

# Reaction Kinetics

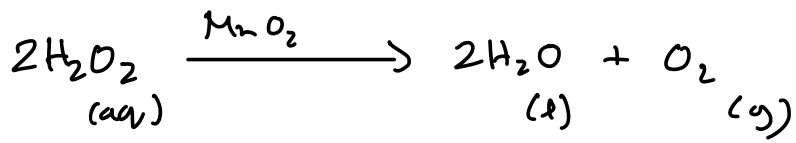
$$\text{Rate} = \frac{\text{Change in amount of reactant or product}}{\text{Time}}$$

## ① The effect of temperature on the rate of the reaction

- ⊖ Rate of the reaction increases with the increase of temperature.
- ⊖ particles have more kinetic energy.
- ⊖ particles move faster
- ⊖ More collisions per second / frequency of collisions increase.
- ⊖ More particles have energy greater than / equal the activation energy.
- ⊖ Number of effective collisions increase.

## ② The effect of concentration on the rate of a chemical reaction

- ⊖ More particles per unit volume.
- ⊖ Frequency of collisions increase
- ⊖ Number of effective collisions increase.



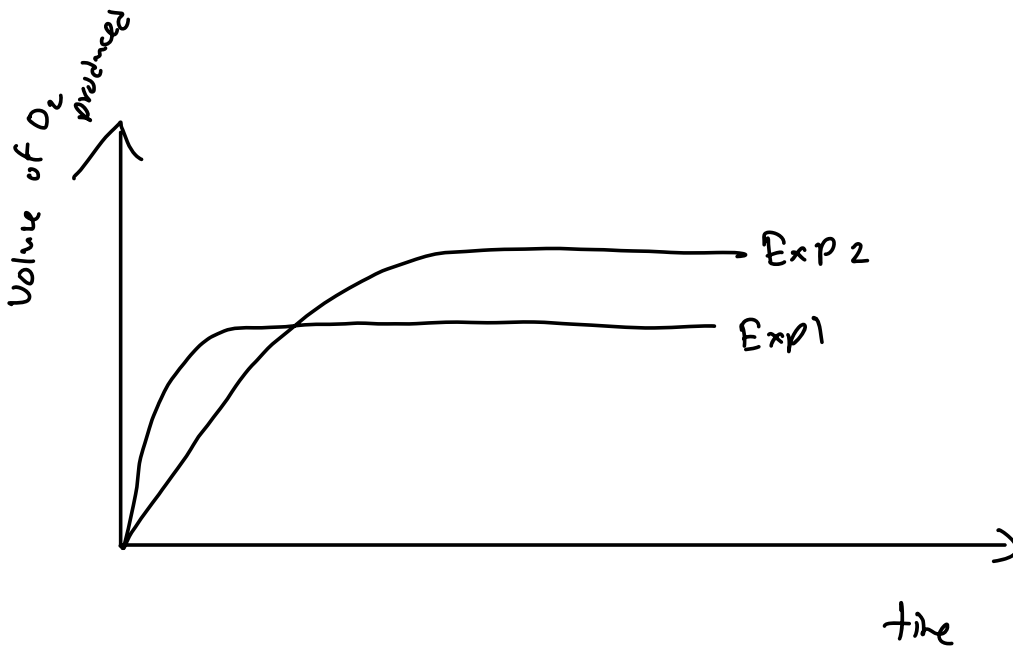
Exp-1

100 cm<sup>3</sup>  
1.0 mol dm<sup>-3</sup>

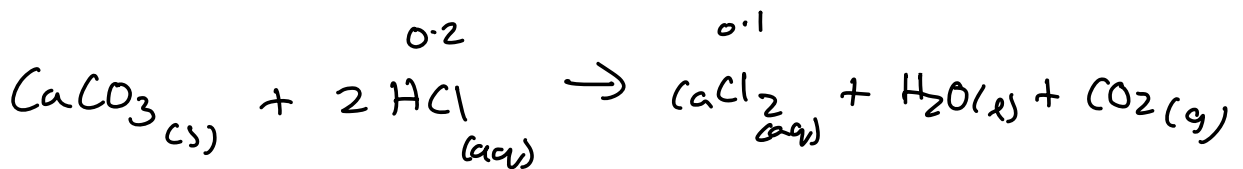
H<sub>2</sub>O<sub>2</sub>

Exp-2

100 cm<sup>3</sup>  
1.0 mol dm<sup>-3</sup>  
+ 200 cm<sup>3</sup> 0.5 mol dm<sup>-3</sup>



