3^{rd} Year Science

Revision

For

Mr Fogarty's Classes

St. Mary's Secondary School
New Ross
Co. Wexford

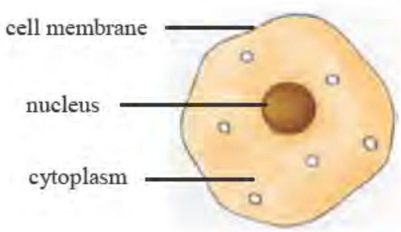
Based on 'Discovering Science' Text Book.

Chapter 1 Biology - Living Things

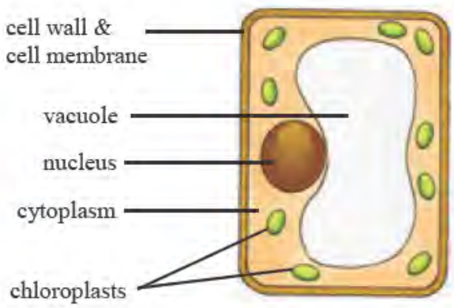
- The **7 characteristics** of living things are: **Movement**, **Respiration**, **Sensitivity**, **Feeding**, **Excretion**, **Reproduction** and **Growth**.
- **Respiration** is the release of **energy** from our food.
- The **Animal Kingdom** is divided into 2 main groups: the **Invertebrates** (no backbone); and the **Vertebrates** (animals with a backbone).
- Green **plants** make their own food by photosynthesis. They use a green chemical called chlorophyll.
- **Animals** are consumers - they can only consume food.
- A **key** is a **set of questions** used to identify an animal or plant.

Chapter 2 Animal and Plant Cells

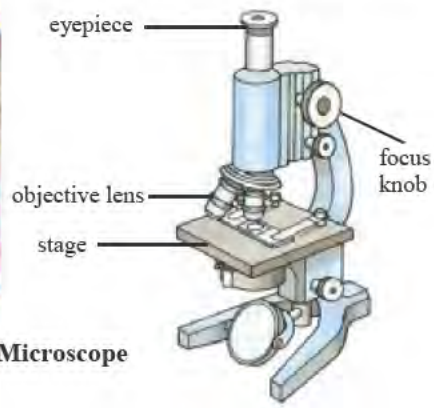
- All cells have a **cell membrane**, **cytoplasm**, **nucleus**, and **small vacuoles**.
- Plant cells also have **chloroplasts**, a **cell wall**, and a **large central vacuole**.
- The microscope has 4 main parts; the **eyepiece**, the **stage**, the **objective lens** and the **focus knob**.



Animal Cell



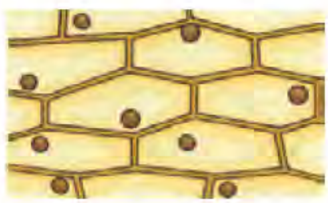
Plant Cell



Microscope

- A **tissue** is a group of similar cells with a special function.
- An **organ** is a group of different tissues that work together to carry out a special function.
- A **system** is a group of organs working together.
- **Growth** results from cells dividing.

Plant cells seen under high power



EXPERIMENTS:

2.1 *Using the Microscope*

2.2 *To Examine Plant Cells*
Plant cells are stained with **iodine**.

2.3 *To Examine Animal Cells*
Stain with **methylene blue**.

Animal cells seen under high power

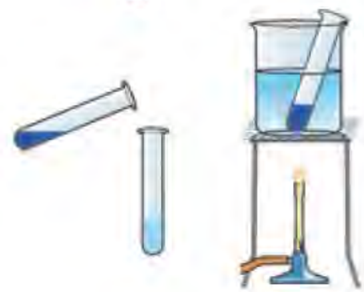
Chapter 3 Food

- Food is needed for **energy**, **growth**, **repair** and **protection** against disease.
- The 5 major nutrients are: **Carbohydrates**, **Fats**, **Proteins**, **Vitamins** and **Minerals**.
- A **balanced diet** has 6 constituents: carbohydrates (including fibre), fats, proteins, vitamins, minerals and water.
- **Vitamin C**, found in **citrus fruits**, is for **healthy skin and gums**.
- **Vitamin D**, found in **milk**, yogurt and cheese, is for strong, **healthy bones**.
- The mineral **calcium**, found in **milk** and cheese, is for **healthy bones**.
- The mineral **iron**, found in **liver** and cabbage, is used to make **red blood cells**.
- A **balanced diet** is one that contains the **right amounts** of all the nutrients needed to stay healthy.
- A **food pyramid** shows **how much** of each food type is needed for a healthy diet.

EXPERIMENTS:

3.2 To Test for the Presence of Starch
Starch is tested for by adding **iodine** solution to it.
If starch is present, it turns **blue-black** in colour.

3.3 To Test for the Presence of Glucose - a Reducing Sugar
Glucose is tested for by adding **Benedict's solution**, and **heating**.
It turns a **brick red** colour.



3.4 To Test for the Presence of Protein (the Biuret Test)
Protein is tested for by adding **copper sulfate** to protein with **sodium hydroxide** added.
It turns a **violet** colour.

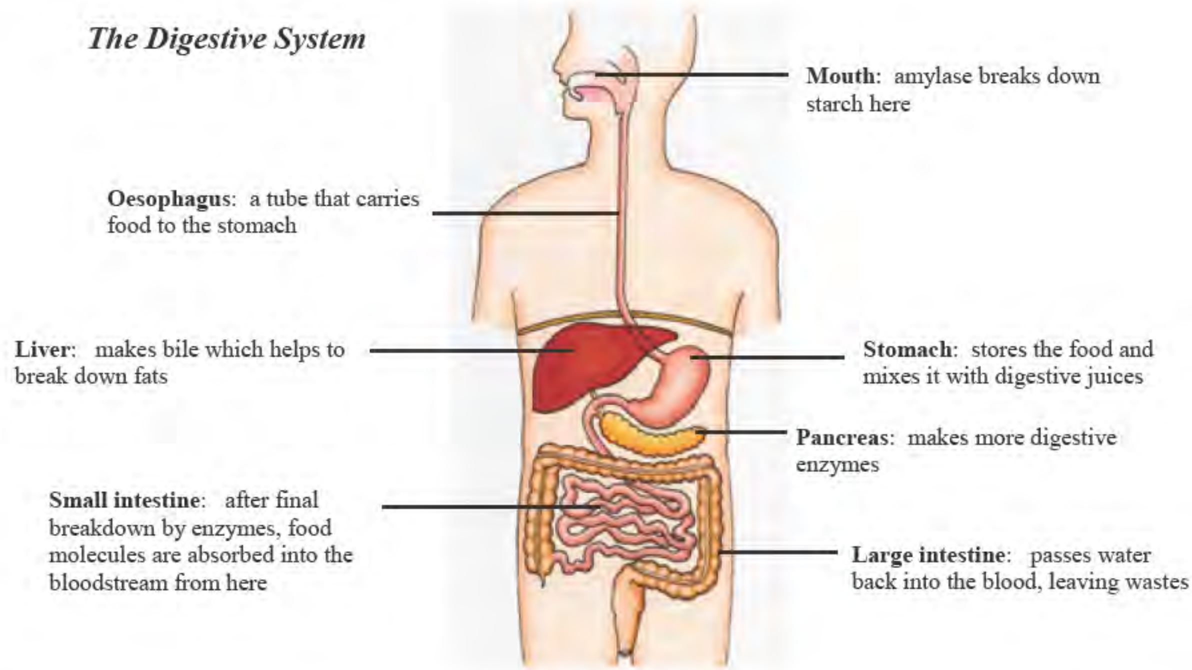
3.5 To Test for the Presence of Fats (the Brown Paper Test)
Fats are tested for by rubbing them on **brown paper**.
A **translucent spot** appears.

3.6 To Investigate the Conversion of Chemical Energy in Food to Heat Energy
Food is burned and the **heat energy** released is used to raise the temperature of water in a test tube.

Chapter 4 The Digestive System

- The **digestive system** is a group of organs working together to **break down** food into **tiny molecules**.

The Digestive System

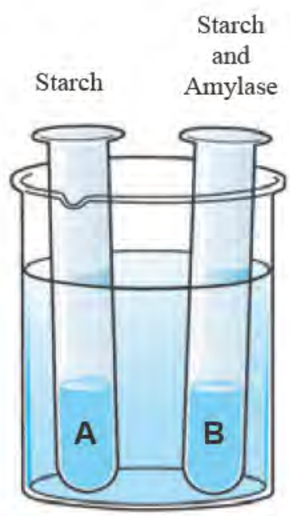


- The **5 stages** of nutrition are: **Ingestion**; **Digestion**; **Absorption**; **Assimilation**; **Egestion**.
- **Physical digestion** involves chewing the food into smaller pieces in the mouth.
- There are **4 types** of teeth: **Incisors**; **Canines**; **Premolars**; **Molars**.
- **Chemical digestion** involves the use of chemicals, called **enzymes**, to **chemically break down** the food.
- An **enzyme** is a chemical, made in a living cell, which can **speed up** a **chemical reaction**, without itself being changed.
- An **enzyme** acts on its **substrate** and breaks it down into the **product**.
- **Starch** is broken down by the enzyme **amylase** into the sugar **maltose**.

EXPERIMENT:

4.1 To Show the Action of Amylase on Starch

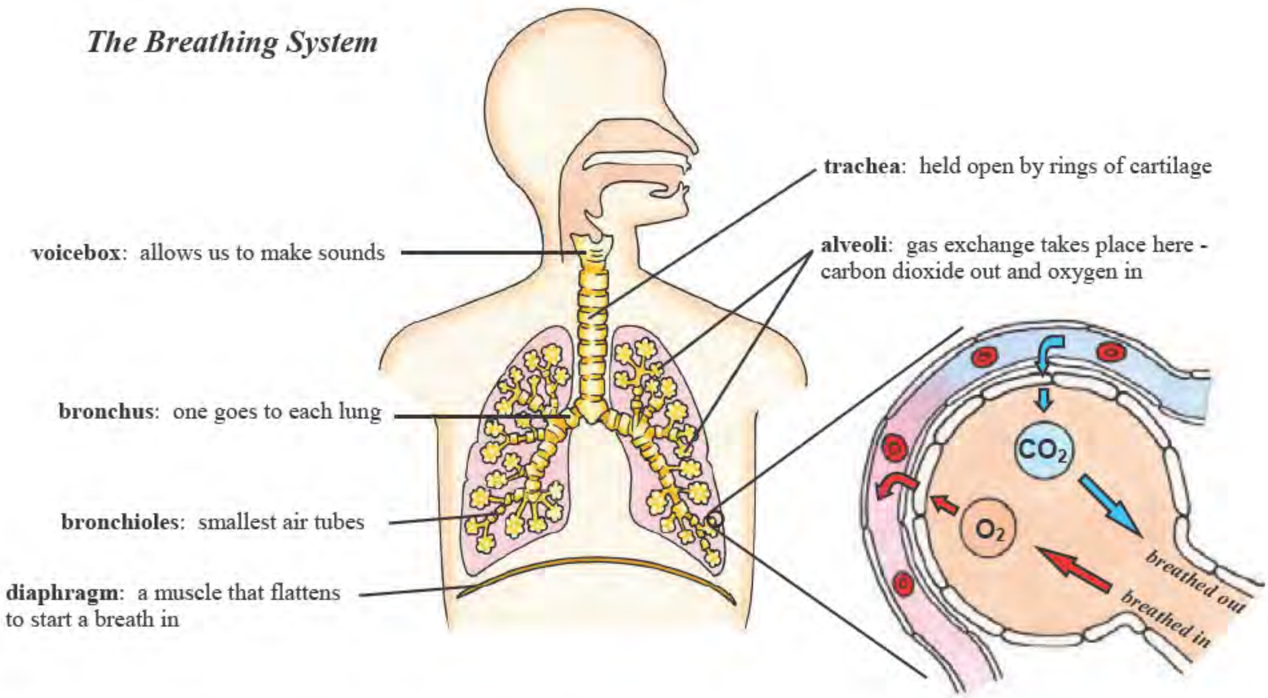
Two test tubes, **A** (**containing starch**) and **B** (**containing starch and amylase**) are heated. The contents of each test tube are tested for the presence of (i) **starch** and (ii) the **reducing sugar maltose**.
A tests **positive** for **starch**, **negative** for **maltose**.
B tests **negative** for **starch**, **positive** for **maltose**, as the amylase in **B** broke down the starch to maltose.



Chapter 5 Respiration and Breathing

- **Respiration** is the **release of energy** from food.
- **Aerobic respiration** requires **oxygen**.
- The **word equation** for aerobic **respiration** is:
  Glucose + Oxygen ⟶ Energy + Carbon dioxide + Water Vapour.
- **Respiration** occurs in **every living cell** to produce the energy the cell needs.
- The human breathing organs are the **lungs**.
- The human breathing system consists of the **nose**, **mouth**, **trachea**, **bronchi**, **bronchioles**, **alveoli**, and **diaphragm**.

The Breathing System



- Smoking causes cancer, bronchitis and heart attacks.

EXPERIMENTS:

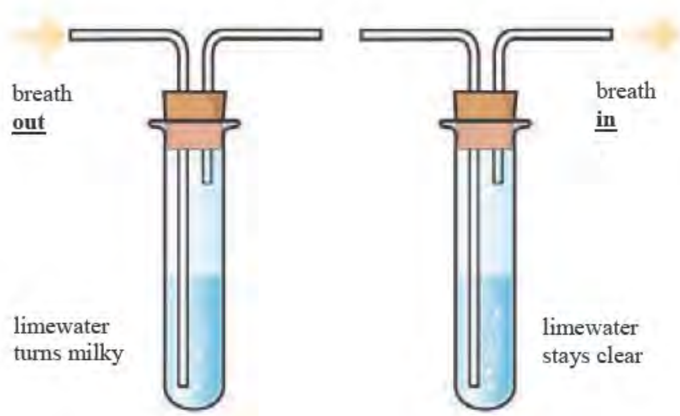
5.1 To Show that Expired Air has more Carbon Dioxide than Inspired Air

Expired air is breathed out through the **long tube** in the first test tube.

This bubbles **carbon dioxide rich air** through the **limewater**, turning it **milky** very quickly.

Inspired air is breathed in through the **short tube** in the second test tube.

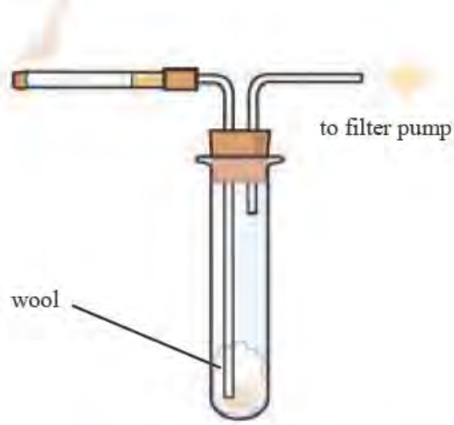
The limewater is **slower** to turn milky.



5.2 To Show how Smoking Affects the Lungs

The **filter pump** draws cigarette smoke through the **wool** in the bottom of the test tube.

Tar from the smoke gets deposited on the wool. This shows the effect of smoking on the **alveoli** and **small airways** of the lungs.

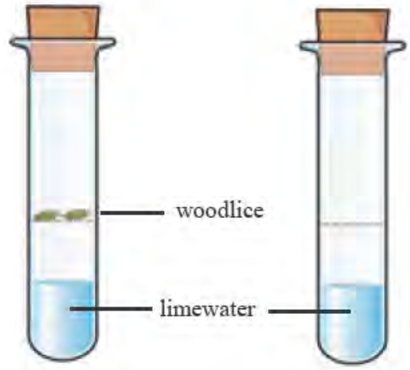


5.3 To Show that Respiration Produces Carbon Dioxide

Living woodlice are placed on a gauze tray in a stoppered test tube. **Limewater** is placed in the test tube.

The **limewater** turns **milky** showing that the **respiration** of the woodlice produces **carbon dioxide**.

The second test tube acts as a **control** - it contains no woodlice and so the limewater stays clear.

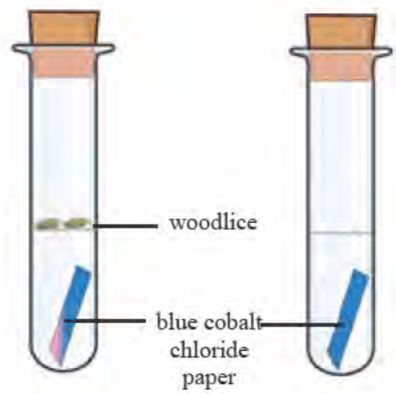


5.4 To Show that Respiration Produces Water Vapour

Living woodlice are placed on a gauze tray in a stoppered test tube. **Blue cobalt chloride paper** is placed in the test tube.

The **blue cobalt chloride paper** turns **pink** showing that **respiration** of the woodlice produces **water vapour**.

The second test tube acts as a **control** - it contains no woodlice and so the cobalt chloride paper stays blue.

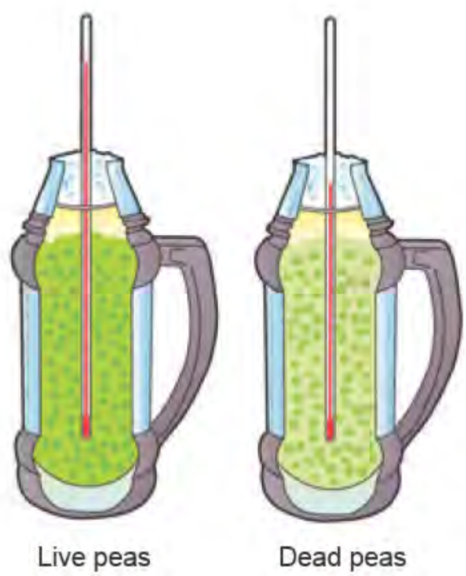


5.5 To Show that Respiration Produces Energy

The **first flask** contains **living peas** that are **respiring**.

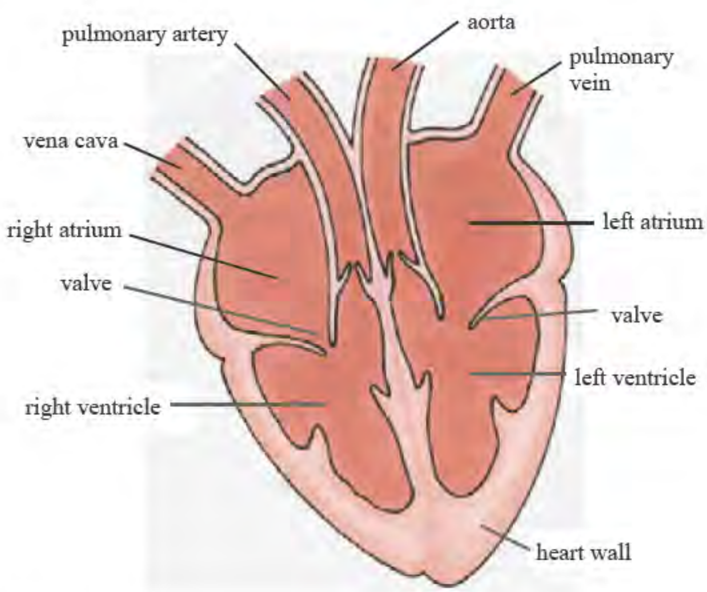
The **temperature** in this flask **rises** by about 20°C after three days, showing that respiration produces (heat) **energy**.

The **second flask** contains **dead peas** and acts as a **control**. The temperature does not rise in this flask as no respiration is taking place.



Chapter 6 The Circulation System

- The **circulation system** consists of the **blood**, **arteries**, **veins**, **capillaries**, and the **heart**.
- Blood is made up of a watery **plasma** in which are suspended red blood cells, white blood cells, and platelets.
- **Red blood cells** contain the chemical **haemoglobin** which carries **oxygen**.
- **White blood cells** protect the body against disease by **eating bacteria** and **making poisons** called **antibodies** to kill them.
- **Platelets** help the blood to **clot**.
- The **functions** of the blood are **transport** and **protection** against disease.
- **Transport**: **red blood cells** carry **oxygen** and the watery blood **plasma** carries dissolved substances such as **carbon dioxide** and **food molecules** around the body.
- There are **3 types** of blood vessels: **arteries**, **veins** and **capillaries**.
- **Arteries** have thick walls, a narrow lumen, no valves, and carry blood away from the heart.
- **Veins** have thin walls, a wide lumen, valves, and carry blood to the heart.
- **Capillaries** link arteries to veins. Their wall is only one cell thick and this allows substances to pass into and out of the blood.
- The **heart** is made of **cardiac muscle -** it never tires.
- There are **4 chambers** in the heart: **right** and **left atria**, and **right** and **left ventricles**.
- The **left ventricle** has a **thick wall** because it pumps blood all around the body.
- Normal **body temperature** of the human body is **37°C**.
- The average **resting pulse rate** is **70 beats per minute**.
- **Heart disease** is prevented by: regular **exercise**, a healthy **diet**, not **smoking**, and avoiding too much **stress**.



EXPERIMENTS:

6.1 To Show the Effect of Exercise on the Pulse Rate

Exercise increases the **pulse rate**.
This allows more food to the cells of the body.

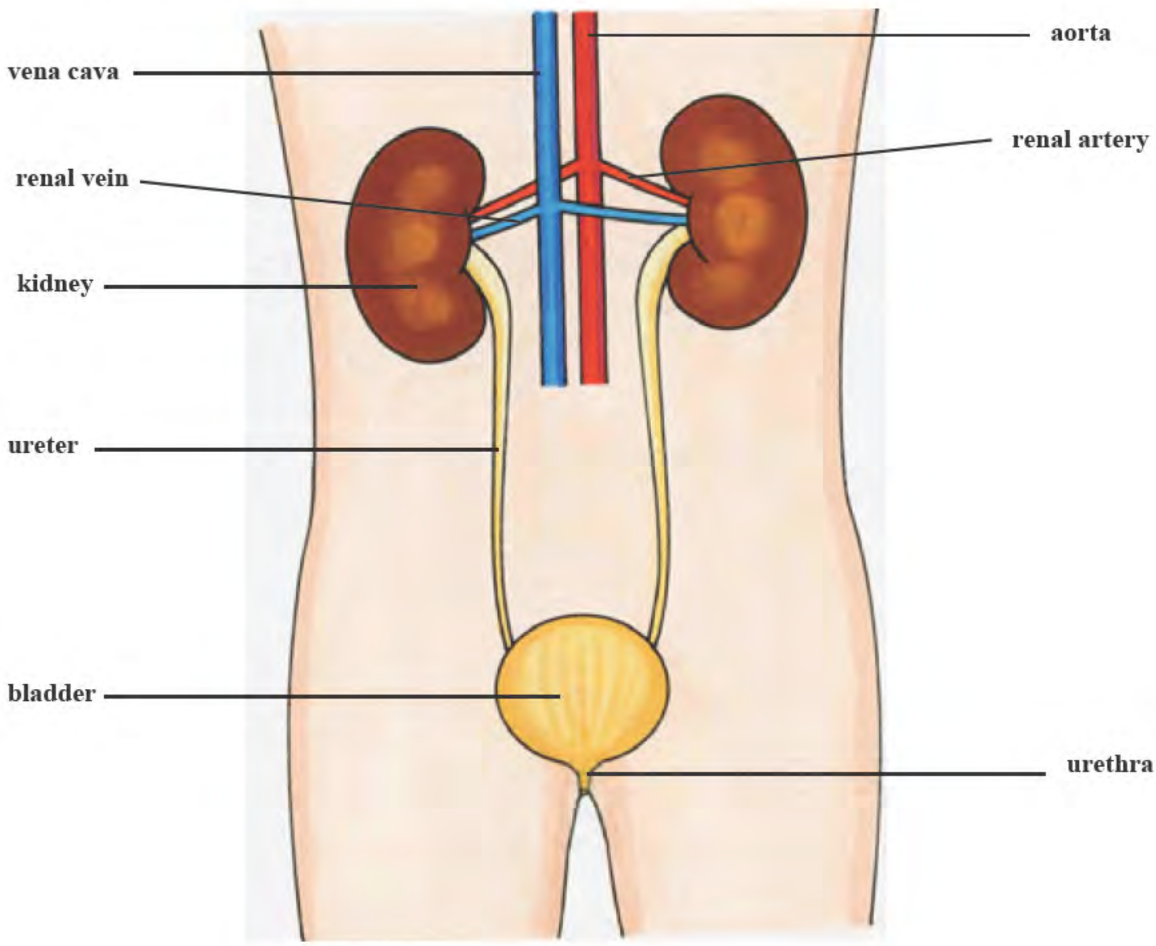
6.2 To Show the Effect of Exercise on the Breathing Rate

Exercise increases the **breathing rate**.
This allows more oxygen to the cells of the body

Chapter 7 Excretion

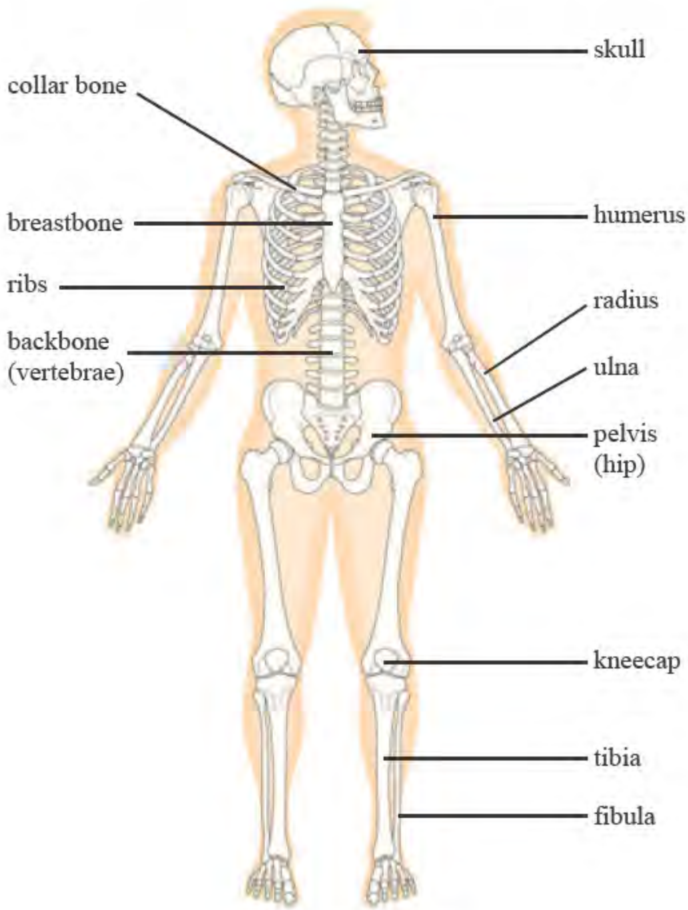
- **Excretion** is the removal of wastes made in the body.
- The three excretory organs are the **lungs**, the **skin** and the **kidneys**.
- The **lungs** excrete **carbon dioxide** and **water vapour**.
- The **skin** excretes **sweat** (water and salts).
- The **kidneys** excrete **urine** (urea, salts and water).
- Blood enters the kidney in the **renal artery** and exits in the **renal vein**.
- The kidneys **filter the wastes out of the blood**.
- The kidneys **control the amount of water in the blood**.
- The **bladder** stores urine.
- Urine passes from the kidneys, through the **ureters**, **bladder** and **urethra** to the outside.

