

# Acids, Bases and Reaction Rate

## Chemical Reactions

A chemical reaction is a process that produces a chemical change to one or more substances.

A chemical reaction will produce a new substance. Other observations of a chemical reaction may include a temperature change, a colour change or production of gas.

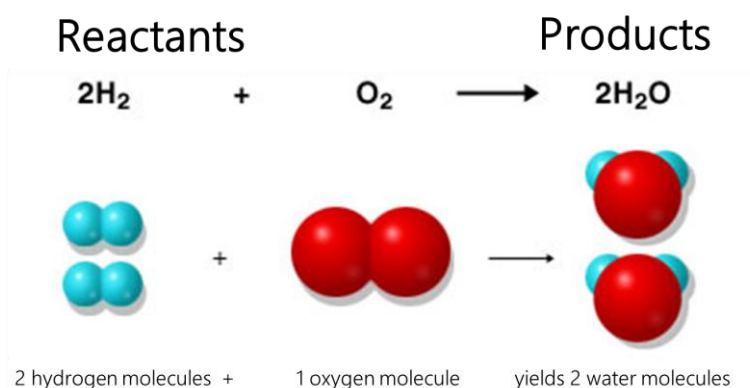


Reactants:  $\text{Zn} + \text{I}_2$   $\longrightarrow$  Product:  $\text{Zn I}_2$

The original substances that you start with, in a chemical reaction are known as reactants. Those that are formed are known as products. It is important to note that no matter is created or destroyed during a chemical reaction, but rather rearranged to form new substances.

Reactants join to form new products during chemical reactions

The atoms present in the reactants rearrange themselves in different combinations and form new bonds. The new combinations of atoms are called products and can either be single atoms or molecules.



## Chemical reactions –equations

When we convert descriptions of reactions into word equations there is a set way of writing it. A word equation can also be written as a formula equation.

The word equation therefore will be:

Reactants  
on the left

Products on  
the right

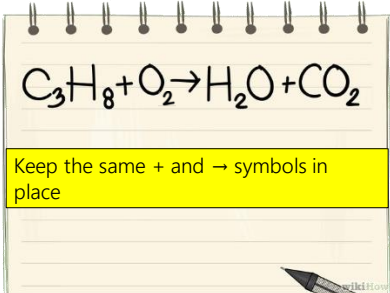
Propane + oxygen  $\rightarrow$  water + carbon dioxide

Add  
chemicals  
with a +

Show reactants turning  
into products with a  $\rightarrow$

The word equation is:

Propane + oxygen  $\rightarrow$  water + carbon dioxide



Keep the same + and  $\rightarrow$  symbols in place

Once you can write word equations practice by writing the formula underneath

You are expected to know the formula for simple compounds

water –  $\text{H}_2\text{O}$

Carbon dioxide –  $\text{CO}_2$

Oxygen gas –  $\text{O}_2$

Hydrogen gas –  $\text{H}_2$

You will also need to remember formula for common acids and bases (given later in the unit)

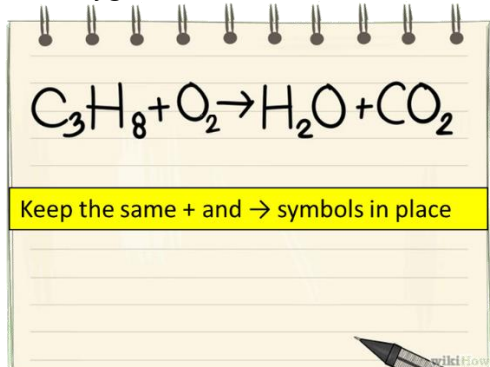
You will need to use ion charts to write the formula for compounds made of ions.

## Writing and Balancing symbol equations (Extension)

In a chemical equation the total number of atoms in the reactants must equal the total number of atoms in the products as no atoms are created or destroyed just rearranged with new bonds formed or bonds broken

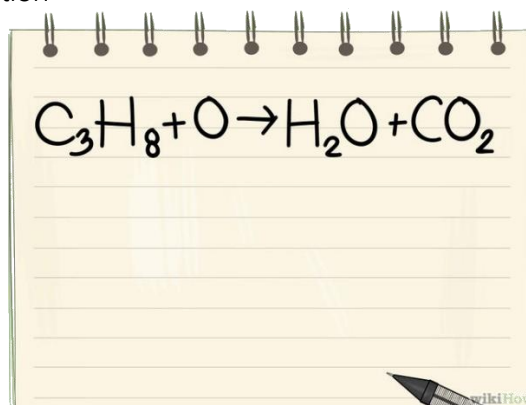
1. The word equation is:

Propane + oxygen → water + carbon dioxide



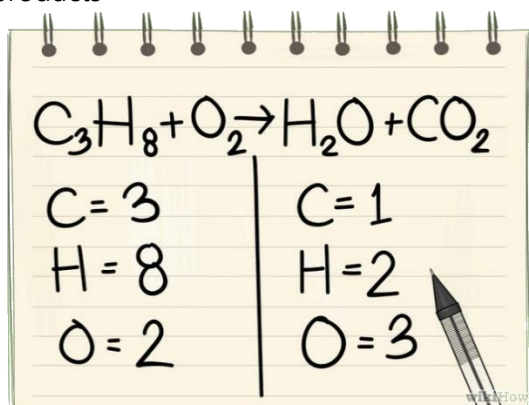
Once you can write word equations practice by writing the formula underneath

2. To balance an equation first write down the equation

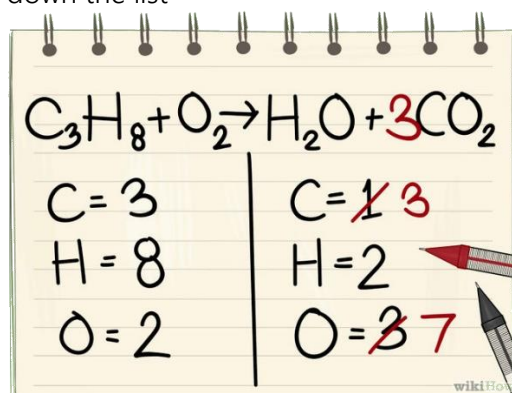


The total number of each type of atom must be the same for reactants and products if the equation is balanced

