

## PAPER - 1

1. The generation time of any substance is the time in which its concentration doubles. The growth of a certain bacteria follows first order kinetics. If the population of bacteria triples in 96 hours, what is the generation time (in hours) for it? ( $\log 2 = 0.3$ ,  $\log 3 = 0.48$ )

$$\frac{d[A]}{dt} = k[A]$$

$$[A]_t = [A]_0 e^{kt}$$

$$k = \frac{1}{t} \ln \frac{[A]_t}{[A]_0} = \frac{1}{96} \ln 3 = \frac{1}{t} \ln 2$$

4. Find (O – O) bond enthalpy in  $\text{H}_2\text{O}_2$  (kJ/mol)

Given:  $\Delta H_f(\text{H}_2\text{O}_2, \ell) = -200 \text{ kJ/mol}$

$\Delta H_f(\text{H}_2\text{O}, \ell) = -285 \text{ kJ/mol}$

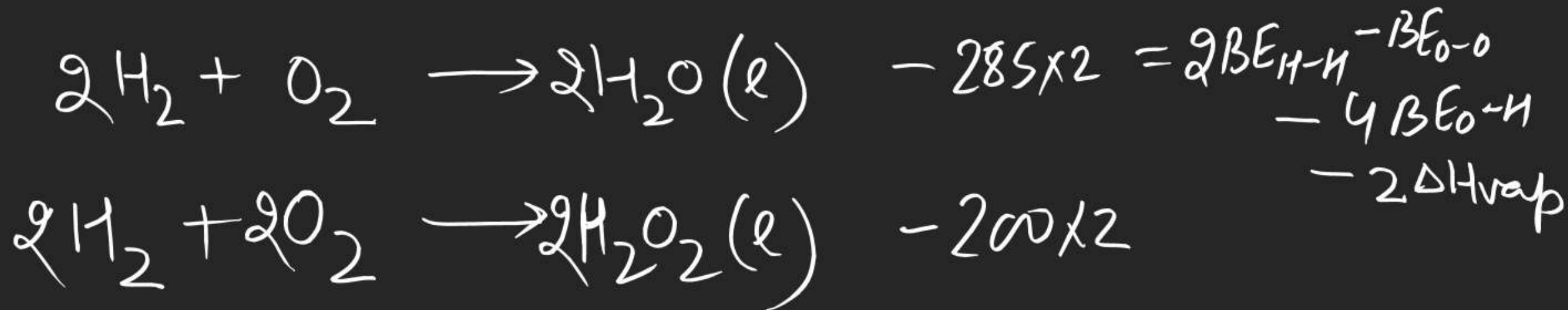
$\Delta H_{\text{vap.}}(\text{H}_2\text{O}_2, \ell) = 60 \text{ kJ/mol}$

$\Delta H_{\text{vap.}}(\text{H}_2\text{O}, \ell) = 40 \text{ kJ/mol}$

$\Delta H_{\text{atomisation}}(\text{O}_2, \text{g}) = 300 \text{ kJ/mol}$



Fill your answer as sum of digits (excluding decimal places) till you get the single digit answer.



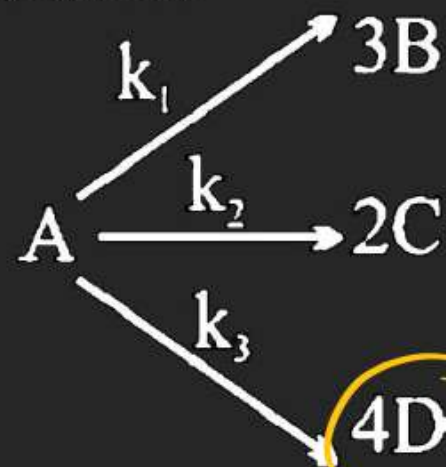
9. Which of the following statements is/are correct:

- (A) The coordination number of each type of ion in CsCl is 8 T
- (B) A metal that crystallises in BCC structure has a coordination number 8 T
- (C) A unit cell of an ionic crystal shares some of its ions with other unit cells T
- (D) The length of the unit cell in NaCl is 552pm

$$[r_{\text{Na}^+} = 95\text{pm}; r_{\text{Cl}^-} = 181\text{pm}]$$



12. For the 1 order parallel reaction



$$k_1 \times 3 : k_2 \times 2 : k_3 \times 4$$

$$3 : 4 : 12$$

$$\frac{k_2}{k_1 + k_2 + k_3} \times 1 \times 2$$

If  $k_1 : k_2 : k_3$  is 1:2:3, then, select the correct statement(s) ( $[A]_0 = 1M$ )

✓ (A) at  $\infty$  time  $[C]$  is  $2/3M$

✗ (B)  $[B]_t > [C]_t$

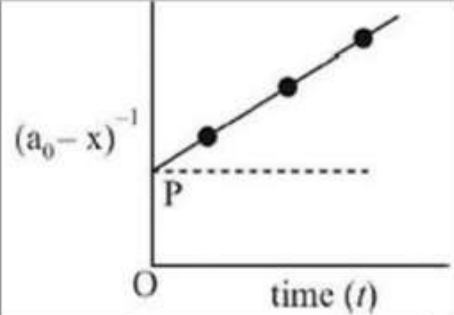
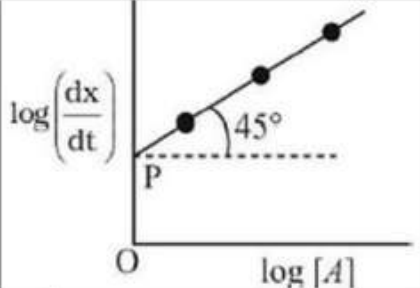
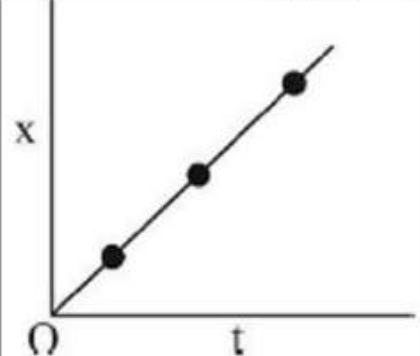
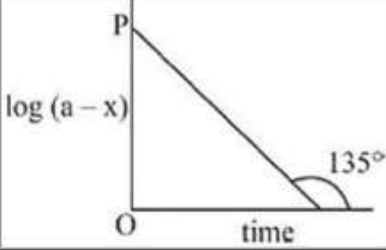
✓ (C) When  $[A]_t = 1/2M$  then  $[D] = 1M$

✓ (D)  $[A]_t + \frac{[B]_t}{3} + \frac{[C]_t}{2} + \frac{[D]_t}{4} = 1M$

$$\frac{k_3}{k_1 + k_2 + k_3} \times 4$$

$$\left(\frac{3}{6}\right) \times \left(\frac{1}{2}\right) \times 4$$

# 15. Match the graph in Column I with their, related properties in Column II.

	Column I		Column II
(P)		(1)	Rate constant is equal to rate of reaction
(Q)		(2)	If $OP = 0.5$ $[A]_0 = 2$
(R)		(3)	If $OP = 0.3010$ Half-life = 0.693 at $[A]_0 = 2M$
(S)		(4)	If $OP = 0.3010$ $k = 2$
		(5)	Half-life is independent of initial concentration
		(6)	Rate becomes 4 times on doubling $[A]$

(A)(P – 2, 6; Q – 1; R – 4, 5; S – 3, 5)

(B)(P – 4, 5; Q – 2, 6; R – 1; S – 3, 5)

(C)(P – 2, 6; Q – 4, 5; R – 3, 5; S – 1)

