## SOLVED PROBLEMS

## SUBJECTIVE

## Problem 1:

Rate of a reaction $A+B \rightarrow$ Products; is given below as a function of different initial concentrations of $A$ and $B$
[A] mol/litre
[B] mol litre $^{-1}$
0.01
0.01
Initial rate mol litre ${ }^{-1}$ time $^{-1}$
0.02
0.01
0.005
0.01
0.02
0.010
0.005

D
Determine the order of the reaction with respect to $A$ and with respect to $B$. What is the half life of $A$ in the reaction?

## Solution :

Let order with respect to $A$ is $m$ and with respect to $B$ is ' $n$ '.
Rate $=\mathrm{K}[\mathrm{A}]^{\mathrm{m}}[\mathrm{B}]^{\mathrm{n}}$
$0.005=\mathrm{K}[0.01]^{\mathrm{m}}[0.01]^{\mathrm{n}}$
$0.010=K[0.02]^{\mathrm{m}}[0.01]^{\mathrm{n}}$
$0.005=\mathrm{K}[0.01]^{\mathrm{m}}[0.02]^{\mathrm{n}}$
Dividing Eq. (i) by (ii), we get
$\frac{0.005}{0.010}=\left[\frac{0.01}{0.02}\right]^{\mathrm{m}} \quad \Rightarrow \quad \frac{1}{2}=\left[\frac{1}{2}\right]^{\mathrm{m}}$
Thus, order with respect to A is one.
Dividing Eq. (i) by (ii), we get
$\frac{0.005}{0.005}=\left[\frac{0.01}{0.02}\right]^{\mathrm{n}} \quad \Rightarrow \quad 1=\left[\frac{1}{2}\right]^{\mathrm{n}} \quad \therefore \mathrm{n}=0$
Thus, order with respect to $B$ is zero.
Substituting the values of $m$ and $n$ in Eq. (i), we get
$0.005=\mathrm{K}[0.01]^{1}[0.01]^{0}$
$\therefore \frac{0.005}{0.01}=0.5$
$\mathrm{t}_{1 / 2}($ Half life period $)=\frac{0.693}{\mathrm{~K}}=\frac{0.693}{0.5}=1.386$ time

## Problem 2 :

The decomposition of $\mathrm{Cl}_{2} \mathrm{O}_{7}$ at 440 K in the gas phase to $\mathrm{Cl}_{2}$ and $\mathrm{O}_{2}$ is a first order reaction.
(i) After 55 seconds at 400 K the pressure of $\mathrm{Cl}_{2} \mathrm{O}_{7}$ falls from 0.062 to 0.044 atm., calculate that rate constant.
(ii) Calculate the pressure of $\mathrm{Cl}_{2} \mathrm{O}_{7}$ after 100 sec. of decomposition at this temperature.

## Solution :

(i) In the present equation we may apply the formula

$$
\mathrm{K}=\frac{2.303}{\mathrm{t}} \log \frac{\mathrm{p}_{0}}{\mathrm{p}_{\mathrm{t}}}=\frac{2.303}{55} \log \frac{0.062}{0.044}=6.2364 \times 10^{-3} \mathrm{sec}^{-1}
$$

(ii) Pressure after 100 sec may be calculated as

$$
\begin{aligned}
& 6.2364 \times 10^{-3}=\frac{2.303}{100} \log \frac{0.062}{\mathrm{p}_{\mathrm{t}}} \\
& \mathrm{p}_{\mathrm{t}}=0.0332 \mathrm{~atm}
\end{aligned}
$$

## Problem 3 :

Rate law for the following reaction; is

$$
\text { Ester }+\mathrm{H}^{+} \rightleftharpoons \text { Acid }+ \text { Alcohol; is } \frac{d x}{d t}=K[e s t e r]^{l}\left[H^{+}\right]^{0}
$$

What would be the effect on the rate if
(i) Concentration of ester is doubled?
(ii) Concentration of $\mathbf{H}^{+}$ion is doubled?

## Solution :

The rate law expression in this question, suggests that concentration of acid is nothing to play with velocity.
(i) When concentration of ester is doubled; velocity of the reaction will become double.
(ii) When concentration of $\mathrm{H}^{+}$ion is doubled velocity will be unaffected.

## Problem 4 :

The reaction $2 A+B+C \rightarrow D+2 E$; is found to be first order in $A$; second order in $B$ and zero order in $C$.
(i) Give the rate law for the above reaction in the form of a differential equation.
(ii) What is the effect on the rate of increasing the concentration of $A, B$ and $C$ two times?

## Solution :

(i) The rate law according to given information may be given as, $\frac{\mathrm{dx}}{\mathrm{dt}}=\mathrm{K}[\mathrm{A}]^{1}[\mathrm{~B}]^{2}[\mathrm{C}]^{0}$
(ii) When concentration of $\mathrm{A}, \mathrm{B}$ and C are doubled then rate will be

$$
\frac{\mathrm{dx}}{\mathrm{dt}}=\mathrm{K}[2 \mathrm{~A}][2 \mathrm{~B}]^{2}[\mathrm{C}]^{0}=8 \mathrm{~K}[\mathrm{~A}][\mathrm{B}]^{2}[\mathrm{C}]^{0}
$$

i.e., rate becomes 8 fold, the original rate.

## Problem 5:

At $27^{\circ} \mathrm{C}$ it was observed, during a reaction of hydrogenation that the pressure of $\mathrm{H}_{2}$ gas decreases from 2 atm to 1.1 atm in 75 min . Calculate the rate of reaction (molarity/ sec). Given $\left(R=0.082 /\right.$ litre atom $K^{-1}$ mole $\left.{ }^{-1}\right)$

## Solution :

$$
\text { Rate }=\frac{\text { Decrease in pressure }}{\text { Time duration }}=\frac{2-1.1}{75}=0.012 \mathrm{~atm} / \mathrm{min}
$$

Rate in $\mathrm{atm} / \mathrm{sec}=\frac{0.012}{60}=2 \times 10^{-4} \mathrm{~atm} / \mathrm{sec}$.
Answer is required in molarity per second
$\therefore \mathrm{PV}=\mathrm{nRT}$
$\frac{\mathrm{P}}{\mathrm{RT}}=\frac{\mathrm{n}}{\mathrm{V}}$
$\frac{\mathrm{P} / \mathrm{sec}}{\mathrm{RT}}=\left(\frac{\mathrm{n}}{\mathrm{V}}\right) / \mathrm{sec}$
$\left(\frac{\mathrm{n}}{\mathrm{V}}\right) / \sec =$ molarity per second
$\frac{2 \times 10^{-4}}{0.0821 \times 300}=\left(\frac{\mathrm{n}}{\mathrm{V}}\right) / \mathrm{sec}$
$8.12 \times 10^{-6}$. Rate in molarity $/ \mathrm{sec}=(\mathrm{n} / \mathrm{V}) / \mathrm{sec}$

## Problem 6:

In presence of an acid $N$-chloro acetanilide changes slowly into p-chloro acetanilide. Former substance liberated iodine from KI and not the later and hence progress of reaction can be measured by titrating iodine liberated with $\mathrm{Na}_{2} \mathrm{~S}_{2} \mathrm{O}_{3}$ solution, the results obtained were as follows :

| Time (hours) | 0 | 1 | 2 | 4 | 6 | 8 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |


| $(a-x) i . e ., ~ h y p o ~$ | 45 | 32 | 22.5 | 11.3 | 3.7 | 2.9 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |

show that reaction is uniomlecular and find out the fraction of $N$-chloroacetanilide decomposed after three hours.

## Solution :

The present reaction is :


Let us apply the kinetics of first order reaction.
After 1 hour

$$
\mathrm{K}=\frac{2.303}{1} \log \left\{\frac{45}{32}\right\}=0.34098 \text { hour }^{-1}
$$

After 2 hours

$$
\mathrm{K}=\frac{2.303}{2} \log \left\{\frac{45}{22.5}\right\}=0.34660 \text { hour }^{-1}
$$

After 4 hours

$$
\mathrm{K}=\frac{2.303}{4} \log \left\{\frac{45}{11.3}\right\}=0.3455 \text { hour }^{-1}
$$

After 6 hours

$$
\mathrm{K}=\frac{2.303}{6} \log \left\{\frac{45}{3.7}\right\}=0.4164 \text { hour }^{-1}
$$

After 8 hours

$$
\mathrm{K}=\frac{2.303}{8} \log \left\{\frac{45}{2.9}\right\}=0.3428 \text { hour }^{-1}
$$

Average value of constant $=0.3584$ hours $^{-1}$
Since, on applying first order kinetics, we get almost same values of rate constant after different time intervals, hence, the reaction is of first order.
Let us see the fraction decomposed after 3 hours.
$K=\frac{2.303}{t} \log \left\{\frac{a}{a-x}\right\}$
$0.3584=\frac{2.303}{3} \log \frac{a}{a-x}$
$\therefore \frac{a}{a-x}=2.98$
$\therefore \frac{a-x}{a}=0.3412$
$1-\frac{\mathrm{x}}{\mathrm{a}}=0.3412$
$\therefore \frac{\mathrm{x}}{\mathrm{a}}=0.658$ [fraction decomposed]

## Problem 7:

For the decomposition of dimethyl ether, $A$ in the Arrhenius equation $K=A e^{-E / R T}$ has a value of $1.26 \times 10^{13}$ and $E_{a}$ value of 58.5 kcal . Calculate half life period for first order decomposition at $527^{\circ} \mathrm{C}$.

## Solution :

Taking logarithm of Arrhenius equation
$K=A e^{-E / R T}$ we get
$\log \mathrm{K}=\log \mathrm{A}-\frac{\mathrm{E}}{2.303 \mathrm{RT}}$
Given $\mathrm{A}=1.26 \times 10^{13}$
$\mathrm{E}=58.5 \mathrm{kcal}$
$\mathrm{T}=527+273=800 \mathrm{~K}$
Substituting these value in Eq. (i), we get
$\log \mathrm{K}=\log \left(1.26 \times 10^{13}\right)-\frac{58.5 \times 10^{2}}{2.303 \times 1.987 \times 800}=13.1003-15.9799=-2.8796$
$\mathrm{K}=1.3194 \times 10^{-3} \mathrm{sec}^{-1}$
$\mathrm{t}_{1 / 2}=\frac{0.693}{1.3194} \times 10^{3} \mathrm{sec}=525 \mathrm{sec}$

## Problem 8 :

For the reaction,
$2 \mathrm{NO}(\mathrm{g})+\mathrm{H}_{2}(\mathrm{~g}) \longrightarrow \mathrm{N}_{2} \mathrm{O}(\mathrm{g})+\mathrm{H}_{2} \mathrm{O}(\mathrm{g})$ at 900 K , the following data are obtained :

Initial pressure
of NO (atm) Initial pressure of $\mathrm{H}_{2}$ (atm)
0.150 0.400 0.400 0.200
0.150

Rate (atm min $^{-1}$ )
0.020
0.005

Find the rate law and the value of rate constant.

