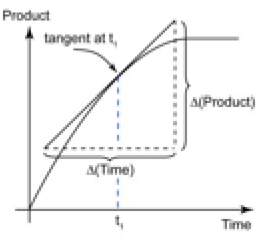
Rate of Reaction

The rate of reaction is the speed at which a chemical reaction is happening. This can vary hugely from reaction to reaction.

The rate of reaction can be calculated either by measuring the quantity of **reactant used or the quantity of product made in a certain length of time**. The quantity can either be a volume measured in cm^3 or a mass measure in grams (g).

Measuring Rate of Reaction -Higher Tier



The gradient of a volume or mass/time graph will give you the rate of reaction at a given point. However when the line is a curve you need to draw a **tangent** to measure the gradient. To draw a tangent follow the following steps

1. Line you ruler up across your graph, so that it touches the line on the point that you want to find out the gradient
2. Adjust the ruler until the space between the ruler and the curve is equal on both sides
3. Draw the line and pick two easy points that will allow you to calculate the gradient of the line.

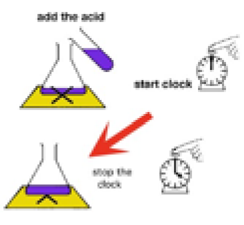
Key Terms	**Definitions**
Rate of Reaction	The rate at which reactants are being turned into products
Reactant	What is used in a chemical reaction
Product	What is made in a chemical reaction
Catalyst	A substance which speeds up a chemical reaction without being used up
Tangent	A straight line that touches a curve at a point

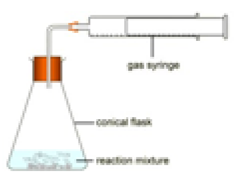
Equation	**Meanings of terms in equation**
Rate of Reaction= $\frac{Reactant\ used}{time}$	*Reactant used can eitherr be measured in grams or cm³*
Rate of Reaction= $\frac{Product\ Made}{time}$	*Reactant used can eitherr be measured in grams or cm³*

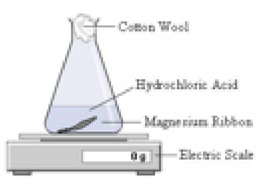
Measuring the Rate of Reaction

There are several experiments that can be used to measure the rate of a chemical reaction.

1. Measuring the mass lost in a chemical reaction (marble chips and acid is a good example)
2. Measuring the volume of gas produced (decomposition of hydrogen peroxide is a good example)
3. Time taken to make an X disappear (sodium thiosulphate and acid is a good example)

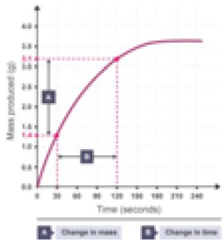






Calculating the Mean Rate of Reaction -Higher Tier

To calculate the mean rate of reaction from a graph you need to pick two y values on the graph and two x values, subtract the largest from the smallest and the divide the value on the y axis by the valued on the x axis.



Factors which affect Rate of Reaction

Being able to slow down and speed up chemical reactions is important in everyday life and in industry. We can change the rate of a reaction by:

- Changing temperature
- Changing pressure
- Changing the concentration of a solution
- Changing the surface area
- Adding a catalyst

Collision Theory

Collision Theory: reactions occur when particles **collide** with a certain amount of **energy**.

The minimum amount of energy needed for the particles to react is called the **activation energy**, which is different for each reaction.

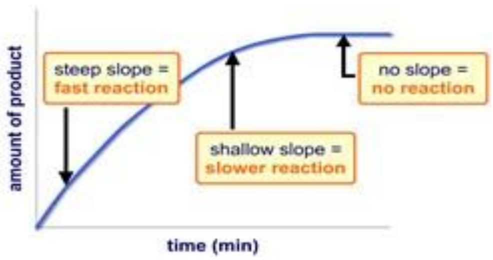
The rate of a reaction depends on two things:

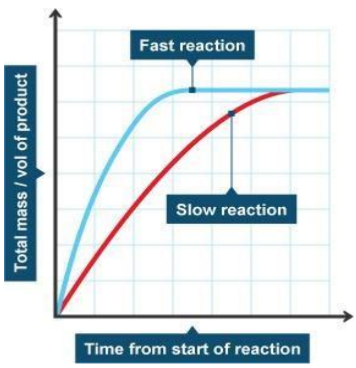
- the **frequency** of collisions between particles. The more often particles collide, the more likely they are to react.
- the **energy** with which particles collide. If particles collide with less energy than the activation energy, they will not react.

Interpreting Rate of Reaction Graphs

The results from rate of reaction experiments can be plotted on a line graph. For example how the mass changes against time or how much gas is made against time. Different lines can be plotted for different conditions, the **steeper the gradient, the faster the reaction.**

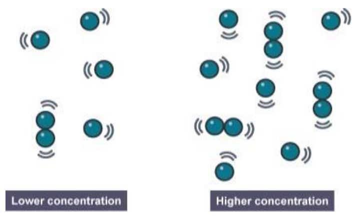
It is important to remember that the graphs flatten off (plateau) at the same point as the same amount of reactant is being used.





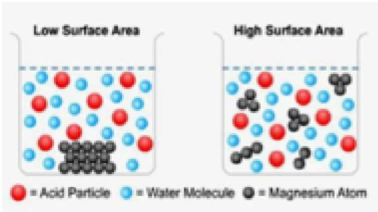
Collision Theory- in more detail Concentration

If the concentration of a solution is increased then there are more particles in a given volume, therefore collisions are **more frequent** and the chemical reaction is faster. Concentration **is directly proportional** to rate of reaction (if you double the concentration you double the rate).