The Urinary System

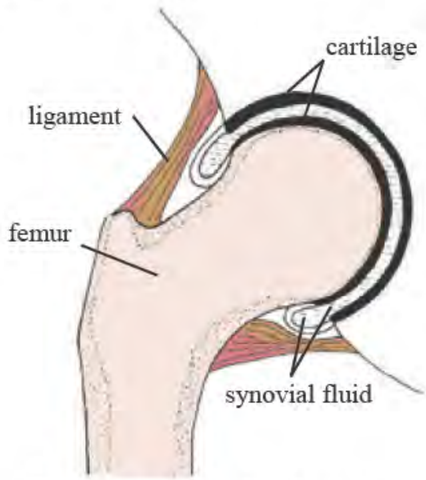


Chapter 8. The Skeleton and Movement

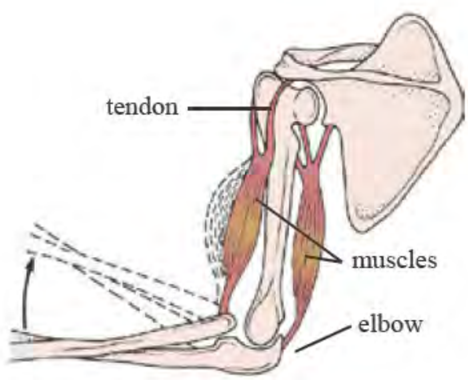
- The **functions** of the skeleton are: **Support**; **Protection**; and **Movement**.
- **Bone** consists of **cells** (the living part) and **calcium compounds** (the non-living part).
- Bones of the **arm** are the **humerus**, **radius** and **ulna**.
- Bones of the **leg** are the **femur**, **tibia** and **fibula**.
- The **spine** is made up of bones called **vertebrae**.
- A **joint** is where bones meet.
- **Fused joints** in the skull are immovable.
- **Moveable joints** contain **synovial fluid** and are called synovial joints.
- Examples of **synovial joints** are: **ball and socket joint** (e.g. hip and shoulder); **hinge joint** (e.g. knee and elbow).
- Both **cartilage** and **synovial fluid** in the joint help to **reduce friction** where bones meet.
- **Cartilage** also acts as a **shock absorber** in the joints.
- **Ligaments** join bone to bone. **Tendons** join muscle to bone.
- **Antagonistic muscles** work opposite each other (e.g. the biceps and triceps).



The human skeleton



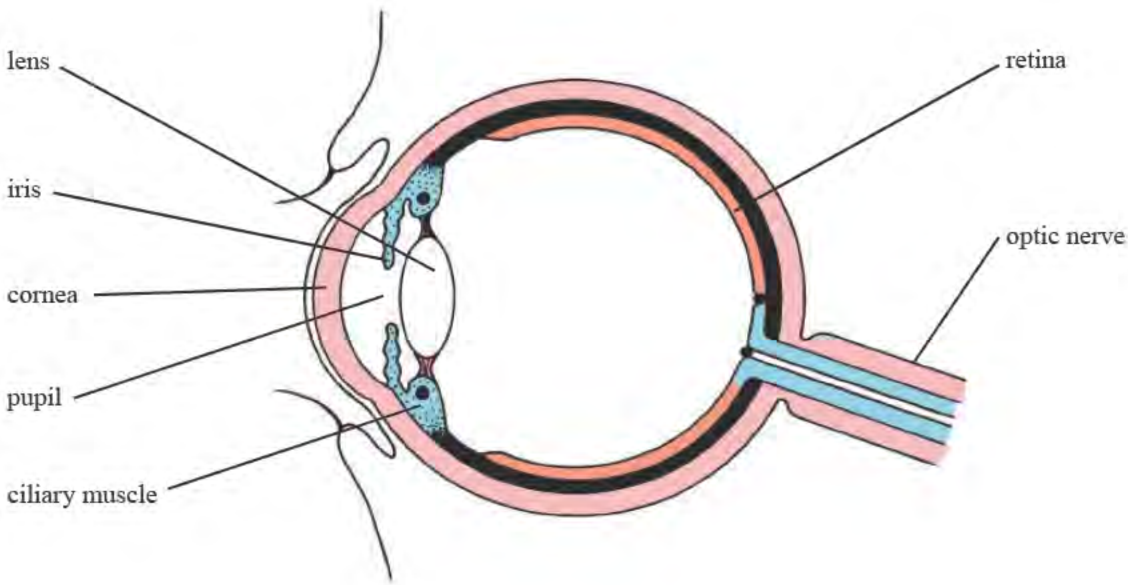
The hip - A ball and socket joint.



The arm showing an antagonistic muscle pair.

Chapter 9. Senses and Nervous System

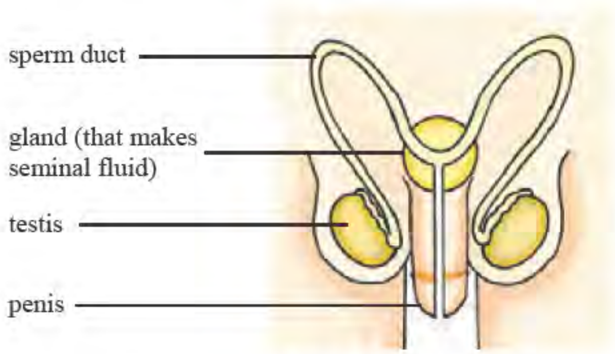
- **Sensitivity** means **detecting** and **responding** to a stimulus.
- The **sense organs**, the **eyes**, **ears**, **nose**, **tongue** and **skin** can detect stimuli.
- **Responses** to stimuli are controlled by the nervous and endocrine systems.
- The **nervous system** consists of the **brain**, **spinal cord**, and all the **nerves**.
- A **sensory nerve** sends a message **to the brain** or spinal cord from a sense organ.
- A **motor nerve** sends a message **from the brain** or spinal cord to a muscle.
- **Messages** are sent along nerves as pulses of **electricity**.
- The **eye** contains the **cornea**, **iris**, **lens**, **pupil**, **retina**, **optic nerve** and **ciliary muscle** - all of which have important functions.



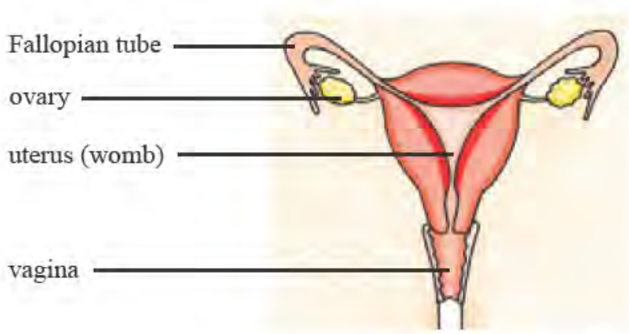
- The **lens focuses light** onto the retina at the back of the eye.
- The **iris** (the coloured part of the eye), **controls the amount of light** entering the eye.
- The **pupil** is the hole (black) that **allows light into** the eye.
- The **ciliary muscle** can **change the shape of the lens** for focusing.
- The **retina** is where the image lands - it contains cells that **can detect light and images**.
- The **optic nerve** takes the **message from the retina to the brain**.

Chapter 10. Human Reproduction

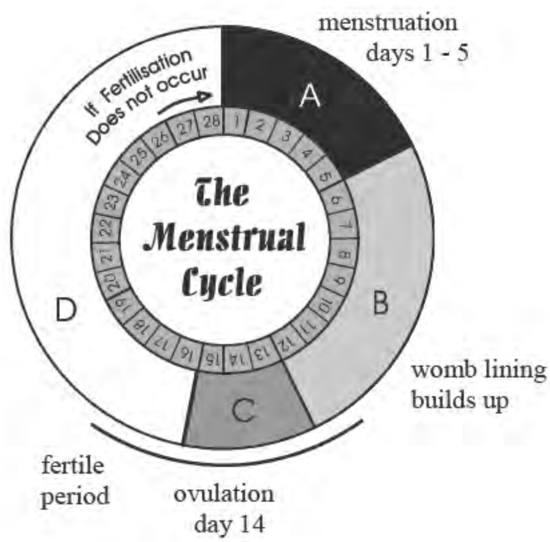
- **Sexual reproduction** involves the **fusion** of a male and female **gamete**.
- The **male gamete** is the **sperm cell**; the **female gamete** is the **egg**.
- **Sperm** cells are produced in the **testes**.
- **Egg** cells are produced in the **ovaries**.
- **Ovulation** is the **release of an egg** from an ovary on day 14 of the monthly cycle.
- **Fertilisation** is the **fusion** of the male and female gametes.
- Fertilisation occurs in the **fallopian tube**.
- **Puberty** is the time when **hormones** cause **changes** in the body.
- **Menstruation** is the **shedding** of the **lining of the uterus** (i.e. having a period).
- The **fertile period** is the time in the menstrual cycle that a woman is most likely to conceive.
- **Implantation** occurs when a **fertilised egg**, after dividing, lodges (implants) itself into the **lining of the uterus**.
- The average length of human **pregnancy** is **40 weeks**.
- The **placenta** acts as a **link** between the mother's bloodstream and that of the developing embryo.
- **Contraception** is the means by which **fertilisation is prevented**.



Male Reproductive System



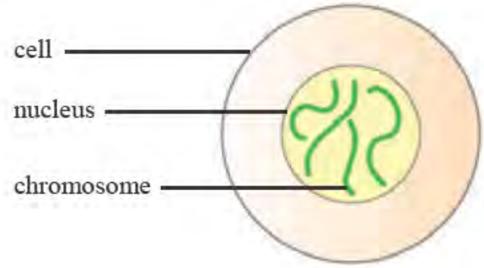
Female Reproductive System

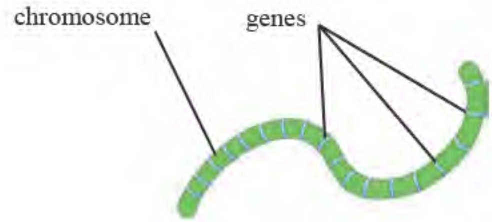


The Menstrual Cycle

Chapter 11. Genetics

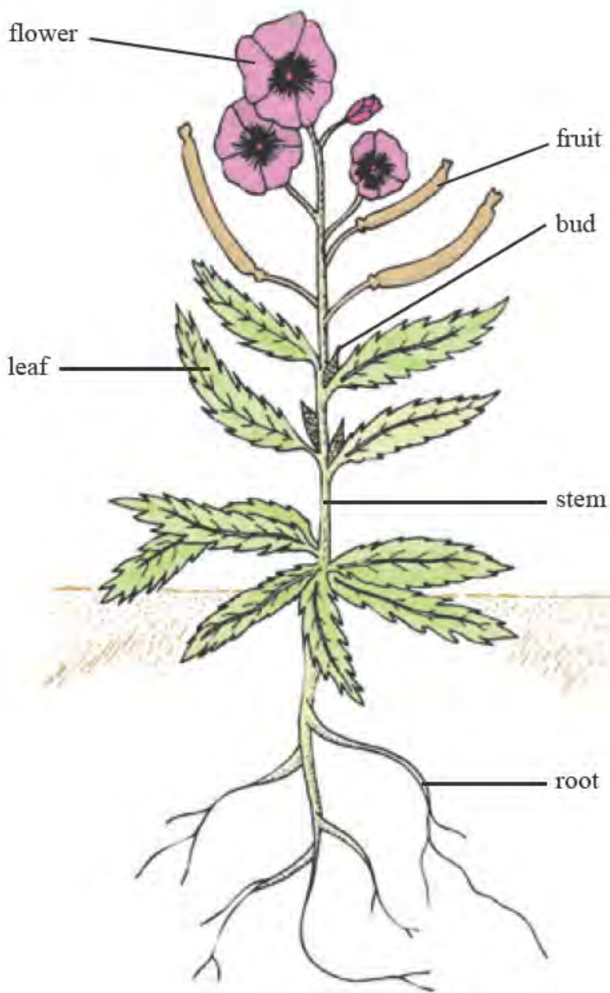
- **Genetics** is the study of the **inheritance** of characteristics.
- **Inherited characteristics** include:
  type of ear lobe, eye colour, shape of nose etc.
- **Non-inherited characteristics** have been gained during a person's lifetime e.g. ability to ride a bicycle, fitness, ability to speak French etc.
- **Chromosomes** are thread-like structures found in the nucleus of a cell.
- **Chromosomes** are made of **DNA** and **protein**.
- Human body cells contain **23 pairs** of chromosomes.
- **Genes** are **chemicals** found on **chromosomes** that carry information.





Chapter 12 Plant Structure

- **Flowering plants** consist of a **shoot** and a **root**.
- The **shoot** consists of the stem, leaves, buds and flowers.
- The **root anchors** the plant, **absorbs** water and minerals from the soil, and **stores** food made in the leaves.
- The **stem supports** the leaves and flowers and allows for the **transport** of materials up and down the plant.
- The **leaf makes** food, **loses** water vapour, and **exchanges** the gases **carbon dioxide** and **oxygen** with the air.
- The **flower** is for **reproduction**, it forms the **seeds**.
- **Plants** are **identified** by their **flowers** and **leaves**.



Chapter 13 Photosynthesis

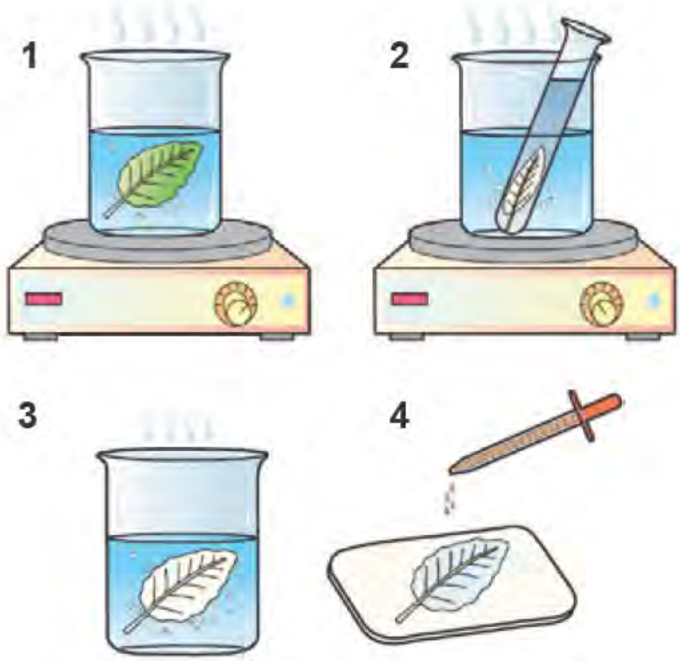
- **Photosynthesis** is the process by which **green plants make food**.
- **Chlorophyll** is the green chemical needed for photosynthesis.
- Chlorophyll is found in the **chloroplasts** of plant cells.
- **Photosynthesis** is carried out in all the green (chlorophyll-containing) parts of the plant - especially the leaves.
- **Chlorophyll traps light's energy** and uses it to combine **carbon dioxide** and **water**, to form **glucose** and **oxygen**.
- **Glucose** travels around the plant in special cells called **phloem**.
- **Leaves** are specially designed for photosynthesis. They are flat and thin, have air spaces between the cells and tiny pores on their surface called **stomata**.
- **Carbon dioxide**, **water**, **light** and **chlorophyll** are needed for photosynthesis to occur.
- **Carbon dioxide** enters the leaf from the **air**, **water** is absorbed from the soil through the **roots**.
- The word equation for photosynthesis is:

$$\textbf{Carbon dioxide} + \textbf{Water} \xrightarrow[\text{chlorophyll}]{\text{light}} \textbf{Glucose} + \textbf{Oxygen}$$

EXPERIMENT:

13.1 To Test a Leaf for Starch

1. **Leaf in boiling water for 1 minute.**
   (To kill cells and soften leaf).
2. **Leaf in hot methylated spirit or alcohol.**
   (To remove chlorophyll from the leaf).
3. **Leaf rinsed in hot water.**
   (To soften it).
4. **Leaf placed on white tile and iodine added.**
   (To test the leaf for the presence of starch - if starch is present, leaf turns black).



Testing a leaf for starch

Chapter 14 Transport in Plants

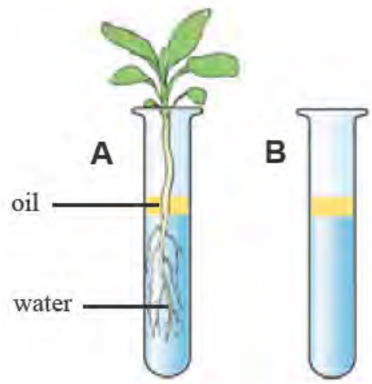
- **Water** is absorbed through the **roots** of a plant.
- **Water** and **minerals** move up through the plant in the **xylem vessels**.
- **Transpiration** is the loss of water vapour from the leaves of a plant.
- Water leaves the plant through the **stomata** of the leaf.
- The **flow** of water through a plant is called the **transpiration stream**.
- **Transpiration** provides **water** for **photosynthesis**, **carries minerals** in the water, and **cools** the plant.
- **Food** is transported from the leaves to the rest of the plant in the **phloem**.

EXPERIMENTS:

14.1 To Show the Absorption of Water by the Roots

A **plant** is placed in a test tube containing **water** and an **oil layer** (to **prevent** water **evaporation**) as shown. The second test tube has no plant and acts as the **control**.

After a week, the water level drops in **A** but not in **B**. **Water was absorbed by the roots in test tube A**.



14.2 To Show the Movement of Water in Plants

A plant stem (e.g. celery) is placed in a beaker of **coloured water** for a week.

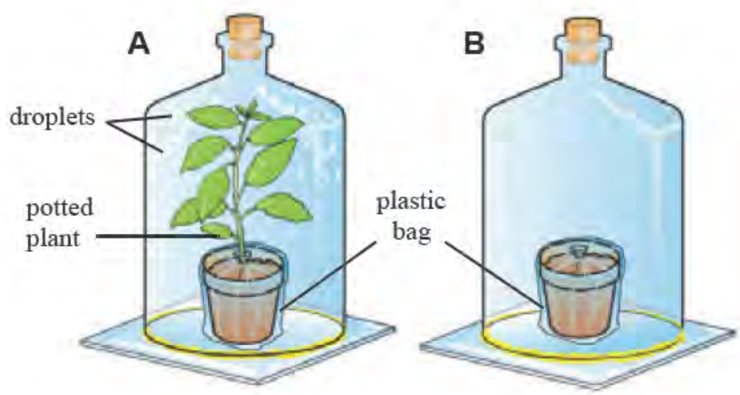
The stem is then cut and the coloured dye is seen in the bundles of xylem vessels in the stem. This shows that **water travels in the xylem vessels up the stem**.

14.4 To Demonstrate Transpiration

A **potted plant**, with the pot sealed in a **plastic bag** is placed in a bell jar as shown. The plastic bag prevents evaporation of water from the pot. Bell jar **B** is set up in the same way, but with no plant - it is the **control**.

After a few hours, **droplets of water** are seen inside bell jar **A**, but not **B**.

Transpiration has occurred in **A** as water evaporated from the leaves.



Chapter 15. Sensitivity in Plants

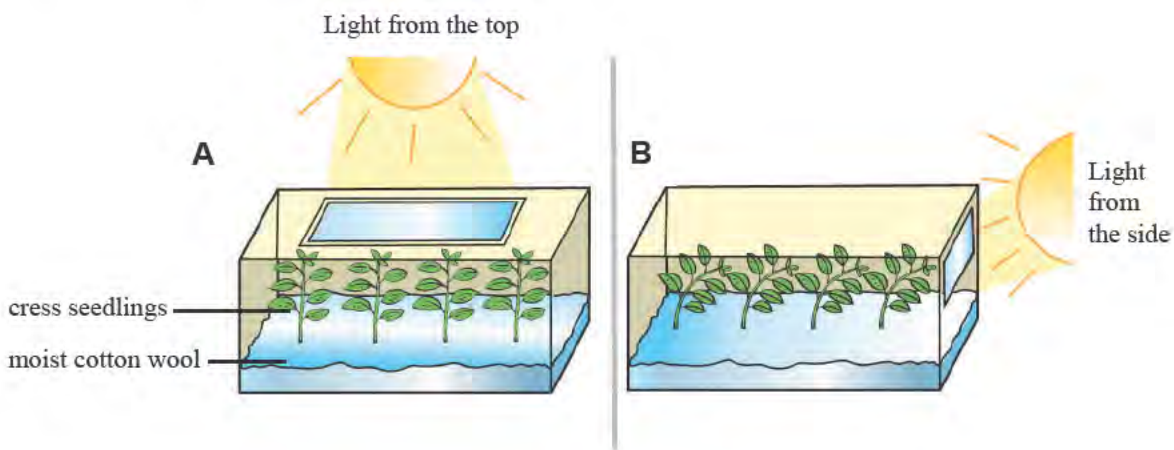
- A **tropism** is the growth of a plant in **response** to a **stimulus**.
- **Phototropism** is a plant's growth response to **light**.
- Plant stems grow towards the light.
- **Geotropism** is a plant's growth response to **gravity**.
- Plant roots grow towards the source of gravity.

EXPERIMENTS:

15.1 To Show Phototropism in Plants

Cress seeds are placed on **moist cotton wool** in boxes with light entering from the **top** (**A**), and light entering from the **side** (**B**).

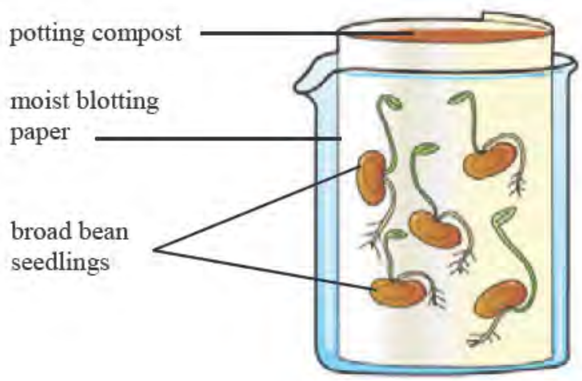
After a **week**, the seedlings are seen to grow **towards the light**.
This experiment demonstrates **phototropism**.



15.2 To Show Geotropism in plants

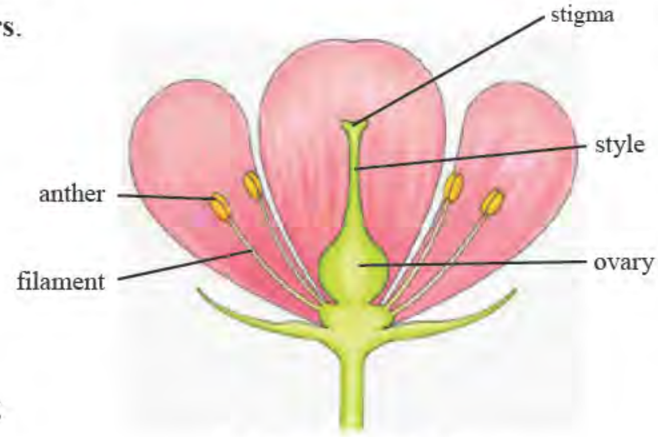
Soaked **broad bean seeds** are placed at different angles in a beaker containing **potting compost** and **moist blotting paper** as shown.

After a week, the young roots are all seen to grow **downwards**.
This experiment demonstrates **geotropism**.



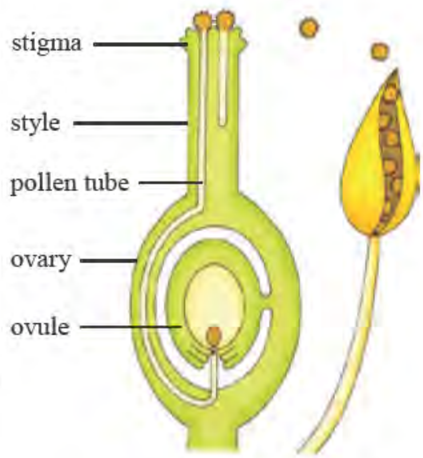
Chapter 16. Plant Reproduction

- **Plants reproduce sexually** by means of **flowers**.
- The **male part**, or **stamen**, consists of the **anther** and **filament**.
- The **female part**, or **carpel**, consists of the **stigma**, **style** and **ovary**.
- **Pollen** is made in the **anther** of the **stamen**.
- The **egg** is made in the **ovary** of the **carpel**.
- Reproduction involves **5 stages**: 1. **Pollination**; 2. **Fertilisation**; 3. **Seed and fruit formation**; 4. **Seed dispersal**; 5. **Germination**.



The Structure of a Flower

- **Pollination** is the **transfer of pollen** from anther to stigma.
- Plants are pollinated by either **insects** or **wind**.
- **Fertilisation** is the **fusion** of the **pollen nucleus** with the **egg nucleus**.
- A **seed** is a **fertilised ovule**.
- The **ovary wall** becomes the **fruit**.
- Seeds are **dispersed** to avoid competition.
- Seeds are **dispersed** by **animal**, **wind**, **self-dispersal**, or **water**.
- **Germination** is the growth of a **seed** into a **new plant**.
- **Water**, **oxygen** and **heat** are needed for **germination**.
- **Asexual reproduction** involves only **one parent**.



Pollination and Fertilisation

(Note: The terms anther, filament, stigma, style and ovary are Higher Level material only. Ordinary Level students need only refer to the stamen as the male part, and the carpel as the female part of the plant).

EXPERIMENT:

16.1 To Show that Water, Oxygen and Heat are Needed for Germination

Four test tubes, with **cress seeds** are set up as follows:

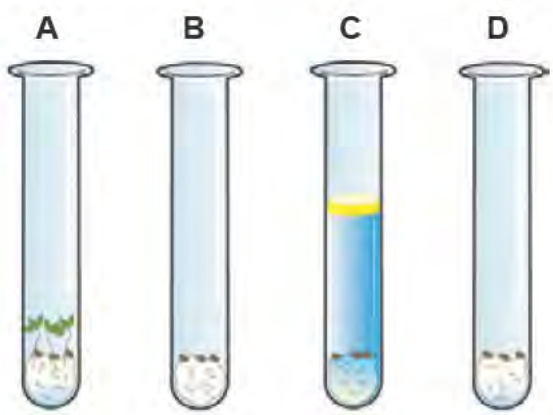
A: **Control** - water, oxygen and heat.