Example-2



Exp 1

100 cm<sup>3</sup> 2.0 mol / dm<sup>-3</sup> 0.2  
0.1 mol CaCl<sub>2</sub>

Exp 2

50 cm<sup>3</sup>

4.0 mol/dm<sup>3</sup> HCl

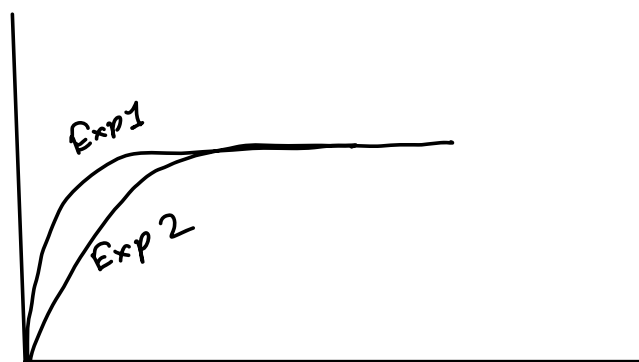
+ 150 cm<sup>3</sup> H<sub>2</sub>O

0.1 mol CaCl<sub>2</sub>

Yield

Both yield same.

Rate : Exp 1 higher.



Effect of surface area (Applicable for the solid reactants)

- ⊖ Rate of the reaction increases with the increase of surface area of the solid reactants.
- ⊖ More particles are exposed to react.
- ⊖ Frequency of collisions increase.
- ⊖ Number of effective collisions increase.
- ⊖ With the increase of the particles size,

surface area decreases.

## Effect of pressure on the rate of the reaction

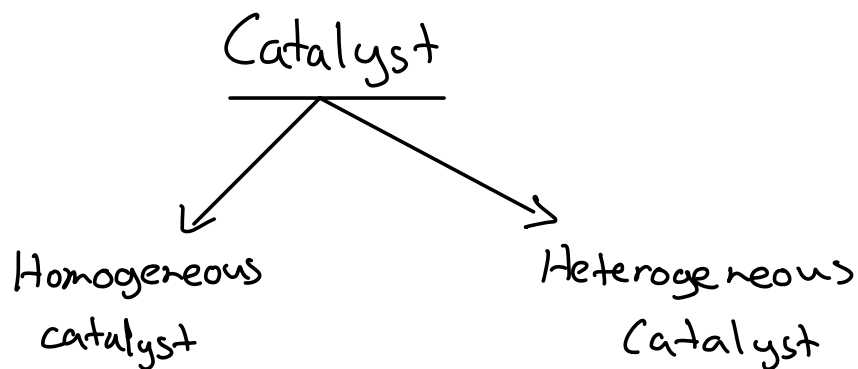
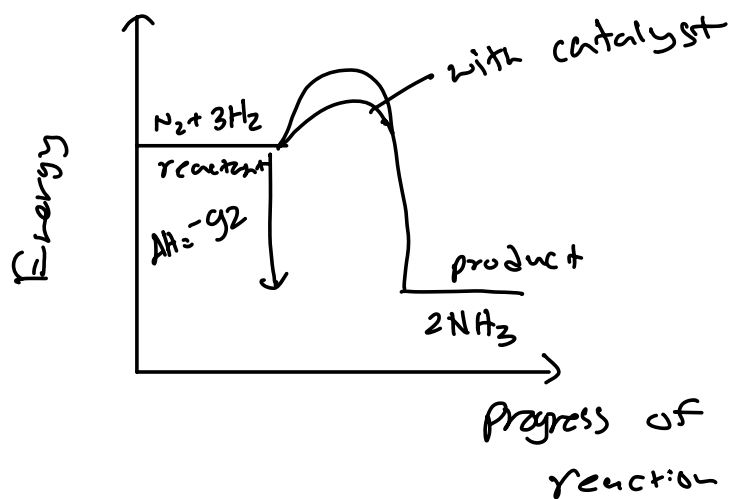
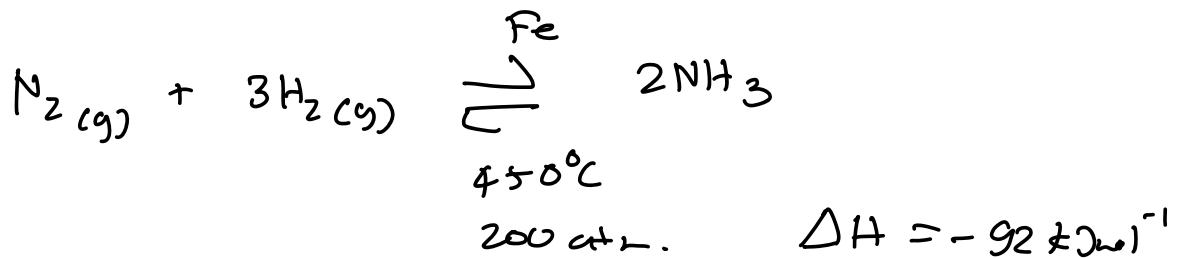
(Applicable for the gaseous reactant)

- ⊖ Rate of the reaction increases with the increase of pressure of the gaseous reactants.
- ⊖ Gas molecules are closer.
- ⊖ Frequency of collisions increase.
- ⊖ Number of effective collisions increase.

