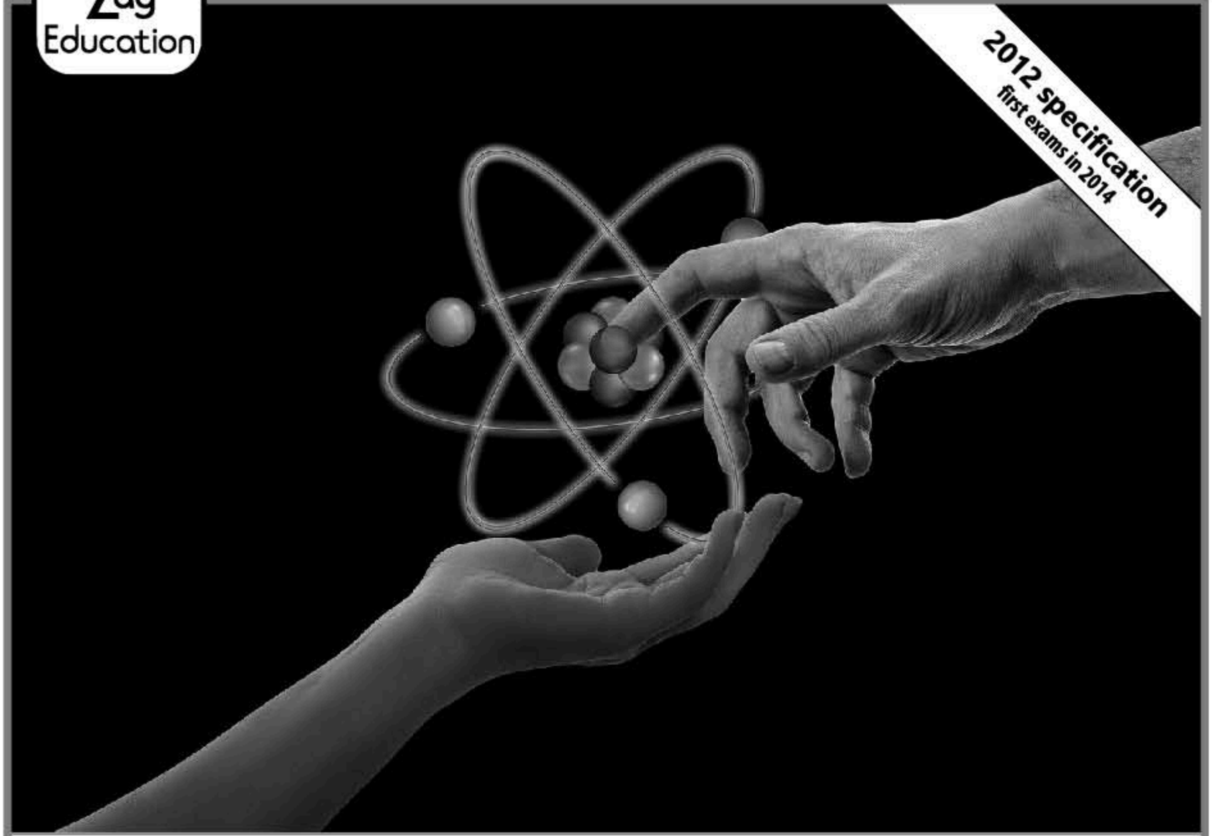

Revision Guide

for BTEC First Award / Extended Certificate
in Applied Science

Unit 1: Principles of Science

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POD
12708

Contents

Teacher's Introduction

Remember!
Always check the exam board website for new information, including changes to the specification and sample assessment material.

This pack is designed to give your students a focused and accessible review of the required knowledge for the Unit 1 external exam entitled Principles of Science, which is part of the BTEC Firsts Applied Science courses. The resource is applicable for students studying the Extended Certificate, First Award or First Diploma, for which Unit 1 is mandatory.

It is mainly designed as a revision aid, with each section easily photocopiable to give a set of comprehensive notes for revision. The notes and questions can also be used as a summary in the event of staff absence, or to fill gaps in students' notes. The sample assessment materials have been used as a guide for the pitch and depth of material, ensuring that students' revision best prepares them for the actual exam.

The resource is divided into six chapters, corresponding to the learning aims outlined in the specification:

- **Key concepts in Biology**
  Chapter A – exploring cells, organs and genes
  Chapter B – exploring the roles of the nervous and endocrine systems in homeostasis and communication
- **Key concepts in Chemistry**
  Chapter C – exploring atomic structure and the periodic table
  Chapter D – exploring substances and chemical reactions
- **Key concepts in Physics**
  Chapter E – exploring the importance of energy stores, energy transfers and energy transformations
  Chapter F – exploring the properties and applications of waves in the electromagnetic spectrum

Features included:

- Each chapter contains revision notes with 'Quick questions' every few pages, designed to test students' surface knowledge of a topic. These should be answered elsewhere, e.g. in a student's workbook.
- There are 'Exam-style questions' at the end of the chapter, which will require a deeper level of understanding. They are provided in reduced photocopying non-write-on format within the resource, but there are also full write-on versions available in the appendix which will prepare your students for the style and layout of the BTEC examinations.
- A write-on checklist is also given at the end of each chapter, so that students can self-assess/evaluate their understanding of the topics.