B: No **water** - dry cotton wool.

C: No **oxygen** - boiled water + layer of oil.

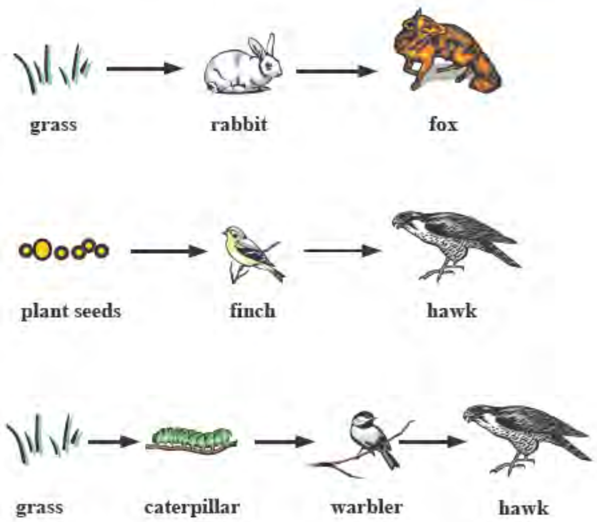
D: No **heat** - left in a fridge.

After one week, **only** the seeds in tube **A** will have germinated - only they have the **water oxygen** and **heat** needed for germination.

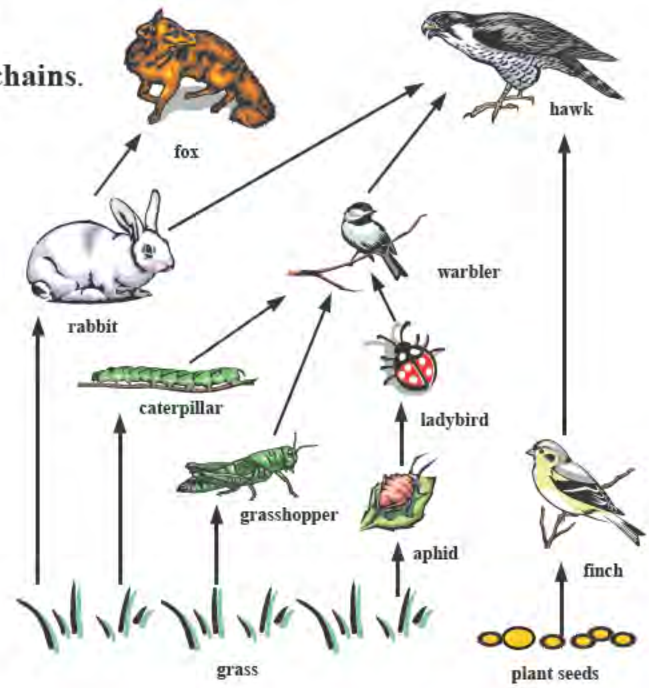


Chapter 17. Ecology

- **Ecology** is the study of the **relationships** of living things, both with their **environment**, and with **one another**.
- The **environment** is everything that surrounds an organism.
- The **habitat** is the place where an animal or plant **lives**.
- Each **habitat** has its own **community** of **animals** and **plants**.
- A **food chain** shows how organisms are **linked** by what they eat.
- **Every food chain** must start with a **green plant**.
- A **food web** is a number of **interconnected food chains**.



3 Food Chains from a Woodland Habitat

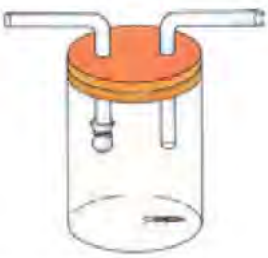


A Food Web from a Woodland Habitat

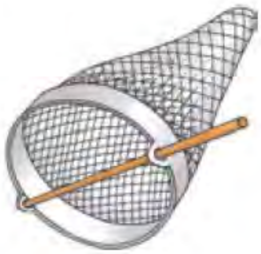
- **Energy** from the **Sun** gets **transferred** through a food chain.
- **Producers** make their **own food** (e.g. green plants).
- **Consumers** are all organisms other than green plants.
- **Decomposers** are organisms that feed on **dead animals** and **plants**.
- The **feeding level** is the **position** an organism has in the food chain.
- **Green plants** are at the **first** feeding level.
- **Competition** occurs when organisms seek a **resource** in the habitat that is **limited**.
- **Plants** compete for **light**, **water**, **minerals** and **space**.
- **Animals** compete for **food**, **shelter**, **territory** and **mates**.
- **Interdependence** is how organisms depend on each other for their survival.
- **Organisms** are **adapted** to their environment so that they can **compete successfully**.

Chapter 18. Habitat Study

- **Examples** of **habitats** include: **woodland** habitat, **pond** habitat, **hedgerow** habitat.
- A habitat study involves **5 stages**. They are: (**1**) making a simple map; (**2**) measuring the environmental factors; (**3**) collecting samples; (**4**) identifying and listing samples; (**5**) estimating the numbers of organisms present.
- A **simple map** should include the **direction North**, a **scale** and a **legend**.
- **Air**, **water** and **soil temperatures** are taken using a **thermometer**.
- **Light intensity** in the habitat is measured using a **light meter**.
- Equipment used for **collecting animals** include a **pooter**, a **net**, a **beating tray**, and a **pitfall trap**.



A **pooter** is used to suck up insects into the collecting jar. A gauze on one tube prevents insects from being swallowed.



A **sweep net** is swept through long grass or hedges to collect insects.

A **beating tray** is used to collect small animals from trees and shrubs.

A **pitfall trap** is used to collect small, crawling animals. It is a jam-jar, dug into the ground, with a slate placed over the top.

- A **quadrat** is used to estimate **plant numbers**. A square frame, it is placed on the ground at random. About 10 throws are made and, for each throw, the plants present are recorded in a table.
  The **% frequency** of each plant in the habitat can then be found, and the results shown on a **bar chart**.
- A **line transect** is used to show changes in plant numbers across a boundary in the habitat.
- **Plants and animals** in the habitat may be identified by using simple **keys**.
  A **key** is a set of simple **questions** which are asked about the organism you are trying to identify.
  Your answer leads you to **another question** and so on, until you have made an identification.

A **quadrat** is used to estimate the numbers of plants (% frequency) in the habitat.

Chapter 19. Conservation and Pollution

- **Conservation** is the **protection**, **preservation** and **careful use** of our **natural resources**.
- **Pollution** is adding **unwanted wastes** to the environment, causing **damage** to it.
- **Air pollution** is caused by **smoke**, **dust** and **harmful gases**.
- When a **fossil fuel** is **burned**, the gases **carbon dioxide** and **sulfur dioxide** are released. They dissolve in rainwater to form **acid rain**.
- **Acid rain** damages **plants**, kills **fish** and eats away the **stonework** of buildings.
- Increasing levels of **carbon dioxide** cause the **'Greenhouse effect'**.
- **Soil pollution** is caused by **pesticides**, **fertilisers** and **acid rain**.
- **Water pollution** is caused by **fertilisers**, **sewage**, **slurry** and **oil**.
- **Waste management** involves the careful use of **incineration**, **landfill sites**, and **burial at sea**, so as not to harm the environment.
- Materials such as **paper**, **glass**, some **metals** and **plastics** can be **recycled**.
- Living organisms affect the environment in **positive ways** as well as in negative ways.
- **Positive ways** include using **unleaded petrol**, cars with **low exhaust emissions**, using **less plastic bags** due to the bag tax and using **smokeless coal**.

The effect of acid rain on a statue.

Overuse of artificial fertilisers and pesticides causes soil pollution.

'Bottle banks' allow individuals to recycle some kinds of materials

Landfill sites are commonly used to mansge wastes.

Chapter 20. Micro-organisms

- **Microbiology** is the **study** of micro-organisms **- viruses**, **bacteria** and **fungi**.
- **Viruses** can only reproduce inside **living cells** - they all cause **disease**.
- **Viruses** cause **colds**, **'flu**, **measles**, **mumps**, and **AID's**.
- **Bacteria** are simple **living cells** and are found almost everywhere.
- **Soil bacteria** break down (**decompose**) **dead plant** and **animal** material and release their **nutrients** back to the **soil**.
- **Bacteria** are used to: **decay wastes**, and to **make cheese**, **yoghurt**, and **silage**.
- **Harmful bacteria** cause **diseases**, **food spoilage** and **tooth decay**.
- **Fungi** are used in **brewing**, **baking**, making **antibiotics**, and some are **edible**.
- **Harmful fungi** cause animal and plant **diseases**, **food spoilage** and are **poisonous**.
- **Biotechnology** is the use of **living things** (micro-organisms) to make **useful substances**.
- Examples of **biotechnology** are: using **bacteria** to make **cheese; yeast** to make **alcohol.**

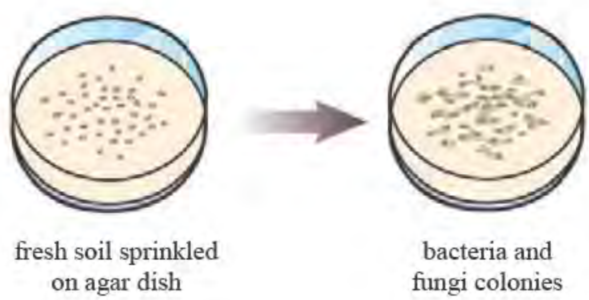
EXPERIMENTS:

20.1 To Show the Presence of Micro-organisms in Air

- Leave one agar dish **open to the air** for 20 minutes, replace the lid and incubate for 2 days. As a **control**, leave another **agar dish closed** and incubate as above.
- **Colonies** of bacteria and fungi are seen on the **plate left open**. The **unopened dish** remains **clear**.
- **Bacteria** and **fungi** from the **air** had landed on the agar dish and started to grow.

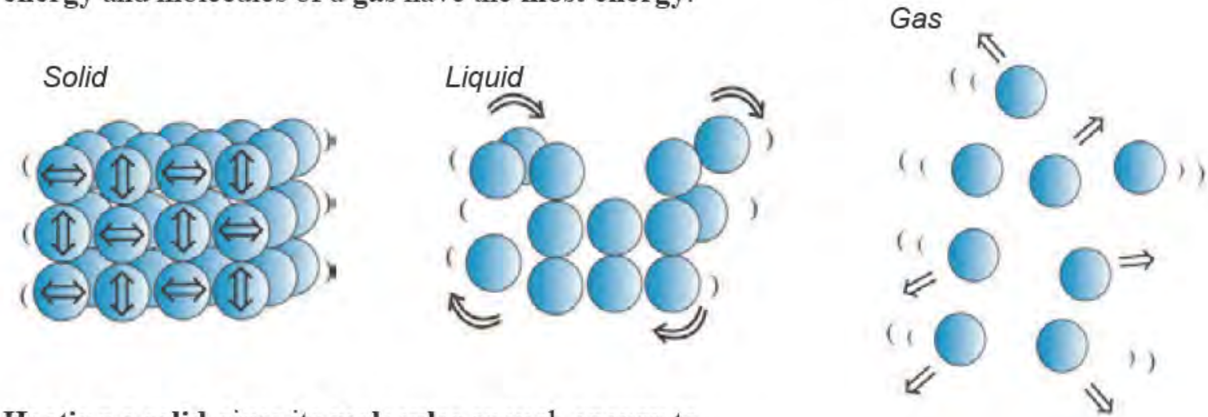
20.2 To Show the Presence of Micro-organisms in Soil

- Sprinkle **fresh soil** on one agar dish and leave at room temperature for one week. As a **control**, sprinkle another dish with **sterilised soil** (strongly heated) and leave as above.
- **Colonies of bacteria and fungi** are seen on the fresh soil dish. The other dish remains clear.
- **Micro-organisms** in the **fresh soil** had grown on the agar dish.

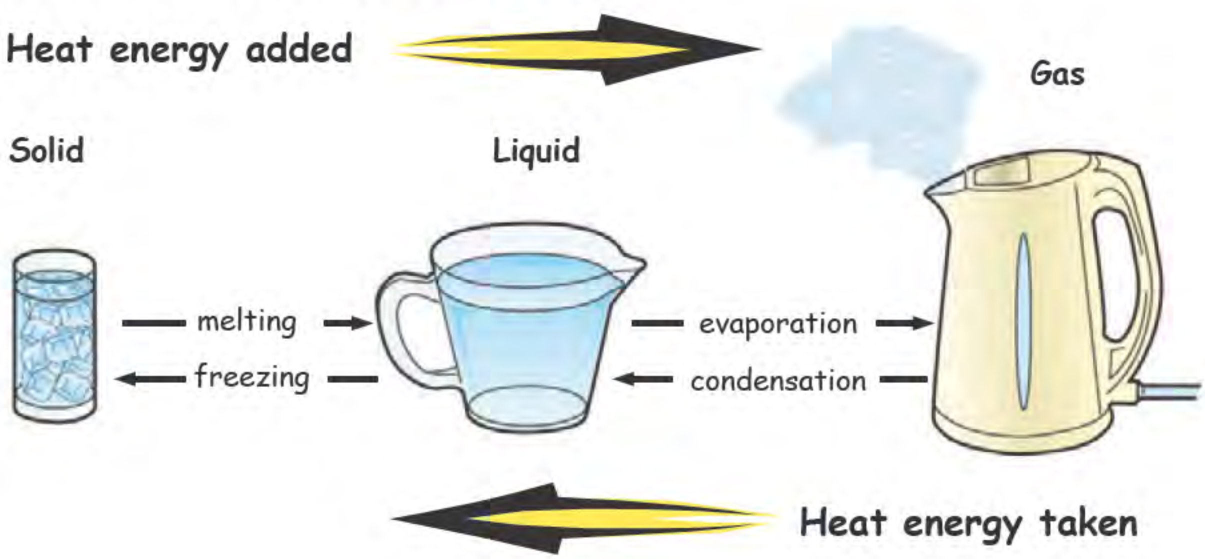


Chapter 21. States of Matter

- **Matter** is anything that takes up **space** and has **mass**.
- **Solids** have a **definite mass**, **definite shape** and **definite volume**.
  They do not flow and can't be squeezed into a smaller space.
- **Liquids** have a **definite mass**, **definite volume** but **no definite shape**.
  They can **flow** but can't be squeezed into a smaller space.
- **Gases** have a **definite mass**, but **no definite volume** or **shape**.
  They move into the available space and can be squeezed into a smaller space.
- **Molecules** of a **solid** have the **least energy**, molecules of a **liquid** have **more energy** and molecules of a **gas** have the **most energy**.

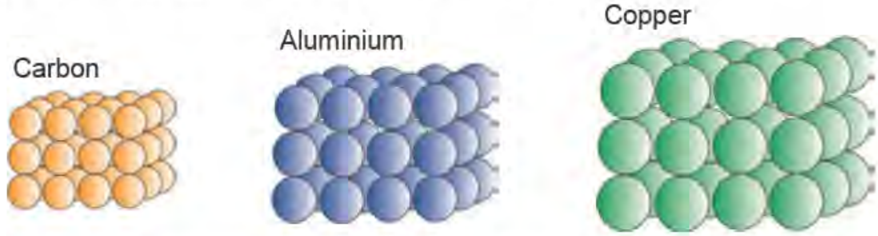


- **Heating a solid** gives its **molecules** enough **energy** to behave like a liquid (it **melts**).
- **Heating a liquid** gives its **molecules** enough **energy** to behave like a gas (it **evaporates**).
- The **melting point** of a solid is the temperature at which both the solid and liquid states of a substance exist together.
- **Evaporation** is the changing of a liquid to a gas or vapour.
- The **boiling point** of a liquid is the temperature at which evaporation begins to occur throughout the liquid.
- **Condensation** is the changing of a gas to a liquid.



Chapter 22. Elements, Compounds, Mixtures

- An **element** is a substance which cannot be broken down into simpler substances by chemical means.
- **Examples of elements** that are **metals** are: iron (Fe), copper (Cu), zinc (Zn), aluminium (Al), silver (Ag), gold (Au), and sodium (Na).

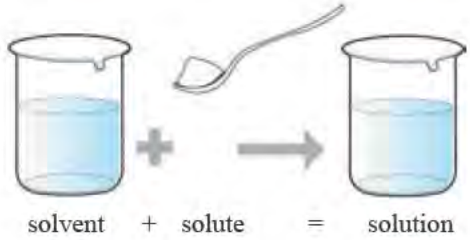


- **Examples of elements** that are **non-metals** are: carbon (C), sulfur (S), chlorine (Cl), oxygen (O), hydrogen (H), and nitrogen (N)
- An **atom** is the smallest part of an element that still has the properties of that element.
- A **compound** is formed when two or more elements combine chemically.
- **Examples of compounds** are: water (H_2O), carbon dioxide (CO_2), sodium chloride (NaCl), magnesium oxide (MgO), and iron sulfide (FeS).
- A **compound** is a completely new substance with its own properties.
- A **molecule** is the smallest part of an element or compound that can exist on its own.
- **Examples of molecules** are: H_2O, CO_2, HCl, MgO, FeS, O_2, H_2, and Cl_2.

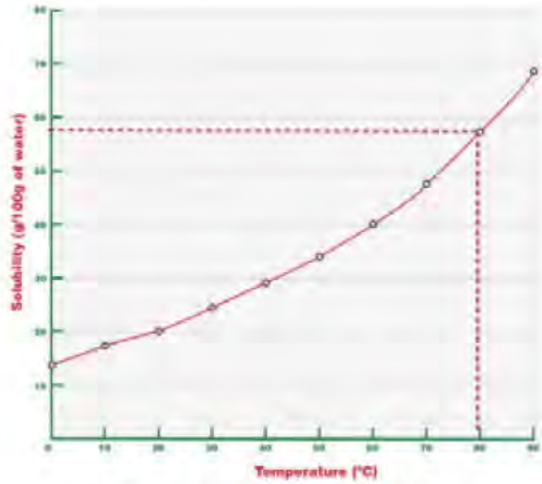
- A **mixture** consists of two or more different substances **mingled** together but **not chemically combined**.
- **Examples of mixtures** are: air (nitrogen + oxygen + carbon dioxide), seawater (water + salt), **ink** (water + various dyes), steel (iron + carbon).
- **Differences** between mixtures and compounds:

	MIXTURE	*COMPOUND*
1.	Consists of two or more substances.	Consists of a single substance
2.	The proportion of each substance in the mixture does not matter	The elements in a compound are always in a fixed proportion.
3.	The properties are the same as those of the substances used.	The properties are very different to those of the elements used.
4.	Usually easy to separate.	Very difficult to separate.

Chapter 23. Solutions



- A **solution** is a **mixture** of a **solute** and a **solvent**.
- A **solute** is the substance which is **dissolved**.
- A **solvent** is the **liquid** in which the **solute dissolves**.
- When blue **copper sulfate** (**solute**) is dissolved in **water** (**solvent**) a **solution** of copper sulfate in water is formed.
- The **hotter** a solution of copper sulfate is, the **more** solute it will dissolve.
- A **saturated solution** is one which contains as much dissolved solute as possible, at a given temperature.
- A **solubility curve** shows how the solubility of a substance changes with increasing temperature.
- A **concentrated solution** has a large amount of solute in a small amount of solvent.
- A **dilute solution** has a small amount of solute in a large amount of solvent.



solubility curve for copper sulfate

- A **dilute solution** can be made more concentrated by either **adding** more solute, or by **evaporating** off some of the solvent.
- **Crystallisation**: The forming of crystals when a hot saturated solution is cooled.
- When a **hot saturated solution** of copper sulfate is allowed to **cool**, blue **crystals** of copper sulfate are formed.

EXPERIMENTS:

24.1 To Investigate the Solubility of Different Substances in Water

A **spatula full** of each substance is added to water in a test tube.

The test tube is **stoppered** and **shaken** to see which dissolve.

24.2 To Investigate the Solubility of Copper Sulfate at Different Temperatures

The mass of **copper sulfate** that will dissolve in **100 g** of **water** at **20°C** is found using an **electronic balance**.

The water is **heated** to **30°C** and **more copper sulfate** is added to find the mass that can dissolve at this temperature.

This is repeated for temperatures of **40°C** , **50°C** and **60°C**.

The results are **plotted** on graph paper to give a **solubility curve** for copper sulfate (see above).

24.3 Growing Copper Sulfate Crystals

A **hot**, **concentrated solution** of copper sulfate is poured onto a warm evaporating dish. The dish is left for 3 hours.

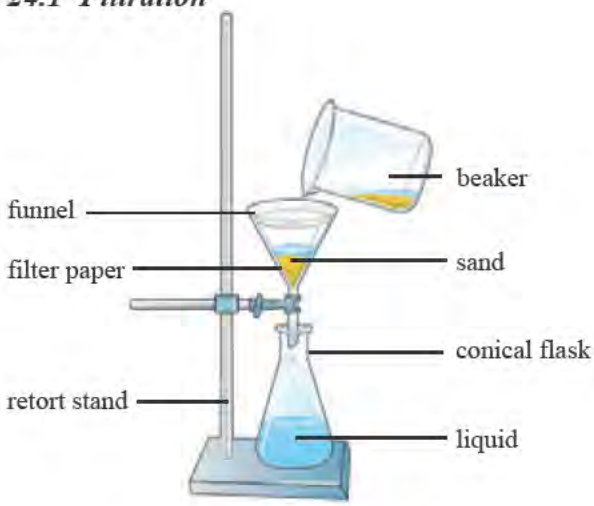
Crystals of **copper sulfate** form as the solution cools.

Chapter 24. Separating Mixtures

- **Filtration** is a method used to separate small **insoluble solids** from a **liquid** by using **filter paper** to trap the solids.
- **Evaporation** is a method used to separate **soluble solids** from a **solution** by **evaporating** off the liquid to leave the solids.
- **Crystallisation** occurs when crystals appear from a solution which has been **evaporated**.
- **Crystallisation** occurs when crystals appear from a **hot**, **concentrated solution** which has **cooled**.
- **Distillation** is used to separate **two liquids** with different **boiling points** such as alcohol and water. It is also used to separate a **soluble solid** from a **liquid** (e.g. seawater) to give a pure sample of each.
- **Chromatography** is a method used to separate a mixture of dissolved substances in a solution.

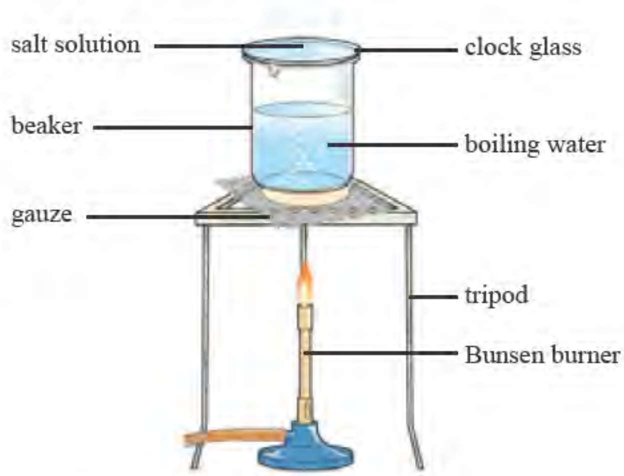
EXPERIMENTS:

24.1 Filtration



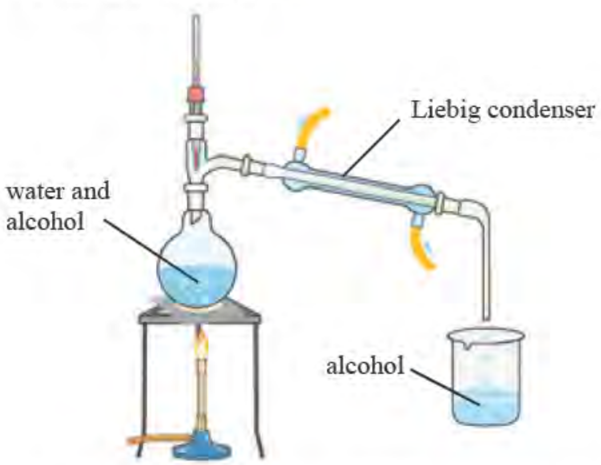
- The sand is trapped in the filter paper, the water goes through.

24.2 Evaporation



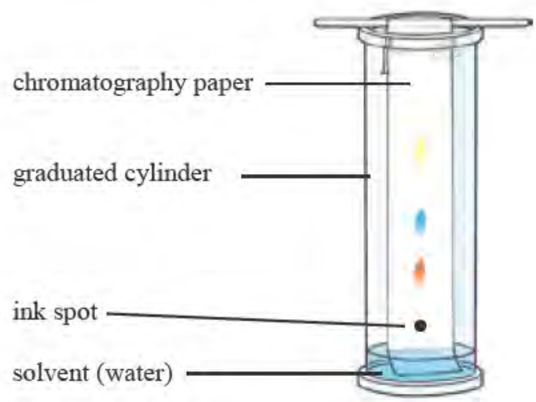
- The water evaporates, the salt remains on the clock glass and forms crystals.

24.3 Distillation



- The alcohol (boiling point 78°C) evaporates first, condenses in the Liebig condenser and is collected.

24.4 Chromatography



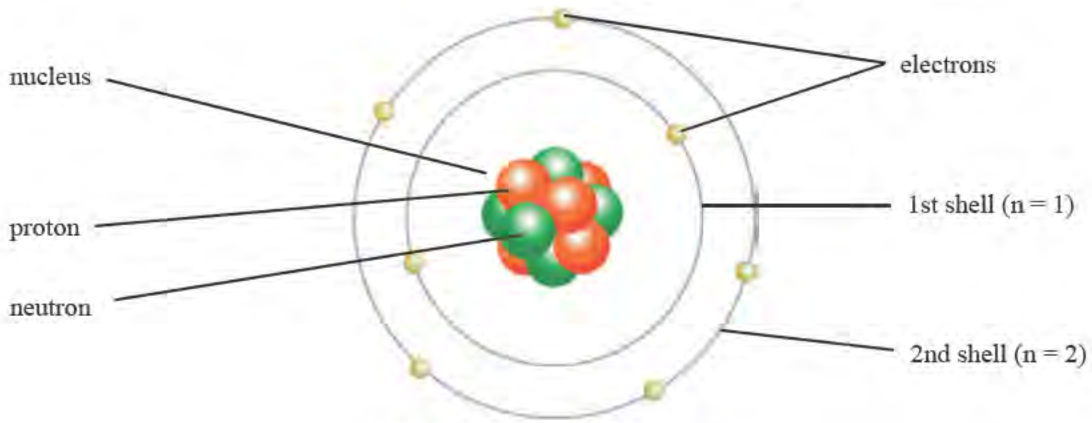
- The more soluble dyes stay in solution longer and get deposited further up the chromatography paper.

Chapter 25. The Atom - A Closer Look

- The **atom** is made up of sub-atomic particles called **protons**, **neutrons** and **electrons**.