(D)(P – 2, 6; Q – 4, 5; R – 1; S – 3, 5)

$$\log \frac{dx}{dt} = \log k + \log [A]^n$$

$$\frac{dx}{dt} = k [A]^n$$

**Q.9** For which of the following process entropy of system containing ideal gas increases

☒ (A) Single stage adiabatic compression

$$\Delta S_{\text{sur}} = 0$$

☐ (B) Reversible adiabatic expansion  $\Delta S = 0$

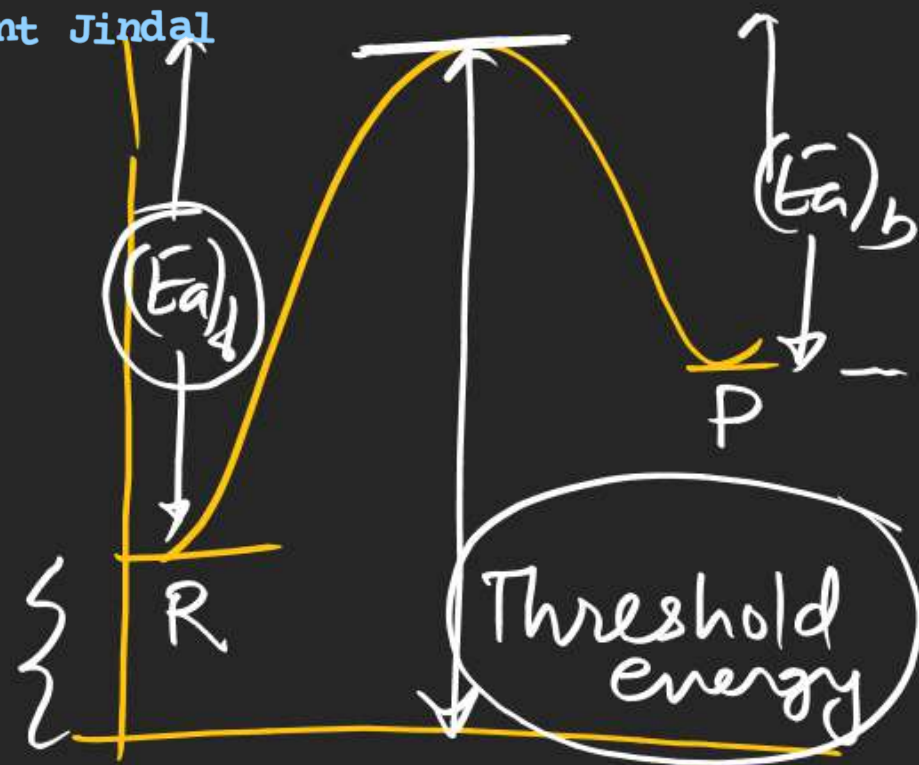
☒ (C) Irreversible adiabatic expansion

☐ (D) Isobaric cooling

$$\Delta S = nC_p \ln \frac{T_2}{T_1} + nR \ln \frac{P_1}{P_2}$$



PE



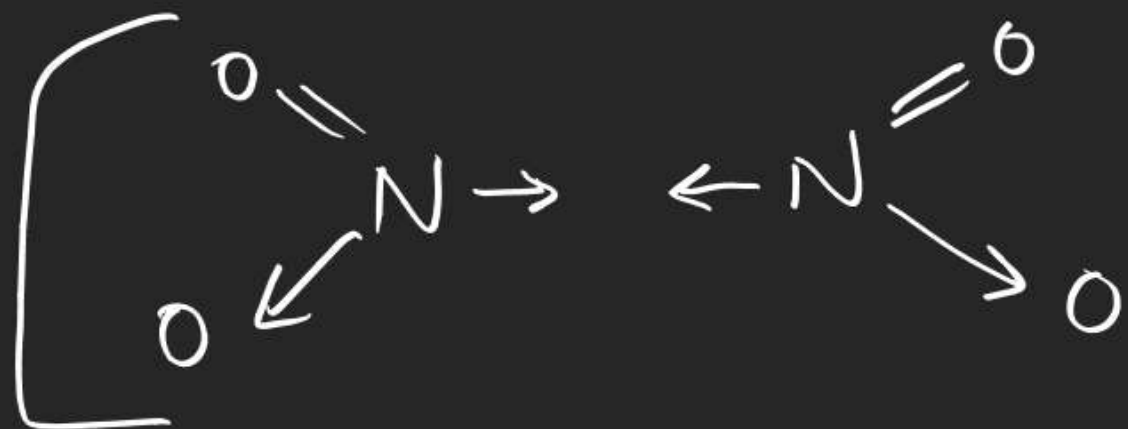
Rxn coordinate

$$\Delta H = (E_a)_f - (E_a)_b$$

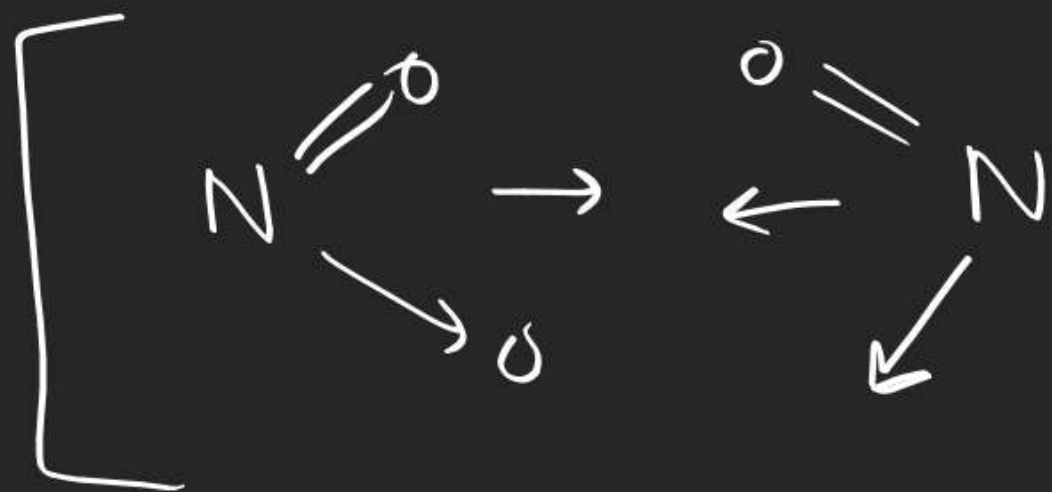


Threshold energy : Minimum Energy required to form product is called threshold energy

## ② Orientation barrier : →



proper



improper

Probability of proper orientation (steric factor) =  $p$



$$\text{Rate} = Z_{AB} \times e^{-E_a/RT} \times P$$

$$\text{Rate} = \underbrace{\pi \sigma^2 V_{\text{rel}} (N_A)^2 P}_{\text{collision frequency}} e^{-E_a/RT} [A][B]$$

$$= \underline{A e^{-E_a/RT} [A][B]}$$

$$= k [A][B]$$

$$\boxed{k = A e^{-E_a/RT}} \leftarrow \text{Arrhenius eqn}$$

rate constant

$A$  = frequency factor  
or

Arrhenius const

or  
pre-exponential factor

$$Z_{AB} = \pi \sigma^2 V_{\text{rel}} (N_A)^2 [A][B]$$

↑  
collision frequency

$$\sigma = r_A + r_B$$

$V_{\text{rel}}$  = relative speed of  
A wrt B

Acc to Arrhenius

$A$  &  $E_a$  are temperature independent.