Answers to both the quick questions and the exam-style questions are given at the end of this pack.

February 2025

Chapter A: Cells, organs and g

In this chapter you will learn about cells and how they work in animals and
about the genetic information contained in cells, and how characteristics ar

A1: Cells, tissues and organ

Definitions

Cell	the smallest unit that is alive
Organelle	a part of a cell, e.g. a nucleus or a chloroplast
Tissue	a group of similar cells that work together to perform a
Organ	a body part which is made up of different tissues and pe e.g. the heart and the liver are organs
Photosynthesis	a chemical reaction that enables plants to make their ov
Respiration	a chemical reaction that releases energy from food for t

All living organisms are made up of cells. Organisms can range from a sing
bacterium, through to complex organisms like trees or mammals, which hav

Some cells are highly specialised in what they look like and what they do.

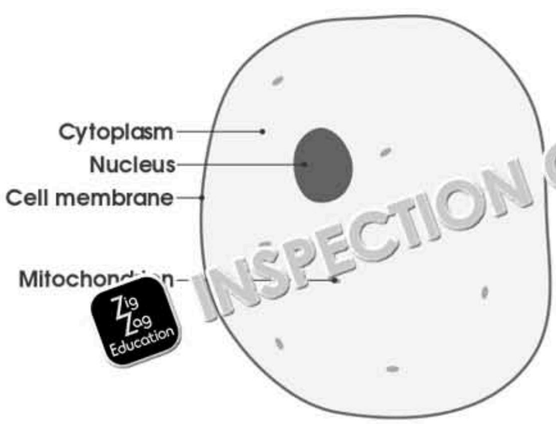
Parts of a cell are called **subcellular structures**, or **organelles**.

Animal and plant cells

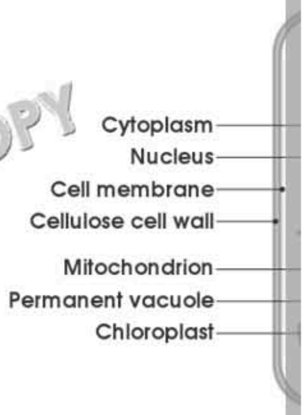
Most animal and plant cells have the following parts:

- A **nucleus**, which contains DNA and **controls the activities of the cell**
- **Cytoplasm**, a liquid gel where most of the chemical reactions take plac
- A **cell membrane** which controls the movement of substances into anc
- **Mitochondria**, which provide the **energy** for the cell through **respirati** glucose into carbon dioxide and water and releasing energy. Cells whic nerve and muscle cells, have more mitochondria.

ANIMAL CELL



PLANT



Plant cells also have:

- A **cell wall** surrounding the cell membrane. This is made of cellulose. It is rigid and helps to strengthen and support the cell.
- A **vacuole** – large permanent central space filled with cell sap, which is a weak solution of sugars and mineral salts. The cell sap helps to keep the cells rigid and support the plant.

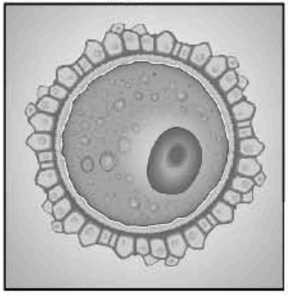
These two features are important for the support of the plant – plants have
without this support they'd just be all floppy and shapeless.

- Green plant cells also have **chloroplasts**. These contain the green pig
food for the plant by **photosynthesis**, absorbing the energy from light
dioxide and water into glucose and oxygen.

Specialised cells

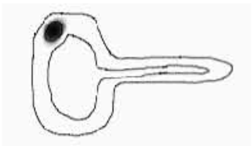
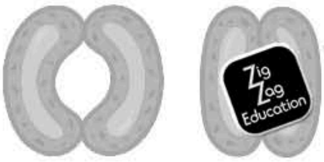
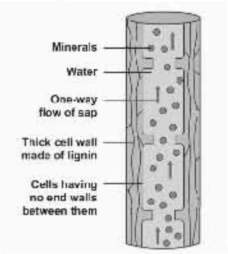
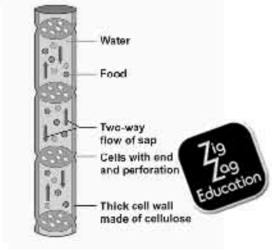
Many animal and plant cells do specific jobs, and they have special features
You need to be able to relate the **structure** of a cell (what it looks like) to it
Here are some examples you need to know about:

