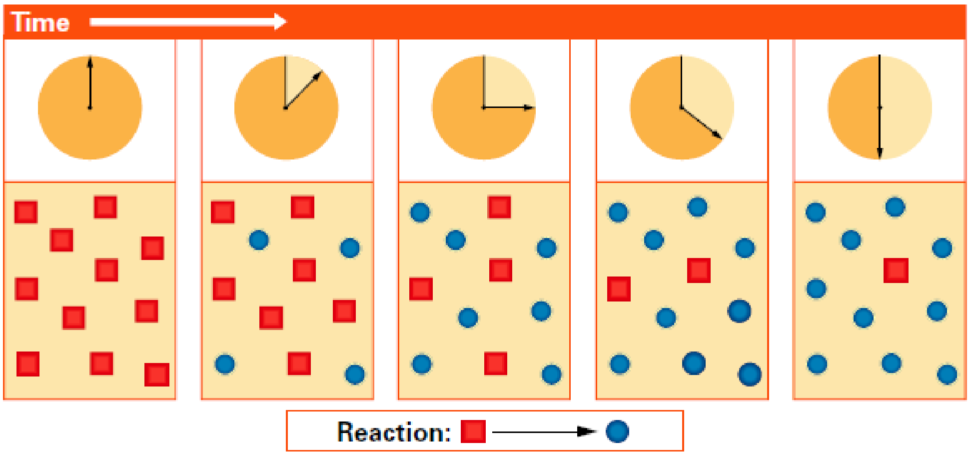
Collision-Reaction Theory

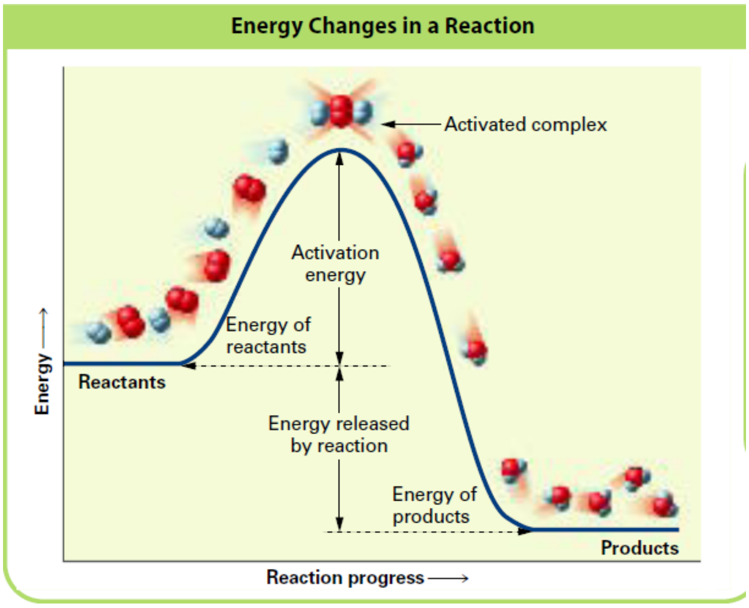
Main principles of the **collision-reaction theory** :
1. all chemical reactions involve collisions between atoms, ions or molecules
2. a certain amount of kinetic energy is required for a reaction to occur
3. a certain orientation of particles is required

Rate of Reaction

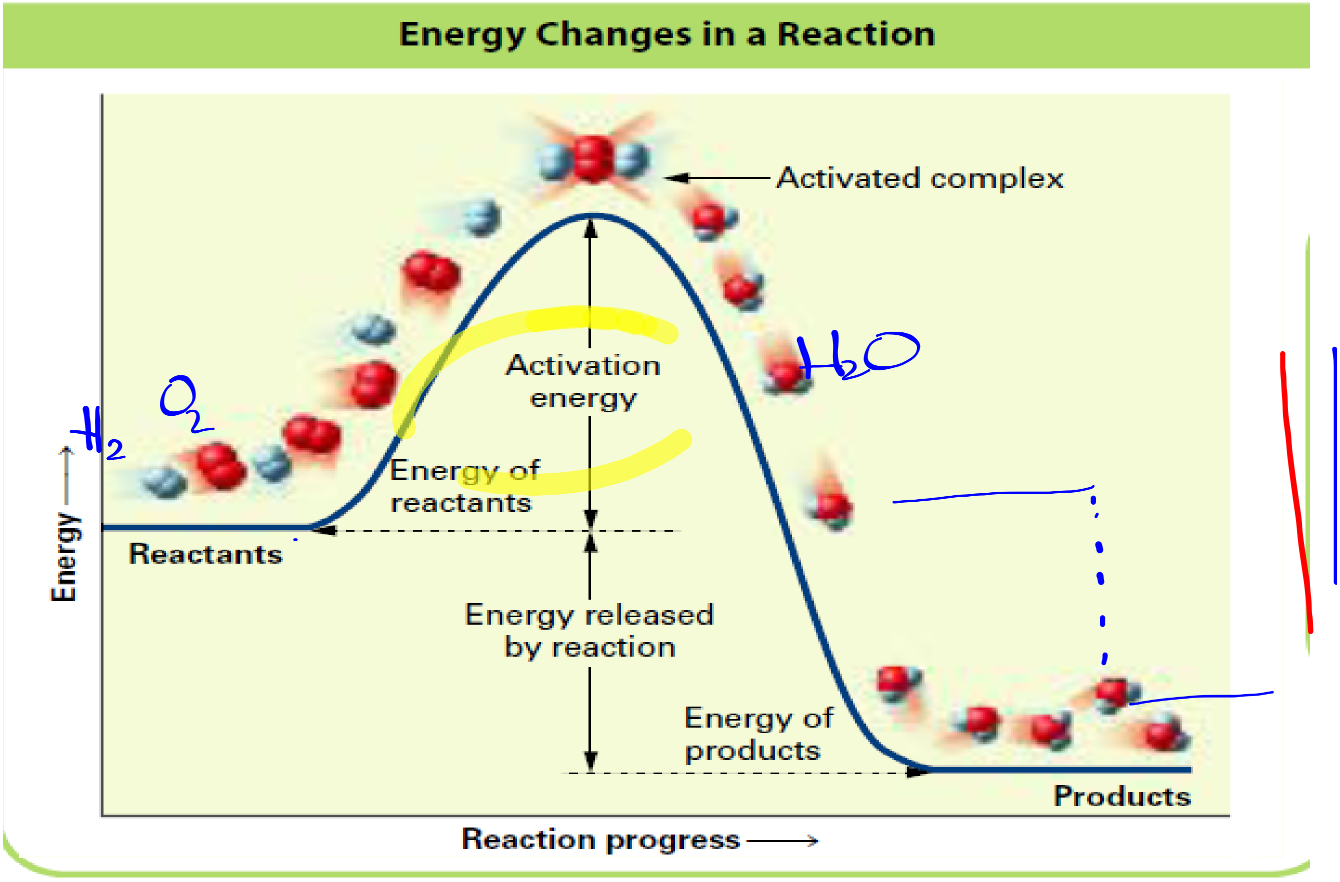
Reaction Rate
Amount of reactant changing per unit time



