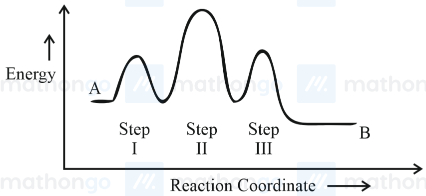
1. For the adsorption of hydrogen on platinum, the activation energy is $30\ \text{kJ}\ \ \text{mol}^{-1}$ and for the adsorption of hydrogen on nickel, the activation energy is $41.4\ \text{kJ}\ \ \text{mol}^{-1}$. The logarithm of the ratio of the rates of chemisorption on equal areas of the metals at 300 K is _______ (Nearest integer)
Given: $\ln 10 = 2.3$
$R = 8.3\ \text{J K}^{-1}\ \ \text{mol}^{-1}$
[2023 (06 Apr Shift 1)]

2. Consider the following reaction that goes from A to B in three steps as shown below:



Choose the correct option

	Number of Intermediates	Number of Activated Complexes	Rate determining step
(1)	2	3	I
(2)	2	3	III
(3)	2	3	II
(4)	3	2	II

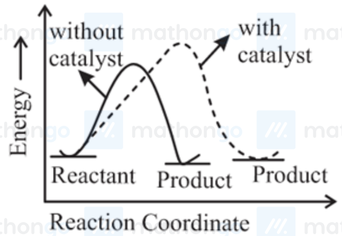
[2023 (06 Apr Shift 2)]
(1) (1)
(2) (2)
(3) (3)
(4) (4)

3. The number of given statement/s which is/are correct is_____
(A) The stronger the temperature dependence of the rate constant, the higher is the activation energy.
(B) If a reaction has zero activation energy, its rate is independent of temperature.
(C) The stronger the temperature dependence of the rate constant, the smaller is the activation energy.
(D) If there is no correlation between the temperature and the rate constant then it means that the reaction has negative activation energy.
[2023 (08 Apr Shift 1)]

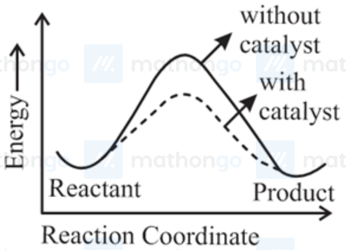
4. The correct reaction profile diagram for a positive catalyst reaction.

[2023 (08 Apr Shift 2)]

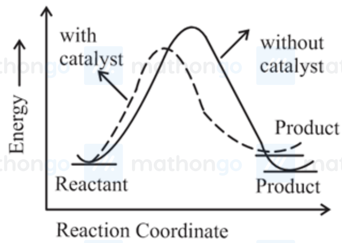
(1)



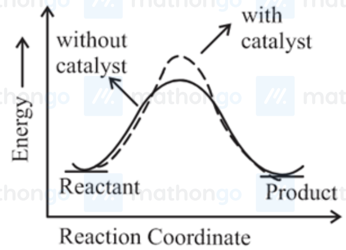
(2)



(3)



(4)



5. A molecule undergoes two independent first order reactions whose respective half lives are 12 min and 3 min. If both the reactions are occurring then the time taken for the 50% consumption of the reactant is ______ min. (Nearest integer)

[2023 (10 Apr Shift 1)]

6. The number of incorrect statement/s from the following is ______________

A. The successive half lives of zero order reactions decreases with time.

B. A substance appearing as reactant in the chemical equation may not affect the rate of reaction

C. Order and molecularity of a chemical reaction can be a fractional number

D. The rate constant units of zero and second order reaction are $mol L^{-1} s^{-1}$ and $mol^{-1} L s^{-1}$ respectively

[2023 (10 Apr Shift 2)]

7. $KClO_3 + 6FeSO_4 + 3H_2SO_4 \rightarrow KCl + 3Fe_2(SO_4)_3 + 3H_2O$

The above reaction was studied at 300 K by monitoring the concentration of $FeSO_4$ in which initial concentration was 10 M and after half an hour became 8.8 M. The rate of production of $Fe_2(SO_4)_3$ is _______ $\times 10^{-6}$ mol L^{-1} s^{-1}

(Nearest integer)

[2023 (11 Apr Shift 1)]

8. For a chemical reaction $A + B \rightarrow$ Product, the order is 1 with respect to A and B.

Rate $\text{mol L}^{-1}\text{ S}^{-1}$	**[A]** mol L^{-1}	**[B]** mol L^{-1}
0.10	20	0.5
0.40	x	0.5
0.80	40	y

What is the value of x and y?

[2023 (11 Apr Shift 2)]

(1) 160 and 4
(2) 80 and 4
(3) 80 and 2
(4) 40 and 4

9. The reaction $2NO + Br_2 \rightarrow 2\,NOBr$ takes place through the mechanism given below

$NO + Br_2 \rightleftharpoons NOBr_2$ (fast)

$NOBr_2 + NO \rightarrow 2\,NOBr$ (slow)

The overall order of the reaction is _____.

