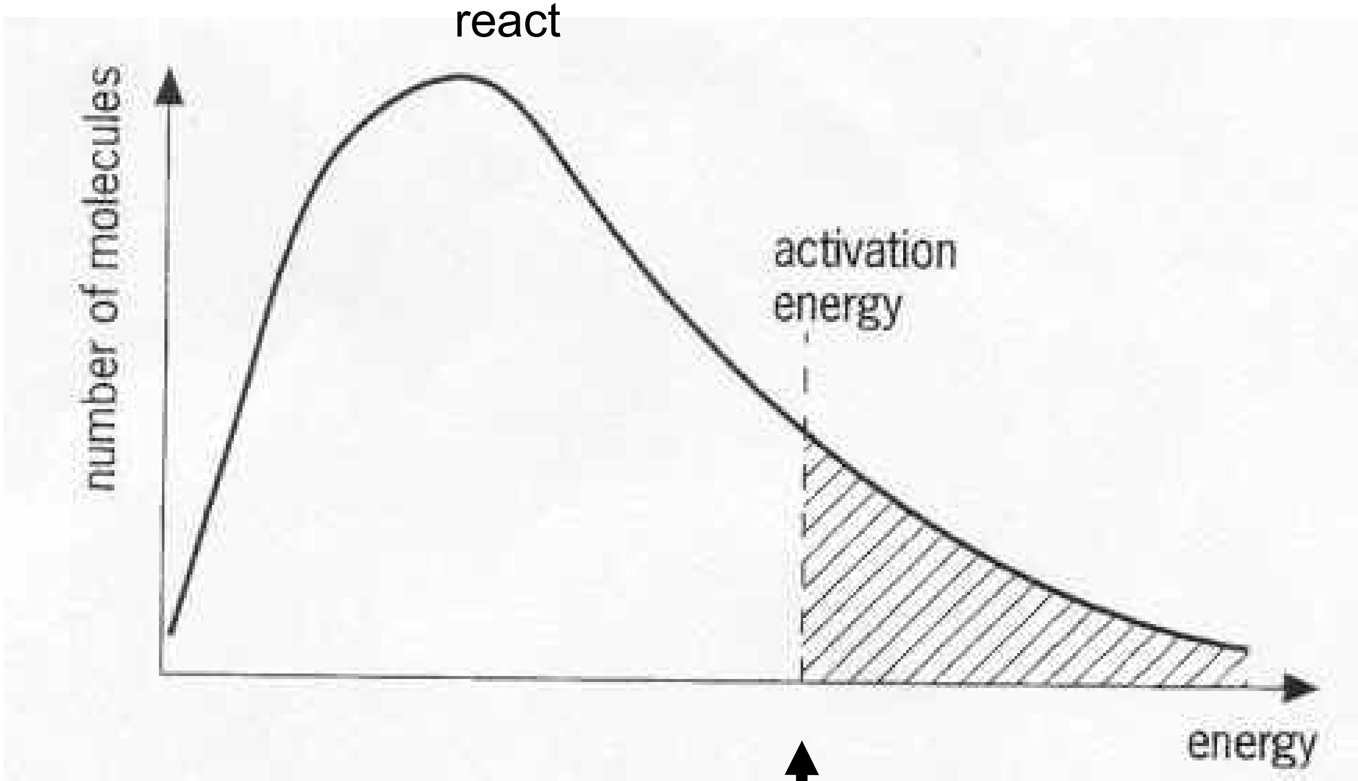
Collision Theory of Reaction Rates

- If you have two reactants, they can only react if they come into contact with each other
- i.e. if they collide
- Then, they **MAY** react
- Why May?
  - Collision alone is not enough
  - They must collide the right way
  - They must have enough energy for bonds to break

