

KS4

Combined Science [F]

Knowledge Book

Name: _____
Teacher: _____
Form: _____



Saint Benedict
A Catholic Voluntary Academy



Love, Belief, Integrity, Knowledge



OUR VALUES

**BE WHO GOD MEANT YOU TO BE AND YOU
WILL SET THE WORLD ON FIRE.**

LOVE

As we know we are loved by God, we will learn to love ourselves and care for our own body mind and soul.

We will show love to one another by being patient and kind, not by being rude, boastful or proud.

As one body in Christ, we will ensure that no member of our community is left out or left behind

BELIEF

We will encourage one another and build each other up.

We will let our light shine, making the world a better place for all.

KNOWLEDGE

We will value knowledge: intelligent hearts acquire knowledge, the ears of the wise seek knowledge.

INTEGRITY

We will always strive to make the right choice even when this is the harder path to take.

We will live and work sustainably.

**AT SAINT BENEDICT
WE DEVELOP THE
CHARACTER OF OUR
COMMUNITY THROUGH
OUR CURRICULUM AND
CULTURE.**

Kindness

Key word

Empathy	Understand and share feelings of others
Compassion	Concern for misfortune of others
Compliment	Praise or congratulate others
Considerate	Thoughtfulness and sensitivity to others
Generous	Being liberal with things

Treat others how you would want to be treated yourself.

What is Kindness?

The quality of being friendly, generous and considerate

What does it mean to be kind?

To have empathy/sympathy, be compassionate, looking for good in people.

Why is it important to be kind?

Makes you feel happy, feel good about yourself

Builds strong relationships

Inspires others

How can we show kindness?

Smile

Hold the door open for somebody

Say something nice (compliment)

Invite somebody sat on their own to join you

Manners

Listen to somebody

3

Emotions

Key Words

Feelings	An emotional state or reaction.
Relationships	The state of being connected with someone else.
Instinct	A fixed pattern of behaviour.
Intuitive	Using what you feel to be true even without conscious reasoning.
Reaction	Something done, felt or thought in response to a situation or event.
Identification	The act or process of identifying someone or something.

Work and play in harmony

What are emotions?

Emotions are biological states associated with the nervous system.

Thoughts, feelings, behavioural responses, and relationships all generate emotions.

An instinct or, intuitive reaction or feeling can create emotions

Identifying feelings

Making sense of what and how you feel is not always easy. To do this, we need to regularly check in with ourselves, making time to think about the feelings we are having and naming them. To do this, we need to think about our daily lives which may help us to see patterns of behaviour.

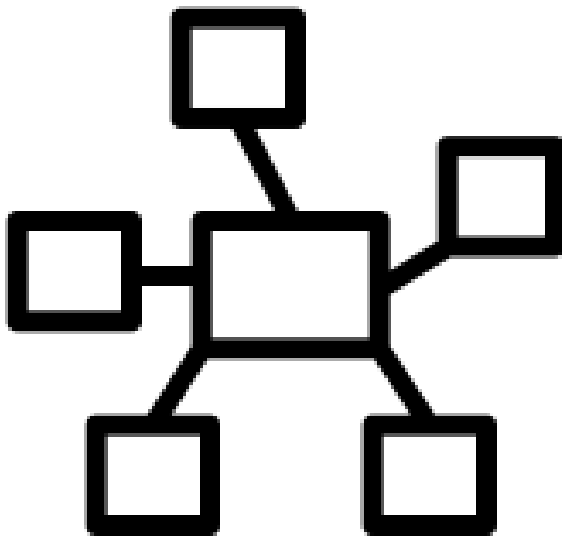
Not all feelings or emotions are bad or negative!

It is important to recognise when you feel happy; relaxed and good about yourself. Knowing what has led to these feelings can help us identify things we do not like which may cause us negative feelings.

4

Study Skills – Ways to learn and remember

Elaboration



Think about the topic that you are studying

Ask questions such as who, what, why, where, when how. Try to find the answers

See how these ideas connect - a mind map will be useful for this

3

Study Skills – Ways to learn and remember

Concrete Examples

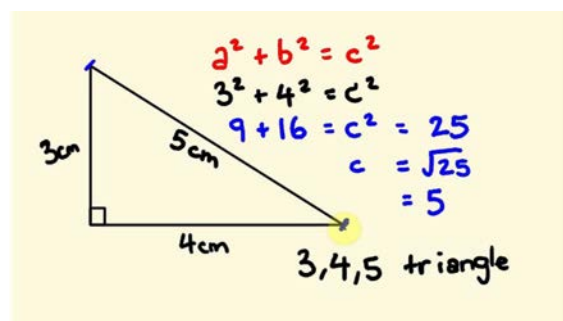


Pythagoras theorem example

If you tried to explain Pythagoras's theorem to someone verbally, it would be quite hard to understand.

By using a concrete example that shows exactly how to use Pythagoras theorem, it is much easier to remember, understand and use

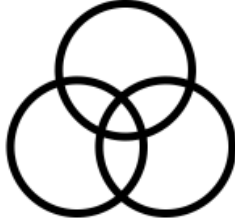
A concrete example is an clear example of an abstract idea



4

Study Skills – Ways to learn and remember

Interleaving



Research says we will actually learn more effectively if we mix our study skills up rather than using the same techniques all the time

1. Try to use different study skills rather than just one technique.
2. When revising for exams, prepare a revision timetable and try to revise more than one subject during a session

5

Study Skills – Ways to learn and remember

Dual Coding



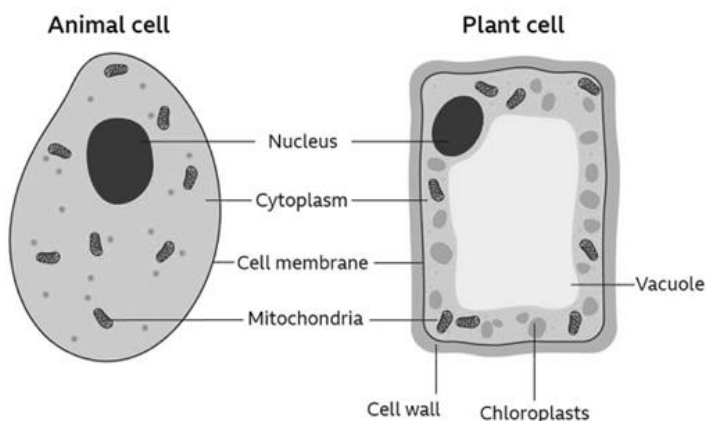
As well as **writing** information down, **create an icon/ drawing** too for individual facts. This helps your brain to remember the information

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Biology Paper 1 (Combined Science: Higher & Foundation)

1. Cells
2. Organisation of cells
3. Eukaryotic and prokaryotic cells
4. Animal specialised cells
5. Plant specialised cells
6. Nucleus
7. Stem cells and microscopes
8. Transport in and out of cells – diffusion
9. Levels of organisation
10. Organisation of cells in the digestive system 1
11. Enzymes in the digestive system
12. Organisation of cells in the breathing system
13. Organisation of cells in the circulatory system 1
14. Organisation of cells in the circulatory system 2
15. Cross section of leaf
16. Organisation of cells in plants
17. Coronary heart disease
18. Cell division: Mitosis and cancer
19. Communicable disease: pathogens
20. Communicable disease: viruses
21. Communicable disease: bacteria, fungi and protists
22. Human defences against pathogens
23. Medical drugs
24. Health issues
25. Transport – osmosis and active transport
26. Photosynthesis
27. Limiting factors of photosynthesis (Higher)
28. Respiration
29. Response to exercise and metabolism
30. Required Practicals 1: Microscopy & food tests
31. Required Practical 2: Osmosis
32. Required Practical 3: Enzymes
33. Required Practical 4: Photosynthesis

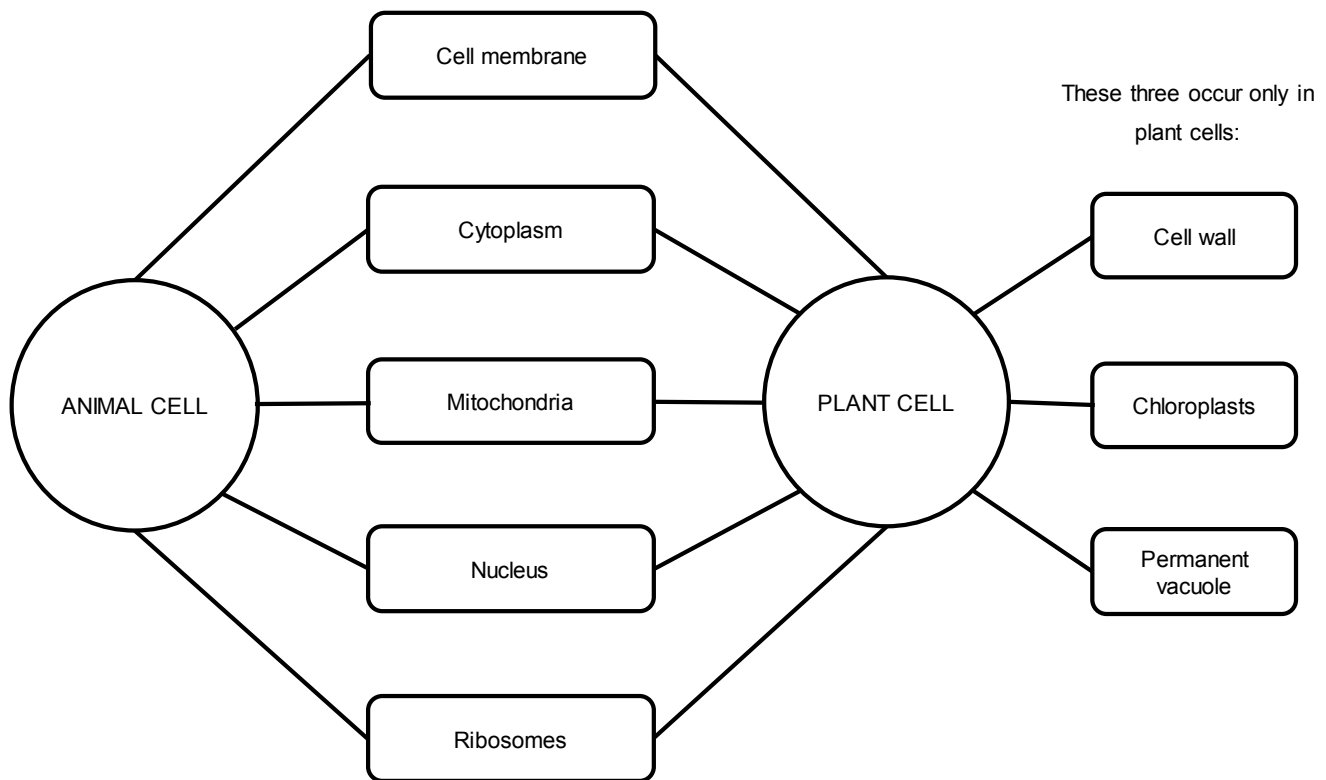
1. Cells



Both animal and plant cells contain a nucleus, cytoplasm, cell membrane, mitochondria and ribosomes. Plant cells also contain a cell wall, chloroplasts, and a permanent vacuole.

Cell organelle	Description
Cell membrane	Controls what enters and leaves the cell.
Cell wall	Made of cellulose, to strengthen the cell.
Chloroplast	The site of photosynthesis.
Cytoplasm	The site of chemical reactions.
Mitochondria	To release energy during respiration.
Nucleus	Contains chromosomes made of DNA molecules. Each chromosome carries a large number of genes.
Permanent vacuole	Filled with cell sap (a weak solution of sugars and salts).
Ribosomes	The site of protein synthesis (where proteins are made).

2. Organisation of Cells



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3. Eukaryotic and prokaryotic cells

Eukaryotic cells contain a nucleus.

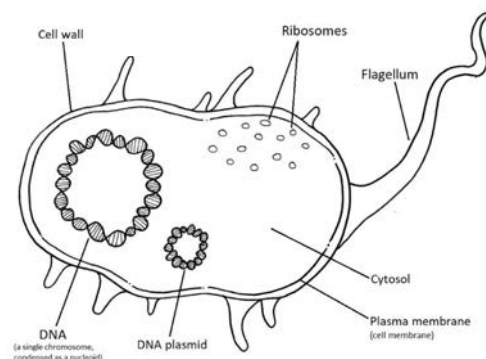
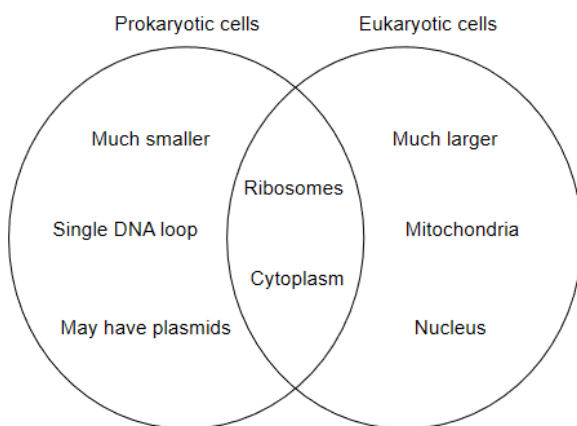
Plant cells and animal cells are eukaryotic.

Prokaryotic cells (bacteria) are much smaller than eukaryotic cells.

They do not have a nucleus.

They do not have mitochondria but do have ribosomes.

They have a single DNA loop and may also have small rings of DNA called plasmids.



1000nm (nanometres) = 1 μ m

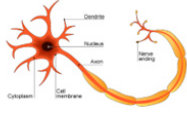

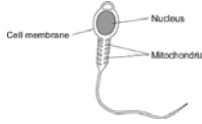
1000 μ m (micrometres) = 1mm

1000mm (millimetre) = 1m

10mm = 1cm (centimetre)

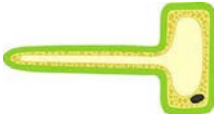
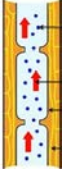

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4. Animal Specialised Cells

Type of specialised cell	Function	Adaptations
Nerve cell 	Carry electrical impulses around the body	Lots of dendrites to make connections to other cells A very long axon that carries the electrical impulse from one place to another Contain lots of mitochondria to provide the energy needed to make special transmitter molecules, to carry impulses across gaps (synapses) between one nerve cell and the next
Muscle cells 	Contract and relax to allow movement	Contain special fibres that can slide over one another to allow the muscle to contract and relax Contain lots of mitochondria to provide energy for contraction Store glycogen which can be converted into glucose for respiration
Sperm cells 	Fertilise an egg cell	A tail for movement Middle section full of mitochondria to provide energy for tail to move Digestive enzymes in acrosome to digest a pathway into the egg A large nucleus containing half the genetic information needed to make an organism

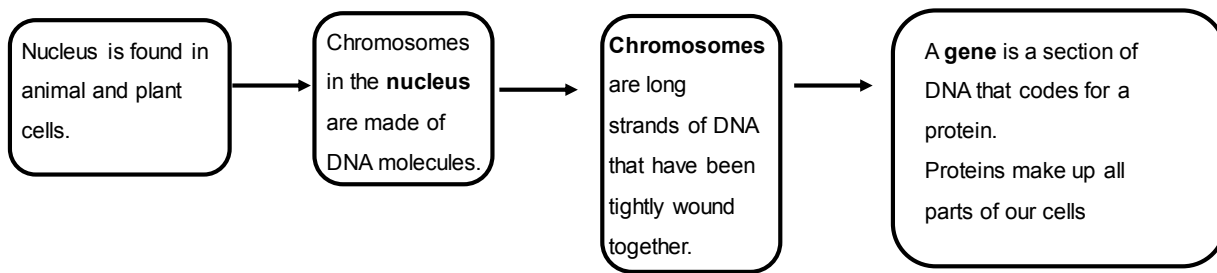
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5. Plant Specialised Cells

Specialised cell	Function	Adaptations
Root hair cell 	Absorb water and mineral ions	Large surface area available for water to move into cell by osmosis Large permanent vacuole that speeds up osmosis Lots of mitochondria that carry out respiration to provide the energy needed for active transport of mineral ions
Xylem cells 	Transport water and mineral ions from the roots to the highest leaves and shoots - always upwards.	When first formed xylem cells are alive but due to build-up of lignin the cells die and form long hollow tubes (vessels). The lignin makes the xylem vessels very strong and helps them withstand the pressure of water moving up the plant.
Phloem cells 	Transport sugars up and down the plant	End walls between cells break down to form sieve plates that allow water carrying dissolved sugars to move up and down the phloem. Neighbouring companion cells are packed with mitochondria to provide their energy needs.

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6. Nucleus



The nucleus contains **chromosomes** made of DNA molecules.

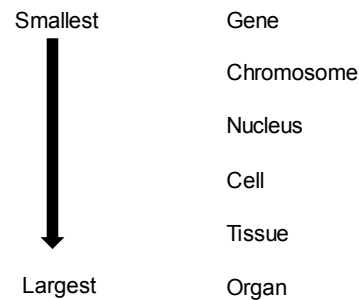
Each chromosome carries a large number of genes.

Gametes (sperm and egg cells) only have 1 set of chromosomes, so they have 23 chromosomes.

When human gametes come together in fertilisation, they form a zygote (fertilised egg cell) with 23 pairs of chromosomes (46 chromosomes).

Human body cells contain 23 pairs of chromosomes.

Biological structures in size order



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7. Stem Cells and Microscopes

Use the EVERY model to complete calculations:

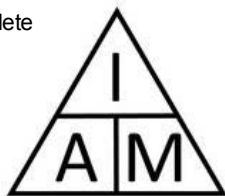
E = equation

V = values

E = enter results

R = result

Y = units



Magnification = $\frac{\text{size of image}}{\text{size of real object}}$

Magnification increases the size of the image.

Resolution increases the detail of the image.

Electron microscopes have higher magnification and higher resolution than **light microscopes**.

They have allowed scientists to study cells in much finer detail.

They have increased our understanding of sub-cellular structures such as mitochondria.

Type	Description
Adult stem cells	Adult cells which can form many types of cells, including blood cells.
Embryonic stem cells	Stem cells from embryos which divide and differentiate into specialised cells.
Differentiation	Specialisation of cells
Stem cells	Undifferentiated cells, capable of dividing to make lots of cells, and of differentiating to form specialised cells.
Meristem tissue	Tissue made up of stem cells in plants. It can differentiate into any type of plant cell, throughout the plant's life. Can be used to produce plant clones quickly and economically. Can be used to clone rare species. Can be used to clone plants with useful features, e.g. disease resistance.
Therapeutic cloning	Scientists can use embryo stem cells to make different types of human cells. The cells are not rejected by the patient's body, but some people have ethical or religious concerns.

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8. Transport in and out of cells: diffusion

Diffusion: The overall movement of particles from high concentration to low concentration – they spread out.

Examples

Oxygen and carbon dioxide diffuse in and out of cells in **gas exchange**.

Urea moves out of cells into the blood plasma. It is a waste product. It goes to the kidney to be excreted.

Factors that affect the rate of diffusion

- The bigger the difference in concentrations, the faster diffusion is.
- The higher the temperature, the faster diffusion is.
- The bigger the surface area of the membrane, the faster diffusion is.

Diffusion and single celled organisms

Single celled organisms have a large surface area compared with their volume.

Diffusion is enough to get them all the molecules that they need.

Diffusion and larger organisms

Larger organisms have a small surface area compared to their volume.

They need exchange surfaces and transport systems to allow them to absorb enough oxygen and move it around the body.

Exchange surfaces in plants have:

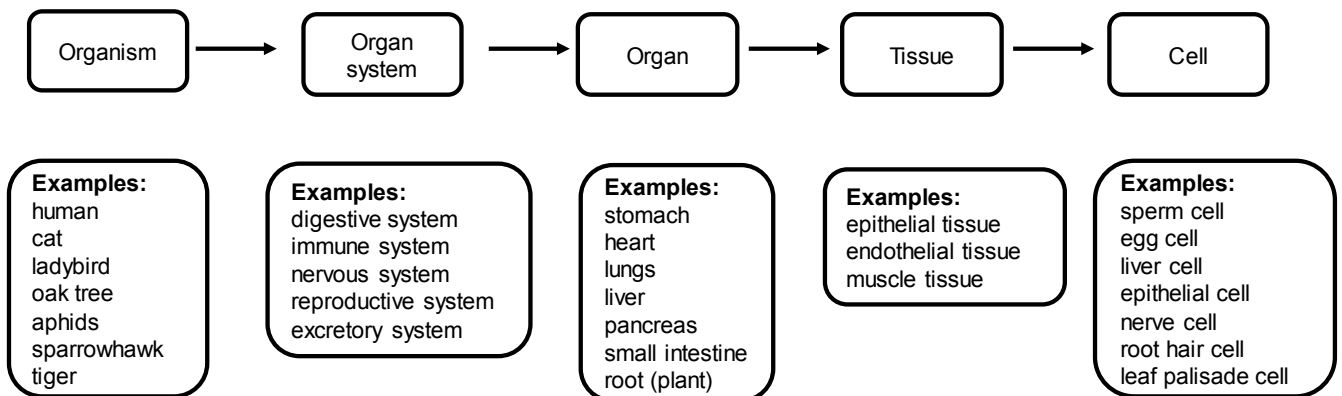
1. a large surface area.
2. thin membranes, to provide a short diffusion path.

Exchange surfaces in animals have:

1. a large surface area
2. thin membranes, to provide a short diffusion path.
3. a good blood supply
4. good ventilation (they breathe)

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9. Levels of organisation



Basics of organisation

Cells are the building blocks of all organisms.

A tissue is a group of cells with a similar structure and function.

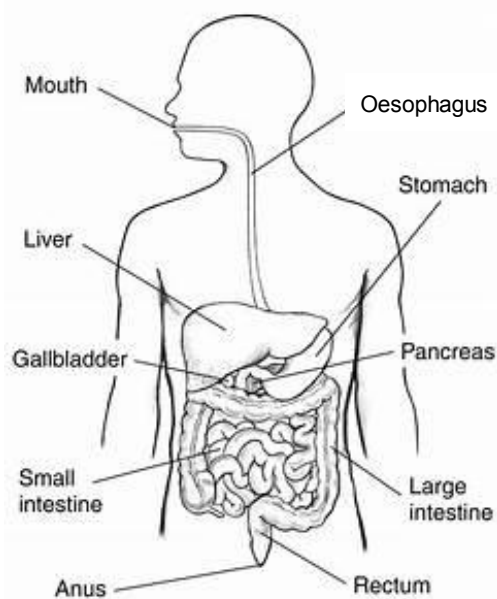
An organ is a group of tissues performing similar functions.

An organ system is a group of organs, which work together to perform a particular function.

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10. Organisation of cells in the digestive system

The **human digestive system** is an example of an organ system in which several organs work together to digest and absorb food.



Organ	Function
Mouth	First stage of digestion, teeth break up food with mechanical digestion and salivary amylase breaks down food in chemical digestion.
Oesophagus	Transports food from the mouth to the stomach.
Stomach	Churns food and adds acid.
Small intestine	Adds digestive enzymes (amylase, lipase, and protease) and absorbs nutrients from the food.
Large intestine	Absorbs water, producing waste.
Rectum	Stores waste.
Anus	Waste passes out of the anus.
Liver	Produces bile. Bile neutralises stomach acid and emulsifies fats. Food does not pass through here.
Gall bladder	Stores bile which has been produced in the liver. Food does not pass through here.
Pancreas	Produces digestive enzymes: amylase, lipase, and protease. Food does not pass through here.

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11. Enzymes in the digestive system

Digestive enzymes break down food into small soluble molecules that can be absorbed into the blood stream.

Digestive Enzyme	Produced by	Converts...	Into...
Amylase (carbohydrase)	Mouth, small intestine, pancreas	Starch (carbohydrate)	Sugar
Lipase	Small intestine, pancreas	Lipid (fat)	Glycerol + fatty acid
Protease	Stomach, small intestine, pancreas	Protein	Amino acids

Enzymes are **specific**.

They have a specific shape (**the active site**) which works on a specific substrate – like a lock and key.

If the active site changes shape, it no longer works. Changes in pH and temperature can **denature** – change the shape of the active site - so that it no longer works.

The products of digestion are used to build new carbohydrates, lipids and proteins. Glucose can also be respired.



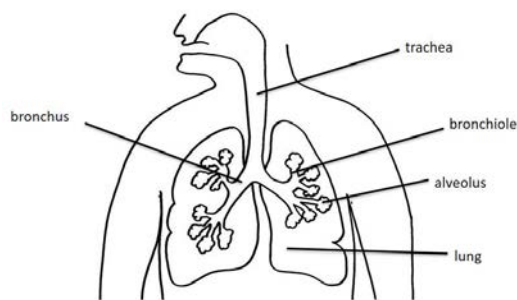
Bile is made in the liver and is stored in the gall bladder.

It is alkaline and neutralises the hydrochloric acid from the stomach.

It emulsifies fat to form small droplets, increasing the surface area. This makes fat digestion quicker.

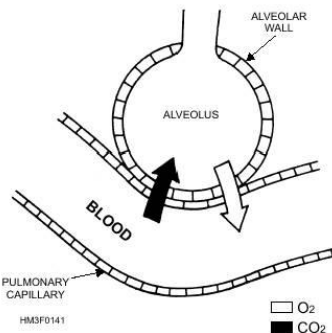
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12. The breathing system



The lungs provide a good exchange surface for oxygen:

1. **Large surface area** provided by alveoli.
2. **Thin walls** of alveoli (one cell thick) and blood supply (capillary), providing a short diffusion distance.
3. **Good blood supply** to transport the oxygen away from the lungs.
4. **Well ventilated** to supply more oxygen.



Air enters the body through the **mouth** and **nose**.



Air enters the **trachea**.



The trachea divides into two **bronchi**.
One **bronchus** enters each lung.



Each bronchus branches out into smaller tubes called **bronchioles**.
Air travels through these bronchioles.



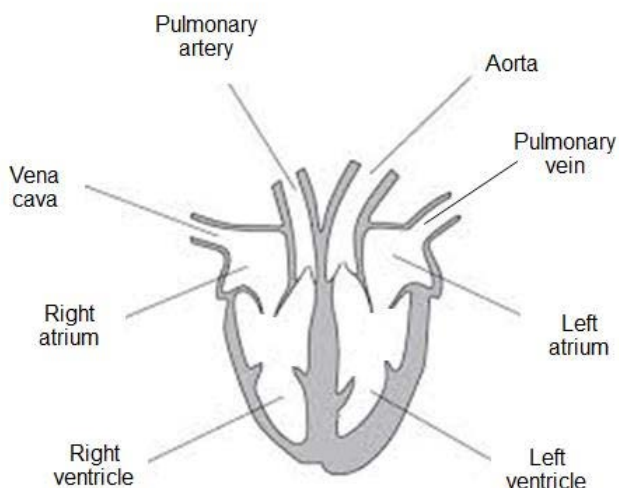
At the end of the bronchioles, the air enters one of the many millions of **alveoli** where gaseous exchange takes place

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13. Organisation of cells in the circulatory system 1

The heart is an **organ**.

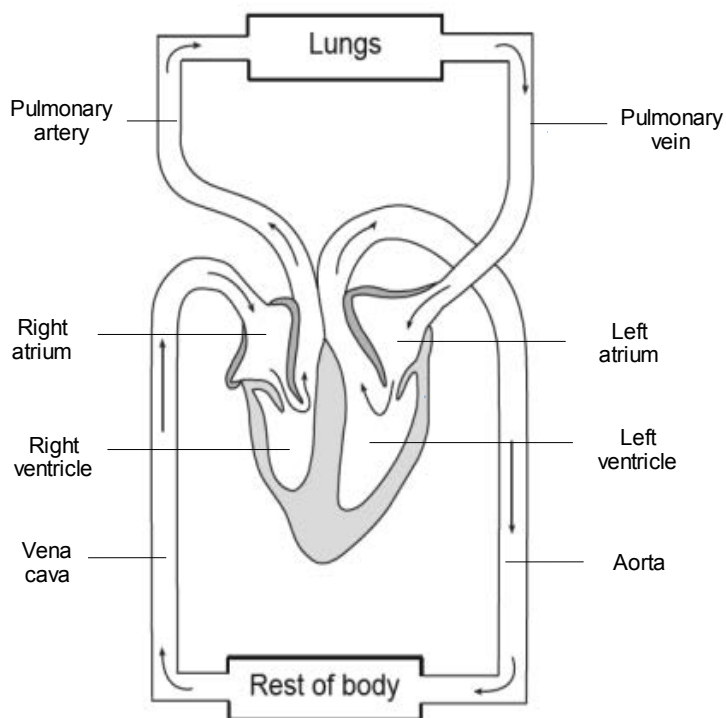
The function of the heart is to pump blood around the body. Humans have a **double circulatory system**, which means that blood must pass through the heart **twice** to complete a full circuit of the body.



Organ	Function
Heart	Organ that pumps blood around the body in a double circulatory system.
Vena cava	Vein which brings blood from the body to the right atrium of the heart.
Right ventricle	Chamber which pumps blood to the lungs where gas exchange takes place.
Pulmonary artery	Artery takes blood from the right ventricle to the lungs.
Left ventricle	Chamber which pumps blood around the rest of the body
Pulmonary vein	Vein which brings blood from the lungs to the left atrium of the heart.
Aorta	The aorta takes blood from the left ventricle to the body.
Pacemaker	In the wall of the right atrium, controls heart rate.