## Solution :

Let order with respect to $\mathrm{NO}(\mathrm{g})$ is ' m ' and order with respect to $\mathrm{H}_{2}(\mathrm{~g})$ is ' n '
Then, Rate $=\mathrm{K}\left[\mathrm{P}_{\mathrm{NO}}\right]^{\mathrm{m}}\left[\mathrm{P}_{\mathrm{H}_{2}}\right]^{\mathrm{n}}$
$0.020=K[0.15]^{\mathrm{m}}[0.40]^{\mathrm{n}}$
$0.005=K[0.075]^{\mathrm{m}}[0.40]^{\mathrm{n}}$
$0.010=K[0.15]^{\mathrm{m}}[0.2]^{\mathrm{n}}$
Dividing Eq. (2) by (3), we get
$\frac{0.020}{0.005}=\left(\frac{0.15}{0.075}\right)^{\mathrm{m}}$
$\mathrm{m}=2$
Dividing Eq. (2) by (4), we get $\frac{0.020}{0.010}=\left(\frac{0.4}{0.2}\right)^{n}$
$\mathrm{n}=1$
Rate $=\left[\mathrm{P}_{\mathrm{NO}}\right]^{2}\left[\mathrm{P}_{\mathrm{H}_{2}}\right]^{1}$
Substituting the values of $m, n$ in Eq. (2), we get
$0.020=\mathrm{K}(0.15)^{2}[0.40]$
$\mathrm{K}=2.22 \mathrm{~atm}^{-2} \mathrm{~min}^{-1}$

## Problem 9 :

10 gram atoms of an $\alpha$-active radio isotope are disintegrating in a sealed container. In one hour the helium gas collected at STP is $11.2 \mathrm{~cm}^{3}$. Calculate the half-life of the radio-isotope.

## Solution :

No. of atoms of helium is 11.2 cc at NTP $=\frac{11.2}{22400} \times 6.02 \times 10^{23}=3.01 \times 10^{20}$ atoms
Since, helium atom corresponds to $\alpha$-particle. Thus, Rate of disintegration $=3.01 \times 10^{20}$ per hour.
We know, Rate $=$ Rate constant $\times$ concentration in atom
$3.01 \times 10^{20}=\mathrm{K} \times 10 \times 6.0210^{23}$
$\mathrm{K}=0.05 \times 10^{-3}$ hour $^{-1}$
$\mathrm{T}_{1 / 2}=\frac{0.693}{\mathrm{~K}}=\frac{0.693}{0.05 \times 10^{-3}}=13860$ hours
$\mathrm{T}_{1 / 2}=\frac{13860}{24 \times 365}=1.58$ years

## Problem 10 :

A carbon radio isotope $Z_{Z} X^{4}$ (half life 10 days) decays to give ${ }_{Z-2} Y^{A-4}$. If 1.00 gm atom of $X^{4}$ is kept in a sealed tube, how much helium will accumulate in 20 days? Express the result in $\mathrm{cm}^{3}$ at $\operatorname{STP}$.

## Solution :

Initial concentration $\left(\mathrm{N}_{0}\right)$ of radio-isotope is 1 gm atom. Concentration remained after 20 days may be calculated as

$$
\mathrm{N}_{\mathrm{t}}=\mathrm{N}_{0}\left(\frac{1}{2}\right)^{\mathrm{n}}
$$

where $\mathrm{n}=\mathrm{n}_{0}$ of half lives $=20 / 10=2=1\left(\frac{1}{2}\right)^{2}=\frac{1}{4}$
Concentration decayed to $\alpha$-particles $=1-\frac{1}{4}=\frac{3}{4}$ gm atom. An $\alpha$-particle takes 2 electron from air and from helium gas. Thus,
Helium formed $=\frac{3}{4} \mathrm{gm}$ atom $=\frac{3}{4} \times 22400 \mathrm{cc}=16800 \mathrm{cc}$

Problem 11 :
Radioactive decay is a first order process. Radioactive carbon wood sample decays with a half life of 5770 years. What is the rate constant in (years) ${ }^{-1}$ for the decay? What fraction would remain after 11540 years?

## Solution :

$$
\begin{aligned}
& \mathrm{K}=\frac{0.693}{\mathrm{~T}_{1 / 2}}=\frac{0.693}{5770}=1.201 \times 10^{-4} \mathrm{year}^{-1} \\
& \mathrm{~K}=\frac{2.303}{\mathrm{t}} \log \frac{\mathrm{~N}_{0}}{\mathrm{~N}_{\mathrm{t}}} \\
& 1.201 \times 10^{-4}=\frac{2.303}{11540} \log \frac{\mathrm{~N}_{0}}{\mathrm{~N}_{\mathrm{t}}} \\
& 4.002=\frac{\mathrm{N}_{0}}{\mathrm{~N}_{\mathrm{t}}} \\
\therefore \quad & \left.\frac{\mathrm{~N}_{\mathrm{t}}}{\mathrm{~N}_{0}} \text { (Remaining fraction }\right)=\frac{1}{4.002}
\end{aligned}
$$

## Problem 11:

A sample of ${ }_{53} I^{131}$, as iodide ion, was administered to a patient in a carrier consisting of 0.10 mg of stable iodide ion. After 4.00 days, $67.7 \%$ of the initial radioactivity was detected in the thyroid gland of the patient. What mass of the stable iodide ion had migrated to the thyroid gland? Given $T_{1 / 2} I^{131}=8$ days.

## Solution :

We know,

$$
\begin{aligned}
& \frac{0.693}{\mathrm{~T}_{1 / 2}}=\frac{2.303}{\mathrm{t}} \log _{10}\left[\frac{\mathrm{~N}_{0}}{\mathrm{~N}}\right] \\
& \frac{0.693}{8}=\frac{2.303}{4} \log _{10}\left[\frac{\mathrm{~N}_{0}}{\mathrm{~N}}\right] \\
& \frac{\mathrm{N}}{\mathrm{~N}_{0}}=0.707
\end{aligned}
$$

$\Rightarrow \quad 70.7 \%$ of initial activity is present. Given that $67.7 \%$ activity is migrated to thyroid gland.
Thus, weight of $\mathrm{I}^{-}$migrated to thyroid gland may be calculated as

$$
\frac{67.7}{70.7} \times 100=95.75 \%
$$

i.e,

$$
0.1 \times \frac{95.75}{100}=0.09575 \mathrm{mg}
$$

## OBJECTIVE

## Problem 1:

If a reaction $A+B \longrightarrow C$ is exothermic to the extent of $30 \mathrm{~kJ} / \mathrm{mol}$ and the forward reaction has an activation energy $70 \mathrm{~kJ} / \mathrm{mol}$, the activation energy for the reverse reaction is
(A) $30 \mathrm{~kJ} / \mathrm{mol}$
(B) $40 \mathrm{~kJ} / \mathrm{mol}$
(C) $70 \mathrm{~kJ} / \mathrm{mol}$
(D) $100 \mathrm{~kJ} / \mathrm{mol}$

Solution : (D)


By seeing the curve, activation energy for backward reaction $=100 \mathrm{~kJ}$

## Problem 2 :

The rate constant, the activation energy and the Arrhenius parameter of a chemical reaction at $25^{\circ} \mathrm{C}$ are $3.0 \times 10^{-4} \mathrm{~s}^{-1}, 104.4 \mathrm{~kJ} \mathrm{~mol}^{-1}$ and $6.0 \times 10^{14} \mathrm{~s}^{-1}$ respectively the value of the rate constant as $T \longrightarrow \infty$ is :
(A) $2.0 \times 10^{18} \mathrm{~s}^{-1}$
(B) $6.0 \times 10^{14} \mathrm{~s}^{-1}$
(C) $\infty$
(D) $3.6 \times 10^{30} \mathrm{~s}^{-1}$

Solution : (B)
$\mathrm{K}=\mathrm{Ae}^{-\mathrm{Ea} / \mathrm{RT}}$
When $\mathrm{T} \longrightarrow \infty$
$\mathrm{K} \longrightarrow \mathrm{A}$
$\mathrm{A}=6 \times 10^{14} \mathrm{~s}^{-1}$

## Problem 3 :

The inversion of cane sugar proceeds with half-life of 500 minute at pH 5 for any concentration of sugar. However if $\mathbf{p H}=6$, the half-life changes to 50 minute. The rate law expression for the sugar inversion can be written as
(A) $r=K[s u g a r]^{2}[H]^{6}$
(B) $r=K[\text { sugar }]^{1}[H]^{0}$
(C) $r=K[\text { [sugar }]^{0}\left[H^{+}\right]^{6}$
(D) $r=K[\text { sugar }]^{0}\left[H^{+}\right]^{1}$

## Solution : (B)

Since $t_{1 / 2}$ does not depends upon the sugar concentration means it is first order respect to sugar concentration. $\mathrm{t}_{1 / 2} \propto[\text { sugar }]^{1}$.

$$
\begin{aligned}
\mathrm{t}_{1 / 2} \times \mathrm{a}^{\mathrm{n}-1} & =\mathrm{k} \\
\frac{\left(\mathrm{t}_{1 / 2}\right)_{1}}{\left(\mathrm{t}_{1 / 2}\right)_{2}} & =\frac{\left[\mathrm{H}^{+}\right]_{1}^{1-\mathrm{n}}}{\left[\mathrm{H}^{+}\right]_{2}^{1-\mathrm{n}}} \\
\frac{500}{50} & =\left(\frac{10^{-5}}{10^{-6}}\right)^{1-\mathrm{n}} \\
\text { Hence } \quad \mathrm{n} & =0
\end{aligned}
$$

## Problem 4 :

Two substances $A$ and $B$ are present such that $\left[A_{\theta}\right]=4\left[B_{\theta}\right]$ and half-life of $A$ is 5 minute and that of B is 15 minute. If they start decaying at the same time following first order kinetics how much time later will the concentration of both of them would be same.
(A) 15 minute
(B) 10 minute
(C) 5 minute
(D) 12 minute

