Q1 - 2024 (04 Apr Shift 1)

Consider the following transformation involving first order elementary reaction in each step at constant temperature as shown below.

$$A + B \underset{\text{Step 3}}{\overset{\text{Step 2}}{\underset{\text{Step 1}}{C}}} \longrightarrow P$$

Some details of the above reactions are listed below.

Step	Rate constant $\left(\mathbf{sec^{-1}}\right)$	Activation energy $\left(\mathbf{kJ\ mol^{-1}}\right)$
1	k_1	300
2	k_2	200
3	k_3	Ea_3

If the overall rate constant of the above transformation (k) is given as $k = \frac{k_1 k_2}{k_3}$ and the overall activation energy (E_a) is 400 kJ mol^{-1}, then the value of Ea_3 is _____ $kJmol^{-1}$ (nearest integer)

Q2 - 2024 (04 Apr Shift 2)

Consider the following reaction, the rate expression of which is given below

$$\mathrm{A + B \rightarrow C}$$
$$\text{rate } = \mathrm{k[A]^{1/2}[\,B]^{1/2}}$$

The reaction is initiated by taking 1M concentration of A and B each. If the rate constant (k) is 4.6×10^{-2} s^{-1}, then the time taken for A to become 0.1M is _____ sec. (nearest integer)

Q3 - 2024 (05 Apr Shift 1)

During Kinetic study of reaction $2A + B \rightarrow C + D$, the following results were obtained :

	A [M]	B [M]	initial rate of formation of D
I	0.1	0.1	6.0×10^{-3}
II	0.3	0.2	7.20×10^{-2}
III	0.3	0.4	2.88×10^{-1}
IV	0.4	0.1	2.40×10^{-2}

Based on above data, overall order of the reaction is _____

Q4 - 2024 (05 Apr Shift 2)

Consider the following single step reaction in gas phase at constant temperature.

$2\ A_{(g)} + B_{(g)} \rightarrow C_{(g)}$

The initial rate of the reaction is recorded as r_1 when the reaction starts with 1.5 atm pressure of A and 0.7 atm pressure of B. After some time, the rate r_2 is recorded when the pressure of C becomes 0.5 atm. The ratio $r_1 : r_2$ is _____ $\times 10^{-1}$. (Nearest integer)

Q5 - 2024 (06 Apr Shift 1)

Time required for 99.9% completion of a first order reaction is _____ times the time required for completion of 90% reaction.(nearest integer)

Q6 - 2024 (08 Apr Shift 1)

Consider the following reaction

$$A + B \rightarrow C$$

The time taken for A to become $1/4^{th}$ of its initial concentration is twice the time taken to become $1/2$ of the same. Also, when the change of concentration of B is plotted against time, the resulting graph gives a straight line with a negative slope and a positive intercept on the concentration axis.

The overall order of the reaction is _____

Q7 - 2024 (08 Apr Shift 2)

For a reaction $A \xrightarrow{K_1} B \xrightarrow{K_2} C$

If the rate of formation of B is set to be zero then the concentration of B is given by :

(1) $(K_1 + K_2)\,[A]$

(2) $(K_1/K_2)\,[A]$

(3) $(K_1 - K_2)\,[A]$

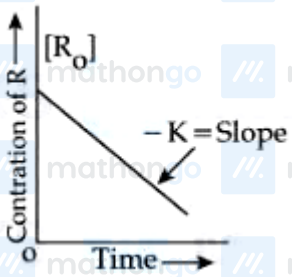
(4) $K_1\ K_2[\ A]$

Q8 - 2024 (09 Apr Shift 1)

Given below are two statements :

Statement I: The rate law for the reaction $A + B \rightarrow C$ is rate $(r) = k[A]^2[B]$. When the concentration of both A and B is doubled, the reaction rate is increased " x " times.

Statement II :



The figure is showing "the variation in concentration against time plot" for a " y " order reaction.