[2023 (12 Apr Shift 1)]

10. $t_{87.5}$ is the time required for the reaction to undergo 87.5% completion and t_{50} is the time required for the reaction to undergo 50% completion. The relation between $t_{87.5}$ and t_{50} for a first order reaction is $t_{87.5} = x \times t_{50}$

The value of x is _________. (Nearest integer)

[2023 (13 Apr Shift 1)]

11. $A(g) \rightarrow 2\,B(g) + C(g)$ is a first order reaction. The initial pressure of the system was found to be 800 mm Hg which increased to 1600 mm Hg after 10 min. The total pressure of the system after 30 min will be mm Hg. (Nearest integer)

[2023 (13 Apr Shift 2)]

12. For a reversible reaction $A \rightleftharpoons B$, the ΔH forward reaction $= 20\ \text{kJ mol}^{-1}$. The activation energy of the uncatalyzed forward reaction is $300\ \text{kJ mol}^{-1}$. When the reaction is catalysed keeping the reactant concentration same, the rate of the catalysed forward reaction at $27^{\circ}C$ is found to be same as that of the uncatalyzed reaction at $327^{\circ}C$. The activation energy of the catalysed backward reaction is _______ kJ mol^{-1}.

[2023 (15 Apr Shift 1)]

ANSWER KEYS

1. (2)	**2.** (3)	**3.** (2)	**4.** (2)	**5.** (2)	**6.** (1)	**7.** (333)	**8.** (3)
9. (3)	**10.** (3)	**11.** (2200)	**12.** (130)				

1. (2)

According to Arrhenius's equation,

$k = Ae^{-E_a/RT}$

$\log k = \log A - \frac{E_a}{2.3RT}$

E_{a1} =For the adsorption of hydrogen on platinum, the activation energy

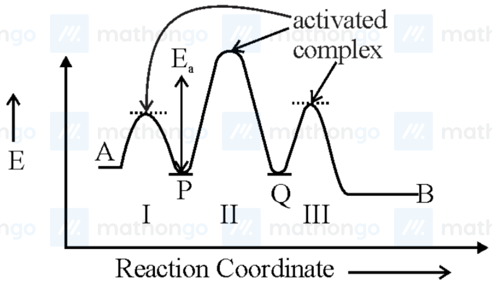
E_{a2} =for the adsorption of hydrogen on nickel, the activation energy

$\log\left(\frac{k_2}{k_1}\right) = \frac{E_{a2}-E_{a1}}{2.3\ RT} = \frac{11.4\times1000}{2.3\times8.3\times300}$

$= 1.990 \approx 2$

2. (3)

The curve contain three activated complex as shown below in the curve.In the curve P and Q are the intermediates. The step with the highest activation energy is the rate determining step. Hence, in the given reaction, two intermediates, three activated complexes are involved and step-II is the rate determining step.



3. (2)

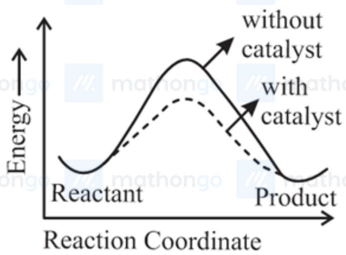
Rate constant is given by Arrhenius equation

$k = Ae^{-E_a/RT}$

Higher the magnitude of activation energy, stronger is the temperature dependence of the rate constant. The pre-exponential factor is a measure of the rate at which collisions occur, irrespective of their energy. If the activation energy of reaction is zero, temperature will have no effect on the rate constant.

4. (2)

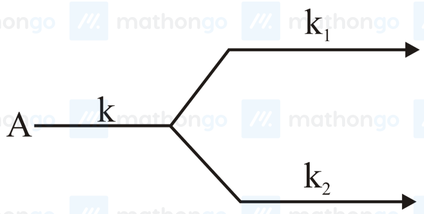
Most of the chemical reactions have energy barrier. A positive catalyst in a chemical reaction increases the rate of reaction by lowering the energy barrier. It does not alter the energy of reactant as well as product.



In the above graph, the curve in the presence of catalyst is having less activation energy. The enthalpy change is constant after addition of the positive catalyst

5. (2)

For parallel reaction



When adding the rate constants of the two reactions, we need to use the formula for combining rate constants of two reactions in parallel, which is:

$k = k_1 + k_2$

where k_1 and k_2 are the rate constants of the individual reactions.

In this case, the half-lives of the two reactions are 12 min and 3 min, respectively. The rate constants of the two reactions can be calculated using the formula for half-life of a first-order reaction:

$\frac{1}{t_{1/2}} = \frac{1}{12} + \frac{1}{3} = \frac{5}{12}$

Net $t_{1/2} = \frac{12}{5} = 2.4 \text{ min} \approx 2 \text{ min}$

Hence time taken for 50% consumption of reactant will be close to 2 min.

