# CHEMISTRY

# BOOKS - BETTER CHOICE PUBLICATION

# CHEMICAL KINETICS

## Question Bank

**1.** Express the instantenus rate of the reaction

`N_2(g) + 3H_2(g) rarr 2NH_3(g)'

In terms of various reactants and products.

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**2.** Define rate constant (k).

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**3.** What is the difference between instantaneous rate of a reaction and rate constant?

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**4.** For a reaction : $X \rightarrow Y$, what is the significance of plus and minus signs in the following expression ?

rate=$\frac{-d[X]}{dt} = \frac{+d[Y]}{dt}$

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**5.** What are the units of rate constant for a third order reaction ?

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**6.** Unit of rate constant for zero order reaction is

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**7.** Unit of rate constant for zero order reaction is

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**8.** Write the unit of the rate constant for a gaseous reaction for 1st order.

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**9.** What is the order of the reaction if the unit of rate constant is $s^{-1}$?

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**10.** What is the unit of rate constant for second order reaction ?

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**11.** Explain the rate law.

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**12.** Define order of a reaction

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**13.** Does a zero order reaction has zero molecularity?

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**14.** Give four characteristics of rate constant.

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**15.** Can order of a reaction be fractional ? Give an example.

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**16.** Give one example of zero order reaction.

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**17.** Define molecularity of a reaction.

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**18.** Define average rate of a reaction.

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**19.** Write two three difference between average rate of reaction and instantaneous rate of reaction

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**20.** The rate of a zero reaction does not change with time. Explain.

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**21.** For the reaction

$2H_2(g) + 2NO(g) \rightarrow N_2(g) + 2H_2O(g)$

the proposed mechanism is as followed

(i) `2NO(g) (ii)$N_2O_2(g) + H_2(g) \rightarrow N_2O(g) + H_2O(g)$

$N_2O(g) + H_2(g) \rightarrow N_2(g) + H_2O(g)$

If the second step is the rate determining step then what Is the molecularity of the reaction

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**22.** If rate of reaction between a and B is expressed as $k[A][B]^2$ , the reaction is

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**23.** The rate law for a reaction is

Rate = $k[A]^{1/2}[B]^2$

Can the reaction be an elementry reaction. Explain.

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**24.** What is difference between order of reaction and molecularity of reaction ?

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**25.** Explain why reactions with molecularity of three or more are rare ?

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**26.** Nitric oxide reacts with oxygen to produce nitrogen dioxide.

$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$

What is the predicted rate law, if the mechanism is ,

$NO + O_2 \xrightarrow{k} NO_2(\text{fast})$

$NO_2 + N \xrightarrow{K_1} NO_2 + NO_2(\text{slow})$

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**27.** The rate expression for the chemical reaction,

$2NO_2Cl \rightarrow 2NO_3 + Cl_2$,

is given as : Rate= $k[NO_2Cl]$

Propose a possible mechanism for the above reaction and give the order of the reaction.

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**28.** Explain the factors affecting rate of a reaction.

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**29.** Discuss briefly the effect of concentration on the rate of a reaction.

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**30.** What is the effect of exposure to radiation on the rate of a chemical reaction.

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**31.** What is the effect of surface area on the rate of chemical reaction.

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**32.** Define half life period of a reaction.

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**33.** Define zero order reaction. Derive integrated rate equation for rate constant of a zero order reaction.

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**34.** Derive an expression for half life period of a zero order reaction.

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**35.** Derive the integrated rate equation for the rate constant for a first order reaction. What would be units of the first order rate constant, if

the concentration is expressed in moles per litre and time to seconds ?

Also give graphical representation of integrated rate law equation.

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**36.** Show that for a first order reaction, the time taken to complete half of the change is Independent of the initial concentration of the reactant.

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**37.** What are the difference between zero order and first order reactions.

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**38.** Explain with suitable example how the molecularity of a reaction Is different from the order of reaction ?

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**39.** What are pseudochemical or pseudo-order reactions ? Give one example.