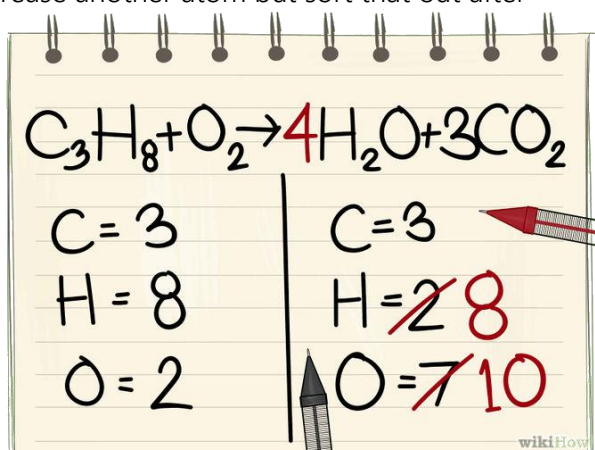
3. Count the total number of each atom for reactants and products



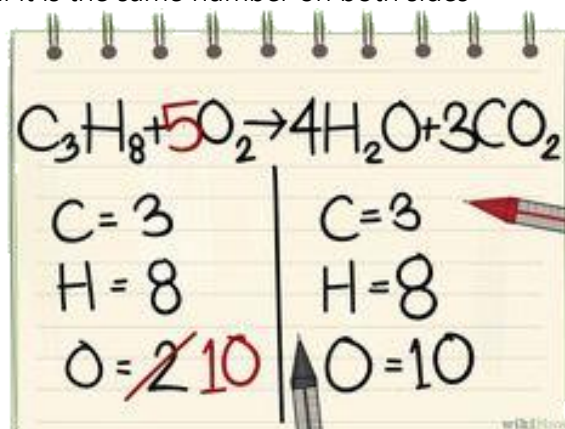
4. Starting with the first atom (C) multiply until it is the same on both sides – and place this number in front of the compound. You may change the number of another atom but you can sort this as you move down the list



5. Moving down the list to the next atom (H) multiply until both sides are the same – again you may also increase another atom but sort that out after



6. Moving to the last atom on this list (O) multiply until it is the same number on both sides

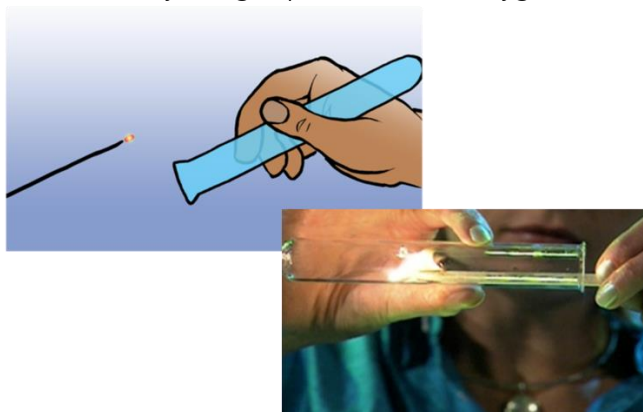


If all atoms are the same number on both sides then the equation is balanced!

## Testing for Oxygen gas

### How to test for Oxygen Gas

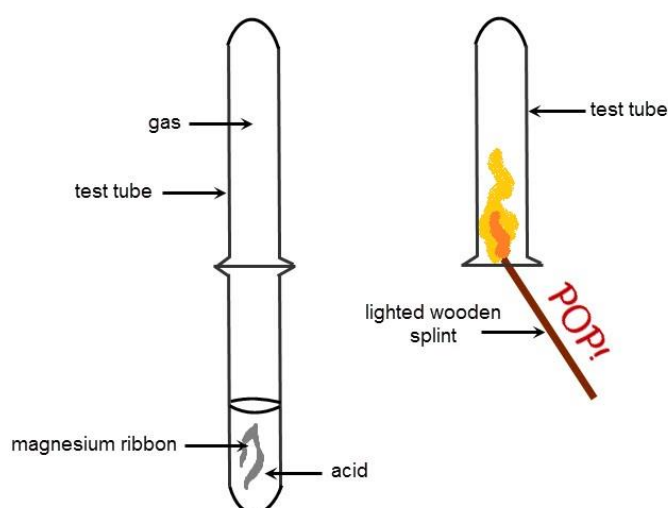
1. Put a small amount of Manganese dioxide into a boiling tube and add hydrogen peroxide.  
BE CAREFUL WITH THESE CHEMICALS and ALWAYS FOLLOW LAB SAFETY RULES
2. Put a bung with a delivery tube over the boiling tube and put the delivery tube into an upside down test tube to collect any gas.
3. Heat the tube gently with a Bunsen burner.
4. Remove delivery tube and place thumb over test tube.
5. Remove thumb quickly and place a glowing splint into the test tube.
6. If the splint re-ignites then it is likely the gas produced was oxygen.



## Testing for Hydrogen gas

### How to test for Hydrogen Gas

1. Put a small piece of magnesium metal into a test tube with a small amount of dilute hydrochloric acid.
2. Place another test tube upside down over top of the first test tube
3. Collect the gas in the upside down test-tube.
4. Place thumb over top of the test tube
5. Hold a lit match at the mouth of the test tube and remove thumb quickly
6. If the gas makes a loud 'pop' then it is likely that the gas produced is hydrogen.

