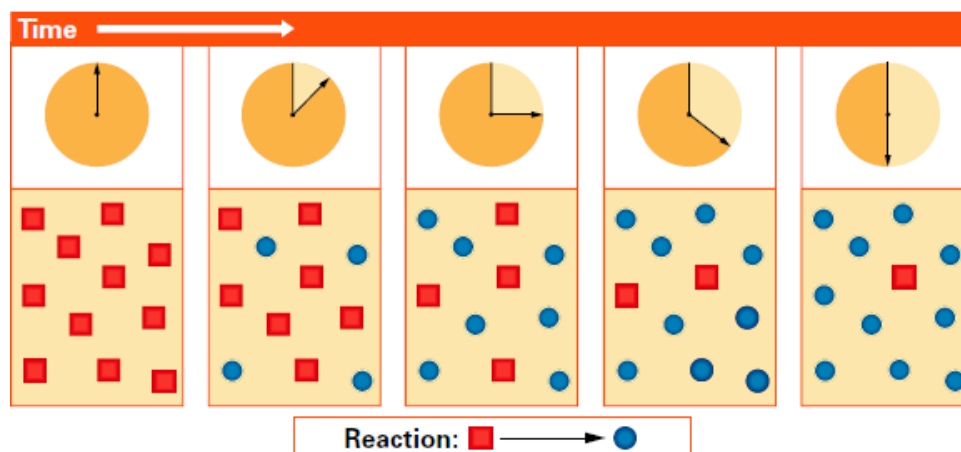# Collision-Reaction Theory

Main principles of the **collision-reaction theory** :
1. all chemical reactions involve collisions between atoms, ions or molecules
2. a certain amount of kinetic energy is required for a reaction to occur
3. a certain orientation of particles is required
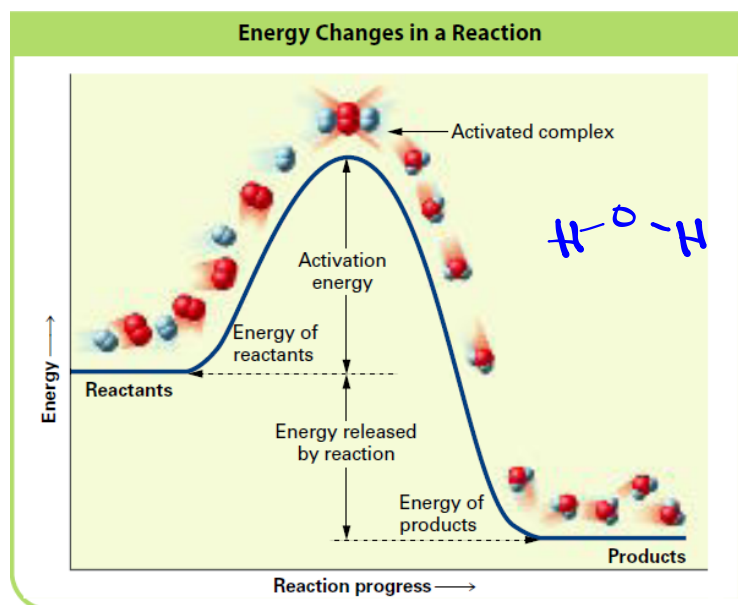
Rate of Reaction

Reaction Rate
Amount of reactant changing per unit time

Reaction: ■ ⟶ ●

Activation Energy
Minimum amount of energy that colliding particles must have in order to react