$$k = A e^{-E_a/RT}$$

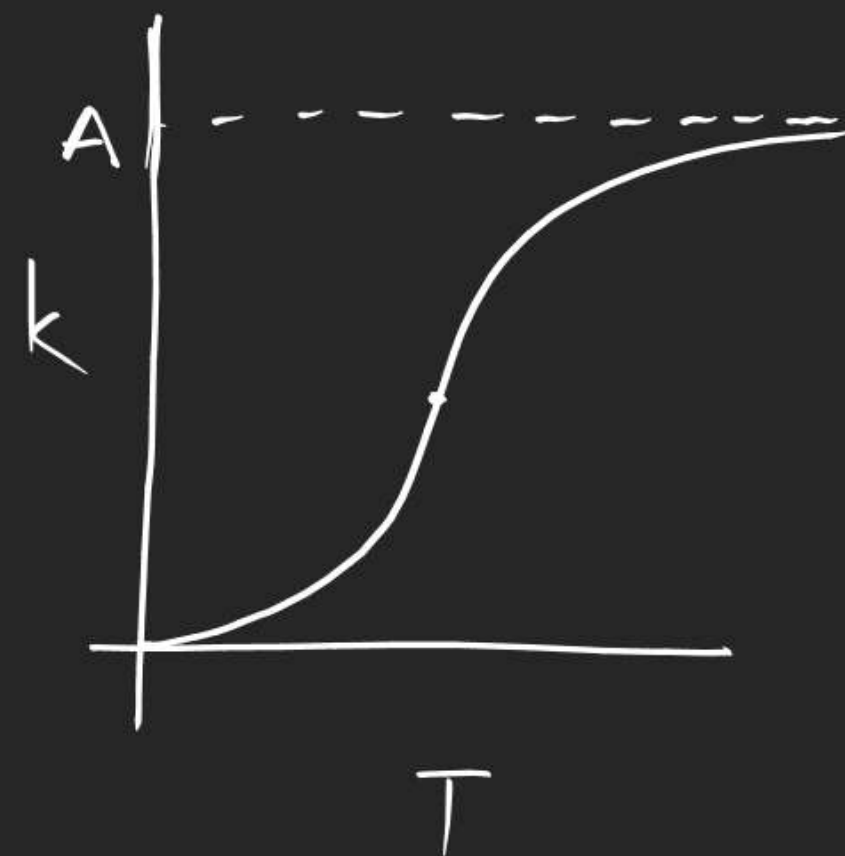
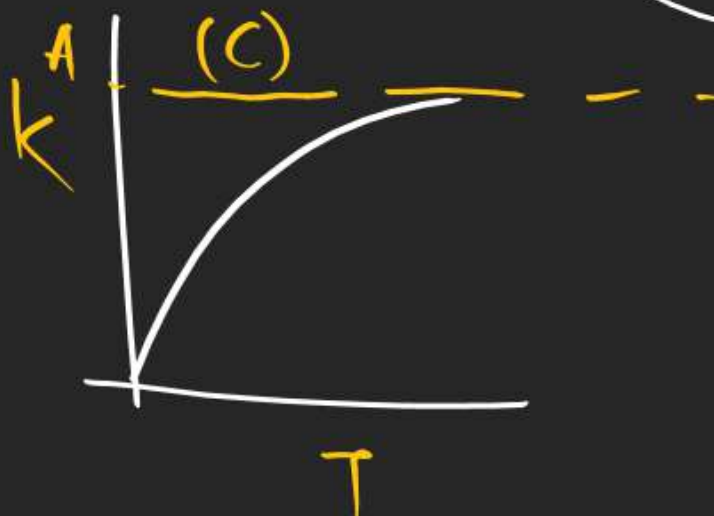
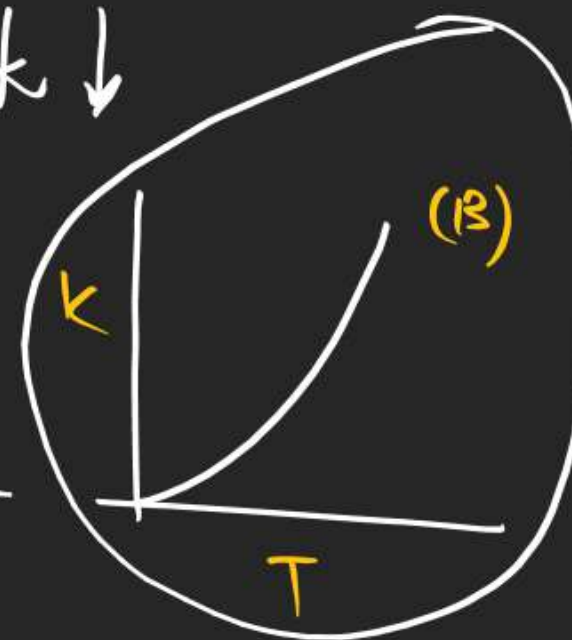
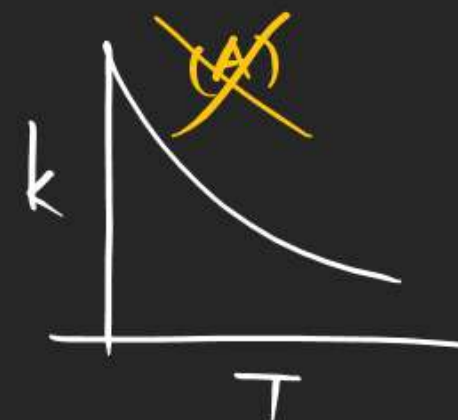
As  $T \uparrow$   $k \uparrow$

