^{-2} mol/L/s$ .  
What will be (i) rate of the reaction (ii) rate of change in concentration of  $A$  and  $C$ ?  
(3/5, AI 2008)

36. The data given below is for the reaction,  
 $2N_2O_{5(g)} \rightarrow 4NO_{2(g)} + O_{2(g)}$  at 298 K :

S. No.	$[N_2O_5]$ ( $mol L^{-1}$ )	Rate of disappearance of $N_2O_5$ ( $mol L^{-1} min^{-1}$ )
1.	$1.13 \times 10^{-2}$	$34 \times 10^{-5}$
2.	$0.84 \times 10^{-2}$	$25 \times 10^{-5}$
3.	$0.62 \times 10^{-2}$	$18 \times 10^{-5}$

Determine for this reaction :

- (i) order of reaction  
(ii) rate constant  
(iii) rate law. (AI 2008C)
37. The decomposition of  $NH_3$  on platinum surface :  
 $2NH_{3(g)} \xrightarrow{Pt} N_{2(g)} + 3H_{2(g)}$   
is a zero order reaction with  $k = 2.5 \times 10^{-4} mol L^{-1} s^{-1}$   
What are the rates of production of  $N_2$  and  $H_2$ ?  
(Delhi 2007)

**LA (5 marks)**

38. The following results have been obtained during the kinetic studies of the reaction :  
 $2A + B \rightarrow C + D$

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

Calculate the rate of formation of D when  $[A] = 0.5 \text{ mol L}^{-1}$  and  $[B] = 0.2 \text{ mol L}^{-1}$ .

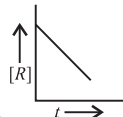
(Delhi 2010C)

### 4.3 Integrated Rate Equations

#### VSA (1 mark)

39. Define the half-life period of reaction ( $t_{1/2}$ ).  
(Delhi 2014)
40. If half-life period of a first order reaction is  $x$  and  $3/4^{\text{th}}$  life period of the same reaction is  $y$ , how are  $x$  and  $y$  related to each other?  
(1/5, Delhi 2013C)

#### SA I (2 marks)

41. For a chemical reaction  $R \rightarrow P$ , the variation in the concentration  $[R]$  vs. time ( $t$ ) plot is given as   
(i) Predict the order of the reaction.  
(ii) What is the slope of the curve? (AI 2014)
42. Define half-life of a reaction. Write the expression of half-life for  
(i) zero order reaction and  
(ii) first order reaction. (Foreign 2014)
43. For a first order reaction, show that time required for 99% completion is twice the time required for the completion of 90% of reaction.  
(2/5, Delhi 2013)
44. Rate constant  $k$  for a first order reaction has been found to be  $2.54 \times 10^{-3} \text{ sec}^{-1}$ . Calculate its  $3/4^{\text{th}}$  life. ( $\log 4 = 0.6020$ ) (Delhi 2013C)
45. The thermal decomposition of  $\text{HCO}_2\text{H}$  is a first order reaction with a rate constant of  $2.4 \times 10^{-3} \text{ s}^{-1}$  at a certain temperature. Calculate how long will it take for three-fourth of initial quantity of  $\text{HCO}_2\text{H}$  to decompose. ( $\log 0.25 = -0.6021$ ) (AI 2011)
46. In a first order reaction, the concentration of the reactant is reduced from  $0.6 \text{ mol L}^{-1}$  to

$0.2 \text{ mol L}^{-1}$  in 5 minutes. Calculate the rate constant of the reaction. (AI 2011C)

47. Show that for a first order reaction, the time required for half the change (half-life period) is independent of initial concentration.  
(Delhi 2009C)
48. A first order decomposition reaction takes 40 minutes for 30% decomposition. Calculate its  $t_{1/2}$  value. (Delhi, AI 2008)

#### SA II (3 marks)

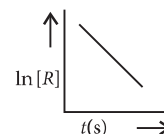
49. For the first order thermal decomposition reaction, the following data were obtained:  
 $\text{C}_2\text{H}_5\text{Cl}_{(g)} \longrightarrow \text{C}_2\text{H}_4_{(g)} + \text{HCl}_{(g)}$

Time/sec	Total pressure/atm
0	0.30
300	0.50

Calculate the rate constant.

(Given :  $\log 2 = 0.301$ ,  $\log 3 = 0.4771$ ,  $\log 4 = 0.6021$ )  
(AI 2016)

50. A first order reaction takes 30 minutes for 50% completion. Calculate the time required for 90% completion of this reaction. ( $\log 2 = 0.3010$ )  
(3/5, Delhi 2015)
51. A first order reaction takes 10 minutes for 25% decomposition. Calculate  $t_{1/2}$  for the reaction. (Given :  $\log 2 = 0.3010$ ,  $\log 3 = 0.4771$ ,  $\log 4 = 0.6021$ ) (3/5, Foreign 2015)
52. For a chemical reaction  $R \longrightarrow P$ , the variation in the concentration,  $\ln [R]$  vs. time (s) plot is given as



- (i) Predict the order of the reaction.  
(ii) What is the slope of the curve?  
(iii) Write the unit of the rate constant for this reaction. (3/5, Foreign 2015)
53. The rate constant for a first order reaction is  $60 \text{ s}^{-1}$ . How much time will it take to reduce the initial concentration of the reactant to its  $1/10^{\text{th}}$  value? (AI 2015C, 2007)
54. The following data were obtained during the first order thermal decomposition of  $\text{SO}_2\text{Cl}_2$  at a constant volume :  
 $\text{SO}_2\text{Cl}_{2(g)} \longrightarrow \text{SO}_{2(g)} + \text{Cl}_{2(g)}$

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

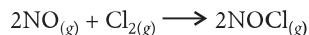
Calculate the rate constant.