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**40.** What are pseudochemical reactions ? Give an example.

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**41.** Define threshold energy and activation energy. How are they related?

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**42.** What Is activated complex ?

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**43.** The energy of activation of a reaction cannot be zero. Explain.

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**44.** What is temperature coefficient of a reaction ? Why temperature coefficient for most of the reactions at room temperature is nearly two ?

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**45.** The rate of reactions become double by rise of $10^{\circ}$ temperature. Explain

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**46.** What is the effect of temperature on rate of a reaction.

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**47.** What is Arrhenius equation to describe the effect of temperature on rate of a reaction ? How can it be used to calculate the activation energy of a reaction ?

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**48.** How is rate constant of a reaction related to its activation energy?

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**49.** Explain the effect of catalyst on the rate of reaction with diagram.

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**50.** Define collision frequency. Write short note on collision theory of chemical reactions.

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**51.** Write two postulates of colloision theory of reaction rates.

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## Numerical Problems

**1.** The rate constant of a reaction is $1.5 \times 10^7 \sec^{-1}$ at $50^\circ$C and $4.5 \times 10^7 \sec^{-1}$ at $100^\circ C$. Calculate energy of the activation for the reaction.

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**2.** The rate constant for the decomposition of $N_2O_6$,

$$N_2O_6 \rightarrow N_2O_4 + \frac{1}{2}O_2$$

is $3.46 \times 10^{-5}$ at $25^\circ$C and $4.87 \times 10^{-3}$ at $65^\circ$C. Calculate the energy of activation of the reaction.

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**3.** The first order rate constant for the decomposition of ethyl iodide by the reaction $C_2H_5I(g) \rightarrow C_2H_4(g) + HI(g)$ at 600K is $1.60x10^{-5}s^{-1}$. Its energy of activation is 209 kJ/mol. Calculate the rate constant of the reaction at 700K.

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**4.** The three fourth of a first order reaction is completed in 32 minutes. What is the half-life period of the reaction ?

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**5.** 60% of a first order reaction was completed in 60 minutes. When was it half completed ?

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**6.** A first order reaction is 75% complete in 60 min. Find the half-life of the reaction.

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**7.** Ammonia and oxygen react at high temperature as : $4NH_3(g) \rightarrow 4NO(g) + 6H_2O(g)$ in an experiment, the rate of formation of NO is $3.6 \times 10^{-3} molL^{-1} \sec^{-1}$. Calculate the rate on formation of $H_2O$.

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**8.** The reaction $2N_2O_5(g) \rightarrow NO_2(g) + O_2(g)$ takes place in a closed contaner. It is found that the concentration of $NO_2$ increases by $1.6 \times 10^{-2} mol L^{-1}$ in four seconds . Calculate the rate of change of concentration of $N_2O_5$.

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**9.** A reaction $3X \rightarrow 2Y + Z$ procees in a closed vessel. The rate of disappearance of X is found to be 0.072 mol $L^{-1}s^{-1}$. Calculate the rate of appearance of Y.

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**10.** A first order reaction is 50% complete in 69.3 minutes. Calculate the time for 80% completion of the reaction.

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**11.** A first order reaction is 20% complete in the 10 minutes. Calculate the time period for 75% completion of the reaction.

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**12.** A first order reaction is 15% complete in 20 minutes. How long will it take to complete 60%?

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**13.** A first order reaction is 20% complete in the 10 minutes. Calculate the time period for 75% completion of the reaction.

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**14.** A first order reaction is 15% complete in 20 minutes. How long will it take to complete 60%?

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**15.** A first order reaction is 40% complete in 50 minutes. In what time will the reaction be 80% compelete ?

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**16.** The rate constant for the first order reactior becomes three times when the temperatur is raised from $20^{\circ}$ C to $50^{\circ}$ C. Calculate the energy of activation for the reaction.

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**17.** The rate constant for a first order reaction becomes six times when the temperature is raised from 350 K to 400 K. Calculate activation energy for the reaction.