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14. Organisation of cells in the circulatory system 2



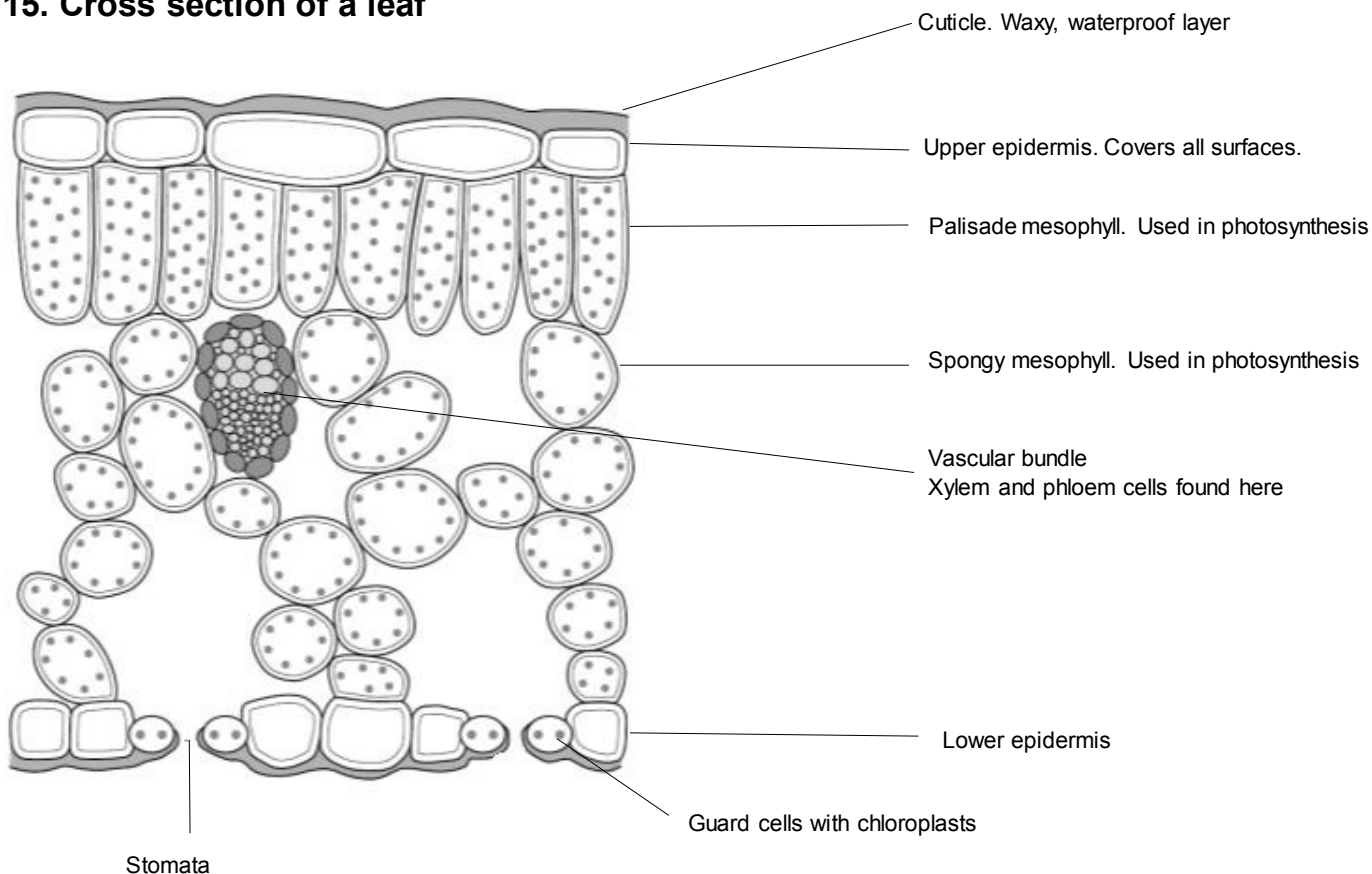
The blood is a tissue.

Blood component	Role
Plasma	Solution in which cells are suspended; carries dissolved food and hormones around the body
Red blood cells	Carry oxygen
White blood cells	Involved in immune response to fight pathogens
Platelets	Involved in blood clotting

Blood vessel	Role	Description
Artery	Carry blood away from heart	Walls contain lots of strong elastic tissue to withstand pressure
Capillary	Allow substances to diffuse into and out of the blood	Walls are one cell thick and include small holes to allow substances to move in and out easily
Vein	Carry blood to the heart	Have valves to keep blood flowing in one direction only

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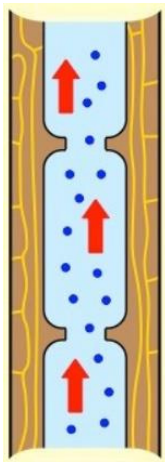
15. Cross section of a leaf



16. Organisation of cells in plants

Water is absorbed (by osmosis) by **root hair cells** that have a large surface area.
The root hair cells also absorb mineral ions (by active transport).

Xylem Cells



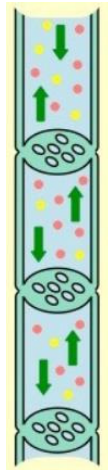
Transports **water and mineral ions** from the roots to the stems and leaves.
Made of hollow tubes, strengthened by lignin.

Transpiration is the transport of water and minerals up the xylem of a plant, and the evaporation of water through the stomata.

Transpiration is increased by

- Increased temperature
- Increased air movement
- Increased light intensity
- Decreased humidity

Phloem Cells



Translocation is the transport of sugars in the phloem, to all parts of the plant.

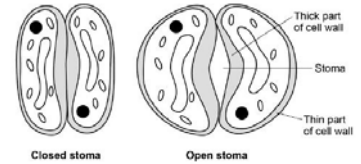
The leaves make sugars through photosynthesis.

The **phloem** transports dissolved sugars from the leaves to the rest of the plant for respiration or for storage of starch.

Phloem is made of tubes of elongated cells.

Cell sap (dissolved sugars) moves from one phloem cell to the next through pores in the end walls.

Stomata and Guard Cells



The **stomata** (small holes in the underside of the leaf) are needed for gas exchange in the leaf.

Water is also lost to the surroundings through the stomata.

To reduce water loss, **guard cells** can change the size of the stomata.

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17. Coronary Heart Disease

Term	Definition
Disease	dis-ease (not at ease; something in our body or mind is not working correctly)
Coronary Heart Disease	a non-communicable disease (you can't catch it)
Coronary arteries	supply the heart muscle with oxygen and glucose
Coronary heart disease	The coronary arteries have layers of fatty material building up in them. They get narrower. Less blood can flow through the coronary arteries, so the heart muscle lacks oxygen.

Treatment	Description
Statins	Tablets used to reduce blood cholesterol. They slow down the rate of fatty material build up.
Stents	Used to keep the coronary arteries open.
Heart valve replacement	Valves keep blood flowing through the heart in the right direction. Sometimes the valves don't open fully or become leaky. This prevents blood flowing through the heart properly. The patient becomes out of breath and lacks energy. Faulty heart valves can be replaced with new biological valves (from a donor) or mechanical valves.
Heart failure	Can be treated with a new heart and lungs. The heart would come from a donor. Mechanical hearts can be used to keep the patient alive whilst waiting for a heart transplant.

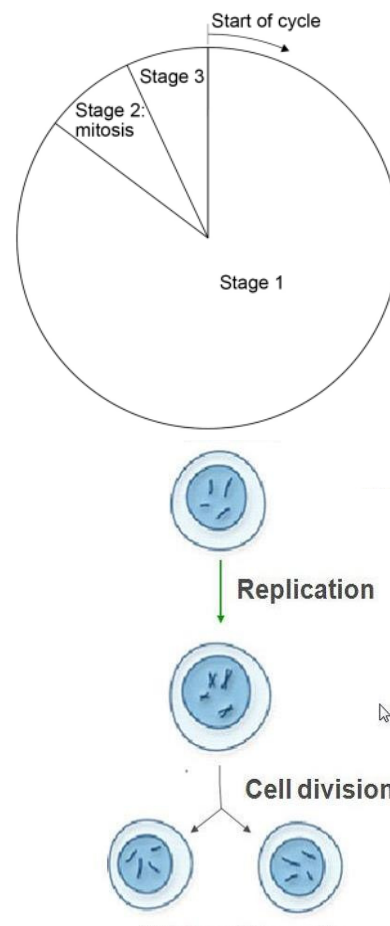
17

18. Cell Cycle: Mitosis

Stage of the cell cycle	Events
1	The cell grows. The DNA replicates to form two copies of each chromosome. New mitochondria and ribosomes are made.
2	Mitosis: one set of chromosomes is pulled to each end of the cell. The nucleus divides.
3	The cytoplasm and cell membranes divide. There are now two identical cells.

Uses of cell division by mitosis

1. Growth
2. Repair of tissues
3. Asexual reproduction



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19. Communicable diseases: pathogens

Communicable diseases are diseases caused by pathogens – they can spread from one organism to another.

Pathogens are organisms that cause infectious disease.

They can be viruses, bacteria, protists or fungi.

Pathogens may infect plants or animals.

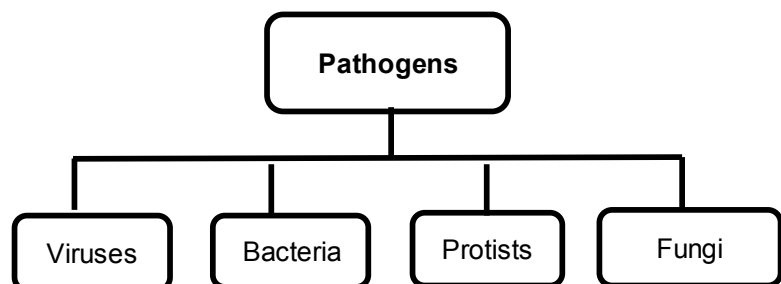
Pathogens can spread by direct contact, water or by air.

Bacteria reproduce rapidly inside the body.

Bacteria produce poisons/toxins that damage tissues and make us feel ill.

Viruses reproduce rapidly inside the body.

Viruses live and reproduce inside cells, causing cell damage.



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20. Communicable diseases: viruses

Pathogen	Disease	Transmission	Symptoms	Treatment or prevention
Virus	Measles	Sneezing and coughing produces droplets containing the virus; these droplets can be inhaled by others.	Fever and red skin rash. It can be fatal if there are complications.	Most young children are vaccinated against measles.
Virus	HIV/AIDs	Sexual contact or exchange of body fluids such as blood.	Flu-like illness, which then attacks the body's immune cells. Late stage HIV, known as AIDS , happens when the immune system is so damaged that it cannot deal with infections or cancers	treated with antiretroviral drugs.
Virus	Tobacco mosaic virus (TMV)	By direct contact	A distinctive mosaic pattern of discoloration on the leaves. The leaves can't photosynthesise as well, which affects the growth of the plant.	Remove infected plants; wash hands when handling plants to prevent transfer from one to another

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21. Communicable diseases: bacteria, fungi and protists

Pathogen	Disease	Transmission	Symptoms	Treatment or prevention
Bacterium	Salmonella (food poisoning)	Undercooked chicken, or contamination of surfaces from raw chicken	Fever, abdominal cramps, vomiting and diarrhoea, caused by the bacteria and the toxins from the bacteria.	Poultry (chicken, turkey and ducks) are vaccinated against salmonella to control the spread
Bacterium	Gonorrhoea	sexually transmitted disease	Thick yellow or green discharge from the vagina or penis; as well as pain when urinating.	Antibiotics, although there are many resistant strains. Barrier methods of contraception can reduce the spread.
Fungus	Rose black spot	by wind or water	Purple or black spots develop on leaves. The leaves turn yellow and drop off. The leaves don't photosynthesise well, which affects the growth of the plant.	Fungicides and removing and destroying the affected leaves.
Protist	Malaria	Spread by mosquito bites.	Recurrent (repeating) episodes of fever. It can be fatal.	Prevented by stopping mosquitos from breeding, and by avoiding being bitten e.g. with a mosquito net.

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22. Human defences against pathogens

Humans have several **non-specific defences** against pathogens.

These defences are general i.e. they work on most pathogens.

Primary line of defense:

Skin is a physical barrier.

Nose, trachea, bronchi contains mucus and hairs to trap pathogens.

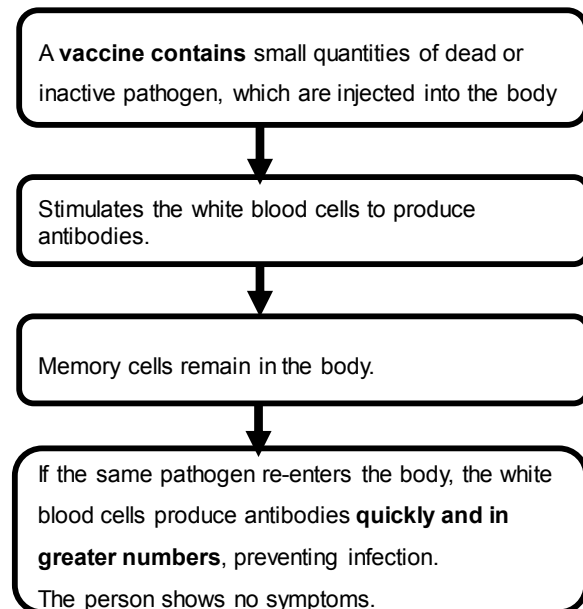
Stomach contains acid which kills pathogens.

Secondary line of defense:

If a pathogen enters the body, the **immune system** tries to destroy it.

White blood cells kill pathogens by:

1. Phagocytosis (absorbing the pathogen and destroying it. This is non-specific)
2. Antibody production (they make pathogens stick together. This is specific)
3. Antitoxin production



Benefits of Vaccinations:

Prevent infection in individuals (see above).

Prevent the spread of infection from one person to another.

22

23. Medical Drugs

Antibiotics are medicines that help to cure bacterial disease.

They kill infectious bacteria inside the body. An example is penicillin. It is important that the right antibiotic is used for the right bacteria. Antibiotics cannot be used to kill viruses. Resistant strains of bacteria have evolved – e.g. MRSA – these are not affected by antibiotics.

Painkillers do not kill pathogens, but they do treat the symptoms of disease.

Antivirals are difficult to produce. They tend to damage body tissues as well as kill the virus.

New drugs

Traditional drugs came from plants and microorganisms.

New drugs are synthesised by chemists in the pharmaceutical industry. However, the starting point may still be a chemical extracted from a plant.

Testing new drugs

New medical drugs must be tested and trialled to check that they are safe and effective.

They are tested for **toxicity**, **efficacy** (does it work), and **dose**.

Preclinical trials use cells, tissues and animals

Clinical trials use healthy volunteers and patients

1. Very low doses are given at the start.

2. If it is safe, further clinical trials are done to find the optimum dose.

3. In double blind trials, some patients are given a placebo.

A **placebo** looks like the drug but contains no drug.

In a **double blind trial**, neither the scientist nor the patient knows if they have been given the drug, or the placebo.

Drug	Source	Purpose
Digitalis	Foxgloves	Heart disease
Aspirin	Willow	Painkiller
Penicillin	Penicillium mould	Antibiotic (discovered by Alexander Fleming)

23

24. Health Issues

Health is the state of physical and mental wellbeing.
Health may be affected by diet, stress and life situations.

Diseases often interact:

Defects in the immune system increase the chance of infectious disease.

Viruses living in cells can trigger cancers.

Pathogens can cause immune reactions; the immune reactions can then trigger allergies, such as asthma and skin rashes.

Severe physical illness can lead to mental illness e.g. depression.

Lifestyle has an effect on some non-communicable diseases
Many diseases are caused by the interaction of a number of risk factors.

Examples include:

Poor diet, smoking and lack of exercise are risk factors for cardiovascular disease.

Obesity is a risk factor for type 2 diabetes.

Alcohol can affect liver and brain function.

Smoking is a risk factor for lung disease and lung cancer.

Smoking and alcohol have effects on unborn babies.

Carcinogens, including ionising radiation, are risk factors for cancer.

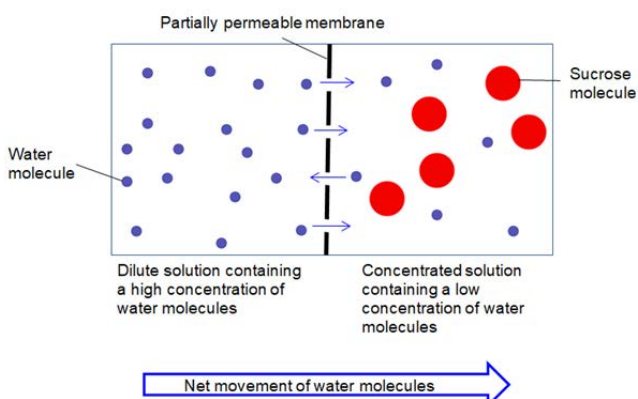
24

25. Transport across membranes: osmosis and active transport

Osmosis is the **diffusion** of **water** through a partially permeable membrane.

Water moves from a **dilute solution to a concentrated solution**.

Cell membranes are partially permeable.
This means that they allow some things to cross e.g. water, but not other things e.g. sugar.

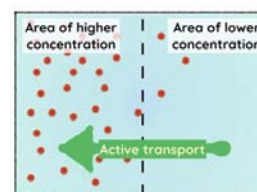


Active Transport is the movement of substances from a **low concentration to a high concentration**.

This is the opposite of diffusion.

Active transport needs **energy** from respiration.

This is because it moves substances against the concentration gradient; from **low to high** concentration.



Active transport is used by plant root hairs to move mineral ions from the soil to the plant. The mineral ions are needed for growth.

Active transport is used in the small intestine to move sugar molecules into the blood. Sugar molecules are used for cell respiration.

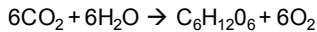
25

26. Photosynthesis

Photosynthesis

carbon dioxide + water → glucose + oxygen

We remember it as COW → GO



Light is needed to provide the energy for photosynthesis.

Photosynthesis is endothermic.

During photosynthesis, energy is transferred from the environment to chloroplasts.

Rate of photosynthesis

The rate of photosynthesis is **increased** when:

The light intensity increases

The carbon dioxide concentration increases

The amount of chlorophyll increases

The temperature increases*

*if the temperature increases too much, enzymes that control photosynthesis are denatured, and the rate decreases.

Uses of glucose from photosynthesis

The glucose produced in photosynthesis may be:

Used for **respiration**

Converted into insoluble **starch** for storage

Used to produce amino acids for **protein** synthesis

Used to produce **cellulose**, to strengthen the cell wall

Used to produce **fat** or oil for storage

(RSPCF)

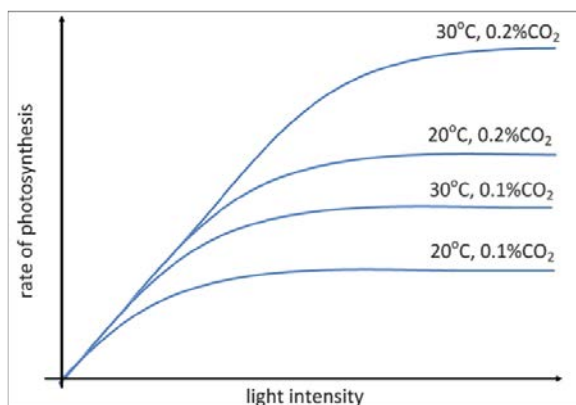
To produce amino acids, plants also use nitrate ions.

Nitrate ions are absorbed from the soil.

They are absorbed by root hair cells by active transport.

26

27 Limiting Factors in Photosynthesis: Higher only



Why does this matter?

Limiting factors are important in the economics of enhancing the conditions in greenhouses to gain the maximum rate of photosynthesis while still maintaining profit.

Carbon dioxide concentration, temperature, light intensity and the amount of chlorophyll all affect the rate of photosynthesis.

Any of these factors may be the factor that limits the rate of photosynthesis. For example, if there is plenty of carbon dioxide, but light intensity is low, then light intensity will be the limiting factor.

A

B

C

D

You will need to be able to tell from a graph which factor is the limiting factor.

At first, as light intensity increases, the rate of photosynthesis increases, meaning that light intensity is the limiting factor.

Then, light intensity continues to increase, but photosynthesis does not. This means that there is another limiting factor.

By comparing line C and D, or line A and B, we can see that when the temperature increases, the rate of photosynthesis increases. This means that temperature is a limiting factor.

By comparing line A and C, or line B and D, we can see that when the concentration of carbon dioxide increases, the rate of photosynthesis increases. This means that concentration of carbon dioxide is a limiting factor.

27

28. Respiration

Cellular respiration happens continuously in living cells.

It is exothermic.

It transfers all the energy needed for living processes.

It can be aerobic (using oxygen) or anaerobic (without oxygen).

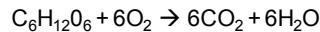
Organisms need energy for

- Chemical reactions to build larger molecules
- Movement
- Keeping warm

Aerobic respiration

Glucose + oxygen → carbon dioxide + water

Remember it as GO → COW



Anaerobic respiration in muscles

Glucose → lactic acid

Anaerobic respiration transfers much less energy than aerobic respiration, as oxidation is incomplete.

Anaerobic respiration in plants and yeast cells

Glucose → ethanol and carbon dioxide

Anaerobic respiration in yeast cells is called fermentation.

It is important in the manufacture of bread and alcoholic drinks.

28

29. Response to exercise and metabolism

Response to exercise

During exercise, the body needs more energy.

The heart rate, breathing rate, and breath volume increase to supply the muscles with more oxygenated blood.

If muscles do not get enough oxygen, anaerobic respiration occurs.

Problems:

Incomplete oxidation of glucose means that less energy is released.

Lactic acid is produced.

An oxygen debt is caused.

Muscles become fatigued and stop contracting efficiently.

After exercise (Higher only)

Lactic acid is transported by the blood from the muscles to the liver

It is converted back to glucose

This conversion requires oxygen.

The amount of oxygen required to convert the lactic acid back to glucose is called the **oxygen debt**.

Metabolism

Metabolism is the total of all the reactions in a cell, or in the body.

The energy transferred by respiration in cells is used by the organism for the constant enzyme-controlled reactions that synthesise new molecules. These reactions are known as metabolism.

Metabolism includes:

respiration

glucose → starch/ glycogen/ cellulose

glucose + nitrate ions → amino acids → proteins

glycerol + fatty acids → lipids

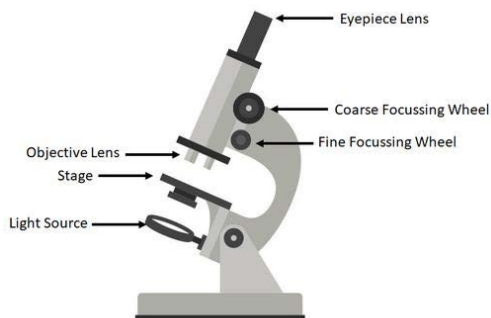
breakdown of excess proteins → urea for excretion

29

30 Required Practicals 1: Microscopy and Food Tests

Using a Microscope

1. Light on
2. Platform (stage) high
3. Lowest magnification objective lens first
4. Coarse focus first then fine focus



Food tests

Food	Test	Positive result
Starch	add iodine solution	turns black
Sugars	add Benedict's solution → heat	makes (orange) precipitate
Protein	add Biuret solution	turns purple
Fats (lipids)	add ethanol → shake → add water → shake	cloudy white emulsion

Rules for Biological Drawings

- Sharp pencil
- Smooth lines
- Ruler for label lines
- No arrowheads
- Add magnification (multiply eyepiece lens by objective lens)

30

31. Required Practical 2: Osmosis

Investigate the effect of concentration of salt or sugar solutions on mass of potato

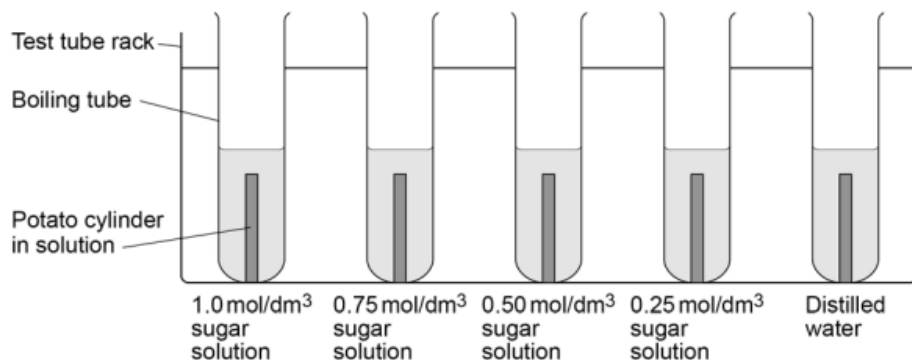
IV: concentration of salt (or sugar) solution (need at least 5 different concentrations)

DV: change in mass of potato cylinders

CV: volume of salt solution; surface area of potato; time in solution; all potato skin removed; method of drying the potato

Method

1. Use a cork borer to cut 5 pieces of potato; make them the same length.
2. Place a known volume of each salt solution into each of 5 boiling tubes.
3. Weigh each potato cylinder.
4. Add one potato to each boiling tube, recording the mass for each.
5. After 30 minutes, remove each piece of potato; dry by rolling three times on a paper towel.
6. Reweigh each potato piece.
7. Calculate the change in mass of the potato and the % change in mass.
8. Plot a graph of salt concentration against % change in mass.



31

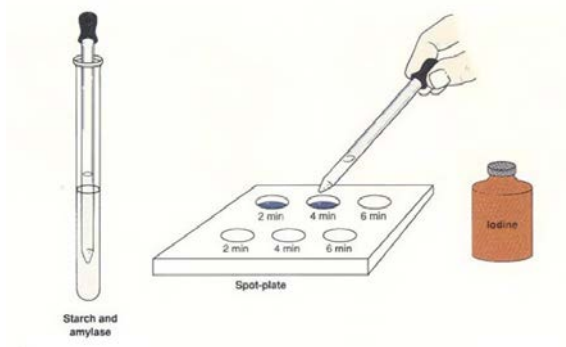
32. Required Practical 3: Enzymes

Investigate the effect of pH on the reaction of amylase enzyme

IV: pH (change using at least 5 different buffer solutions)

DV: time taken to digest starch (measured as the time it takes for a sample of the mixture **not** to turn black when mixed with iodine solution)

CV: volume and concentration of amylase solution; volume and concentration of starch solution; temperature; time for samples



Method:

1. Place known volume of starch solution into a boiling tube.
2. Place known volume of amylase solution into the boiling tube.
3. Stir using a glass rod.
4. Take a sample of mixture and place onto a spot tile.
5. Add a drop of iodine solution to the spot tile; repeat every 30s; record the time taken for the mixture not to turn black.
6. Repeat steps 1 – 5 for at least 5 different pHs.

32

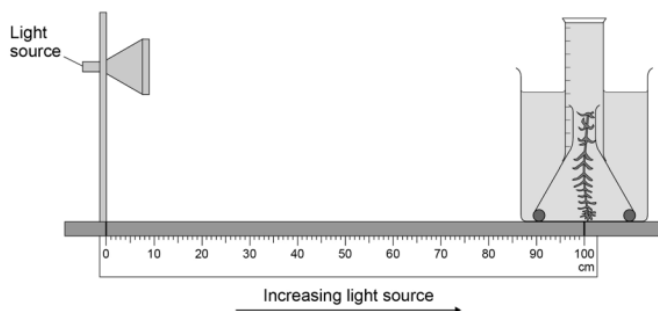
33. Required Practical 4: Photosynthesis

Investigate the effect of light intensity on the rate of photosynthesis

IV: light intensity (using at least 5 different distances from lamp to pondweed)

DV: number of bubbles released from pondweed per minute

CV: concentration of carbon dioxide; power of the bulb; no background light; time; length of pondweed



Method:

1. Cut a piece of pondweed, with a diagonal cut.
2. Place cut end uppermost into a boiling tube.
3. Immerse in water or a dilute solution of sodium hydrogen carbonate (to provide carbon dioxide).
4. Place a lamp 10cm away from the boiling tube; turn off all other lights.
5. When bubbles appear, start to count bubbles for one minute.
6. Using same pondweed, repeat the experiment, increasing the distance from the lamp by 10cm each time, for at least 5 distances.
7. Plot a graph of distance from the lamp against number of bubbles produced per minute.

33

Biology Paper 2 (Combined Science: Higher & Foundation)

- 34. Homeostasis
- 35. Reflex actions
- 36. Endocrine System
- 37. Control of blood glucose
- 38. Diabetes
- 39. Adrenaline, thyroxine
- 40. Hormones in human reproduction
- 41. Hormones to treat infertility
- 42. Contraception
- 43. Adaptation and independence
- 44. Competition
- 45. Organisation of an ecosystem
- 46. Recycling materials: carbon
- 47. Recycling materials: water
- 48. Biodiversity and human interaction 1
- 49. Biodiversity and human interaction 2
- 50. Variation
- 51. Chromosomes
- 52. Cell division: mitosis
- 53. Cell division: meiosis
- 54. Reproduction: asexual and sexual
- 55. Genetic crosses: definitions and inheritance
- 56. Genetic crosses: Punnett squares
- 57. Evolution
- 58. Evidence for evolution: fossils, extinction
- 59. Evidence for evolution: resistant bacteria
- 60. Selective breeding
- 61. Cloning
- 62. Genetic engineering
- 63. Classification
- 64. Required practical 6: Human reaction time
- 65. Required practical 7: Field investigations 1
- 66. Required practical 8: Field investigations 2
- 67-68 Maths in Science

34. Homeostasis

Homeostasis is maintaining constant internal conditions, so that cells can survive.

Cells in the body can only survive within narrow physical and chemical limits. Outside of these limits, enzyme action and all cell functions stop.

Homeostasis maintains optimal conditions.

This includes

Blood glucose concentration

Body temperature

Water levels.

Homeostasis is **automatic**.

There are two automatic control systems in the body.

1. The nervous system
2. The endocrine system (chemicals called hormones).

The nervous system enables humans to react to changes in surroundings and to coordinate behaviour.

Automatic control systems have three parts.

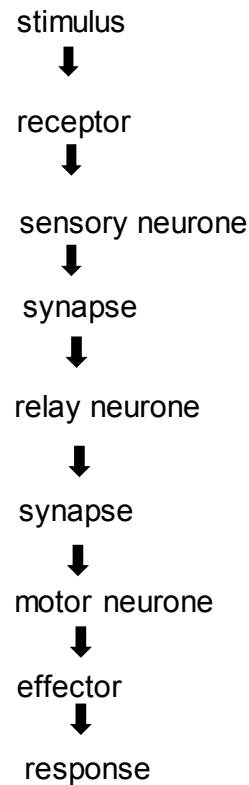
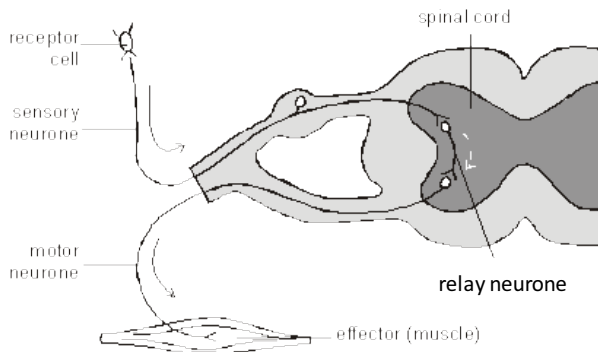
- 1. Receptors:** cells that detect stimuli, and pass this information along neurones as electrical impulses.
- 2. Coordination centre** is the central nervous system, which receives and processes information from receptors. The CNS sends instructions to...
- 3. Effectors** that make changes to restore optimum levels, e.g. muscles or glands.

35. Reflex Actions

Reflexes are quick and short lasting.

They do not involve the conscious part of the brain.

Gaps between neurones are called synapses.



35

36. The Endocrine System

Examples of endocrine glands

Pituitary gland

Thyroid

Pancreas

Adrenal gland

Ovary

Testes

The Endocrine System

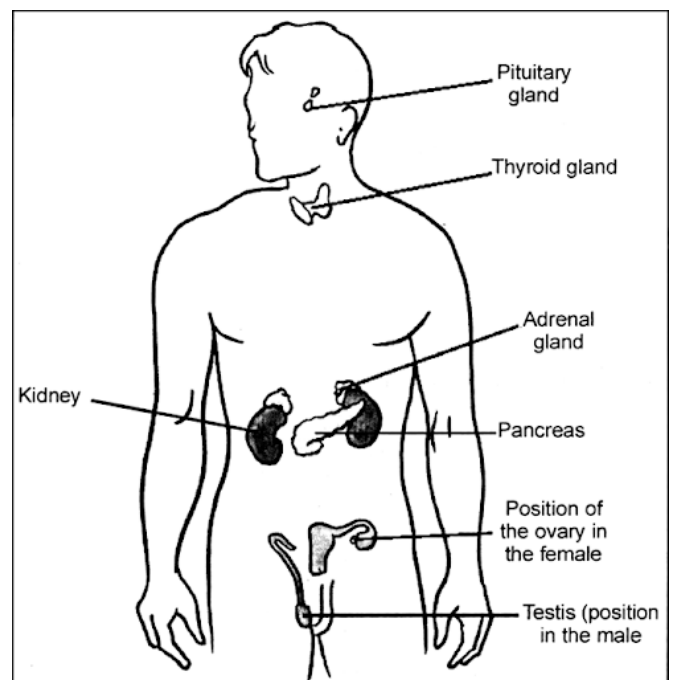
The endocrine system is made of glands.