	MASS	CHARGE	LOCATION
PROTON	1 amu	+1	In the nucleus
NEUTRON	1 amu	0	In the nucleus
ELECTRON	1/1840 amu	–1	Orbiting the nucleus

- The **atomic number** of an atom is the **number** of **protons** it has in its nucleus.
- Atoms are arranged in the **Periodic Table** according to the **number** of **protons** they have.
- Atoms are **electrically neutral** because they have the **same number** of **electrons** as **protons**.
- **Electrons** are found in **shells** around the nucleus.
  The **first shell** can only hold **2 electrons**, all the others can hold a maximum of **8**.
- Shells are filled from the **inside** (1st shell) **outwards**.
- The **atomic number** of **sodium** (Na) is **11**, - it has 11 protons and therefore 11 electrons.
  Its **electronic configuration** is **2**, **8**, **1** (i.e. three shells of electrons).
- The electronic configuration of **calcium** (atomic number = **20**) **is 2**, **8**, **8**, **1**.
- The **atom** shown below is an atom of **nitrogen** (N). How do you know?



The Bohr structure of the atom

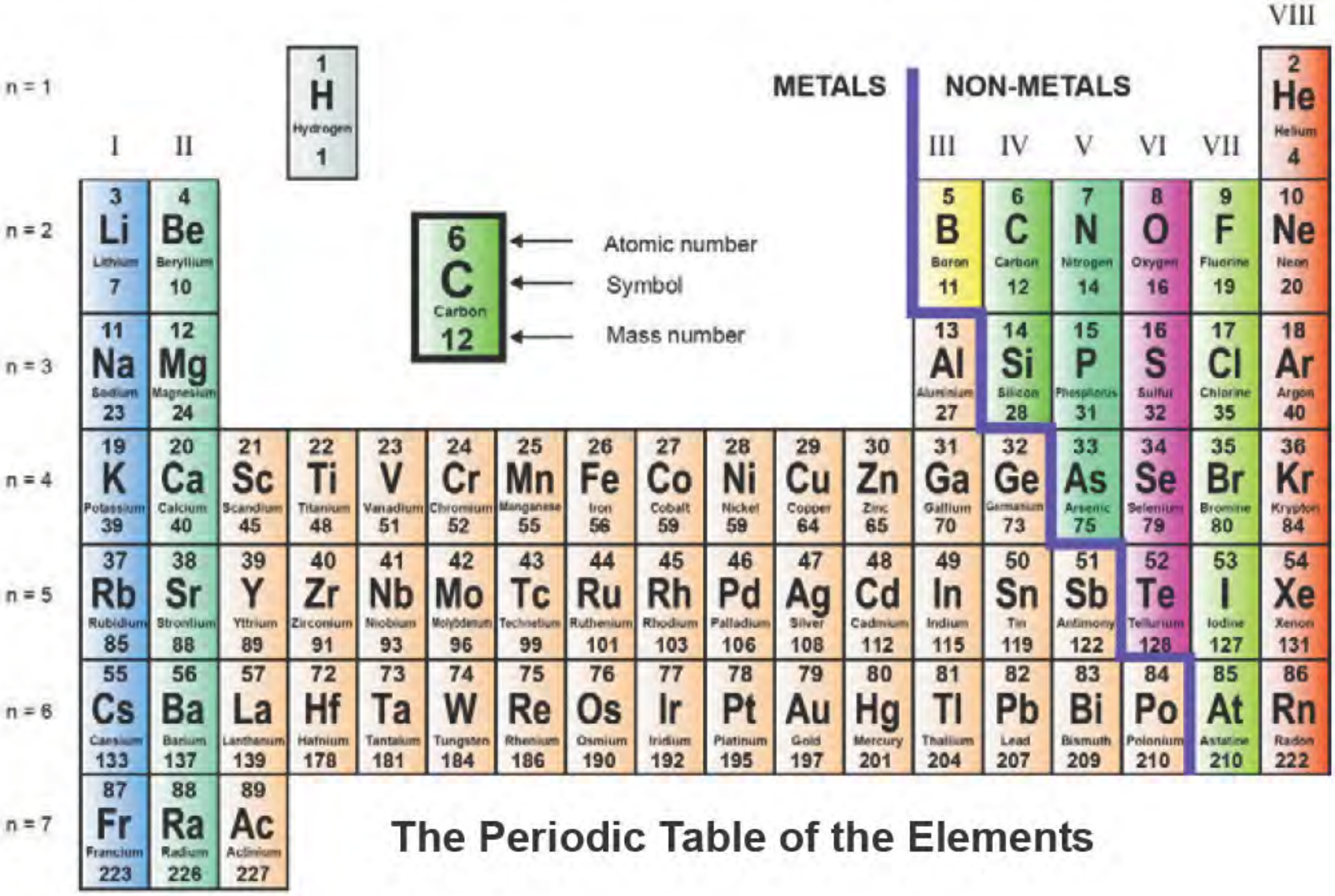
- The **mass number** of an atom is the number of **protons plus** the number of **neutrons** in its nucleus.
- **The mass number** is the **larger number**, written **below** the element symbol in the **Periodic Table**.
- **An atom of sodium** has **11 protons** (atomic number 11) and **11 electrons**, it has 23 protons plus neutrons (mass number 23), so it has **12 neutrons** in its nucleus (23 – 11 = 12).

11
Na
23

- **Isotopes** are **atoms** of the **same element**, which have **different numbers of neutrons**.
- **Isotopes** of an element therefore have the **same atomic number**, but **different mass numbers**.

Chapter 26. The Periodic Table

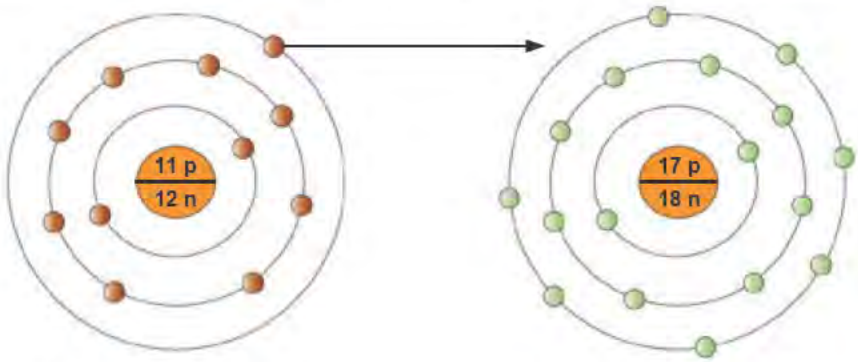
- The **atomic number** of an atom is the number of **protons** in the nucleus of that atom.
- The **Periodic Table** arranges the elements in order of **increasing atomic number**.



- A **Group** is a **vertical column** of elements that all have the same number of electrons in their outside shells.
- **All the elements** in a particular Group behave in a similar manner chemically.
- Group I is the **Alkali Metals**, and includes the elements **lithium**, **sodium** and **potassium**.
- Group II is the **Alkaline Earth Metals**, and includes the elements **magnesium** and **calcium**.
- Group VII is the **Halogens**, and includes the elements **helium**, **neon** and **argon**.
- Group VIII is the **Noble Gases**.
- A **Period** is a **horizontal row** of elements in the Periodic Table.
- **Periods are numbered** n=1; n=2; n=3; etc.
- All the elements in a Period have the same number of electron shells.
- The Periodic Table can be divided into **metals** (on the left and middle), and **non-metals** (on the right).
- Common **metal elements** include: Cu, Zn, Al, Pb, Fe, Ag and Au.
- Common **non-metal elements** include: C, O, S, H and N.

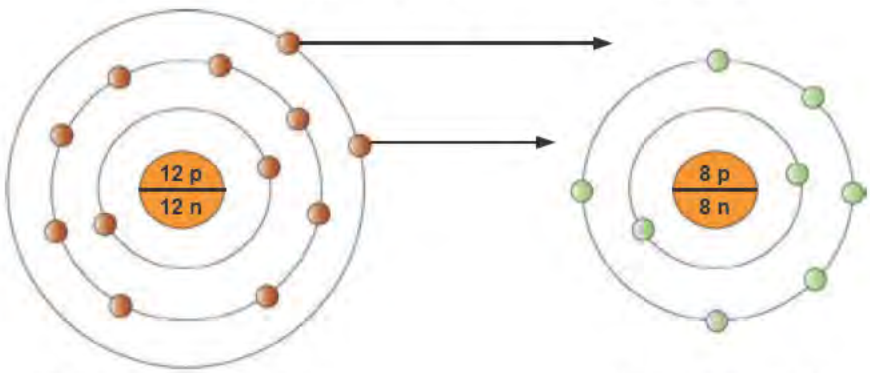
Chapter 27. Chemical Bonding I - Ionic

- Atoms combine with each other to form **compounds**.
- A **chemical bond** holds atoms together in a compound.
- The **noble gases** (Group VIII elements) have the **most stable** electron setup. They have an outer shell of 8 electrons (i.e. they all have a **full outer shell**).
- The **Octet Rule** states that atoms bond together so that each atom ends up with an electron arrangement with 8 electrons in its outermost shell.
- An **ionic bond** is formed when electrons are **given** or **taken** by atoms.
- An **ion** is a positively or negatively charged atom or group of atoms.
- When an atom **loses electrons**, it becomes a **positively charged** ion.
- When an atom **gains electrons**, it becomes a negatively **charged** ion.
- A **sodium atom** (2, 8, 1) gives its outer electron to a **chlorine atom** (2, 8, 7) to form NaCl, **sodium chloride**, made up of **sodium ions** (Na^+) and **chloride ions** (Cl^-). An **ionic bond** is formed and both **ions** now have a **full outer shell** of 8 electrons.



Sodium atom (2,8,1) Chlorine atom (2,8,7)

- In the same way, a **magnesium atom** forms an **ionic bond** with an **oxygen atom** by **giving** it its two outer electrons. The ionic compound, **magnesium oxide** (MgO) is formed.

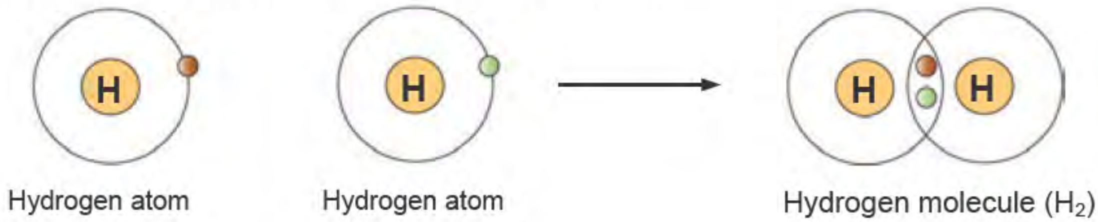


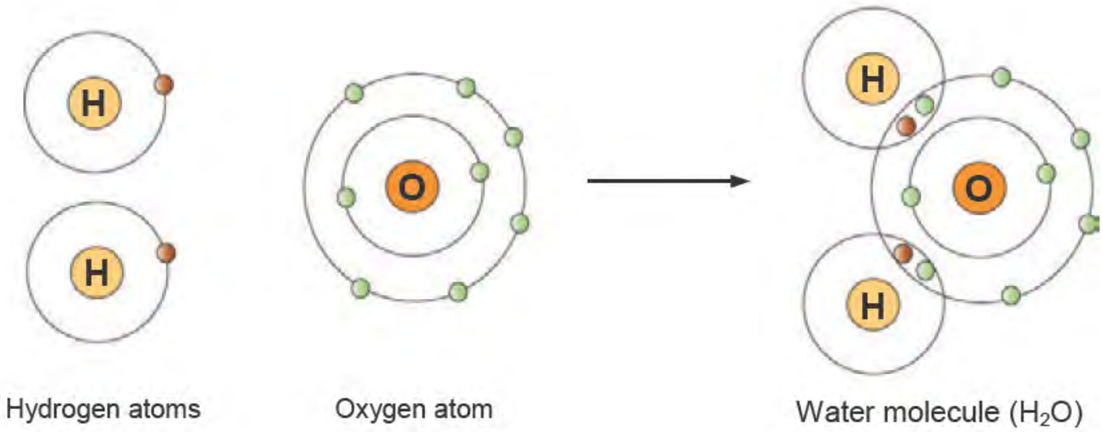
Magnesium atom (2,8,2) Oxygen atom (2,6)

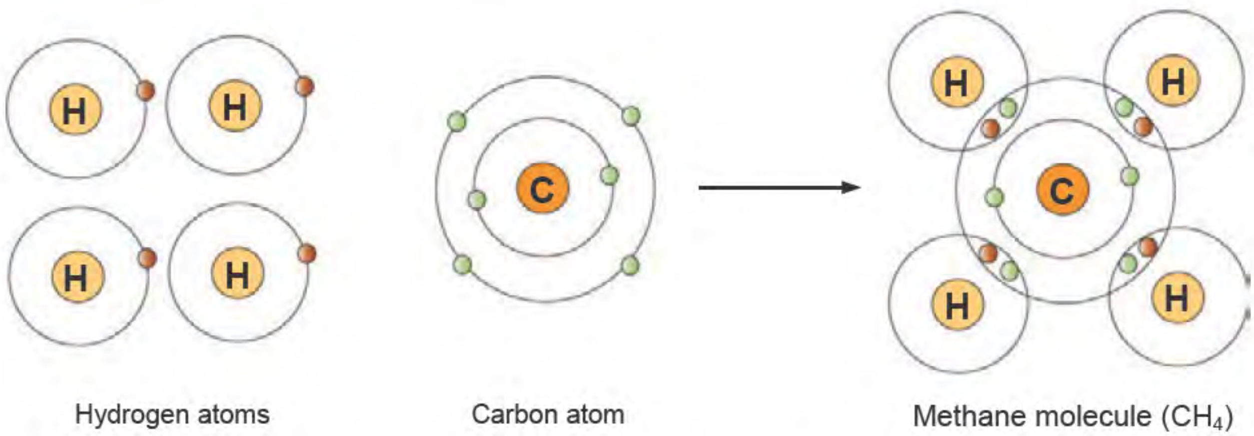
- An **ionic bond** is formed by the **force of attraction** between a **positive** and a **negative ion**.

Chapter 28. Chemical Bonding II - Covalent

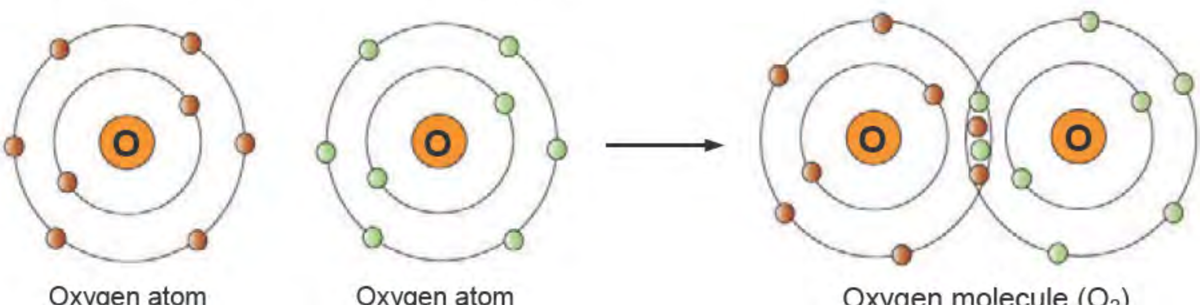
- A **covalent bond** is formed when atoms combine by **sharing electrons** so that each atom has a stable outer shell of electrons.
- A **single** covalent bond is formed when atoms share **one pair** of electrons.
- **Single covalent bonds** occur in the following molecules:





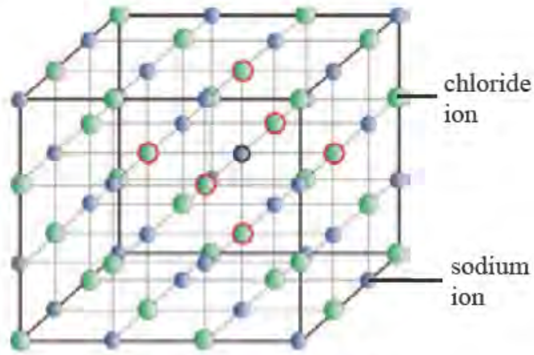


- A **double covalent bond** is formed when atoms share **2 pairs** of electrons.
- A **double bond** occurs in the **oxygen molecule**:



Chapter 29. Ionic & Covalent Compounds

- **Ionic bonds** are formed between **metals** and **non-metals**.
- **Ionic compounds** consist of many oppositely charged ions held together strongly to form a **crystal lattice**.
- Examples of ionic compounds include: **sodium chloride** ($NaCl$), and **magnesium oxide** (MgO).
- A **covalent compound** is made up of separate, **single molecules**.
- In a covalent compound, there is a fairly **weak attraction *between*** the individual molecules.
- Examples of **covalent compounds** include: **water** (H_2O), **carbon dioxide** (CO_2), and **methane gas** (CH_4).



The sodium chloride crystal lattice

ionic compounds	covalent compounds
Consist of crystal lattices	**Consist of separate molecules**
Usually crystalline solids	**Usually liquids or gases**
High melting and boiling points	**Low melting and boiling points**
Usually soluble in water	**Usually insoluble in water**
Conduct electricity when melted or in solution (see experiment below)	**Do not conduct electricity (see experiment below)**

EXPERIMENT:

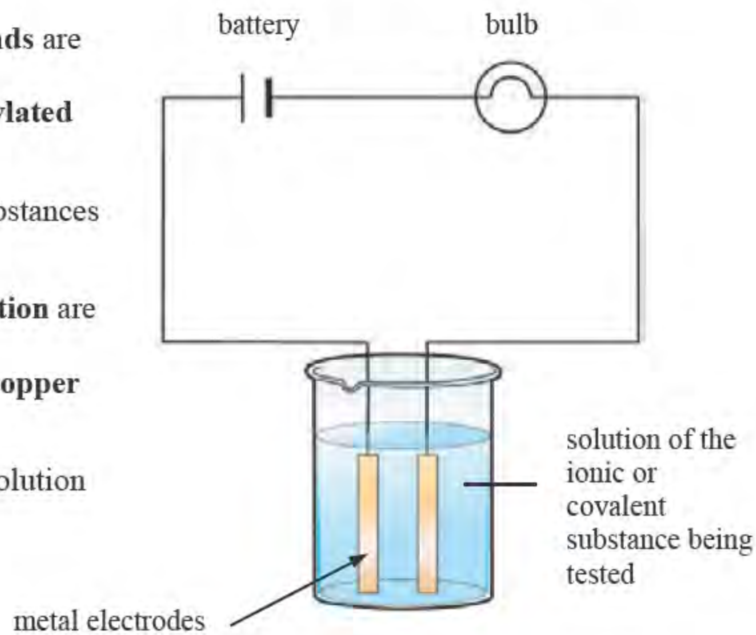
29.1 To Investigate the Ability of Ionic and Covalent Compounds to Conduct Electricity

A circuit is set up as shown.
A variety of **covalent liquid compounds** are poured into the beaker.
Examples include: **paraffin oil**, **methylated spirit**, **distilled water**.

The **bulb does not light**. **Covalent** substances will **not conduct electricity**.

A variety of **ionic compounds in solution** are poured into the beaker.
Examples include: **sodium chloride**, **copper sulfate**, **sodium hydroxide**.

The bulb lights. **Ionic** substances in solution will **conduct electricity**.



Chapter 30 ACIDS & BASES

- An **acid** is a substance that **turns blue litmus** paper **red**.
- **Strong acids** are **hydrochloric acid** (HCl) and **sulfuric acid** H_2SO_4.
- **Weak acids** include **vinegar**, **lemon juice**, and **acid rain**.
- A **base** is a substance that **turns red litmus** paper **blue**.
- **Bases** that are **soluble in water** are called **alkalis**.
- **Strong bases** are **sodium hydroxide**, NaOH, and **calcium hydroxide**, $Ca(OH)_2$.
- **Weak bases** include **toothpaste**, **soap** and **window cleaner**.
- An **indicator** is a chemical which shows, by means of a colour change, whether a substance is an acid or a base. **Litmus** is an indicator.
- The **pH scale** goes from **0 to 14** and measures the strength of an acid or a base.
- **Universal indicator paper** is used to **measure the pH** of a substance.
- **Neutral solutions** have a pH of 7.
  Acids have a pH of **less than** 7.
  Alkalis have a pH of **greater than** 7.
- A **neutralisation reaction** occurs when an **acid** and a **base** react together and neutralise each other to form a **salt** and **water**.
- An experiment to neutralise an acid (HCl) with a base (NaOH) is called a **titration**. A **burette**, **pipette**, **conical flask** and **white tile** are used.

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

- A **salt** (e.g. NaCl) is formed when the **hydrogen in the acid** is replaced by a **metal**.
- The **salt** can be seen by **evaporating off** the water in a **clock glass**.
- Acids are involved in the following reactions:

$$\text{Acid} + \text{Base} \longrightarrow \text{Salt} + \text{Water}$$
$$HCl + NaOH \longrightarrow NaCl + H_2O$$

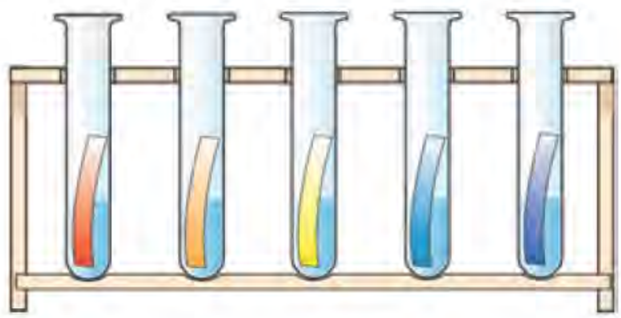
$$\text{Acid} + \text{Carbonate} \longrightarrow \text{Salt} + \text{Water} + \text{Carbon dioxide}$$
$$2HCl + CaCO_3 \longrightarrow CaCl_2 + H_2O + CO_2$$

EXPERIMENTS:

30.1 Testing the pH of Various Chemicals

Various **acids** and **alkalis** are placed in test tubes and tested with strips of **universal indicator paper**.

The **colour change** of the paper is then compared with a **pH colour chart** to find the **pH** of the solution.

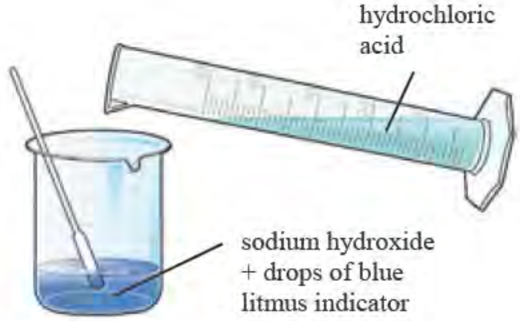


30.2 To Show the Neutralisation of an Acid with a Base

A graduated cylinder is used to add **dilute hydrochloric acid** to a beaker containing 25 ml of **dilute sodium hydroxide**, and a few drops of **litmus solution**.

Neutralisation is complete when the contents of the beaker **just** begin to change colour from blue to red.

Record how much acid is just neutralised by the 25 ml of alkali used.



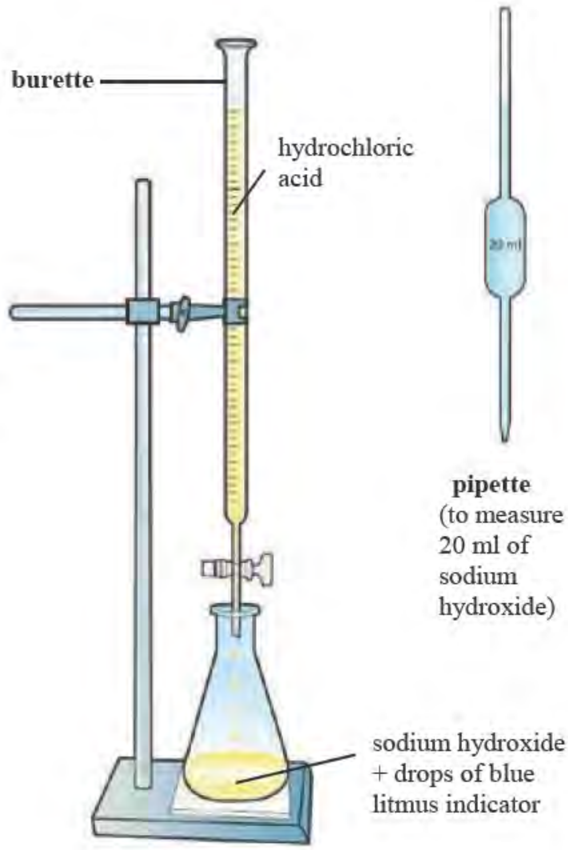
30.3 To Neutralise an Acid with a Base by Titration

A fixed volume of **hydrochloric acid** is placed in a **burette**. A **pipette** is used to measure 20 ml of **sodium hydroxide** into a **conical flask**.
A few drops of **litmus indicator** is added to the flask. A **white tile** is placed under the flask to see the colour change easily.

The **acid** is **added slowly** while the **flask is shaken**. When the solution in the flask **just begins** to change colour, **neutralisation** is complete, and the **volume of acid used** is noted. This is repeated and an **average volume** of acid needed is calculated.

The **titration** is repeated again, without litmus indicator and using the volume of acid calculated before.

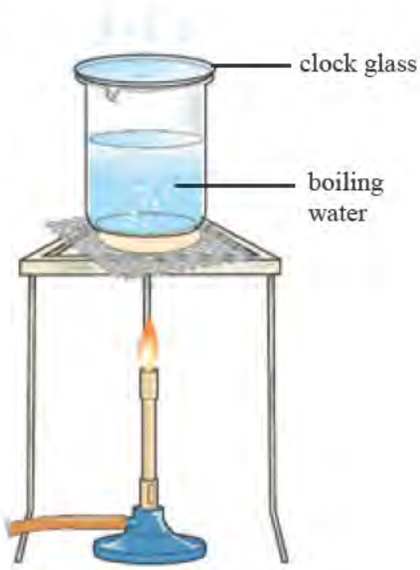
The flask now contains the salt, **sodium chloride** and **water**.



30.4 To Show the Salt formed from the Neutralisation Reaction

A sample of the **salt solution** from the flask (***30.3***) is placed in a clock glass.
The **water** in the **clock glass** is **evaporated off** as shown.

This leaves crystals of **sodium chloride** on the clock glass.



CHAPTER 31 AIR

- Air consists of the **elements** nitrogen (78%), oxygen (21%), argon (<1%), and the **compounds** carbon dioxide (0.03%) and water vapour (0 - 4%).

- Air is a **mixture** because:
  - Its **composition varies** from place to place.
  - The different gases **condense** as liquids at **different temperatures**.

- **Cobalt chloride paper** is used to test for the presence of **water**. It is **blue** when **dry**, **pink** when **wet**.

- **Limewater** is used to test for **carbon dioxide**. Carbon dioxide turns limewater **milky**.