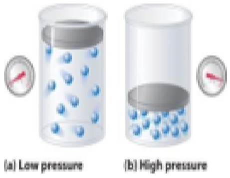
Collision Theory in more detail Surface Area

When you increase the surface area of a solid (you cannot increase the surface area of a liquid or gas). You increase the number of particles that are available for collision, therefore increasing the frequency of collisions therefore increase the rate of reaction.



Collision Theory in more detail gas pressure

If the reaction is carried out in the gaseous state, then increasing the pressure will increase the rate of reaction. If there are more particles in a given volume of gas, then collisions will be more frequent and therefore the reaction will be faster.



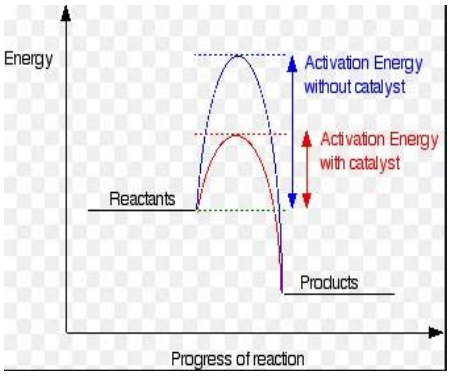
Collision Theory in more detail Temperature

When you increase the temperature of something the particles will move around faster, this increases the **frequency of the collisions.** As well as that, as the particles are moving faster the particles collide with more energy making it more likely that collisions exceed the **activation energy.**

Collision Theory in more detail Catalysts

A catalyst is a substance which speeds up a chemical reaction without being used up. It speeds up a reaction because it lowers the activation energy by providing an alternative pathway and this means that there are more successful collisions and a faster reaction.

The effect of a catalyst is shown on the reaction profile below:



Catalysts are not included in a chemical equation as they are not used up in a chemical reaction.

Key Terms	Definitions
Enzymes	A biological catalyst
Reaction Profile	A graph which show the energies of the reactants and products at different stages of the chemical reaction

Enzymes

Enzymes **are biological catalysts**, they speed up chemical reactions in biological systems for example in digestion in animals. Unlike catalysts enzymes have an optimum temperature where they work best, this is usually around 37 degrees Celsius.

Key Terms	Definitions
Equilibrium	A reaction that is reversible
Le Chatelier's principle	A principle which states, "If a system is at equilibrium and a change is made to any of the conditions, then the system responds to **counteract the change**"
Dynamic Equilibrium	An equilibrium where the forward and backward reactions are happening at the same rate

Key Terms	Definitions
Activation Energy	The minimum energy required for a chemical reaction to take place
Collision Theory	The theory that states for a chemical reaction to happen, particles must collide with sufficient energy
Gradient	The measurement of how steep a line is on a graph
Frequency	The amount of times something happens in one second
Concentration	The number of particles in a given volume

Equilibrium

Some chemical reactions are reversible, this means they can happen in both the **forward and reverse directions.** The symbol we use to represent an equilibrium reaction is shown in the equation below:

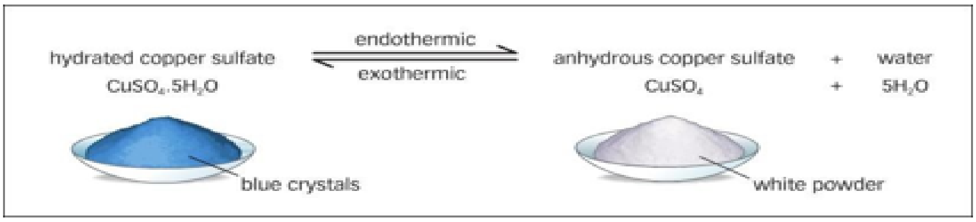
$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

In a dynamic equilibrium reaction, the forward and reverse reactions are happening at the **same rate.**

A dynamic equilibrium has to occur in a **closed system**, where no reactants and products are allowed to escape.

If the equilibrium lies to the left, it means that there is a **greater concentration of reactants than products**
If the equilibrium lies to the right it means there is a **greater concentration of products than reactants.**

Most equilibrium reactions are endothermic in one direction and exothermic in another direction. A good example is the hydration and dehydration of copper sulphate. It is exothermic when water is added to the copper sulphate, it is endothermic when water is removed.



Changing Conditions-Le Chatelier's principle- Higher Tier

The Haber process is a good example to explain Le Chatelier's principle, the equation for the Haber process is shown below. The reaction is carried out in the gaseous state. Remember this is one of many reactions but the principles always stay the same.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

Endothermic in this direction

Exothermic in this direction

Condition Change	Effect
Increase the temperature	Shifts the equilibrium to the left as this is the endothermic direction. The amount of reactants increases.
Decrease the temperature	Shifts the equilibrium to the right as this is the exothermic direction. The amount of product increases
Increase the concentration of reactants	Equilibrium shifts to the right to make more product, to reach equilibrium again
Increase the concentration of products	Equilibrium shifts to the left to reach equilibrium again
Increase the pressure in the gas	Equilibrium shifts to the right, where there are fewer molecules of gas, this will decrease the pressure.
Decrease the pressure in the gas	Shifts the equilibrium to the left as there are more gas molecules on that side of the equation.