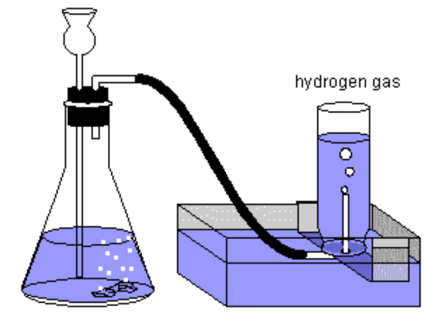
Chemical Reactions

- Physical and chemical changes. In a physical change no new substances are being formed. All that changes is the physical state of the material. Eg 1. Melting ice (solid to liquid) is easily reversed by cooling eg ice and liquid water are still the same H_2O molecules. Eg 2. Dissolving, eg a solid mixes completely with a liquid to form a solution which can be reversed by evaporating the liquid e.g. dissolving copper sulfate in water. On evaporation the original copper sulfate is regained.
- In a chemical change a new substance is formed. Often it is very difficult or even impossible to reverse this change. Signs that a chemical change or chemical reaction has occurred include: colour changes, temperature changes, a gas may be given off, a sound may be heard and change in mass.
- Chemical changes are often summarised in chemical equations in words or symbols. The reactant(s) (the chemicals you start with) are changed into the products (the new substance(s) made). Eg magnesium + oxygen → magnesium oxide. $2Mg + O_2 \rightarrow 2MgO$
- Acids are corrosive chemicals and must be treated with care. Some acids you use in the lab are: sulfuric acid (H_2SO_4), hydrochloric acid (HCl), nitric acid (HNO_3) and ethanoic acid (CH_3COOH). Lemon juice contains an acid – citric acid.
- Metal + acid → salt + hydrogen. When a reactive metal such as magnesium is added to dilute hydrochloric acid, a chemical reaction takes place. The magnesium gets smaller and smaller and eventually "dissolves", the contents of the tube get quite hot and bubbles of a colourless gas, hydrogen, are produced. Magnesium and hydrochloric acid are the reactants. Magnesium chloride and hydrogen are the products. Magnesium chloride is a member of a group of chemicals called salts. (Note: Some metals are too unreactive to give a salt and hydrogen gas eg copper will not react. However this works well with magnesium, zinc and iron). Effervescence is another word for bubbles of gas.

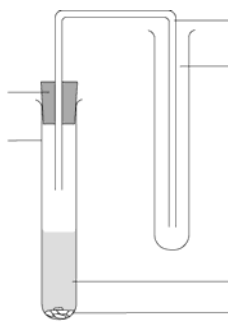
  Magnesium + Hydrochloric acid → magnesium chloride + hydrogen $Mg + 2HCl \rightarrow MgCl_2 + H_2$

  Zinc + Hydrochloric acid → zinc chloride + hydrogen $Zn + 2HCl \rightarrow ZnCl_2 + H_2$

- Collecting hydrogen. Hydrogen gas is lighter than air and so you need to put your thumb over the top of the test tube to trap it. It can also be collected by the "displacement of water" technique because it is insoluble in water.



- Test for hydrogen. Trap some of the gas in the test tube with your thumb. Bring a burning splint or match to the mouth of the tube (moving your thumb at the last moment!). The gas burns with a squeaky pop noise – a little explosion.
- Metal carbonate + acid → salt + water + carbon dioxide. When marble chips (calcium carbonate) are added to hydrochloric acid, a chemical reaction takes place. The marble chips slowly "disappear" and there is a colourless gas produced. This time the gas is carbon dioxide.
- Calcium carbonate + hydrochloric acid → calcium chloride + water + carbon dioxide. $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$



- Collecting carbon dioxide. Carbon dioxide gas is heavier than air and so you don't need to put your thumb over the top of the test tube to trap it. It can be collected by "downward delivery". It can also be collected by the "displacement of water" technique because it is only slightly soluble in water.

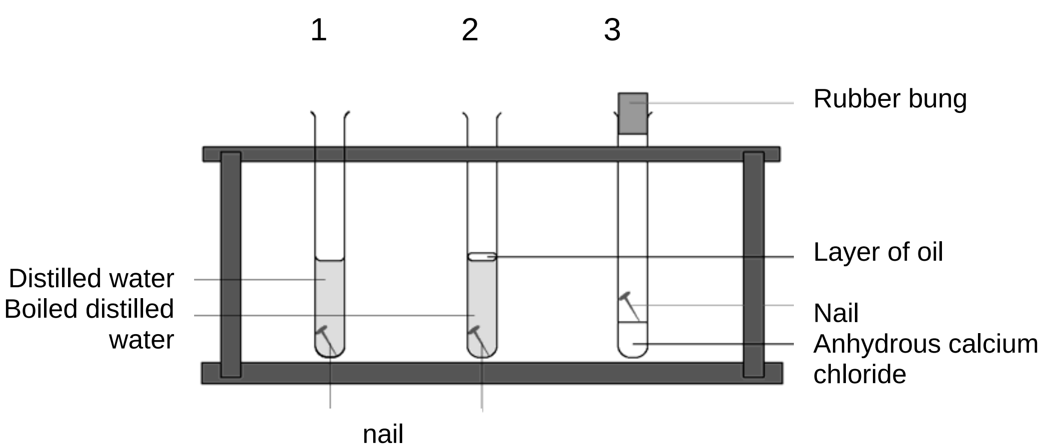
- Test for carbon dioxide. Bubble the gas through limewater. If the gas is carbon dioxide the limewater turns from clear to cloudy/milky white.
- Carbon dioxide facts!! This is the gas that puts the fizz in fizzy drinks. It's the gas we breathe out. It is used in fire extinguishers because it doesn't allow things to burn in it. (Chemists say "it does not support combustion!")
- Reactive metals. Some metals are very reactive and react readily with water and air. Sodium (Na) is an example. It is stored in a jar filled with oil to keep it away from moisture in the air and oxygen in the air. It looks a dull grey when it is first removed but if it is cut with a scalpel the newly exposed surface is shiny. However it soon goes dull as it reacts with the air. When a small piece of sodium is dropped into water it floats! The reaction with water generates so much heat that the sodium melts into a little ball, and moves around the surface of the water. Hydrogen gas is given off. So much heat may be produced that the metal and gas ignite and burn with a bright yellow flame. If Universal indicator solution is added to the water afterwards, it turns purple (which shows an alkaline substance has been made – sodium hydroxide).