Glands secrete (release) chemicals called hormones.

Hormones are secreted straight into the blood stream.

The blood carries the hormone to a target organ where it produces an effect.

Compared to the nervous system, the effects are slower but last longer.

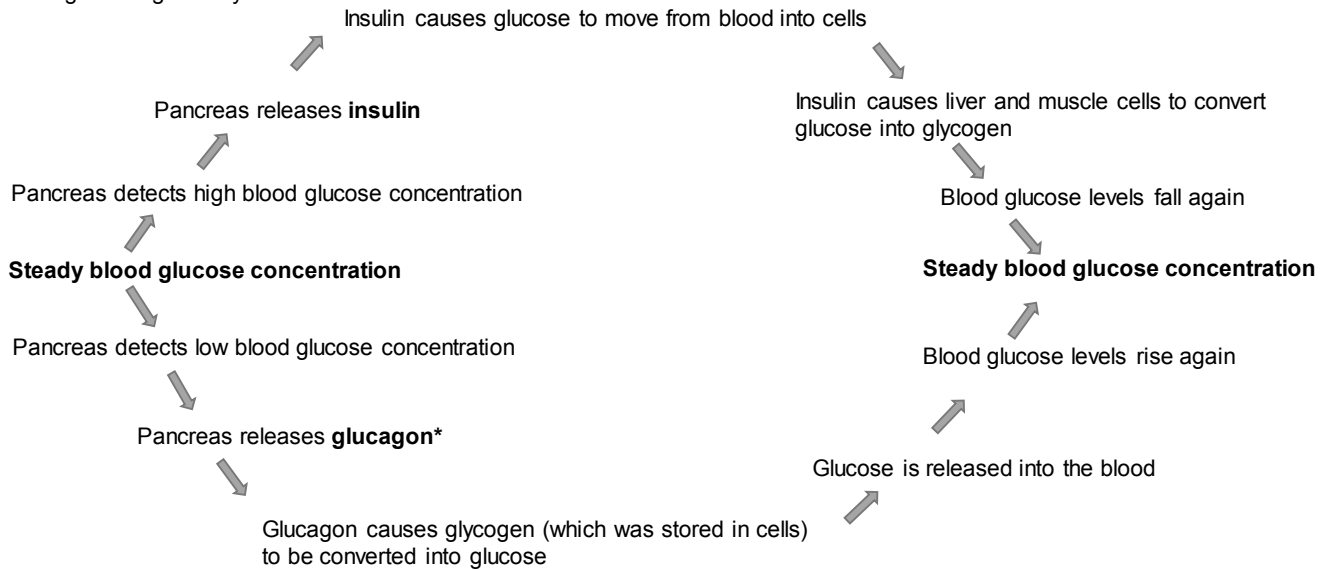


36

37. Control of blood glucose

Blood glucose concentration is monitored and controlled by the pancreas.

*Glucagon is higher only



37

38. Diabetes

Type 1 diabetes is a disorder.

The pancreas does not produce enough insulin.

People with type 1 diabetes have uncontrolled high blood glucose levels.

Type 1 diabetes is treated with insulin injections.



Type 2 diabetes is a disorder.

Cells do not respond to insulin.

Obesity is a risk factor for type 2 diabetes.

Type 2 diabetes is treated with a carbohydrate-controlled diet (e.g. starch rather than sugar) and exercise regimes.



38

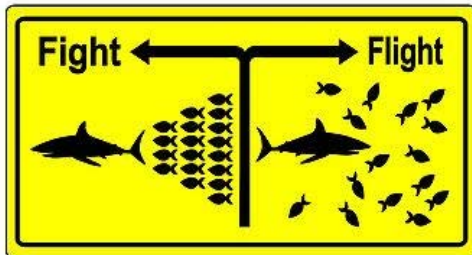
39. Adrenaline and thyroxine: higher only

Adrenaline is produced by the adrenal glands.

Adrenaline is produced in times of fear or stress.

Adrenaline increases the heart rate.

It increases the delivery of oxygen and glucose to the brain and muscles, preparing the body for fight or flight.



Thyroxine is produced by the thyroid gland.

Thyroxine stimulates the basal metabolic rate.

Thyroxine plays an important role in growth and development.



When thyroxine levels increase, signals sent to the thyroid gland turn off thyroxine production, so that levels decrease again.

This is another example of negative feedback.

39

40. Hormones in Human Reproduction

Secondary sex characteristics include the changes that take place at puberty.

During puberty reproductive hormones cause secondary sex characteristics to develop.

Testosterone is the main male hormone.

It is produced by the testes.

It stimulates sperm production.

Female hormone	Produced by	Function
Follicle stimulating hormone (FSH)	pituitary gland	causes an egg in the ovary to mature
Luteinising hormone (LH)	pituitary gland	causes the mature egg to be released into the oviduct – ovulation
Oestrogen	ovary	involved in thickening the lining of the uterus inhibits FSH
Progesterone	ovary	involved in maintaining the thickened lining of the uterus

40

41. Hormones to treat infertility: higher only

The use of hormones to treat infertility

The woman may be given a 'fertility drug'.

This drug contains FSH and LH.

She may become pregnant in the normal way.

The couple may have **IVF treatment (in vitro fertilisation)**.

The woman is given FSH and LH to stimulate the maturation of several eggs.

The eggs are collected from the mother and fertilised by sperm from the father in the laboratory.

The fertilised eggs develop into embryos.

When they are tiny balls of cells, one or two embryos are inserted into the mother's uterus (womb).

Positives of fertility treatment

Gives a woman/couple a chance to have a baby of her/their own.

Negatives of fertility treatment

It is very emotionally and physically stressful.

The success rate is not high.

It can lead to multiple births, which are a risk to the babies and mother.

41

42. Contraception

Contraception can be used to control fertility.

Contraceptives may be classified as hormonal or non-hormonal.

Type	Method	How it works
Hormonal	Oral contraceptives	contain hormones to inhibit FSH production, so that no eggs mature
	Injection, skin patch or implant of slow-release progesterone	inhibit the maturation of eggs for a number of months or years
	Intrauterine devices (IUD)	prevent the implantation of an embryo or release a hormone
Non-hormonal	Barrier methods such as condoms and diaphragms	prevent the sperm reaching an egg
	Spermicidal agents	kill or disable sperm
	Abstaining from intercourse when an egg may be in the oviduct	prevents fertilisation
	Surgical methods of male and female sterilisation	eggs cannot move along oviduct; sperm cannot move along sperm ducts

42

43. Adaptation and interdependence

Ecosystem	The interaction of a community of living organisms with the non-living parts of their environment.
Community	A group of species that live in the same place. A change in an abiotic or a biotic factor can affect the community.
Interdependence	Each species in a community depends on other species for food, shelter, pollination, seed dispersal etc. If one species is removed it can affect the whole community.
Stable community	All the biotic and abiotic factors are in balance. Population sizes remain fairly constant.

Adaptation

Organisms have features (adaptations) that enable them to survive in their natural environment.

Adaptations can be:

structural

behavioural

functional

Some organisms are adapted to very extreme environments – high temp, pressure or salt concentration. They are known as

extremophiles e.g. bacteria in deep sea vents.

43

44. Competition

To survive and reproduce, organisms require materials – from biotic and abiotic sources.

These materials are limited; this leads to competition between individuals.

Competition in plants

Light

Space

Water

Mineral ions

Competition in animals

Food

Mates

Territory

Abiotic factors caused by non-living things:

light intensity

temperature

moisture levels

soil pH

soil mineral content

carbon dioxide (for plants)

oxygen (for aquatic animals)

wind intensity and direction

Biotic factors: caused by living organisms

availability of food

new predators

new pathogens

one species outcompeting another, leaving too few individuals to breed

44

45. Organisation of an ecosystem

Feeding relationships are shown in food chains.

Every food chain starts with a producer.

Producers synthesise (make) molecules.

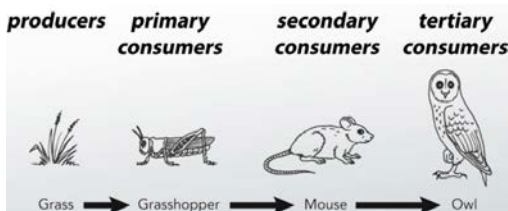
Usually, the **producer** is a green plant or alga that makes glucose by photosynthesis.

Photosynthetic organisms are the producers of biomass for life on Earth.

Producers are eaten by **primary consumers**.

Primary consumers may be eaten by **secondary consumers** and then **tertiary consumers**.

In a food chain, the arrow shows the direction of energy or biomass movement – from producer to consumer.



Predators kill and eat other animals.

Animals that are eaten are **prey**.

In a stable community the numbers of predators and prey rise and fall in cycles.

Environmental changes affect the distribution of species in an ecosystem.

These changes include:

temperature

availability of water

composition of atmospheric gases (abiotic factors)

The changes may be seasonal, geographic or caused by human interaction.

45

46. Recycling materials: carbon

All materials in the living world are recycled to provide the building blocks for future organisms. Two examples are the carbon and the water cycle.

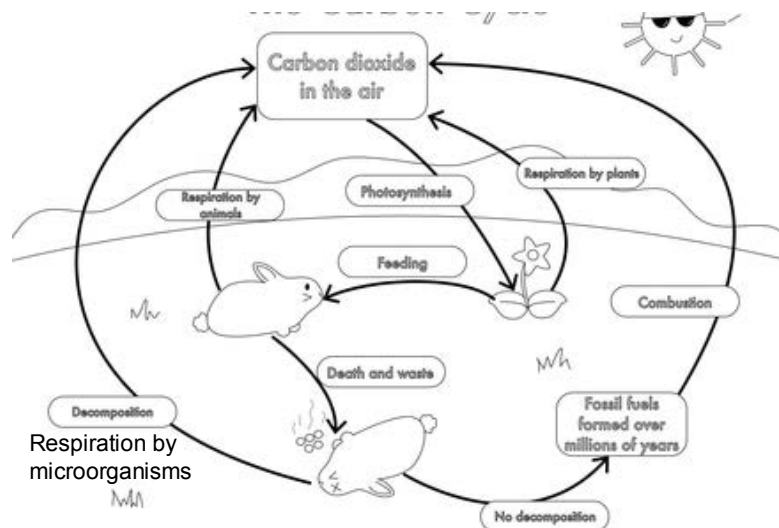
Carbon Cycle

Carbon moves from the atmosphere into organisms through photosynthesis.

It is released from organisms to the atmosphere through respiration.

When living things die and decay, microorganisms (bacteria and fungi) break chemicals down.

They return carbon dioxide to the atmosphere and mineral ions to the soil.



46

47. Recycling materials: water

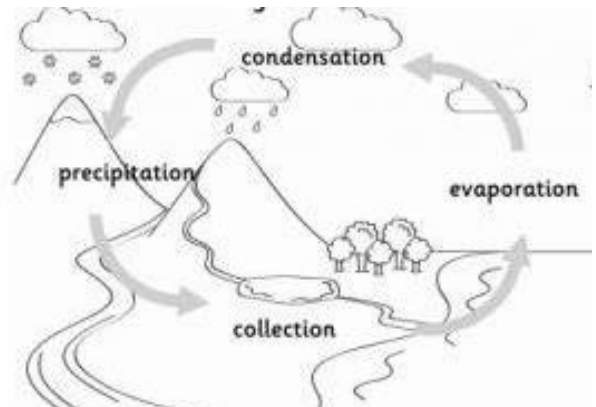
Water cycle

Rain provides fresh water for plants and animals on land.

The water drains into the sea through rivers.

There is continuous evaporation of water from land and sea.

There is continuous precipitation of water onto the land and into the sea.



47

48. Biodiversity and human interaction 1

Biodiversity: the variety of all the different species of organism on earth, or within an ecosystem.

High biodiversity is good for the stability of ecosystems.

It reduces the dependence of species on one another for food and shelter.

Biodiversity is good for humans too – for food, for medicines, for materials.

Human activities have reduced biodiversity.

Only recently have humans made efforts to stop this reduction.

Pollution is increasing.

There are more humans and an increase in the standard of living, so we are using more resources and producing more waste.

Pollution kills plants and animals; this reduces biodiversity.

Pollution can occur:

In water – from sewage, fertiliser or toxic chemicals

In air – from smoke and acidic gases

On land – from landfill and toxic chemicals

Global warming is happening.

This is the consensus of scientists all over the world, based on thousands of peer-reviewed publications.

We have increased the levels of carbon dioxide and methane in the atmosphere.

Global warming impacts:

loss of habitat

loss of food

the spread of disease

This will lead to extinctions and the loss of biodiversity.

48

49. Biodiversity and human interaction 2

Land use

Humans use land for building, quarrying, farming and dumping waste.

This reduces the land available for animals and plants.

We have destroyed **peat bogs** to produce cheap compost.

This reduces the habitat and reduces biodiversity.

Compost increases food production.

When peat decays or burns, it releases carbon dioxide into the atmosphere.

Deforestation is the reduction in size of forests. Deforestation is a big problem in tropical areas. People want the land for cattle and rice fields, and to grow crops for biofuels.

Stopping the decline in biodiversity

There are breeding programmes for endangered species.

Rare habitats are protected and regenerated.

Farmers have reintroduced hedgerows to promote biodiversity.

Some governments have passed laws to reduce deforestation and carbon dioxide emissions.

Some governments have passed laws to increase recycling resources instead of dumping waste in landfill.

49

50. Variation

There is usually extensive genetic variation within a population of a species.

Variation means differences in the characteristics of individuals in a population.

Causes of variation:

The genes they have inherited (genetic causes)

The conditions in which they have developed (environmental causes)

A combination of genes and the environment.

50

51. Chromosomes

Refer back to paper 1 page 6

A **genome** is the entire genetic material of an organism.
The whole human genome has been studied.

In a eukaryotic cell, genetic material is found in the nucleus, and contained in chromosomes.

Humans have 23 pairs of chromosomes in their body cells.

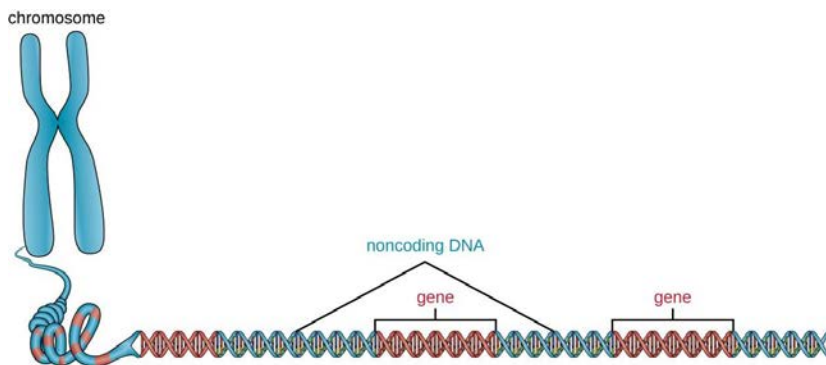
Genetic material is made of a chemical called DNA.

A **gene** is a short section of DNA on a chromosome

A gene codes for a sequence of amino acids, making a specific protein.

Not all parts of DNA code for proteins.

Non-coding parts of DNA can switch genes on and off, so variations in these areas of DNA may affect how genes are expressed.



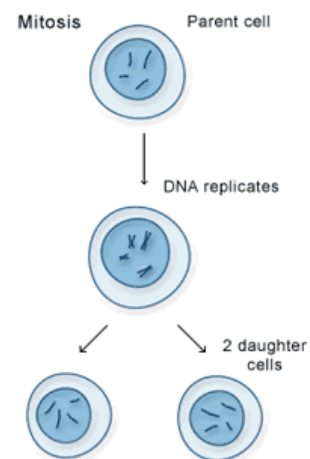
51

52. Cell Division: Mitosis (reminder from paper 1)

Mitosis happens in body cells.

In mitosis, the number of chromosomes remains the same.

Stage of the cell cycle	Events
1	The cell grows. The DNA replicates to form two copies of each chromosome. New mitochondria and ribosomes are made.
2.	Mitosis: one set of chromosomes is pulled to each end of the cell. The nucleus divides.
3	The cytoplasm and cell membranes divide. There are now two identical cells.



Uses of cell division by mitosis

1. Growth
2. Repair of tissues
3. Asexual reproduction

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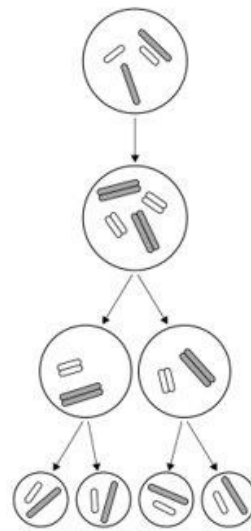
53. Cell Division: Meiosis

Meiosis happens in reproductive organs: ovaries and testes.

In meiosis, the number of chromosomes is halved.

The full number of chromosomes is restored when the male and female gametes fuse during fertilisation.

Stage of the cell cycle	Events
1	The cell grows. The DNA replicates to form two copies of each chromosome. New mitochondria and ribosomes are made.
2.	Meiosis: the chromosomes are pulled to opposite poles twice.
3	The cytoplasm and cell membranes divide twice. There are now four genetically different gametes (sex cells) Each gamete has just one set of chromosomes.



At fertilisation

Male and female gametes join.

The new cell has two sets of chromosomes.

The new cell divides by mitosis.

After fertilisation

The cells continue to divide by mitosis.

The cells begin to differentiate.

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54. Reproduction: Asexual and Sexual

Asexual reproduction involves only one parent.

There is no fusion of gametes.

There is no mixing of genetic information.

The offspring are genetically identical.

They are clones.

Only mitosis is involved.

Sexual reproduction involves the fusion of male and female gametes (sex cells)

In animals, these are sperm and egg cells.

In flowering plants, these are pollen and egg cells.

Sexual reproduction involves the mixing of genetic information.

This leads to variety in the offspring.

Gametes are made through **meiosis**.

54

55. Genetic Crosses: definitions and inheritance

Term	Meaning
gene	part of a chromosome that codes for a protein e.g. codes for eye colour
allele	version of a gene e.g. blue eyes, brown eyes
genotype	the alleles that an organism has e.g. AA, Aa or aa
phenotype	the characteristics that an organism has e.g. tall, dimples, red flowers
dominant	A dominant allele is always expressed, even if there is only one copy
recessive	two copies of a recessive allele are required for it to be expressed
homozygous	two of the same alleles for a gene e.g. AA or aa
heterozygous	two different alleles for a gene e.g. Aa

Polydactyly causes extra fingers or toes.

It is caused by a dominant allele.

Cystic fibrosis is a disorder of cell membranes, causing mucus to block narrow passages such as the bronchioles.

It is caused by a recessive allele.

Sex determination

Humans have 23 pairs of chromosomes in each nucleus but only one pair determines sex.

Human females have XX.

Human males have XY.

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56. Genetic Crosses: Punnett Squares

Parents: Pp x Pp

Gametes: P, p P, p

		Father	
		P	p
Mother	P	PP	Pp
	p	Pp	pp

The chance of any one offspring being pp is 1 in 4 or 25%

Parents: pp x Pp

Gametes: p, p P, p

		Father	
		p	p
Mother	P	Pp	Pp
	p	pp	pp

The chance of any one offspring being pp is 50% or 1 in 2

56

57. Evolution

Evolution is a change in the inherited characteristics of a population over time through a process of natural selection. This may result in the formation of a new species

The theory of evolution by natural selection states that all species of living things have evolved from simple life forms that first developed more than three billion years ago.

Natural Selection

Mutation causes variation in the population

Individuals with characteristics most suited to the environment are more likely to survive to breed successfully. These characteristics are then passed on to the next generation.

Over many generations, the proportion of the population with this characteristic increases.

57

58. Evidence for evolution: fossils and extinction

Charles Darwin was criticised in the 1800s as he didn't have sufficient evidence for his theory of natural selection. There is now lots of evidence for natural selection.

Fossils are evidence for natural selection.

Fossils are the remains of organisms from millions of years ago, found in rocks.

We can learn from fossils about how life changed over time.

Fossils show us that extinctions happen.

Extinction is due to :

New disease

New predator

Climate change

Habitat loss

Single catastrophic events e.g. an asteroid

Formation of fossils:

Replacement of hard parts of organisms with minerals as they decay

Imprints of organisms e.g. footprints, burrows, rootlet traces

Preserved parts of organisms that have not decayed, due to lack of oxygen, water or warmth

Problems with the fossil record

Many early life forms were soft bodied.

They have left few traces behind.

These have mainly been destroyed by geological activity.

So we can't be certain about how life began.

58

59. Evidence for evolution: antibiotic resistant bacteria

Resistant bacteria are evidence for natural selection
(refer to page 23 – medical drugs)

Mutation causes variation in the population – some bacteria are more resistant to antibiotics than others.

Resistant bacteria have an advantage as they are less likely to be killed by antibiotics.

These individuals survive and reproduce.

The genes for the resistance are passed on.

The resistant strain becomes more common.

To combat resistant strains:

Doctors should not give antibiotics for mild infections or viral infections

Patients should complete the whole course of antibiotics so all bacteria are killed and none survive to mutate and become resistant

Antibiotics should be used less by farmers in pigs, cows, sheep etc.

59

60. Selective breeding

Selective breeding is the process where humans breed plants and animals for particular characteristics.

People have been doing this for thousands of years to produce food crops and domesticated animals.

Mutations cause variation in the population.

Individuals with a particular characteristic are chosen by humans.

These individuals are allowed to reproduce.

The genes for the characteristic are passed on and become more common over time.

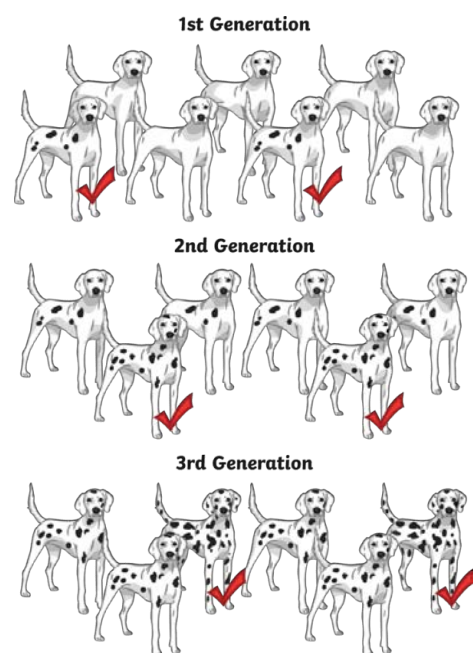
Examples include:

Disease resistance in crops

Animals that produce more meat or milk

Domestic dogs with a gentle nature

Large or unusual flowers



Disadvantages:

Selective breeding can lead to inbreeding.

Some breeds are prone to disease.

60

62. Genetic Engineering

Genetic engineering is where a genome of an organism is changed by technology.

A gene is taken from one organism and given to another to produce a desired characteristic.

Examples:

Plants have been genetically engineered to produce a bigger yield and be resistant to disease.

Bacteria have been engineered to produce useful chemicals e.g. insulin.

The method (higher only)

Enzymes are used to cut out the useful gene from one organism.

The useful gene is inserted into a vector

The vector inserts the useful gene into the required cell

This is done at an early stage of development

Objections

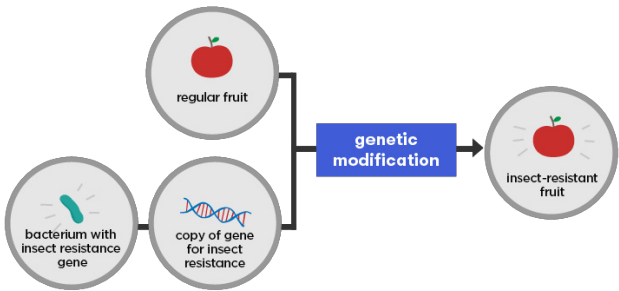
Some people object to genetic engineering.

There may be risks to human health that we don't yet understand.

There may be an effect on wild populations of flowers and insects.

Benefits


Genetic engineering could be used to cure diseases.



63. Classification

Classification

Originally **Carl Linnaeus** classified organisms by their structure and characteristics into the following system:



Animal Example	Taxonomic Rank
Animalia	Kingdom
Chordata	Phylum
Mammalia	Class
Primate	Order
Hominidae	Family
<i>Homo</i>	Genus
<i>sapiens</i>	Species
Human	Common Name

The genus and the species gives the binomial name, e.g. *Homo sapiens*

The genus always starts with a capital letter, and the species with a small case letter.

Our understanding of internal structures, biochemistry and genetics meant that some organisms were reclassified.

Three new groups called domains were proposed by **Carl Woese**.

- Archaea – bacteria living in extreme environments
- Bacteria – true bacteria
- Eukaryota – animals, plants, fungi and protists.

64. Required Practical 5 – Human Reaction Time

Plan and carry out an investigation into the effect of a factor on human reaction time.

IV: number of times a ruler is dropped

DV: measuring the distance where it is caught (we get faster, up to a point)

CV: same person

CV: same hand

CV: rest elbow on the table

CV: hold ruler in same position

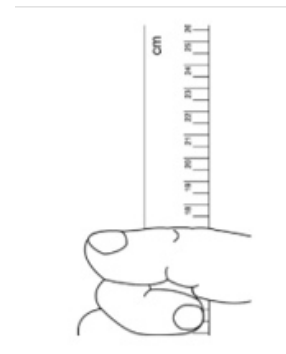
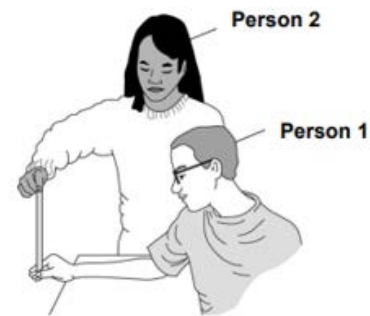
1. Method

- Place your weakest hand on a table with your hand over the edge.
- Your partner holds a metre ruler at 0 cm above your hand so the top of your thumb is at the zero mark.
- Without any notice, your partner drops the ruler and you catch it.
- Read metre ruler from the top of the thumb.
- Repeat steps 1-4 four more times.
- Convert the distance on the ruler into reaction time in seconds using a table of data.

To improve the method

To be more confident of the results, carry out 3 replicates on different people to identify anomalies; remove any anomalous results; calculate a mean.

Use a computer to give a more precise reaction time because they remove the possibility of human error and it is more accurate.



64

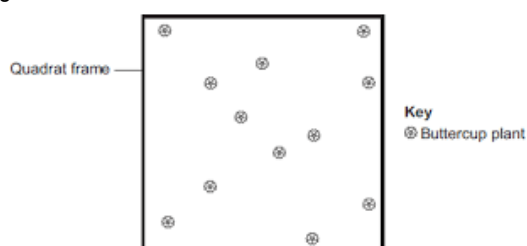
65. Required Practical 6 – Field Investigations 1

Measure the population size of a common species in a habitat.

Use sampling techniques to investigate the effect of a factor on the distribution of this species.

Quadrats are square shapes that are placed on the ground; the numbers of organisms in the square can be counted.

Transects are lines that are placed on the ground; quadrats can be placed at regular intervals along the transect to find out if the number of organisms changes along the line.



Method to estimate population size

- Choose one area to investigate.
- Divide the area into an imaginary grid.
- Use a random number generator to select points in the area e.g. 4m in one direction, and 3m at right angles to this point.
- Place the quadrat down so that the left-hand bottom corner is on the identified point.
- Count the number of dandelion plants in the quadrat.
- Record the number in your results table.
- Repeat at least 10 times.
- Calculate the mean number of dandelions per quadrat.
- Calculate the total area of the field.
- Divide the area by the area of one quadrat, then multiply this number by the mean number of dandelions per quadrat.

To improve the method

Dependent on random sampling, so will be more valid if more quadrats are used, or larger quadrats are used.

Repeat at different times of the year.

65

66. Required Practical 7 – Field Investigations 2

Use sampling techniques to investigate the effect of a factor on the distribution of this species.

Quadrats are square shapes that are placed on the ground; the numbers of organisms in the square can be counted.

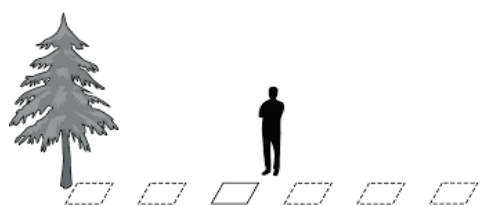
Transects are lines that are placed on the ground; quadrats can be placed at regular intervals along the transect to find out if the number of organisms changes along the line.

IV: light intensity

DV: number of daisies per quadrat

CV: size of quadrat

CV: sample every 1m along transect



Method to investigate the effect of light intensity

1. Choose two areas where dandelions grow; one in a sunny area and one in the shade.
2. Measure the light intensity in the sunny area.
3. Put down a transect line in the sunny area – do not look at the grass as you lay the line down.
4. Place the quadrat down next to the line at the start.
5. Count the number of dandelion plants in the quadrat.
6. Record the number in your results table.
7. Move the quadrat 1m further along the transect and repeat at least 8 times.
8. Repeat in the shady area.

Problems with the design of the method

Other variables are not controlled in this method. The soil pH, temperature, water availability and trampling may all affect the distribution of plants.

To improve the method

Complete three transects in each area.

Record observations.

Repeat at different times of the year.

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67. Maths in Science 1

Prefixes

1 kJ = 1×10^3 J = 1000 J

1 pm = 1×10^{-12} m

1 mm = 1×10^{-3} m = 0.001 m

kilo	10^3
centi	10^{-2}
milli	10^{-3}
micro	10^{-6}
nano	10^{-9}
pico	10^{-12}

5607.376

Standard form: 5.607×10^3

2 decimal places: 5607.38

3 significant figures: 5610

0.03581

Standard form: 3.581×10^{-2}

2 decimal places: 0.04

3 significant figures: 0.0358

Anomalous result A number that does not fit the pattern

Mean Adding up a list of numbers and dividing by how many numbers are in the list.
Exclude the anomalous result.

Median The middle value when a list of numbers is put in order from smallest to largest

Mode The most common value in a list of numbers.
If two values are tied then there are two modes.
If more than two values are tied then there is no mode.

Range The largest number take away the smallest value in a set of data or written as X-Y.