6. (1)

A. $C_0 \xrightarrow{t=\frac{C_0}{2k}} \frac{C_0}{2} \xrightarrow{t=\frac{C_0}{4k}} \frac{C_0}{4} \xrightarrow{t=\frac{C_0}{8k}} \frac{C_0}{8}$

Successive half lives of zero order reactions decreases with time

Note: successive half lives of first order reactions remains same

B. For zero order reactions, the rate of reaction is independent on the concentration of reactants.

C. In some reaction molecularity (theoretical value) may be equal to the order of a reaction (experimental value). The order of a reaction may be fractional, zero, positive or negative. Molecularity can never be fractional.

(D) Unit of k $= \frac{\text{Units of rate}}{[\text{units of concentration}]^{\text{order}}}$

Zero order = mollit^{-1} sec^{-1}

Second order = mol^{-1} lit^{-1}

7. (333)

$KClO_3 + 6FeSO_4 + 3H_2SO_4 \rightarrow KCl + 3Fe_2(SO_4)_3 + 3H_2O$

From the above equation, rate of decomposition $FeSO_4$ and rate of production of $Fe_2(SO_4)_3$ can be written as follows,

$\frac{1}{6} \times \text{Rate of decomposition}_{FeSO_4} = \frac{1}{3} \times \text{Rate of production}_{Fe_2(SO_4)_3}$

Rate of decomposition of $FeSO_4$

$\frac{\text{Change in concentration}}{\text{time in seconds}} = \frac{(10-8.8)}{30\times60}$

$= \frac{1.2}{1800} \text{ mol L}^{-1} \text{ s}^{-1}$

Rate of production of $Fe_2(SO_4)_3$

$= \frac{0.6}{1800} = 3.33 \times 10^{-4}$

$= 333.3 \times 10^{-6} \text{ mol}^{-1} \text{ s}^{-1}$

8. (3)

To determine the values of x and y, we can use the information provided and the rate expression for the given reaction, which is first order with respect to both A and B:

Rate r $= K[A]^1 [B]^1$

$0.1 = K(20)^1 (0.5)^1 \ldots \text{(i)}$

$0.40 = K(x)^1 (0.5)^1 \ldots \text{(ii)}$

$0.80 = K(40)^1 (y)^1 \ldots \text{(iii)}$

From (i) and (ii)

$x = 80$

From (i) and (iii)

$y = 2$

9. **(3)**

On applying Law of mass action over slowest step,

$R = k[NOBr_2][NO]$

The slowest step is the rate determining step.

On applying Law of mass action on equilibrium of Step I

$k = \frac{[NOBr_2]}{[NO]\,[Br_2]}$

$[NOBr_2] = k[NO][Br_2]$

Hence, overall rate equation will be

$R = k[NO]^2[Br_2]$

$= k'[NO]^2[Br_2]$

The overall order is equal to sum of the powers of the concentration terms in the rate law.

The overall order of the reaction is 3.

10. **(3)**

The time for completion of the reaction and concentration of reactant relation is as follows,

$A_t = A_0 \times \frac{12.5}{100} = \frac{A_0}{8}\left[87.5\%\ \text{completed}\right]$

$A_0 \xrightarrow{t_{1/2}} \frac{A_0}{2} \xrightarrow{t_{1/2}} \frac{A_0}{4} \xrightarrow{t_{1/2}} \frac{A_0}{8}$

$t_{87.5} = 3t_{1/2}$

So, $x = 3$

11. **(2200)**

The final pressure of each component can be calculated as follows,

	$A(g) \rightarrow$	$2B(g)$	$+\ C(g)$
intial	800	0	0
At time = t	800 − p	2p	p

$800 + 2p = 1600$

$2p = 800$

$p = 400$

The first order reaction rate constant can be calculated as follows,

$K = \frac{2.303}{10}\log\frac{800}{400} = \frac{2.303 \times \log 2}{10}$

For 30 min,

$K = \frac{2.303}{30}\log\frac{(800)}{(800-y)}$

$\frac{2.303 \times \log 2}{10} = \frac{2.303}{30}\log\left(\frac{800}{800-y}\right)$

$\Rightarrow \left(\frac{800}{800-y}\right) = 8$

$100 = 800 - y$

$y = 700$

Total pressure after 30 min

$(800 - y) + (2y) + (y)$

$= 800 + 2y$

$= 800 + 1400$

$= 2200$ mm Hg

12. **(130)**

As per the question

To determine the activation energy of the catalyzed backward reaction, we need to use the Arrhenius equation and the given information.

The Arrhenius equation is given by:

$k = Ae^{(-Ea/RT)}$

$Ae^{-\frac{300\times10^3}{600\times R}} = Ae^{\frac{-Ea}{300\times R}}$

$\Rightarrow \frac{10^3}{2} = \frac{Ea}{300}$

$\Rightarrow E_a = 150 \times 10^3\ J\ mol^{-1}$

$\Rightarrow E_a = 150\ kJ\ mol^{-1}$

$\therefore$ Activation energy of catalysed backward reaction

Energy of activation for backward reaction $E_b = E_a - \Delta H$

$= 150 - 20 = 130\ kJ\ mol^{-1}$