Solution: (A)
Amount of A left in $n_{1}$ halves $=\left(\frac{1}{2}\right)^{\mathrm{n}_{1}}\left[\mathrm{~A}_{0}\right]$
Amount of B left in $n_{2}$ halves $=\left(\frac{1}{2}\right)^{\mathrm{n}_{2}}\left[\mathrm{~B}_{0}\right]$
At the end, according to the question
$\frac{\left[\mathrm{A}^{0}\right]}{2^{\mathrm{n}_{1}}}=\frac{\left[\mathrm{B}_{0}\right]}{2^{\mathrm{n}_{2}}} \quad \Rightarrow \frac{4}{2^{\mathrm{n}_{1}}}=\frac{1}{2^{\mathrm{n}_{2}}},\left[\left[\mathrm{~A}_{0}\right]=4\left[\mathrm{~B}_{0}\right]\right]$
$\therefore \frac{2^{n_{1}}}{2^{n_{2}}}=4 \Rightarrow 2^{n_{1}-n_{2}}=(2)^{2} \therefore n_{1}-n_{2}=2$
$\therefore \mathrm{n}_{2}=\left(\mathrm{n}_{1}-2\right)$
Also $t=n_{1}^{\prime} t_{1 / 2(A)} t=n_{2} \times t_{1 / 2(B)}$
(Let concentration of both become equal after time $t$ )
$\backslash \frac{n_{1}{ }^{\prime} t_{1 / 2(A)}}{n_{2}{ }^{\prime} t_{1 / 2(B)}}=1 \mathrm{P} \frac{n_{1}{ }^{\prime} 5}{n_{2}{ }^{\prime} 15}=1 \mathrm{P} \frac{n_{1}}{n_{2}}=3$
For equation (1) and (2)
$\mathrm{n}_{1}=3, \mathrm{n}_{2}=1$
$\mathrm{t}=3 \times 5=15$ minute

## Problem 5:

Fill in the blank
${ }_{92}^{235} \boldsymbol{U}+{ }_{0}^{1} \boldsymbol{n} \longrightarrow ?+{ }_{36}^{92} \mathrm{Kr}+3_{0}^{1} \boldsymbol{n}$
(A) ${ }_{56}^{141} \boldsymbol{B a}$
(B) ${ }_{56}^{139} \boldsymbol{B a}$
(C) ${ }_{54}^{139} \mathrm{Ba}$
(D) ${ }_{54}^{141} \mathrm{~B}$

Solution: (A)
$92+0=\mathrm{Z}+36+0 \Rightarrow \mathrm{Z}=56$
$235+1 \longrightarrow \mathrm{~A}+92+3$
$\therefore \quad A=144$
Missing nuclide is ${ }_{56}^{141} \mathrm{Ba}$

## Problem 6 :

The rate of a reaction increases 4-fold when concentration of reactant is increased 16 times. If the rate of reaction is $4 \times 10^{-6}$ mole $L^{-1} S^{-1}$ mole $L^{-1}$ when concentration of the reactant is $4 \times 10^{-4}$, the rate constant of the reaction will be
(A) $2 \times 10^{-4} \mathrm{~mole}^{1 / 2} \mathrm{~L}^{-1 / 2} \mathrm{~S}^{-1}$
(B) $1 \times 10^{-2} S^{-1}$
(C) $2 \times 10^{-4} \mathrm{~mole}^{-1 / 2}, L^{1 / 2} \mathrm{~S}^{-1}$
(D) 25 mole $^{-1} \mathrm{~L} \mathrm{~min}^{-1}$

Solution : (A)
Rate $\propto \sqrt{\text { concentration }}$, Rate $=\mathrm{k} \sqrt{\text { concentration }}$
$\mathrm{k}=\frac{\text { Rate }}{(\text { concen })^{1 / 2}}=\frac{4 \times 10^{-6}}{\left(4 \times 10^{-4}\right)^{1 / 2}}=\frac{4 \times 10^{-6}}{2 \times 10^{-2}}=2 \times 10^{-4} \mathrm{~mole}^{1 / 2} \mathrm{~L}^{-1 / 2} \mathrm{~S}^{-1}$

## Problem 7 :

A catalyst lowers the activation energy of a reaction from 20 kJ mole ${ }^{-1}$ to 10 kJ mole ${ }^{-1}$. The temperature at which the uncatalysed reaction will have the same rate as that of the catalysed at $27^{\circ} \mathrm{C}$ is
(A) $-123{ }^{\circ} \mathrm{C}$
(B) $327^{\circ} \mathrm{C}$
(C) $327^{\circ} \mathrm{C}$
(D) $+23{ }^{\circ} \mathrm{C}$

Solution : (B)

$$
\frac{\mathrm{E}^{\prime} \mathrm{a}}{\mathrm{~T}_{1}}=\frac{\mathrm{E}_{\mathrm{a}}}{\mathrm{~T}_{2}}=\frac{10}{300}=\frac{20}{\mathrm{~T}_{2}} \quad \therefore \quad \mathrm{~T}_{2}=600 \mathrm{~K}=327^{\circ} \mathrm{C}
$$

## Problem 8 :

The reaction , $A(\mathrm{~g})+2 B(\mathrm{~g}) \longrightarrow C(\mathrm{~g})+D(\mathrm{~g})$ is an elementary process. In an experiment, the initial partial pressure of $A$ and $B$ are $P_{A}=0.60$ and $P_{B}=0.80 \mathrm{~atm}$. When $P_{C}=0.2$ atm the rate of reaction relative to the initial rate is
(A) $1 / 48$
(B) $1 / 24$
(C) $9 / 16$
(D) 1/6

Solution : (D)
$\mathrm{R}_{1}=\mathrm{K}[\mathrm{A}][\mathrm{B}]^{2}=\mathrm{K}[0.6][0.80]^{2}$
After reaction

| A | + | 2B |  | C | + | D |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 0.6-0.2 |  |  |  | 0.2 |  | 0.2 |
| 0.4 |  | 0.4 |  | 0.2 |  | 0.2 |

$\frac{\mathrm{R}_{2}}{\mathrm{R}_{1}}=\frac{\mathrm{K}(0.4)(0.4)^{2}}{(0.6)(0.8)^{2}}=\frac{1}{6}$

## Problem 9 :

Thermal decomposition of a compound is of first order. If $50 \%$ of a sample of the compound is decomposed in 120 minutes, show how long will it take for $90 \%$ of the compound to decompose?
(A) 399 min
(B) 410 min
(C) 250 min
(D) 120 min

Solution : (A)

$$
\begin{align*}
& K=\frac{0.6932}{120}  \tag{1}\\
& K=\frac{2.303}{t} \log \frac{a}{0.10 a}=\frac{2.303}{t} \log 10 \tag{2}
\end{align*}
$$

Equating (1) and (2) $\quad \frac{0.6932}{120}=\frac{2.303}{t}$
$\mathrm{t}=399$ minutes

## Problem 10 :

If concentration are measured in mole/litre and time in minutes, the unit for the rate constant of a $3^{\text {rd }}$ order reaction are
(A) mol lit $^{-1} \mathrm{~min}^{-1}$
(B) lit $^{2} \boldsymbol{m o l}^{-2} \boldsymbol{m i n}^{-1}$
(C) lit $\mathrm{mol}^{-1} \mathrm{~min}^{-1}$
(D) $\boldsymbol{m i n}^{-1}$

Solution : (B)
$\mathrm{K}=[\text { conc. }]^{1-\mathrm{n}} \min ^{-1}$
For $3^{\text {rd }}$ order reaction $=[\text { mole } / \text { litre }]^{1-3} \mathrm{~min}^{-1}=1 \mathrm{lit}^{2} \cdot \mathrm{~mole}^{-2} \mathrm{~min}^{-1}$

## Problem 11 :

What is the activation energy for the decomposition of $\mathrm{N}_{2} \mathrm{O}_{5}$ as

$$
\mathrm{N}_{2} \mathrm{O}_{5} \rightleftharpoons 2 \mathrm{NO}_{2}+\frac{1}{2} \mathrm{O}_{2}
$$

If the values of the rate constants are $3.45 \times 10^{-5}$ and $6.9 \times 10^{-3}$ at $27^{\circ} \mathrm{C}$ and $67^{\circ} \mathrm{C}$ respectively.
(A) $102 \times 10^{2} \mathrm{~kJ}$
(B) 488.5 kJ
(C) 112 kJ
(D) 112.5 kJ

Solution : (D)
$\log \frac{\mathrm{K}_{2}}{\mathrm{~K}_{1}}=\frac{\mathrm{Ea}}{2.303 \mathrm{R}}\left[\frac{\mathrm{T}_{2}-\mathrm{T}_{1}}{\mathrm{~T}_{1} \mathrm{~T}_{2}}\right]$
$\log \frac{6.9 \times 10^{-3}}{3.45 \times 10^{-5}}=\frac{\mathrm{Ea}}{2.303 \times 8.31}\left[\frac{40}{300 \times 400}\right]$
$\mathrm{E}_{\mathrm{a}}=112.5 \mathrm{~kJ}$

## Problem 12:

Half life period for a first order reaction is 20 minutes. How much time is required to change the concentration of the reactants from 0.08 M to 0.01 M
(A) 20 minutes
(B) 60 minutes
(C) 40 minutes
(D) 50 minutes

Solution : (B)

$$
\begin{aligned}
& \mathrm{K}=\frac{2.303}{\mathrm{t}} \log \frac{\mathrm{a}}{\mathrm{a}-\mathrm{x}} \\
& \frac{0.6932}{20}=\frac{2.303}{\mathrm{t}} \log \frac{0.08}{0.01}=\frac{2.303}{\mathrm{t}} \log 8=\frac{2.303 \times 3 \times \log 2}{\mathrm{t}} \\
& \frac{1}{20}=\frac{3}{\mathrm{t}} \\
& \mathrm{t}=60 \text { minutes }
\end{aligned}
$$

## Problem 13 :

The kinetic datas for the reaction: $2 A+B_{2} \longrightarrow 2 A B$ are as given below:

## [A]

mol $L^{-1}$
Rate
0.5 mol $L^{-1}$
mol $\mathbf{L}^{-1}$ min $^{-1}$
1.0
$2.5 \times 10^{-3}$
1.0
1.0
$5.0 \times 10^{-3}$
0.5
2.0
$1 \times 10^{-2}$
Hence the order of reaction w.r.t. $A$ and $B_{2}$ are, respectively,
(A) 1 and 2
(B) 2 and 1
(C) 1 and 1
(D) 2 and 2

Solution : (A)

$$
\begin{align*}
& 2.5 \times 10^{-3}=\mathrm{K}[0.5]^{\alpha}[1.0]^{\beta}  \tag{1}\\
& 5 \times 10^{-3}=\mathrm{K}[1.0]^{\alpha}[1.0]^{\beta}  \tag{2}\\
& 1 \times 10^{-2}=\mathrm{K}[0.5]^{\alpha}[2.0]^{\beta} \tag{3}
\end{align*}
$$

Dividing equation (1) and (2)

$$
\frac{1}{2}=\left[\frac{1}{2}\right]^{\alpha}
$$

hence $\alpha=1$
Dividing equation (1) and (3)

$$
\begin{aligned}
& \frac{2.5 \times 10^{-3}}{1 \times 10^{-2}}=\left(\frac{1.0}{2.0}\right)^{\beta} \\
& \frac{1}{4}=\left(\frac{1}{2}\right)^{\beta} \\
& \beta=2
\end{aligned}
$$

## Problem 14 :

For the first order reaction $A_{(g)} \longrightarrow 2 B_{(g)}+C_{(g)}$, the initial pressure is $P_{A}=90 \mathrm{~mm} \mathrm{Hg}$, the pressure after 10 minutes is found to be 180 mm Hg . The rate constant of the reaction is :
(A) $1.15 \times 10^{-3} \mathrm{sec}^{-1}$
(B) $2.3 \times 10^{-3} \mathrm{sec}^{-1}$
(C) $3.45 \times 10^{-3} \mathrm{sec}^{-1}$
(D) $6 \times 10^{-3} \mathrm{sec}^{-1}$

Solution : (A)

| A |  |  |
| :--- | :--- | :--- |
| P |  |  |
| $\mathrm{P}-\mathrm{x}$ | $\longrightarrow$ | 2 B |
| 0 | + | C |
| D |  | 0 |
| x |  |  |

At equilibrium
$180=\mathrm{P}-\mathrm{x}+2 \mathrm{x}+\mathrm{x}$
$180=90+2 x$
$2 \mathrm{x}=90, \mathrm{x}=45$
$\mathrm{K}=\frac{2.303}{\mathrm{t}} \log \frac{\mathrm{P}}{\mathrm{P}-\mathrm{x}}=\frac{2.303}{10} \log \frac{90}{90-45}=\frac{2.303}{10} \log 2=\frac{0.6932}{10}$
$=0.6932=\frac{0.06932}{60}=1.1555 \times 10^{-3} \mathrm{sec}^{-1}$

## ASSIGNMENTS

## OBJECTIVE QUESTIONS

## Level - I

Q. 1 The rate of the simple reaction $2 \mathrm{NO}+\mathrm{O}_{2} \longrightarrow 2 \mathrm{NO}_{2}$, when the volume of the reaction vessel is doubled-
(A) will grow eight times of its initial rate
(B) rate reduce to one-eights of its initial rate
(C) will grow four times of its initial rate
(D) reduce to one-fourth of its initial rate
Q. 2 The rate expression for the reaction $\mathrm{A}(\mathrm{g})+\mathrm{B}(\mathrm{g}) \rightarrow \mathrm{C}(\mathrm{g})$ is rate $=\mathrm{KC}_{A}{ }^{2} \mathrm{C}_{\mathrm{B}}{ }^{1 / 2}$. What changes in the initial concentration of A and B will cause the rate of reaction increase by a factor of eight
(A) $\mathrm{C}_{\mathrm{A}} \times 2 ; \mathrm{C}_{\mathrm{B}} \times 2$
(B) $\mathrm{C}_{\mathrm{A}} \times 2 ; \mathrm{C}_{\mathrm{B}} \times 4$
(C) $\mathrm{C}_{\mathrm{A}} \times 1 ; \mathrm{C}_{\mathrm{B}} \times 4$
(D) $\mathrm{C}_{\mathrm{A}} \times 4 ; \mathrm{C}_{\mathrm{B}} \times 1$
Q. 3 Given that $k$ is the rate constant for some order of any reaction at temperature T, then the value of $\mathrm{T} \xrightarrow{\lim } \infty \log \mathrm{k}$, (where A is the Arrhenius constant) is -
(A) A/2.303
(B) A
(C) 2.303 A
(D) $\log \mathrm{A}$
Q. 4 According to the Arrhenius equation a straight line is to be obtained by plotting the logarithm of the rate constant of a chemical reaction (log k) against -
(A) T
(B) $\log \mathrm{T}$
(C) $1 / \mathrm{T}$
(D) $\log 1 / T$
Q. 5 Select the rate law that corresponds to the data shown for the following reaction :

$$
\mathrm{A}+\mathrm{B} \longrightarrow \mathrm{C}
$$

| Extp. No. | $[\mathbf{A}]_{0}$ | $[\mathbf{B}]_{0}$ | initial rate |
| :---: | :---: | :---: | :---: |
| 1. | 0.012 | 0.035 | 0.10 |
| 2. | 0.024 | 0.070 | 0.80 |
| 3. | 0.024 | 0.035 | 0.10 |
| 4. | 1.012 | 0.070 | 0.80 |

(A) rate $=\mathrm{k}[\mathrm{B}]^{3}$
(B) rate $=\mathrm{k}[\mathrm{B}]^{4}$
(C) rate $=\mathrm{k}[\mathrm{A}][\mathrm{B}]^{3}$
(D) rate $=\mathrm{k}[\mathrm{A}]^{2}[\mathrm{~B}]^{2}$
Q. 6 If in the fermentation of sugar in an enzymatic solution that is 0.12 M , the concentration of the sugar is reduced to 0.06 M in 10 h to 0.03 M in 20 h , what is the order of the reaction :
(A) 1
(B) 2
(C) 3
(D) 0
Q. 7 Which of the following curves represents a $\mathrm{I}^{\mathrm{st}}$ order reaction :
(A)

(B)

(C)

(D)

Q. 8 Rate constant of a reaction with a virus is $3.3 \times 10^{-4} \mathrm{~s}^{-1}$. Time required for the virus to become $75 \%$ to activate is :
(A) 35 min
(B) 70 min
(C) 105 min
(D) 175 min
Q. 9 Inversion of a sugar follows first order rate equation which can be followed by noting the change in rotation of the plane of polarization of light in the polarimeter. Of $r_{\infty}, r_{t}$ and $r_{0}$ are the rotation at $\mathrm{t} \longrightarrow \infty, \mathrm{t}=\mathrm{t}$ and $\mathrm{t}=0$, then first order reaction can be written as -
(A) $\mathrm{k}=\frac{1}{\mathrm{t}} \ln \frac{\mathrm{r}_{\mathrm{t}}-\mathrm{r}_{\infty}}{\mathrm{r}_{0}-\mathrm{r}_{\infty}}$
(B) $\mathrm{k}=\frac{1}{\mathrm{t}} \ln \frac{\mathrm{r}_{0}-\mathrm{r}_{\infty}}{\mathrm{r}_{\mathrm{t}}-\mathrm{r}_{\infty}}$
(C) $\mathrm{k}=\frac{1}{\mathrm{t}} \ln \frac{\mathrm{r}_{0}}{\mathrm{r}_{\mathrm{t}}}$
(D) $\mathrm{k}=\frac{1}{\mathrm{t}} \ln \frac{\mathrm{r}_{\infty}-\mathrm{r}_{\mathrm{t}}}{\mathrm{r}_{\infty}-\mathrm{r}_{0}}$
Q. 10 The half life period of a first order reaction , $\mathrm{A} \longrightarrow$ Product is 10 minutes. In what period of time is the concentration of A is reduced to $10 \%$ of the original concentration:
(A) 26 min
(B) 33 min
(C) 71 min
(D) 90 min
Q. 11 For the reaction $B+2 D \rightarrow 3 T,-\frac{\mathrm{dC}_{B}}{d t}=\mathrm{kC}_{\mathrm{B}} \mathrm{C}_{\mathrm{D}}{ }^{2}$. The expression for, $-\frac{\mathrm{dC}_{\mathrm{D}}}{\mathrm{dt}}$ will be :
(A) $2 \mathrm{k} \mathrm{C}_{\mathrm{B}} \mathrm{C}_{\mathrm{D}}{ }^{2}$
(B) $\frac{1}{2} \mathrm{k} \mathrm{C}_{\mathrm{B}} \mathrm{C}_{\mathrm{D}}{ }^{2}$
(C) $4 \mathrm{k} \mathrm{C}_{\mathrm{B}} \mathrm{C}_{\mathrm{D}}{ }^{2}$
(D) $\frac{1}{4} \mathrm{kC}_{\mathrm{B}} \mathrm{C}_{\mathrm{D}}{ }^{2}$
Q.12 For a given reaction of first order, it takes 20 minutes for the concentration to drop from 1.0 M to 0.6 M . The time required for the concentration to drop from 0.6 M to 0.36 M will be :
(A) more than 20 minutes
(B) less than 20 minutes
(C) equal to 20 minutes
(D) infinity
Q. 13 Time required to decompose half of the substance for nth order reaction is inversely proportional to :
(A) $\mathrm{a}^{\mathrm{n}+1}$
(B) $a^{n-1}$
(C) $a^{n-2}$
(D) $a^{n}$
Q. $14 \mathrm{~A} \longrightarrow \mathrm{~B}, \Delta \mathrm{H}=-10 \mathrm{~kJ} \mathrm{~mol}^{-1}, \mathrm{E}_{\mathrm{a}}=50 \mathrm{kj} \mathrm{mol}^{-1}$, then $\mathrm{E}_{\mathrm{a}}$ of $\mathrm{B} \longrightarrow \mathrm{A}$ will be :
(A) $40 \mathrm{kj} \mathrm{mol}^{-1}$
(B) $50 \mathrm{kj} \mathrm{mol}^{-1}$
(C) $-50 \mathrm{kj} \mathrm{mol}^{-1}$
(D) $60 \mathrm{kj} \mathrm{mol}^{-1}$
Q. 15 If for any reaction, the rate constant is equal to the rate of the reaction at all concentration . The order is :
(A) 0
(B) 2
(C) 1
(D) 3
Q. 16 For a given reaction the concentration of the reactant plotted against time gave a straight line with negative slope. The order of the reaction is :
(A) 3
(B) 2
(C) 1
(D) 0
Q. 17 What is the order of a chemical reaction $A+2 B \xrightarrow{k} C$. If the rate of formation of $C$ increases by a factor of 2.82 on doubling the concentration of $A$ and increases by a factor of 9 on tripling the concentration of B .
(A) $7 / 2$
(B) $7 / 4$
(C) $5 / 2$
(D) $5 / 4$
Q. 18 When a $\beta$-particle is emitted by the atom of a radioactive element, the new species formed possesses:
(A) same atomic mass and atomic number less by one unit
(B) same atomic mass and atomic number less by two units
(C) same atomic mass and atomic number higher by one unit
(D) same atomic mass and atomic number higher by two units
Q. 19 The number of $\alpha$ - and $\beta$-particle emitted in the nuclear reaction ${ }_{90}^{228} \mathrm{Th} \longrightarrow{ }_{83}^{212} \mathrm{Bi}$ are :
(A) $8 \alpha, 1 \beta$
(B) $4 \alpha, 7 \beta$
(C) $3 \alpha, 7 \beta$
(D) $4 \alpha, 1 \beta$
Q. 20 A radioactive element A on disintegration gives two elements $B$ and $C$. , If $B$ is helium and $C$ is the element of atomic number 90 and atomic mass 234, the element $A$ is :
(A) ${ }_{92}^{238} \mathrm{U}$
(B) ${ }_{88}^{234} \mathrm{Ra}$
(C) ${ }_{90}^{234} \mathrm{Sc}$
(D) ${ }_{91}^{234} \mathrm{~Pa}$
Q. 21 The number of $\alpha$-particles emitted per second by 1 g of ${ }^{226} \mathrm{Ra}$ is $3.7 \times 10^{10}$. The decay constant is
(A) $1.39 \times 10^{-11} \mathrm{sec}^{-1}$
(B) $13.9 \times 10^{-11} \mathrm{sec}^{-1}$
(C) $139 \times 10^{-10} \mathrm{sec}^{-1}$
(D) $13.9 \times 10^{-10} \mathrm{sec}^{-1}$
Q. 22 One curie of activity is equivalent to :
(A) $3.7 \times 10^{17}$ disintegrations per sec
(B) $3.7 \times 10^{10}$ disintegrations per sec
(C) $3.7 \times 10^{14}$ disintegrations per sec
(D) $3.7 \times 10^{3}$ disintegrations per sec
Q. 23 Radioactivity of a radioactive element remains $1 / 10$ of the original radioactivity after 2.303 seconds. The half life period is :
(A) 2.303
(B) 0.2303
(C) 0.693
(D) 0.0693
Q. 24 The half life periods of four isotopes are given below :
(i) 7.6 years
(ii) 4000 years, (iii) 6000 years (iv) $3.2 \times 10^{5}$ years