Uncertainty range $\div 2$

Surface area of a cube (area of 1 side) $\times 6$ sides

Volume of a cube Width \times height \times depth

Area of a circle $\pi \times (\text{radius})^2$

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68. Maths in Science 2

Calculating percentage: (part ÷ whole) x 100

e.g. Out of 90 insects, 40 of them were ladybirds. What is the % of ladybirds?

$$(40 \div 90) \times 100 = 44 \%$$

Calculating percentage change:

$$(\text{difference} \div \text{starting value}) \times 100$$

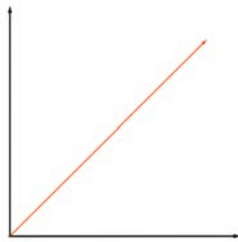
$$(0.59 \div 2.22) \times 100 = 26.6 \%$$

Conc of Sucrose (M)	Mass of potato at start (g)	Mass of potato at end (g)	Change in mass (g)
0	2.22	2.81	0.59

Graphs

Proportional (α)

When the line passes through the origin

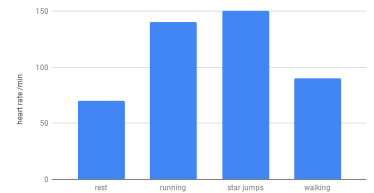


x axis = independent variable = left hand column of results table

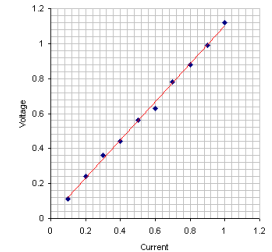
y axis = dependent variable = right hand column of results table

Categoric data: data put into groups e.g. colour of eyes
Draw a bar chart

The effect of exercise on heart rate

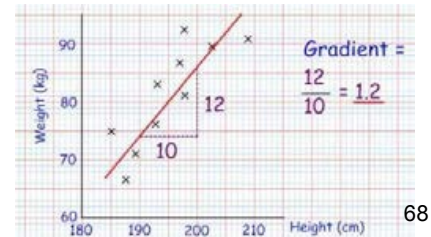


Continuous data: data that can take any value e.g. current
Draw a line graph



Gradient and Graphs

$$\text{Gradient} = \frac{\text{Change in y}}{\text{Change in x}}$$



Chemistry Paper 1 (Combined Foundation)

CONTENTS

1. Atoms, elements, compounds and mixtures
2. Structure of the atom
3. Separating mixtures
4. History of the atom
5. Comparing atomic models
6. Ionic and covalent bonding
7. Giant covalent bonding
8. Metallic bonding and alloys
9. Quantitative chemistry
10. Acids and alkalis
11. Reactions of acids to make a salt
12. Energy changes
13. The development of the periodic table
14. Chemical formulae
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16. Reactivity of metals
17. Properties of ionic compounds and simple molecules
18. Structure of giant covalent substances
19. Properties of giant covalent substances
20. Graphene
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22. Properties of metallic bonding and alloys
23. Polymers
24. Fullerenes
25. Electrolysis
26. Processes occurring during electrolysis
27. Extraction of aluminium using electrolysis
28. Required practicals 1 – making a salt and electrolysis
29. Required practicals 2 – energy changes

1. Atoms, Elements, Compounds and Mixtures

Keyword	Definition
Atom	smallest part of an element
Element	made up of only one type of atom
Compound	made from at least two elements, chemically combined
Mixture	made of two or more elements or compounds not chemically combined together

Radius of an atom = 0.1nm ($1 \times 10^{-10}\text{m}$).

Radius of a nucleus is less than 1/10 000 of that of an atom.
This is $1 \times 10^{-14}\text{m}$.

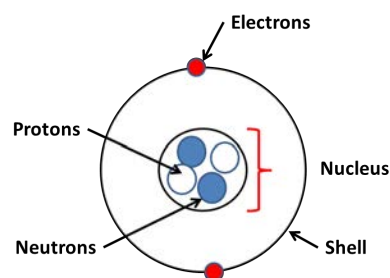
Atoms are **neutral** (no electrical charge) because:
-The number of protons and electrons are the same.
-The charges cancel out

Atomic number = Proton number

Mass number = Number of protons and neutrons

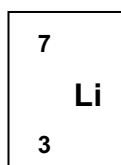
Number of electrons = Number of protons

Structure of the atom (Nuclear model)



Subatomic particle	Relative charge	Relative mass
Proton	+1	1
Neutron	0	1
Electron	-1	1/1840

2. Structure of the Atom



Top number

Bottom number

Proton = bottom number

Electron = bottom number

Neutron = top number – bottom number

Electronic Configuration

Electrons are arranged in shells.

1st shell – maximum of 2 electrons

2nd shell – maximum of 8 electrons

3rd shell – maximum of 8 electrons

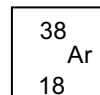
Isotopes:

Atoms of the same element that have different numbers of neutrons but the same number of protons and electrons.

They have the same chemical properties but different physical properties.



18 protons
18 electrons
21 neutrons



18 protons
18 electrons
20 neutrons

Calculating Relative Isotopic Abundance

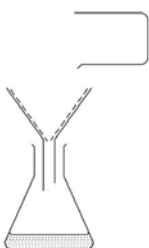
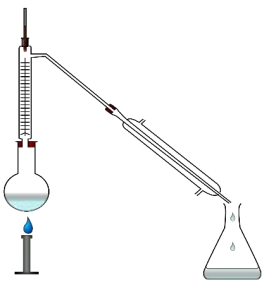
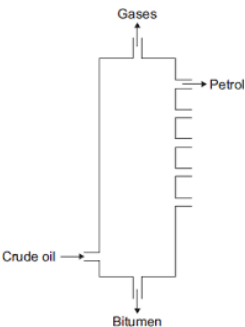
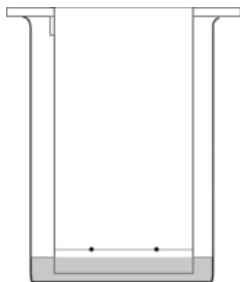
Mass number	Abundance (%)
39	93.1
41	6.9

$$= \frac{(39 \times 93.1) + (41 \times 6.9)}{93.1 + 6.9}$$

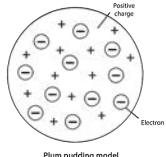
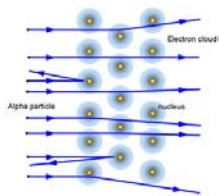
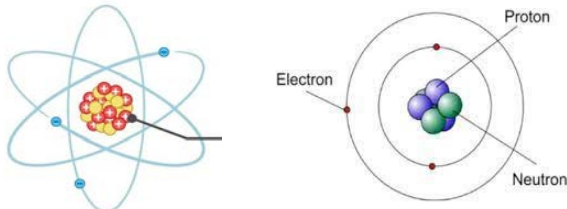
$$= 39.1$$

2

3. Separating Mixtures

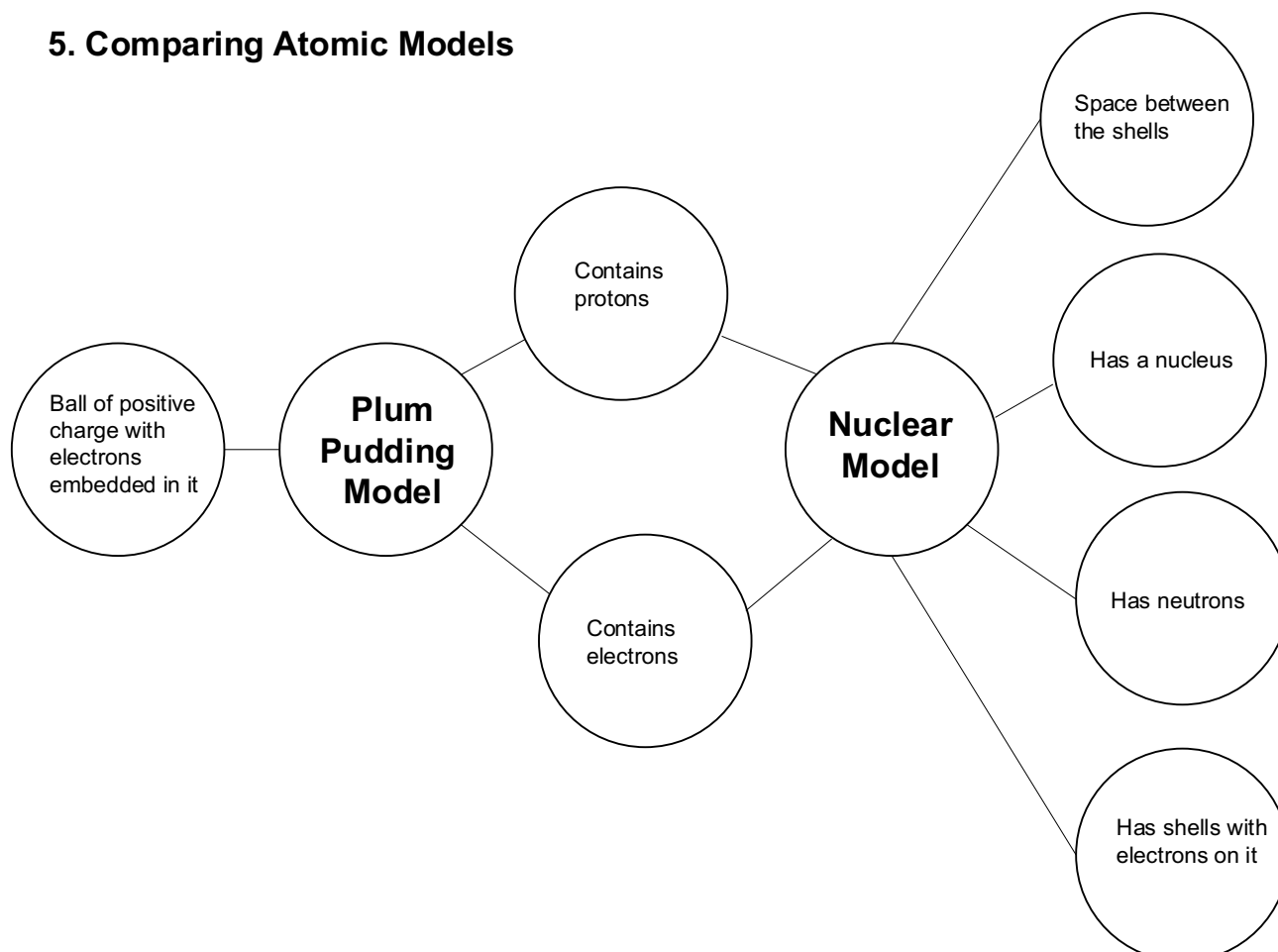
Process	Filtration	Distillation	Fractional distillation	Chromatography
Diagram				
Physical property	Difference in solubility	Difference in boiling points	Difference in boiling points	Difference in solubility
Example	Sand and salt	Ink and water	Ink, water and oil Crude oil	Different colours in dyes

4. History of the Atom

Atomic model	Plum pudding model	Nuclear model			
Diagram					
Discovery	Electron	Positive nucleus in the centre of the atom	Electrons occupy shells Electrons are at specific distances from the nucleus	Neutrons	<ul style="list-style-type: none">Atomic radius: 1×10^{-10} mRadius of a nucleus is less than 1/10 000 of the radius of an atom.Most of the mass of an atom is concentrated in the nucleus.The electrons are arranged at different distances from the nucleus.
Description	The atom is a ball of positive charge with negative electrons embedded in it.	Positively charged alpha particles were fired at thin gold foil. Most alpha particles went straight through the foil. A few were scattered in different directions by the atoms in the foil. It showed that the mass of an atom was in the centre (the nucleus) and the nucleus was positively charged.		Proved the existence of isotopes	
Discovered by	Thompson	Rutherford	Bohr	Chadwick	

4

5. Comparing Atomic Models



5

6. Ionic and Covalent Bonding

Ionic Bonding (metal & non-metal)

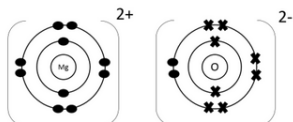
Structure: Giant ionic lattice

Electrons are lost or gained to achieve a full outer shell.

Ionic bond: Electrostatic attraction between oppositely charged ions.

Ions held in a fixed lattice.

Charge of ion: +2 (loses 2 electrons) and -2 (gains 2 electrons)

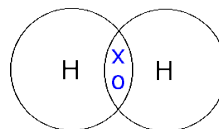


Covalent Bonding (2 x non-metals)

Covalent bond: Pairs of electrons are shared between the atoms.

Sharing one pair of electrons = single bond

Sharing two pairs of electrons = double bond



Describing the formation of an ionic compound

Example 1: NaF

Na atom loses 1 electron to form Na^{1+} ion.

F atom gains 1 electron to form F^{1-} ion

Example 2: Na_2O

Two Na atoms each lose 1 electron to form two Na^{1+} ions.

One O atom gains 2 electrons to form O^{2-} ion.

Simple Molecules

(2 x non-metals, covalent bonding)

Simple molecules (small molecules)

e.g. H_2 , Cl_2 , O_2 , N_2 , HCl , H_2O

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7. Giant Covalent Bonding

	Diamond	Graphite	Silicon dioxide
Bonding	Giant covalent	Giant covalent	Giant covalent
Made of	Carbon	Carbon	Silicon and oxygen
Structure	Each carbon atom forms four C-C covalent bonds.	Each carbon atom forms three covalent bonds with three other carbon atoms, forming layers of hexagonal rings. The 4 th electron is delocalised	Each silicon atom forms four covalent bonds with oxygen atoms
Diagram			

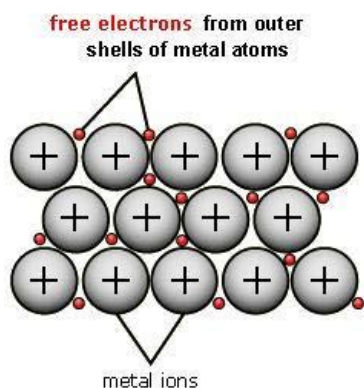
8. Metallic Bonding and Alloys

Metallic Bonding

Metallic bond: Attraction

between the positive metal ion and delocalised electrons.

Structure: Layers of metal positive ions surrounded by delocalised electrons

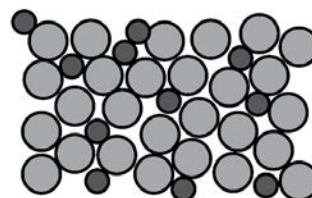


Alloy

Mixtures of metals with metals or a non-metal

e.g. stainless steel is a mixture of iron and carbon

Structure: Irregular layers



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9. Quantitative Chemistry

Relative formula mass (RFM or M_r)

This is the mass in grams of 1 mole of the substance.

To calculate M_r (top number) you need to add up the atomic mass (Ar) of all of the atoms in the molecule.

Example 1. $\text{NaCl} = \text{Na} + \text{Cl} = 23 + 35.5 = 58.5$

Example 2. $\text{MgF}_2 = \text{Mg} + (2 \times \text{F}) = 24 + (2 \times 19) = 62$

% Mass of an Element in a compound

$$\% \text{ mass of an element} = \frac{\text{Atomic mass of element} \times \text{number of atoms}}{\text{Relative formula mass of compound}} \times 100$$

Remember: $\frac{\text{part}}{\text{whole}} \times 100$

Conservation of Mass

During a chemical reaction, no atoms are made, no atoms are destroyed.

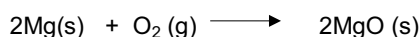
Decrease in mass:



Carbon dioxide is a gas which is a product

Carbon dioxide escapes into the air.

Increase in mass:



Mg reacts with oxygen in the air

Oxygen has added to the magnesium

Concentration of a solution

$$\text{dm}^3 \xrightleftharpoons[\div 1000]{\times 1000} \text{cm}^3$$

$$\text{Concentration (g/dm}^3\text{)} = \text{mass (g)} \div \text{volume (dm}^3\text{)}$$

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10. Acids and Alkalis

Acid	Chemical formula
Sulfuric acid	H ₂ SO ₄
Nitric acid	HNO ₃
Hydrochloric acid	HCl

Alkali	Chemical formula
Sodium hydroxide	NaOH
Potassium hydroxide	KOH

Acid	Salt name ending
Hydrochloric	-chloride
Nitric acid	-nitrate
Sulfuric	-sulfate

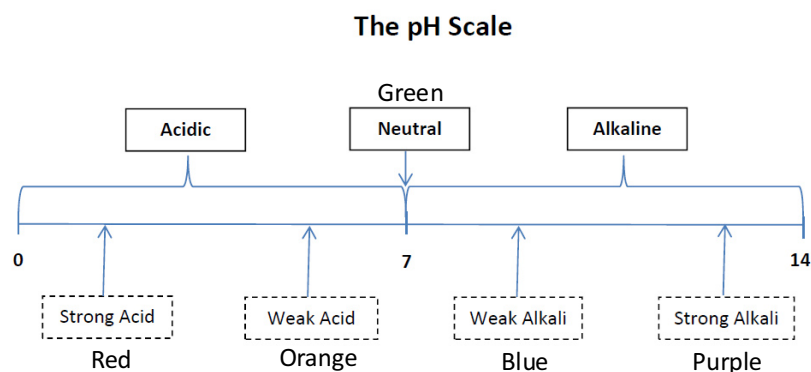
The pH Scale

It can be measured with a pH probe, or universal indicator.

Acid: pH 0-6

Neutral: pH 7

Alkali: pH 8-14



Neutralisation

Acids contain hydrogen ions (H⁺)

Alkalis contain hydroxide ions (OH⁻)

acid + alkali → water

Ionic equation: H⁺ (aq) + OH⁻ (aq) → H₂O (l)

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11. Reactions of Acids to Make a Salt (Neutralisation)

Reaction 1	Reactions of Acids with Metals (Neutralisation)
------------	---

Rule acid + metal → salt + hydrogen

Example hydrochloric acid + magnesium → magnesium chloride + hydrogen

Reaction 2	Reactions of Acids with Metal Oxide (Neutralisation)
------------	--

Rule acid + metal oxide → salt + water

Example sulfuric acid + magnesium oxide → magnesium sulfate + water

Reaction 3	Reactions of Acids with Metal Hydroxide (Neutralisation)
------------	--

Rule acid + metal hydroxide → salt + water

Example nitric acid + magnesium hydroxide → magnesium nitrate + water

Reaction 4	Reactions of Acids with Metal Carbonate (Neutralisation)
------------	--

Rule acid + metal carbonate → salt + water + carbon dioxide

Example nitric acid + magnesium carbonate → magnesium nitrate + water + carbon dioxide

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12. Energy Changes

Exothermic Reaction. Energy is transferred from particles to the surroundings. Temperature increases.

Examples: Combustion, many oxidation reactions, neutralisation.

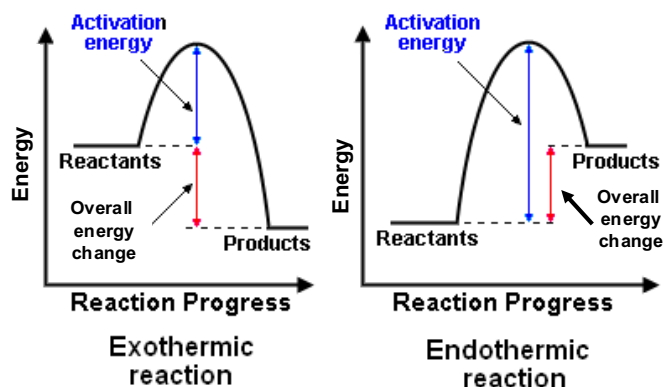
Every day uses: self-heating cans and hand warmers.

Endothermic reaction. Energy is transferred from the surroundings to the particles. Temperature decreases.

Example: Thermal decomposition and the reaction between citric acid and sodium hydrogencarbonate.

Every day uses: sports injury packs.

Activation energy: minimum amount of energy required for the reaction to start.



Exothermic energy profile:

Reactants are **higher** in energy than the products.

Energy is released to the surroundings.

Endothermic energy profile:

Reactants are **lower** in energy than the products.

Energy is absorbed by the surroundings.

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13. The Development of the Periodic Table

Newland's Periodic Table	Similarities	Mendeleev's Periodic Table
Included only the elements known at the time	Ordered elements by atomic weight	Left gaps for elements he predicted would be discovered later
Maintained a strict order of atomic weights	Missing noble gases	Swapped the order of some elements if that fitted their properties better e.g. Te and I
Mendeleev's version was accepted because: -he predicted properties of missing elements -the elements discovered filled the gaps -the properties matched Mendeleev's predictions		

Modern Periodic Table

It is called a **Periodic Table** because similar properties occur at regular intervals

Elements arranged in order of atomic **number** (proton number)

Groups (columns): Elements with similar chemical properties

Group number = number of outer shell electrons = similar chemical properties

Period (row): Elements have the same number of shells

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14. Chemical Formulae

Group number	Charge of ion formed
1	+1
2	+2
3	+3
5	-3
6	-2
7	-1

Name of ion	Chemical formula of ion
Sulfate	SO ₄ ²⁻
Hydroxide	OH ¹⁻
Ammonium	NH ₄ ¹⁺
Nitrate	NO ₃ ¹⁻
Carbonate	CO ₃ ²⁻

Chemical Formulae

NaCl – 1 x Na atom and 1 x Cl atom

H₂O – 2 x H atoms and 1 x O atom

Mg(OH)₂ – 1 x Mg atom, 2 x O atoms and 2 x H atoms

CaCO₃ – 1 x Ca atom, 1 x C atom and 3 x O atoms

How to deduce chemical formulae

	Mg ²⁺	Br ¹⁻
Identify the number	2	1
Swap the numbers	1	2
Chemical formula	Mg Br ₂	

	NH ₄ ¹⁺	SO ₄ ²⁻
Identify the number	1	2
Swap the numbers	2	1
Chemical formula	(NH ₄) ₂ SO ₄	

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15. Reactions of Group 1, Group 7 and Group 0

	Group 1	Group 7	Group 0
Name	Alkali Metals	Halogens (non-metal)	Noble gases
Reactivity	Increases down the group	Decreases down the group	Unreactive (inert). Full outer shell of electrons
Reactivity explanation	-more shells -outer electron is further away from the nucleus -less nuclear attraction between the nucleus and the outer electron -electron is lost more easily	-more shells -outer electron is further away from the nucleus -less nuclear attraction between the outer electron and the nucleus -electron is gained less easily	Already has a full outer shell of 8 electrons (except helium which has 2). No need to react.
Trend in melt. pt.	Decreases	Increases	Increases
Explanation for trend in melting point		-molecules increase in size -intermolecular forces increase -more energy is required	-atoms increase in size -intermolecular forces increase -more energy is required
Reactions	Reaction with oxygen: 4M + O ₂ → 2M ₂ O	Displacement: A more reactive halogen can displace a less reactive halogen from its salt e.g. 2KBr + Cl ₂ → 2KCl + Br ₂ Chlorine more reactive than bromine. Displacement occurs. 2KBr + I ₂ → no reaction Iodine cannot displace bromine	
	Reaction with chlorine: 2M + Cl ₂ → 2MCl Vigorous reaction Na = silver solid; Cl ₂ = green gas Reaction = orange flame Product = white solid NaCl produced		
	Reaction with water: 2M + 2H ₂ O → 2MOH + H ₂ Hydroxide ions (OH ⁻) make solutions alkali. Metal floats and moves. Effervescence.		

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16. Reactivity of Metals

Oxidation and Reduction (adding and losing oxygen)

Oxidation: When the metal gains oxygen to become a metal oxide.

Reduction: When the metal oxide loses oxygen to become a metal.

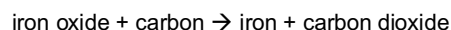
The Reactivity Series

Potassium	}	Extracted by electrolysis of a molten ionic compound
Sodium		
Calcium		
Magnesium		
Aluminium		
Carbon	}	Extracted from its oxide by reduction using carbon
Zinc		
Iron		
Tin		
Lead		
Hydrogen		
Copper		
Silver		
Gold		
Platinum – least reactive		

Extraction of metals

Metals above carbon in the reactivity series: Extracted by electrolysis

Metals below carbon: Extracted from their oxides by reduction with carbon.



The iron has been reduced – it has lost oxygen. The carbon has been oxidised.

Silver, gold and platinum: Found in the Earth as the metal itself because they are unreactive.

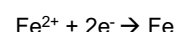
Oxidation and Reduction (adding and losing electrons)

Oxidation: Loss of electrons.

Reduction: Gain of electrons.

Remember **OIL RIG**

For example:



The iron ion gains two electrons and becomes an iron atom.

The iron has been reduced – it has gained two electrons.

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17. Properties of Ionic Compounds and Simple Molecules

Property of Ionic Compounds	Explanation
High melting point	Giant ionic structure. Lots of energy needed to break strong electrostatic attraction between oppositely charged ions.
Conducts electricity in solution/molten	Ions are mobile and carry charge.
Does not conduct electricity as a solid	Ions are in a fixed lattice. Ions are not mobile so cannot carry a charge

Simple Molecules

(2 x non-metals, covalent bonding)


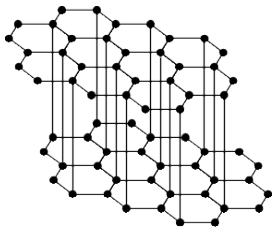
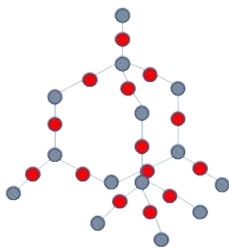
Simple molecules (small molecules)

e.g. H₂, F₂, Cl₂, O₂, N₂, HCl, H₂O, CO₂

Property of Simple Molecules	Explanation
Low melting points and boiling points. (Gas at room temperature)	-Simple molecule -Weak intermolecular forces between the molecules. -Little energy needed to overcome these forces.
Does not conduct electricity	Molecules do not have any mobile ions or delocalised electrons

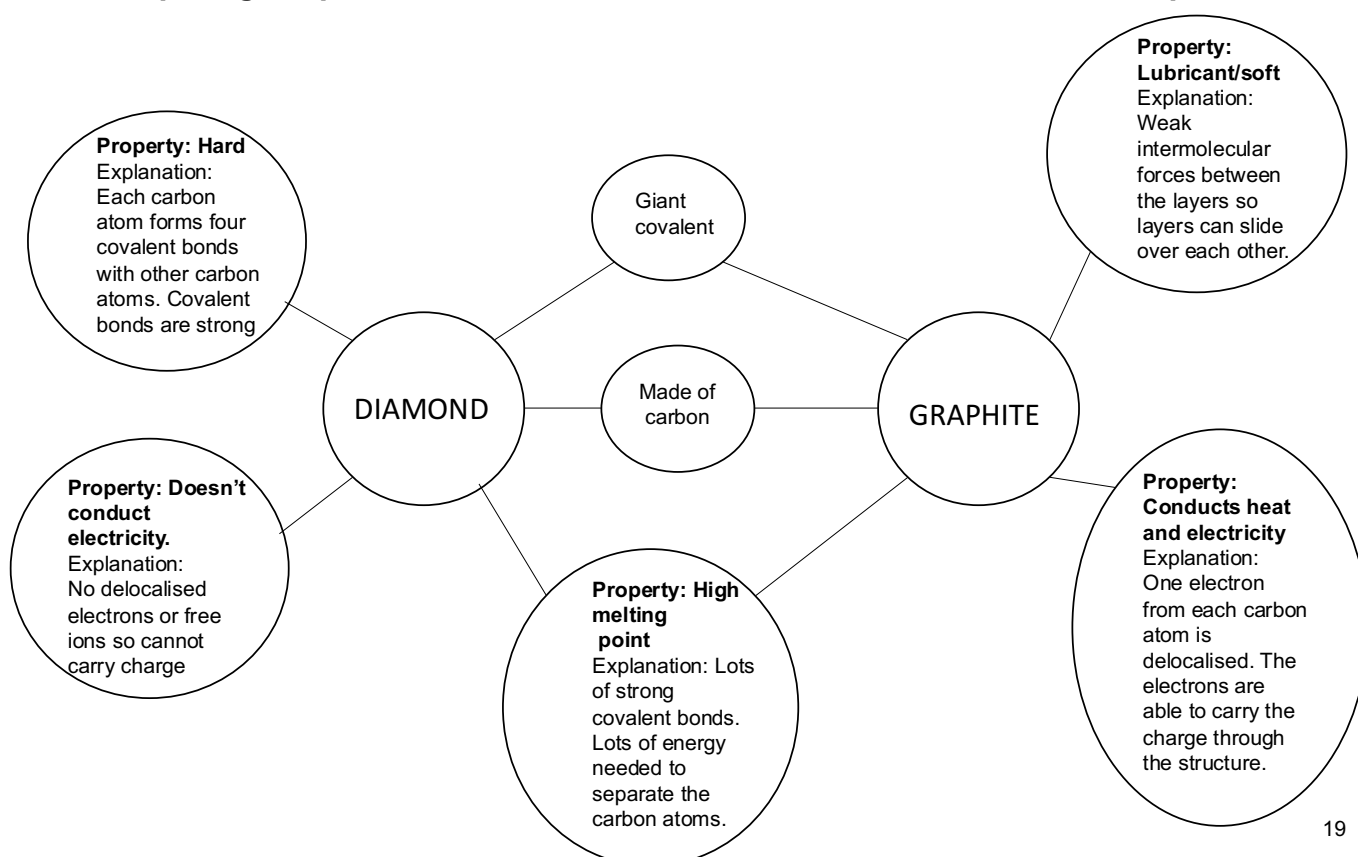
17

18. Structure of Giant Covalent Substances

	Diamond	Graphite	Silicon dioxide
Bonding	Giant covalent	Giant covalent	Giant covalent
Made of	Carbon	Carbon	Silicon and oxygen
Structure	Each carbon atom forms four C-C covalent bonds.	Each carbon atom forms three covalent bonds with three other carbon atoms, forming layers of hexagonal rings. The 4 th electron is delocalised	Each silicon atom forms four covalent bonds with oxygen atoms
Diagram			

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19. Comparing Properties of Giant Covalent Substances: Diamond and Graphite



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20. Graphene

Graphene	
Single layer of graphite. Made of carbon atoms. One atom thick	
Structure	Each carbon atom forms three covalent bonds with three other carbon atoms, forming layers of hexagonal rings. The 4 th electron is delocalised and carries the charge through the structure.
Property & Explanation	Conducts heat and electricity Explanation: One electron from each carbon atom is delocalised. The electrons are able to carry the charge through the structure.
Property & Explanation	High melting point Explanation: Lots of strong covalent bonds. Lots of energy needed to separate the carbon atoms.

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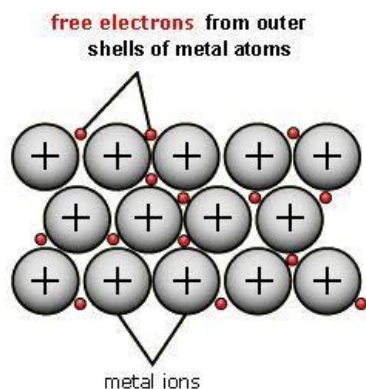
21. Structure of Metals and Alloys

Metallic Bonding

Metallic bond: Attraction

between the positive metal ion and delocalised electrons.

Structure: Layers of metal positive ions surrounded by delocalised electrons

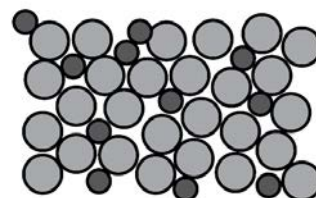


Alloy

Mixtures of metals with metals or a non-metal

e.g. stainless steel is a mixture of iron and carbon

Structure: Irregular layers



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22. Properties of Metallic Bonding and Alloys

Property of metals	Explanation
Conduct electricity	Delocalised electrons are free to move and carry the charge through the metal.
Conducts thermal energy	Delocalised electrons move Energy transferred
Strong High melting point	Strong attraction between the metal positive ion and the delocalised electrons, so lots of energy needed to overcome attraction
Bent and shaped (malleable)	Layers of atoms are able to slide over each other.