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**18.** The rate constant for a first order reaction becomes six times when the temperature is raised from 350 K to 400 K. Calculate activation energy for the reaction.

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**19.** For the reaction $:N_2 + 3H_2 \rightarrow 2NH_3$ The rate of reaction measured as $\frac{\Delta[NH_3]}{\Delta t}$ we found to be $2 \times 10^{-4} molL^{-1} \sec^{-1}$. Calculate the rate of reaction expressed in terms of $N_2$.

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**20.** The decomposition of hydrogen peroxide in the presence of iodide ion has been found to be first order in $H_2O_2$:

$2H_2O_2(aq) \xrightarrow{1^-(aq)} 2H_2O(l) + O_2(g).$

The rate constant has been found to be $1.01 \times 10^{-2}$ $\min^{-1}$ :

(a) Calculate the rate of reaction when $[H_2O_2] = 0.4 \text{ mol lit}^{-1}$.

(b) What concentration of $[H_2O_2]$ would give a rate of $1.12 \times 10^{-2} \text{ mol lit}^{-1} \text{ min}^{-1}$ ?

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**21.** For the reaction :

$2N_2O_5 \rightarrow 4NO_2 + O_2$

the rate of reaction measured as $\frac{\Delta[NO_2]}{\Delta t}$ was found to be $4 \times 10^{-3} \text{ mol L}^{-1}$ is $s^{-1}$. Calculate the rate of reaction, expressed in terms of $N_2O_5$

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**22.** The decomposition of $N_2O_5$ in carbon tetrachloride solution has been found to be first order with respect to $N_2O_5$ with rate constant, $k = 6.2 \times 10^{-4} s^{-1}$

$N_2O_5(G) \rightarrow 2NO_2(g) + \frac{1}{2}O_2(g)$

What concentration of $N_2O_5$ would give a rate of $4.2 \times 10^{-3} molL^{-1}s^{-1}$?

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**23.** For the reaction $:N_2 + 3H_2 \rightarrow 2NH_3$ The rate of reaction measured as $\frac{\Delta[NH_3]}{\Delta t}$ we found to be $2 \times 10^{-4} molL^{-1} \sec^{-1}$. Calculate the rate of reaction expressed in terms of $N_2$.

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**24.** The rate of a reaction $A \rightarrow B$ has the rate law, rate $= k[A]$ with the rate constant, $= k = 0.50 \sec^{-1} Q$.

What concentration of A would give a rate of $2.4 \times 10^{-2} molL^{-1} \sec^{-1}$?

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**25.** The rate constants of a reaction at 300 and 320 K are $0.0231s^{-1}$ and $0.0693s^{-1}$ respectively. Calculate the value of activation energy of the reaction. [R=8.314J $K^{-1}mol^{-1}$, $\log 3 = 0.4771$]

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**26.** The rate of decomposition of hydrogen peroxide at a particular temperature was measured by titrating its solution with acidic $KMnO_4$ solution. Following results were obtained :

| | | | |
|---|---|---|---|
| Time t (s) | 0 | 10 | 20 |
| Vol. of $KMnO_4$(ml) | 11.4 | 6.9 | 4.15 |

Show that the reaction is of first ordre.

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**27.** The rate constants of a reaction at 500K and 700K are $0.02s^{-1}$ and $0.07s^{-1}$ respectively. Calculate the values of $E_a$ and A.

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**28.** The rate of decomposition of hydrogen peroxide at a particular temperature was measured by titrating its solution with acidic $KMnO_4$ solution. Following results were obtained.

| | | | |
|---|---|---|---|
| time,t (min) | 0 | 10 | 20 |
| Vol. of $KMnO_4$(ml.) | 22.8 | 13.8 | 8.3 |

Show that the reaction is of first order.