Animal cells

Cell	Function	
Nerve cell (neurone) 	Carries electrical signals around the body. Joins up with other nerve cells to pass on the signal. Sensory and motor neurones are covered in more detail in Chapter B.	Long insulate wire, to keep right directio Lots of point with other ce Many mitoch for the electr
Egg cell 	Joins with the sperm cell during reproduction. It needs to stay alive for several days without a blood supply and be penetrated by just one sperm.	It's a large ce containing n mitochondria cell division i Protective ou
Sperm cell 	Swims up through the female reproductive system to fertilise an egg. Penetrates the egg cell and joins with it.	Long tail for Lots of mitoc energy to m Long, thin st sperm to swi Pointed hea

Cell	Function	Adaptatio
Red blood cell 	Carries oxygen around the body. Needs to be able to get through very tiny blood vessels.	No nucleus, so there's more carry oxygen. Large surface area helps ox out of the cell quickly. Contains haemoglobin, whi Round flat shape means it w other blood cells.
White blood cell 	Kills diseases such as bacteria and viruses	The cell membrane and cyto flexible, and this allows the through the walls of blood infected tissues. Some white blood cells can called antibodies, which des

Plant cells

Cell	Function	Adap
Root hair cell 	Absorbs water and nutrients from the soil. Needs to be able to absorb as much as possible.	Root hairs give a for absorption. Large vacuole to
Guard cells 	Guard cells open and close tiny holes in leaves called **stomata**. When the stomata are open, carbon dioxide can enter the leaves for photosynthesis, and water can evaporate out of the leaf.	The cell wall is thi outside of the cel the cell is well hy cells swell up in a open the stomata
Xylem cells 	Xylem vessels transport water up the plant from the roots to the leaves. They also support the plant.	Xylem cells have no end walls, so t continuous tube flow through. The cell walls are with a tough wat called **lignin**.
Phloem cells 	Phloem tubes carry glucose and other food substances from the leaves to other parts of the plant.	The end walls of perforations so th substances can b The cells are cylin they stack togeth

Tissues, organs and systems

In complex living creatures:

- A group of similar cells working together form a **tissue**.
- A group of tissues working together form an **organ**.
- A group of organs working together form an **organ system**.
- A group of organ systems form a whole body or **organism**.

The cells of multicellular organisms **differentiate** and become adapted for
A tissue is a group of specialised cells that have a similar structure and func

Examples of tissues include:

- **muscle tissue**, which can contract to bring about movement
- **glandular tissue**, which can produce substances such as enzymes and
- **epithelial tissue**, which covers internal surfaces in the body

Organs are made up of lots of tissues. One organ may contain several diffe
e.g. the heart is mainly made up of muscle tissue but it also contains nerve

Organ systems are groups of organs that work together. The human body
systems, including:

- The cardiovascular system, which transports oxygen and nutrients arou
- The digestive system, which absorbs nutrients from the food we eat.

The heart is part of the **cardiovascular** system, together with the blood ves

Each system in the body has a specific function and together they make up

Quick questions 1

1. List **three** structures that are present in both animal and plant cells.
2. Give **three** ways in which a plant cell is **different** from a human cell.
3. What is the function of a sperm cell?
4. Put these terms in order, starting with the smallest:
   organ, organism, cell, organ system, tissue

A2: Plant organs and system

Most plants are multicellular organisms. They contain specialised cells, tiss

	Definitions
Stomata	tiny pores in the surface of a leaf that allow carbo leaf for photosynthesis
Transpiration	the evaporation of water vapour from leaves thro
Transpiration stream	the transport of water from the roots to the leave
Turgid	a plant cell is turgid when the vacuole is full and i
Flaccid	a plant cell is flaccid when it is dehydrated. The va becomes floppy.

Organs of plants

- **Roots:** anchor the plant firmly into the ground and absorb water and mineral ions from the soil. Root cells have *root hairs **to increase** the surface area* so that the plant can absorb substances more quickly.
- **Flower:** contains the reproductive organs.
- **Leaf:** carries out **photosynthesis** to make food for the plant. Photosynthesis uses light energy to convert carbon dioxide and water into a sugar called glucose.
- **Stem:** transports substances up and down and keeps the plant upright so that the leaves get sunlight.

Flowerin

The **stem** [illegible] **leaves** contain these two specialised transport tissues:

- **Xylem** vessels extend from the roots to the leaves. They transport water and mineral nutrients to the leaves and other parts of the plant. Xylem consists of dead cells with no end substance called lignin to form stiff tubes.
- **Phloem** tubes carry the sugars such as glucose from the leaves where and other parts of the plant. This sugar can then be stored, e.g. as star Phloem is formed of living cells which are lined with cytoplasm, with wa perforated end walls called sieve plates.