As  $T \uparrow$  rate also  $\uparrow$ es  
mainly because fraction of  
molecules having  $KE > E_a$   
increases.

$$k = A e^{-E_a/RT}$$

$$T \rightarrow \infty \quad k \rightarrow A$$

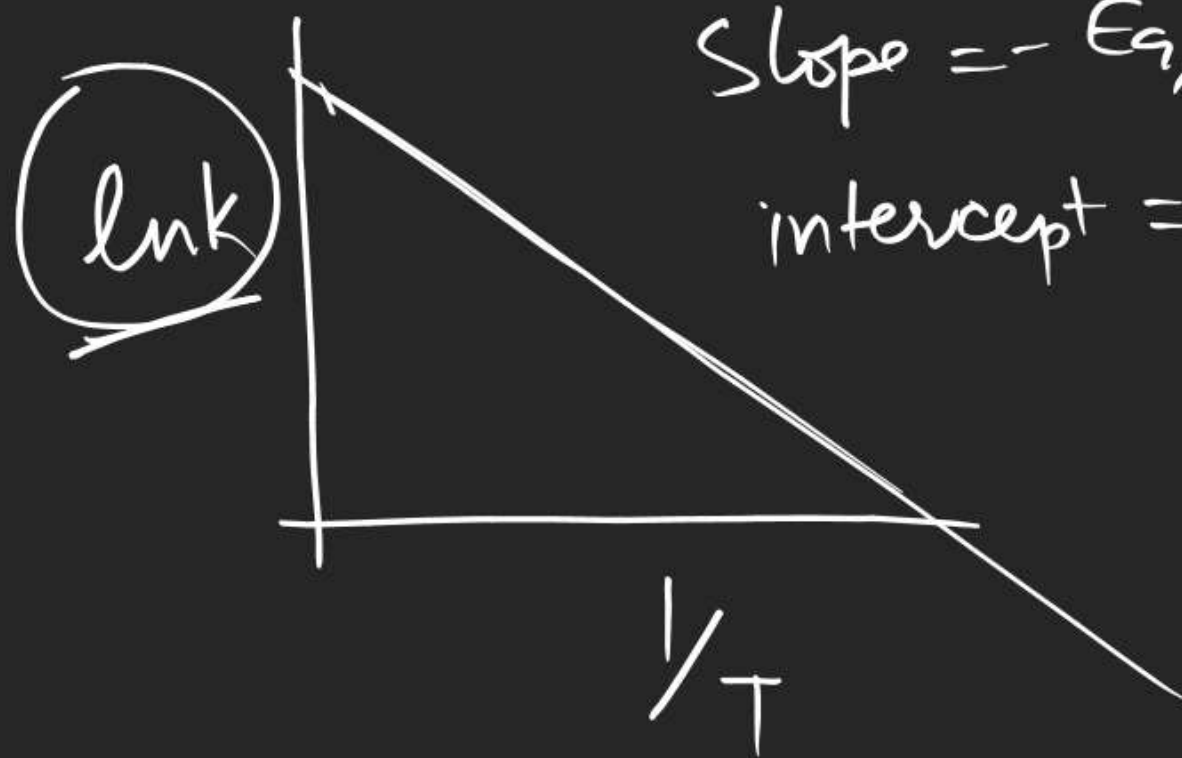
# As  $E_a \uparrow$   $k \downarrow$



$$k = A e^{-E_a/RT}$$

$$y = e^{-1/x}$$

$$\ln k_1 = \ln A - \frac{E_a}{R} \left( \frac{1}{T_1} \right) \text{---(1)} \quad \ln k_2 = \ln A - \frac{E_a}{R} \left( \frac{1}{T_2} \right) \text{---(2)}$$