Which of the above isotopes is most stable?
(A) iv
(B) iii
(C) ii
(D) i
Q. 25 Which of the following transformations is not correct?
(A) ${ }_{33}^{75} \mathrm{As}+{ }_{2}^{4} \mathrm{He} \longrightarrow{ }_{35}^{78} \mathrm{Br}+{ }_{0}^{1} \mathrm{n}$
(B) ${ }_{3}^{7} \mathrm{Li}+{ }_{1}^{1} \mathrm{H} \longrightarrow{ }_{4}^{7} \mathrm{Be}+{ }_{0}^{1} \mathrm{n}$
(C) ${ }_{21}^{45} \mathrm{Sc}+{ }_{0}^{1} \mathrm{n} \longrightarrow{ }_{20}^{45} \mathrm{Ca}+{ }_{0}^{1} \mathrm{n}$
(D) ${ }_{83}^{209} \mathrm{Bi}+{ }_{1}^{2} \mathrm{H} \longrightarrow{ }_{84}^{210} \mathrm{Po}+{ }_{0}^{1} \mathrm{n}$
Q. 26 A sample of rock from moon contains equal number of atoms of uranium and lead ( $\mathrm{t}_{1 / 2}$ for $\mathrm{U}=4.5 \times 10^{9}$ years). The age of the rock would be :
(A) $9.0 \times 10^{9}$ years
(B) $4.5 \times 10^{9}$ years
(C) $13.5 \times 10^{9}$ years
(D) $2.25 \times 10^{9}$ years

## Level - II

Q. 1 The rate of reaction becomes 2 times for every $10^{\circ} \mathrm{C}$ rise in temperature. How the rate of reaction will increase when temperature is increased from $30^{\circ} \mathrm{C}$ to $80^{\circ} \mathrm{C}$ :
(A) 16
(B) 32
(C) 64
(D) 128
Q. 2 For the consecutive unimolecular-type first order reaction $A \xrightarrow{k_{1}} R \xrightarrow{k_{2}} S$, the concentration of component $R, C_{R}$ at any time $t$ is given by :

$$
C_{R}=C_{A O} K_{1}\left[\frac{e^{-k_{1} t}}{\left(k_{2}-k_{1}\right)}+\frac{e^{-k_{2} t}}{\left(k_{1}-k_{2}\right)}\right]
$$

if $\mathrm{C}_{\mathrm{A}}=\mathrm{C}_{\mathrm{AO}}, \mathrm{C}_{\mathrm{R}}=\mathrm{C}_{\mathrm{RO}}=0$ at $\mathrm{t}=0$
the time at which the maximum concentration of R occurs is :
(A) $\mathrm{t}_{\text {max }}=\frac{\mathrm{k}_{2}-\mathrm{k}_{1}}{\ln \left(\mathrm{k}_{2} / \mathrm{k}_{1}\right)}$
(B) $\mathrm{t}_{\text {max }}=\frac{\ln \left(\mathrm{k}_{2} / \mathrm{k}_{1}\right)}{\mathrm{k}_{2}-\mathrm{k}_{1}}$
(C) $t_{\max }=\frac{e^{k_{2} / k_{1}}}{k_{2}-k_{1}}$
(D) $\mathrm{t}_{\max }=\frac{\mathrm{e}^{\mathrm{k}_{2}-\mathrm{k}_{1}}}{\mathrm{k}_{2}-\mathrm{k}_{1}}$
Q. 3 A consecutive reaction $A \xrightarrow{k_{1}} B \xrightarrow{k_{2}} C$ is characterised by -
(A) maxima in the concentration of A
(B) maxima in the concentration of B
(C) maxima in the concentration of C
(D) high exothermicity
Q. 4 For the chemical reaction $\mathrm{A}+\mathrm{B}+\mathrm{C} \xrightarrow{\mathrm{k}} \mathrm{D}$, it was found that the rate of the reaction doubled when the concentration of $B$ was doubled, that the rate of reaction doubled when the concentration of both $A$ and $B$ were doubled, and quadrupled when the concentration of both $B$ and $C$ were doubled. The order of the reaction is :
(A) 2
(B) 3
(C) 4
(D) 6
Q. 5 A substance undergoes first order decomposition. The decomposition follows two parallel first order reactions as :


The percentage distributions of $B$ and $C$ are :
(A) $80 \%$ B and $20 \%$ C
(B) $76.83 \% \mathrm{~B}$ and $23.17 \% \mathrm{C}$
(C) $90 \% \mathrm{~B}$ and $10 \% \mathrm{C}$
(D) $60 \% \mathrm{~B}$ and $40 \% \mathrm{C}$
Q. 6 For a gas reaction at $T(K)$ the rate is given by $-\frac{d p_{A}}{d t}=k^{\prime} p_{A}{ }^{2} \mathrm{~atm} / \mathrm{hr}$. If the rate equation is expressed as : $-\mathrm{r}_{\mathrm{A}}=-\frac{1}{\mathrm{~V}} \frac{\mathrm{dN}_{\mathrm{A}}}{\mathrm{dt}}=\mathrm{kC}_{\mathrm{A}}^{2}, \mathrm{~mol} /($ litre-hr), the rate constant k is given by -
(A) $\mathrm{k}=\mathrm{k}^{\prime}$
(B) $k=k^{\prime} R T$
(C) $\mathrm{k}=\mathrm{k}^{\prime} / \mathrm{RT}$
(D) $\mathrm{k}=\mathrm{k}^{\prime}(\mathrm{RT})^{2}$
where $\mathrm{R}=$ ideal gas law constant, $\mathrm{cal} / \mathrm{g} \mathrm{mol} \mathrm{K}$.
Q. 7 The activation energies of two reactions are $\mathrm{E}_{\mathrm{a} 1}$ and $\mathrm{E}_{\mathrm{a} 2}$ with $\mathrm{E}_{\mathrm{a} 1}>\mathrm{E}_{\mathrm{a} 2}$. If the temperature of the reacting system is increased from $\mathrm{T}_{1}$ to $\mathrm{T}_{2}$ predict which of the following alternative is correct
(A) $\frac{\mathrm{K}_{1}^{\prime}}{\mathrm{K}_{1}}=\frac{\mathrm{K}_{2}^{\prime}}{\mathrm{K}_{2}}$
(B) $\frac{\mathrm{K}_{1}^{\prime}}{\mathrm{K}_{1}}>\frac{\mathrm{K}_{2}^{\prime}}{\mathrm{K}_{2}}$
(C) $\frac{\mathrm{K}_{1}^{\prime}}{\mathrm{K}_{1}}<\frac{\mathrm{K}_{2}^{\prime}}{\mathrm{K}_{2}}$
(D) $\frac{\mathrm{K}_{1}^{\prime}}{\mathrm{K}_{1}}<2 \frac{\mathrm{~K}_{2}^{\prime}}{\mathrm{K}_{2}}$
Q. 8 The reaction $\mathrm{v}_{1} \mathrm{~A}+\mathrm{v}_{2} \mathrm{~B} \rightarrow$ products is first order with respect to A and zero-order with respect to $B$. If the reaction is started with $\left[\mathrm{A}_{0}\right]$ and $\left[\mathrm{B}_{0}\right]$, the integrated rate expression of this reaction would be -
(A) $\lambda n \frac{[\mathrm{~A}]_{0}}{[\mathrm{~A}]_{0}-\mathrm{x}}=\mathrm{k}_{1} \mathrm{t}$
(B) $\lambda n \frac{[A]_{0}}{[A]_{0}-v_{1} \mathrm{x}}=\mathrm{v}_{1} \mathrm{k}_{1} \mathrm{t}$
(C) $\lambda n \frac{[A]_{0}}{[A]_{0}-v_{1} \mathrm{x}}=\mathrm{k}_{1} \mathrm{t}$
(D) $\lambda \mathrm{n} \frac{[\mathrm{A}]_{0}}{[\mathrm{~A}]_{0}-\mathrm{v}_{1} \mathrm{x}}=-\mathrm{v}_{1} \mathrm{k}_{1} \mathrm{t}$
Q. 9 When the mechanism of reaction is not known, one often attempts to fit the data with an $\mathrm{n}^{\text {th }}$ order rate equation of the form