## Catalyst

- ⊖ Substances which can speed up a chemical reaction by lowering the activation energy by creating an alternative route are called catalyst.
- ⊖ Catalysts change the reaction mechanism.
- ⊖ Catalysts can not
  - change the equilibrium composition.
  - change the equilibrium position
  - change the enthalpy change

- change the yield of the product.

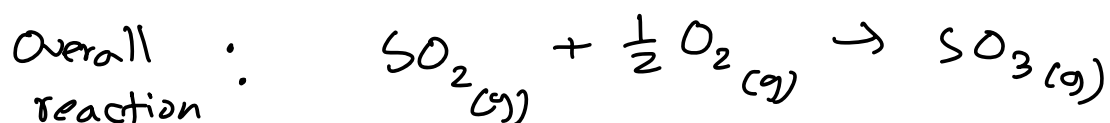
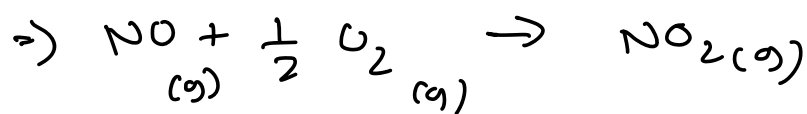
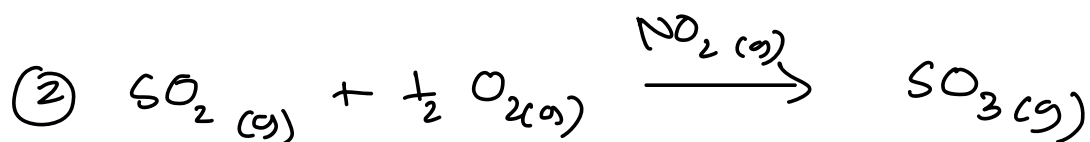
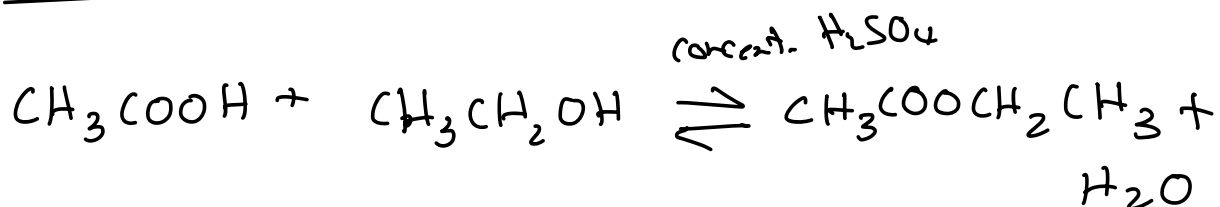


### Homogeneous Catalysts

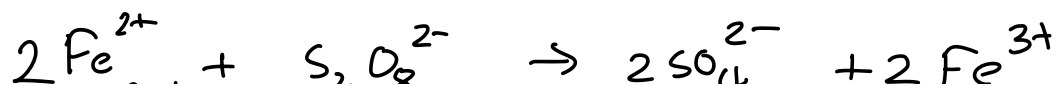
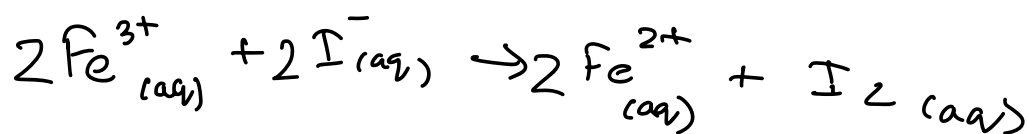
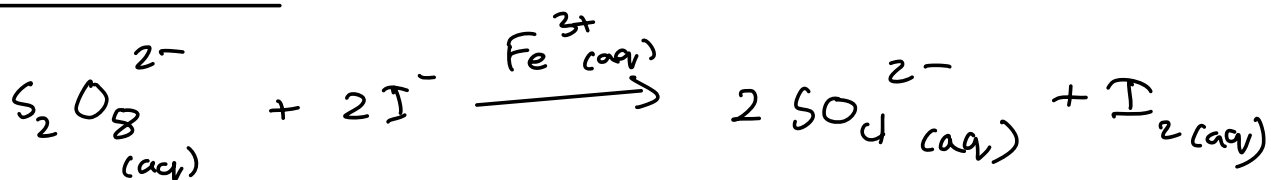
Reactants and catalysts are existed in the same physical state (same phase).