  Limewater + Carbon dioxide ⟶ Chalk + Water

  $Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O$

- **Oxygen** is prepared by the breakdown of **hydrogen peroxide** (H_2O_2) in the presence of **manganese dioxide** (MnO_2).

- **Manganese dioxide** is a **catalyst - it speeds up** the breakdown of the hydrogen peroxide into water and oxygen.

- A **catalyst** is a substance that **speeds up** a chemical reaction.

- A **glowing splint** is used to test for **oxygen**. **Oxygen relights** a **glowing splint**.

- **Carbon dioxide** is prepared by the reaction between dilute **hydrochloric acid** (HCl) and **marble chips** (calcium carbonate, $CaCO_3$).

Calcium carbonate + hydrochloric acid ⟶ calcium chloride + water + carbon dioxide

$CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + CO_2$

Properties of Oxygen	
Physical	**Chemical**
1. colourless, odourless, tasteless **2**. slightly heavier than air **3**. slightly soluble in water	**1**. supports burning (combustion) **2**. very reactive element, easily forming oxides: $2Mg + O_2 \longrightarrow 2MgO$ $C + O_2 \longrightarrow CO_2$ **3**. neutral to litmus paper

Properties of Carbon dioxide	
Physical	**Chemical**
1. colourless, odourless, tasteless 2. heavier than air 3. moderately soluble in water	1. does not supports burning 2. turns limewater milky 3. forms carbonic acid in water $CO_2 + H_2O \longrightarrow H_2CO_3$ 4. acidic to litmus paper

- **Oxygen** is used for **breathing**, **welding** and **burning**.

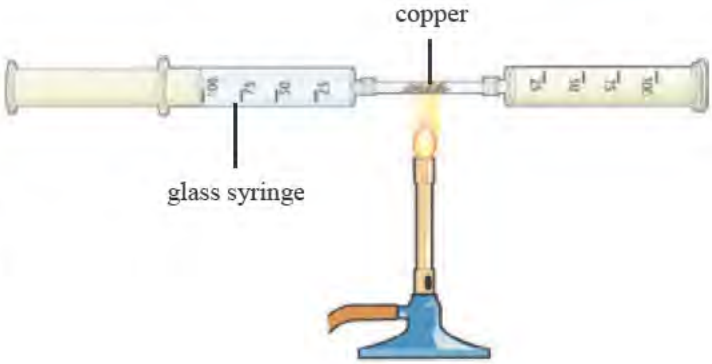
- **Carbon dioxide** is used in **photosynthesis**, **fire extinguishers** and **fizzy drinks**.

EXPERIMENTS:

31.1 To Measure the Percentage of Oxygen in Air

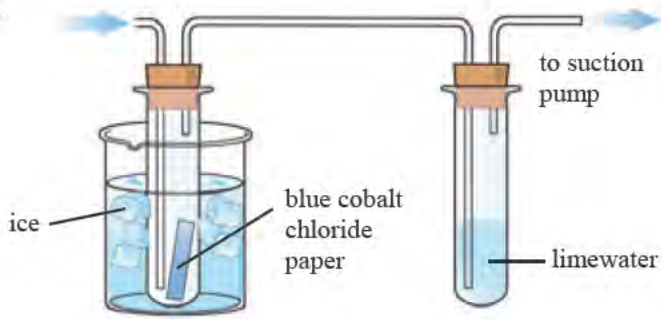
100 cm^3 of air is repeatedly passed from one syringe to the other.
Copper is heated strongly in the tube.

The oxygen in the air reacts with the **copper**, forming **copper oxide**.
Only 79 cm^3 of air remains.
Oxygen comprises **21%** of air.



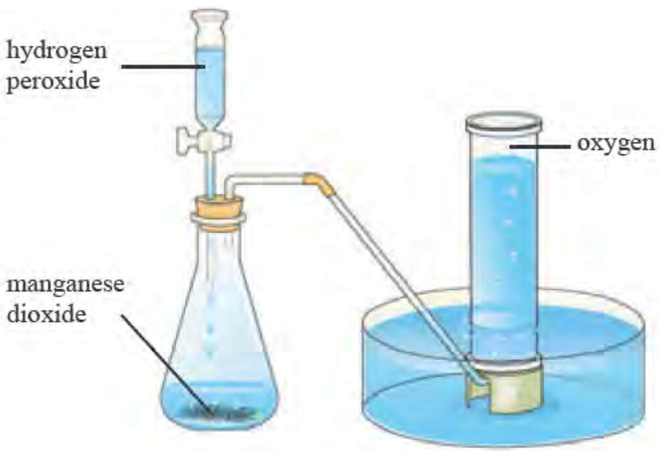
31.2 To Show the Presence of Water Vapour and Carbon Dioxide in Air

Water in the air turns the **blue cobalt chloride paper pink**.
Carbon dioxide in the air turns the **limewater milky**.
Air contains water vapour and carbon dioxide.



31.3 To Prepare Oxygen Gas

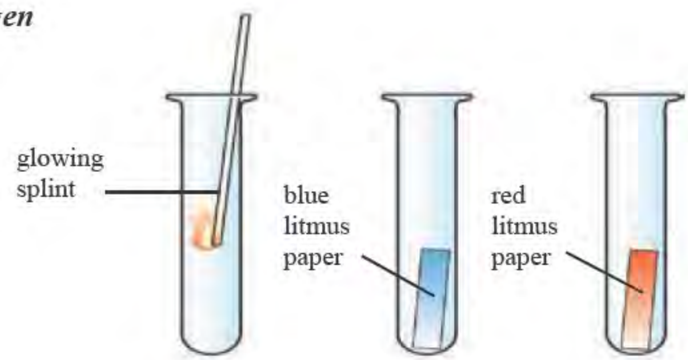
Oxygen is prepared by the breakdown of **hydrogen peroxide** in the presence of the **catalyst**, **manganese dioxide**.
Oxygen is collected in the gas jar.



31.4 To Investigate the Properties of Oxygen

Oxygen relights a glowing splint.
Oxygen has no effect on moist **blue litmus paper**.
Oxygen has no effect on moist **red litmus paper**.

Oxygen **supports combustion** and is a **neutral** gas.

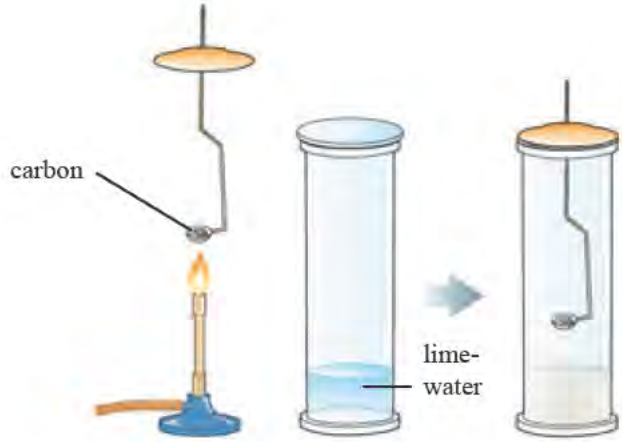


31.5 Burning Carbon and Magnesium in Oxygen

Carbon or **magnesium** are heated on a deflagrating spoon and then plunged into a jar of **oxygen**.

Carbon reacts to form **carbon dioxide** which turns some **limewater milky**.

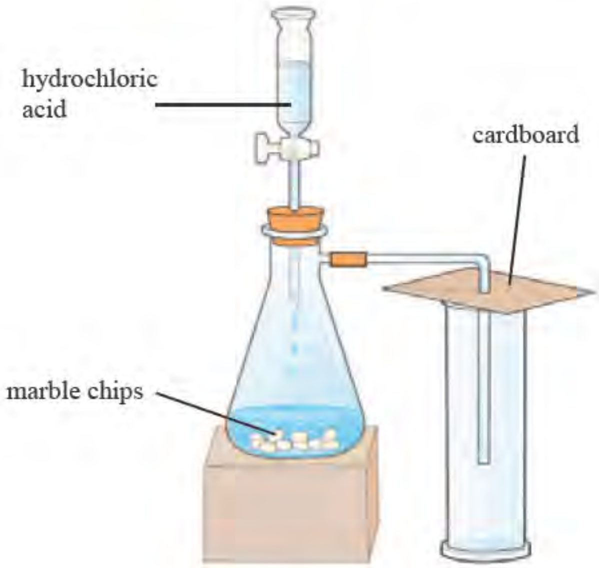
Magnesium forms white specks of **magnesium oxide** - a **basic oxide** which turns moist red **litmus paper blue**.



31.6 To Prepare Carbon Dioxide Gas

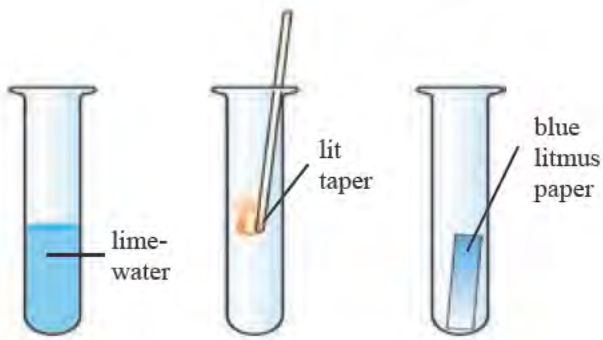
Carbon dioxide is prepared by the reaction between dilute **hydrochloric acid** (HCl) and **marble chips** ($CaCO_3$).

Carbon dioxide is **denser** than air and is therefore collected as shown.



31.7 To Investigate the Properties of Carbon Dioxide

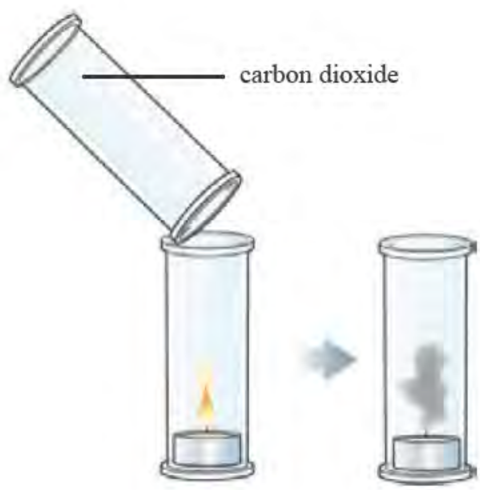
Carbon dioxide turns **limewater milky**.
Carbon dioxide does **not** support combustion.
Carbon dioxide turns moist **blue litmus paper red** - it is an **acidic oxide**.



31.8 To Show that Carbon Dioxide is Denser than Air

Carbon dioxide can be **poured** from one gas jar to another - this shows that it is **denser than air**.

The **candle** is **extinguished**, showing that carbon dioxide does **not** support combustion.



Chapter 32 Water

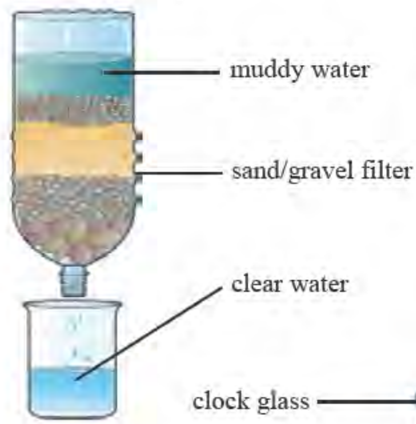
- Blue **cobalt chloride paper** is used to test for water. It is **blue** when **dry** - water turns it **pink**.
- The **freezing point** of pure water is **0ºC**. Its **boiling point** is **100°C**.
- **Ice** is **less dense** than water, therefore it **floats** on water.
- **Water** is an **excellent solvent**. Many substances dissolve in it.
- The **water cycle** is how water is recycled on the planet.
- **Water treatment** consists of 5 stages:
  screening (wire mesh), **settling** (settling tanks), **filtration** (sand and gravel filter beds), **chlorination** (adding chlorine to kill bacteria), and **fluoridation** (fluoride for teeth).
- **Hard water** is water that does **not easily** form a **lather** with soap.
- **Soft water** is water that forms a **lather easily** with soap.
- **Hardness** in water is caused by the presence of **calcium ions** dissolved in the water.
- **Calcium carbonate** (limestone) + **rainwater** (acidic) $\longrightarrow$ **calcium ions** in the water
- **Hardness** can be **removed** by passing the water through an **ion exchange resin**, or by **distillation**.
- **Ion exchange resin** exchanges **calcium ions** for **hydrogen ions** to remove hardness.
- Water can be broken down into its elements, **hydrogen** and **oxygen** by **electrolysis**.
- **Electrolysis** is the production of a **chemical reaction** by using **electricity**.
- A **Hoffman voltameter** is used in the **electrolysis** of water to form $\mathbf{H_2}$ and $\mathbf{O_2}$.
- **Hydrogen** gas forms at the **negative electrode**, **oxygen** forms at the **positive electrode**.
- **Twice as much hydrogen** as **oxygen** is formed because water is H_2O.

EXPERIMENTS:

32.1 To Use a Sand/Gravel Filter Model to Purify Water

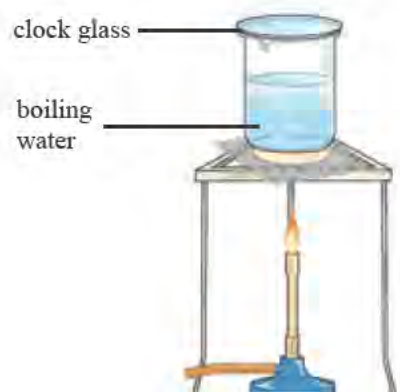
Muddy water is poured through the **filter**, set up as shown.

The water gets **filtered** and is **clear** when it enters the **beaker**.



32.2 To Show that Water Contains Dissolved Solids

Various **water samples** are **evaporated** in the **clock glass**.
Dissolved solids remain on the clock glass.
Hard waters such as **mineral water** and water from **limestone areas** contain the **most** dissolved solids. **Rainwater** contains **least**.

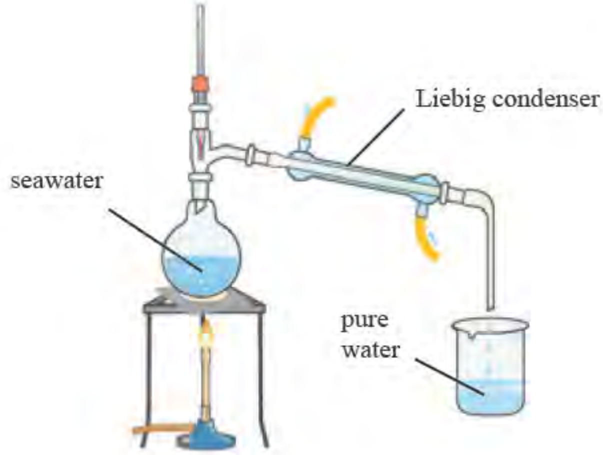


32.3 To Obtain Pure Water from Seawater

Seawater is placed in the **flask** of the **Liebig condenser** apparatus.

Pure water evaporates and condenses in the Liebig condenser and is collected in the beaker. The **salt remains** in the **flask**

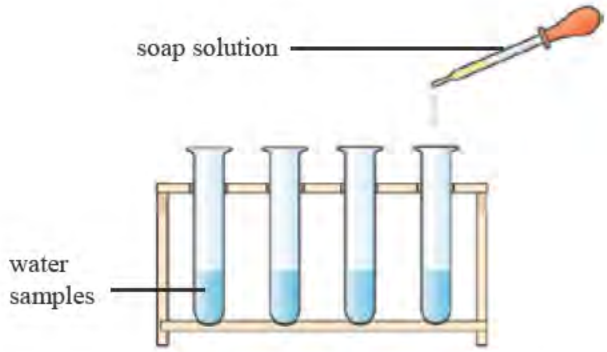
Pure water collects in the **beaker**.



32.4 To Test Various Water Samples for Hardness

Equal amounts of various **water samples** are placed in test tubes.
Soap solution is added to each test tube, a **drop** at a time, and the tube **shaken** to see if a **lather forms**.

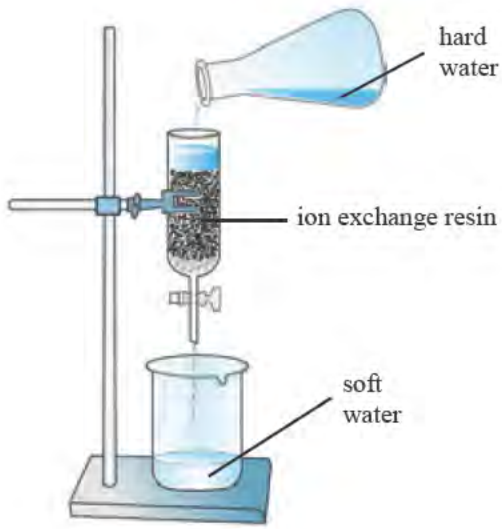
Hard water samples will need **more** drops of **soap solution** to form a **lather** than soft water samples.



32.5 To Remove Hardness from Water Using Ion Exchange Resin

A **tap funnel** is filled with ion **exchange resin**. **Hard water** is then poured through the resin as shown.

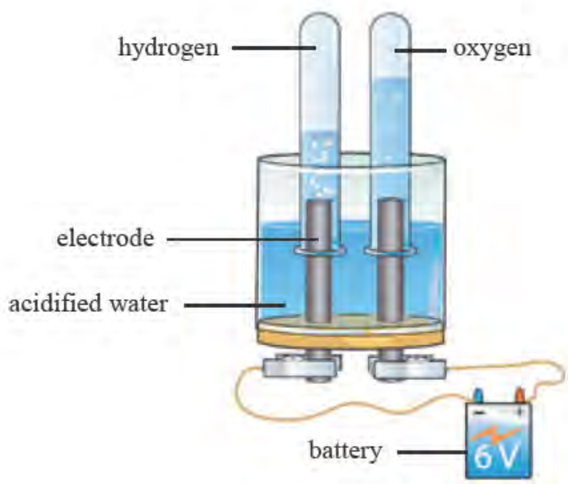
The water collected in the **beaker** is **soft water**. This can be **tested** by using **soap solution** as described in Experiment 32.4 above.



32.6 To Show the Composition of water by Electrolysis

The **Hoffman voltameter** and the two test tubes are filled with water to which a few **drops of acid** have been added to help **conduct** the **electricity**.

Oxygen collects in the test tube above the **positive electrode** - it can be **tested** for by using a **glowing splint**, which **relights**.
Twice as much **hydrogen** collects in the test tube above the **negative electrode** - it can be **tested** for by using a **lit taper**.
Hydrogen gives a '**pop**' sound when lit.



Chapter 33 Groups of Elements

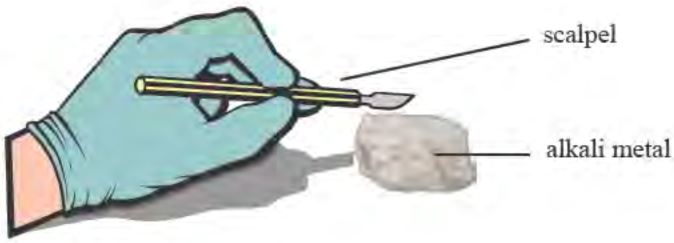
- **Atoms** of **elements** in the **same Group** all have the **same number** of **electrons** in their **outermost shells**.
- All **elements** in the **same Group** show **similar chemical properties**.
- **Group I** elements, the **alkali metals** are **soft** and **shiny**, with **low densities**.
- The first three alkali metals are: **lithium**, **sodium**, and **potassium**.
- The alkali metals react with **oxygen** to form **oxides**.
  Sodium metal gets a white coat of **sodium oxide** when it is cut with a knife.
- The alkali metals react with **water** to form **hydroxides** and **hydrogen** gas.
  Sodium metal in water produces hydrogen gas which bursts into flame.
- **Reactivity increases** going **down** the Group in the alkali metals.
- **Lithium** is used to make watch and camera batteries.
- **Sodium** is used in street lights that give a soft orange glow.
- **Potassium** is used in plant fertilisers.

EXPERIMENTS:

33.1 To React an Alkali Metal with Air

A sample of **sodium** or **lithium** is cut with a **scalpel**.

The shiny cut surface gains a **dull** layer of **sodium** or **lithium oxide**.
Alkali metals react easily with **oxygen** in the air to form the **metal oxide**.

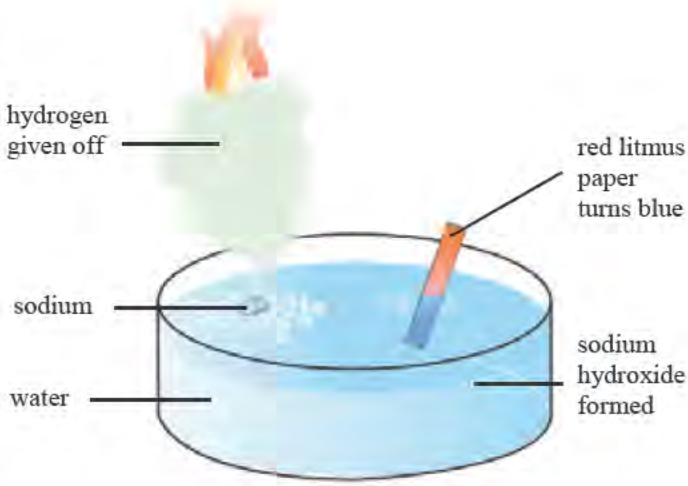


33.2 To React an Alkali Metal with Water

A sample of **sodium**, lithium or potassium is placed in water.

Hydrogen gas, which sometimes lights and explodes, is given off.
The **metal hydroxide** (e.g. NaOH) is formed and **dissolves** in the **water**.

The **alkali** formed turns **red litmus** paper **blue**.



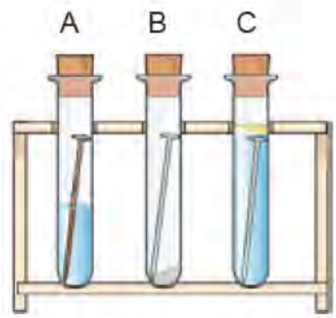
Chapter 34 Metals

- Metals are usually **dense**, **hard**, **shiny solids** with **high** melting points.
- Metals are **ductile** and **malleable**, are **good conductors** of **heat** and **electricity**, and most **corrode**.
- **Corrosion** is a reaction in which a metal **slowly reacts** with **oxygen** or some other element in the air, to form an **oxide** or some other compound.
- The **corrosion** of **iron** or **steel** is called **rusting**.
- **Rusting** takes place in the presence of **water** and **oxygen** (air).
- Corrosion is **prevented** by **painting**, **greasing**, **galvanising** or **chrome plating**.
- **Galvanising** involves coating **iron** with a **layer of zinc**.
- An **alloy** is a **mixture** of **metals**.
- **Bronze** (copper and tin), **brass** (copper and zinc), **steel** (iron and carbon) and **solder** (lead and tin) are all metal alloys.
- The **Activity Series** is a list of metals placed in order of **how reactive** they are.
- When **metals** react with an **acid**, **hydrogen** gas is given off.
- **Zinc** reacts with **hydrochloric acid** to form **zinc chloride** and **hydrogen**.

$$Zn + 2HCl \longrightarrow ZnCl_2 + H_2$$

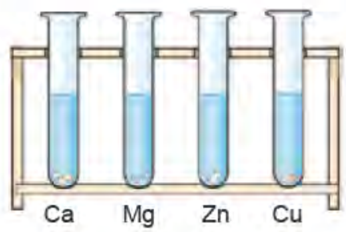
EXPERIMENTS:

34.1 To Investigate the Conditions Necessary for Rusting



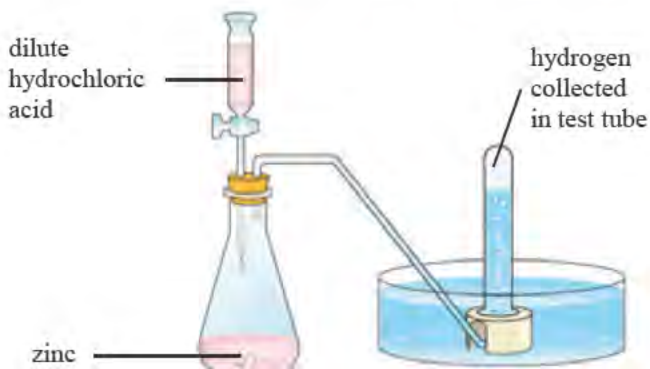
Tube **A** has both **water** and **oxygen** - this is the **control**.
Tube **B** has **no water** - removed by **calcium chloride**.
Tube **C** has **no oxygen** - cooled, **boiled water** was used.
Only the nail in test tube **A** will rust.

34.2 To Compare the Reactivity of Metals



When tested with **water** and dilute **hydrochloric acid**, **calcium** is found to be **most reactive**, then **magnesium**, **zinc** and finally, **copper**.

34.3 To React Zinc with Hydrochloric Acid and Test for Hydrogen



Dilute hydrochloric acid reacts with **zinc** to form **zinc chloride** and **hydrogen** gas.

The hydrogen is collected in a test tube and tested with a **lit taper** - it goes **'pop'**.

Chapter 35 Chemistry in Everyday Life

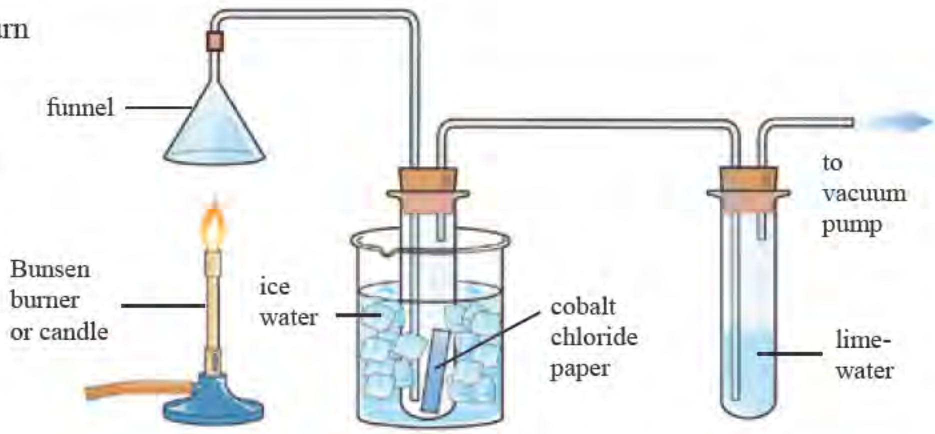
- **Fossil fuels** are formed from the **remains** of **plants** and **animals** that lived millions of years ago.
- **Coal**, **oil** and **gas** are fossil fuels.
- All **fossil fuels** contain the elements **carbon** and **hydrogen**.
- **Natural gas** is mainly **methane** (CH_4).
- **Fossil fuels** produce **carbon dioxide** (CO_2) and **water** (H_2O) when burned.
- Some **fossil fuels** (coal and oil) contain **sulfur compounds** which release the gas **sulfur dioxide** (SO_2) on **burning**.
- **Sulfur dioxide** combines with **rainwater** to form **sulfuric acid**, causing **acid rain**.
- Acid rain **kills fish**, is harmful to **plants** and erodes **limestone buildings**.
- **Plastics** are man-made materials made from chemicals called **monomers** extracted from **crude oil**.
- The **monomers** are **reacted together** to make long chains of molecules called **polymers** which are used to make plastics.
- **Plastics** are **lightweight**, **durable**, **waterproof**, **easy** to **clean** and can be easily **moulded** into different shapes.
- **Plastics** are **non-biodegradable** which means they cannot be broken down by living organisms, such as bacteria and fungi in the soil.