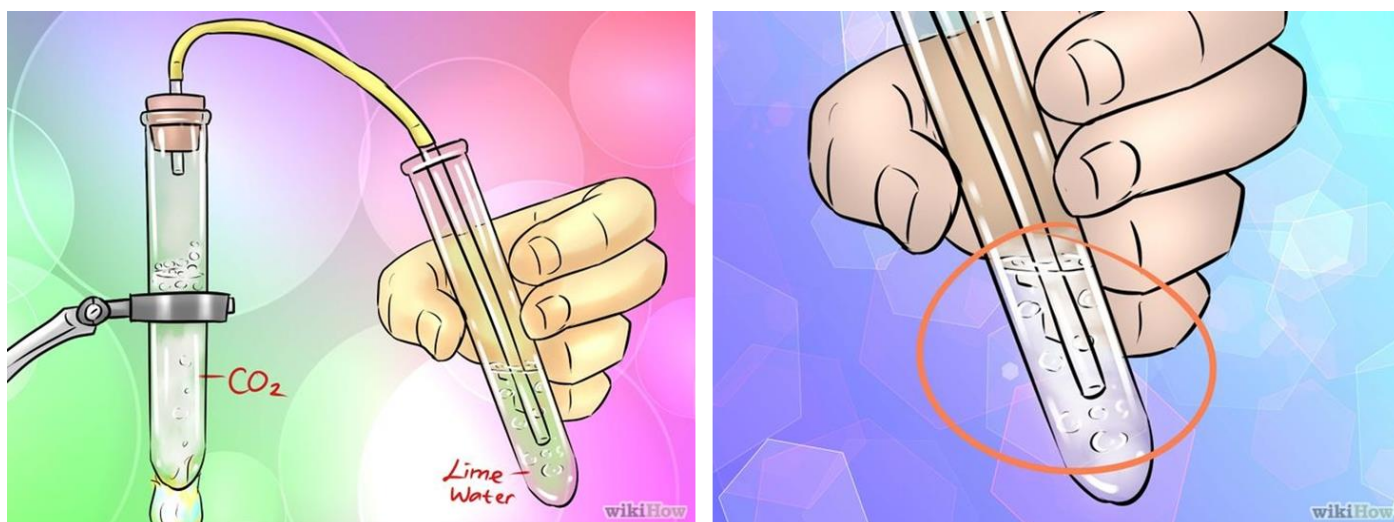


## Testing for Carbon Dioxide gas

### How to test for Carbon Dioxide Gas

1. Put a small amount of calcium carbonate with dilute hydrochloric acid into a boiling tube.
2. Put a bung with a delivery tube over the boiling tube.

3. Place the delivery tube into a test-tube filled with clear limewater
4. Observe the gas bubbling into the limewater.
5. If the limewater turns cloudy then it is likely that the gas produced is carbon dioxide.



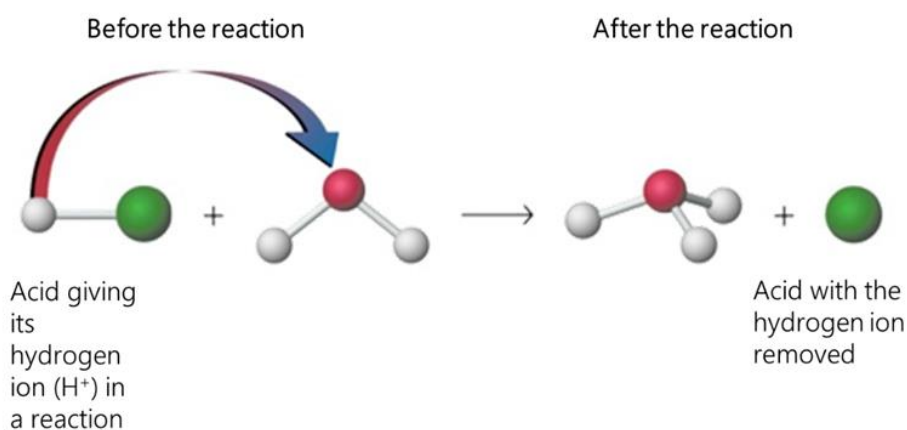
Carbon Dioxide is a colourless gas and limewater is a solution of calcium hydroxide in water, which is also colourless. The carbon dioxide gas reacts with the limewater and changes it into calcium carbonate which is not soluble (cannot dissolve) in water and appears as a milky white colour.

#### Acids – their characteristics

Acids are a family of substances which all show acidic characteristics or properties. These properties relate to how the acids react with other chemicals. They have a sour taste and react with metals. Acids can be found in nature and called organic acids or manufactured in the laboratory and called mineral acids.

Name	Chemical formula
Hydrochloric Acid	HCl
Sulfuric Acid	H <sub>2</sub> SO <sub>4</sub>
Nitric Acid	HNO <sub>3</sub>

All acids contain hydrogen. When an acid reacts it gives away its Hydrogen ion (H<sup>+</sup>), which is really just a proton, and the electron remains behind.



## Bases – their characteristics

Bases are a family of Chemicals that have hydroxide ions present ( $\text{OH}^-$ ). They have opposite properties from acids. Common Household bases include floor clearers and antacid tablets to fix indigestion. A Base that dissolve into water is called an alkali.

Name	Chemical formula
Sodium Hydroxide	$\text{NaOH}$
Calcium carbonate	$\text{CaCO}_3$
Ammonia	$\text{NH}_3$
Potassium hydroxide	$\text{KOH}$

Bases include metal oxides ( $\text{MO}$ ), metal hydroxides ( $\text{MOH}$ ), metal carbonates ( $\text{MCO}_3$ ) and metal hydrogen carbonates ( $\text{MHCO}_3$ ) with  $\text{M}$  = metal

Indicators determine whether substances are acid, base or neutral.

Indicators can be used to determine the pH of a solution by the colour change. An indicator is a large organic molecule that works like a "colour dye". They respond to a change in the hydrogen ion concentration. Most of the indicators are themselves weak acids.

The most common indicator is found on litmus paper. It turns/remains red for acid and turns/remains blue for a base.

Universal Indicator, which is a solution of a mixture of indicators that provide a full range of colours for the pH scale.