Property of alloys	Explanation
Harder than pure metals	The atoms are different sizes. Layers are distorted and cannot easily slide over each other.
Does not conduct as well as pure metals	Alloys have different sized atoms and distort the layers Movement of delocalised electrons is restricted

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23. Polymers

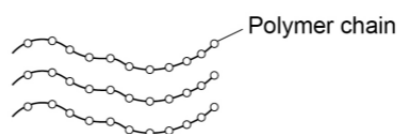
Keyword	Definition
Monomer	Made of a C=C bond. An alkene
Polymers	Large molecules linked to other atoms by strong covalent bonds.
n	Number of monomers/repeating units
Polymerisation	The C=C double bond in the monomer breaks open. Many monomers join together to form a long chain molecule (polymer).

Property of polymers	Explanation of property
Solid at room temperature/ High melting point	The intermolecular forces between polymer molecules are relatively strong. Lots of energy needed to break bonds.

Structure and bonding in a polymer chain

Strong covalent bonds between the atoms

Weak intermolecular forces between the chains



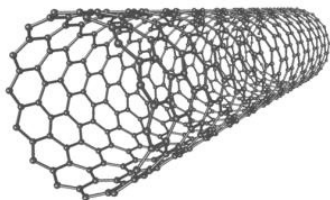
Name of monomer	Name of polymer
Vinyl chloride	Polyvinyl chloride
Styrene	Polystyrene
Ethene	Polyethene

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24. Fullerenes

Fullerenes

Fullerenes are molecules of carbon atoms with hollow shapes based on hexagonal rings of carbon atoms.



Properties: High tensile strength, electrical conductivity and conducts heat.

Uses:

Drug delivery into the body as it has a hollow structure.

Lubricants

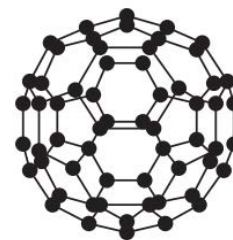
Catalysts.

Buckminster fullerene:

Molecular formula: C_{60}

Spherical shaped

Uses: Lubricant as they can roll over each other



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25. Electrolysis

Electrolysis: The splitting of an ionic compound into its elements using electricity.

Electrolyte: A molten ionic compound or an ionic solution e.g. sodium chloride. They conduct electricity.

Reaction condition for electrolysis to occur:

In a solid, ions are not free to move.

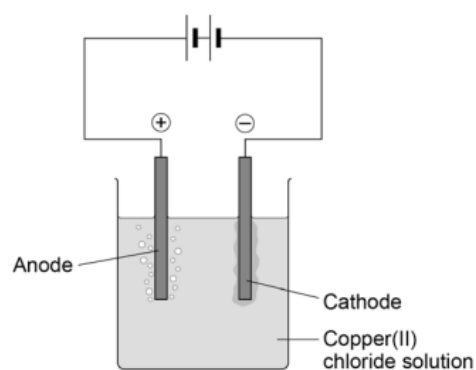
In solution or molten, the ions are free to move and carry the charge.

Electrolysis Apparatus

Remember PANIC (Positive Anode Negative Is Cathode)

Positive ions move to the cathode (negative electrode)

Negative ions move to the anode (positive electrode)



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26. Processes Occurring During Electrolysis

Reaction at the Anode

Non-metal ions (anions) move to the anode. Non-metal molecules are produced.

Half Equation:



Each chloride ions lose 1 electron to form a chlorine molecule. It has been oxidised.

Remember OIL RIG (Oxidation Is Loss Reduction Is Gain)

Processes at the anode

If the anion is sulfate (SO_4^{2-}) or a nitrate (NO_3^{1-}) oxygen gas (O_2) is produced

If the non-metal ion is a halide e.g. Br^- , the halogen molecule will be produced (Br_2)

Reaction at the Cathode

Metal ions (cations) move to the cathode. Metal atoms are produced.

Half Equation: $\text{Li}^+ + \text{e}^- \rightarrow \text{Li}$

Lithium ion has gained 1 electron to form lithium atoms.

It has been reduced.

Remember OIL RIG (Oxidation Is Loss Reduction Is Gain)

Competition between two positive ions at the cathode

A positive metal ion e.g. K^+ , and a positive hydrogen ion, H^+ are both in solution.

At the cathode, hydrogen gas (H_2) is produced if the metal is more reactive than hydrogen e.g. K^+ and H^+ ions are in solution.

Refer to reactivity series on page 18

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27. Extraction of Aluminium Using Electrolysis

Electrolysis to extract metals

Metals above carbon in the reactivity series – extracted from their ores using electrolysis.

Metals below carbon in the reactivity series – extracted from their ores using carbon. This is called reduction.

Aluminium

Aluminium ore – Bauxite (aluminium oxide, Al_2O_3)

Uses of aluminium: make cars and plane and tin foil

Reaction at the cathode



Al^{3+} has gained 3 electrons to form Al atoms.

Expensive - Large amounts of energy are needed to melt the metal compound, and to produce electricity.

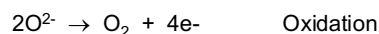
Molten mixture: Aluminium oxide and cryolite

Why a molten mixture of aluminium oxide is used:

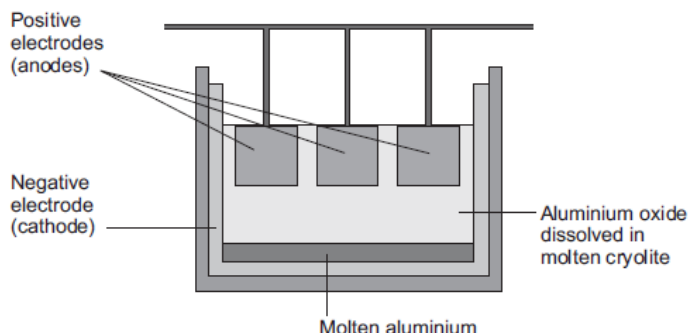
Mixed with cryolite. This lowers the melting point, so less energy is needed.

Carbon anodes replaced because the carbon anode reacts with oxygen produced at the anode. The anode fizzes away as CO_2 is produced.

Reaction at the anode



Two O^{2-} ions have lost 2 electrons each to form an O_2 molecule.



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28. Required Practicals 1: Making a salt and Electrolysis

Making a soluble salt

1. Add excess copper oxide to sulfuric acid in a beaker
2. Stir using a stirring rod
3. Filter using a funnel and filter paper into a conical flask.
4. Evaporate the water from the copper sulfate solution in an evaporating dish using gentle heat until half the volume is left.
5. Leave on windowsill to form crystals.
6. Pat dry crystals.

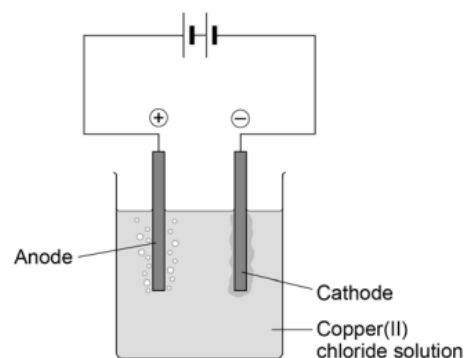
Reasoning for the steps

- Step 1: Excess metal oxide used so that all the acid reacts.
Step 2: Reaction stirred so all the chemicals react.
Step 3: Removal of excess copper oxide. Excess copper oxide used as it is easier to remove than excess acid
Step 4: Slow this step down by using a water bath

Observations:

Black solid (copper oxide) is left in the filter paper
Colour change

Electrolysis of aqueous solutions



Cathode: Metal attracted. Metal atoms are formed.

If the **metal is more reactive than hydrogen**, the metal ion will stay in solution and hydrogen ions will attract to the cathode, producing hydrogen gas

Anode: If the anion is sulfate (SO_4^{2-}) or a nitrate (NO_3^{1-}) oxygen gas (O_2) is produced

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29. Required Practicals 2 – Energy Changes

Reacting two solutions, e.g. acid and alkali

1. Place the polystyrene cup inside the glass beaker
2. Using a measuring cylinder, measure 25 cm^3 of acid
3. Add to polystyrene cup.
4. Record the temperature of the acid using a thermometer.
5. Add 5 cm^3 of alkali to the polystyrene cup and record the temperature obtained.
6. Repeat with 5 cm^3 of alkali until 40 cm^3 of alkali has been added

IV: Volume of alkali

DV: Temperature of reaction mixture

CV: Type of acid and alkali, volume of acid

To improve the accuracy

Use polystyrene cup

Add a lid

Repeat the experiment and calculate the mean ignoring anomalous results

Valid results: Repeat 3 times, identify the anomalous results, calculate the mean

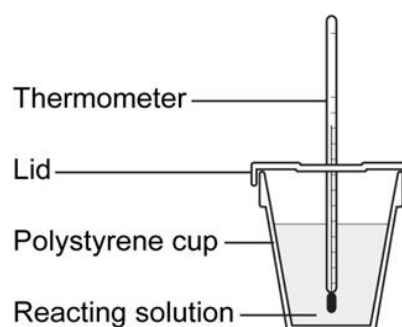
Reacting a solid with a solution, e.g. metal and solution

1. Place the polystyrene cup inside the glass beaker to make it more stable.
2. Using a measuring cylinder, measure 25 cm^3 of copper sulfate solution
3. Place the solution in a polystyrene cup.
4. Record the temperature of the solution using a thermometer.
5. Using a balance, weigh out 1g zinc powder
6. Add the zinc powder and record the temperature.
7. Repeat steps 1-6 with different masses of zinc powder

IV: Mass of metal

DV: Temperature of reaction mixture

CV: Concentration and volume of copper sulfate solution



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Chemistry Paper 2 (Combined Foundation)

CONTENTS

- 30. Rates of reaction
- 31. Rates of reaction graphs
- 32. Rates of reaction and equilibrium
- 33. Evolution of the atmosphere
- 34. Greenhouse effect
- 35. Polluting our atmosphere
- 36. Alkanes
- 37. Fractional distillation of crude oil
- 38. Combustion and cracking
- 39. Alkenes
- 40. Mixtures and test for gases and test for water
- 41. Chromatography
- 42. Potable water
- 43. Saving resources
- 44. Required practicals 4 – rates of reaction
- 45. Required practicals 5 – chromatography, potable water
- 46. Maths in science 1
- 47. Maths in science 2

30. Rates of Reaction

Explaining the rate of reaction in terms of particles

Collision theory	Chemical reactions can occur only when reacting particles collide with each other and with sufficient energy.
Activation energy	The minimum amount of energy that particles must have to react energy.
Factors that affect the rate of a reaction	Concentration; Temperature Pressure; Catalyst Surface area

The higher the temperature,
particles move faster,...

The higher the concentration/pressure,
more particles in a given volume,...

The higher the surface area,
more area for the reactants to collide,...

...the faster the rate of
reaction due to a higher
frequency of successful
collisions.

Measure the rate of reaction by:

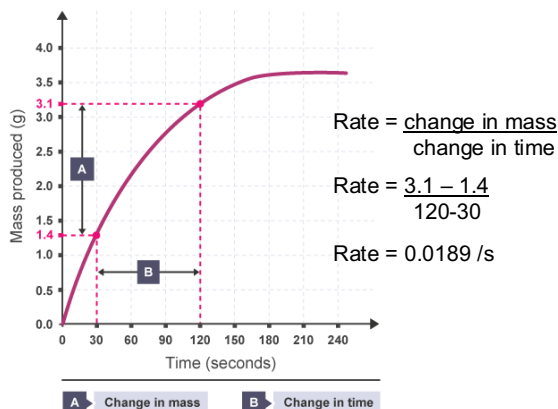
Equipment needed:

Stop clock
Balance or measuring cylinder/gas syringe

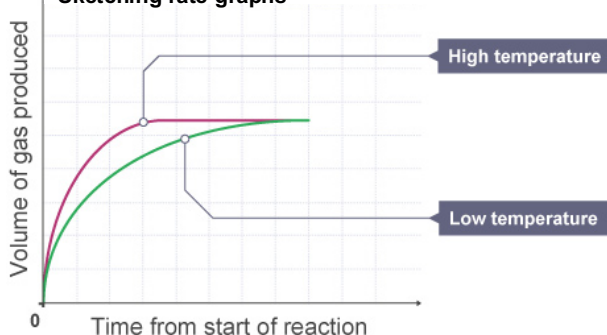
- a) Loss of mass of the reactants (use a balance)
- b) Volume of gas produced (use a gas syringe or upturned measuring cylinder)
- c) Time taken for the solution to become cloudy (place conical flask on cross and watch it disappear)

31. Rates of Reaction Graphs

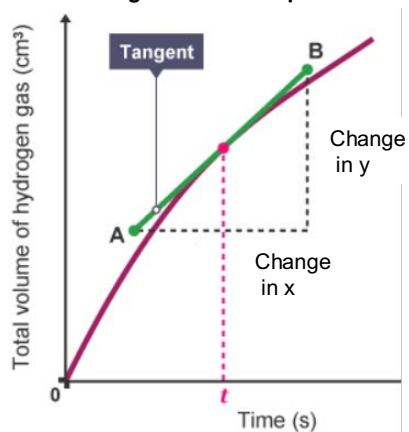
Calculating average rate



Sketching rate graphs



Calculating the rate at a specific time



1. Draw a tangent at that point approximately 10 cm long.
2. Draw a triangle
3. Calculate change in y
4. Calculate change in x
5. Gradient = $\frac{\text{change in y}}{\text{change in x}}$

Steeper the curve

Faster the rate of reaction

Horizontal line on graph

Reaction is finished (reactants used up)

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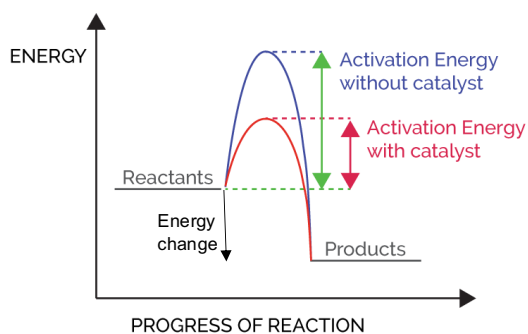
32. Rates of Reaction and Equilibrium

Catalysts increase the rate of reaction by providing a different pathway for the reaction that has a lower activation energy.

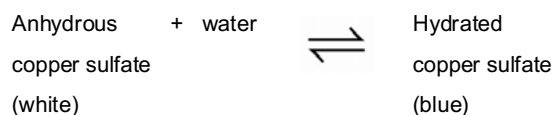
They reduce energy costs.

Catalysts are not included in the chemical equation for the reaction.

Biological catalyst: enzyme



Reversible reaction



Closed system

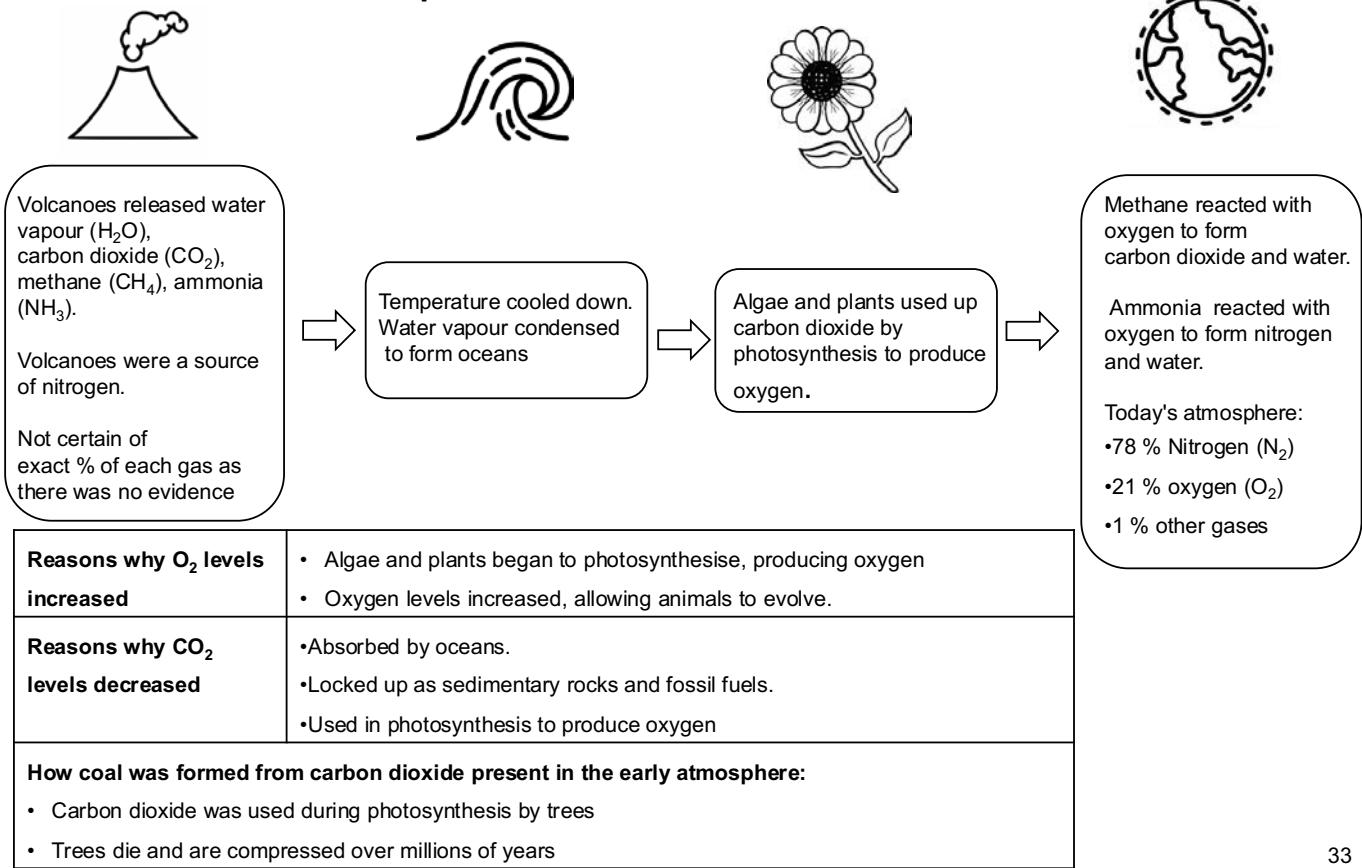
When reactants or products cannot enter or leave the system

What does it mean by equilibrium?

The rate of the forward and reverse reaction is the same. The concentrations of reactants and products are constant. It is a closed system

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33. Evolution of the Atmosphere

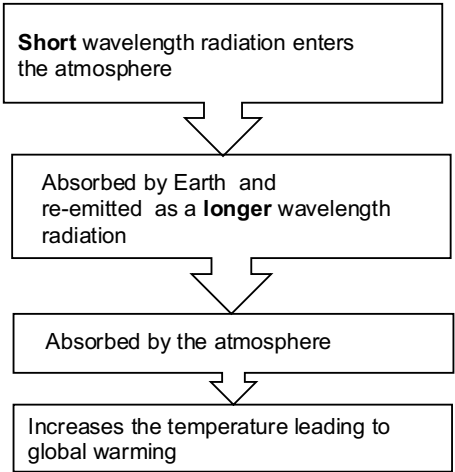


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34. Greenhouse effect

Greenhouse Gases <ul style="list-style-type: none">•Water vapour (H₂O)•Carbon dioxide (CO₂)•Methane (CH₄)
Effects of Global Climate Change
Sea level rise, which may cause flooding and increased coastal erosion
More frequent and severe storms
Changes to the distribution of wildlife species
Human Activities Which Increase Greenhouse Gases
Combustion of fossil fuels releasing more carbon dioxide
Deforestation leading to less trees so less photosynthesis occurring
More animal farming (digestion, waste decomposition) so more methane released
Decomposition of rubbish in landfill sites so more methane released)

How greenhouse gases cause global warming



How trees reduce global warming:

- Trees use carbon dioxide
- For photosynthesis
- Carbon dioxide causes global warming

35. Polluting our Atmosphere

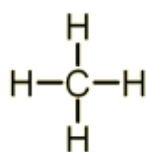
Pollutant	How it is made	Effect on health/environment
Sulfur dioxide (SO ₂)	Sulfur in fossil fuels reacts with oxygen to form sulphur dioxide.	Cause respiratory problems in humans and causes acid rain. Acid rain damages plants and buildings.
Carbon monoxide (CO)	Incomplete combustion of hydrocarbons.	A toxic gas which causes death.
Carbon particulates (unburned hydrocarbons)	Incomplete combustion of hydrocarbons.	Causes global dimming and damages lungs.
Oxides of nitrogen (NO _x)	Made from nitrogen and oxygen in air reacting at a high temperature in a car engine.	Causes respiratory problems in humans and cause acid rain.

Carbon Footprint	The total amount of carbon dioxide and other greenhouse gases emitted over the full life cycle of a product, service or event.
How to Reduce the Carbon Footprint	<ul style="list-style-type: none"> - Increased use of alternative energy supplies e.g. wind - Use energy efficient appliances - Carbon capture and storage (CCS)
Problems on Reducing the Carbon Footprint	<ul style="list-style-type: none"> - Lifestyle changes e.g. using public transport - Economic considerations e.g. can countries afford to build more wind turbines?

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36. Alkanes

Hydrocarbon	Made of only hydrogen and carbon
Alkane	A hydrocarbon made of C-C single bonds.
Alkane General Formula	C _n H _{2n + 2}
Functional group of an alkane	C-C single bond Alkanes are saturated as all the C bonds are used up.
Homologous series	A family of hydrocarbons with similar chemical properties who share the same general formula



Methane

A compound

A hydrocarbon

Covalent bonds between the C-H atoms

Homologous series: Alkanes

Alkane	Molecular Formula	Displayed formula
Methane	CH ₄	$ \begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}-\text{H} \\ \\ \text{H} \end{array} $
Ethane	C ₂ H ₆	$ \begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{H}-\text{C}-\text{C}-\text{H} \\ \quad \\ \text{H} \quad \text{H} \end{array} $
Propane	C ₃ H ₈	$ \begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{H} \\ \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \end{array} $
Butane	C ₄ H ₁₀	$ \begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{C}-\text{H} \\ \quad \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \end{array} $

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37. Fractional Distillation of Crude Oil

Keyword	Definition
Boiling point	The temperature at which a liquid turns into a gas
Combustion	Burning in oxygen
Flammability	How easily a substance ignites (catches on fire)
Fossil fuels	(non-renewable/finite fuels) Coal, oil, natural gas
Fraction	Molecules with a similar number of carbon atoms
Viscosity	The runniness of a liquid Higher the viscosity of the liquid, the longer it will take for the liquid to flow
Volatility	How easily a liquid changes into a gas

Physical property:
Fractional distillation relies of mixtures having different **boiling points** to enable the mixture to be separated

How coal is made: Trees die and are compressed over millions of years.

How crude oil is made: Made by the decomposition of plankton buried in mud over millions of years

Coal has more carbon than oil and natural gas

Fractional distillation of crude oil

1. Crude oil is heated and evaporated
2. Temperature decreases from the bottom to the top of the column
3. Fractions condense at different heights
4. Fractions have different boiling points

Properties of fractions as you go down the column

Boiling point - increase with increasing molecular size

Viscosity - increase with increasing molecular size

Flammability - decreases with increasing molecular size

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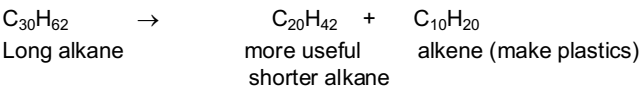
38. Combustion and Cracking

	Complete combustion (FO COW)	Incomplete combustion
Reaction conditions	Lots of oxygen	Little oxygen
Reactants	Fuel and oxygen	Fuel and oxygen
Products	Carbon dioxide and water	Carbon monoxide (or carbon particulates /soot) and water
	Test for carbon dioxide: Bubble through limewater Result: Turns cloudy	Carbon monoxide is toxic

Cracking - Hydrocarbons can be broken down (cracked) to produce smaller, more useful molecules. Also known as thermal decomposition.

Thermal decomposition – breaking down a compound using heat.

Example:



Reason for cracking: Turns long hydrocarbon chains into more useful shorter hydrocarbon chains.

Short alkanes are useful as they are flammable and used for fuels

Alkenes are used to make plastics via polymerisation (see page 24)

Catalytic Cracking

Reaction conditions: High temperature and a catalyst

Steam Cracking

Reaction conditions: High temperature

Cracking vs Distillation

Cracking Requires a catalyst

Distillation Does not require a catalyst

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39. Alkenes

Alkene	A hydrocarbon made of C=C double bonds.
Alkene General Formula	$C_n H_{2n}$
Functional group of an alkene	C=C double bond Alkenes are unsaturated
Chemical test for alkene	Add bromine water Alkene = Orange to colourless Alkene = stays orange

Alkene	Molecular Formula	Displayed formula
Ethene	C_2H_4	<pre> H H C = C H H </pre>
Propene	C_3H_6	<pre> H H H H - C - C = C H H H </pre>

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40. Mixtures, Test for Gases and Test for Water

Keyword	Definition
Boiling point	The temperature at which a liquid turns into a gas. Water has a boiling point of 100 °C
Formulation	A mixture that has been designed as a useful product e.g. shampoo Formulations include fuels, cleaning products, medicines, paints, alloys, fertilisers and foods.
Melting point	The temperature at which a solid turns into a liquid. Ice has a melting point of 0 °C
Pure substance	A single element or compound

Gas	Chemical test	Result
Hydrogen (H ₂)	Lit splint	Pop sound
Oxygen (O ₂)	Glowing splint	Splint relights in oxygen
Carbon Dioxide (CO ₂)	Bubble through limewater	Turns milky/cloudy
Chlorine (Cl ₂)	Damp litmus paper	Paper is bleached (white)

	Test	Result
Pure water	Boil it	Boils at exactly 100 °C
Water	Add anhydrous copper sulfate	Turns from white to blue

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41. Chromatography

Chromatography can be used to separate mixtures and identify substances.

Relies on the difference in **solubility** (physical property) of the mixture

Mobile phase – the solvent e.g. water running up the chromatogram.

Stationary phase – the paper.

Evidence that the dye is a mixture

- More than 1 spot
- In a vertical column

Substances move between the phases. If a substance is more attracted to the mobile phase, it will move further up.

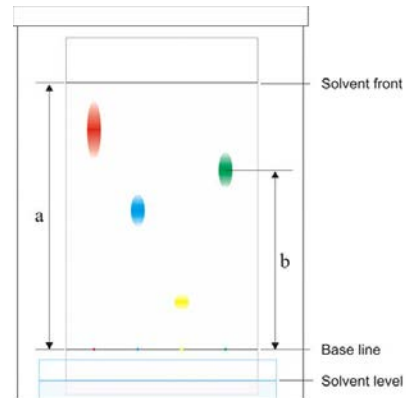
The R_f value tells you how far the substance has moved, relative to the solvent.

$$R_f = \frac{\text{distance moved by substance}}{\text{distance moved by solvent}}$$

The R_f value can be used to identify the substance.

The R_f values would be compared to the known substance.

R_f value will always be **less than 1**



$$R_f = b \div a$$

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42. Potable Water

Finite resource (non-renewable):

A source from the Earth that is running out e.g. coal

Renewable source:

A source that isn't running out e.g. wood

Potable water.

Safe to drink. Contains **low** levels of dissolved salts and microbes. Not pure.

	Potable water from salty water using distillation	Potable water from rainwater/groundwater	Potable water from the sea (desalination)	Potable water from waste water (sewage)
Method	<ol style="list-style-type: none"> 1. Heat salty water. 2. Water evaporates. 3. Cool the water vapour 4. The vapour condenses to form potable water 	<ol style="list-style-type: none"> 1. Rainwater collected in reservoirs. 2. Passing the water through filter beds to remove any solids. 3. Sterilise to kill microbes. <p>Sterilising agents: chlorine, ozone or ultra-violet light.</p>	Distillation or by processes that use membranes such as reverse osmosis.	<ol style="list-style-type: none"> 1. Removal of organic matter and harmful chemicals 2. Screening and grit removal 3. Sedimentation to produce sewage sludge and effluent 4. Anaerobic digestion of sewage sludge 5. Aerobic biological treatment of effluent.
Issues		Reliant on rainfall	These processes require large amounts of energy.	Expensive: Needs filtering and sterilising to remove harmful bacteria. Lots of steps

42

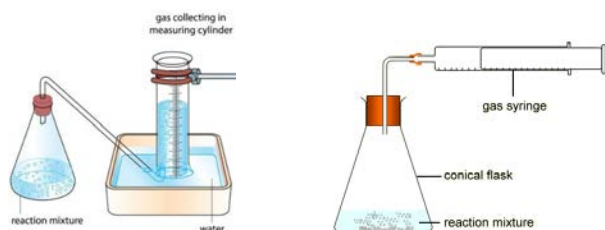
43. Saving Resources

Reduces	Limits the use of raw materials, energy consumption, waste and environmental impacts (quarrying and mining for raw materials).
Reuse	Use the item for another purpose e.g. a glass bottle is refilled.
Recycle	Turn the item into something else e.g. plastic bottles recycled to make fleeces, scrap steel is added to iron from a blast furnace. Benefits: conserves metal ores; uses less energy; reduces waste
Sustainable development	Development that meets the needs of current generations without compromising the resources for future generations.
Life Cycle Assessments (LCAs)	To assess the environmental impact (of the stages in the life of a product). <ul style="list-style-type: none"> • Extracting the raw material • Processing the raw material • Manufacturing • Disposal at the end of its useful life

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44. Required practicals 4: Rates of Reaction

Measuring the rate of reaction by collecting a gas



Method

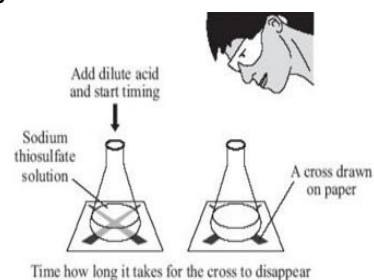
1. Set up equipment as shown in diagram.
2. Add 5 cm magnesium strip and 30 cm³ of a highly concentrated acid.
3. Collect gas for 1 minute.
4. Repeat steps 1-3 with different concentrations of acid

IV: concentration of acid

DV: volume of gas collected in 1 minute

CV: volume and type of acid, length of magnesium strip, time period of gas collection.

Measuring the rate of reaction by the formation of a precipitate



Method

1. Place conical flask on a black cross
2. Add sodium thiosulfate and hydrochloric acid to the flask.
3. Time how long it takes for the cross to disappear.
4. Repeat steps 1-3 with different concentrations of sodium thiosulfate.