$$
-\mathrm{r}_{\mathrm{A}}=-\frac{\mathrm{dC}_{\mathrm{A}}}{\mathrm{dt}}=\mathrm{kC}_{\mathrm{A}}^{\mathrm{n}}
$$

for $\mathrm{n} \neq 1$, the integration of this equation yields -
(A) $\mathrm{C}_{\mathrm{A}}{ }^{1+\mathrm{n}}-\mathrm{C}_{\mathrm{A}_{0}}^{1+\mathrm{n}}=(1+\mathrm{n}) \mathrm{kt}$
(B) $\mathrm{C}_{\mathrm{A}}{ }^{1-\mathrm{n}}-\mathrm{C}_{\mathrm{A}_{0}}^{1-\mathrm{n}}=(1-\mathrm{n}) \mathrm{kt}$
(C) $\mathrm{C}_{\mathrm{A}}{ }^{1-\mathrm{n}}-\mathrm{C}_{\mathrm{A}_{0}}^{1-\mathrm{n}}=(\mathrm{n}-1) \mathrm{kt}$
(D) $\mathrm{C}_{\mathrm{A}}{ }^{1-\mathrm{n}}-\mathrm{C}_{\mathrm{A}_{0}}^{1-\mathrm{n}}=\mathrm{kt} /(\mathrm{n}-1)$
Q. 10 For the chemical reaction $\mathrm{A} \rightarrow$ products, the rate of disappearance of A is given by :

$$
-\mathrm{r}_{\mathrm{A}}=-\frac{\mathrm{dC}_{\mathrm{A}}}{\mathrm{dt}}=\mathrm{k}_{1} \mathrm{C}_{\mathrm{A}} /\left(1+\mathrm{k}_{2} \mathrm{C}_{\mathrm{A}}\right)
$$

At low $\mathrm{C}_{\mathrm{A}}$ the reaction is of the first-order with rate constant:
(A) $\mathrm{k}_{1} / \mathrm{k}_{2}$
(B) $\mathrm{k}_{1}$
(C) $\mathrm{k}_{1} \cdot \mathrm{k}_{2}$
(D) $\mathrm{k}_{1} /\left(\mathrm{k}_{1}+\mathrm{k}_{2}\right)$
Q. 11 A first order homogeneous reaction of the type $\mathrm{X} \longrightarrow \mathrm{Y} \longrightarrow \mathrm{Z}$ (consecutive reaction) is carried out in a CSTR. Which of the following curves respectively show the variation of the concentration of $\mathrm{X}, \mathrm{Y}$ and Z with time -
(A) I, II, II
(B) III, II, I
(C) III, I, II
(D) II, III, I
Q. 12 For the consecutive unimolecular-type first order reaction $A \xrightarrow{k_{1}} R \xrightarrow{k_{2}} S$, the concentration of component $\mathrm{A}, \mathrm{C}_{\mathrm{A}}$ at any time t is given by -
(A) $\mathrm{C}_{\mathrm{A}}=\mathrm{C}_{\mathrm{A}_{0}} \mathrm{e}^{\left(\mathrm{k}_{1}+\mathrm{k}_{2}\right) \mathrm{t}}$
(B) $\mathrm{C}_{\mathrm{A}}=\mathrm{C}_{\mathrm{A}_{0}} \mathrm{e}^{-\left(\mathrm{k}_{1}+\mathrm{k}_{2}\right) \mathrm{t}}$
(C) $C_{A}=C_{A_{0}} e^{-k_{1} t}$
(D) $\mathrm{C}_{\mathrm{A}}=\mathrm{C}_{\mathrm{A}_{0}} \mathrm{e}^{\mathrm{k}_{\mathrm{t}} \mathrm{t}}$
Q. 13 The energy of activation for a reaction is $100 \mathrm{~kJ} / \mathrm{mol}$. Presence of a catalyst lowers the energy of activation by $75 \%$. The ratio of $\mathrm{k}_{\text {cat }} / \mathrm{k}_{\text {uncat }}(\mathrm{T}=298 \mathrm{~K})-$
(A) $23.4 \times 10^{15}$
(B) $2.34 \times 10^{13}$
(C) $1.324 \times 10^{5}$
(D) $3.25 \times 10^{6}$
Q. 14 For a certain reaction of order $n$, the time for half change, $\mathrm{t}_{1 / 2}$, is given by $\mathrm{t}_{1 / 2}=\frac{[2-\sqrt{2}]}{\mathrm{k}} \times \mathrm{C}_{0}^{1 / 2}$ where k is the rate constant and $\mathrm{C}_{0}$ is the initial concentration what is n :
(A) 1
(B) 2
(C) 0
(D) 0.5
Q. 15 In the Lindemann theory of unimolecular reactions, it is shown that the apparent rate constant for such a reaction is $\mathrm{k}_{\mathrm{app}}=\frac{\kappa_{1} C}{1+\alpha C}$ where C is the concentration of the reactant, $\mathrm{k}_{1}$ and $\alpha$ are constants. Calculate the value of C for which $\mathrm{k}_{\text {app }}$ has $90 \%$ of its limiting value at C tending to infinitely large values, given $\alpha=9 \times 10^{5}$.
(A) $10^{-6} \mathrm{~mol} /$ litre
(B) $10^{-4} \mathrm{~mol} /$ litre
(C) $10^{-5} \mathrm{~mol} /$ litre
(D) $5 \times 10^{-5} \mathrm{~mol} /$ litre
Q. 16 Given that for a reaction of order n the integrated form of the rate equation is
$\mathrm{k}=\frac{1}{\mathrm{t}(\mathrm{n}-1)}\left[\frac{1}{\mathrm{C}^{\mathrm{n}-1}}-\frac{1}{\mathrm{C}_{0}^{\mathrm{n}-1}}\right]$ where $\mathrm{C}_{0}$ and C are the values of the reactant concentration at the start and after time $t$. What is the relationship between $t_{3 / 4}$ and $t_{1 / 2}$ where $t_{3 / 4}$ is the time required for C to become $1 / 4 \mathrm{C}_{0}$ :
(A) $t_{3 / 4}=t_{1 / 2}\left[2^{n-1}+1\right]$
(B) $t_{3 / 4}=t_{1 / 2}\left[2^{n-1}-1\right]$
(C) $t_{3 / 4}=t_{1 / 2}\left[2^{n+1}-1\right]$
(D) $t_{3 / 4}=t_{1 / 2}\left[2^{n+1}+1\right]$
Q. 17 Rate constant of a reaction is $0.0693 \mathrm{~min}^{-1}$. Starting with 10 mol , rate of the reaction after 10 $\min$ is :
(A) $0.693 \mathrm{~mol} \mathrm{~min}^{-1}$
(B) $0.0693 \times 2 \mathrm{~mol} \mathrm{~min}^{-1}$
(C) $0.0693 \times 5 \mathrm{~mol} \mathrm{~min}^{-1}$
(D) $0.0693 \times(5)^{2} \mathrm{~mol} \mathrm{~min}^{-1}$
Q. 18 The instantaneous rate of disappearance of the $\mathrm{MnO}_{4}^{-}$ion in the following reaction is $4.56 \times 10^{-3} \mathrm{Ms}^{-1}$

$$
2 \mathrm{MnO}_{4}^{-}+10 \mathrm{I}^{-}+16 \mathrm{H}^{+} \longrightarrow 2 \mathrm{Mn}^{2+}+5 \mathrm{I}_{2}+8 \mathrm{H}_{2} \mathrm{O}
$$

The rate of appearance of $\mathrm{I}_{2}$ is :
(A) $1.14 \times 10^{-3} \mathrm{Ms}^{-1}$
(B) $5.7 \times 10^{-3} \mathrm{Ms}^{-1}$
(C) $4.56 \times 10^{-4} \mathrm{Ms}^{-1}$
(D) $1.14 \times 10^{-2} \mathrm{Ms}^{-1}$
Q. 19 Which of the following statements is not correct?
(A) Law of mass action and rate law expressions are same for single step reactions
(B) Molecularity of the slowest elementary step of a complex reaction gives molecularity of reaction
(C) Both order and molecularity have normally a maximum value of 3
(D) Molecularity of a complex reaction $\mathrm{A}+2 \mathrm{~B} \longrightarrow \mathrm{C}$ is 3 .
Q. 20 Which of the following are correct?
(A) total collision rate $\propto$ mean speed $\propto$ absolute temperature
(B) total collision rate $\propto \frac{1}{\text { mean speed }} \propto \frac{1}{\text { absolute temperature }}$
(C) total collision rate $\propto$ mean speed $\propto\left(\right.$ absolute temperature) ${ }^{1 / 2}$
(D) total collision rate $\propto(\text { mean speed })^{2} \propto(\text { absolute temperature })^{3}$
Q. 21 The rate equation for an autocatalytic reaction,

$$
\mathrm{A}+\mathrm{R} \xrightarrow{\mathrm{k}} \mathrm{R}+\mathrm{R} \text { is }-\mathrm{r}_{\mathrm{A}}=-\frac{\mathrm{dC}_{A}}{\mathrm{dt}}=\mathrm{k} \mathrm{C}_{\mathrm{A}} \mathrm{C}_{\mathrm{R}}
$$