Red and Blue Litmus paper works as an indicator

Added to...	Blue Litmus	Red litmus
Acid solution	Turns red	Stays red
Base solution	Stays blue	Turns blue
Neutral solution	Stays blue	Stays red



Blue litmus paper turning red in acid



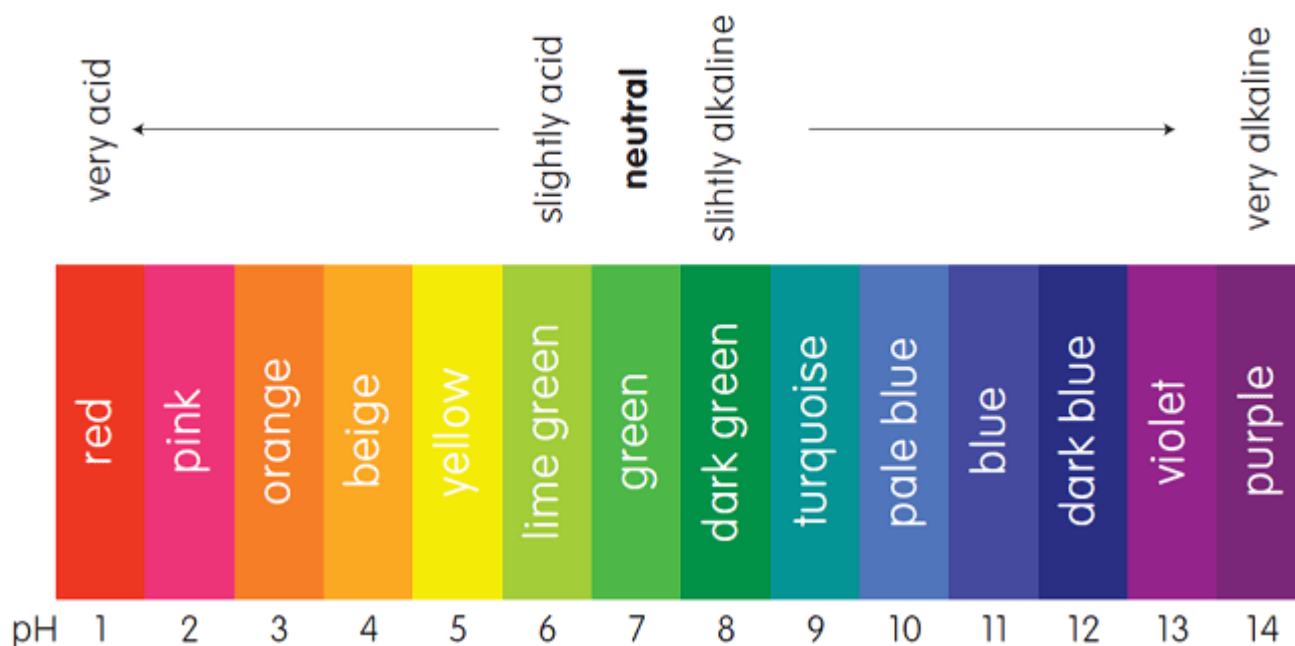
Red litmus paper turning blue in base

Litmus paper is easy to use, but it does not tell you how acid or base a solution is, or if it is neutral – unless you use both red and blue litmus paper

Universal Indicator is used to give the strength of the acid or base

The Universal Indicator is similar to the Litmus paper in that the acids turn the indicator mostly red and the bases turn the indicator mostly blue.

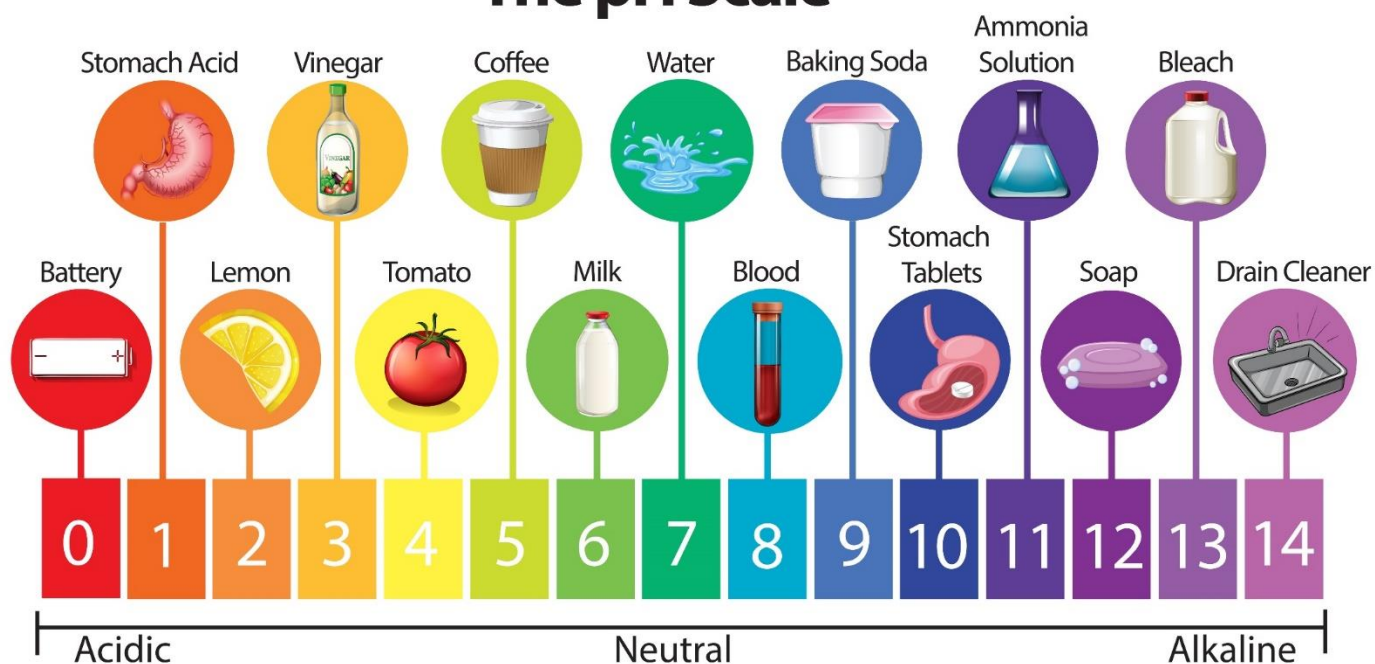
It does have an advantage over the litmus paper, as it shows neutral by having a green colour and has different colours for weak acids and weak bases.