IV: concentration of acid

DV: time taken for cross to disappear

CV: volume and type of acid

Why there is mass loss:

- Sulfur dioxide gas is made
- Escapes into the air

Why the solution goes cloudy:

Solid sulfur is made

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45. Required practicals 5: Chromatography and Potable Water

Chromatography

Method:

1. Draw pencil start line on chromatography paper and place spot of dye on start line.
2. Place solvent in beaker and place chromatography paper in beaker so the paper is in solvent but solvent is below start line.
3. Wait for solvent to travel up the paper and mark solvent front.
4. Dry the paper

Measurements to take:

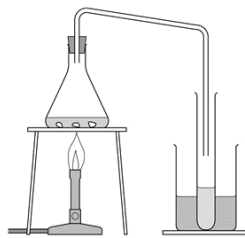
Measure distance between start line and centre of spot.

Measure distance between start line and solvent front.

Use of measurements to determine R_f value

Use of pencil – pencil is insoluble. Does not interfere with ink.

Line is above solvent level – so ink travels up the paper with the rising solvent



Method:

1. Heat seawater in conical flask.
2. Water evaporates
3. Water vapour condenses in delivery tube
4. Condenses in test tube

Chemical test	Test for seawater in conical flask	Test for pure water in test tube
Flame test to test for Na ⁺ ions. Dip wooden splint in each type of water and heat in blue Bunsen flame	Orange flame.	No change in colour
Test for Cl ⁻ ions. Add silver nitrate	White precipitate	No change in colour

45

46. Maths in Science 1

Anomalous result	A number that does not fit the pattern
Mean	Adding up a list of numbers and dividing by how many numbers are in the list. Exclude the anomalous result.
Median	The middle value when a list of numbers is put in order from smallest to largest
Mode	The most common value in a list of numbers. If two values are tied then there are two modes. If more than two values are tied then there is no mode.
Range	The largest number take away the smallest value in a set of data or written as X-Y.
Uncertainty	range ÷ 2
Surface area of a cube	(area of 1 side) x 6 sides
Volume of a cube	Width x height x depth
Area of a circle	π x (radius) ²

Prefixes

$$1 \text{ kJ} = 1 \times 10^3 \text{ J} = 1000 \text{ J}$$

$$1 \text{ pm} = 1 \times 10^{-12} \text{ m}$$

$$1 \text{ mm} = 1 \times 10^{-3} \text{ m} = 0.001 \text{ m}$$

kilo	10 ³
centi	10 ⁻²
milli	10 ⁻³
micro	10 ⁻⁶
nano	10 ⁻⁹
pico	10 ⁻¹²

5607.376

Standard form: 5.607 x 10³

2 decimal places: 5607.38

3 significant figures: 5610

0.03581

Standard form: 3.581 x 10⁻²

2 decimal places: 0.04

3 significant figures: 0.0358

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47. Maths in Science 2

Calculating percentage: $(\text{part} \div \text{whole}) \times 100$

e.g. Out of 90 insects, 40 of them were ladybirds. What is the % of ladybirds?

$$(40 \div 90) \times 100 = 44 \%$$

Calculating percentage change:

$$(\text{difference} \div \text{starting value}) \times 100$$

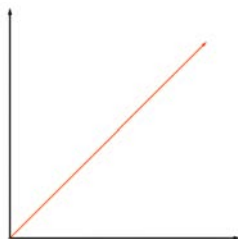
$$(0.59 \div 2.22) \times 100 = 26.6 \%$$

Conc of Sucrose (M)	Mass of potato at start (g)	Mass of potato at end (g)	Change in mass (g)
0	2.22	2.81	0.59

Graphs

Proportional (α)

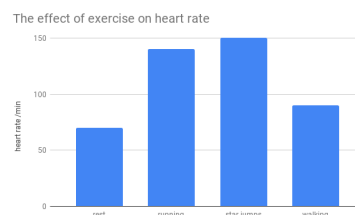
When the line passes
through the origin



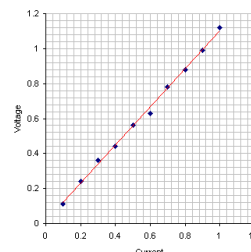
x axis = independent variable = left hand column of results table

y axis = dependent variable = right hand column of results table

Categoric data: data put into groups e.g. colour of eyes
Draw a bar chart

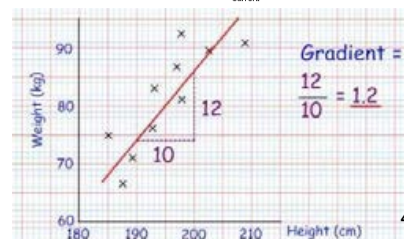


Continuous data: data that can take any value e.g. current
Draw a line graph



Gradient and Graphs

$$\text{Gradient} = \frac{\text{Change in } y}{\text{Change in } x}$$



47

1

2

1

H

hydrogen

1

4

He

helium

2

7

Li

lithium

3

9

Be

beryllium

4

23

Na

sodium

11

24

Mg

magnesium

12

relative atomic mass

atomic symbol

name

atomic (proton) number

11

B

boron

5

12

C

carbon

6

14

N

nitrogen

7

16

O

oxygen

8

19

F

fluorine

9

20

Ne

neon

10

27

Al

aluminium

13

28

Si

silicon

14

31

P

phosphorus

15

32

S

sulfur

16

35.5

Cl

chlorine

17

40

Ar

argon

18

39

K

potassium

19

40

Ca

calcium

20

45

Sc

scandium

21

48

Ti

titanium

22

51

V

vanadium

23

52

Cr

chromium

24

55

Mn

manganese

25

56

Fe

iron

26

59

Co

cobalt

27

59

Ni

nickel

28

63.5

Cu

copper

29

65

Zn

zinc

30

70

Ga

gallium

31

73

Ge

germanium

32

75

As

arsenic

33

79

Se

selenium

34

80

Br

bromine

35

84

Kr

krypton

36

85

Rb

rubidium

37

88

Sr

strontium

38

89

Y

yttrium

39

91

Zr

zirconium

40

93

Nb

niobium

41

96

Mo

molybdenum

42

[98]

Tc

technetium

43

101

Ru

ruthenium

44

103

Rh

rhodium

45

106

Pd

palladium

46

108

Ag

silver

47

112

Cd

cadmium

48

115

In

indium

49

119

Sn

tin

50

122

Sb

antimony

51

128

Te

tellurium

52

127

I

iodine

53

131

Xe

xenon

54

133

Cs

caesium

55

137

Ba

barium

56

139

La*

lanthanum

57

178

Hf

hafnium

72

181

Ta

tantalum

73

184

W

tungsten

74

186

Re

rhenium

75

190

Os

osmium

76

192

Ir

iridium

77

195

Pt

platinum

78

197

Au

gold

79

201

Hg

mercury

80

204

Tl

thallium

81

207

Pb

lead

82

209

Bi

bismuth

83

[209]

Po

polonium

84

[210]

At

astatine

85

[222]

Rn

radon

86

[223]

Fr

francium

87

[226]

Ra

radium

88

[227]

Ac*

actinium

89

[261]

Rf

rutherfordium

104

[262]

Db

dubnium

105

[266]

Sg

seaborgium

106

[264]

Bh

bohrium

107

[277]

Hs

hassium

108

[268]

Mt

meitnerium

109

[271]

Ds

darmstadtium

110

[272]

Rg

roentgenium

111

[285]

Cn

copernicium

112

[286]

Uut

ununtrium

113

[289]

Fl

flerovium

114

[289]

Uup

ununpentium

115

[293]

Lv

livermorium

116

[294]

Uus

ununseptium

117

[294]

Uuo

ununoctium

118

* The Lanthanides (atomic numbers 58 – 71) and the Actinides (atomic numbers 90 – 103) have been omitted.

Relative atomic masses for **Cu** and **Cl** have not been rounded to the nearest whole number.

Physics Paper 1 (Combined Foundation)

1. Energy stores and systems
2. Kinetic energy and elastic potential energy
3. Work done
4. Gravitational potential energy
5. Specific heat capacity and power
6. Conservation of energy
7. Efficiency
8. Methods of heat transfer
9. Non-renewable Energy Resources
10. Renewable Energy Resources 1
11. Renewable Energy Resources 2
12. Electrical terms
13. Electrical components
14. Series and Parallel circuit rules
15. Current, potential difference and resistance
16. I-V characteristics and devices 1
17. I-V characteristics and devices 2
18. I-V characteristics and devices 3
19. National Grid and AC/DC supply
20. Electricity in the home
21. Electrical power and charge
22. The particle model
23. Internal energy
24. Specific latent heat
25. Particles in gases
26. Atomic Models
27. Isotopes and radiation
28. Nuclear radiation
29. Nuclear equations and half lives
30. Application of radiation, contamination and irradiation
31. Required practical 1: Specific heat capacity
32. Required practical 2: Thermal insulation
33. Required practical 3: Resistance of a wire
34. Required practical 4: Component IV characteristics
35. Required practical 5: Calculating density

1. Energy stores and systems

Energy System

System:

An object or group of objects.

When a system changes there are changes in the way energy is stored within it.

Closed system:

Where neither matter nor energy enters or leaves.

Conservation of energy:

Energy is not created or destroyed but may be transferred between different energy stores.

The energy in a system can be transferred between different stores when work is done by:

- Heating
- Current flowing
- Mechanical by force
- Waves

Energy Store	Example
Thermal	Cup of hot tea
Kinetic	Moving car
Gravitational Potential	Water in a reservoir at the top of a mountain
Elastic Potential	Stretched bungee cord
Chemical	Battery, food
Magnetic	Two opposing north poles on bar magnet
Electrostatic	Two electrons repelling each other
Nuclear	The energy available to be released by fission when splitting an atom

2. Kinetic Energy and Elastic Potential Energy

Kinetic Energy

Kinetic energy of an object depends on the:

- mass
- speed

Kinetic energy (J) = 0.5 x mass (kg) x velocity² (m/s)

E_k = 0.5mv²

Unit conversions:

kJ to J: x 1000
g to kg: ÷ 1000

Elastic Potential Energy

A force acting on an object may cause the shape of an object to change.

Elastic objects can store elastic potential energy if they are stretched or squashed. For example, this happens when a catapult is used or a spring is stretched.

Objects can also store elastic potential energy when they are squashed.

Elastic potential energy (J) = 0.5 x spring constant (N/m) x extension² (m)

Unit conversions:

kJ to J: x 1000
cm to m: ÷ 100

3. Work Done

A car braking to slow down

The friction force from the brakes does work. Energy is transferred from the car's kinetic store to the thermal store of its brakes, the brakes then transfer heat to the surroundings.

Energy transferred = work done

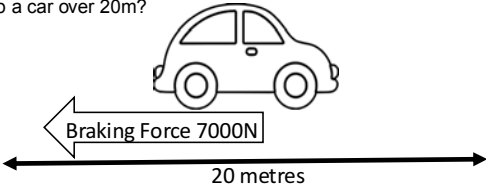
work done (J) = force (N) x distance (m)

W = Fs

Unit conversions:

kJ to J: x 1000
cm to m: ÷ 100
km to m: x 1000

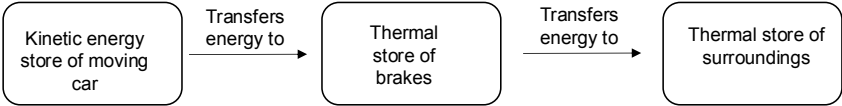
Example: How much work is done by the brakes if a 7000N braking force is used to stop a car over 20m?



Use the EVERY model to complete calculations:

E	= equation
V	= values
E	= enter results
R	= result
Y	= units
E	W = F x s
V	F = 7000 N and s = 20 m
E	W = 7000 x 20
R	W = 140 000
Y	J

W = 140000J or 140 kJ



4. Gravitational Potential Store (E_p)

Raising an object off the ground increases its gravitational potential energy store.

The amount of energy depends on the mass and height of the object and strength of the gravitational field it is in.

Gravitational potential energy store (J) = mass (kg) x gravitational field strength (N/kg) x change in height (m)

$$E_p = mgh$$

Unit conversions:

kJ to J: x 1000
cm to m: ÷ 100
km to m: x 1000
g to kg: ÷ 1000

Note: weight = mass x gravitational field strength

$$W = m \times g$$

Therefore, we have a second formula for E_p

$$E_p = \text{Weight} \times \text{change in height}$$

$$E_p = W \times \Delta h$$

Example: What is the gravitational energy required to lift a 100 kg mass up by 100 m?

Gravitational field strength = 9.81 N/kg

Use the EVERY model to complete calculations:

E = equation

V = values

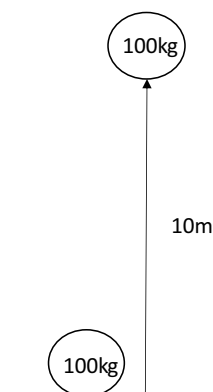
E = enter results

R = result

Y = units

E $E_p = m \times g \times h$
V $m = 100 \text{ kg}; g = 9.81; h = 100 \text{ m}$
E $E_p = 100 \times 9.81 \times 100$
R $E_p = 98100$
Y J

$$E_p = 98100 \text{ J}$$



4

5. Specific Heat Capacity (c) and Power

The amount of energy needed to raise the temperature of 1 kg of a substance by 1 °C.

Change in thermal energy (J) = mass (kg) x specific heat capacity (J/kg°C) x change in temperature (°C)

$$\Delta E = mc\Delta T$$

Unit conversions:

kJ to J: x 1000
g to kg: ÷ 1000

Example: How much energy is released into the surroundings when a cup of tea holding 250g of fluid cools from 90°C to 20°C? $c = 4200 \text{ J/kg}^\circ\text{C}$

Use the EVERY model to complete calculations:

E = equation

V = values

E = enter results

R = result

Y = units

E $\Delta E = m \times c \times \Delta \theta$
V $m = 250 \text{ g} = 0.25 \text{ kg}; c = 4200; \Delta \theta = 90 - 20 = 70$
E $\Delta E = 0.25 \times 4200 \times 70$
R 73 500
Y J

$$\Delta E = 73500 \text{ J or } 73.5 \text{ kJ}$$

Power

Power is the rate at which energy is transferred and is measured in watts.

1 watt = 1 joule of energy transferred per second.

$$\text{Power (W)} = \text{energy transferred (J)} \div \text{time (s)}$$

$$\text{Power (W)} = \text{work done (J)} \div \text{time (s)}$$

$$P = E \div t$$

Unit conversions:

kJ to J: x 1000
minutes to seconds: x 60
hours to seconds: x 3600
W to kW: ÷ 1000

Example. Calculate the power of a motor that uses 60,000 J of energy to lift an object in 20 seconds. Give your answer in kW.

E $P = E \div t$
V $E = 60\,000 \text{ J}; t = 20 \text{ s}$
E $P = 60\,000 \div 20$
R 3000
Y W

$$P = 3000 \text{ W or } 3 \text{ kW}$$

A more powerful device can transfer more energy in a given time or will transfer the same amount of energy in a faster time.

5

6. Conservation of Energy

Dissipation of energy	Wasting energy. More energy needs to be put into appliance to account for dissipated energy. Useful dissipation of energy example: back of a fridge Example of dissipation of energy is bad: light bulbs, engines and TV's as heat
Conservation of energy	Energy can be transferred usefully, stored or dissipated, but it cannot be created or destroyed
Heat	When an object is heated, thermal energy is being transferred to it
Temperature	A measure of hot or cold something is

Reducing Wasted Energy (dissipated energy)

Friction	Between two moving objects causes thermal energy to be dissipated. It can be reduced by lubrication.
Lubrication	• Friction between two moving objects causes energy to be dissipated as sound and to the thermal store.
Insulation	Reduces energy transfer by heating
Cavity wall insulation	Fills the air gap between the inner and outer wall reducing heat loss by convection.
Loft insulation	Reduces heat loss by convection.
Double glazing	• Creates an air gap between the two panes of glass to reduce energy loss by conduction. • Gases are good insulators
Draught excluders	Reduce energy loss by convection when placed around windows and doors.
Reflective material behind radiators	To keep infrared radiation in the room

6

7. Efficiency

Appliance	Useful Energy	Dissipated (wasted) Energy
Light bulb	Light	• Heating the bulb and surroundings
Hair Dryer	• Kinetic energy of the fan to push air • Heating of the air	• Sound of the motor. • Heating of the dryer and surroundings
Electric Motor	• Kinetic energy of objects driven by motor. • Gravitational potential energy of objects lifted by motor	• Heating of the motor and surroundings. • Sound of the motor turning

Efficiency

An efficient device wastes less energy than a less efficient device. It can be calculated as a decimal or multiplied by 100 to give a percentage.

$$\text{Efficiency} = \frac{\text{useful energy output}}{\text{total energy output}}$$

$$\text{Efficiency} = \frac{\text{useful power output}}{\text{total power input}}$$

Example: Calculate the wasted power and efficiency of a motor that has a rated power of 500W and transfers 300W usefully.

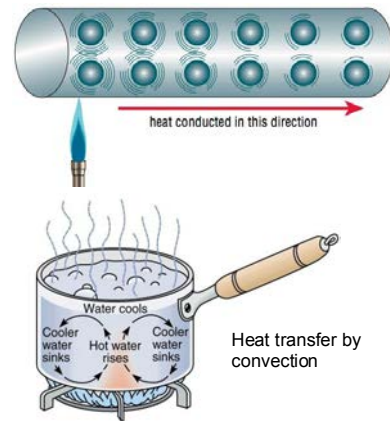
Wasted power = input power - output power = 500 - 300 = 200W

$$\text{Efficiency} = \frac{300}{500} = 0.6 \text{ Or } 60\%$$

7

8. Methods of Heat Transfer

Heat Transfer Method	Description
Conduction (Occurs in solids)	When heated particles vibrate more with an increase in their kinetic energy. They collide more with surrounding particles transferring the heat
Convection (Occurs in liquids and gases)	Particles are free to move (in a liquid and gas). Increase in their kinetic store. Particles move faster. The space between the particles increases, so the density decreases. The warmer less dense region rises and the cooler, denser regions sink.
Infrared Radiation (Occurs in all objects)	The hotter an object the more infrared radiation it emits in a given time. An object at constant temperature emits and absorbs infrared radiation at the same rate A perfect black body absorbs all the infrared radiation that falls upon it and then emits it back at the same rate as it absorbs it.



Conductivity

How well a material transfers electricity or thermal energy.

Metals have a higher conductivity than non-metals as they have delocalised electrons which can move through the structure transferring energy

The best insulator has **low** conductivity

8

9. Non-Renewable Energy Resources

Renewable energy resources will never run out. It is an energy resource that can be replenished quickly.

Non-renewable resources will one day run out (fossil fuels). Fossil fuels are coal, oil and natural gas.

Energy Resource	Uses	Advantages	Disadvantages
Coal	Electricity generation, heating, steam trains in some countries	<ul style="list-style-type: none"> Reliable energy resource Low extraction costs High energy per kg 	All fossil fuels are running out. Burning fossil fuels releases carbon dioxide a greenhouse gas which causes global warming. SO ₂ found in coal leads to acid rain when burned.
Oil	Electricity generation, heating, basis for petrol and diesel	<ul style="list-style-type: none"> Reliable energy resource Low extraction costs High energy per kg 	Burning fossil fuels releases carbon dioxide a greenhouse gas which causes global warming.
Gas	Electricity generation, heating, cooking	<ul style="list-style-type: none"> Reliable energy resource Gas fired power stations can be started quickly to meet changing energy demands 	Burning fossil fuels releases carbon dioxide a greenhouse gas which causes global warming.
Nuclear	Electricity generation Fuel: Uranium or plutonium	<ul style="list-style-type: none"> Reliable energy resource It has the highest energy density per kg of any fuel. Does not require combustion and therefore does not release carbon dioxide into the atmosphere 	The waste products from nuclear plants is dangerous radioactive waste which needs to be stored safely for hundreds of years.

9

10. Renewable Energy Resources 1

Energy Resource	Uses	Advantages	Disadvantages
Solar Energy	<ul style="list-style-type: none"> • Heating domestic hot water. • Photovoltaic cells inside solar cells can create electricity to charge batteries. • Electricity generation in large scale solar power plants 	<ul style="list-style-type: none"> • No atmospheric pollution due to burning of fossil fuels • In sunny countries it is more reliable (during the day) • Useful for remote places not supplied by the national grid. • No fuel costs and minimal running costs 	<ul style="list-style-type: none"> • Cannot increase supply to match demand • High initial costs • Unreliable due to weather • Cannot use at night
Wind Power	Electricity generation	<ul style="list-style-type: none"> • No atmospheric pollution due to burning of fossil fuels • No fuel costs and minimal running costs • No permanent damage to the landscape when removed. • Fast start-up 	<ul style="list-style-type: none"> • Visual and noise pollution • Cannot increase supply to match demand • High initial costs • Cannot generate electricity if there is too little wind • Unreliable
Geothermal	<ul style="list-style-type: none"> • Electricity generation • Heating 	<ul style="list-style-type: none"> • Reliable • No atmospheric pollution due to burning of fossil fuels 	<ul style="list-style-type: none"> • Few suitable locations (only possible in volcanic areas) • High cost to build power station
Bio-fuels	<ul style="list-style-type: none"> • Electricity generation • Heating • Fuel for transport 	<ul style="list-style-type: none"> • Carbon neutral (plants absorb carbon dioxide that is released when the fuel is burnt). • Reliable as crops grow quickly 	<ul style="list-style-type: none"> • High costs to refine the fuel • Space for growing food taken up • Forests cleared to make space – decay and burned vegetation release CO₂ and methane.

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11. Renewable Energy Resources 2

Energy Resource	Uses	Advantages	Disadvantages
Hydro-Electric	Electricity generation	<ul style="list-style-type: none"> • Can respond immediately to increased demand, fast start-up. • Reliable (except if there is a drought) • No fuel costs and minimal running costs • Potential to be used as part of pumped storage scheme 	<ul style="list-style-type: none"> • Requires land to be flooded to create a dammed reservoir • Loss of animal habitats • Relies on rainfall to keep reservoir full unless part of pumped storage system
Tidal barrage	Electricity generation	<ul style="list-style-type: none"> • No atmospheric pollution due to burning of fossil fuels • No fuel costs and minimal running costs 	<ul style="list-style-type: none"> • Visual pollution • Difficulty providing access for boats / wildlife • Initial costs are high • Environmental impact during building phase due to multiple vehicles and large amounts of concrete being used
Wave power	Electricity generation	<ul style="list-style-type: none"> • No atmospheric pollution due to burning of fossil fuels • Smaller solution for limited populations 	<ul style="list-style-type: none"> • Unreliable • Few suitable locations



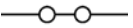
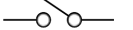

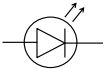



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12. Electrical Terms

Keyword	Definition
Ampere (A)	Unit of electric current.
Current (I)	The flow of electrical charge. Measured in Amps (A)
Electric circuit	A collection of electronic components connected by a conductive wire that allows for electric current to flow.
Ohm (Ω)	Unit for resistance.
Potential difference (V)	A measure of energy, per unit of charge, transferred between two points in a circuit Measured in volts (V).
Resistance (R)	Reduces the flow of current. Measured in ohms (Ω).
Resistor	Component that prevents the flow of electric current.
Volt (V)	The standard unit of measure for electric potential (voltage).
Watt (W)	The standard unit of measure used for electric power.

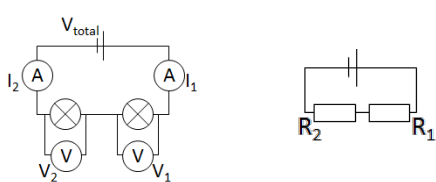
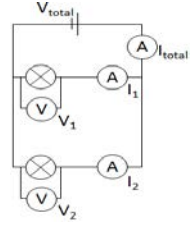
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13. Electrical Components

Component	Circuit symbol	Function
Cell		Provides electrons with energy to move around a complete circuit.
Battery		
Closed switch		Break and complete a circuit, so turn on and off.
Open switch		
Variable resistor		Allows the current in a circuit to be varied. Placed in series within the circuit.
Light emitting diode (LED)		Emits light when current passes through it. Placed in series within the circuit.
Ammeter		Used to measure current through a circuit. Placed in series within the circuit.
Fuse		A thin wire that melts if the current gets too high. Placed in series within the circuit.
Voltmeter		Used to measure potential difference (voltage) across a component. Placed in parallel within the circuit.

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14. Series and Parallel Circuit Rules

	Series Circuit	Parallel Circuit
Number of loops	1	2+
Current	Same all the way round	Shared across the components $I_{total} = I_1 + I_2 + \dots$
Potential difference	Shared across the components $V_{total} = V_1 + V_2 + \dots$	Same across the components $V_1 = V_2 = \dots$
Resistance	Add together $R_{total} = R_1 + R_2 + \dots$	Total resistance will decrease if two or more resistors are added in parallel. Resistors in parallel have the same pd across them as the power supply. Adding another loop to the circuit means the current has more than one way it has to go.
	$V_{total} = IR_{total}$	$R_1 = V_{total} / I_1$ I_1 = current flowing through R_1 R_1 = Resistance of lamp 1
Example of a circuit		

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15. Current, potential difference and resistance

The current (I) through a component depends on both the resistance (R) of the component and the potential difference (V) across the component.

The resistance of an electrical component can be found by measuring the electric current flowing through it and the potential difference across it.

Ohm's Law
At a constant temperature, the potential difference is **directly proportional** to the current.

Potential difference (V) = Current (A) x Resistance (Ω)

$V = IR$

Resistance is the opposite to current:
The higher the resistance of a circuit, the lower the current
Good conductors have a **low** resistance and insulators have a **high** resistance

The current through a component depends on both the resistance R of the component **and** the potential difference V across the component
The **greater** the resistance R of the component, the **lower** the current for a given potential difference V across the component
The **lower** the resistance R of the component, the **greater** the current for a given potential difference V across the component

16. I-V Characteristics and Circuit Devices 1

Fixed Resistor



Purpose: Limits the current in a circuit.

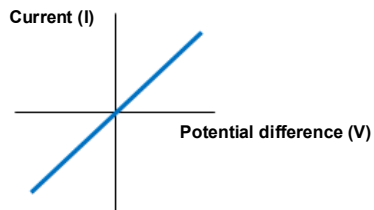
At a constant temperature, the potential difference is **directly proportional** to the current.

If the potential difference increases, the current increases.

The resistance doesn't change when the current changes.

Obeys Ohm's law. It is an ohmic conductor.

Obeys $V = IR$



If the temperature changes, the resistance will change.

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17. I-V Characteristics and Circuit Devices 2

Filament bulb



Property: Emits light when current flows through it.

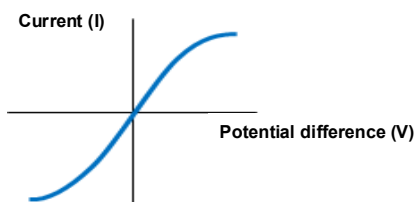
As the current increases, the filament wire gets hotter. The higher the current, the higher the temperature.

Resistance increases.

Harder for current to flow.

Graph gets less steep.

It is a non-ohmic conductor



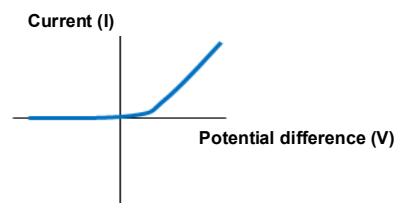
Diode



Property: allows current through in only one direction

The resistance depends on the direction of the current. As a diode only lets current flow in one direction, it has a very high resistance in the opposite direction, which makes it hard for the current to flow that way.


It is a non-ohmic conductor



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18. I-V Characteristics and Circuit Devices 3

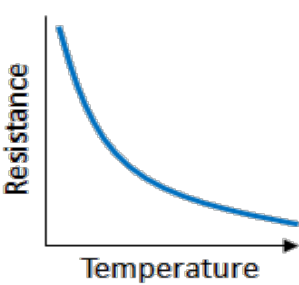
Thermistor



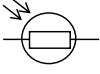
Use: central heating thermostats

High temperature– low resistance

Cold temperature – high resistance



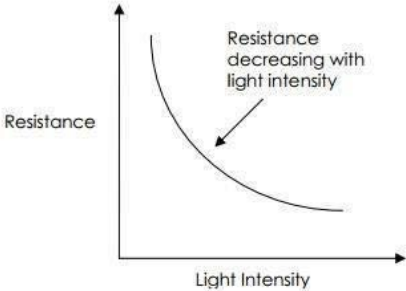
Light Dependent Resistor (LDR)



Used for: Automatic night lights

Bright light – low resistance

Darkness – high resistance



19. National Grid and AC DC supply

National Grid: A network of cables and transformers that connect power stations to consumers.

How step up transformers makes the National Grid efficient:

- Increases the potential difference
- Decreases the current
- Less energy loss

A huge amount of power is needed.

Increase efficiency: Use a high potential difference but a low current.

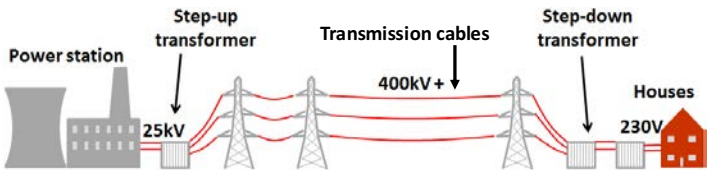
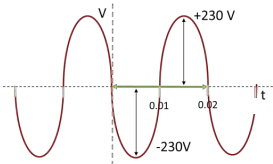
A high current would cause the wires to heat up, wasting a lot of energy (dissipated as heat).

Alternating Current (AC)

The current constantly changes direction. It is produced by an alternating voltage where the positive and negative ends keep alternating.

The UK mains supply is AC at 230V.

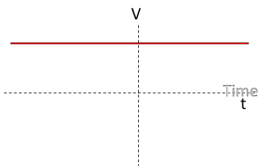
It has a frequency of 50Hz.



Direct Current (DC)

The current always flows in the **same direction**.

Batteries produce a DC voltage.



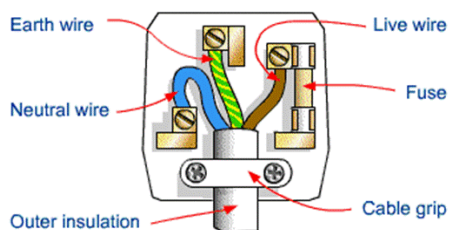
	Underground cables	Overground cables
Advantages	No visual pollution Less affected by the weather	No need to dig up the ground. Easy to repair
Disadvantages	Bigger disturbance to the land Difficult to access to repair	Visual pollution Affected by the weather

20. Electricity in the home

Electrical Wiring

Most electrical appliances are connected to the mains with a three-core cable (3 copper wires coated in insulating plastic).

Wire	Colour	Voltage (V)	Purpose
Live	Brown	230	Provides an alternating potential difference
Neutral	Blue	0	Completes the circuit carrying the current out of the appliance
Earth	Green and yellow	0	A safety feature. Prevents the appliance becoming live if there is a fault so does not normally carry a current.



Live Wire

If you touch the live a large pd is produced across your body and the current flows through you.

This electric shock can injure or kill you.

A connection between the live and earth creates a low resistance path to earth so a large current will flow.

This could cause a fire.

Fuses are placed in series with the live wire to limit the amount of current flowing in a circuit. If a fault occurs the current can be very high, so a fuse is used for safety.

A fuse is a thin piece of wire which all the current flows through, it gets hot and melts if too high a current flows through it, preventing any current flow.