EXPERIMENTS:

35.1 To Investigate the Products of Combustion

Use a very low flame to burn **methane gas** as shown.

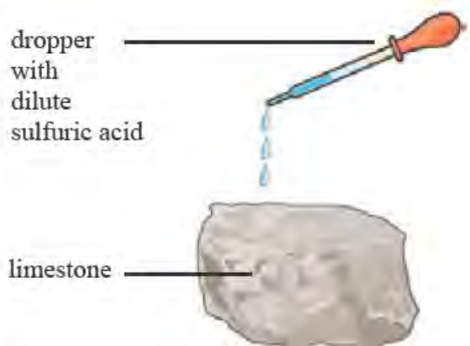
Water from the burning fuel turns the **blue cobalt chloride paper pink**. **Carbon dioxide** from the burning fuel turns the **limewater milky**.



35.2 To Show the Effect of Acid Rain on Limestone

Dilute sulfuric acid is dropped onto **limestone**. This acid is found in **acid rain**.

The **limestone fizzes** as the sulfuric acid reacts with it.



Chapter 36. Measurements & Units

- **Length** is measured using a **metre stick** (straight lines), an **opisometer** (short curved lines), a **trundle wheel** (long, curved lengths) or a **Vernier calipers** (diameters or widths of solid objects).

Opisometer

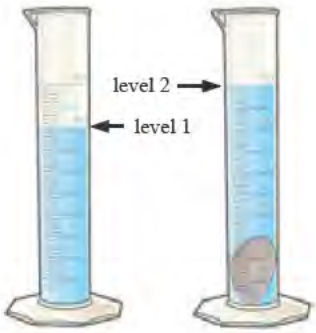
Vernier callipers

Trundle wheel

- The **area** of an object is a measure of the **amount of surface** it has.
- **Area** is measured in **cm^2**, **m^2** or **km^2**.
- The **area of a rectangle** is the **length** multiplied by the **breadth**.
- The **area of an irregularly-shaped object** (e.g. your hand or a leaf) is found by counting the number of squares it covers on **graph paper**.
- The **volume** of an object is the **amount of space** it takes up. **Volume** is measured in **cm^3**, **m^3**, or **L**.
- The **volume** of a **box** is the **length** multiplied by the **breadth** multiplied by the **height**.
- The **volume** of an **irregularly-shaped object** (e.g. a stone) is found by using a **graduated cylinder** or an **overflow can** and a **graduated cylinder**.

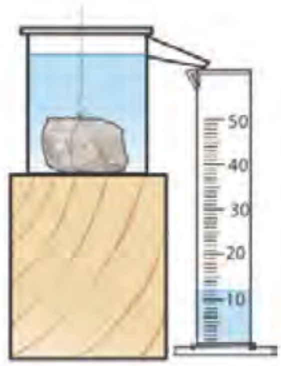
Finding the volume of a stone

using a graduated cylinder.



Finding the volume of a stone

using an overflow can and graduated cylinder.



EXPERIMENTS:

36.1 To Measure the Length of Straight Lines Using a Ruler

36.2 To Measure the Length of Curved Lines Using an Opisometer

36.3 To Measure Lengths Using a Vernier Callipers

36.4 To Find the Area of Regularly-Shaped Objects (Rectangles)

36.5 To Find the Area of an Irregularly-Shaped Object (Your Hand)

36.6 To Measure the Volume of a Liquid

36.7 To Measure the Volume of an Irregularly-Shaped Object (a Stone)

36.8 To Measure the Volume of an Irregularly-Shaped Object (a Stone), Using an Overflow Can

Chapter 37. Energy

- **Energy** is the **ability** to do **work**.
- **Energy** is measured in **joules** (J).
- Different **forms** of **energy** include: **potential**, **kinetic**, **heat**, **light**, **sound**, **electrical**, **chemical** and **nuclear**.
- **Kinetic energy** is the energy that **moving** things have.
- **Potential energy** is **stored energy** (e.g. a coiled spring or a brick at a height).
- Energy cannot be **created** or **destroyed**, but can **only change** from one form to another.
- An **energy converter** (e.g. a toaster, radio, torch, battery, leaf, light bulb **changes energy** from **one form to another**.
- A **good insulator** (e.g. a lagging jacket) keeps heat energy in.
- **Non-renewable sources** of energy cannot be replaced when they are used up. They are the **fossil fuels**, coal, oil, gas and turf.
- **Renewable sources** of energy are constantly being **replaced by Nature**. They include **solar**, **hydro-electric**, **wind**, **wave**, **biomass** and **geothermal**.
- The **sun** provides almost all of our energy - it is our **primary source** of energy.
- **Nuclear energy** is the energy stored in the **nuclei** of **atoms**.

EXPERIMENTS:

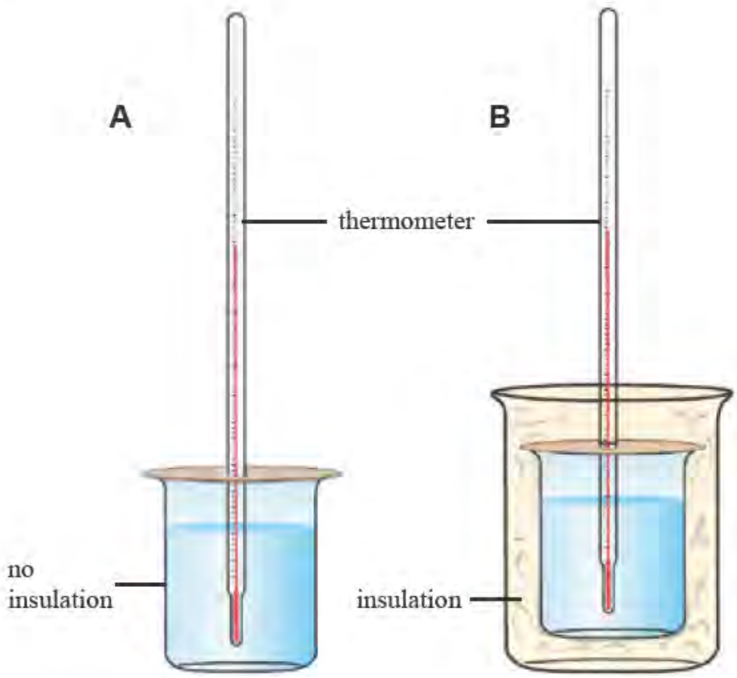
37.1 To Compare the Insulating Ability of Different Materials

Beaker **B** is **insulated** with various insulating materials.
Beaker **A** is left with **no insulation** - it acts as the **control**.
Boiling water is added equally to both beakers and the **temperature** taken using a **thermometer**.

After **10 minutes**, there is seen to be a **greater heat loss** from the beaker with **no insulation** than from the insulated beaker.

The amount of heat loss depends on how good the insulator used is.

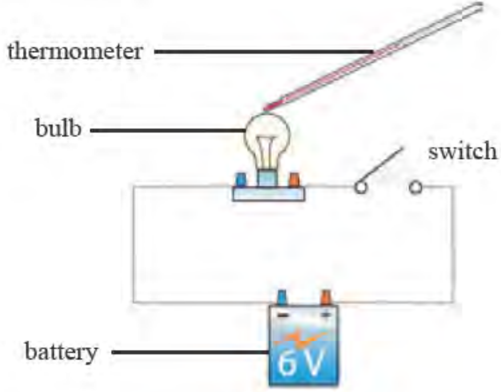
Insulation reduces heat loss.



37.2 To Convert Chemical Energy to Electrical Energy to Heat Energy

The **battery** converts **chemical energy** into **electrical energy** in the wires.

The **electrical energy** is converted into light and **heat energy** in the bulb. The heat energy is detected using a **thermometer**.



37.3 To Convert Electrical Energy to Magnetic Energy to Kinetic Energy

The **electrical energy** from the battery is converted to **magnetic energy** in the nail.

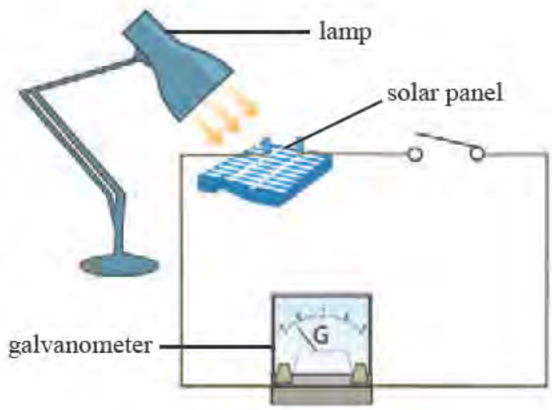
The **magnetic energy** is then converted into **kinetic energy** in the paper clips, as they are lifted and move.

37.4 To Convert Light Energy to Electrical Energy to Kinetic Energy

Light energy from the lamp is converted into **electrical energy** in the solar panel.

The **electrical energy** is then converted into **kinetic energy** in the needle of the galvanometer, which moves.

If the current is large enough, a **small motor**, in place of the galvanometer could be used to show the kinetic energy.



Chapter 38. Speed, Velocity & Acceleration

			Measured in:
•	**Speed**:	The **speed** of an object is the **distance** it travels per **unit time**.	m/s or ms^{-1}
		Speed = $\frac{\text{Distance (m/s)}}{\text{Time taken (s)}}$	
•	**Velocity**:	The **velocity** of an object is the distance it travels per unit time, in a **given direction**.	m/s or ms^{-1}
•	**Acceleration**:	**Acceleration** is the **change** in **velocity** per second.	m/s/s, or ms^{-2}, or m/s^2
		Acceleration = $\frac{\text{Change in velocity (m/s)}}{\text{Time taken (s)}}$	

Chapter 39. Mass, Density & Flotation

- The **mass** of an object is the **amount of matter** in it.
  Mass is measured in **kilograms** (kg) or **grams** (g).
- The **density** of a substance is the **mass** of **1 cm^3** of it.
  Density is measured in **grams per cubic centimetre**. (g/cm^3).
- **Density** = $\dfrac{\text{Mass (g)}}{\text{Volume (cm}^3\text{)}}$
- To find the density of any substance, first find its **mass** on an **electronic balance**, and then find its **volume**, using an **overflow can** and **graduated cylinder**.
  Then **divide** the **mass** by the **volume** to find the density. (answer in g/cm^3).
- The **density** of **water** is 1 g/cm^3.
- An object **sinks** if its **density** is **greater** than the density of the liquid it is in.
- An object **floats** if its **density** is **less** than the density of the liquid it is in.
- **Ice floats** in **water** because its **density** (0.9 g/cm^3) is **less** than the density of water.

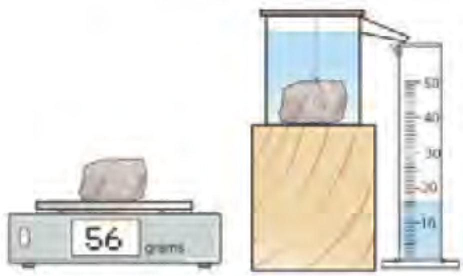
EXPERIMENTS:

39.1 To Find the Density of a Regularly Shaped Solid (e.g. a Block of Wood)

The **mass** is found on an **electronic balance**.
The **volume** is length x breadth x height.
The **mass divided by the volume** gives **density**.

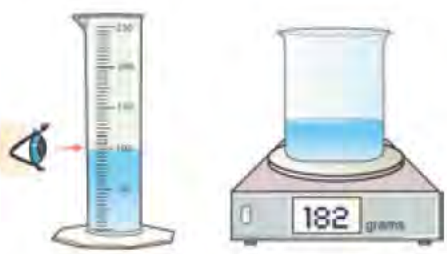
39.2 To Find the Density of an Irregularly Shaped Solid (e.g. a Stone)

The **volume** is found using an **overflow can**.
Mass divided by volume gives **density**.



39.3 To Find the Density of a Liquid

Volume is found using a **graduated cylinder**.
Mass divided by volume gives **density**.



39.4 To Study Flotation

Various substances are placed in **water**.
Those with a density less than that of water **float**.

39.5 To Show the Expansion of Water on Freezing

A bottle filled with **water** and left in a **freezer** bursts as the **ice expands**.

Chapter 40. Force, Work & Power

	Measured in:
• A **force** is anything which causes an object to **move** or **change** its **velocity**.	**newtons** (N)
• **Push**, **pull**, **weight** and **friction** are all examples of **forces**.	
• **Forces** are measured using a **spring balance**.	
• **Friction** is a force which **prevents easy movement** between two objects in contact.	**newtons** (N)
• The **weight** of an object is the **force of gravity** acting on it.	**newtons** (N)
• **Hooke's Law** states that the **extension** of a spring depends on the size of the **weight** (force) attached to it.	
• A **graph** of **spring extension** against the **weight** (force) attached to it, gives a **straight line** through the **origin** (0,0)	
• **Energy** is the **ability** to do **work**.	**joules** (J)
• **Work** is done when a **force** moves an **object**. **Work** (J) = **Force** (N) x **Distance** (m)	**joules** (J)
• **Power** is the **rate** at which **work** is done. **Power** is the amount of **work** done in **1 second**.	**watts** (W)

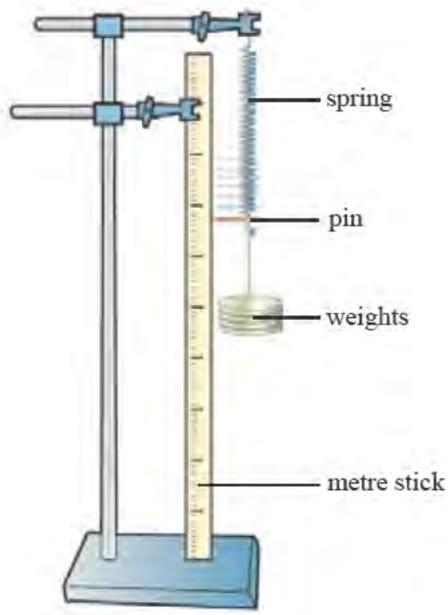
- **Power** = $\frac{\text{Work done (J)}}{\text{Time taken (s)}}$

EXPERIMENTS:

40.1 To Investigate the Law of the Spiral Spring (Hooke's Law)

The **spring** and **metre stick** are held in the retort stand as shown.
The position of the **pin** is **noted** as each **weight** is added to the spring.
The **extension** of the spring for each **total weight** is noted.

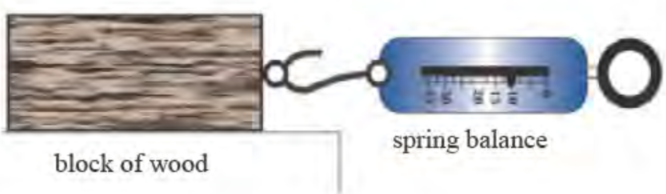
The **bigger** the **weight**, the **greater** the **extension** of the spring. They are in **direct proportion**, and so would give a **straight line graph** through (0,0).



40.2 To Investigate the Force of Friction

The **force of friction** is measured on the spring balance as the block just **begins** to **move**.

Sandpaper or **oil** could be placed under the block to **increase/decrease friction**.



Chapter 41. Weight

- The **weight** of an object is the **force of gravity** acting on it.
- **Weight** is a **force** and is measured in **newtons** (N).
- The **force of gravity on Earth** is 10 N on every 1 kg of mass.
- **Weight** (N) = **Mass** (kg) x **10** N/kg (earth's gravity).
- To **find the weight** on Earth, **multiply** the **mass** (in kg's) by **10**.
- The weight of something in **outer space** is the mass multiplied by **0**. It is **weightless**.

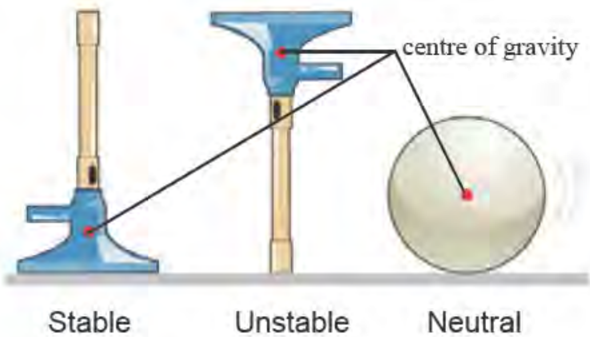
DIFFERENCES BETWEEN MASS AND WEIGHT

MASS	WEIGHT
1. Measured in **kilograms** (kg)	1. Measured in **newtons** (N)
2. Is **fixed**, never changes.	2. **Varies**, depends on where you are.
3. Is a **fixed feature** of all things - like length or volume.	3. Is a **force** or pull on something.

Chapter 42. Turning Forces, Centre of Gravity

- The **moment** of a force is the **turning effect** of a force. **Moment** = (**Force**) x (**Distance from the fulcrum**).

- A **lever** is any **rigid body** which is free to turn about a a fixed point called the **fulcrum**.
- **Examples** of **levers** are: door, door handle, pliers, scissors, metre stick, screwdriver (used to open paint tin), etc.
- The **Law of the Lever** states that when a lever (e.g. a metre stick) is **balanced**, the total **clockwise moments equal** the total **anticlockwise moments**.
- The **centre of gravity** of an object is the point through which all the weight of the object appears to act. (i.e. the centre of its weight).
- **Stable equilibrium** is present if when an object is **slightly tilted**, its **centre of gravity** is **raised**, and it goes back to the original position on release.
- Objects in **stable equilibrium** will have a **wide base** and a **low** centre of gravity.
- **Unstable equilibrium** is present if when an object is **slightly tilted**, its **centre of gravity** is **lowered**, and it takes a new position when released (i.e. it falls over on its side).
- **Neutral equilibrium** is present if when an object is moved, its **centre of gravity** is **neither raised** nor **lowered**. The object never becomes unstable - it does not fall over and just takes up a new position where it is still in neutral equilibrium.

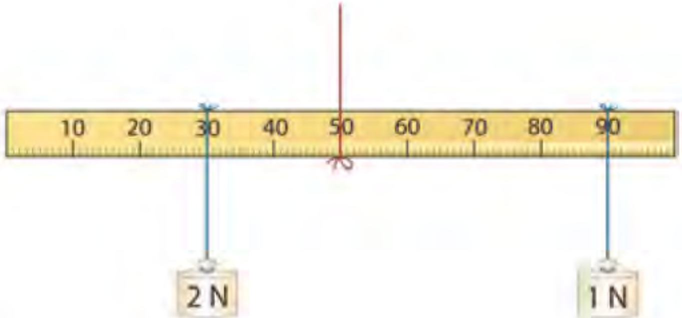


The three states of Equilibrium

EXPERIMENTS:

42.1 To Prove the Law of the Lever

The metre stick is hung from the **50 cm mark** and **weights** are hung from each side, **balancing the metre stick** each time.

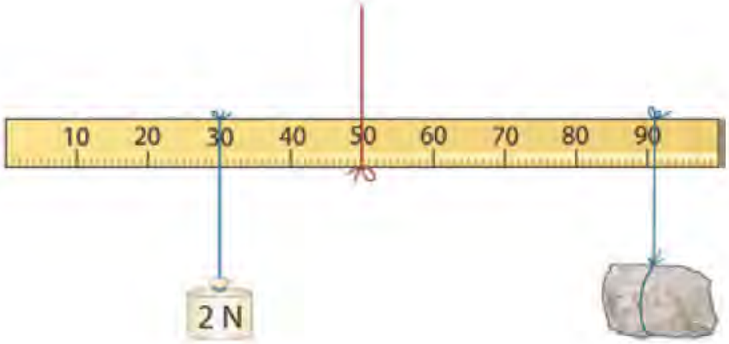


The **moments** are calculated on each side by **multiplying** the **weight** by the **distance** to the **fulcrum**.
When the **clockwise moments** equal the **anticlockwise moments**, the metre stick is balanced.

This proves the **Law of the Lever**.

42.2 To Find the Weight of an Object Using the Law of the Lever

A **known weight** is hung on one side of the metre stick and a **stone** on the other side, so that they **balance**.



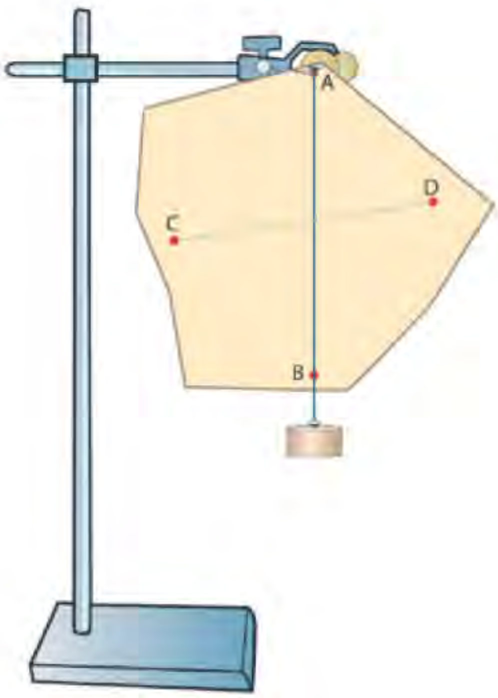
The **moments** caused by the **weight** is calculated and this must **equal** the **moments** caused by the **stone**.

Therefore, moments caused by the weight = (weight of stone) x (distance of stone from the fulcrum).

The **weight** of the **stone** can then be found by **dividing**.

42.3 To Find the Centre of Gravity of an Irregularly Shaped Cardboard

The **cardboard** and a **plumbline** are hung from a **pin**, stuck in a **cork** and held as shown in a **retort stand**.



Using the plumbline as a guide, the line **AB** is drawn on the **cardboard**.
The cardboard is then hung from a different point (e.g. **C**), and, again, the plumbline is used to draw the line **CD**.

This is repeated twice more from **other points** at the edge of the cardboard, and vertical lines drawn, as before.

Where all the lines **meet** is the **centre of gravity** of the cardboard.

Chapter 43. Pressure

- **Pressure** is the **force** per **unit area**.
- **Pressure** $= \frac{\text{Force (N)}}{\text{Area (m}^2\text{)}}$
- **Pressure** is measured in **newtons per square metre** (N/m^2), or **pascals** (Pa). $1\ N/m^2 = 1$ Pa.
- The **smaller the area**, the **greater the pressure**.
- **Pressure** in a **liquid increases** with **depth**.
- The **pressure** in a **liquid** acts **equally** in all directions.
- **Atmospheric pressure** is caused by the **weight** of the **atmosphere**.
- **Atmospheric pressure decreases** the **higher** you go above sea-level.

- A **barometer** is used to measure atmospheric pressure.
- **Normal atmospheric pressure** can hold up **76 cm of mercury** in a mercury barometer.
- Normal atmospheric pressure is **76 cm of mercury** or **1013 hectopascals**.
- An **altimeter** is a **barometer** used to measure **height**.
- **High atmospheric pressure** gives **good**, settled **weather**.
- **Low atmospheric pressure** gives **bad**, unsettled **weather**.

EXPERIMENTS:

43.1 To Find the Pressure Exerted by Different Objects

Find the **weight** of the block by **multiplying** its **mass** in **kg's** by **10** to give its **weight** in **newtons**.
The mass is found using an electronic balance.

Find the **area** under the block by **multiplying** its **length** (in **metres**) by its **breadth** (in **metres**).

Then **divide** the **weight** (in newtons) by the **area** (in m^2) to find the **pressure** under it in pascals.

Find the **weight** of the beaker and water by **multiplying** its **mass** (in **kg's**) by **10** to give its **weight** in **newtons**.
The mass is found using the electronic balance.

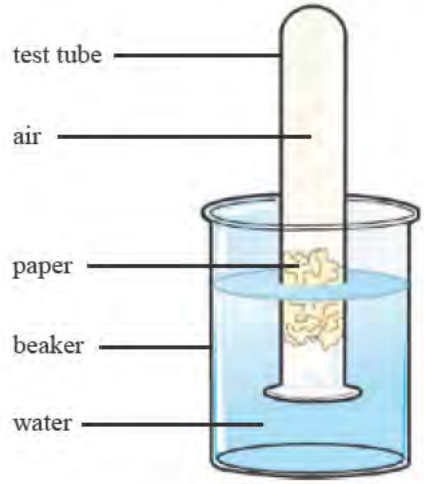
Find the **area** under the beaker by using cm^2 **graph paper** and **counting** the number of cm^2 boxes it covers.
Convert the area in cm^2 to m^2 by **dividing** by **10,000**.

Then **divide** the **weight** (in newtons) by the **area** (in m^2) to find the **pressure** under it in pascals.

43.2 To Show that Air Occupies Space

The **dry paper** in the test tube remains dry when removed from the beaker.

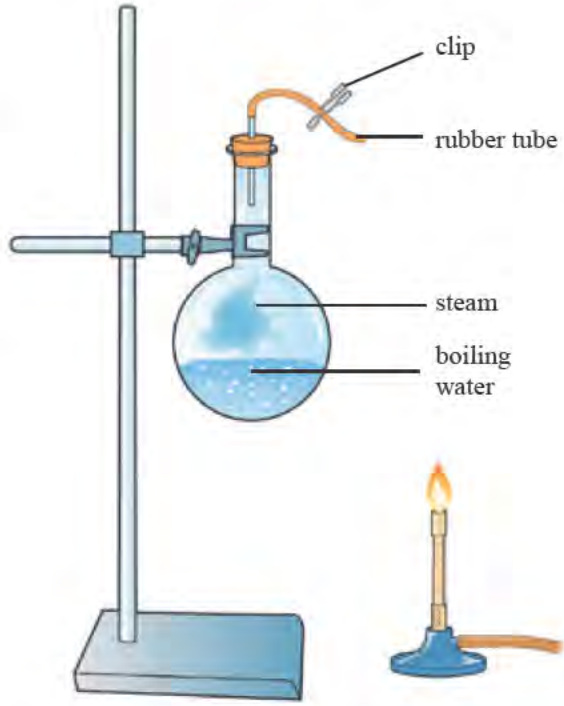
The **water** did **not enter** the test tube because **air** was **taking up space** in the test tube.