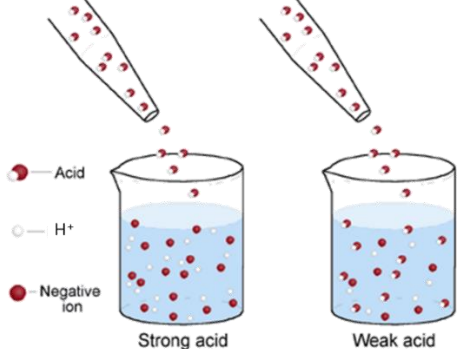
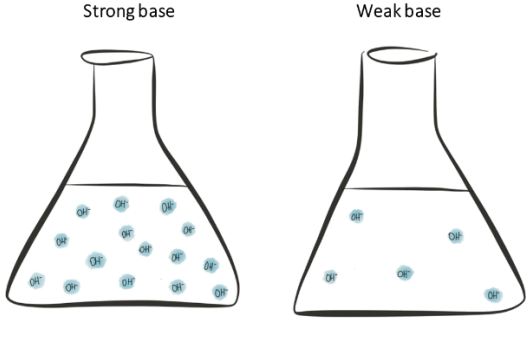


Common acidic, alkaline and neutral substances.

Pure water is neutral. But when chemicals are mixed with water, the mixture can become either acidic or basic.

## The pH Scale

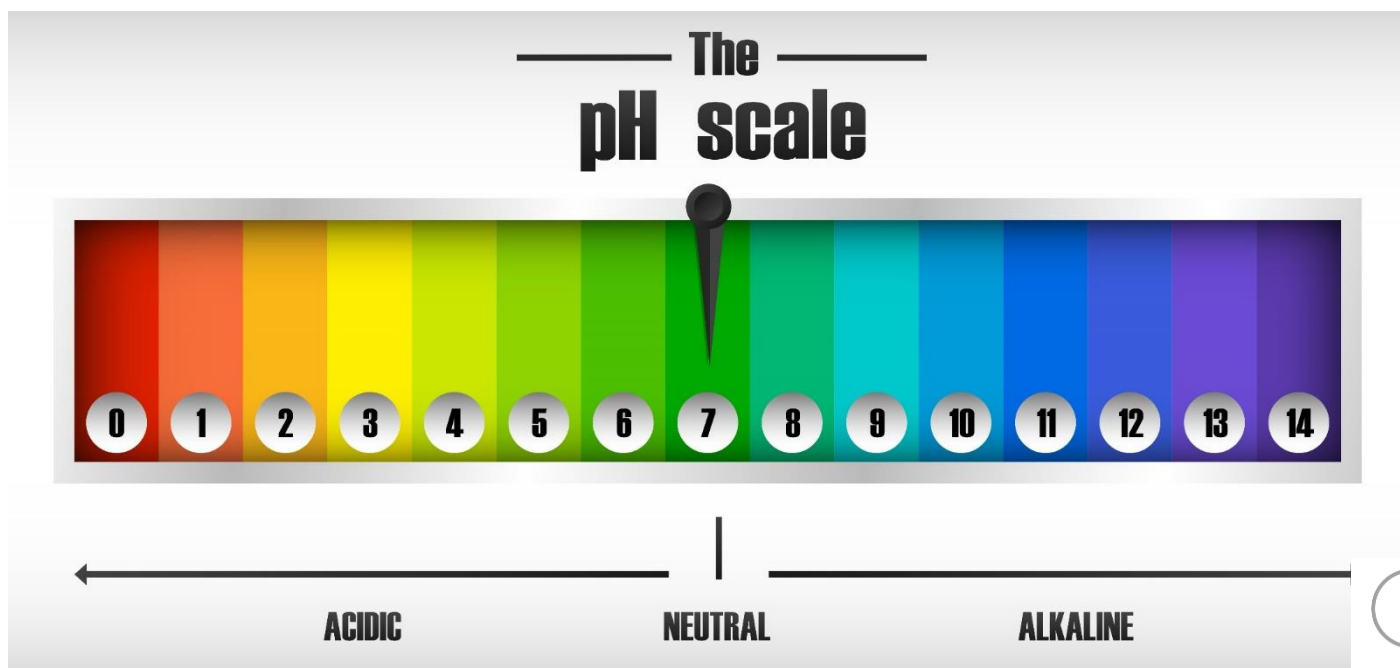


<p><b>Strong and weak acids</b></p> <p>You can define acids and bases as being "strong" or "weak". Strong acids are compounds that release a large amount of <math>\text{H}^+</math> ions. A weak acid releases much less <math>\text{H}^+</math> ions.</p>	<p><b>Strong and weak bases</b></p> <p>You can define bases as being "strong" or "weak". Strong bases are compounds where they release a large amount of <math>\text{OH}^-</math> ions. A weak base is a compound where there are much less <math>\text{OH}^-</math> ions released. Most weak base molecules remain unreacted.</p>
	

## The pH

The pH scale measures how acidic or alkaline a substance is. Substances with a pH of 7 are neutral, substances with a pH greater than 7 are alkaline (or 'basic') and substances with a pH lower than 7 are acidic. Remember alkalis are 'bases' that are soluble in water. (All alkalis are bases but not all bases are alkalis.)

A scale from 0-14 is used to indicate how acid or base a substance is. The pH scale is logarithmic and as a result, each whole pH value below 7 is ten times more acidic than the next higher value. For example, pH 4 is ten times more acidic than pH 5 and 100 times more acidic than pH 6.

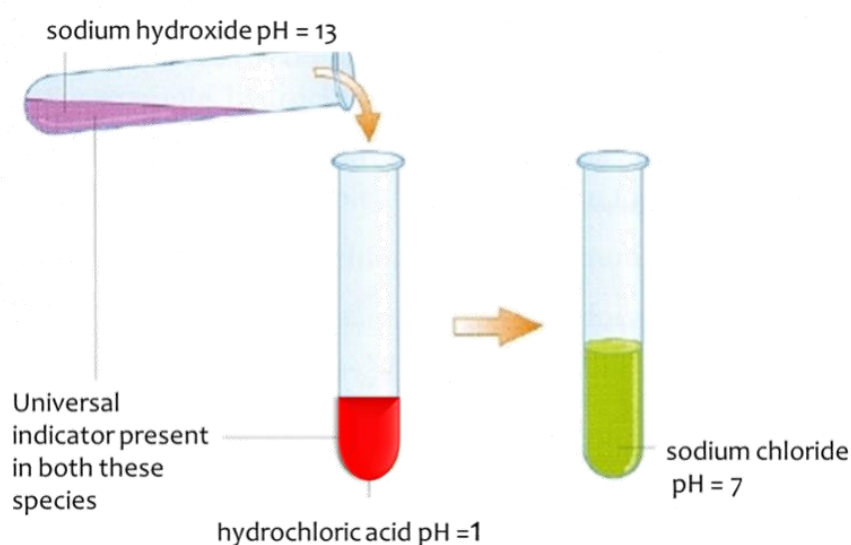
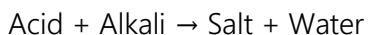


The pH scale measures level of acidity and alkalinity

The pH of a substance is determined by the concentration of hydrogen ions compared to hydroxide ions. The higher the concentration of hydrogen ions the lower the pH.