## Examples

### ① Esterification

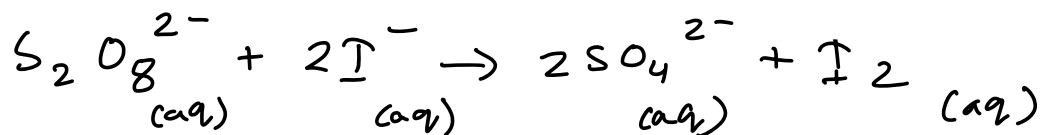


### Example -3





## Overall reaction



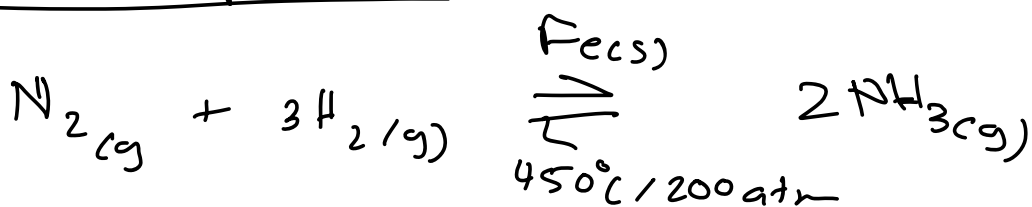
⊖ Here,  $\text{S}_2\text{O}_8^{2-}$  and  $\text{I}^-$  have same charge so they repel causing more activation energy.

## Heterogeneous Catalyst

Reactants and catalysts do not exist in the same physical state, rather they have different physical states.

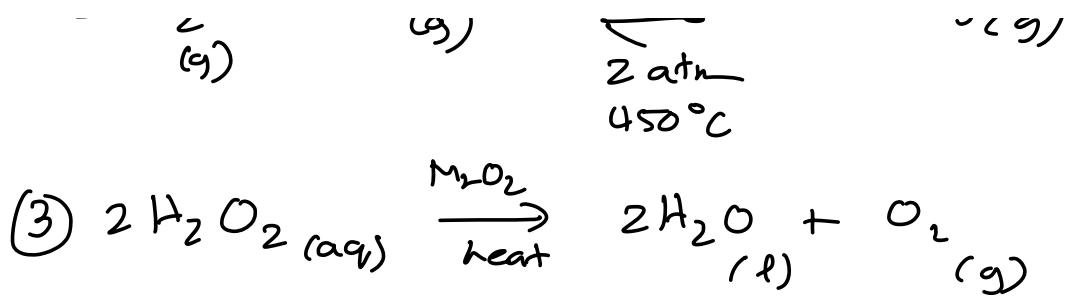
## Examples

### ① Haber process

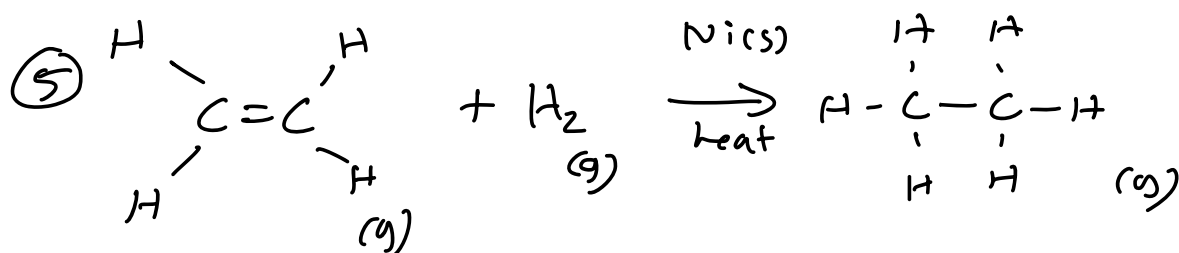
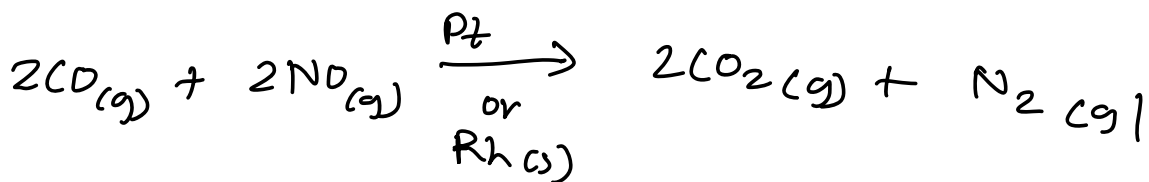