43.3 To Show that Air has Mass

With the **clip open**, **water** is **boiled** in the flask.
The steam **drives** all the **air** out of the flask.
The **Bunsen burner** is then removed and the **clip closed** so no more air can get in.
As the steam cools, it **condenses** back into water, leaving **no air** in the **flask** above the water.

An **electronic balance** is then used to find the **mass** of the flask **without air**.
The clip is then opened, **allowing air back** into the **flask**.
The **mass** of the **flask with air** is then found.
By **subtracting** the two masses, the **mass of air in the flask** is found.

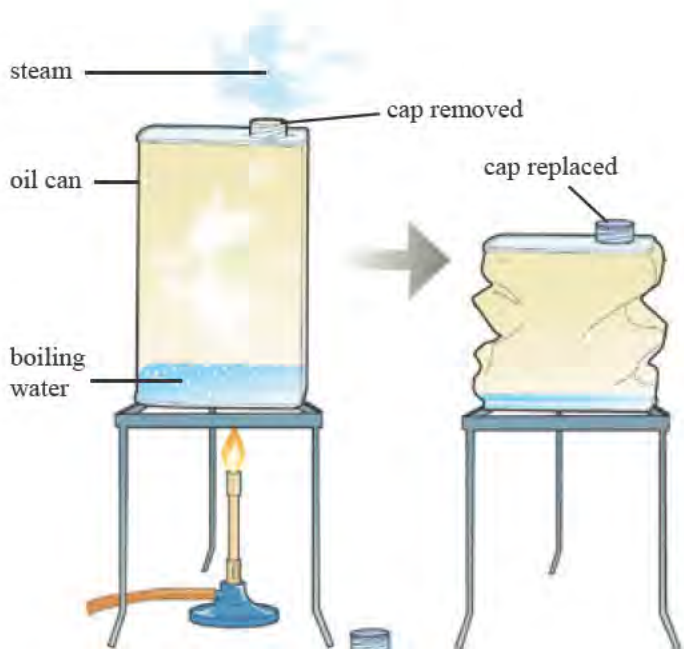


43.4 To Demonstrate Atmospheric Pressure

A small amount of **water** is **boiled** for five minutes in the can, with the **cap removed**.
The **steam** drives all the air out of the can.
The Bunsen burner is then removed and the cap replaced so **no more air** can get in.

As the steam cools, it **condenses** back into **water**, leaving **no air in the can** above the water.

With no air inside the can, **atmospheric pressure** outside the can crushes it.



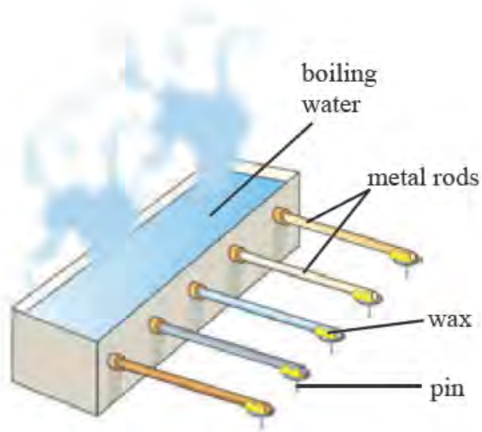
Chapter 44. Heat

- **Heat** is a form of **energy**; it is measured in **joules** (J).
- **Heat** always moves from a **hot area** to a **cold area**.
- **Conduction** is the transfer of heat through a substance **without** the particles in the substance **moving out of position**.
- **Metals** are very **good conductors** of heat.
- An **insulator** is a substance that does **not allow heat** to pass through it easily. Insulators are very poor conductors.
- **Convection** is the transfer of heat through a **liquid** or **gas** when **molecules** of the liquid or gas **move upwards** and carry the heat.
- **Radiation** is the transfer of heat, in **rays**, from a hot object, **without** needing a **medium** to pass through.
- A **dull, black surface radiates** heat out better than a **bright shiny surface**.
- A **dull, black surface absorbs** heat better than a **bright, shiny surface**.
- **Solids, liquids and gases** all **expand** when **heated** and **contract** on **cooling**.
- When **water** is cooled **below 4°C**, it begins to **expand**.
- **Ice is less dense than liquid water** and so **floats** on water - this is important for fish to survive.

EXPERIMENTS:

44.1 To Compare the Conductivity of Various Metals

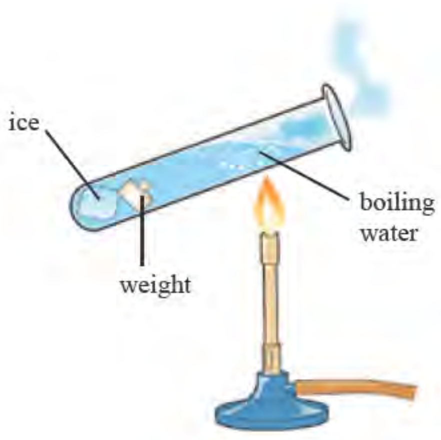
Heat travels by **conduction** through the **metal rods**. The **wax melts** and the **pin drops** off the metal that is the **best conductor** of heat first.



44.2 To Show that Water is a Poor Conductor of Heat

The **ice** at the bottom of the test tube does **not melt**, even though the **water** at the **top** is **boiling**.

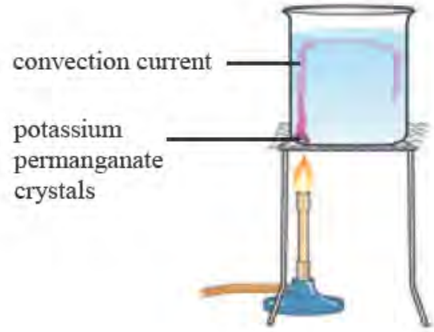
As heat cannot reach the ice by convection (where molecules move upwards to carry heat), the **water** above the ice must be a **very bad conductor** of heat.



44.3 To Show Convection Currents in Water

Some potassium permanganate **crystals** are placed at the bottom of the beaker, to **colour the water**.

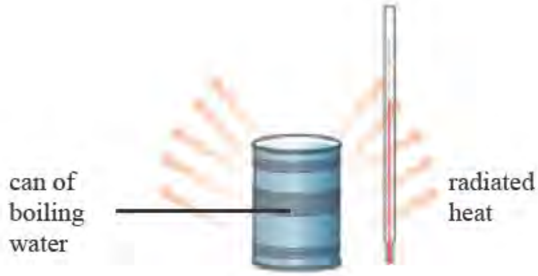
The **movement** of the **coloured water**, shows a **convection current** in the water, as **heated water** moves **upwards** and is **replaced** by **colder water** moving **downwards**.



44.4 To Show Heat Transfer by Radiation

The **tin can** is filled with **boiling water** and the **thermometer bulb** is placed **beside** it as shown.

Heat transfer from the hot can, by **radiation**, **raises** the **temperature** on the thermometer.



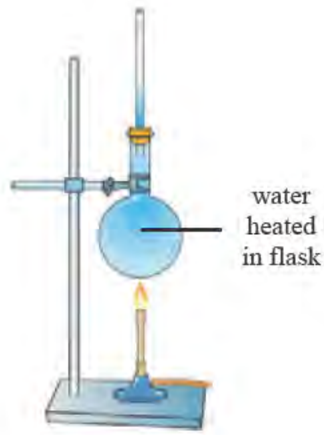
44.5 To Show that Solids Expand when Heated and Contract when Cooled

The **metal ball can fit** through the **ring** when the ball is **cold**.
When the ball is **heated**, it **expands** and can **no longer fit** through the ring.
On **cooling**, the ball **contracts** and can fit through the ring again.

44.6 To Show that Liquids Expand when Heated and Contract when Cooled

When the **water** in the flask is **heated** it **expands** and **rises up** the glass tube.
On **cooling**, the water **contracts** and moves back **down** the tube.

The **expansion** of a **liquid** on **heating** and its **contraction** on **cooling** explains how a **thermometer** works.

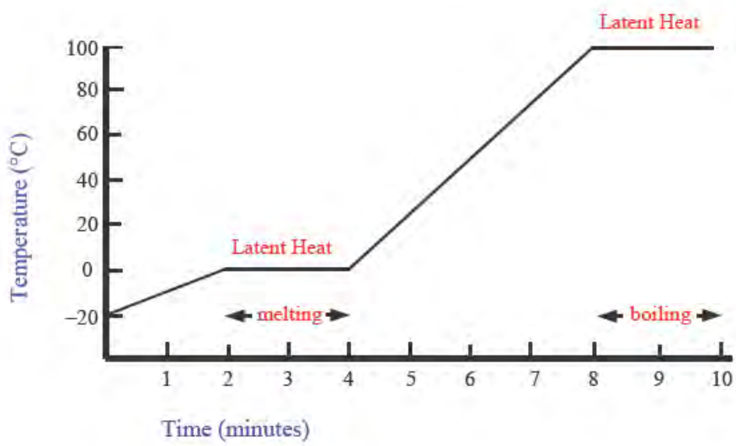


44.5 To Show that Gases Expand when Heated and Contract when Cooled

When **heated**, the **air in the flask expands** and some escapes causing **bubbles** in the water in the beaker.
On **cooling**, the **air contracts** and **water** from the **beaker** gets **sucked up** the tube.

Chapter 45. Temperature

- **Temperature** is a measure of **how hot** an object is.
- A **mercury** or **alcohol thermometer** is used to **measure** temperature accurately.
- **Thermometers** work because **liquids expand** when **heated** and **contract** when **cooled**.
- **Temperature** is measured in **degrees Celsius** (°C).
- **Water freezes** at **0°C**, and **boils** at **100°C** at normal atmospheric pressure.
- The **amount of heat** in a substance **depends** on its **temperature**, its **mass**, and **what the substance is**.
- **200 ml** of **water** at **60°C** contains **twice** as much heat as **100 ml** of **water** at **60°C**.
- **200 ml** of **water** at **60°C** contains **more heat** than **200 ml** of **oil** at **60°C**.
- **Latent heat** is the heat used by a substance to **change its state** - it does **not** raise the temperature.
- Latent heat:

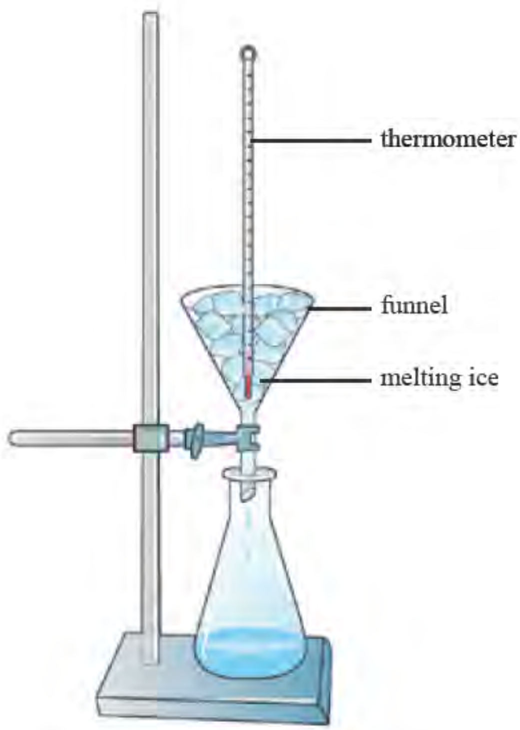


EXPERIMENTS:

45.1 To Determine the Melting Point of Ice

A **thermometer** is placed in a **funnel** of **melting ice**, as shown.

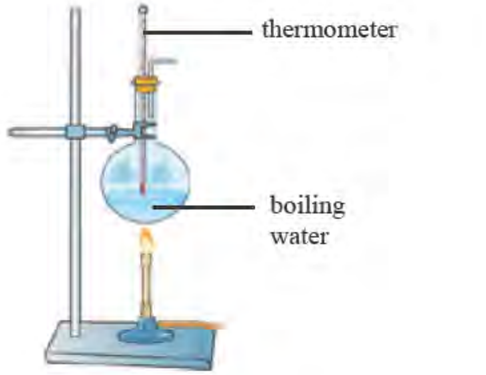
The temperature remains **steady** at **0°C** as the **ice melts** - this is the **melting point** of ice.



45.2 To Determine the Boiling Point of Water

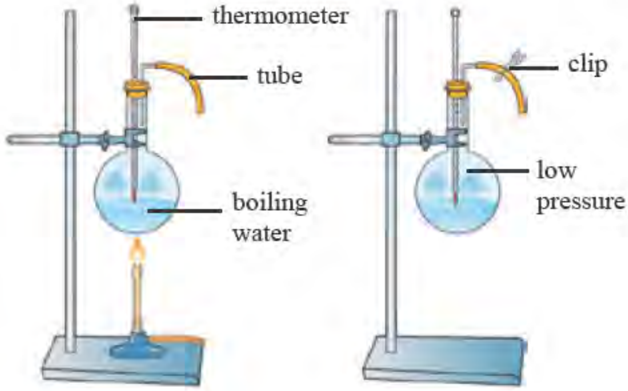
A **thermometer** is placed just **above** the **surface** of **boiling water** in a flask, as shown.

Note the **steady temperature** of **100 °C** in the steam - this is the **boiling point** of water.



45.3 To Show the Effect of Pressure on the Boiling Point of Water

With the **tube open**, the **water** in the flask is **boiled** for **three minutes**.
The **steam** drives all the **air out** of the flask.
The **Bunsen burner** is then **removed** and the **tube clamped**.
The **steam** then **condenses** leaving a **partial vacuum** (with very **low pressure**) above the water in the flask.
At this **low pressure**, the water is seen to boil again at temperatures of as **low as 60°C**.

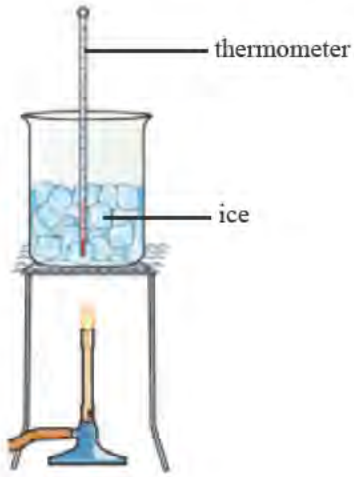


45.4 To Demonstrate Latent Heat

A **thermometer** is placed in ice taken **directly** from the **freezer**. This ice should show a temperature of **less than 0°C**, and, as it **melts**, the temperature **rises** to **0°C**.

The **ice** and **water** will **remain at 0°C** until **all** the ice has **melted**. The heat being supplied is **latent heat** - it is being used to **change the state**, and does **not raise** the **temperature**.

The **temperature** will then **increase** steadily to **100°C** when the water begins to **boil**. The **temperature** will **not rise above 100°C**, as, once again, the heat supplied is being used to **change the state (latent heat)**.



45.5 To Plot a Cooling Curve for Naphthalene

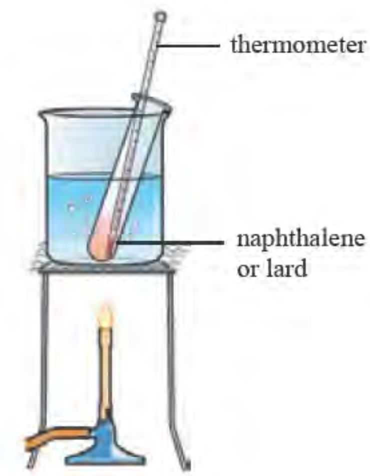
A **thermometer** is placed in a **test tube** containing **naphthalene** (freezing point 80°C) or **lard** (F.P. 30°C). The **naphthalene** is heated to **100°C**, or **lard** to **60°C**.

The liquid is then allowed to **cool**, and the temperature is **noted** every **minute** for 10 minutes.

A **graph** is drawn with **time** (minutes) on the X-axis and **temperature** (°C) on the Y-axis.

As the **liquid freezes** to a **solid** (80° for naphthalene and 30°C for lard), the **temperature** does **not fall** for several minutes, until **all** the liquid has turned to solid.

The heat (**latent heat**) is being given off as the liquid changes state to a solid.



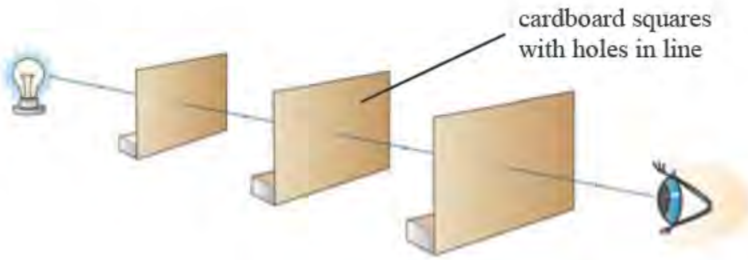
Chapter 46. Light

- **Light** is a form of **energy** - it can make things move.
- The **Crooke's radiometer** and the **solar-powered calculator** show that light is a form of **energy**.
- **Luminous objects** give out light, e.g. the **Sun**, a **light bulb**, a **candle**.
- **Light travels** in **straight lines** - this gives rise to **shadows**.
- A **solar eclipse** occurs when the **Moon** passes between **Sun** and **Earth**.
- **Reflection** occurs when light **bounces** back off a surface.
- Light is **reflected** in a **regular manner** off a **shiny surface** e.g. a mirror.
- **Refraction** is the **bending of light** as it goes from one medium to another.
- Light **rays** are always **refracted towards** the **denser medium**.
- A **convex** or **converging lens** brings light **rays together**.
- A **concave** or **diverging lens** spreads light **rays apart**.
- **White light** is a mixture of the **7 colours** of the **spectrum**.
- **Dispersion** is the **breaking up** of **white light** into its 7 colours.

EXPERIMENTS:

46.1 To Show that Light Travels in Straight Lines

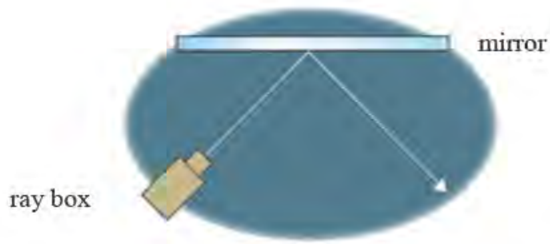
The bulb can only be seen when the three holes in the cardboard squares are in a straight line.



46.2 To Show the Reflection of Light

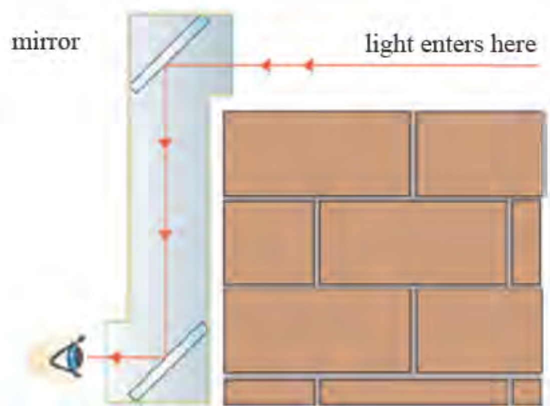
The **light ray** from the **ray box** strikes the **mirror** and gets **reflected** back.

The ray gets **reflected** back at the **same angle** as it strikes the mirror with.



Light from an **object** enters the **periscope** and strikes the **top mirror**.
It is then **reflected down** to the **bottom mirror** which reflects it **into the eye**.

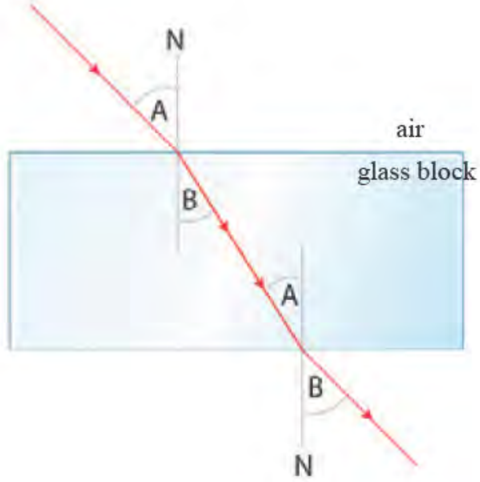
Both mirrors must be at an angle of **45°** for the periscope to work.



46.3 To Show the Refraction of Light

A **light ray** from a **ray box** is seen to **change direction** (bend) as it goes from **air** into the **glass block**.

The **angle B** is **less** than the **angle A** as the light ray gets pulled in **towards** the **denser medium** (the glass).



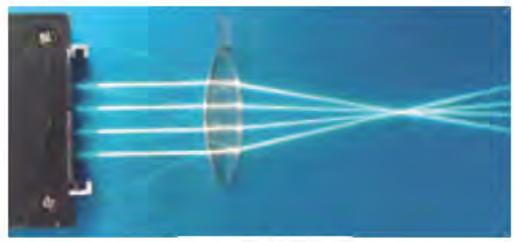
46.4 To Show the Effect of Convex and Concave Lenses

Light rays from a **ray box** are passed through a **convex** and a **concave** lens.

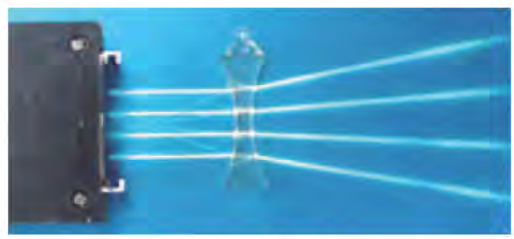
Light rays striking a glass with a **curved surface** get **refracted** at different angles.

A **convex** (**converging**) lens refracts the light rays entering it so that they all **meet at a point**.

A **concave** (**diverging**) lens refracts the light rays entering it so that they **spread out** as they leave the lens.



convex lens

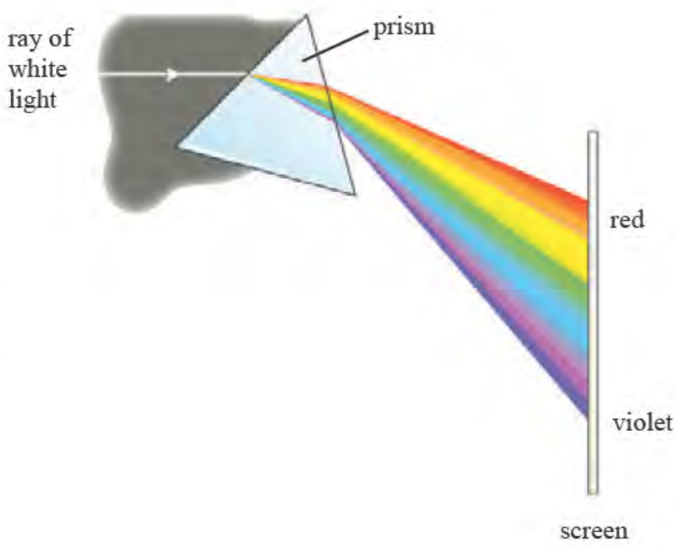


concave lens

46.5 To Show the Dispersion of White Light

A **ray** of **white light** is passed through a glass **prism**.
The prism **disperses** (breaks up) the light into its **7 different colours**.

Each colour is **refracted differently** through the prism - **red light** is **refracted** the **least**, and **violet**, the **most**.
This causes the colours to **spread out** as seen on a **screen**.



Chapter 47. Sound

- **Sound** is a form of **energy** caused by **vibrating objects**.
- **Sound**, unlike light, **needs a medium** to pass through.
- **Sound** is **reflected** off hard surfaces, resulting in echoes.
- **Ultrasound** has **frequencies** too **high** for humans to **hear**.
- **Sound travels** at **340 m/s** - much **slower** than **light** (300,000,000 m/s).
- **Thunder** and **lightning** show that **light travels faster** than sound.
- The **loudness** of sound is measured in units called **decibels**.

EXPERIMENTS:

47.1 To Show that Sound is a Form of Energy

Sound from the **speaker** travels through the air and causes the **table tennis ball** to **move**.

This shows that **sound** is a form of **energy** and can be **converted** into other forms.

47.2 To Show that Sound Cannot Travel in a Vacuum

A **vacuum pump** is used to **remove** the **air** from inside the bell jar.
The **phone** can be heard **ringing** when there **is air** in the bell jar - the **sound** can **travel** through **air**.

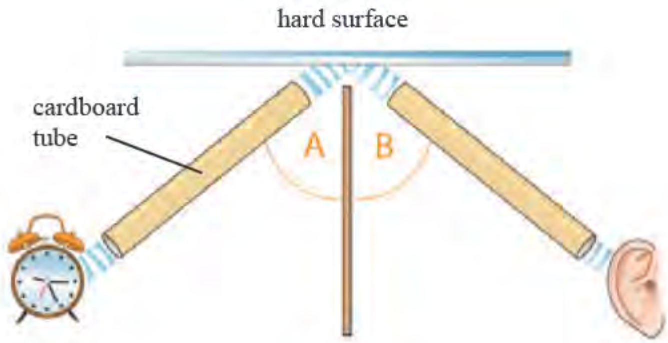
When the **air** is **removed**, even though the phone is still ringing, **no sound** is **heard**.
Sound cannot travel through a **vacuum**.

47.3 To Demonstrate the Reflection of Sound

Sound from the ticking clock is directed through the **cardboard tube**, to a **hard surface**.

The **reflected sound** is then heard through the **second tube**.
The reflected sound is heard the **loudest** when the **angle A equals** the **angle B**.

This shows that sound, like light, reflects off a surface at the **same angle** it enters.



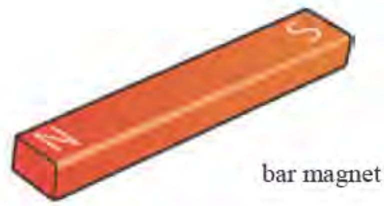
Chapter 48. Magnetism

- **Iron**, **nickel**, **cobalt** or their **alloys** can be **magnetised**.
- The **magnetic effect** of a magnet is strongest at the **two ends** - called the **north pole** and the **south pole**.
- The north pole of a freely suspended magnet always points North.
- **Like poles repel** each other, **unlike poles attract**.
- A **magnetic compass** contains a small **magnet balanced** on a **thin spindle** which is free to move. Its **north pole** points **North**.
- A **magnetic field** is the **space** around a magnet where a **magnetic force** can be seen.
- **Magnetic fields** can be shown using **iron filings** or **plotting compasses**.
- **Magnetic field lines** go from the **north pole** to the **south pole** of a magnet.
- The **Earth** has a **magnetic field** as if it had a huge **bar magnet** at its **centre**, with the **magnet's south pole** in the **northern hemisphere**.
- Magnets are used in **electric motors**, **telephones**, **loudspeakers**, **compasses**, press and **fridge doors**, **dynamos** etc.

