CBSE Test Paper-02

Class - 12 Chemistry (Chemical Kinetics)

1. Molecularity of a reaction
   a. Cannot be less than 2
   b. Can have a fractional values
   c. Is always a whole number
   d. Can be zero
2. Activation energy of a reaction is
   a. The energy released during the reaction
   b. Energy evolved when activated complex is formed
   c. The minimum amount of energy required to overcome the barrier
   d. The energy absorbed during a reaction
3. What is the order of a reaction which has a rate expression ; Rate = $k[A]^{\frac{3}{2}}[B]^{1}$
   a. 0
   b. 1
   c. $\frac{3}{2}+1$
   d. $\frac{3}{2}$
4. For the reaction $A \leftrightarrow B,\ \triangle H=+40 kJ/mol.$ IF E_a for the forward reaction is 60 kJ/mol. E_a for the backward reaction is
   a. 20 kJ/mol
   b. 80 kJ/mol
   c. 140 kJ/mol
   d. 100 kJ/mol
5. For the reaction A $\rightarrow$ products, at $[A] \ = \ 0.4\ M,\ t_{1/2}=24\ s$ and at $[A] \ = \ 0.2\ M,\ t_{1/2}= \ 12\ s$. The unit for the rate constant is
   a. mol/L/s
   b. mol $L^{-1}s^{-1}$
   c. $L^2/mol^2/s$
   d. S^{-1}

6. Identify the reaction order if the unit of rate constant is sec^{-1}.

7. Is there any reaction for which reaction rate does not decrease with time?

8. The decomposition reaction of ammonia gas on platinum surface has a rate constant k = 2.5 $\times 10^{-4}$ mol L^{-1} s^{-1}. What is the order of the reaction?

9. Distinguish between molecularity and order of reaction.

10. Express the rate of the following reaction in terms of disappearance of hydrogen in the reaction.
$3H_2(g) + N_2(g) \rightarrow 2NH_3(g)$

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

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

Experiment	**A/mol L^{-1}**	**B/mol L^{-1}**	**Initial rate of formation of D/mol L^{-1} min^{-1}**
I	0.1	0.1	6.0×10^{-3}
II	0.3	0.2	7.2×10^{-2}
III	0.3	0.4	2.88×10^{-1}
IV	0.4	0.1	2.40×10^{-2}

Determine the rate law and the rate constant for the reaction.

13. For a decomposition reaction the values of rate constant K at two different temperatures are given below:
$K_1 = 2.15 \times 10^{-8} L\, mol^{-1} s^{-1}$ at 650 K
$K_2 = 2.39 \times 10^{-7} L\, mol^{-1} s^{-1}$ at 700 K
Calculate the value of activation energy for this reaction. (R = 8.314 JK^{-1} mol^{-1})

14. Sucrose decomposes in acid solution into glucose and fructose according to the first order rate law, with $t_{1/2} = 3.00 hours$. What fraction of sample of sucrose remains after 8 hours?

15. The rate of the chemical reaction doubles for an increase of 10 K in absolute temperature from 298 K. Calculate E_a.

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Solutions

1. c. Is always a whole number

   Explanation: Molecularity means minimum no. of atoms molecules or ions which undergo collision for conversion of reactant to Product. So it is a whole no. Cannot be fractional or negative.

2. c. The minimum amount of energy required to overcome the barrier

   Explanation: The minimum extra amount of energy required by the reactants to form the activated complex is known as activation energy.

   Activation energy = Threshold energy - normal energy of reactant.

3. c. $\frac{3}{2}+1$

   Explanation: Order of a reaction may be defined as sum of the powers of the concentration of each reactant in the rate law expression.
   therefore, order of this reaction is $\frac{3}{2}+1=\ \frac{5}{2}=\ 2\frac{1}{2}$

4. a. 20 kJ/mol

   Explanation: $\Delta H=E_{af}-E_{ab}$
   $\Rightarrow 40=60-E_{ab}$
   $\Rightarrow\ E_{ab}=60-40=20\,KJ\,mol^{-1}$
   $\triangle\ H=\ E_{a_f}-E_{a_b}$
   $\Rightarrow 40=60\ -E_{a_b}$
   $\Rightarrow E_{a_b}=60-40=20\ KJ\ mol^{-1}$

5. b. mol $L^{-1}s^{-1}$

   Explanation: The order of reaction will be zero because as concentration is decreased half life is also decreasing so rate constant unit will be

6. First order reaction.

7. Zero order reaction.

8. Zero order of reaction.

9.

Molecularity of Reaction	Order of Reaction
1. Moleularity is the number of reaction species undergoing simultaneous collision in the elementary reaction.	1. Order of reaction is the sum of the power of the concentration terms of the reaction in experimentally determined rate law.
2. Molecularity is never Zero or fractional.	2. It can be zero or whole number or fractional value.
3. Its a theoretical concept.	3. Its an experimental term.

10. $Rate = -\frac{1}{3}\frac{d[H_2]}{dt}$

11. Rate expression is the way to express rate of reaction in terms of concentration of reactants.
    For a chemical reaction $aA + bB \rightarrow cC + dD$
    $Rate = k[A]^x[B]^y$
    Rate constant (k) is defined as the rate of reaction when the concentration of reactants are taken unity.