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**29.** The rate constants of a reaction at 300 and 320 K are $0.0231s^{-1}$ and $0.0693s^{-1}$ respectively. Calculate the value of activation energy of the reaction. [R=8.314J $K^{-1}mol^{-1}$, $\log 3 = 0.4771$]

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**30.** In a pseudo first order hydrolysis of ester in water the following results were obtained :

| | | | |
|---|---|---|---|
| Time t(s) | 0 | 30 | 60 |
| Ester (mol $L^{-1}$) | 0.55 | 0.31 | 0.17 |

Calculate the pseudo first order rate constant

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**31.** For a chemical reaction $X \rightarrow Y$, the rate. increases by a factor 2.25 when the concentration of X is increased by 1.5. What is the order of reaction ?

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**32.** The rate of a reaction $2A + B \rightarrow A_2B$.

has rate law : rate = k $[A]^2$ with the rate constant equal to 0.50 $mol^{-1}$ L $\sec^{-1}$. Calculate the rate of reaction when

(i) [A] = 0.60 mol $L^{-1}$, [B] =-0.05 mol $L^{-1}$ and

(ii) When concentration of A and B have been reduced to 1/4 th

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**33.** For a chemical reaction $A \rightarrow B$, the rate of reaction doubles when the concentration of A is doubled. What is the order of reaction ?

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**34.** The decomposition of $N_2O_5$ in carbon tetrachloride solution has been found to be first order with respect to $N_2O_5$ with rate constant,

$k - 6.2 \times 10^{-4} s6 - 1$

$N_2O_5(G) \rightarrow 2NO_2(g) + \frac{1}{2}O_2(g)$

Calculate the rate of reaction when

$[N_2O_5] = 2.50 mol L^{-1}$

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**35.** For a chemical reaction $R \rightarrow P$, the rate of reaction does not change when the concentration of R is changed. What is the order of reaction ?

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**36.** The decomposition of $H_2O_2$, in the presence of Iodide ion has been found to be first order in $H_2O_2$ .

The rate constant has been found to be $1.01 \times 10^{-2}\ \text{min}^{-1}$. What concentration of $H_2O_2$ would give rate of `1.12 xx 10^-2 mol L^-1 min^-1?

$$2\,H_2O_2(aq) \xrightarrow{I^-(aq)} 2H_2O\,(l) + O_2(g)$$

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**37.** A first order reaction taken 16 minutes for 50% completion. How much time will it take for 75% completion ?

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**38.** A first order reaction taken 32 minutes for 50% completion. Hew much time will it take for 90% completion ?

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**39.** A first order reaction taken 45.4 minutes for 50% completion. How much time will it take for 60% completion ?

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**40.** Rate constant for a first order reaction is $60s^{-1}$. How much time will it take to reduce the concentration of the reaction on $\frac{1}{10}$ th of its initial value.

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**41.** Reaction beween $NO_2$ and $F_2$ to give $NO_2F$ takes place by the following machanism:

$NO_2(g) + F_2(g) \xrightarrow{\text{slow}} NO_2F(g) + F(g), NO_2(g) + F_2(g) \xrightarrow{\text{Fast}} NO_2F(g)$

Wiite the rate expression and order of the rection.

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**42.** Calculate two-third life of a first order reaction having

$k = 5.48 \times 10^{-14} s^{-1}$

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**43.** Reaction between $NO_2$ and $CO$ to give $CO_2$ and NO takes place by the following mechanism:

Write the rate expression and order of the reaction. What is the unit of

rate constant ?

$$NO_2 + NO_2 \xrightarrow{Slow} NO + NO_3$$

$$NO_3 + CO \xrightarrow{Fast} CO_2 + NO_2$$

$$NO_2 + CO \longrightarrow CO_2 + NO$$

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**44.** The half life period for a reaction of first order is $2.31 \times 10^3$ min. How long will it take for $\frac{1}{5^{th}}$ of the reactants to be left behind.

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**45.** Thermal decomposition of dinitrogen pentoxide takes place by the following mechanism :

$N_2O_5 \xrightarrow{\text{Slow}} NO_2 + NO_3$

$N_2O_5 = NO_3 \xrightarrow{\text{Fast}} 3NO_2 + O_2$

Write the rate'expression and order of the reaction.