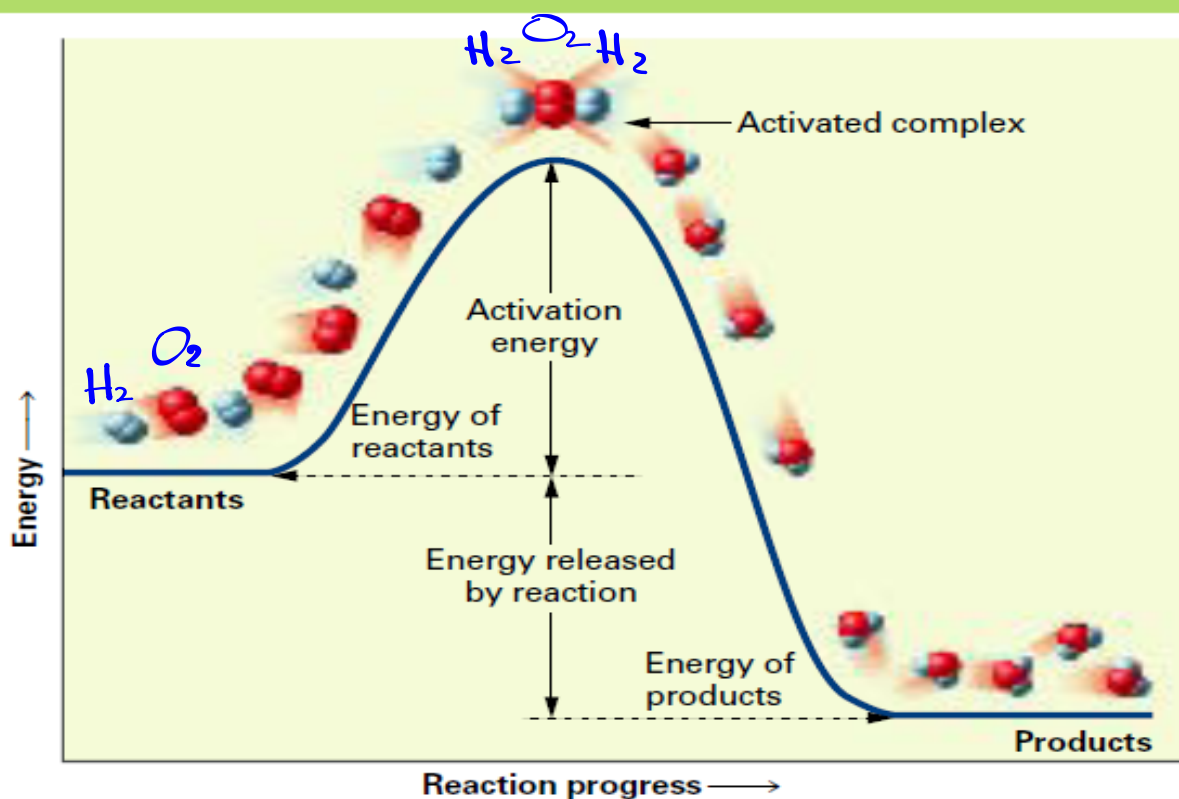## Activated Complex (Transition State)
Unstable arrangement of atoms that forms at the peak of the activation-energy barrier

$$2H_2 + O_2 \longrightarrow$$

Energy Changes in a Reaction

$$H_2 \overset{O_2}{-} H_2$$

Activated complex

Activation energy

Energy of reactants

O_2

H_2

Reactants

Energy released by reaction

Energy of products

Products

Energy ⟶

Reaction progress ⟶

http://www.youtube.com/watch?v=VbIaK6PLrRM

http://www.youtube.com/watch?v=rl50M-wNVcs

Factors Affecting Reaction Rates

Temperature
Raising the temperature speeds up the rate of reaction
● More collisions, and more particles with enough kinetic energy
to overcome activation energy barrier
Ex. burning of charcoal

Concentration
Increased concentration increases rate of reaction
● More particles, more collisions, higher rate of reaction
Ex. glowing splint in pure oxygen

Particle Size
Larger the particle, slower the rate of reaction
● Larger particle, less surface area, less reactant available for collision
Ex. Burning log in a fire

Catalyst
Lowers the activation energy for a reaction, increasing rate of reaction
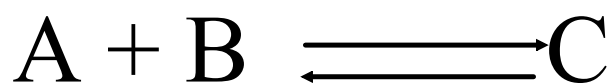● Not consumed in chemical reaction
Ex. Enzymes in digestive tract

Inhibitor - substance that interferes with the action of a catalyst,
often by reacting with the catalyst

Chemical Equilibrium

Reversible Reaction
Reaction in which both the forward and reverse processes are occuring simultaneously.

$$A + B \rightleftharpoons C$$

Chemical equilibrium
A system is said to have reached chemical equilibrium when the forward and reverse reactions are occuring at the same rate.

→ no net change occurs in the concentration of components of the system

Percent Reaction

Percent Reaction (percent yield) - is the amount of product measured at equilibrium compared with the maximum possible amount of product.

Equilibrium position
relative concentration of reactants and products at equilibrium
$\Rightarrow$ 0 % indicates no product formed
$\Rightarrow$ 100 % indicates the maximum possible product formed

- maximum amount of possible product is found using stoichiometry, assuming a forward reaction with no reverse reaction.