### ② Contact Process



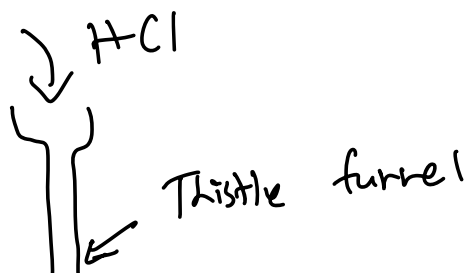
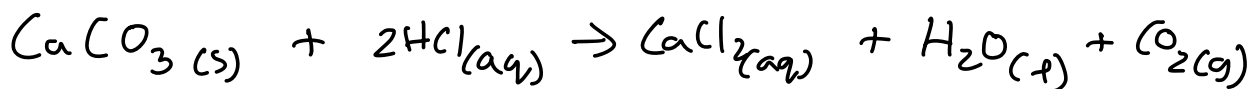


(4) Reaction in the catalytic converter

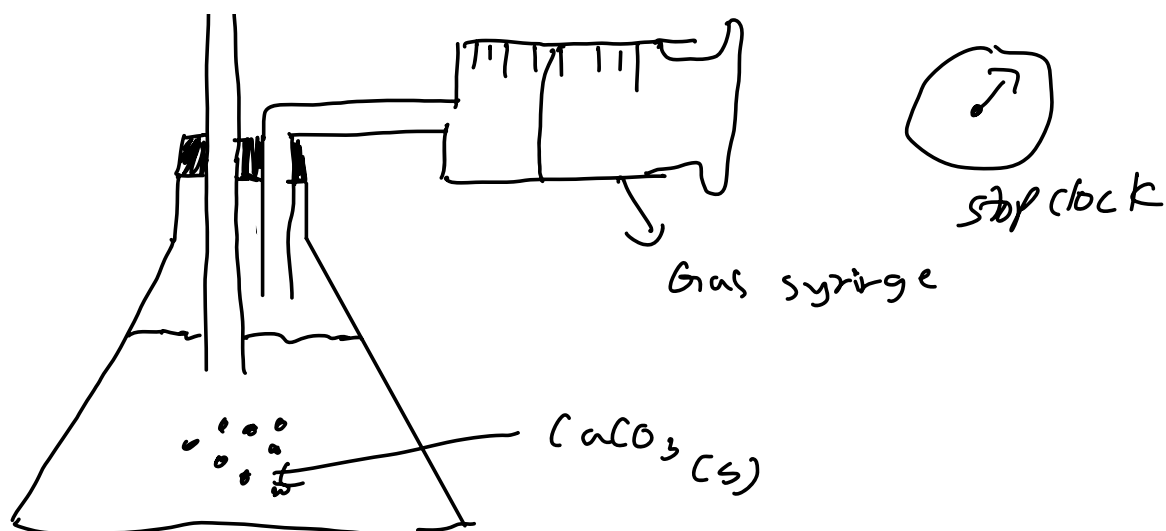


Experiment to determine the rate of a chemical reaction

Reaction: Example - 1

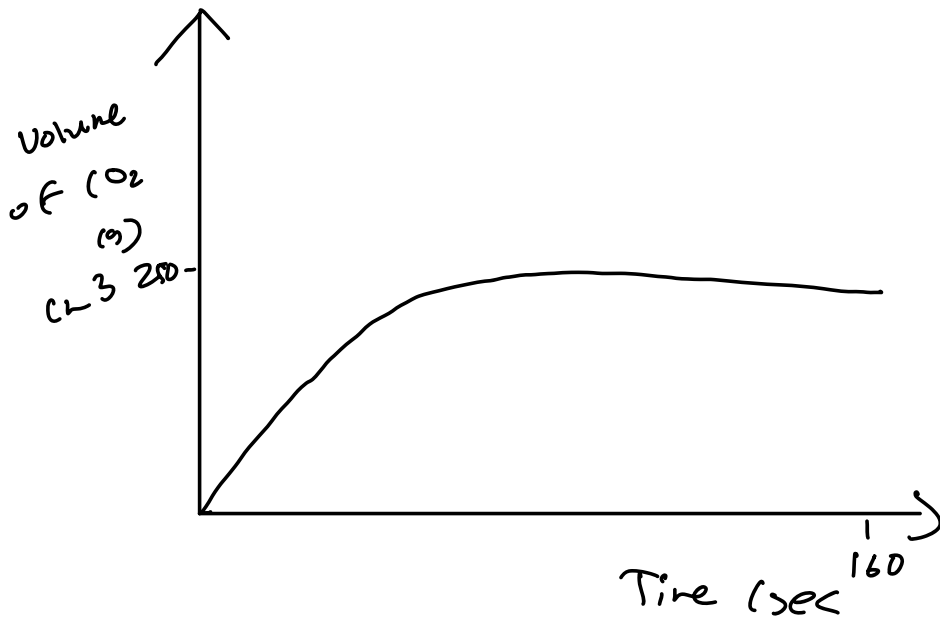