The rate of disappearance of reactant A is maximum where :
(A) $\mathrm{C}_{\mathrm{A}}=2 \mathrm{C}_{\mathrm{R}}$
(B) $\mathrm{C}_{\mathrm{A}}=\mathrm{C}_{\mathrm{R}}$
(C) $\mathrm{C}_{\mathrm{A}}=\mathrm{C}_{\mathrm{R}} / 2$
(D) $\mathrm{C}_{\mathrm{A}}=\left(\mathrm{C}_{\mathrm{R}}\right)^{1 / 2}$
Q. 22 The decomposition of a gaseous substance A to yield gaseous products, $\mathrm{A}(\mathrm{g}) \longrightarrow 2 \mathrm{~B}(\mathrm{~g})+\mathrm{C}(\mathrm{g})$ follows first order kinetics. If the total pressure at the start of an experiment \& 9 minutes after the start are 169 mm and 221 mm , what is the rate constant ?
(A) $0.6804 \mathrm{~min}^{-1}$
(B) $0.3024 \mathrm{~min}^{-1}$
(C) $0.4536 \mathrm{~min}^{-1}$
(D) $0.3780 \mathrm{~min}^{-1}$
Q. 23 The decay constant of ${ }^{226} \mathrm{Ra}$ is $1.37 \times 10^{-11} \mathrm{sec}^{-1}$. A sample of ${ }_{226}$ Ra having an activity of 1.5 milli curie will contain $\qquad$ atoms.
(A) $4.05 \times 10^{18}$
(B) $3.7 \times 10^{17}$
(C) $2.05 \times 10^{15}$
(D) $4.7 \times 10^{10}$
Q. 24 Which among the following is wrong about isodiaphers?
(A) they have the same difference of neutrons and protons or same isotopic number
(B) nuclide and its decay product after $\alpha$-emission are isodiaphers
(C) ${ }_{z} \mathrm{~A}^{\mathrm{m}} \longrightarrow{ }_{\mathrm{z}-2} \mathrm{~B}^{\mathrm{m}-4}+{ }_{2} \mathrm{He}^{4}$ ' A ' and ' B ' are isodiaphers
(D) all correct
Q. 25 A radioactive element decays as
$\mathrm{X} \xrightarrow[\mathrm{t}_{1 / 2}=30 \text { min. }]{\alpha \text { decay }} \mathrm{Y} \xrightarrow[\mathrm{t}_{1 / 2}=2 \text { days }]{(-2 \beta) \beta \text { decay }} \mathrm{Z}$
which of the following statements about this decay process is incorrect?
(A) after two hours, less than $10 \%$ of the initial X is left
(B) maximum amount of $Y$ present at any time before 30 min is less than $50 \%$ of the initial amount of X.
(C) atomic number of X and Z are same
(D) the mass number of Y is greater than X
Q. 26 Among the following nuclides, the highest tendency to decay by $\left(\beta^{+}\right)$emission is -
(A) $\mathrm{Cu}^{59}$
(B) ${ }^{63} \mathrm{Cu}$
(C) ${ }^{67} \mathrm{Cu}$
(D) ${ }^{68} \mathrm{Cu}$

## Level - III

Q. 1 Which of the following statement are correct?
(A) The order of a reaction is the sum of the components of all the concentration terms in the rate equation.
(B) The order of a reaction with respect to one reactant is the ratio of the change of logarithm of the rate of the reaction to the change in the logarithm of the concentration of the particular reactant, keeping the concentration all other reactants constant
(C) Orders of reactions can be whole numbers of fractional numbers.
(D) The order of a reaction can only be determined from the stoichiometric equation for the reaction.
Q. 2 Which of the following statements are correct?
(A) The rate of the reaction involving the conversion of ortho-hydrogen to parahydrogen is $-\frac{\mathrm{d}\left[\mathrm{H}_{2}\right]}{\mathrm{dt}}=\mathrm{k}\left[\mathrm{H}_{2}\right]^{3 / 2}$
(B) The rate of the reaction involving the thermal decomposition of acetaldehyde is $\mathrm{k}\left[\mathrm{CH}_{3} \mathrm{CHO}\right]^{3 / 2}$
(C) In the formation of phosgene gas from CO and $\mathrm{Cl}_{2}$, the rate of the reaction is $\mathrm{k}[\mathrm{CO}]\left[\mathrm{Cl}_{2}\right]^{1 / 2}$
(D) In the decomposition of $\mathrm{H}_{2} \mathrm{O}_{2}$, the rate of the reaction is $\mathrm{k}\left[\mathrm{H}_{2} \mathrm{O}_{2}\right]$.
Q. 3 Which of the following isomerization reactions is of the first order?
(A) cyclopropane $\rightarrow$ propane
(B) cis-but-2-ene $\rightarrow$ trans-but-2-ene
(C) vinyl allyl ether $\rightarrow$ pent-4-enal
(D) $\mathrm{CH}_{3} \mathrm{NC} \rightarrow \mathrm{CH}_{3} \mathrm{CN}$
Q. 4 Which of the following reactions is of the first order?
(A) The decomposition of ammonium nitrate in an aqueous solution
(B) The inversion of cane-sugar in the presence of an acid
(C) The acidic hydrolysis of ethyl acetate
(D) All radioactive decays.
Q. 5 Which of the following are examples of unimolecular reactions?
(A) $\mathrm{O}_{3} \rightarrow \mathrm{O}_{2}+\mathrm{O}$
(B)

(C) $\mathrm{NO}+\mathrm{O}_{3} \rightarrow \mathrm{NO}_{2}+\mathrm{O}_{2}$
(D) $\mathrm{O}+\mathrm{NO}+\mathrm{N}_{2} \rightarrow+\mathrm{NO}_{2}+\mathrm{N}_{2}$
Q. 6 The calculation of the pre-exponential factor is based on the
(A) idea that, for a reaction to take place, the reactant species must come together
(B) Calculation of the molecularity of the reaction
(C) idea that the reactant species must come together, leading to the formation of the transition state which then transforms into the products
(D) calculation of the order of the reaction
Q. 7 Which of the following are examples of pseudo-unimolecular reactions?
(A)
$\mathrm{CH}_{3} \mathrm{CO}_{2} \mathrm{C}_{2} \mathrm{H}_{5}+\mathrm{H}_{2} \mathrm{O} \xrightarrow{\mathrm{H}^{+}} \mathrm{CH}_{3} \mathrm{CO}_{2} \mathrm{H}+\mathrm{C}_{2} \mathrm{H}_{5} \mathrm{OH}$
(B)

(C) $\mathrm{CH}_{3} \mathrm{COCl}+\mathrm{H} 2 \mathrm{O} \longrightarrow \mathrm{CH}_{3} \mathrm{CO}_{2} \mathrm{H}+\mathrm{HCl}$
(D) $\mathrm{CH}_{3} \mathrm{CO}_{2} \mathrm{C}_{2} \mathrm{H}_{5}+\mathrm{H}_{2} \mathrm{O} \xrightarrow{\mathrm{OH}^{-}} \mathrm{CH}_{3} \mathrm{CO}_{2} \mathrm{H}+\mathrm{C}_{2} \mathrm{H}_{5} \mathrm{OH}$
Q. 8 In which of the following ways does an activated complex differ from an ordinary molecule?
(A) It is quite unstable and has no independent existence.
(B) $\Delta \mathrm{H}_{\mathrm{f}}^{\circ}$ is probably positive
(C) The system has a greater vibrational character.
(D) The system has no vibrational character.
Q. 9 The basic theory behind Arrhenius's equation is that
(A) the number of effective collisions is proportional to the number of molecules above a certain threshold energy
(B) as the temperature increases, so does the number of molecules with energies exceeding the threshold energy.
(C) the rate constant is function of temperature.
(D) the activation energy and pre-exponential factor are always temperature-independent
Q. 10 In arrhenius's equation, $k=A \exp \left(-\frac{\mathrm{E}_{\mathrm{a}}}{\mathrm{RT}}\right)$. A may be termed as the rate constant at
(A) very low temperature
(B) very high temperature
(C) zero activation energy
(D) the boiling temperature of the reaction mixture
Q. 11 Which of the following statements are correct about half-life period.
(A) It is proportional to initial concentration for zeroth order.
(B) average life $=1.44$ half-life for first order reaction
(C) time of $75 \%$ reaction is thrice of half-life period in second order reaction
(D) $99.9 \%$ reaction takes place in 100 minutes for the case when rate constant is $0.0693 \mathrm{~min}^{-1}$
Q. $12 \mathrm{Zn}+2 \mathrm{H}^{+} \longrightarrow \mathrm{Zn}^{2+}+\mathrm{H}_{2}$

Half-life period is independent of concentration of zinc at constant pH . For the constant concentration of Zn , rate becomes 100 times when pH is decreased from 3 to 2 . Hence
(A) $\frac{\mathrm{dx}}{\mathrm{dt}}=\mathrm{k}[\mathrm{Zn}]^{0}\left[\mathrm{H}^{+}\right] 2$
(B) $\left(\frac{\mathrm{dx}}{\mathrm{dt}}\right)=\mathrm{k}[\mathrm{Zn}]\left[\mathrm{H}^{+}\right]^{2}$
(C) rate is not affected if concentration of zinc is made four times and that of $\mathrm{H}^{+}$ions is halved.
(D) rate becomes four times if concentration of $\mathrm{H}^{+}$ion is doubled at constant Zn concentration,.
Q.13. In which of the following case, $\mathrm{E}_{\mathrm{a}}$ of the backward reaction is greater than that of the forward reaction?
(A) A $+10 \mathrm{kcal} \longrightarrow \mathrm{B}, \mathrm{E}_{\mathrm{a}}=50 \mathrm{kcal}$
(B) A+20 kcal $\longrightarrow \mathrm{B}, \mathrm{E}_{\mathrm{a}}=40 \mathrm{kcal}$
(C) $\mathrm{A}+40 \mathrm{kcal} \longrightarrow \mathrm{B}, \mathrm{E}_{\mathrm{a}}=10 \mathrm{kcal}$
(D) A-40 kcal $\longrightarrow \mathrm{B}, \mathrm{E}_{\mathrm{a}}=20 \mathrm{kcal}$
Q. $14 \underset{(\mathrm{~g})}{\mathrm{A}} \longrightarrow \underset{(\mathrm{g})}{\mathrm{B}}+\underset{(\mathrm{g})}{\mathrm{C}}$
(g) (g) (g)
$\frac{-\mathrm{d}[\mathrm{A}]}{\mathrm{dt}}=\mathrm{k}[\mathrm{A}]$
At the starting pressure is 100 mm and after 10 min , pressure is 120 mm . hence rate constant $\left(\min ^{-1}\right)$ is:
(A) $\frac{2.303}{10} \log \frac{120}{100}$
(B) $\frac{2.303}{10} \log \frac{100}{20}$
(C) $\frac{2.303}{10} \log \frac{100}{80}$
(D) $\frac{2.303}{10} \log \frac{100}{120}$
Q. 15