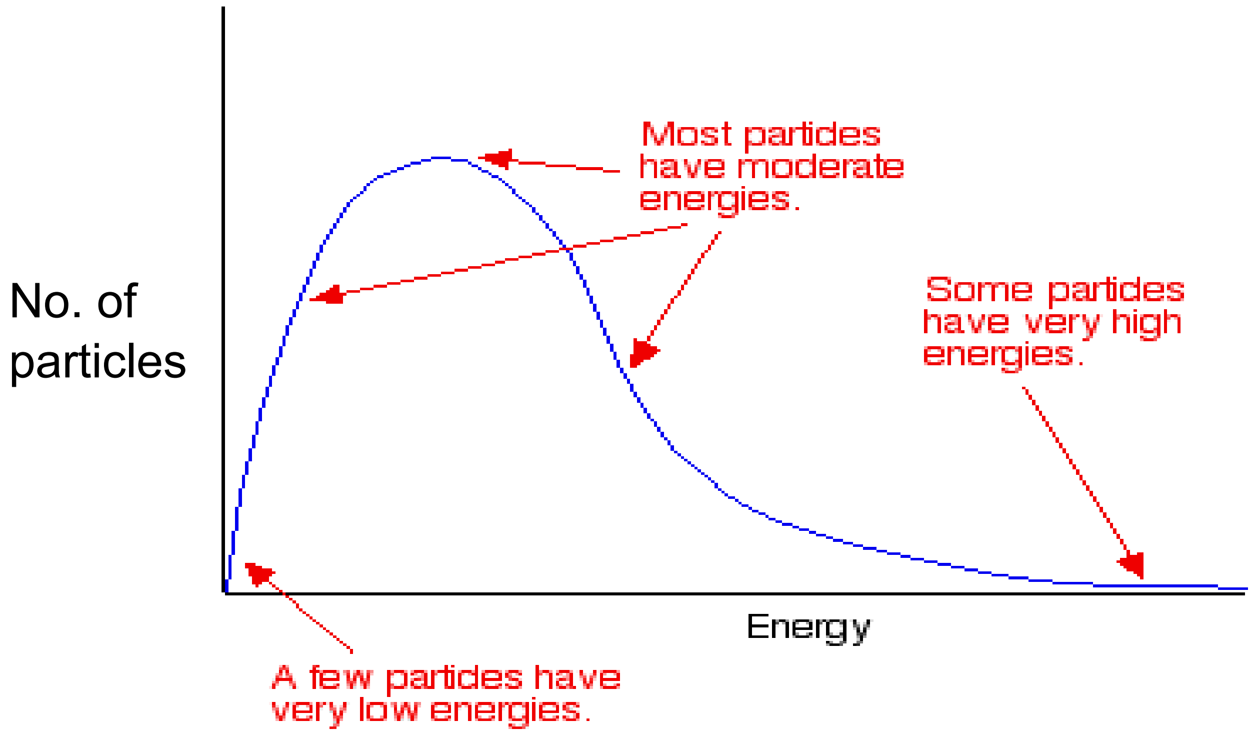
- When there are more than two reactants the chances for a reaction to occur are even smaller
- Even if the collision happens the right way:
  - The reaction will not happen unless the particles collide with a certain minimum energy – activation energy - E_A
- If the particles collide with less energy than EA, no reaction – they will just bounce

- Activation energy acts like a barrier that has to be crossed for a reaction to happen
- In any given system the particles present will have a wide range of energies
- This can be shown on a graph called Maxwell-Boltzmann Distribution
- This applies to only gases
- But conclusions from it can also be applied in reactions involving liquids

The number of particles represented by area under this curve don't have enough energy to react