$(@ eqm)$

% reaction = Experimental yield
                       -------------------------   x 100 % $\longrightarrow$ Stoichiometry
              Theoretical yield (maximum)

Classifying Chemical Equilibria

< 50 % - reactants favored
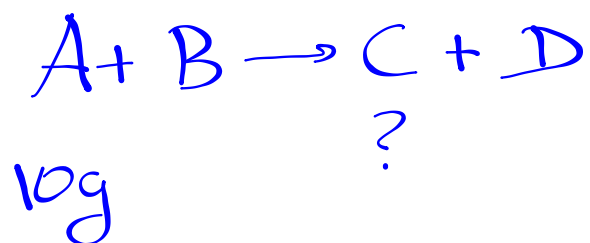**> 50 % - products favored**
> 99 % - quantitative

The equilibrium position of the reaction is indicated in the following manner :

$$78\%$$
$$\text{Ex. } H_{2(g)} + I_{2(g)} <==> 2HI_{(g)} \quad t = 448°$$
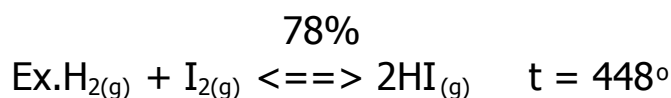
Indicates that 78 % of the total amount of HI possible is produced at 448°C. Therefore this is a **product** favored reaction.

<u>eqm.</u>

$$A + B \rightleftharpoons C + D$$
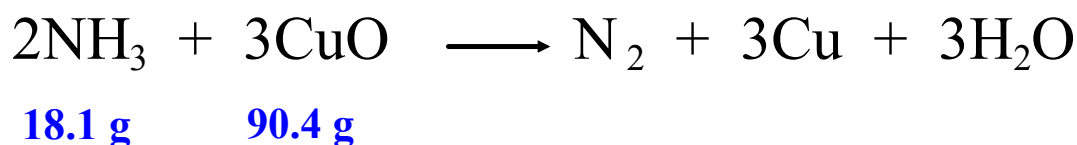
$$A + B \longrightarrow C + D$$
$$?$$
$$10g$$

1

Limiting Reagent

In a chemical reaction, the reactant that will "run out" first is called the **limiting reagent**.
The other reactant is called the **excess reagent**.

$$2NH_3 \ + \ 3CuO \ \longrightarrow \ N_2 \ + \ 3Cu \ + \ 3H_2O$$

18.1 g   **90.4 g**

IF NH_3 is L.R.

18.1g NH_3 × $\dfrac{1 \ mol \ NH_3}{17.04 \ g \ NH_3}$ × $\dfrac{1 \ mol \ N_2}{2 \ mol \ NH_3}$ × $\dfrac{28.02 \ g \ N_2}{1 \ mol \ N_2}$ = 14.86g N_2

IF CuO is L.R.

90.4g CuO × $\dfrac{1 \ mol \ CuO}{79.5 \ g \ CuO}$ × $\dfrac{1 \ mol \ N_2}{3 \ mol \ CuO}$ × $\dfrac{28.02 \ g \ N_2}{1 \ mol \ N_2}$ = 10.62g N_2

∴ CuO is L.R.

SAMPLE PROBLEM : % REACTION

Find the % reaction and write the expression if 6.90 g of $H_{2(g)}$ and 32.0 g of $O_{2(g)}$ react to form 25.75 g of ice at - 70 C°.

$$71.4\%$$

$$2H_{2(g)} + O_{2(g)} \rightleftharpoons 2H_2O_{(s)}$$

init.   6.90g   32.0g   ———

eqm.   25.75g
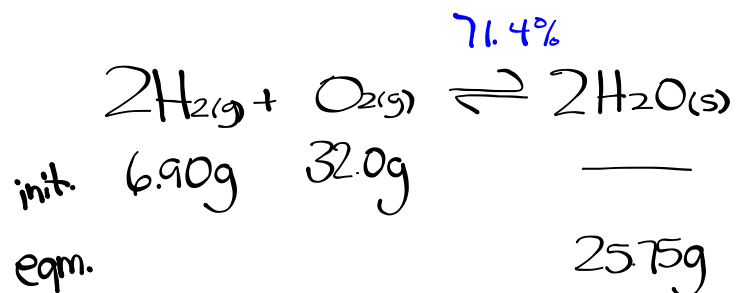
$$\% \, rxn = \frac{exp.}{theor.} \times 100\%$$

find L.R. :

If H_2 is L.R. ...

$$6.90g \, H_2 \times \frac{1 \, mol \, H_2}{2.02g \, H_2} \times \frac{2 \, mol \, H_2O}{2 \, mol \, H_2} \times \frac{18.02g \, H_2O}{1 \, mol \, H_2O} = 61.55g \, H_2O$$

If O_2 is L.R.

$$32.0g \, O_2 \times \frac{1 \, mol \, O_2}{32.00g \, O_2} \times \frac{2 \, mol \, H_2O}{1 \, mol \, O_2} \times \frac{18.02g \, H_2O}{1 \, mol \, H_2O} = \boxed{36.04g \, H_2O}$$

∴ O_2 is L.R.

$$\% \, rxn = \frac{exp.}{theor.} \times 100\%$$

$$\% \, rxn = \frac{25.75g}{36.04g} \times 100\%$$

$$\boxed{\% \, rxn = 71.4\%}$$