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

(Delhi, AI, Foreign 2014)

55. Hydrogen peroxide,  $\text{H}_2\text{O}_{2(aq)}$  decomposes to  $\text{H}_2\text{O}_{(l)}$  and  $\text{O}_{2(g)}$  in a reaction that is first order in  $\text{H}_2\text{O}_2$  and has a rate constant  $k = 1.06 \times 10^{-3} \text{ min}^{-1}$ .
- How long will it take for 15% of a sample of  $\text{H}_2\text{O}_2$  to decompose?
  - How long will it take for 85% of the sample to decompose? (Delhi 2014C)
56. The first order reaction take 100 minutes for completion of 60% of the reaction. Find the time when 90% of the reaction will be completed. (3/5, Delhi 2013C)

57. For the reaction :



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

Exp. No.	Initial [NO](M)	Initial [Cl <sub>2</sub> ](M)	Initial rate of disapp. of Cl <sub>2</sub> (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	?

- Write the expression for rate law.
  - Calculate the value of rate constant and specify its units.
  - What is the initial rate of disappearance of  $\text{Cl}_2$  in exp. 4? (Delhi 2012)
58. A first order reaction is 15% completed in 20 minutes. How long will it take to complete 60% of the reaction? (3/5, Delhi 2012C)
59. Nitrogen pentoxide decomposes according to equation :
- $$2\text{N}_2\text{O}_{5(g)} \longrightarrow 4\text{NO}_{2(g)} + \text{O}_{2(g)}$$
- This first order reaction was allowed to proceed at 40° C and the data below were collected :

[N <sub>2</sub> O <sub>5</sub> ] (M)	Time (min)
0.400	0.00
0.289	20.0
0.209	40.0
0.151	60.0
0.109	80.0

- Calculate the rate constant. Include units with answer.
  - What will be the concentration of  $\text{N}_2\text{O}_5$  after 100 minutes?
  - Calculate the initial rate of reaction. (Delhi 2011)
60. Nitrogen pentoxide decomposes according to the equation :
- $$2\text{N}_2\text{O}_{5(g)} \longrightarrow 4\text{NO}_{2(g)} + \text{O}_{2(g)}$$
- This first order reaction was allowed to proceed at 40°C and the data given below were collected :

[N <sub>2</sub> O <sub>5</sub> ] (M)	Time (min)
0.400	0.00
0.289	20.00
0.209	40.00
0.151	60.00
0.109	80.00

- Calculate the rate constant for the reaction. Include units with your answer.
  - Calculate the initial rate of reaction.
  - After how many minutes will  $[\text{N}_2\text{O}_5]$  be equal to 0.350 M? (3/5, Delhi 2011)
61. A first order reaction has a rate constant value of  $0.00510 \text{ min}^{-1}$ . If we begin with 0.10 M concentration of the reactant, how much of the reactant will remain after 3.0 hours? (3/5, Foreign 2011)
62. A reactant has a half-life of 10 minutes.
- Calculate the rate constant for the first order reaction.
  - What fraction of the reactant will be left after an hour of the reaction has occurred? (Delhi 2011C)
63. The decomposition of a compound is found to follow a first order rate law. If it takes 15 minutes for 20 per cent of original material to react, calculate

- (i) the rate constant.  
 (ii) the time at which 10% of the original material remains unreacted.

(3/5, Delhi 2010C)

64. The half-life for a first order reaction is  $5 \times 10^4$  s. What percentage of the initial reactant will react in 20 hours? (3/5, AI 2009C)
65. A first order reaction is 20% complete in 5 minutes. Calculate the time taken for the reaction to be 60% complete. (AI 2009C)
66. The half-life for decay of radioactive  $^{14}\text{C}$  is 5730 years. An archaeological artifact containing wood has only 80% of the  $^{14}\text{C}$  activity as found in living trees. Calculate the age of the artifact. (Delhi, AI 2008)

#### 4.4 Pseudo First Order Reaction

##### VSA (1 mark)

67. Define the following term :  
 Pseudo first order reaction (1/2, Delhi 2014)

##### SA II (3 marks)

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

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

(3/5, AI 2010C)

##### LA (5 marks)

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

t/s	0	30	60
$[\text{CH}_3\text{COOCH}_3]/\text{mol L}^{-1}$	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 seconds. (Given :  $\log 2 = 0.3010$ ,  $\log 4 = 0.6021$ ) (Delhi 2015)