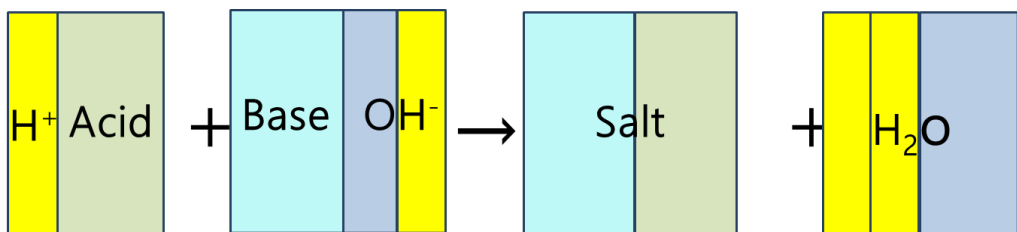
## Neutralisation reactions

Neutralisation is a reaction where an acid reacts with an alkali to form a neutral solution of a salt and water.

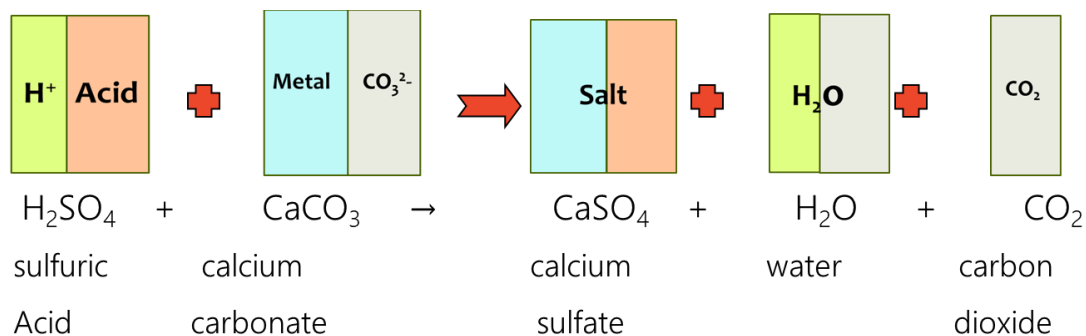


## Balanced equations for salt formation (Extension)

Acids react with hydroxides to give a salt and water. We can test to see if a solution has been neutralized (all of the acids and base has reacted to form salt and water) by testing with universal indicator which will turn green.



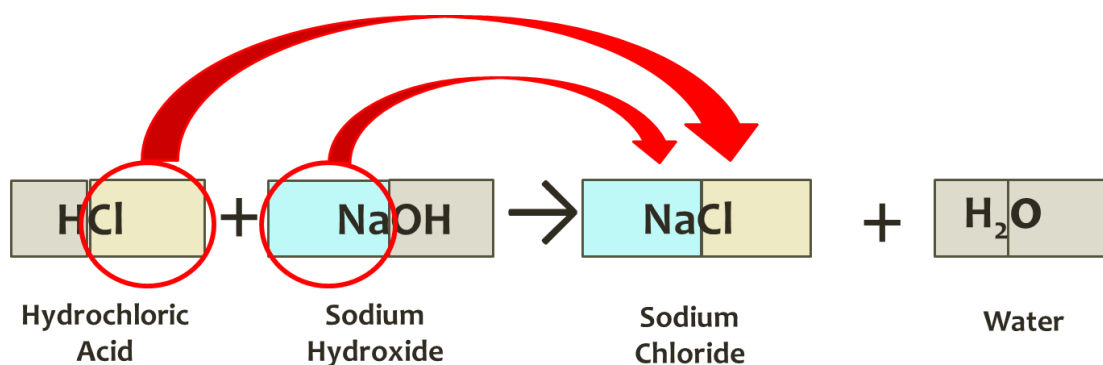
Acids react with Carbonates to give a salt and water and carbon dioxide. We can test to see if carbon dioxide has formed by bubbling the gas into another test tube filled with limewater. The limewater will turn cloudy if the gas is carbon dioxide.



## Names of salts (Extension)

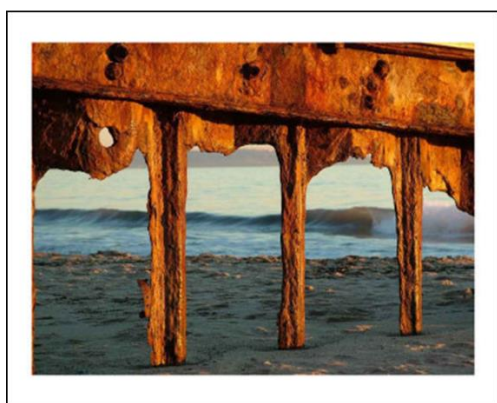
When salts are formed the name depends upon the acid reacted and the metal that forms part of the base compound.