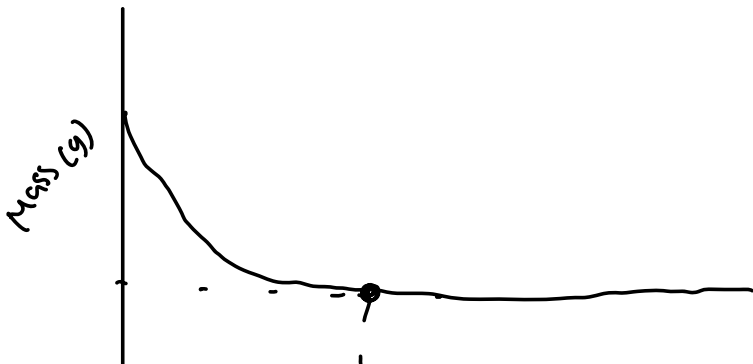
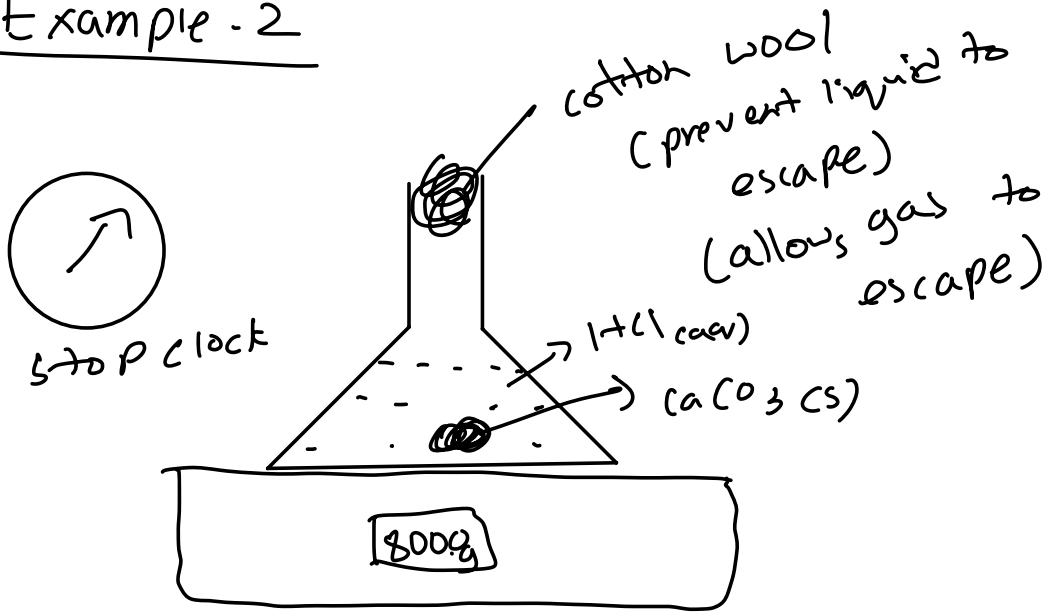


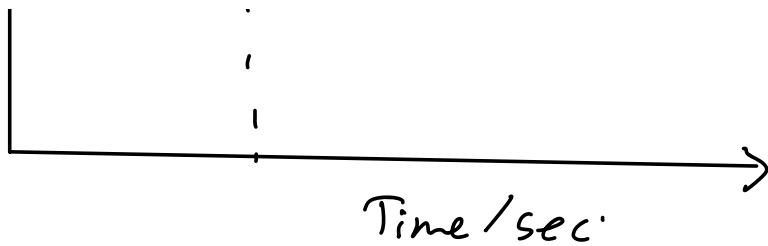
⊖ Measure the volume of gas after a period of time

Time /sec	Volume of $\text{CO}_2(\text{g})$
0.0	0.0
20.0	85.0
40.0	145.0
60.0	185.0
80.0	215.0
100.0	230.0
120.0	240.0
140.0	245.0
160.0	250.0
180.0	250.0