  Sodium + water $\rightarrow$ sodium hydroxide + hydrogen $2Na + 2H_2O \rightarrow 2NaOH + H_2$
- Combustion is the scientific word for burning. Burning needs oxygen gas. The product is called an oxide. Eg magnesium + oxygen $\rightarrow$ magnesium oxide.
- Burning a candle. If a lit candle is stood under a jam jar the flame gradually goes out. It goes out because it is running out of oxygen AND it is extinguished by the carbon dioxide gas produced. If the lit candle is stood in shallow water and a jam jar is placed over the top, the flame goes out again and the water level rises inside the jam jar. It is however a coincidence that it rises approximately 1/5 or 20% (which is similar to the amount of oxygen in air). *Think about it…. The burning flame heats the air which expands and pushes some of the water out of the jar. When it goes out (running out of oxygen AND being extinguished by the carbon dioxide) the air cools and contracts. Water is forced up into the jar. Most of the oxygen in the jar has been used up but another gas has been formed as a product. The carbon dioxide is not particularly soluble in water. Water vapour is also produced by the burning candle which condenses to water.*
- Some other combustion reactions:
  - Magnesium metal burns with a very bright white flame in air, and even more brightly in oxygen gas. Magnesium + oxygen $\rightarrow$ magnesium oxide.
  - Iron (steel wool) glows brightly and sparks if it is heated and plunged into oxygen gas. A black solid – iron oxide – is made. Iron + oxygen $\rightarrow$ iron oxide.
  - Sulfur (a yellow non metal) melts when heated and then burns with a blue flame if it is plunged into oxygen gas. A poisonous colourless gas called sulfur dioxide is formed. Sulfur + oxygen $\rightarrow$ sulfur dioxide.
  - Candle wax is a hydrocarbon, a chemical made up of hydrogen and carbon atoms. When wax burns carbon dioxide and water are formed.

- Oxygen gas. This can be made in the lab using a chemical called hydrogen peroxide (H_2O_2) and a black powder called manganese dioxide. The manganese dioxide is a "catalyst", a chemical that speeds up a reaction without being used up itself. We don't include it as a reactant, therefore, in the word equation. When the catalyst is added to the hydrogen peroxide there is vigorous bubbling – oxygen gas.

  Hydrogen peroxide $\rightarrow$ water + oxygen $2H_2O_2 \rightarrow 2H_2O + O_2$

- Collecting oxygen. Oxygen gas is about the same density as air and so you need to put your thumb over the top of the test tube to trap it. It can also be collected by the "displacement of water" technique because it is only moderately soluble in water.
- Test for oxygen. Trap some of the gas in the test tube with your thumb. Bring a burning splint or match to the mouth of the tube and then shake it or blow it out so that is glowing. Lower the glowing match into the gas. The gas will make the match relight. (Sometimes it relights so vigorously there is a little "pop" but don't confuse this with the test for hydrogen gas).
- Rusting. Iron reacts with moist air in a chemical reaction to form rust. Rust is a red brown flaky solid. The reaction with oxygen in the air is also known as "oxidation" and "corrosion" as well as "rusting". Both water and oxygen (from air) are needed for rusting to occur. This experiment investigates the conditions needed for rusting to occur. Tube 1: Oxygen and water and iron nail. Tube 2: Water and iron nail (Boiling the water removes oxygen and the layer of oil on top stops oxygen redissolving in it). Tube 3: Oxygen and iron nail (Anhydrous calcium chloride absorbs water vapour from the air and the stopper stops more entering the tube). Result: Only the nail in tube 1 rusts.



- Increasing the salinity (saltiness) of the water will speed up the rate at which rusting occurs. Cars in seaside towns rust much faster than those in inland towns. Rusting is also faster in polluted places where substances are dissolved in the water. Rusting (like most chemical reactions) also occurs faster at higher temperatures.
- Analysing rust. The rust that forms on iron and steel objects is called "hydrated iron oxide". If you heat some rust in a test tube you will see condensation forming at the cooler mouth of the test tube. (For experts: rust is $Fe_2O_3{\cdot}xH_2O$ where x is a number from 1-6.)
- Prevention of rusting. The rusting of iron and steel is ugly but also expensive.
  - Covering with a layer of plastic or painting or putting grease on the metal surface will protect the metal from rusting by preventing oxygen and water reaching the metal. However if the plastic coat or paint is scratched then the iron will start to rust.
  - Attaching different types of metal to the iron can prevent rusting (as long as the metal is MORE reactive than iron, and as long as some of that metal remains in contact with the iron). Eg zinc metal bars placed on a ship's hull reduce rusting. The zinc corrodes instead – in a process called "sacrificial protection".
  - Coating with zinc metal (a process called galvanising) combines both ideas – excluding air and water and, if the layer of zinc is scratched, it protects by sacrificial protection.