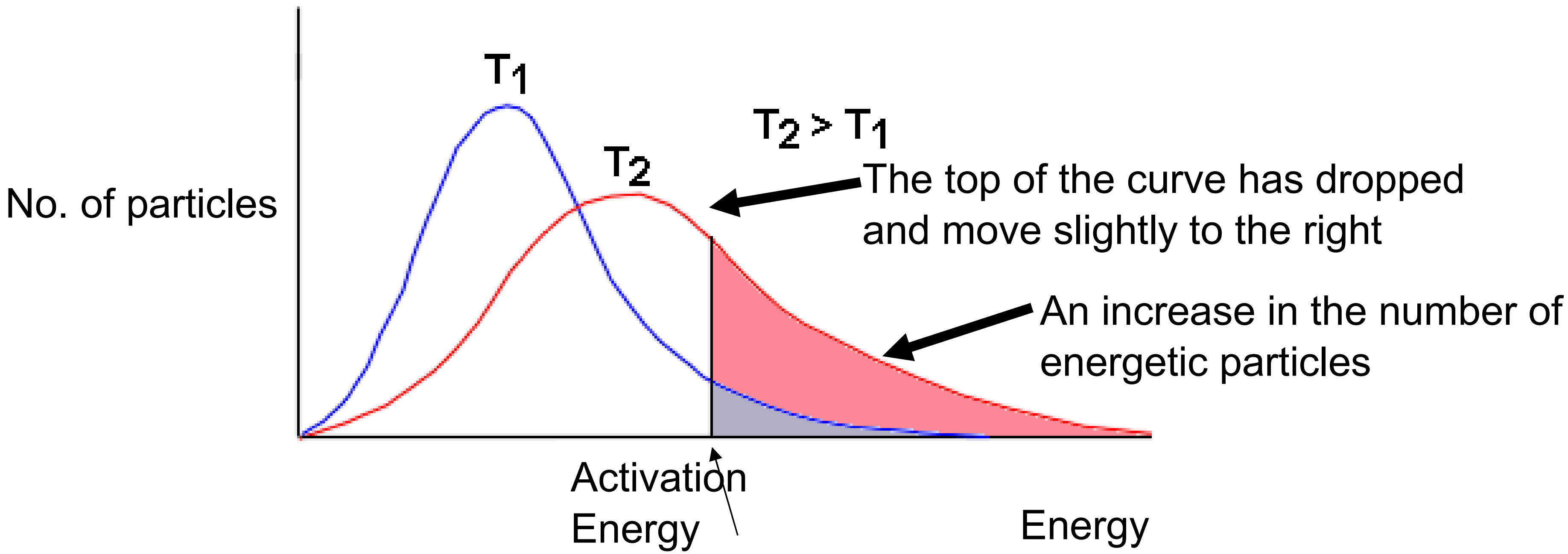
Activation
energy



- The large majority of the particles don't have enough energy to react when they collide

Effect of Temperature on Reaction Rate

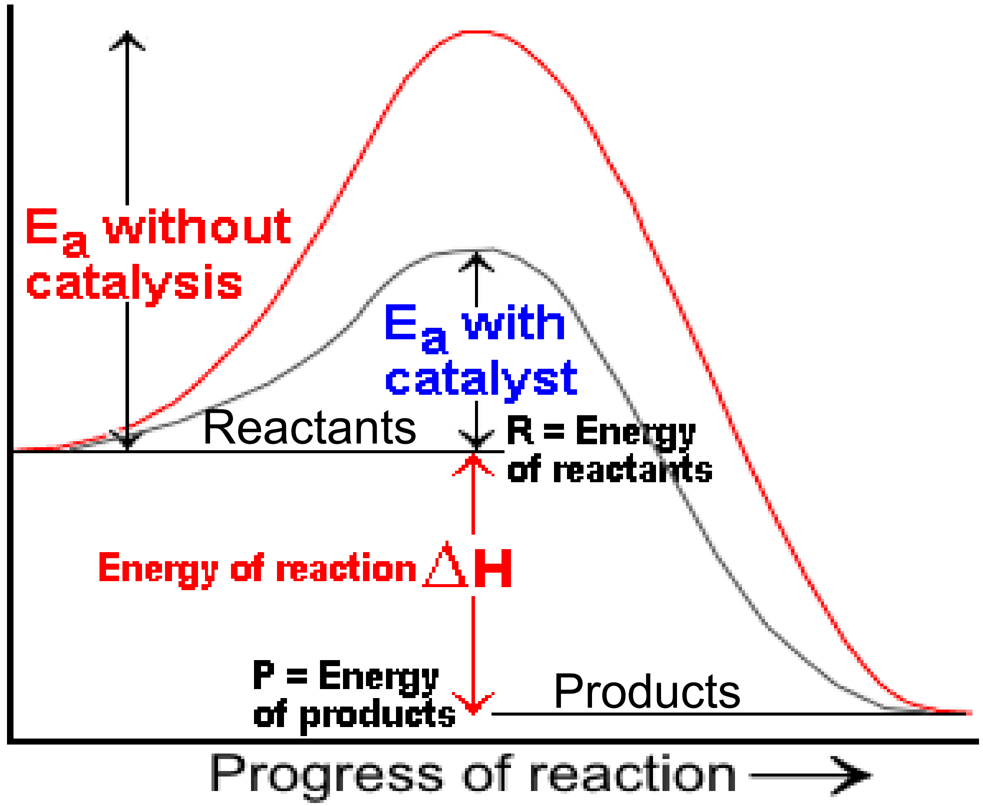
- Particles can only react when they collide
- If a system is heated the particles in the system will
  - Move faster
  - Collide more frequently
- And that will speed up the reaction
- When temperature is increased the number of particles with energy => E_A will increase