Which of the following statements are correct?
(A) it is unimolecular nucleophilic substitution reaction $\mathrm{S}_{\mathrm{N}^{1}}$ if I or II is formed.
(B) it is bimolecular nucleophilic substituton reaction $\mathrm{S}_{\mathrm{N}^{2}}$ if I or II is formed.
(C) it is $\mathrm{S}_{\mathrm{N}^{1}}$ if I and its enantiomer are formed so that mixture is racemic.
(D) it is $\mathrm{S}_{\mathrm{N}^{2}}$ if II is formed.
Q. 16 The reaction, $\mathrm{A}(\mathrm{g})+2 \mathrm{~B}(\mathrm{~g}) \longrightarrow \mathrm{C}(\mathrm{g})+\mathrm{D}(\mathrm{g})$

Initial pressure of $A$ and $B$ are respectively $p_{A}=0.60 \mathrm{~atm}, p_{B}=0.80 \mathrm{~atm}$. When $p_{C}=0.20 \mathrm{~atm}$, the rate of the reaction relative to the initial rate, is
(A) $\frac{1}{48}$
(B) $\frac{1}{24}$
(C) $\frac{1}{6}$
(D) $\frac{1}{4}$
Q. 17 Rate constant k varies with temperature by eqn:

$$
\log \mathrm{k}\left(\min ^{-1}\right)=5-\frac{2000 \mathrm{~K}}{\mathrm{~T}} . \text { We can conclude }
$$

(A) pre-expontial factor A is 5
(B) $\mathrm{E}_{\mathrm{a}}$ is 2000 kcal
(C) pre-exponential factor A is $10^{5}$
(D) $\mathrm{E}_{\mathrm{a}}$ is 9.212 kcal .
Q. 18 The rate law for the dimerisation of $\mathrm{NO}_{2}$ is

$$
\frac{-\mathrm{d}\left[\mathrm{NO}_{2}\right]}{\mathrm{dt}}=\mathrm{k}\left[\mathrm{NO}_{2}\right]^{2}
$$

Which of the following changes will change the value of the specific rate constant, K ;
(A) Doubling the total pressure on the system
(B) doubling the temperature
(C) both
(D) none
Q. 19 For a reaction for which the activation energies of the forward and reverse directions are equal in value:
(A) the stoichiometry is the mechanism
(B) $\Delta \mathrm{H}=0$
(C) $\Delta \mathrm{S}=0$
(D) the order is zero.
Q. 20 A reaction is catalysed by $\mathrm{H}^{+}$ion. In presence of $\mathrm{H}_{A}$, rate constant is $2 \times 10^{-3} \mathrm{~min}^{-1}$ and in presence of $\mathrm{H}_{\mathrm{B}}$ rate constant is $1 \times 10^{-3} \mathrm{~min}^{-1} \mathrm{HA}$ and HB both being stronge acids, we may conclude.
(A) Equilibrium constant is 2
(B) $\mathrm{H}_{\mathrm{A}}$ is stronger than HB
(C) relative strength of HA and HB is 2
(D) HA is weaker than HB and relative strength is 0.5

## Level - IV

Instruction: From Question (1 to 6) match the items under Column (A) with items under Column (B). Select the correct answer from the sets (A), (B), (C) and (D).

1. Match the following

Column A
(i) Half life of first order reaction
(ii) Arrhenius equation
(iii) Molar concentration
(iv) Half life period of zero order reaction

## Column B

(a) Active mass
(b) $\mathrm{k}=\mathrm{Ae}^{-\mathrm{E}_{\mathrm{a}} / \mathrm{RT}}$
(c) $\mathrm{t}_{1 / 2}=\frac{0.693}{\mathrm{k}}$
(d) $\frac{\mathrm{a}}{2 \mathrm{k}}$
(A) i-b, ii-a, iii-d, iv-c
(B) i-a, ii-c, iii-b, iv-d
(C) i-c, ii-b, iii-a, iv-d
(D) i-c, ii-b, iii-d, iv-a
2. Match the following

## Column A

(i) Rate of reaction
(ii) $\frac{\Delta[\mathrm{A}]}{\Delta \mathrm{t}}$
(iii) Unit of rate of reacton
(A) i-c, ii-a, iii-b
(A) i-a, ii-c, iii-b
(B) i-a, ii-b, iii-c
(D) i-b, ii-c, iii-a
3. Match the following

## Column A

(i) Zero order reaction
(ii) First order reation
(iii) Second order reaction
(iv) Instantaneous rate
(v) Temperature coefficient
(vi) Rate equation for third order reaction
(vii) Acidic hydrolysis of ester
(A) i-e, ii-f, iii-g, iv-c, v-a, vi-d, vii-b
(C) i-e, ii-g, iii-f, iv-d, v-a, vi-c, vii-b

## Column B

(a) $\frac{\mathrm{k}_{\mathrm{t}+10}}{\mathrm{k}_{\mathrm{t}}}$
(b) $\frac{\mathrm{dx}}{\mathrm{dt}}$
(c) $\quad-\frac{\mathrm{dx}}{\mathrm{dt}}=\mathrm{k}[\mathrm{A}]^{2}[\mathrm{~B}]$
(d) $\quad \mathrm{H}_{2}+\mathrm{Cl}_{2} \xrightarrow{\mathrm{~h} \nu} 2 \mathrm{HCl}$
(e) $\mathrm{CH}_{3} \mathrm{COOCH}_{3}+\mathrm{NaOH} \rightarrow$ $\mathrm{CH}_{3} \mathrm{COONa}+\mathrm{CH}_{3} \mathrm{OH}$
(f) $\quad 2 \mathrm{H}_{2} \mathrm{O}_{2} \rightarrow \mathrm{H}_{2} \mathrm{O}+\mathrm{O}_{2}$
(g) Pseudo-unimolecular reaction
(B) i-d, ii-f, iii-e, iv-b, v-a, vi-c, vii-g
(D) i-b, ii-c, iii-a, iv-d, v-f, vi-g, vii-e
4. Match the following

## Column I

order
(i) Zero
(ii) One
(iii) Two
(iv) Three
(A) i-b, ii-d, iii-a, iv-c
(C) i-c, ii-a, iii-b, iv-d
5. Match the following

## Column I

Order
(i) Zero
(ii) One
(iii) Two
Column II
Value of $t_{0.5}$
(a) $\mathrm{t}_{0.5}=\frac{0.693}{\mathrm{k}_{1}}$
(B) i-d, ii-b, iii-c, iv-a
(D) i-a, ii-b, iii-c, iv-d
(b) $\quad \mathrm{t}_{0.5}=\frac{\mathrm{A}}{2 \mathrm{k}_{0}}$
(c) $\mathrm{t}_{0.5}=\frac{3}{2 \mathrm{k}_{3} \mathrm{a}^{2}}$
(C) $1^{2}$. mole $^{2}$ time ${ }^{-1}$

## Column II <br> Rate reaction

(a) $\quad \mathrm{k}_{2}=\frac{\mathrm{x}}{\operatorname{at}(\mathrm{a}-\mathrm{x})}$
(b) $\quad \mathrm{k}_{0}=\frac{\mathrm{x}}{\mathrm{t}}$
(c) $\mathrm{k}_{3}=\frac{\mathrm{x}(2 \mathrm{a}-\mathrm{x})}{\mathrm{t} \cdot 2 \mathrm{a}^{2}(\mathrm{a}-\mathrm{x})^{2}}$
(d) $\mathrm{k}_{1}=\frac{2.303}{\mathrm{t}} \log \frac{\mathrm{a}}{\mathrm{a}-\mathrm{x}}$
(iv) Three
(A) i-b,D, ii-a,B, iii-d,A iv-c-C
(C) i-c,C, ii-b,A, iii-a,B iv-d-D
(B) i-a,A, ii-c,B, iii-b,C iv-d-D
(A) i-d,B, ii-c, C, iii-b,D iv-a-A
(d) $\quad \mathrm{t}_{0.5}=\frac{1}{\mathrm{k}_{2 \mathrm{a}}}$
(D) $\mathrm{moll}^{-1}$ time $^{-1}$
6. Match the following

## column I

(i) $\mathrm{N}_{2} \mathrm{O}_{5} \rightarrow \mathrm{~N}_{2} \mathrm{O}_{4}+1 / 2 \mathrm{O}_{2}$
(ii) $\mathrm{N}_{2} \mathrm{O}_{2} \rightarrow \mathrm{~N}_{2} \mathrm{O}+1 / 2 \mathrm{O}_{2}$
(iii) $2 \mathrm{HI} \rightarrow \mathrm{H}_{2}+\mathrm{I}_{2}$
(iv) $2 \mathrm{NO}+\mathrm{O}_{2} \rightarrow 2 \mathrm{NO}_{2}$
(A) i-a,C, ii-b,D, iii-c,A, iv-d,B
(C) i-c,C, ii-d,D, iii-a,B, iv-b,A

## Column II

(a) $\operatorname{Order}=3, \quad$ (A) molecularity $=2$
(b) Order $=2$,
(B) molecularity $=3$
(c) Order $=1$,
(C) molecularity $=1$
(d) $\operatorname{Order}=1$,
(D) molecularity $=1$
(B) i-d, A, ii-c, B, iii-b,C, iv-a,D
*(D) i-d,C, ii-c,D, iii-b,A, iv-a,B

## OBJECTIVE QUESTION ANSWERS

## Level-I

1. B
2. B
3. D
4. C
5. A
6. A
7. B
8. B
9. B
10. $B$
11. A
12. $B$
13. $B$
14. D
15. A
16. C
17. A
18. C
19. D
20. A
21. A
22. B
23. C
24. A
25. C
26. B

## Level-II

1. B
2. B
3. B
4. A
5. B
6. B
7. B
8. B
9. C
10. B
11. B
12. C
13. B
14. D
15. C
16. A
17. C
18. D
19. D
20. C
21. B
22. $B$
23. A
24. D
25. D
26. C

## Level-III

1. ABC
2. ABCD
3. ABCD
4. ABCD
5. AB
6. AC
7. ABC
8. AC
9. ABC
10. BC
11. ABCD
12. BCD
13. D
14. C
15. CD
16. C
17. CD
18. $B$
19. B
20. BC
Level-IV
21. C
22. D
23. B
24. A
25. A
26. D