Name of acid	Name of salt formed
Hydrochloric acid	chloride
Sulfuric acid	sulfate
Nitric acid	nitrate



## Reaction Rate

The reaction rate is the speed at which a chemical reaction occurs. This is measured by how quickly the reactants change into products or how quickly one of the reactants disappears. Reactions can vary in their reaction rate



Iron oxidising



oxygen and hydrogen combusting

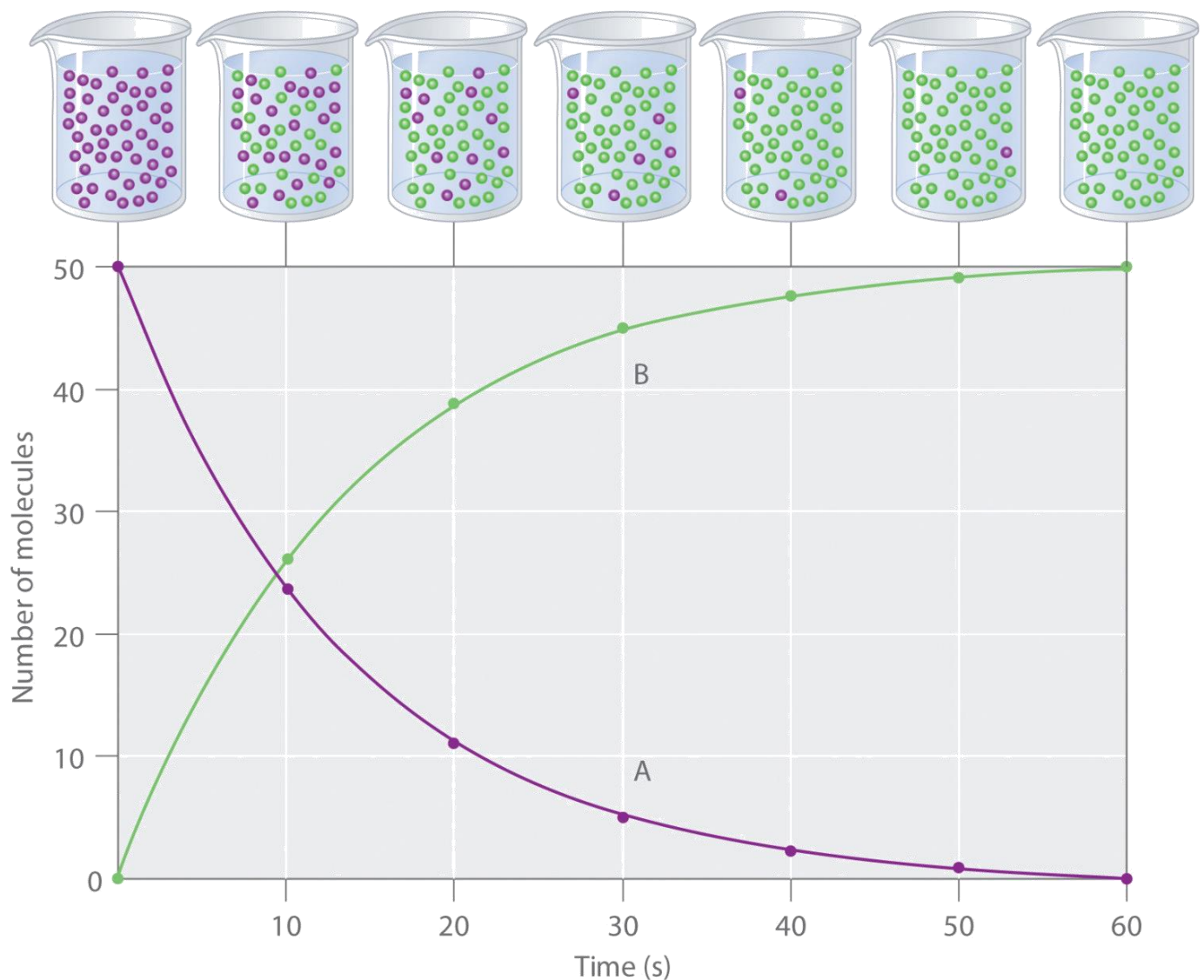
Chemical reactions occur when particles collide successfully

Chemical reactions between particles of substances only occur when the particles collide successfully.

Changing factors such as temperature, concentration of reactants, surface area and adding a catalyst can change how many successful collisions occur or how quickly they occur. This then affects the reaction rate. Increasing these factors will increase the reaction rate.

## Reaction Rate

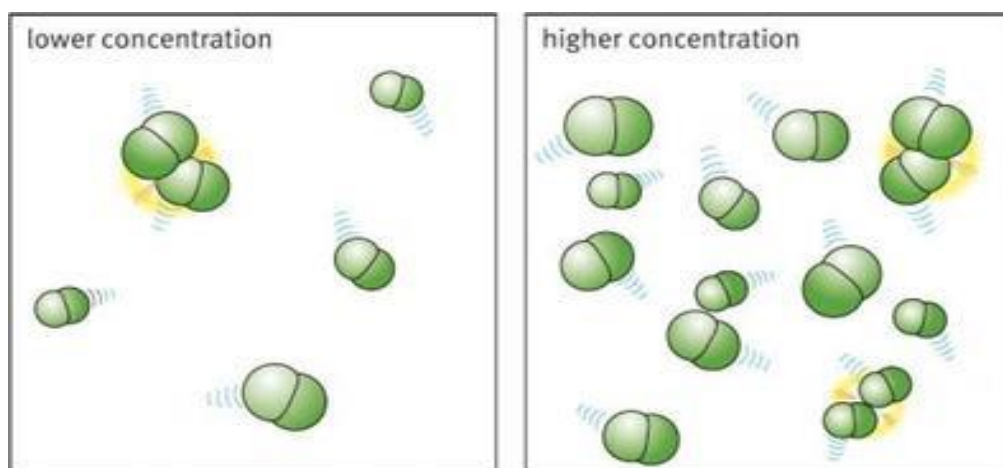
Reactions take place over time. As the amount of reactants decrease the amount of products increase. The reaction rate is shown as a curve because the amount of reactants at the start is greater and the reaction rate slows as they decrease



Reaction rate can be increased by increasing the concentration

Increasing the concentration of one or more of the reactants will increase the reaction rate.