EXPERIMENTS:

48.1 To Test a Variety of Materials for Magnetism

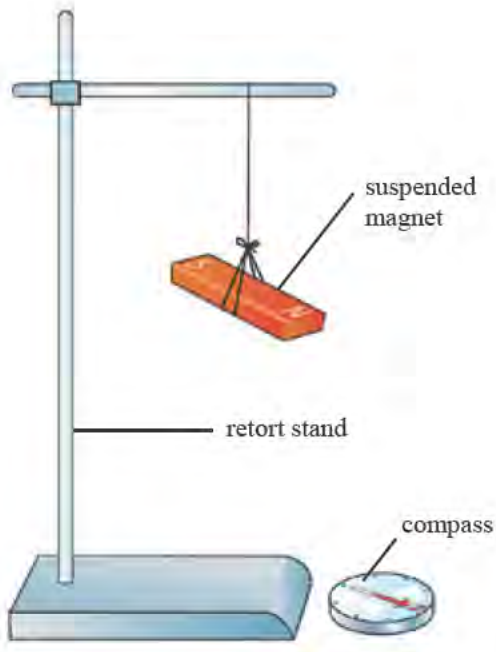
Bring a **bar magnet** close to a variety of materials to see if they are **attracted** to the **magnet**. Materials that contain the elements **iron**, **nickel** or **cobalt** will have magnetic properties.



48.2 To Find the North Pole of a Magnet

One end of a **suspended magnet** points **North**.

A **compass** is used to determine which end of the suspended magnet is pointing **North**.



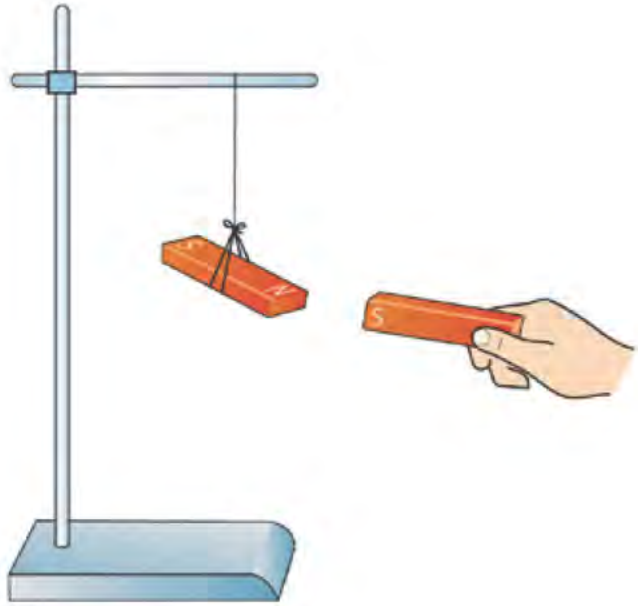
48.3 To Demonstrate the Attraction and Repulsion of Magnets

When the **south pole** of a bar magnet is brought **towards** the **north pole** of a suspended magnet, the **magnets attract** each other.

Unlike poles attract.

When the **north pole** of a bar magnet is brought **towards** the **north pole** of a suspended magnet, the **magnets repel** each other.

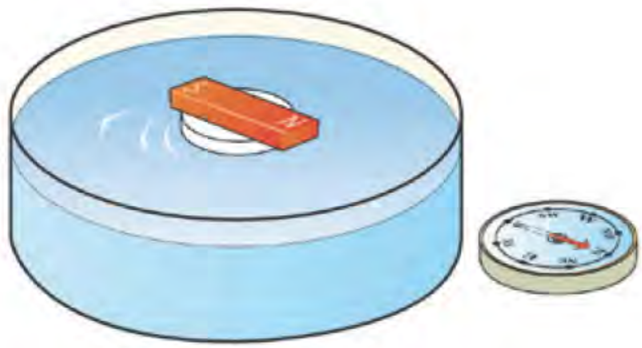
Like poles repel.



48.4 To Make a Floating Compass and Demonstrate the Earth's Magnetic Field

A **bar magnet**, **floating** on a piece of **polystyrene** in a **bowl** of **water**, will have its **north pole** pointing **North**.

The magnet is free to move so it behaves just like the **magnetised pointer** of a **compass**.
Its **north pole** is **attracted** to the **Earth's magnetic south pole** (which is in the **northern hemisphere** of the Earth).

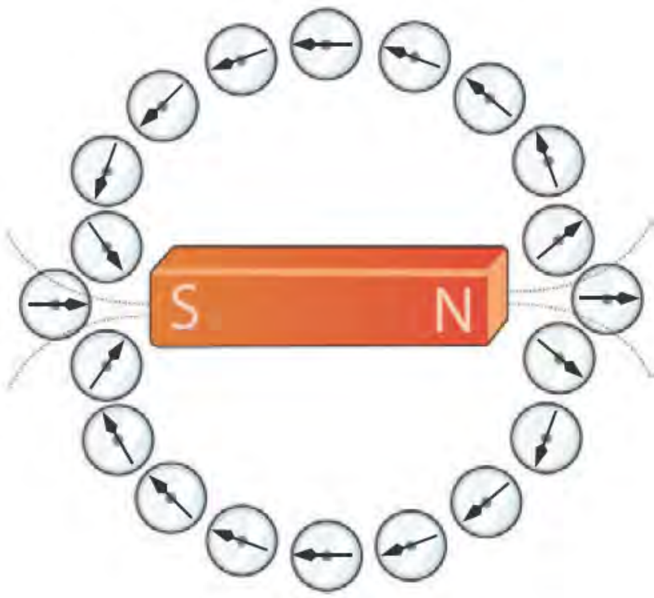


48.5 To Plot the Magnetic Field Around a Bar Magnet Using Plotting Compasses

Plotting compasses are placed around a **bar magnet** as shown.

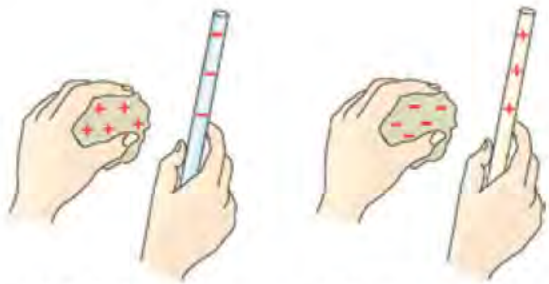
The pointers of the **compasses point** from the **north pole** of the magnet to the **south pole** of the magnet.

This shows that the **magnetic field lines** of a magnet point from **north pole** to **south pole**.



Chapter 49. Static Electricity

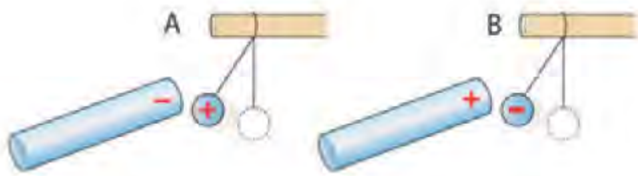
- When two objects are **rubbed together**, **electrons** get **transfered** from one to the other.
- Some substances such as **polythene** and **perspex** (good **insulators**) do not allow these electrons to flow out so they build up an **electric charge** called **static electricity**.
- A **polythene rod gains electrons** from a woollen cloth when it is rubbed with the cloth - the rod **gains** a **negative charge**.
- A **perspex rod loses electrons** to a woollen cloth when it is rubbed with the cloth - the rod **gains** a **positive charge**.
- An object becomes **negatively charged** if it **gains electrons**;
  an object becomes **positively charged** if it **loses electrons**.



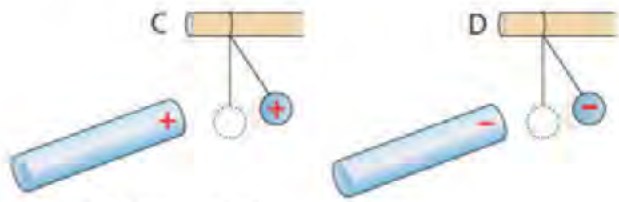
Polythene rod gains electrons

Perspex rod loses electrons

- **Unlike charges attract** each other;
  like charges repel each other.
- **Earthing** occurs when a charged object **loses** its **charge** to the **earth**.



Unlike charges attract



Like charges repel

EXPERIMENTS:

49.1 To Show the Presence of Static Electricity

A **biro** or **polythene rod**, rubbed with a **woollen cloth** will gain a **static charge**.

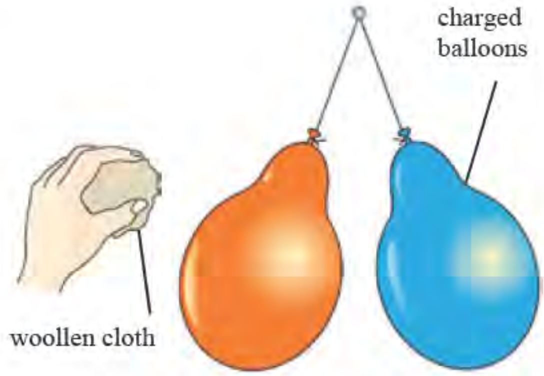
This allows it to pick up small pieces of paper.

A **charged rod** or biro will **attract a stream** of **water** if it is brought close to it.

49.2 To Demonstrate the Force Between Charged Objects

Two **balloons** are **suspended** from a piece of **thread** as shown.
Each balloon is then **rubbed** with a **woollen cloth**, so that each **gains** the **same static charge**.

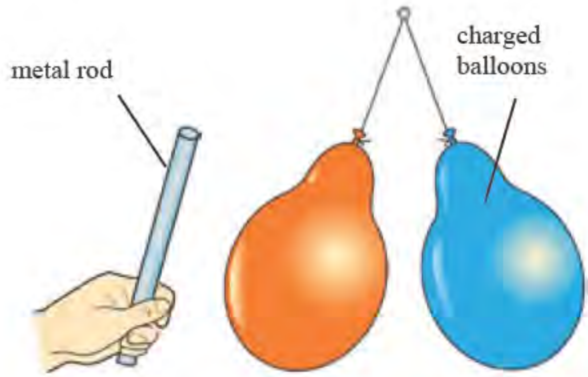
The balloons **move away** from each other as the **like charges** on them **repel**.



49.3 To Demonstrate the Effect of Earthing

A **metal rod** is touched to **each** of the **charged balloons** in turn.
The balloons **fall back together** and touch each other.

Charge has **left each balloon** and **run** to **Earth**, when it was touched with the metal rod (a **conductor**).
The charge on the balloons has been **earthed** - the balloons are no longer charged.



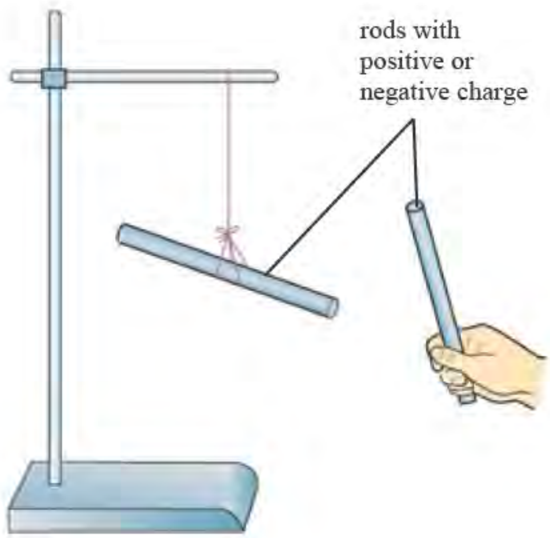
49.4 To Investigate the Forces Between Like and Unlike Charges

A suspended **polythene rod** is **charged** by rubbing it with a **woollen cloth** - it gains a **negative charge**.
When another charged **polythene rod** is brought close to it, the **like charges repel** and the suspended rod **moves away**.

Like charges repel.

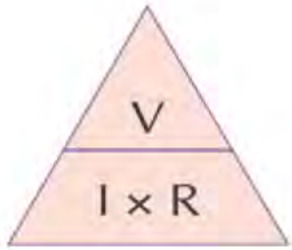
When a **charged perspex rod** (**positive charge**) is brought close to the **negatively charged polythene rod**, the suspended rod **moves towards** it.

Unlike charges attract.



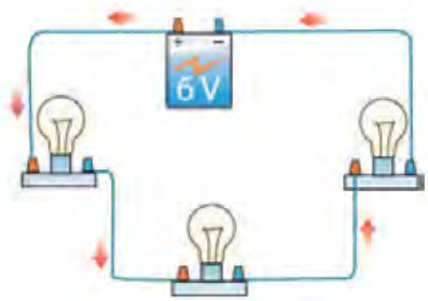
Chapter 50 Current Electricity

- An **electric current** is a **flow** of **electric charge**.
- **Conductors** are substances which **allow** electric **current** to **flow** through them freely (e.g. all metals).
- **Insulators** are substances which do **not allow current** to pass through them.
- A **battery** or **power pack** is an '**electrical pump**' that **pumps electrons** around a circuit.
- **Electrons** are pumped from a region of **high electrical pressure** (the **negative terminal**) to a region of **low electrical pressure** (the **positive terminal**).
- The **difference** in electrical pressure between the **negative** and **positive terminals** is called the **potential difference** or **voltage**.
  It is measured in **volts** (V) using a **voltmeter**.
- **Current** is the **flow** of **electrical charge**. It is measured in **amps** (A) using an **ammeter**.
  The symbol for **current** in amps is (**I**).
- **Resistance** is the ability a substance has to **resist the flow** of **current** in a circuit. It is measured in **ohms** (**Ω**).
- The **larger** the **voltage**, the **larger** the **current** that can flow.
  The **larger** the **resistance**, the **smaller** the **current** in the circuit.
  The **relationship** between voltage (**V**), current (**I**) and resistance (**R**) can be shown using the **VIR triangle**.

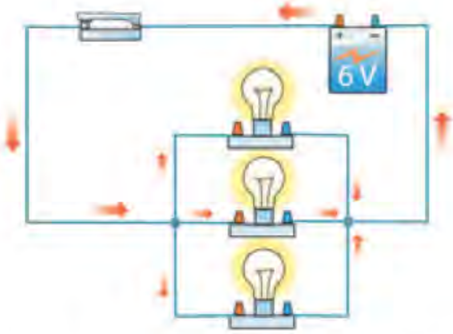


- **Ohm's Law** states that at **constant temperature**, the **voltage** (V) is always **proportional** to the **current** (I) in a circuit.
- **Resistors** (e.g. bulbs) in a circuit can be **wired** either in **series** or **parallel**.

Resistors wired in series

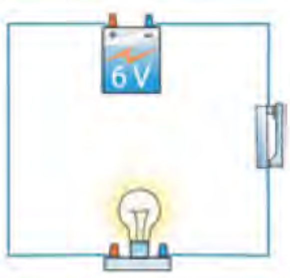


Resistors wired in parallel



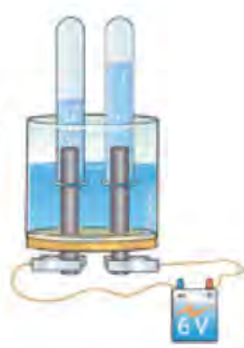
- For **resistors in series**, the **total resistance** is found by adding each of the individual resistances together. $\mathbf{R_{(Total)} = R_1 + R_2 + R_3}$.
- The **three effects** of an **electric current** are **heating**, **magnetic** and **chemical**.

Heating effect



Magnetic effect

Chemical effect

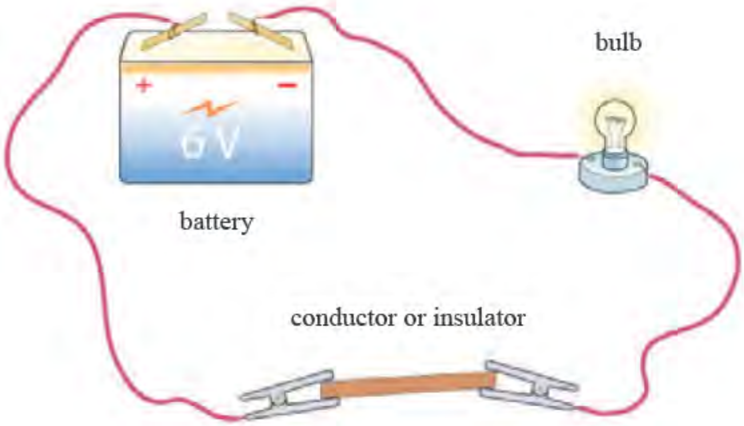


EXPERIMENTS:

50.1 To Distinguish Between Conductors and Insulators

Different materials are placed between the **crocodile clips** to see if they are **conductors** or **insulators** of electricity.

A **conductor allows** the **current** to **flow** in the circuit and the **bulb lights**.
An **insulator** does **not allow** the bulb to light.



50.2 To Verify Ohm's Law

A **circuit** with a **heating element** is set up as shown.
The **voltage** of the circuit may be **changed** using the **voltage dial** on the **power pack**.

The **voltage** is read from the **voltmeter**, which is wired in **parallel** with the **resistor**.

The **current** in the circuit is read from the **ammeter**, which is wired in **series** with the **resistor**.

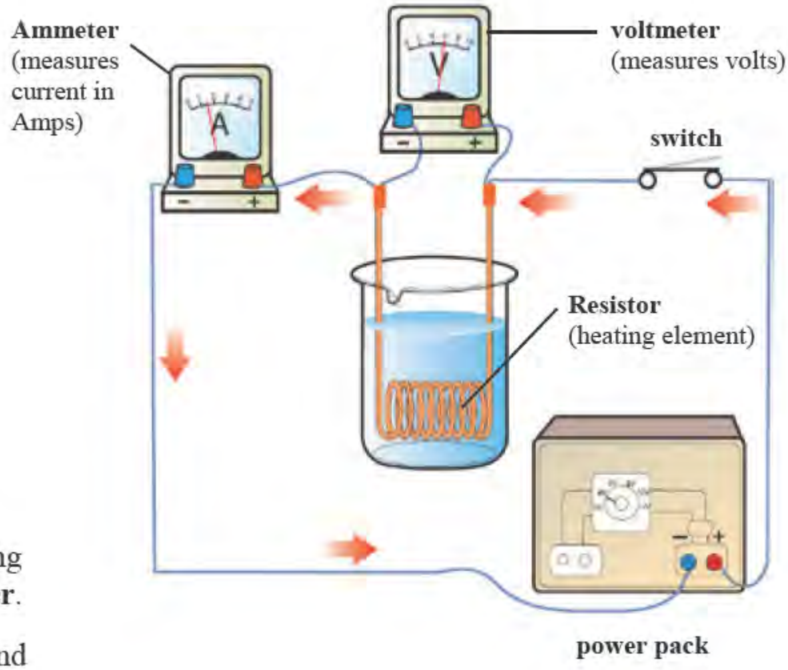
The **resistor** is prevented from heating up too much by immersing it in **water**.

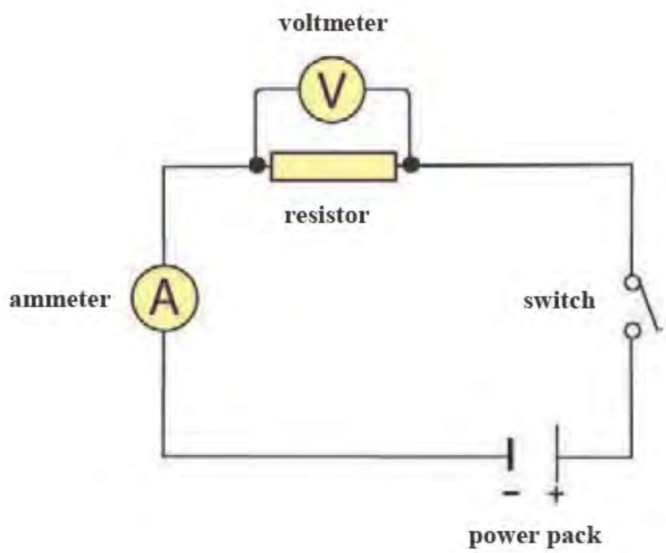
As the **voltage** is **increased**, it is found that the **current** also **increases**.

A **graph** plotted of **current against voltage** gives a **straight line** that passes through the **origin** (0,0).

This **verifies Ohm's Law** which states that, at **constant temperature**, the **current** in a circuit is always in **proportion** to the **voltage** of the circuit.

A **simpler drawing** of the apparatus used is shown on the right.





Chapter 51 Electricity in the Home

- A **fuse** is a **safety device** which **cuts off** the **current** in a circuit if the **current goes above** a certain level. The **thin fuse wire** overheats and **melts** and so **breaks the circuit**. Fuses are now replaced by **circuit breakers**.
- When choosing the **correct fuse** for a circuit, its **amp rating** should be **slightly higher** than the **normal circuit** or appliance requires.
- The terminals of a plug are connected as follows: **Live** on the right (**Brown** wire); **Neutral** on the left (**Blue** wire); **Earth** in the middle (**Yellow/Green** wire). A **fuse** is inserted on the **Live wire**.
- The **power** of an appliance is a **measure** of how quickly it **converts** electrical energy into other forms of energy. **Electrical power** is measured in units called **watts** (W).
- The **ESB's unit of energy** is the **kilowatt hour** (kWh).
  A **kilowatt hour** is the electrical energy used (converted) by a **1 kW** appliance running for **1 hour**.
- The number of kilowatt hours (**units**) **used**: = (**number of kilowatts**) x (**number of hours**).
- **Cost** of electricity = (**number of kilowatt hours or units**) x (**cost per unit**).
- **Direct current** (d.c.) travels in **one** direction only.
  Alternating current (a.c.), supplied by the **ESB**, **changes direction** many times per second. a.c. can easily be converted to d.c. using a **rectifier**.

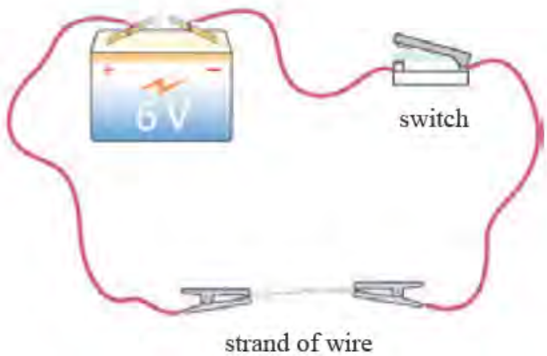
EXPERIMENTS:

51.1 To Show the Action of a Fuse

A **single strand** of fine **wire wool** is placed between the crocodile clips in the circuit.

When the **switch** is closed, the **heating effect** of the **current** heats and **breaks the strand**.

A **fuse** contains a **thin wire** that **melts** and **breaks the circuit** if the current is too big.

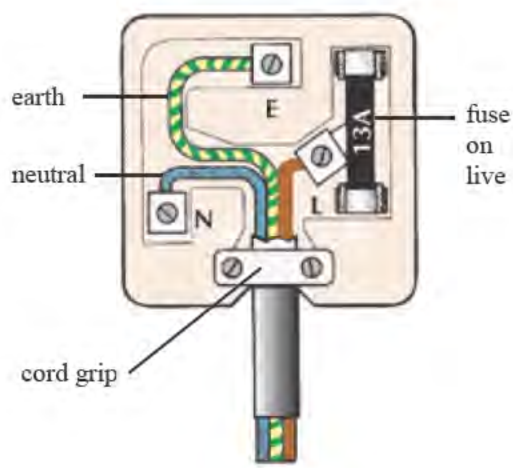


51.2 To Wire a Plug Correctly

About **5 cm** of the **white insulation** is removed from the end of the flex.
The **brown** and **blue** wires are cut back by **3 cm**.
About **0.5 cm** of the **insulation** is removed from each of the **coloured wires**.

The **exposed ends** of the wires are connected to the **terminals** of the plug. **Blue** to **neutral** on the **left**; **yellow/green** to **earth** in the **middle**; and **brown** to **live** on the **right**.

All **screws** on the **terminals**, **cord grip** and **plug cover** are then **tightened** firmly.



Chapter 52 Electronics

- **Electronics** is the careful and exact **control** of very **small electric currents**.
- A **diode** is an **electronic component** that will allow **current** to flow in **one direction** only.
- A **light emitting diode** (**LED**) is a **diode** that gives out **light** when a current flows through it.
- **LEDs** use far **less current** than a bulb.
- A **light dependent resistor** (**LDR**) is a **resistor** whose **resistance depends** on **light**.
- When **light** falls on an **LDR**, its **resistance decreases** and the **current** therefore **increases**.

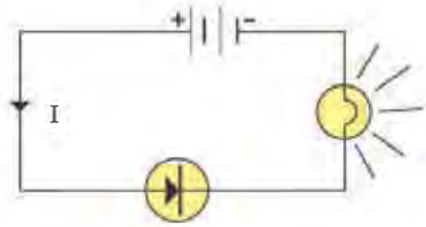
EXPERIMENTS:

52.1 To Show the Action of a Diode

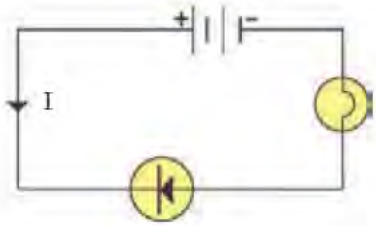
When the **diode** is wired in **forward bias** (**positive** to **positive** of the diode) the **bulb lights**.

When the diode is wired in **reverse bias** (**positive** to **negative** of the diode) the bulb **does not light**.

diode in forward bias

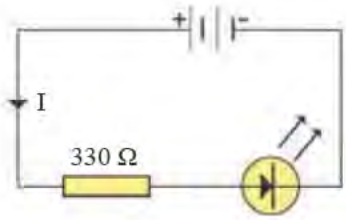


diode in reverse bias



52.2 To Show the Action of an LED

An **LED** gives out **light** when wired in **forward bias** (**positive** to **positive**) as shown.
The **resistor** protects the LED from too high a current.

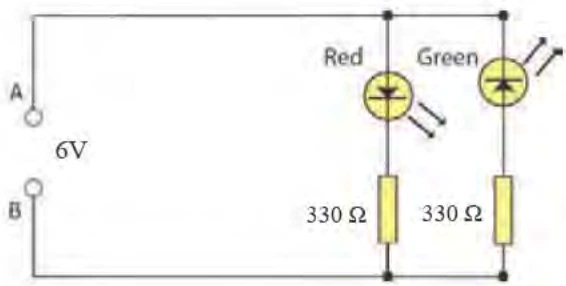


LED

52.3 Using LEDs to Test the Polarity of a Battery

When **terminal A** is connected to the **positive** of the **battery**, the **red** LED (in forward bias) **lights**.

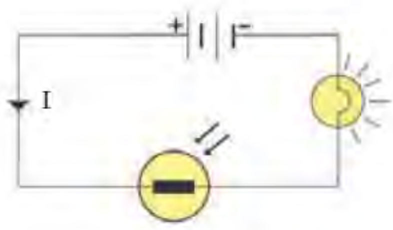
When **terminal A** is connected to the **negative** of the **battery**, the **green** LED (in forward bias) **lights**.



52.4 To Show the Use of an LDR

When **light** is shone on the **LDR**, its **resistance decreases**, the reading on the **ammeter** shows a **higher current** flowing, and the **bulb** lights **brighter**.

The **resistance** of the **LDR decreases** when **light** shines on it.



LDR