Double Insulated Appliances

Some appliances have no earth wire.

They have a plastic non-conducting outer case and are designed so that the live and neutral wires cannot come into contact with the external casing.

This can be done by placing the wire terminals inside a plastic surrounding box.

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21. Electrical power and charge

Power

Energy in an electrical circuit is transferred by a moving charge. The charge has to work against resistance, so work is done. Work done is the same as energy transferred and depends upon power.

$$\text{Energy transferred (J)} = \text{Power (W)} \times \text{Time (s)}$$

$$E = Pt$$

e.g. How much energy is transferred by a 3kW kettle in 2 minutes.

E	E = Pt
V	P = 3 kW = 3000W and t = 2 min = 120s
E	E = 3000 x 120
R	E = 360 000
Y	J

E = 360 000J or 360 kJ.

Power Calculations

$$\text{Power (W)} = \text{Current (A)} \times \text{Potential difference (V)}$$

$$P = IV$$

$$\text{Power (W)} = \text{Current}^2 \text{ (A)} \times \text{Resistance } (\Omega)$$

$$P = I^2R$$

Charge

$$\text{Energy transferred (J)} = \text{Charge (C)} \times \text{Potential difference (V)}$$

$$E = QV$$

$$\text{Charge (C)} = \text{Current (A)} \times \text{Time (s)}$$

$$Q = It$$

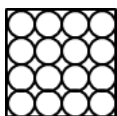
An amp is the amount of charge flow per second.
1 amp = 1 coulomb per second.

Unit conversions

kJ to J	x 1000
minutes to seconds	x 60
hours to seconds	x 3600

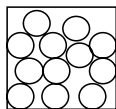
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22. The particle model



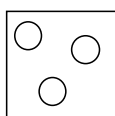
Solids

Have **strong forces** between particles or molecules, holding them close together in a **fixed, regular** arrangement. The particles can only vibrate around fixed positions.



Liquids

Have **weaker forces** between particles so although the particles are close together they can **flow** over each other at low speeds in random directions.



Gases

Have almost **no forces** between particles. Have **more energy** and are **free to move** in random directions and speeds.

Density

Closer the particles, the denser the material

$$\text{Density (kg/m}^3\text{)} = \text{mass (kg)} \div \text{volume (m}^3\text{)}$$

$$\text{Density (g/cm}^3\text{)} = \text{mass (g)} \div \text{volume (cm}^3\text{)}$$

$$\rho = m \div v$$

e.g. What is the density of 1kg of water?

Volume of 1kg of water = 0.001m³.

$$E \quad \rho = m \div v$$

$$V \quad m = 1\text{kg and } v = 0.001\text{m}^3$$

$$E \quad \text{Density} = 1 \div 0.001$$

$$V \quad 1000$$

$$Y \quad \text{kg/m}^3$$

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23. Internal Energy

If we increase the energy of the particles, it will either:

- Increase the temperature of the substance
- Change its state i.e. change from a solid to a liquid

Internal energy = Kinetic energy of particles + Potential energy of particles
(energy stored by particles in a system) (e.g. vibration of atoms) (spacing between the particles)

Temperature is a measure of the average kinetic energy of the particles.

A temperature change depends on the mass of substance, what it is made from and the energy input (see specific heat capacity).

If the substance is heated sufficiently particles have enough energy in their kinetic stores to break the bonds holding them together and so a change in state occurs.

All changes of state do not affect the kinetic energy of the particles so are constant temperature processes.

Evaporation of a liquid: The particles at a liquid's surface sometimes gain enough energy to leave the surface as a gas

Increase rate of evaporation by:

- Increasing the surface area of liquid.
- Increasing the temperature of the liquid.
- Creating a flow of air across the liquid's surface.

Condensation of a gas: The water molecules that are in the air can hit a cool surface, cool down and therefore stay there.

Increase rate of condensation by:

- Increasing surface area
- Reducing surface temperature

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24. Specific latent heat

Specific Latent Heat – the energy needed to change the state of 1kg of a substance

Thermal energy (J) = mass (kg) x specific latent heat (J/kg)

$E = ml$

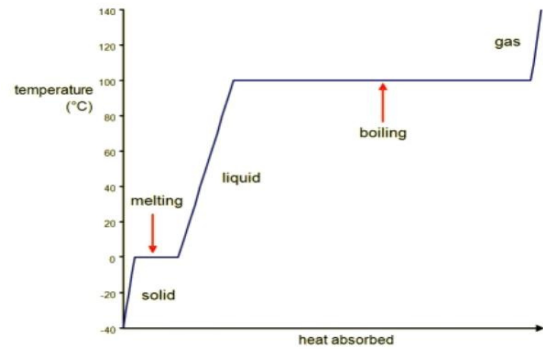
e.g. How much energy is required to melt 1.5kg of ice. L_f water = 334 kJ/kg.

E	$E = ml$
V	mass = 1.5kg and specific latent heat of fusion = 334kJ/kg
E	$E = ml = 1.5 \times 334\,000$
V	$E = 501\,000$
Y	J

$E = 501\,000\text{J}$ or 501 kJ

Specific latent heat of fusion (l_f) = change of state from solid to liquid at a constant temperature

Specific latent heat of vaporisation (l_v) = change of state from liquid to vapour at a constant temperature



Gradient of the line = specific heat capacity of the substance.

Steeper the line, the higher the specific heat capacity of the substance

Horizontal line = specific latent heat

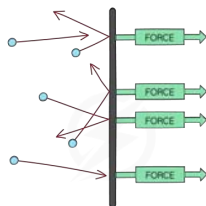
Longer the horizontal line = greater the specific latent heat of fusion/vaporisation

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25. Particles in gases

Gas Pressure:

When the particles in a gas collide with the side of the container they exert a force on it. This force acts at right angles to the container walls.



Pressure = force exerted per unit of area.

In a sealed container, the gas pressure is the total force of all the particles on the area of the container walls.

Increasing the temperature of the gas (whilst keeping the volume constant). Pressure and temperature are **directly proportional** to each other.

- increases pressure
- Increases the average kinetic energy of the particles. Particles move faster so collide with the sides more often and with more momentum
- A larger total force is exerted
- The pressure increases.

Work Done

Work is done when energy is transferred by applying a force.

Work done on a gas increases its internal energy. This can increase the temperature of the gas.

Pumping up a bike tyre does work mechanically. The gas exerts a force on the plunger (due to pressure). To push the plunger down against this force, work must be done. Energy is transferred to the kinetic stores of the gas particles, increasing the temperature.

For a fixed mass of a gas held at a constant temperature:

Constant = Pressure (Pa) x volume (m^3)

Pressure and volume are **inversely proportional** to each other

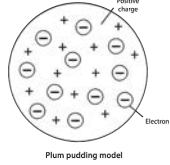
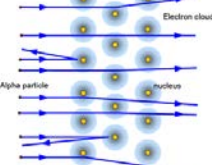
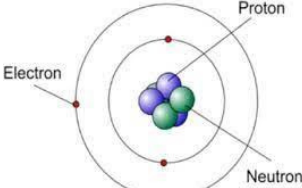
- When the volume **decreases** (compression), the pressure **increases**
- When the volume **increases** (expansion), the pressure **decreases**
- The key assumption is that the **temperature** and the **mass** (and number) of the particles remains the same

By increasing the volume:

- The particles will bump into the container walls less frequently
- Particles must travel further between each impact with the container
- Reduces the total force per metre of surface area
- Pressure reduces.

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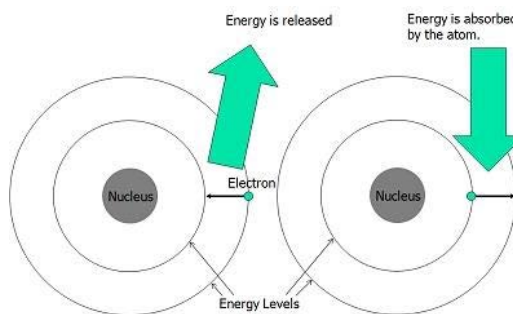
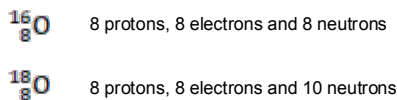
26. Atomic models

Atomic model	Plum pudding model		Nuclear model		
Diagram					
Discovery	Electron	Positive nucleus in the centre of the atom	Electrons occupy shells	Neutrons	<ul style="list-style-type: none"> Atomic radius: 1×10^{-10} m Radius of a nucleus is less than 1/10 000 of the radius of an atom. Most of the atom is empty space
Description	The atom is a ball of positive charge with negative electrons embedded in it.	Positively charged alpha particles were fired at thin gold foil. Most alpha particles went straight through the foil. A few were deflected in different directions by the atoms in the foil. It showed that the mass of an atom was concentrated in the centre (the nucleus) and the nucleus was positively charged.	Shells are also known as energy levels	Proved the existence of isotopes	
Discovered by	Thompson	Rutherford	Bohr	Chadwick	

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27. Isotopes and Radiation

Isotopes: Atoms of the same element that have different numbers of neutrons but the same number of protons and electrons. They have the same chemical properties but different physical properties.



Isotopes that give out nuclear radiation are called radioactive isotopes.

Radioactive atoms have an unstable nucleus.

They give out (emit) radiation from their nucleus.

Doing this makes the atom more stable

When an electron moves to a lower energy level, the electron releases electromagnetic radiation (left hand picture).

When an electron moves to a higher energy level, the electron absorbs electromagnetic radiation (right hand picture).

The further the energy level (shell) from the nucleus, more energy is required to move the electron **up** to that level.

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28. Nuclear Radiation

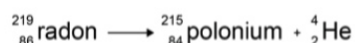
	Alpha	Beta	Gamma
Symbol	${}^4_2\alpha$	${}^0_{-1}\beta$	${}^0_0\gamma$
What is it?	Helium nuclei	Fast moving electron	Electromagnetic wave
Stopped by	Paper, thin sheet of aluminium and lead	Thin sheet of aluminium and lead	Lead
Ionising power (how easy it is to form an ion)	Strong	Weak	Very weak
Penetrating power	Low	Medium	High
Range in air	Few cm	Several metres	Many metres
Uses	Smoke alarms	Monitor thickness of paper and detect leaks in pipes.	Treat cancer. Sterilise medical equipment.

Keyword	Definition
Decay	A process by which a radioactive nucleus changes into a stable nucleus
Random	Impossible to predict when each individual nucleus will decay
Spontaneous	Impossible to make a decay any more/less frequent e.g. increasing temperature of pressure

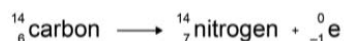
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29. Nuclear equations and half lives

Alpha decay causes the **charge** to decrease by 2 and **mass** to decrease by 4 as the nucleus releases the alpha particle



Beta decay causes the **charge** of the nucleus to **increase** but the mass remains the same. Within the nucleus a neutron is changed into a proton and releases an electron (beta particle)



Gamma rays do not change the mass or charge of the atom they are emitted from

Neutrons can also be an emitted form of non-ionising radiation

Half-Life:

The time taken for the number of radioactive nuclei in an isotope to halve.

Activity (the rate at which a source decays) is measured in Becquerel's Bq (1Bq = 1 decay per second).

e.g. if the initial activity of a sample is 600Bq what will it be after two half-lives?

1 half life = $600 \div 2 = 300\text{Bq}$

2 half lives = $300 \div 2 = 150\text{Bq}$

e.g. What fraction remains radioactive after 40 years if the half-life of an isotope is 10 years?

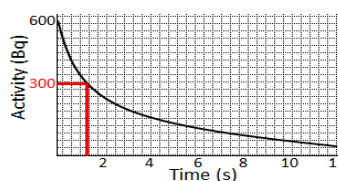
Number of half-lives = $40/10 = 4$ half-lives.

After 1 half life – $\frac{1}{2}$ remains

After 2 half lives – $\frac{1}{4}$ remains

After 3 half lives – $\frac{1}{8}$ remains

After 4 half lives – $\frac{1}{16}$ remains or 6.25%



Finding half-life from a graph:

- Mark where half the activity level is.
- Find the corresponding time (1.8s in this example)

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30. Applications of radiation, contamination and irradiation

Applications of radiation	Radioactive contamination	Irradiation
<p>Destruction of unwanted tissue (cancer) or imaging internal organs.</p> <p>Radio-isotopes with a short half-life are used to limit any damage.</p> <p>Alpha radiation cannot be used for imaging because it cannot penetrate body tissue and it is highly ionising.</p> <p>Over exposure to ionising radiation can damage cells and lead to cancer</p>	<p>The unwanted presence of radioactive materials. The level of hazard depends on the type of radiation and the amount of time you are exposed.</p> <p>Nuclear power plant fuel rods and medical equipment with radioactive sources can have sources that we need to store safely for long periods of time at the end of their useful life.</p>	<p>Where an object is deliberately exposed to a radioactive source.</p> <p>Used to sterilise medical equipment and food.</p> <p>The irradiated object does not become radioactive, so it is safe.</p>

Natural background radiation	It comes from either natural sources such as cosmic rays or radioactive rocks.
Man-made radiation	Medical x-rays or radiotherapy Nuclear testing or accidents e.g. Chernobyl
Dose	<p>The amount of radioactivity we are exposed to.</p> <p>Measured in sieverts (Sv). 1000 mSv = 1Sv</p> <p>How big a dose you receive will depend on where you live and what your job is.</p>
Why radioactive waste should have a short half-life	<p>Activity decreases quickly</p> <p>Risk of harm decreases quickly</p>

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31. Required practical 1: Specific Heat Capacity

Method

1. Take a 1 kg block of copper.
2. Place an immersion heater in the larger hole in the block.
3. Connect the power supply to the joule meter (reset to read 0 Joules).
4. Connect the joule meter to the 12V immersion heater.
5. Place the thermometer into the other hole in the block.
6. Switch the power pack to 12 V. Turn it on.
7. After 1-minute record the temperature of the block and the reading from the joule meter.
8. Continue taking readings every minute until 10 minutes have passed.

IV - Work done – (energy transferred to block measured by joulemeter)

DV - temperature

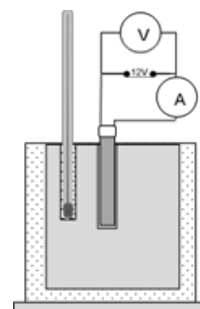
CV – Copper block of 1kg mass

Sources of Error

Heat is lost to the surroundings due to lack of insulation

The immersion heater is not fully immersed into the block

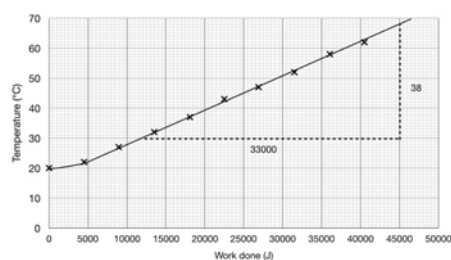
The graph may be curved at the start because it takes time for the heater and block to transfer the energy



Processing data

Plot graph work done against temperature

Specific heat capacity = $1 \div \text{gradient}$



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32. Required Practical 2: Thermal Insulation

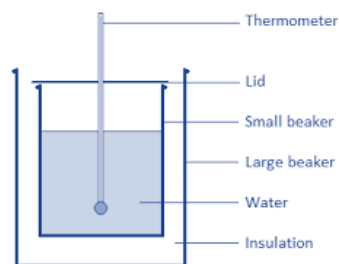
Method

1. Pour 200 cm³ of hot water into a 250 ml beaker with a single layer of insulating material around it.
2. Use a piece of cardboard as a lid for the beaker.
3. Insert the thermometer through the hole in the cardboard lid
4. Record the temperature of the water and start the stopwatch.
5. Record the temperature of the water every 30 seconds for 5 minutes.
6. Repeat steps 1–5 increasing the number of layers of insulating material wrapped around the beaker until you reach 4 layers.
7. Repeat the experiment with no insulation around the beaker.
7. Plot a graph of temperature versus time.

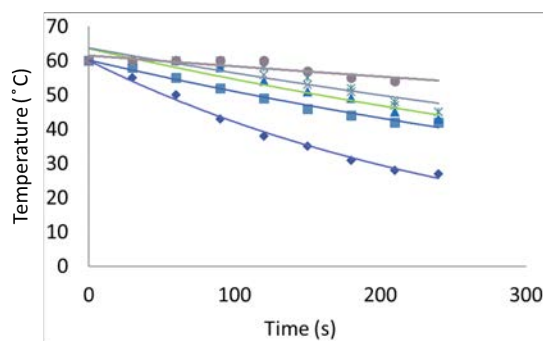
IV – Time (s)

DV – Temperature change

CV – Volume of water, material of insulation, starting temperature.



The more layers of insulation the longer it takes for the temperature to drop, indicating a better insulator.



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33. Required Practical 3: Resistance of a wire

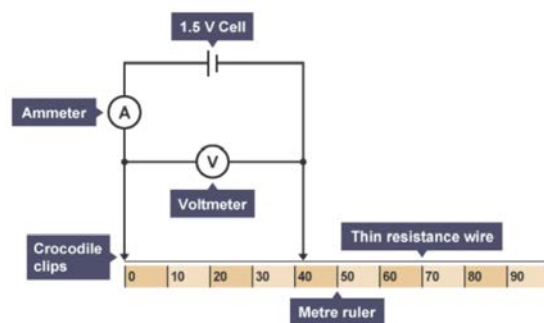
Method:

1. Set up equipment as shown in the diagram.
2. Connect the crocodile clips to the resistance wire, 100 cm apart.
3. Record the reading on the ammeter and on the voltmeter.
4. Move one of the crocodile clips closer until they are 90 cm apart.
5. Record the new readings on the ammeter and the voltmeter.
6. Repeat the previous steps reducing the length of the wire by 10 cm each time down to a minimum length of 10 cm.
7. Plot a line graph of length of wire (x axis) against resistance (y axis)

IV: length of the wire

DV: voltage and current

CV: type of wire, diameter of wire and the battery



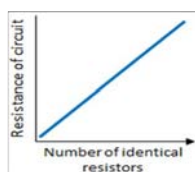
Reason for inaccuracy of readings: The resolution of the length of wire is lower due to where the crocodile clips are attached to the wire

Improve accuracy of readings: Turn off the circuit between the readings. This will stop the wire heating up and the temperature changing

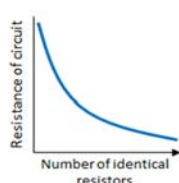
Possible errors: Wire heating up and increasing resistance, incorrect reading of ammeter and voltmeter and internal resistance of equipment

Conclusion: The length of the wire is **proportional** to the resistance of the wire.

Resistors in series



Resistors in parallel



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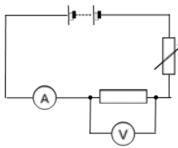
34. Required practical 4: Component IV characteristics

IV—Potential Difference (Volts)

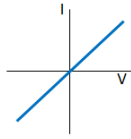
DV—Current (Amps)

CV— Same components, voltage from power pack, temperature – take the readings, immediately, Repeats to reduce the impact of outliers.

Fixed Resistor



At a constant temperature, the current is **directly proportion** to the voltage.
This means it obeys Ohm's Law.



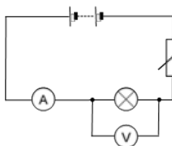
Method

1. Measure the current in the resistor using the ammeter.
2. Measure the potential difference across resistor using the voltmeter.
3. Vary the resistance of the variable resistor
4. Record a range of values of current and potential difference.
5. Ensure current is low to avoid temperature increase.
6. Switch circuit off between readings
7. Reverse connection of the resistor to the power supply.
8. Repeat measurements of I and V in negative direction.
9. Plot a graph of current against potential difference

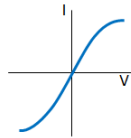
How to improve accuracy of readings:

- Circuit is switched off between readings
- Temperature does not change

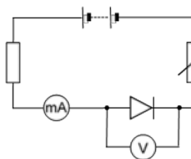
Filament Bulb



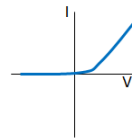
As the voltage increases the current increases. This causes the filament to get hotter, meaning the resistance increases. Therefore as the voltage continues to increase the current levels off.



Diode



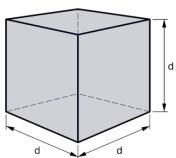
The current can only flow in one direction because a diode has a very high resistance in the opposite direction.



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35. Required practical 5: Calculating density

Regular shaped object



1. Measure the length, width and height using a ruler.
2. Calculate the volume ($l \times w \times h$)
2. Measure the mass using a balance.
3. Use the equation $\text{mass} \div \text{volume}$ to calculate the density.

Irregular shaped object



1. Using a balance, measure the mass of the object.
2. Fill a measuring cylinder with 100 cm^3 of water
3. Put object into measuring cylinder
4. Difference in volume of water is the volume of the object
5. Use the equation $\text{mass} \div \text{volume}$ to calculate the density.

Liquid



1. Using a balance, record the mass of a beaker
2. Pour 100 cm^3 of liquid into the measuring cylinder.
3. Pour liquid into a beaker and record the mass of the beaker and its contents
4. Difference in mass of (beaker + contents) from the beaker is the mass of the liquid.
5. Use the equation $\text{mass} \div \text{volume}$ to calculate the density.

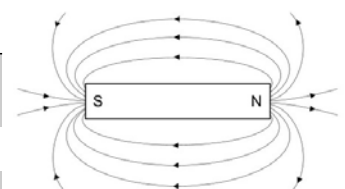
35

Physics Paper 2 (Combined Foundation)

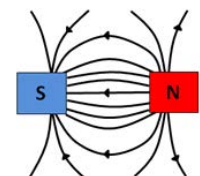
- | | | |
|---|--------------------------------------|---|
| 36. Magnets | 44. Refraction of waves | 51. Thinking, braking and stopping distance |
| 37. Compasses and magnets | 45. Electromagnetic spectrum | 52. Required practical 6: Force and extension |
| 38. Electromagnetism | 46. Forces - vectors and scalars | 53. Required practical 7: The effect of force on acceleration |
| 39. Investigating electromagnetism | 47. Elasticity | 54. Required practical 8: The effect of mass on acceleration |
| 40. Uses for electromagnets | 48. Newtons laws of motion | 55. Required practical 9: Infrared radiation |
| 41. Wave properties | 49. Speed, velocity and acceleration | 56. Required practical 10: The speed of a water wave |
| 42. Transverse and longitudinal waves | 50. Graphs of motion | 57. Maths in science 1 |
| 43. Sound waves and speed of sound experiment | | 58. Maths in science 2 |
| | | 59. Physics equation sheet |

36. Magnets

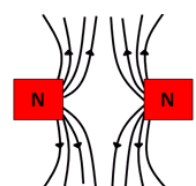
Magnetic metals	Iron (steel), nickel and cobalt
Permanent magnets	Magnetic all the time. Produce their own magnetic field.
Induced magnets	Made from magnetic materials. Only turns into a magnet when held in a magnetic field e.g. core of an electromagnet
North and south pole of a magnet	The part of the magnet where the magnetic field is the strongest
Magnetic field	A region where force is experienced by magnetic materials
Magnetism	A non-contact force from a magnetic to a magnetic field
Field lines	Point away from north and show the direction a north pole would point if it was placed in a field. Closer the field lines in a magnetic field = stronger the magnetic force. Field lines run from north pole to south pole.
Compass	A small bar magnet that is free to move. Always points north in a magnetic field
Evidence that the Earth's core is magnetic	The Earth's iron core creates a magnetic field. The north poles of magnets are attracted to the geographic North Pole of the Earth.



Opposite poles attract



Like poles repel



37. Compasses and magnets

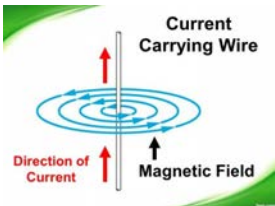
	Iron filings	Plotting compass
Method	Sprinkle iron filings on a piece of paper over the magnet	Use a plotting compass around the magnet with the needle showing the direction.
Advantage	Field lines easily seen	Direction of field lines shown
Disadvantage	Iron filings easily spilt and stick to magnet. Not permanent.	Compasses affected by magnets and do not always work so well. Takes longer.

- Using a plotting compass to find the magnetic field of a bar magnet**
1. Place magnet on a sheet of (plain) paper
 2. Place the compass near the north pole of the magnet
 3. Mark the position that the compass needle points to
 4. Move the compass so the opposite end of the needle is at this position and mark the new position where the compass tip settles
 5. Repeat above until you reach the south pole, then connect the marks together to construct a field line .
 6. Add arrows to field lines (pointing north to south).

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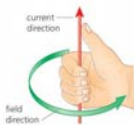
38. Electromagnetism

Magnetic Field around a Wire



- Arrows on the field line show the direction of the magnetic field.
- Reverse the direction of the current, the direction of the magnetic field reverses.
- If the field lines are closer, there is a larger the current.
- Further away from the wire, the weaker the magnetic field

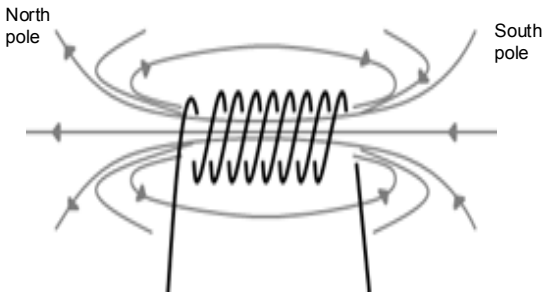
Right Hand Grip Rule



Your thumb points in the direction of the current.

Your fingers point in the direction of the magnetic field.

- Solenoid:** a coil of wire
- Outside solenoid:** Magnetic field lines are like a bar magnet
- Inside solenoid** Magnetic field is strong. Same strength and direction in all places. Field lines are parallel.
- Electromagnet:** a solenoid with an iron core
- Advantages of an electromagnet:**
Can be turned on or off. Strength of magnet can be increased or decreased.



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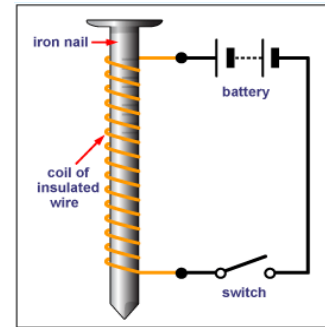
39. Investigating electromagnetism

How to make an electromagnet

1. Set up equipment as shown in diagram
2. Wrap the wire around the nail
3. Connect the wire to the power supply
4. Switch on the power supply

How to test the electromagnet

- the more paperclips suspended, the stronger the electromagnet is
- clamp the electromagnet at different distances from the paperclip(s)
- the further the distance from which paperclips can be attracted the stronger the electromagnet is
- use de-magnetised paper clips



IV: Increase strength of electromagnet by (3 x Cs):

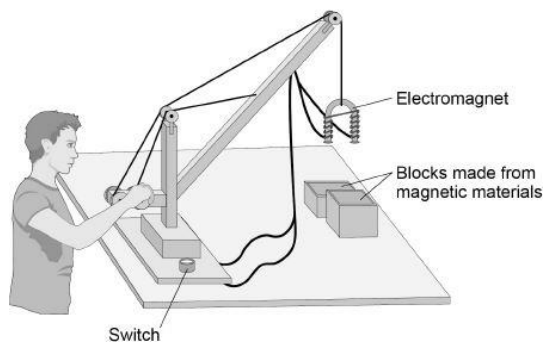
- a) Increase the number of coils
- b) Increase the current
- c) Change the core

DV: Number of paperclips picked up

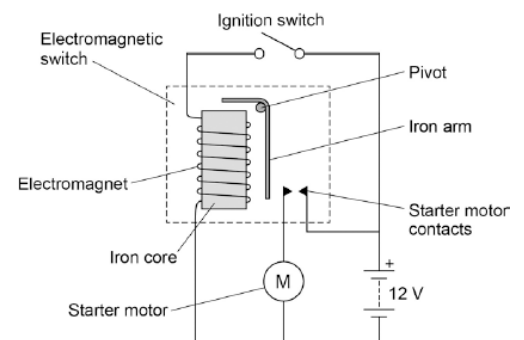
CV: Same type of paperclip.

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40. Uses for Electromagnets



1. Completing the circuit turns the electromagnet on
2. There is a current in the coil
3. A magnetic field is produced around the coil
4. The iron core becomes magnetised
5. Move electromagnet towards the blocks
6. The block is attracted to the electromagnet
7. Moving the crane moves the block
8. Switching off the current switches off the electromagnet
9. Releasing the block



1. Closing the switch causes a current to pass through the electromagnet
2. The iron core of the electromagnet becomes magnetised
3. The electromagnet attracts the short side of the iron arm
4. The iron arm pushes the starter motor together
5. The starter motor circuit is complete
6. A current flows through the starter motor

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41. Wave properties

Mechanical Waves travel through a medium (substance).
The particles oscillate (vibrate) and transfer energy.
The particles do not travel along in the wave.

Frequency (f) - the number of complete waves that pass a point every second.
1 wave per second has a frequency of 1Hz (hertz).

Time period (T) - the time for a complete cycle of a single wave.

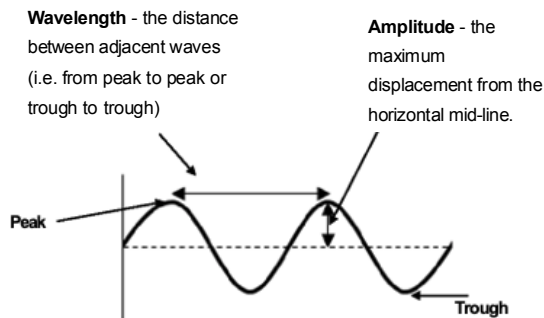
Frequency (Hz) = $1 \div \text{time period (s)}$

$F = 1 \div T$

Example: What is the frequency for a wave with a time period of 0.2s

E $f = 1 \div T$
V $T = 0.2 \text{ s}$
E $f = 1 \div 0.2$
R 5
Y Hz

f = 5Hz



Wave speed (m/s) = frequency (Hz) x wavelength (m)

$$V = f \lambda$$

Example: How fast is a wave travelling which has a 3m wavelength and a frequency of 20Hz?

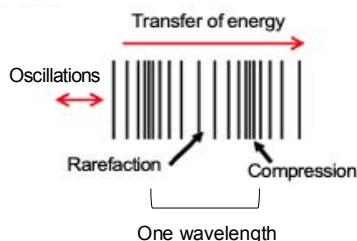
E $V = f \times \lambda$
V $f = 20 \text{ Hz}; \lambda = 3 \text{ m}$
E $V = 20 \times 3$
R $V = 60$
Y m/s

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42. Transverse and Longitudinal waves

Longitudinal Waves

The **oscillations** (vibrations causing the wave) are **parallel** to the direction of **energy transfer**.



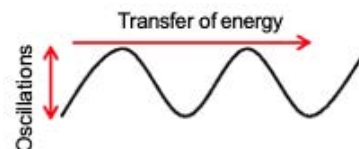
Compression: particles bunch up

Rarefaction: particles spread out

Example: Sound waves

Transverse Waves

The **oscillations** (vibrations causing the wave) are **perpendicular** (90°) to the direction of **energy transfer**.



Example: Light waves, X-rays and water waves (ripples)

All electromagnetic waves

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43. Sound Waves and Speed of Sound experiment

Sound waves are **mechanical longitudinal waves**.