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**46.** A reaction is of first order in reactant A and of second order in reactant B. How is rate of reaction affected when

(a) Concentration of B alone is increased to three times.

(b) The concentration of A as well as B is doubled.

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**47.** From the rate expression for the following reactions, determine their order of reaction and the dimensions of the rate constants: $C_2H_5CI(g) \rightarrow C_2H_4(g) + HCI(g) Rate = k[C_2H_5CI]$

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**48.** For a decomposition reaction, the values of rate constants, k at two different temperatures are given below :

$k_1 = 2.15 \times 10^{-7} L mol^{-1} s^{-1}$ at 650K

$k_2 = 2.39 \times 10^{-7} L mol^{-1} s^{-1}$ at 700K

calculate activation energy for the reaction.

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**49.** From the rate expression for the following reactions, determine their order of reaction and the dimensions of the rate constants: $CH_3CHO(g) \rightarrow CH_4(g) + CO(g) Rate = k[CH_3CHO]^{\frac{3}{2}}$

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**50.** In general it is observed that the rate of a chemical reaction becomes double for every $10^\circ$ rise in temperature. If this generalisation holds for a reaction in the temperature range 2908 K to 398 K, what would be the value of activation energy for the reaction.

(R=8.314 J $K^{-1} mol^{-1}$)

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**51.** State the order with respect to each reactant and overall order for the following reaction :

$H_2O_2 + 3I^- + 2H^+ \rightarrow 2H_2O + I_3^-(aq)$

Rate=$K[H_2O_2][I^-]$

What are the units of rate constant?

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**52.** The rate constant for a first order reaction becomes six times when the temperature is raised from 350 K to 400 K. Calculate activation energy for the reaction.

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**53.** 60% of a first order reaction was completed in 60 minutes. When was it half completed ?

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**54.** A first order reaction takes 69.3 minutes for 50% completion. Calculate the time required for 80% completion of the reaction.

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**55.** The half life period for a reaction of first order is $2.31 \times 10^3$ min. How long will it take for $\frac{1}{5^{th}}$ of the reactants to be left behind.

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**56.** The decomposition of hydrogen peroxide in the presence of iodide ion has been found to be first order in $H_2O_2$:

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The rate constant has been found to be $1.01 \times 10^{-2}$ $\text{min}^{-1}$:

(a) Calculate the rate of reaction when $[H_2O_2] = 0.4$ $\text{mol lit}^{-1}$.

(b) What concentration of $[H_2O_2]$ would give a rate of $1.12 \times 10^{-2}$ mol lit$^{-1}$ min$^{-1}$ ?

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**57.** The decomposition of $N_2O_5$ in carbon tetrachloride solution has been found to be first order with respect to $N_2O_5$ with rate constant, $k - 6.2 \times 10^{-4} s6 - 1$

$$N_2O_5(G) \rightarrow 2NO_2(g) + \frac{1}{2}O_2(g)$$

Calculate the rate of reaction when

$[N_2O_5] = 2.50 molL^{-1}$

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has rate law : rate = k $[A]^2$ with the rate constant equal to 0.50 $mol^{-1}$ L sec$^{-1}$. Calculate the rate of reaction when

(i) [A] = 0.60 mol $L^{-1}$, [B] =-0.05 mol $L^{-1}$ and

(ii) When concentration of A and B have been reduced to 1/4 th

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**59.** First order reaction is found to have rate constant, $k = 5.5 \times 10^{-14} s^{-1}$. Find the half life to the reaction.

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**60.** The half-life period of a chemical reaction is 1443.6 sec, find out k for this reaction.

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**61.** $2NOBr \rightarrow 2NO(g) + Br_2(g)$

Rate=$k[NOBr]_2$

What are the units of rate constant.?

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**62.** A first order reaction is 20% complete in 20 minuts. Calculate the time it will take the reaction to complete 80%.

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**63.** Calculate the time required for the completion of 90% of a reaction of first order kinetics, $t_{\frac{1}{2}} = 44.1$ minutes.

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