The Value of $x + y$ is _____

Q9 - 2024 (09 Apr Shift 2)

Consider the following first order gas phase reaction at constant temperature

$$\mathrm{A(g) \rightarrow 2\,B(\,g) + C(g)}$$

If the total pressure of the gases is found to be 200 torr after 23sec. and 300 torr upon the complete decomposition of A after a very long time, then the rate constant of the given reaction is _____ $\times 10^{-2}$ s^{-1}

(nearest integer)

[Given : $\log_{10}(2) = 0.301$]

Answer Key

Q1 (100) **Q2** (50) **Q3** (3) **Q4** (315)

Q5 (3) **Q6** (1) **Q7** (2) **Q8** (8)

Q9 (3)

Q1

$$K = \frac{K_1 K_2}{K_3}$$

$$Ae^{\frac{-E_3}{RT}} = \frac{A_1 e^{\frac{-E_{a_1}}{RT}} A_2 e^{\frac{-E_{3_2}}{RT}}}{A_3 e^{\frac{-E_{k_3}}{RT}}}$$

$$Ae^{\frac{-E_3}{RT}} = \frac{A_1 A_2}{A_3} e^{\frac{-\left(E_{a_1}-E_{a_2}-E_{3_3}\right)}{RT}}$$

$$E_a = E_{a_1} + E_{a_2} - E_{a_3}$$

$$400 = 300 + 200 - E_{a_3}$$

$$E_{a_3} = 100\ kJ/mole$$

Q2

$$K = \frac{2.303}{t} \log \frac{1}{0.1}$$

$$4.6 \times 10^{-2} = \frac{2.303}{t}$$

$$t = 50 sec.$$

Q3

$$r = K[A]^x[B]^y$$

$$(I) 6 \times 10^{-3} = K[0.1]^x[0.1]^y$$

$$(IV) 2.4 \times 10^{-2} = K[0.4]^x[0.1]^y$$

$$(IV)/(I)$$

$$4 = (4)^x$$

$$x = 1$$

$$r = K[A]^x[B]^y$$

$$(III)\ 2.88 \times 10^{-1} = K[0.3]^x[0.4]^y$$

$$(II)\ 7.2 \times 10^{-2} = K[0.3]^x[0.2]^y$$

$$(III)/(II)$$

$$4 = 2^y$$

$$y = 2$$

$$\text{Overall order} = x + y = 1 + 2 = 3$$

Q4

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$2\,A(g) + B(g) \longrightarrow C(g)$

$r_1 \quad 1.5\ atm \quad 0.7\ atm$

$r_2 \quad 0.5\ atm \quad 0.2\ atm \quad 0.5\ atm$

$\because r = K[P_A]^2\,[P_B]$

$r_1 = K[1.5]^2[0.7]$

$r_2 = K[0.5]^2[0.2]$

$\frac{r_1}{r_2} = 9 \times \frac{7}{2} = 31.5 = 315 \times 10^{-1}$

Ans. 315

Q5

$$K = \frac{1}{t_{99.9\%}} \ln\left(\frac{100}{0.1}\right) = \frac{1}{t_{90\%}} \ln\left(\frac{100}{10}\right)$$

$$t_{99.9\%} = t_{90\%} \frac{\ell n\left(10^3\right)}{\ell n 10}$$

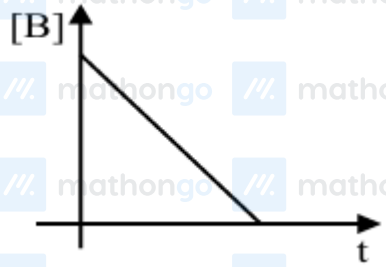
$$t_{99.9\%} = t_{90\%} \times 3$$

Q6

For 1^{st} order reaction

75% life $= 2 \times 50\%$ life

So order with respect to A will be first order.



So order with respect to B will be zero. Overall order of reaction $= 1 + 0 = 1$

Q7

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Rate of formation of B is

$$\frac{d[B]}{dt} = k_1[A] - k_2[B]$$

$$0 = k_1[A] - k_2[B]$$

$$\left(\frac{k_1}{k_2}\right)[A] = [B]$$

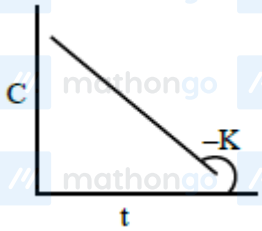
Q8

$$r = K[A]^2|B|$$

if conc. are doubled

$$r' = K[2A]^2[2B]^1$$

$$r' = 8r \Rightarrow x = 8$$



$\Rightarrow$ Zero order, $y = 0$

$$x + y = 8$$

Q9

$$A(g) \rightarrow 2B(g) + C(g)$$

$$P_{23} = P_0 + 2x = 200$$

$$P_\infty = 3P_0 = 300$$

$$P_0 = 100$$

$$K = \frac{1}{t}\ln\frac{P_\infty - P_0}{P_\infty - P_t}$$

$$K = \frac{2.3}{23}\log\frac{300 - 100}{300 - 200}$$

$$= \frac{2.3 \times 0.301}{23} = 0.0301 = 3.01 \times 10^{-2}\text{sec}^{-1}$$

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