#### 4.5 Temperature Dependence of the Rate of a Reaction

##### VSA (1 mark)

70. Define the following :  
 Energy of activation of reaction. (1/5, Foreign 2015, AI 2014C, 2008)

##### SA I (2 marks)

71. How does a change in temperature affect the rate of a reaction? How can this effect on the rate constant of reaction be represented quantitatively? (AI 2014C)
72. With the help of diagram, explain the physical significance of energy of activation ( $E_a$ ) in chemical reactions. (AI 2013C)
73. With the help of a labelled diagram explain the role of activated complex in a reaction. (2/5, Delhi 2012C)
74. The rate of most of the reactions becomes double when their temperature is raised from 298 K to 308 K. Calculate their activation energy. [Given  $R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$ ] (Delhi 2011C)
75. Define "order of a reaction" and "activation energy of a reaction". (AI 2009)

##### SA II (3 marks)

76. The rate constant for the first order decomposition of  $\text{H}_2\text{O}_2$  is given by the following equation :

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

Calculate  $E_a$  for this reaction and rate constant  $k$  if its half-life period be 200 minutes.

(Given :  $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$ ) (Delhi 2016)

77. The rate constant of a first order reaction increases from  $2 \times 10^{-2}$  to  $4 \times 10^{-2}$  when the temperature changes from 300 K to 310 K. Calculate the energy of activation ( $E_a$ ). ( $\log 2 = 0.301$ ,  $\log 3 = 0.4771$ ,  $\log 4 = 0.6021$ ) (Delhi 2015)
78. The rate constants of reaction at 500 K and 700 K are  $0.02 \text{ s}^{-1}$  and  $0.07 \text{ s}^{-1}$  respectively. Calculate the value of activation energy,  $E_a$  ( $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$ ). (Delhi 2015C, 2008)

79. For a decomposition reaction, the values of  $k$  at two different temperatures are given below :  
 $k_1 = 2.15 \times 10^{-8} \text{ L}/(\text{mol}\cdot\text{s})$  at 650 K  
 $k_2 = 2.39 \times 10^{-8} \text{ L}/(\text{mol}\cdot\text{s})$  at 700 K  
 Calculate the value of  $E_a$  for the reaction.  
 $(R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1})$  (AI 2014C, 2009)
80. 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  $-4250 \text{ K}$  is obtained. Calculate ' $E_a$ ' for the reaction.  
 $(R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1})$ . (3/5, Delhi 2013)
81. The rate of a reaction becomes four times when the temperature changes from 293 K to 313 K. Calculate the energy of activation ( $E_a$ ) of the reaction assuming that it does not change with temperature.  
 $[R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}, \log 4 = 0.6021]$   
 (AI 2013)
82. The decomposition of  $A$  into products has a value of  $k$  as  $4.5 \times 10^3 \text{ s}^{-1}$  at  $10^\circ\text{C}$  and energy of activation is  $60 \text{ kJ mol}^{-1}$ . At what temperature would  $k$  be  $1.5 \times 10^4 \text{ s}^{-1}$ ? (3/5, Delhi 2013C)
83. In general it is observed that the rate of a chemical reaction doubles with every 10 degree rise in temperature. If the generalisation holds good for a reaction in the temperature range 295 K to 305 K, what would be the value of activation energy for this reaction?  
 $[R = 8.314 \text{ J}/\text{K}^{-1} \text{ mol}^{-1}]$  (AI 2012C)
84. The decomposition of phosphine,  
 $4\text{PH}_3(\text{g}) \longrightarrow \text{P}_4(\text{g}) + 6\text{H}_2(\text{g})$   
 has the rate law, Rate =  $k[\text{PH}_3]$ .  
 The rate constant is  $6.0 \times 10^{-4} \text{ s}^{-1}$  at 300 K and activation energy is  $3.05 \times 10^5 \text{ J mol}^{-1}$ . Calculate the value of rate constant at 310 K.  
 $[\text{Given} : R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}]$   
 (Delhi 2008C)
85. The first order rate constant for the decomposition of ethyl iodide by the reaction :  
 $\text{C}_2\text{H}_5\text{I}(\text{g}) \rightarrow \text{C}_2\text{H}_4(\text{g}) + \text{HI}(\text{g})$   
 at 600 K is  $1.6 \times 10^{-5} \text{ s}^{-1}$ . Its energy of activation is  $209 \text{ kJ mol}^{-1}$ .  
 Calculate the rate constant of reaction at 700 K.  
 (AI 2007)

#### LA (5 marks)

86. (i) What is the physical significance of energy of activation? Explain with diagram.  
 (ii) In general, it is observed that the rate of a chemical reaction doubles with every 10 degree rise in temperature. If the generalisation holds good for the reaction in the temperature range of 295 K to 305 K, what would be the value of activation energy for this reaction?  
 $[R = 8.314 \text{ J}/\text{K}^{-1} \text{ mol}^{-1}]$  (Delhi 2012C)

### 4.6 Collision Theory of Chemical Reactions

#### VSA (1 mark)

87. 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?  
 (Delhi 2013C)