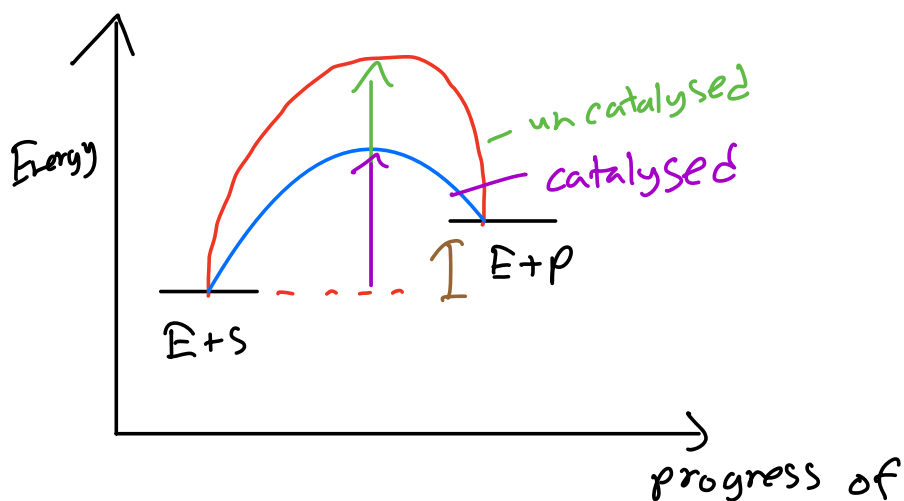
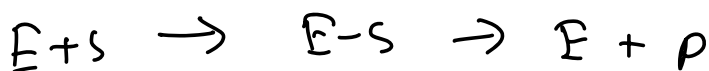
### Example - 2





## Enzyme

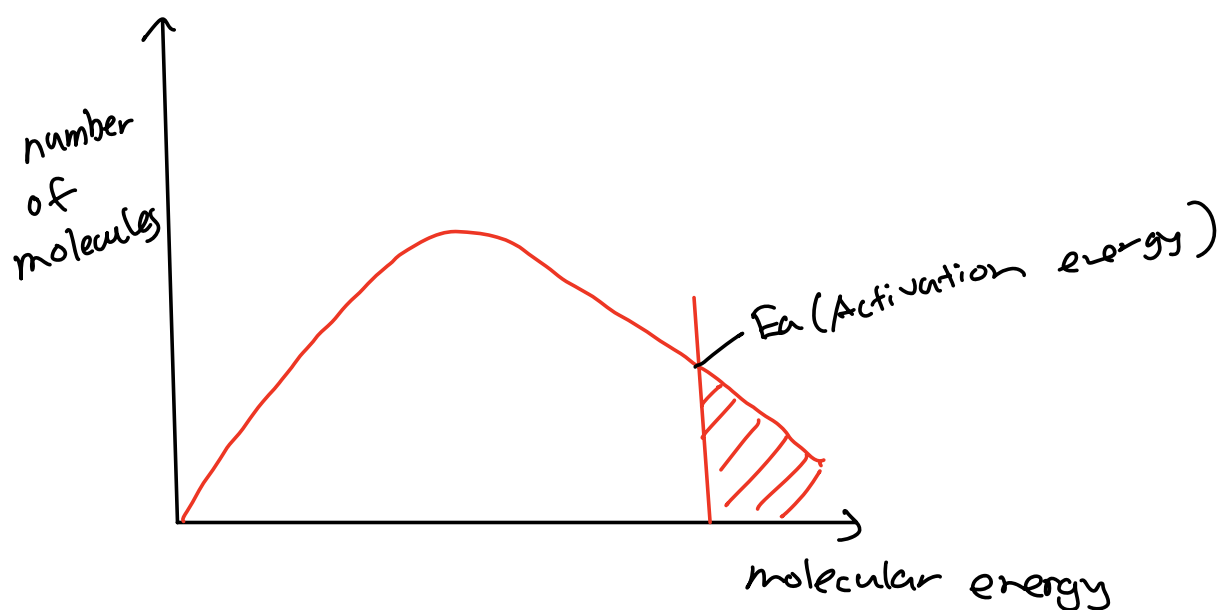
- ⊖ Enzyme is a biological catalyst.
- ⊖ Enzyme can speed up a biological reaction.
- ⊖ Specific for a particular reaction.
- ⊖ Reactants are called substrate.
- ⊖ Enzymes lower the activation energy.
- ⊖ After the reaction enzymes are reformed.
- ⊖ At higher temperature enzyme denatured and can not show catalytic property.