12. Let the order of the reaction with respect to A be x and with respect to B be y.
    Therefore, rate of the reaction is given by,
    $Rate = k[A]^x[B]^y$
    According to the question,
    $6.0 \times 10^{-3} = k[0.1]^x[0.1]^y$ ...... (i)
    $7.2 \times 10^{-2} = k[0.3]^x[0.2]^y$ ..... (ii)
    $2.88 \times 10^{-1} = k[0.3]^x[0.4]^y$ ..... (iii)
    $2.40 \times 10^{-2} = k[0.4]^x[0.1]^y$ ..... (iv)
    Dividing equation (iv) by (i), we obtain
    $\frac{2.40\times10^{-2}}{6.0\times10^{-3}} = \frac{k[0.4]^x\,[0.1]^y}{k[0.1]^x\,[0.1]^y}$
    $4 = \frac{[0.4]^x}{[0.1]^x}$

$4 = \left(\frac{0.4}{0.1}\right)^x$

$(4)^1 = 4^x$

x = 1

Dividing equation (iii) by (ii), we obtain

$\frac{2.88\times10^{-1}}{7.2\times10^{-2}} = \frac{k[0.3]^x\,[0.4]^y}{k[0.3]^x\,[0.2]^y}$

$4 = \left(\frac{0.4}{0.2}\right)^y$

$4 = 2^y$

$2^2 = 2^y$

y = 2

Therefore, the rate law is

$Rate = k[A][B]^2$

$k = \frac{Rate}{[A][B]^2}$

From experiment I, we obtain

$k = \frac{6.0\times10^{-3}\ mol\,L^{-1}\text{min}^{-1}}{\left(0.1\,mol\,L^{-1}\right)\left(0.1\,mol\,L^{-1}\right)^2}$

$= 6.0\,L^2\,mol^{-2}\,\text{min}^{-1}$

From experiment II, we obtain,

$k = \frac{7.2\times10^{-2}\ mol\,L^{-1}\text{min}^{-1}}{\left(0.3\,mol\,L^{-1}\right)\left(0.2\,mol\,L^{-1}\right)^2}$

$= 6.0\,L^2 mol^{-2}\text{min}^{-1}$

From experiment III, we obtain

$k = \frac{2.88\times10^{-1} mol\,L^{-1}\text{min}^{-1}}{\left(0.3 mol\,L^{-1}\right)\left(0.4 mol\,L^{-1}\right)^2} = 6.0\,L^2 mol^{-2}\text{min}^{-1}$

From experiment IV, we obtain

$k = \frac{2.40\times10^{-2} mol\,L^{-1}\text{min}^{-1}}{\left(0.4 mol\,L^{-1}\right)\left(0.1 mol\,L^{-1}\right)^2} = 6.0\,L^2 mol^{-2}\text{min}^{-1}$

Therefore, rate constant, k= $6.0\,L^2 mol^{-2}\text{min}^{-1}$

13. Here $K_1 = 2.15\times10^{-8} L\,mol^{-1}\,s^{-1}$

$K_2 = 2.39\times10^{-7} L\,mol^{-1}\,s^{-1}$

$T_1 = 650\,K,\ T_2 = 700 K$ and

$R = 8.314\,JK^{-1}\,mol^{-1}$

Using the formula

$\log\frac{K_2}{K_1} = \frac{E_a}{2.303R}\left(\frac{T_2 - T_1}{T_1 T_2}\right)$

$\log = \frac{2.39\times10^{-7}}{2.15\times10^{-8}} = \frac{E_a}{2.303\times8.314}\left(\frac{700-650}{650\times700}\right)$
$\log 1.11 \times 10 = \frac{E_a}{19.147} \times \frac{50}{455000}$
$1.0457 = \frac{E_a}{19.147} \times \frac{1}{9100}$
$E_a = 182200.365 \text{ J mol}^{-1}$

14. For a first order reaction, $k = \frac{2.303}{t}\log\frac{[R]_0}{[R]}$
It is given that, $t_{1/2} = 3.00\, hours$
Therefore, $k = \frac{0.693}{t_{1/2}}$
$= \frac{0.693}{3}h^{-1} = 0.231\, h^{-1}$
Then, $0.231\, h^{-1} = \frac{2.303}{8h}\log\frac{[R]_0}{[R]}$
$\log\frac{[R]_0}{[R]} = \frac{0.231\, h^{-1}\times8h}{2.303}$
$\frac{[R]_0}{[R]} = anti\log(0.8024)$
$\frac{[R]_0}{[R]} = 6.3445$
$\frac{[R]}{[R]_0} = 0.1576$ (approx)
= 0.158
Hence, the fraction of sample of sucrose that remains after 8 hours is 0.158.

15. It is given that T_1 = 298 K
Therefore, $T_2 = (298+10)K$ = 308 K
We also know that the rate of the reaction doubles when temperature is increased by 10^0.
Therefore, let us take the value of $k_1 = k$ and that of $k_2 = 2k$
Also, $R = 8.314\, J\, K^{-1}\, mol^{-1}$
Now, substituting these values in the equation:
$\log\frac{k_2}{k_1} = \frac{E_a}{2.303\, R}\left[\frac{T_2-T_1}{T_1T_2}\right]$
We get: $\log\frac{2k}{k} = \frac{E_a}{2.303\times8.314}\left[\frac{10}{298\times308}\right]$
$\log 2 = \frac{E_a}{2.303\times8.314}\left[\frac{10}{298\times308}\right]$
$E_a = \frac{2.303\times8.314\times298\times308\times\log 2}{10}$
$= 52897.78\, J\, mol^{-1} = 52.9\, k\, J\, mol^{-1}$