Rates of Reaction

Collision Theory:

Magnesium and dilute hydrochloric acid react together like this:

magnesium + hydrochloric acid ⟶ magnesium chloride + hydrogen

$Mg\ (s) + 2HCl\ (aq) \longrightarrow MgCl_2\ (aq) + H_2\ (g)$

In order for the magnesium and acid particles to react together:

- **the particles must collide with each other, and**
- **the collision must have enough energy to be successful. In other words, enough energy to break bonds to allow reaction to occur.**

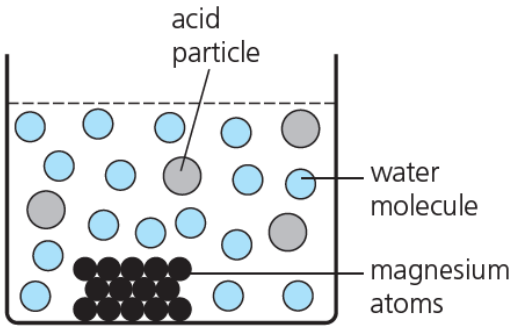
This is called the **collision theory**.

The rate of a reaction depends on how many successful collisions there are in a given unit of time.

Changing the Rates of Reaction:

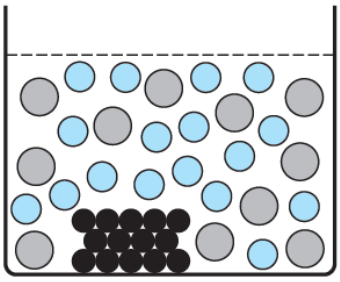
a) Rate increases with concentration.
If the concentration of the acid is increased, the reaction goes faster.
Ex:

In dilute Acid:



In dilute acid, there are not so many acid particles. So there is less chance of an acid particle hitting a magnesium atom.

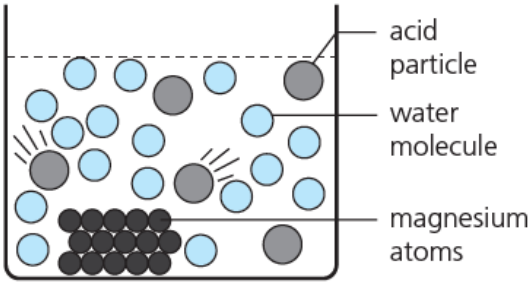
In Concentrated Acid:



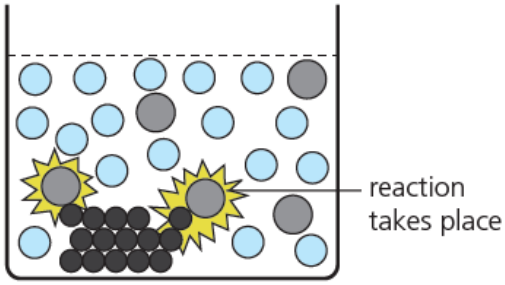
Here the acid is more concentrated – there are more acid particles. So there is now more chance of a successful collision.

The more successful collisions there are, the faster the reaction.

b) Rate increases with temperature.
On heating, *all* the particles take in heat energy.



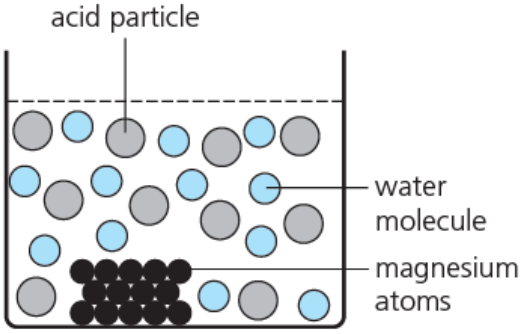
This makes the acid particles move faster – so they collide more often with magnesium particles.



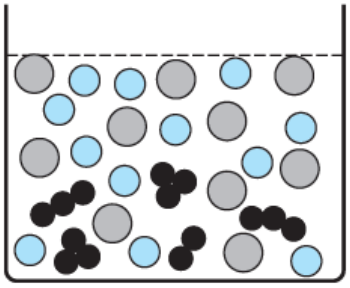
The extra energy also means that more collisions are successful. So the reaction rate increases.

c) Rate increases with surface area.

The reaction between the magnesium and acid is much faster when the metal is powdered.



The acid particles can collide only with the magnesium atoms in the outer layer of the metal ribbon.



In the powdered metal, many more atoms are exposed. So the chance of a collision increases.

d) Catalyst.

A catalyst is a substance that speeds up a chemical reaction, but remains chemically unchanged itself.

Ex: Decomposition of hydrogen peroxide.

Hydrogen peroxide is a colourless liquid that breaks down very slowly to water and oxygen:

$$\text{hydrogen peroxide} \longrightarrow \text{water} + \text{oxygen}$$
$$2H_2O_2\,(l) \longrightarrow 2H_2O\,(l) + O_2\,(g)$$

Decomposition of hydrogen peroxide can be increased 1000 times faster by adding Manganese (IV) oxide catalyst.

Uses of catalysts in chemical industry:

In industry, many reactions need heat. Fuel can be a very big expense.

With a catalyst, a reaction goes faster at a given temperature. So you get the product faster, saving time. Even better, it may go fast enough *at a lower temperature* – which means a lower fuel bill.

So catalysts are very important in the chemical industry. They are often **transition elements** or their **oxides**. Two examples are:

- **iron** used in the manufacture of ammonia
- **vanadium(IV) oxide** used in the manufacture of sulfuric acid.

Biological Catalysts (Enzymes):

Enzymes are proteins made by cells, to act as biological catalysts.

For example some bacteria make enzymes that catalyse the breakdown of fat, starch, and proteins.