They need a medium to travel through.

The speed of sound can be calculated using:

$$\text{Speed (m/s)} = \text{distance (m)} \div \text{time (s)}$$

Unit conversions:

km to m:	x 1000
cm to m:	÷ 100
minutes to seconds:	x 60
hours to seconds:	x 3600

Speed of sound experiment

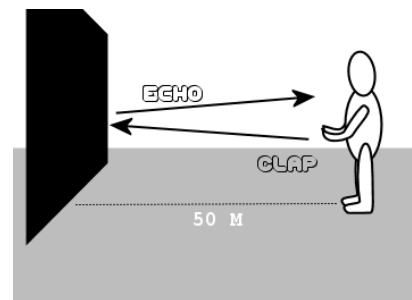
1. Measure the distance between the person and the wall using a metre ruler.
2. Double this distance.
3. Using a stop clock, measure the time taken from the clap being made to hearing its echo.
4. Use the equation,

$$\text{speed} = \text{distance} \div \text{time}.$$

Sound waves

Bigger the amplitude – taller the wave – louder the sound

Higher the frequency – more waves per second – higher pitch



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44. Refraction of waves

Refraction

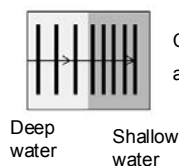
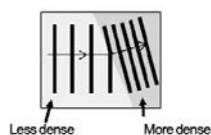
Waves change speed when they cross a **boundary** between two materials of different density or a boundary of different depths.

If the wave enters a medium of higher **density** at an **angle** the ray bends towards the normal (see diagram).

If it enters a medium **along the normal** then the wave does not change direction but the **wavelength** and **speed decrease**.
 (waves closer together on diagram below but have not changed direction)

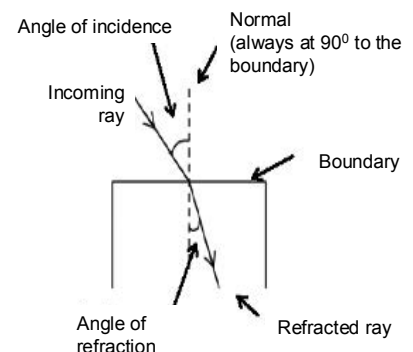
Wave Front Diagrams

The part of the wave front that enters the more dense medium first, slows down as the rest of the wave front continues at the same speed but has to travel further. The difference in distance and speed causes the wave to refract. A wave travelling from deep to shallow water also refracts.



Change in speed but no change in direction as wave entered **along the normal**

Refraction of Light ray



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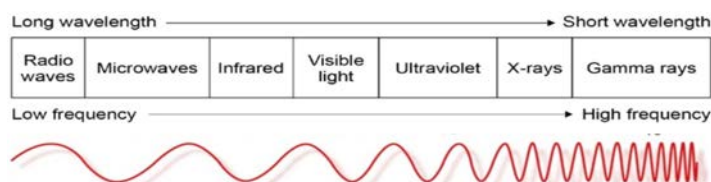
45. Electromagnetic Spectrum

All parts of the EM spectrum travel at the same speed.

They all travel at 300,000,000 m/s.

They are all transverse waves

All parts of the EM spectrum can travel through a vacuum (e.g. space)



Radio Waves	Used for communication. Used for television and radios. Radio waves can be produced by oscillations in electrical circuits. When radio waves are absorbed they may create an alternating current with the same frequency as the radio wave itself, so radio waves can themselves induce oscillations in an electrical circuit.
Microwaves	Used to communicate with satellites (T.V, mobile Phone) Cooking food.
Infra-red Radiation (IR)	Used for electrical heaters, cooking food, infrared cameras
Visible Light	Optical fibres transmit data using light over long distances
Ultra Violet Radiation (UV)	energy efficient lamps, sun tanning UV can damage surface cells, causing sunburn and increasing the risk of skin cancer.
X-Rays	X-Rays pass through flesh but are absorbed by the more dense bone. Ionising, so can cause mutations in DNA, destroy cells and cause cancer
Gamma Rays	Gamma rays can be used as a tracer. A gamma source is injected and its path through the body can be detected. Both are used to treat cancer as they kill cells. Ionising, so can cause mutations in DNA, destroy cells and cause cancer

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46. Forces

Scalar	A quantity which has only magnitude	Speed, distance, time, mass...
Vector	A quantity which has both magnitude and direction	Force, velocity, momentum, acceleration..

Mass: Amount of matter in an object

Measured using a balance

Measured in kg

Weight: A force depending on the object's mass and force of gravity

Measured using a Newton meter

Measured in N

Centre of mass: The point through which the weight of an object acts.

- The **wider** base an object has, the **lower** its centre of mass and it is more **stable**
- The **narrower** base an object has, the **higher** its centre of mass and the object is more likely to topple over if pushed

Contact Force	Involves 2 or more objects that must touch to act on each other	Friction, air resistance
Non contact force	Involves 2 or more objects that do not need to be touching for forces to act on each other	Gravitational force, electrostatic force, magnetic force

Weight (N) = mass (kg) x gravitational field strength (N/kg)

W = mg

e.g. What is the weight of a 2kg mass on earth

E W = m x g
V m = 2kg and g = 9.8N/kg
E W = 2 x 9.8
R W = 19.6
Y N

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47. Elasticity

Extension happens when an object increases in length, and

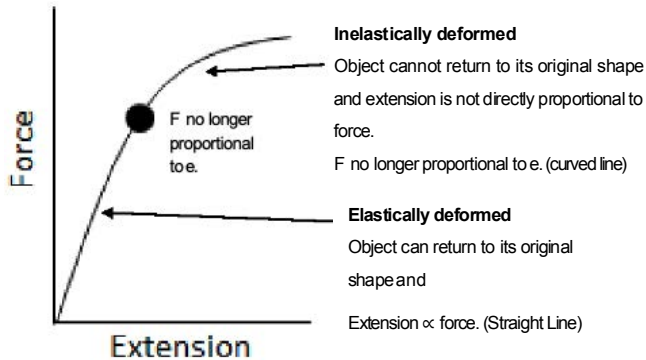
Compression happens when it decreases in length.

The extension of an elastic object, such as a spring, is described by **Hooke's law**:

Extension is directly proportional to force:

$$\text{Force (N)} = \text{spring constant (N/m)} \times \text{extension (m)}$$

$$F = ke$$



Elastic Potential Energy

A force acting on an object may cause the shape of an object to change.

Elastic objects can store elastic potential energy if they are stretched or squashed. For example, this happens when a catapult is used or a spring is stretched.

Objects can also store elastic potential energy when they are squashed.

$$\text{Elastic potential energy (J)} = 0.5 \times \text{spring constant (N/m)} \times \text{extension}^2 \text{ (m)}$$

Unit conversions:

kJ to J: $\times 1000$
cm to m: $\div 100$

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48. Newton's laws of motion

First Law	<p>A body at rest will remain at rest, and a body in motion will remain in motion, unless it is acted upon by an unbalanced force.</p> <p>Inertia is the tendency of a body to remain in the same state of motion</p>	
Second Law	<p>The amount a body accelerates is directly proportional to the force applied to it and inversely proportional to the mass of the body.</p> $F = ma$ <p>e.g. An aeroplane accelerates from a low speed to a high speed with the engines at maximum power</p> <p>At maximum power the forward force of the engines is constant as it accelerates the air resistance increases</p> <p>resultant force = force from engines – air resistance</p> <p>Therefore resultant force decreases acceleration is directly proportional to resultant force</p>	<p>Inertial mass is the property of an object which describes how difficult it is to change its velocity</p> <p>Inertial mass = force \div acceleration</p> <p>Inertial mass is defined as the ratio of force to acceleration</p> <p>Inertial mass is inversely proportional to acceleration (mass = 1 \div acceleration)</p> <p>Larger inertial masses will experience small accelerations</p> <p>Smaller inertial masses will experience large accelerations</p>
Third Law	<p>When two objects interact, the forces they exert on each other are equal and opposite.</p> <p>This is an equilibrium situation - neither object moves because the forces are balanced.</p>	

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49. Speed, velocity and acceleration

Typical Speed Walking	1.5 m/s
Running	3 m/s
Cycling	6 m/s
Car	25 m/s
Train	55 m/s
Plane	250 m/s

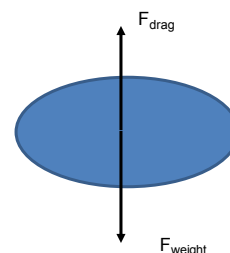
Speed	How fast something is going without reference to a direction. It is a scalar quantity.
Velocity	A speed in a given direction
Acceleration	How quickly something is speeding up, or its rate of change of velocity. Deceleration is how quickly something is slowing down or negative acceleration.

Terminal Velocity

The maximum speed an object will fall at through a fluid (liquid or gas).

As the speed of a falling object increases so does the frictional force (drag) opposing the objects weight (which doesn't change).

The resultant force is therefore reducing until the drag is equal to the weight. Acceleration is reduced to zero and the terminal velocity is reached.



Uniform Acceleration

This can happen due to gravity acting on an object in free fall.

$$v^2 - u^2 = 2 a s$$

v = final velocity (m/s)
u = initial velocity (m/s)
a = acceleration (m/s²)
s = distance (m)

Velocity and circular motion

When an object travels along a circular path, its velocity is always changing

The **speed** of the object moving in a circle is constant (travelling the same distance every second)

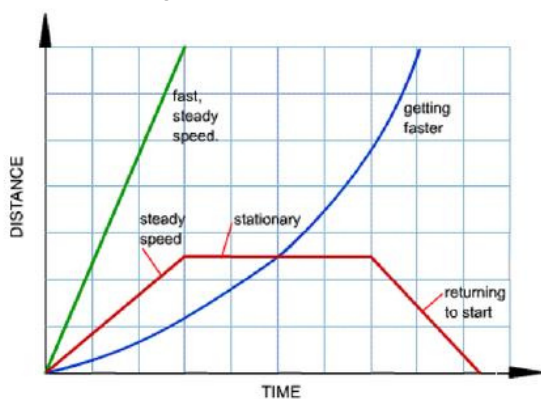
The **direction** of travel is always changing as the object moves along the circular path

This means that an object moving in circular motion travels at a **constant speed** but has a **changing velocity**

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50. Graphs of Motion

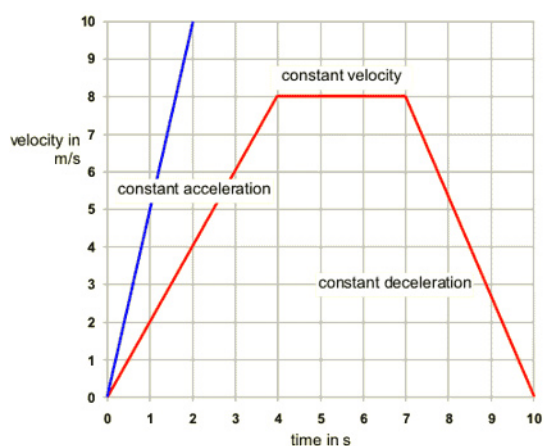
Distance – time graph



Gradient = speed of object

Gradient = $\frac{\text{change in } y}{\text{change in } x}$

Velocity – time graph



Gradient = acceleration of object

Distance travelled = area under the line

Average velocity = $(v + u) / 2$

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51. Thinking, Braking and Stopping Distances

Typical **reaction time** for a person is 0.2-0.9s

Thinking distance – the distance travelled by the vehicle in the time it takes for the driver to react

Braking distance – the distance travelled by the vehicle during the time the braking force acts

Stopping distance = thinking distance + braking distance

Reaction time – the time taken for the driver to react to the stimulus

Thinking distance is affected by:

- Speed
- Your reaction time which is affected by:
 - I. Alcohol
 - II. Drugs
 - III. Sleep deprivation
 - IV. Distractions

Braking distance is affected by:

- Speed
- Weather and the road surface e.g. icy
- Condition of tyres e.g. bald tyres cannot get rid of the water in wet conditions leading to skidding
- Quality of brakes

Reaction time experiment:

Ruler drop test

Computer based experiments

When a force is applied to the brakes of a vehicle, **work done** by the friction force between the brakes and the wheel reduces the kinetic energy of the vehicle and the temperature of the brakes increases.

The greater the speed of a vehicle the greater the braking force needed to stop the vehicle in a certain distance.

The greater the braking force the greater the deceleration of the vehicle. Large decelerations may lead to brakes overheating and/or loss of control.

When the car has stopped, the decrease in energy from the kinetic energy store is equal to the work done by the brakes

Work done (J) = Force (N) x distance (m)

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52. Required Practical 6: Force and extension

Force and Extension

The extension of a spring is directly proportional to the force applied, provided its limit of proportionality is not exceeded

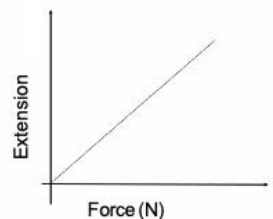
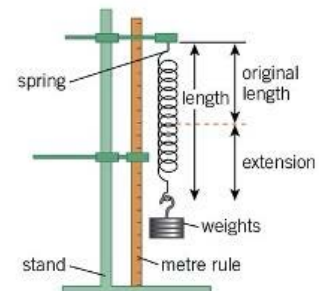
Independent variable - Force applied (N)

Dependent variable - Extension of spring (m)

Control variable - same spring, keep ruler in the same position.

Method

1. Hang the spring on the end of the clamp and gently clamp it to secure it.
2. Measure the original length of the spring and record this length.
3. Add a 100 g (1 Newton) mass holder to the end of the spring.
4. Measure the new length and calculate the extension.
5. Add 100 g masses, one at a time, measuring the length and calculating (and recording) the extension of the spring each time.
6. Stop when you have added a total of 500 g. Be careful not to overstretch the spring.



Spring constant (N/m) = Force (N) ÷ extension (m)
Spring constant = gradient of the line

52

53. Required Practical 7: The effect of force on acceleration

Independent variable – Force (N) (weight due to mass $W=mg$)

Dependent variable – acceleration (m/s^2)

Control variables – mass of trolley, same trolley starts from same position each time

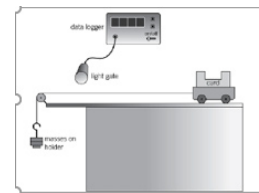
Method

1. Measure the length of each card segment and make a note of this.
2. Set up the apparatus as shown in the diagram below. When the trolley is as close to the pulley as it can get, the bottom of the mass holder should be between 0.5 cm and 1 cm above the floor.
3. During this experiment the trolley will travel towards the pulley.
4. Set up the data logger. You will use its measurements to find the trolley's acceleration.
5. Add mass to the mass holder so that the total mass, including the holder, is 250 g.
6. Pull back the trolley, set the data logger to record, and then let the trolley run to the pulley. Collect the necessary measurements from the data logger.
7. Take 50 g off the mass holder and place it onto the trolley. You may need to use a small amount of tape or sticky tack to hold the mass securely in place. Repeat step 6.
8. Repeat steps 6-7 until there is 200 g on the trolley - this will be the fifth and final run.

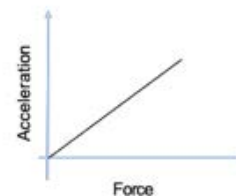
How to reduce random errors

Repeat the measurements/investigation

Ignore anomalies and calculate the mean



The acceleration of an object is **proportional to the resultant force** acting on the object.



The acceleration of an object is proportional to the resultant force acting upon it. $F = ma$ or $a = F/m$

m is the mass of the trolley and not the weight being attached to the string

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54. Required Practical 8: The effect of mass on acceleration

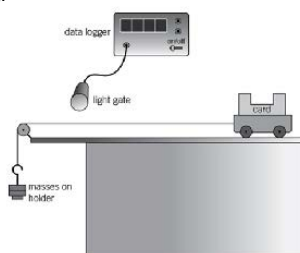
Independent variable – mass of the trolley (N)

Dependent variable – acceleration (m/s^2)

Control variables – Force being applied, trolley starts from same position each time

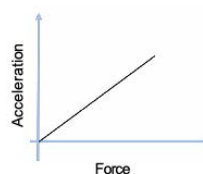
Method

1. Measure the length of each card segment and make a note of this.
2. Set up the apparatus as shown in the diagram below. When the trolley is as close to the pulley as it can get, the bottom of the mass holder should be between 0.5 cm and 1 cm above the floor.
3. During this experiment the trolley will travel towards the pulley. If you need to, place a lump of modelling clay or a block in front of the pulley to protect it from being hit by the trolley.
4. Set up the data logger. You will use its measurements to find the trolley's acceleration. There are different ways of doing this, depending on the data logger and the method your teacher asks you to use.
5. You will be changing the mass (by stacking extra trolleys under the first one) but keeping the applied force the same (by keeping the same number of masses on the mass holder). First, measure the mass of one trolley. (You can assume all trolleys have the same mass.)
6. Each time you change the number of stacked trolleys, measure the acceleration. You may need to change the height of the light gate so that the card still passes through it.



The acceleration of an object is **inversely proportional to the mass** of the object.

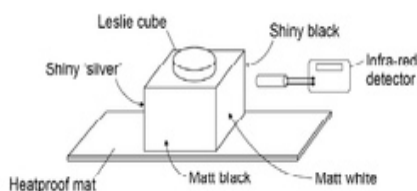
$$a = F/m$$



54

55. Required practical 9: Infra red radiation

Demonstration



Method:

1. Set up equipment as shown in diagram
2. Fill cube with hot water and put on lid
3. Use the detector to measure the amount of radiation from each surface

IV: surface

DV: Amount of IR absorbed or radiated

CV: Distance between surface and IR detector

Advantages of using this cube:

- All surfaces are at the same temperature
- More surfaces are tested
- Volume and temperature of the water does not need to be measured

All bodies (objects) emit and absorb **infrared radiation**.

An object that is good at absorbing radiation is also a good **emitter**, so a perfect black body would be the best possible emitter of radiation.

White and shiny silvery surfaces are the worst absorbers, as they reflect all visible light wavelengths. Poor absorbers are also poor emitters, and do not emit radiation as quickly as darker colours. Radiators in homes are usually painted white so that the infrared radiation is emitted gradually.

Class practical

1. Fill a matt black boiling tube and a shiny boiling tube with equal volumes of hot water.
2. Record temperature of water inside boiling tubes every 30 seconds.
3. Plot results on a graph

IV: surface of boiling tube

DV: temperature of hot water

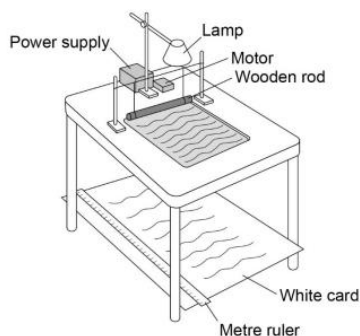
CV: volume of hot water, time intervals recording the temperature

Matt black boiling tube: Temperature drops the most and it is the best at it is the best at emitting heat.

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56. Required practical 10: Speed of water waves

1. Set up the ripple tank as shown in the diagram.
2. Make sure that there is a large sheet of white card or paper on the floor under the tank.
3. Pour water to a depth of about 5 mm into the tank.
4. Adjust the height of the wooden rod so that it just touches the surface of the water.
5. Switch on the overhead lamp and the electric motor.
6. Adjust the speed of the motor to produce low frequency water waves.
7. Adjust the height of the lamp so that the pattern of the waves can be clearly seen on the white card.



How to find the frequency of a wave using a ripple tank: count the number of ripples that pass a point in 10 seconds. Divide the number of waves by 10.

How to measure the wavelength: measure the distance across 10 gaps between the shadow lines. Divide this distance by 10.

How to calculate the speed of the wave

Wave speed (m/s) = frequency (Hz) x wavelength (m)

How to improve the method of calculating the wavelength:

Take a photo of the shadows and the ruler.

Benefit is that the waves are not being disturbed.

Reasons for using a:

Lamp: create shadows of the ripples

Metre ruler: measure the distance between 10 waves.

Signal generator: The vibration generator can have a built in signal generator so that you can directly set the frequency of paddle oscillation i.e. frequency of the ripple waves.

Deeper water means longer wavelength because velocity increases and frequency is constant

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57. Maths in Science 1

Anomalous result	A number that does not fit the pattern
Mean	Adding up a list of numbers and dividing by how many numbers are in the list. Exclude the anomalous result.
Median	The middle value when a list of numbers is put in order from smallest to largest
Mode	The most common value in a list of numbers. If two values are tied then there are two modes. If more than two values are tied then there is no mode.
Range	The largest number take away the smallest value in a set of data or written as X-Y.
Uncertainty	range \div 2
Surface area of a cube	(area of 1 side) \times 6 sides
Volume of a cube	Width \times height \times depth
Area of a circle	$\pi \times (\text{radius})^2$

Prefixes

$$1 \text{ kJ} = 1 \times 10^3 \text{ J} = 1000 \text{ J}$$

$$1 \text{ pm} = 1 \times 10^{-12} \text{ m}$$

$$1 \text{ mm} = 1 \times 10^{-3} \text{ m} = 0.001 \text{ m}$$

tera	10^{12}	T
giga	10^9	G
mega	10^6	M
kilo	10^3	k
centi	10^{-2}	c
milli	10^{-3}	m
micro	10^{-6}	μ
nano	10^{-9}	n
pico	10^{-12}	p

5607.376

Standard form: 5.607×10^3

2 decimal places: 5607.38

3 significant figures: 5610

0.03581

Standard form: 3.581×10^{-2}

2 decimal places: 0.04

3 significant figures: 0.0358

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58. Maths in Science 2

Calculating percentage: (part \div whole) \times 100

e.g. Out of 90 insects, 40 of them were ladybirds. What is the % of ladybirds?

$$(40 \div 90) \times 100 = 44 \%$$

Calculating percentage change:

$$(\text{difference} \div \text{starting value}) \times 100$$

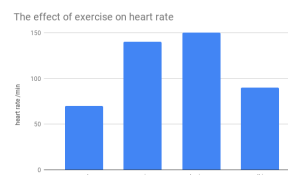
$$(0.59 \div 2.22) \times 100 = 26.6 \%$$

Conc of Sucrose (M)	Mass of potato at start (g)	Mass of potato at end (g)	Change in mass (g)
0	2.22	2.81	0.59

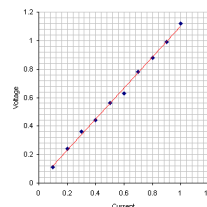
x axis = independent variable = left hand column of results table

y axis = dependent variable = right hand column of results table

Categoric data: data put into groups e.g. colour of eyes
Draw a bar chart



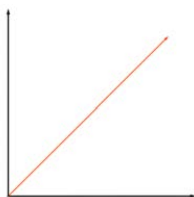
Continuous data: data that can take any value e.g. current
Draw a line graph



Graphs

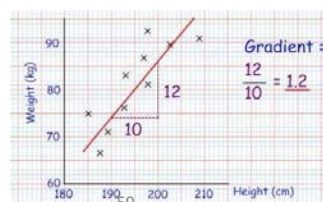
Proportional (\propto)

When the line passes through the origin



Gradient and Graphs

$$\text{Gradient} = \frac{\text{Change in } y}{\text{Change in } x}$$



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kinetic energy = $0.5 \times \text{mass} \times (\text{speed})^2$	$E_k = \frac{1}{2} m v^2$
elastic potential energy = $0.5 \times \text{spring constant} \times (\text{extension})^2$	$E_e = \frac{1}{2} k e^2$
gravitational potential energy = $\text{mass} \times \text{gravitational field strength} \times \text{height}$	$E_p = m g h$
change in thermal energy = $\text{mass} \times \text{specific heat capacity} \times \text{temperature change}$	$\Delta E = m c \Delta \theta$
power = $\frac{\text{energy transferred}}{\text{time}}$	$P = \frac{E}{t}$
power = $\frac{\text{work done}}{\text{time}}$	$P = \frac{W}{t}$
efficiency = $\frac{\text{useful output energy transfer}}{\text{total input energy transfer}}$	
efficiency = $\frac{\text{useful power output}}{\text{total power input}}$	
charge flow = $\text{current} \times \text{time}$	$Q = I t$
potential difference = $\text{current} \times \text{resistance}$	$V = I R$
power = $\text{potential difference} \times \text{current}$	$P = V I$
power = $(\text{current})^2 \times \text{resistance}$	$P = I^2 R$
energy transferred = $\text{power} \times \text{time}$	$E = P t$

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	energy transferred = $\text{charge flow} \times \text{potential difference}$	$E = Q V$
HT	potential difference across primary coil \times current in primary coil = potential difference across secondary coil \times current in secondary coil	$V_p I_p = V_s I_s$
	density = $\frac{\text{mass}}{\text{volume}}$	$\rho = \frac{m}{V}$
	thermal energy for a change of state = $\text{mass} \times \text{specific latent heat}$	$E = m L$
	weight = $\text{mass} \times \text{gravitational field strength}$	$W = m g$
	work done = $\text{force} \times \text{distance (along the line of action of the force)}$	$W = F s$
	force = $\text{spring constant} \times \text{extension}$	$F = k e$
	distance travelled = $\text{speed} \times \text{time}$	$s = v t$
	acceleration = $\frac{\text{change in velocity}}{\text{time taken}}$	$a = \frac{\Delta v}{t}$
	$(\text{final velocity})^2 - (\text{initial velocity})^2 = 2 \times \text{acceleration} \times \text{distance}$	$v^2 - u^2 = 2 a s$
	resultant force = $\text{mass} \times \text{acceleration}$	$F = m a$
HT	momentum = $\text{mass} \times \text{velocity}$	$p = m v$
	period = $\frac{1}{\text{frequency}}$	$T = \frac{1}{f}$
	wave speed = $\text{frequency} \times \text{wavelength}$	$v = f \lambda$
HT	force on a conductor (at right angles to a magnetic field) carrying a current = magnetic flux density \times current \times length	$F = B I l$

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INDEPENDENCE: DIAGNOSIS – THERAPY - TEST	
NAME:	CLASS:
TOPIC:	

DIAGNOSIS: The thing I don't understand
THERAPY: Where am I going to learn about this?
Which of the templates will I use to transform the information?
TEST: 5 questions someone can ask me about my new understanding.



INDEPENDENCE: DIAGNOSE	
NAME:	CLASS:
SUBJECT:	

Be clear about what you know and what you don't know before you begin.

First, use a contents page or a topic list for the subject you are going to revise.

Then, fill in the following table – the topics, and how well you know them.

Next, prioritise. Which topics will you revise first? Spend time studying the topics which will make the biggest difference to your results.

Topic	Knowledge	Priority
	Know it/Sort of know it/Don't know it	
	Know it/Sort of know it/Don't know it	
	Know it/Sort of know it/Don't know it	
	Know it/Sort of know it/Don't know it	
	Know it/Sort of know it/Don't know it	
	Know it/Sort of know it/Don't know it	
	Know it/Sort of know it/Don't know it	
	Know it/Sort of know it/Don't know it	
	Know it/Sort of know it/Don't know it	
	Know it/Sort of know it/Don't know it	
	Know it/Sort of know it/Don't know it	
	Know it/Sort of know it/Don't know it	
	Know it/Sort of know it/Don't know it	
	Know it/Sort of know it/Don't know it	
	Know it/Sort of know it/Don't know it	

Finally, use the **diagnosis – therapy – test** worksheet to plan your independent study.



INDEPENDENCE: PRIORITISE, REDUCE, CATEGORISE, EXTEND

NAME:

CLASS:

TOPIC:

Take a section of text and do the following:

Prioritise: write out the three most important sentences. Rank 1-3 in terms of importance. Justify your decision.

Reduce: reduce the key information to 20 words.

Categorise: sort out the information into three categories. Give each category a title which sums up the information.

Extend: write down three questions you would like to ask an expert in this subject.



INDEPENDENCE: RANKING TRIANGLE

NAME:

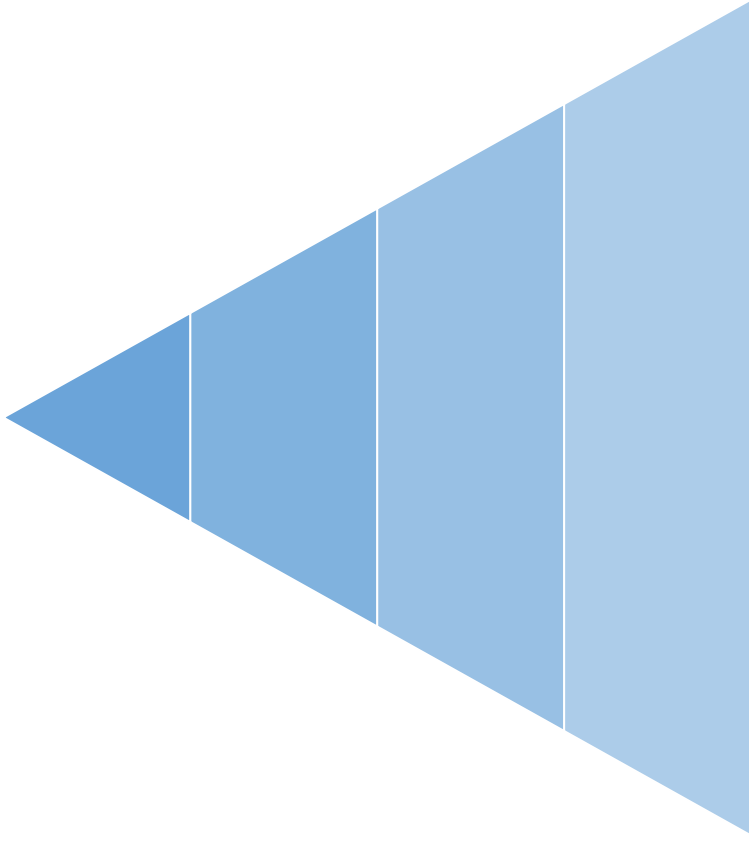
CLASS:

TOPIC:

The most important information goes at the top.

The least important information goes at the bottom.

Justify WHY. Why is it the most important? Why is it the least important?





INDEPENDENCE: QUIZZING

NAME: CLASS:

TOPIC:

Read the text and transform it into 10 questions to ask someone.

Question	Answer
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Question stems:

- State... Explain... Suggest...
- Describe... Evaluate... Compare...



INDEPENDENCE: BOXING UP

NAME: CLASS:

TOPIC:

Take a section of text. Read it and put your thoughts about the text into different boxes.

Needs a boost: 3 things I did not know:
Almost there: 3 things I understand better now:
I've got these: 3 things I already knew:



INDEPENDENCE: OTHER IDEAS

- Steps → flow chart** Transform a sequence of steps into a flow chart or a diagram.
- Flow chart → steps** Transform a flow chart or a diagram into a sequence of steps.
- Look, cover, write, check** Cover a list of key words. Write them down. Check which ones you have got right. Repeat until you get them all right.
- Link key words** Take three words from a topic. Link them together in a sentence or a diagram. Repeat until all the key words have been linked.



INDEPENDENCE: Pictionary

NAME: _____ CLASS: _____

TOPIC: _____

Transform the material into 6 pictures – one per paragraph or one per key piece of information. The pictures should represent the information so that they can act as a reminder of what the text said. Underneath each picture, explain your thinking.

1.	2.	3.

4.	5.	6.