Slope =  $-E_a/R$   
intercept =  $\ln A$

$$\ln \frac{k_2}{k_1} = \frac{E_a}{R} \left[ \frac{1}{T_1} - \frac{1}{T_2} \right]$$

rate const

$$\ln \frac{K_2}{K_1} = \frac{\Delta H}{R} \left[ \frac{1}{T_1} - \frac{1}{T_2} \right]$$

eq<sup>m</sup> const





$$E_a = 20 \text{ kJ}$$



$$E_a = 40 \text{ kJ}$$

$$\ln \frac{k_2}{k_1} = \frac{E_a}{R} \left( \frac{1}{T_1} - \frac{1}{T_2} \right)$$

$$200 \left( \frac{k_{T_2}}{k_{T_1}} \right) < \left( \frac{k_{T_2}}{k_{T_1}} \right) 40$$

100                      10

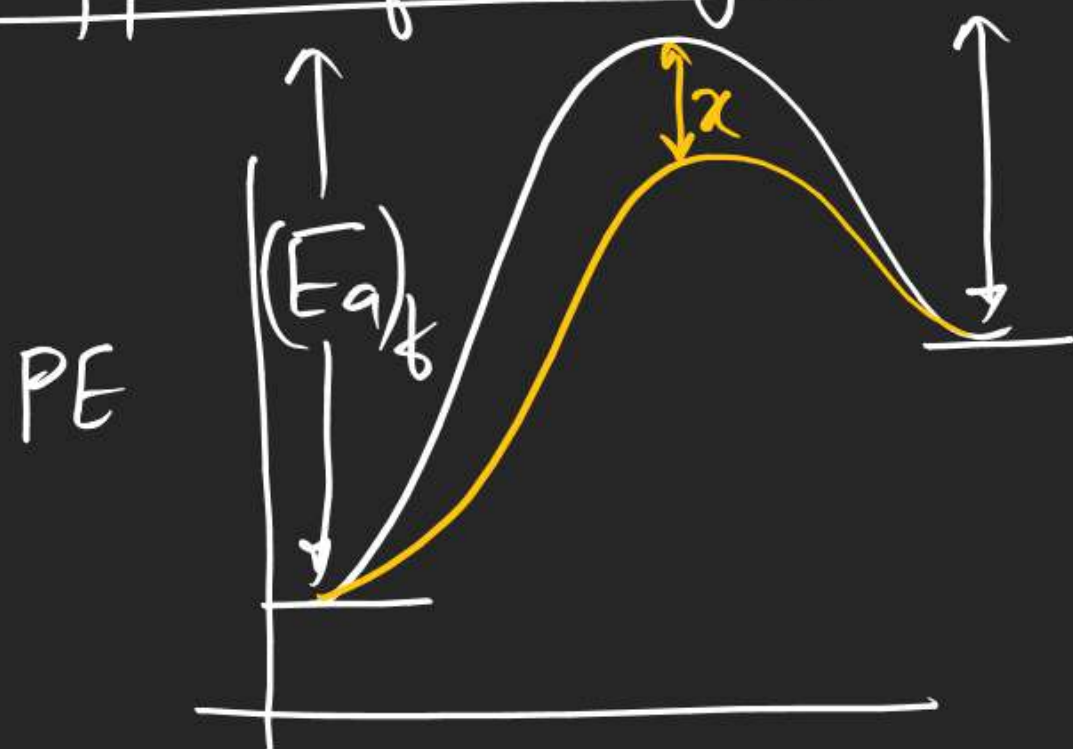
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$$\frac{k_{310}}{k_{300}} > \frac{k_{410}}{k_{400}}$$

$$\ln \frac{k_2}{k_1} = \frac{E_a}{R} \left( \frac{T_2 - T_1}{T_1 T_2} \right)$$

# Effect of catalyst



$$k_f = A_f e^{-(E_a)_f / RT}$$

$$k'_f = A_f e^{-[(E_a)_f - x] / RT}$$

$$= \underbrace{A_f e^{-(E_a)_f / RT}} e^{x / RT}$$

$$k'_f = k_f e^{x / RT}$$

$$k'_b = k_b e^{x / RT}$$

$$\frac{k'_f}{k'_b} = \frac{k_f}{k_b} = K_{eq}$$

Remaining

Kinetics

$S-I$
$O-I$

$T.D-1,2$	$J-Adv$
	$O-I$