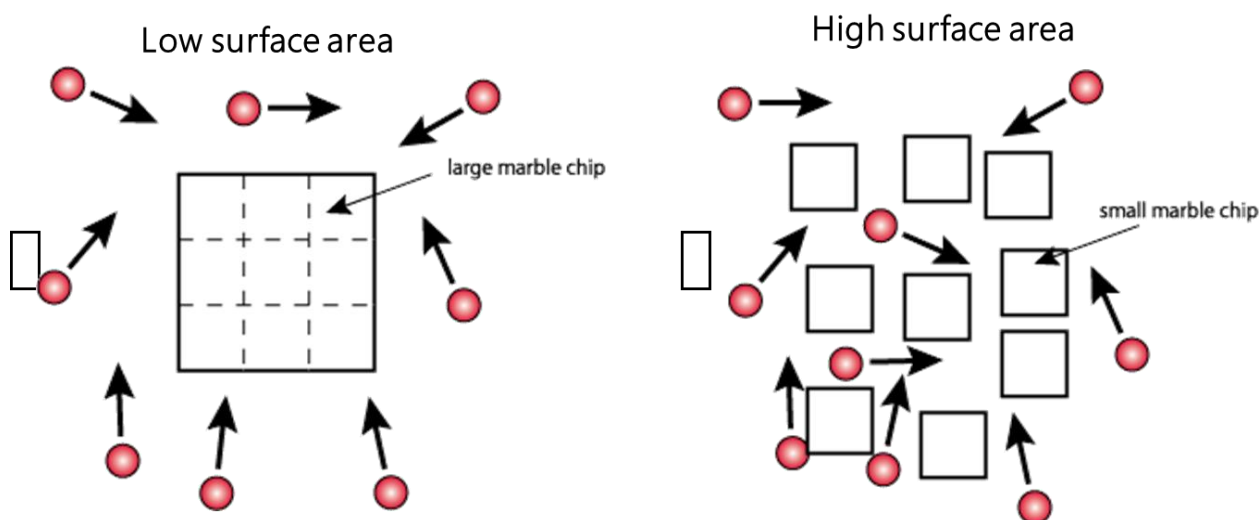
Decreasing the concentration of one or more of the reactants will decrease the reaction rate.



If there is a higher concentration of a reactant, there is a greater chance that particles will collide because there is less space between particles. There are more particles per unit volume. The higher frequency of collisions means there are more collisions per unit of time and this will increase the rate of the reaction. If there is a lower concentration, there will be fewer collisions and the reaction rate will decrease.

Reaction rate can be increased by increasing the Surface Area

Surface area can be increased by grinding and crushing large lumps into a finer powder. The smaller the pieces the greater the surface area.



By increasing surface area, a greater number of reactant particles are exposed and therefore able to collide. The frequency of collisions (number of collisions per unit of time) will increase and therefore the reaction rate will also increase.

Reaction rate can be increased by increasing the Temperature

Increasing the temperature (kinetic energy) of the reacting particles will increase the reaction rate.

Decreasing the temperature (kinetic energy) of the reacting particles will decrease the reaction rate.



Increasing temperature effects the reaction rate in two ways.

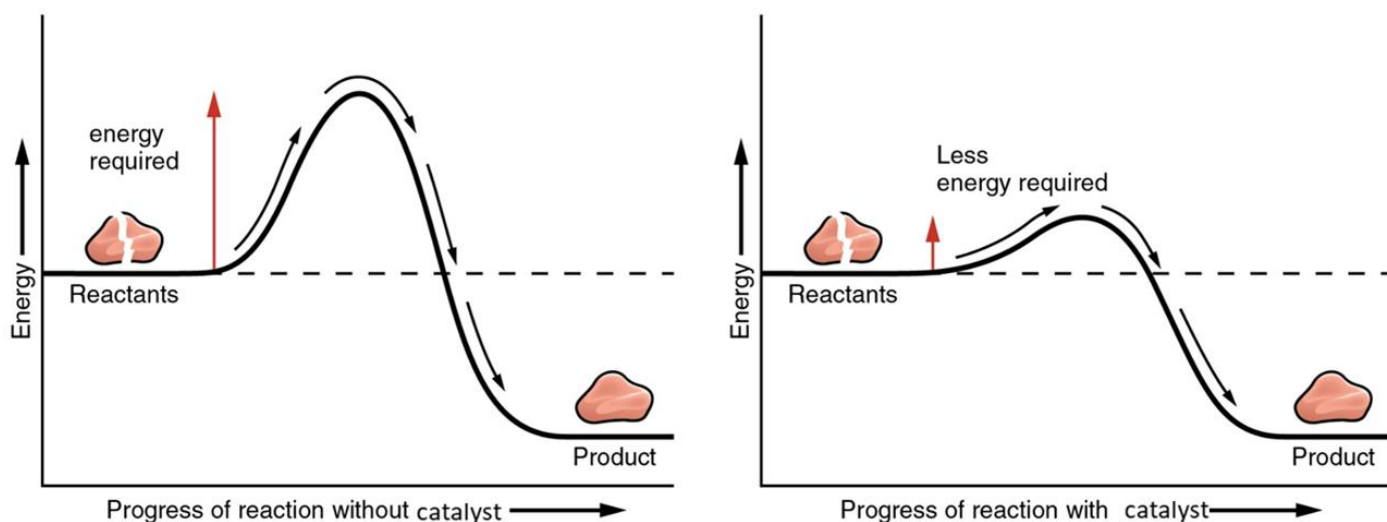
Firstly, when you raise the temperature of a system, the particles move around a lot more (because they have more kinetic energy). When they move around more, they are more likely to collide and the frequency of collisions increases, therefore the reaction rate increases. When you lower the temperature, the molecules are slower and collide less frequently therefore the reaction rate decreases.

Secondly at a higher temperature a larger proportion of particles have sufficient (kinetic) energy to have the energy required during a collision for it to be successful and therefore a reaction to occur. This increases the proportion of successful collisions and therefore the reaction rate.

Reaction rate can be increased by using a catalyst.

A catalyst is a substance that increases the reaction rate without being used up or forming part of the products. Only some reactions have catalysts that are effective, but for many reactions there is no catalyst that works.

A catalyst lowers the minimum amount of energy required for a reaction to take place. This means that the particles can successfully collide with less energy than they required before the catalyst was added. A greater proportion of particles will successfully collide, and therefore the reaction rate will be increased.



Measuring the rate of reaction

When gas is one of the products it can be collected in an upside down cylinder. The water displacement is a measure of the volume of gas produced. The amount produced needs to be recorded at set time intervals and then graphed.

Volume of gas produced  $\text{cm}^3$