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

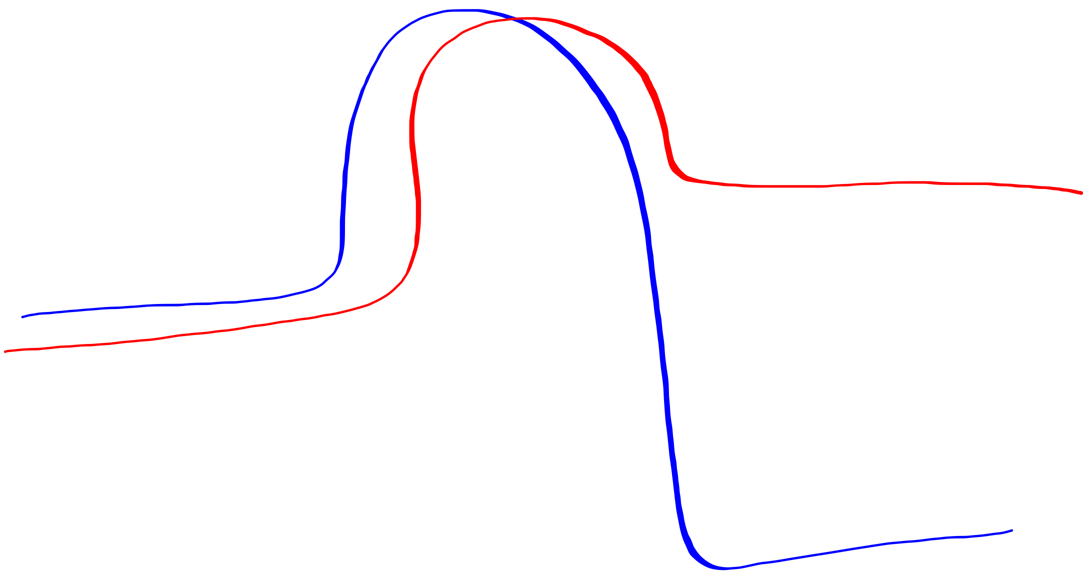


Activated Complex (Transition State)
Unstable arrangement of atoms that forms at the peak of the activation-energy barrier



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.

$\longrightarrow$ 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
⇒0 % indicates no product formed
⇒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.

$$\% \text{ reaction} = \frac{\text{Experimental yield}}{\text{Theoretical yield (maximum)}} \times 100\ \%$$

If forward only

Classifying Chemical Equilibria

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

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

$$\text{Ex.}H_{2(g)} + I_{2(g)} \overset{78\%}{<==>} 2HI_{(g)} \quad t = 448^{o}$$

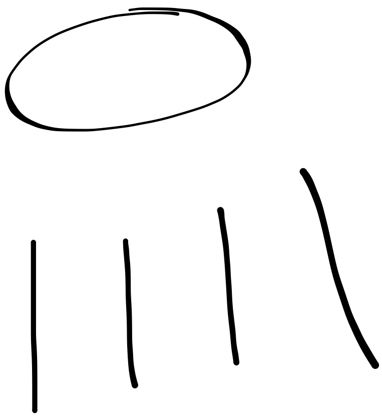
Indicates that 78 % of the total amount of HI possible is produced at 448°C. Therefore this is a **product** favored reaction.

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**



100

200

50

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^{o}.

$$\boxed{2H_{2(g)} + O_{2(g)} \overset{71.4\%}{\rightleftharpoons} 2H_2O_{(s)}}$$

init. 6.90g 32.0g —

eqm. 25.75g

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

Find max. product:

If H_2 is L.R.:

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

If O_2 is L.R.:

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

∴ O_2 is L.R.

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

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

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

% rxn = 99.6%

$$2H_{2(g)} + O_{2(g)} \overset{99.6\%}{\rightleftharpoons} 2H_2O_{(s)}$$

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