- Although the curve has not moved that much, there has been a large increase in the number of particles with energy equal to or greater than activation energy

Catalysts and Rate of Reaction

- A catalyst is a substance speeds up a reaction but is chemically unchanged
  - e.g. MnO2 catalyses decomposition of hydrogen peroxide – H_2O_2
- Remember in any given system only few particles have E_A
- The great majority don't have enough energy



A catalyst provides an alternative route for the reaction with a lower activation energy

A CATALYST DOES NOT LOWER THE ACTIVATION ENERGY OF THE REACTION

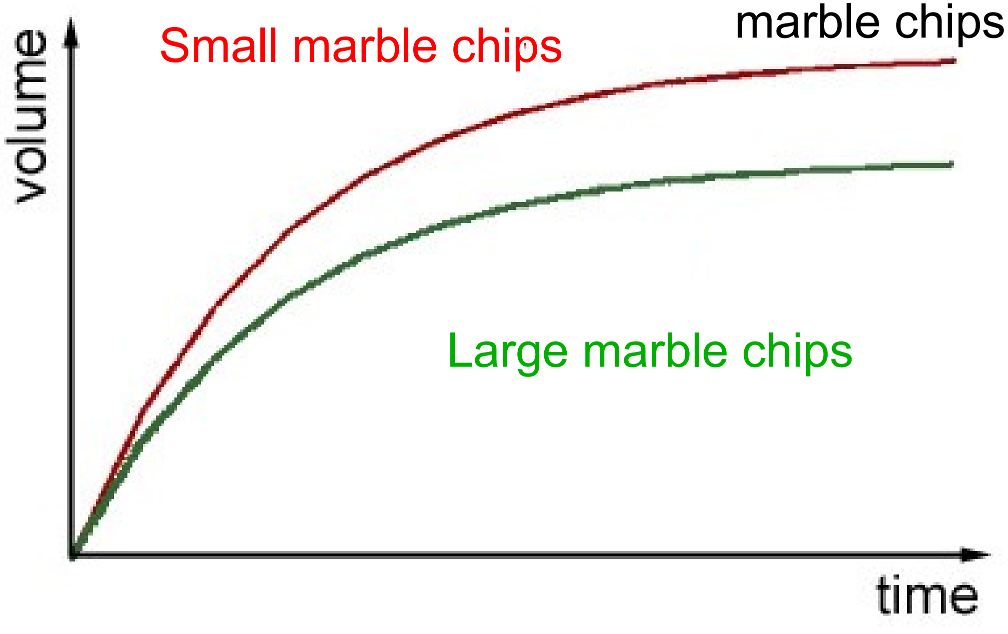
- A catalyst changes the rate of reaction
- Does not take part in the reaction
- Provides a convenient surface for the reaction to occur
- Particles gather on the catalyst surface
  - Collide more frequently
  - Resulting in more collisions giving a reaction because of the new route of reaction
  - e.g. H_2O_2 is bit stable at Room Temperature presence of catalyst cause it to decompose fast
  - The catalyst used is MnO_2

Surface Area on Reaction Rates

- Suppose we have a solid substance to react with a liquid substance
- The reaction can only happen when particles of the liquid collide with the surface of the solid
- The bigger the area of the solid surface the more particles can collide with it per second
- And the faster the reaction is
- Surface area of a solid can be increased by breaking into smaller pieces

- A powder has the largest surface area and will have the fastest reaction rate
  - e.g. $CaCO_3$ and HCl
  - $CaCO_3$ may be used in the form of marble chips
  - You could use large marble chips and compare them with smaller marble chips – but of the same mass

The reaction rate is faster (the slope is deeper) for the reaction with small marble chips (greater surface area)



The Effect of Concentration on Reaction Rates

- For many reactions – involving liquids or gases – increasing the concentration of reactants increases the rate of reaction
  - e.g. if you react zinc grannules with dilute Hcl the reaction is fairly slowly
  - If the acid is concentrated the reaction is much faster
- If the concentration is higher the chances of collision are greater

Both reactants in solution