reacts

## Boltzmann distribution

The effect of temperature on rate of reaction

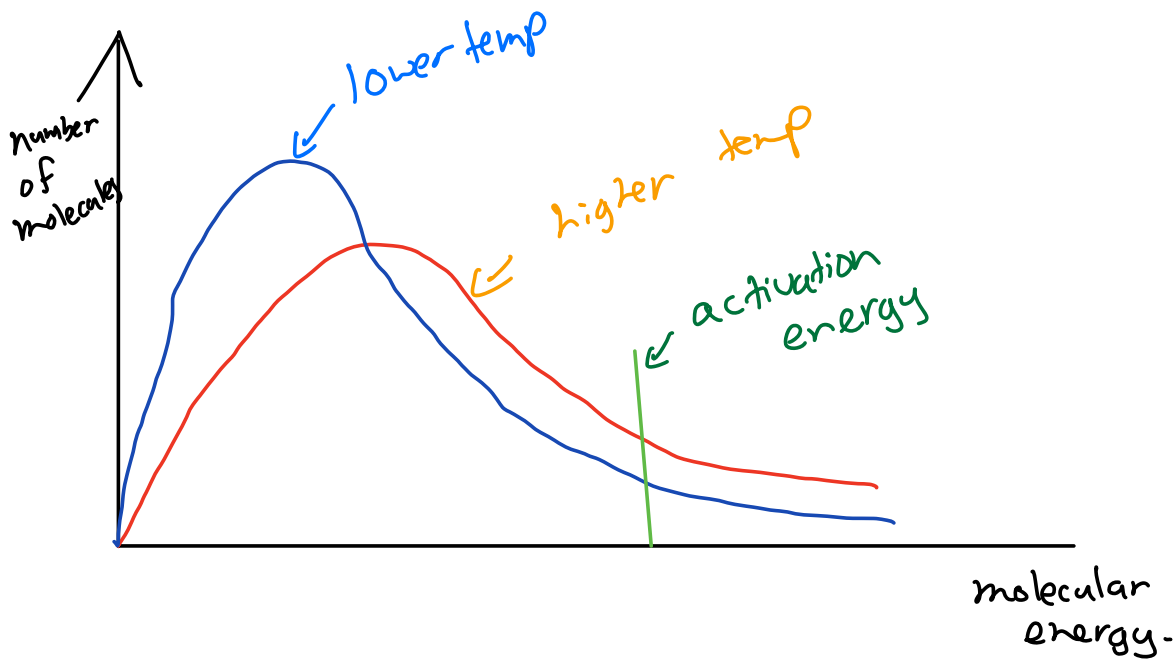


⊖ The shaded area shows the proportion of molecules in the sample that have enough energy to cause a chemical change when they collide.

Temperature increase

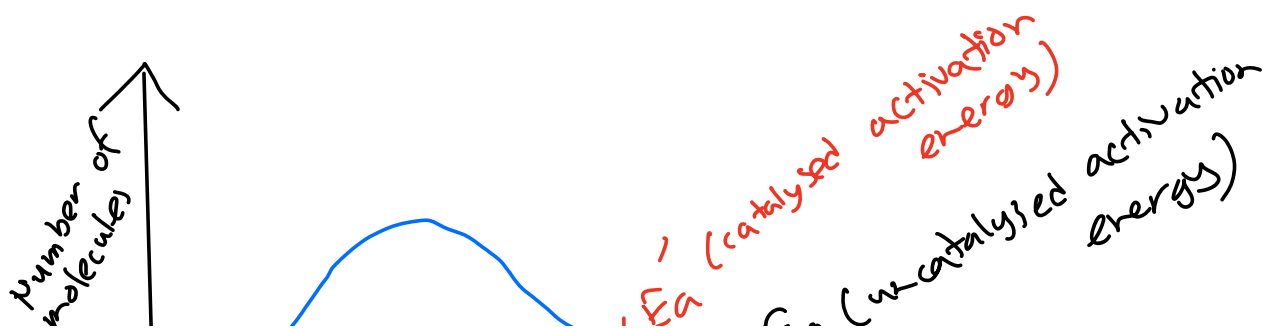
⊖ At higher temperature, more molecules have energy greater than the activation energy.

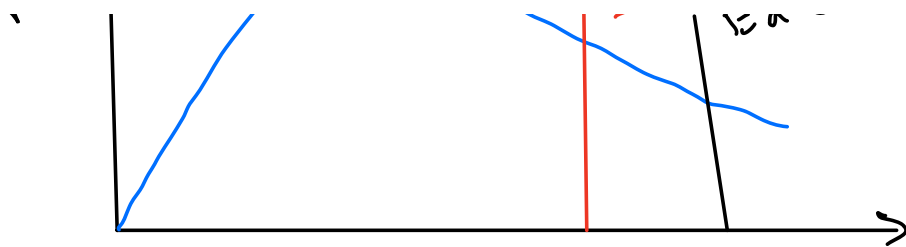
- ⊖ Height of the curve decreases.
- ⊖ Curve shifts from left to right
- ⊖ Position of activation energy can not change.



## Effect of catalyst

- ⊖ Shape of the curve cannot change.
- ⊖ Activation energy decreases.
- ⊖ More molecules have energy greater than the activation energy.





## Autocatalysis

- ⊖ During the autocatalysis, one of the products in a chemical reaction acts as a catalyst.
- ⊖ Initially concentration of the reactants decrease slowly.

## Example

Reaction of acidified  $\text{MnO}_4^-$  with ethanedioic acid ( $\text{HOOC-COOH}$ )

- ⊖ Initially reaction is very slow.
- ⊖ When  $\text{Mn}^{2+}$  ions are formed rate of reaction increases.
- ⊖  $\text{Mn}^{2+}$  ions acts as a catalyst to progress the reactions.

Reactions