Example

Leaves are plant organs, and their [illegible] function is photosynthesis.
Explain **one** way in which leaves are adapted for this function. (2 marks)

*The key [illegible] here is '**explain**', and it's a 2-mark question, so for 1 m adaptation, and for the second mark you say how it helps with photo*

Leaves have a large surface area, which means they can absorb a lot o

Leaf cells contain many chloroplasts, which are specialised for photosy

Leaves have stomata, which allow carbon dioxide to enter the leaf for

Transport

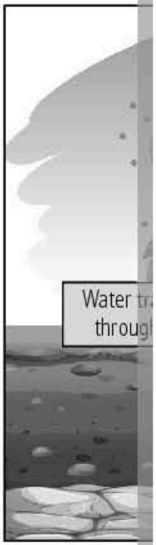
Plants make their own glucose through **photosynthesis** but only some par
For example, the roots cannot photosynthesise because they do not get an

Therefore, they need a transport system to get food from the leaves to othe
get water from the roots up to the leaves for photosynthesis.

This system is made up of many tubes and vessels that branch throughout
circulatory system.

★ The roots take up **water** and transport it to the leaves in **xylem** vessels
★ Minerals dissolved in the water are also transported in **xylem** vessels t
★ **Food** (the product of photosynthesis) travels from the leaves in **phloe**
plant to any part which needs it (for growth or for storage).

Transpiration



When the water reaches the leaves some of it is used up for photosynthesis, and the excess water evaporates and escapes through tiny holes in the leaves called **stomata**. This evaporation is called **transpiration**.

As water evaporates, more water is sucked up from the roots. The passage of water through the plant is called the **transpiration stream**.

Guard cells

Plants control the amount of water lost through transpiration by opening and closing their stomata (singular: stoma).

A stoma is just a hole controlled by two **guard cells** which change shape t
Water enters the cells and so they swell up and change shape to open the

In dry weather, if the plant is dehydrated, the guard cells lose water and go
hole to keep water inside the plant. See page 4 for a diagram of guard cell

★ Transpiration happens more rapidly in hot, dry, windy conditions, just l
line. Plants that live in dry places usually have a smaller number of sto
★ Most of the stomata are on the lower epidermis of the leaf. The lower
plant won't lose too much water.

Quick questions 2

1. Which **two** substances are transported in **xylem** vessels?
2. What is transpiration?
3. From which part of the leaf does transpiration occur?
4. Name **one** environmental condition which would increase the ***rate*** o

A3: DNA, genes and chromoso

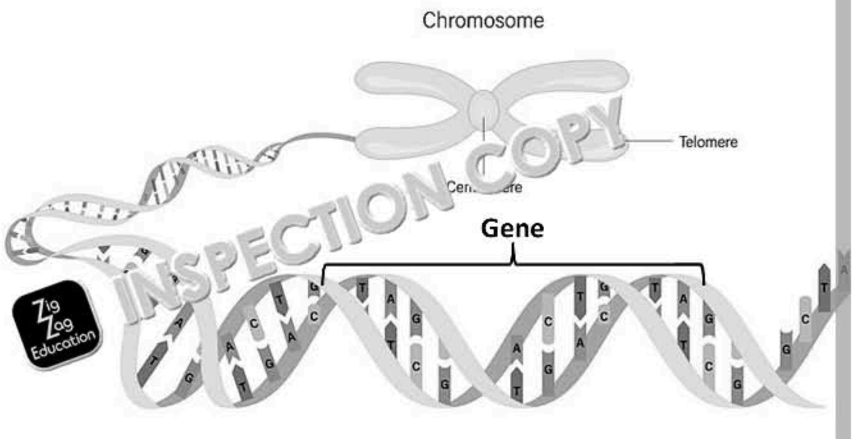
The genetic code is carried by a molecule called **deoxyribonucleic acid**, or

Definitions

Gamete	a sex cell. In humans, the male sex cells are called **sperm** a are called **eggs** or **ova**
Characteristic	a feature of an organism, such as eye colour or blood grou
Double helix	the name given to the shape of the DNA molecule
Bases	the four chemicals in DNA that contain the genetic code
Chromosome	a long strand of DNA, containing a large amount of geneti
Gene	a small section of DNA which codes for one characteristic
Allele	one of the different forms of a particular gene
Mutation	a change in the order of bases in a gene

The DNA strand looks a bit like a twisted ladder. Scientists call this shape a

Inside the nucleus of our cells, long molecules of DNA are coiled up into **ch** chromosome there are hundreds of **genes**. Genes are small sections of DN a particular characteristic.



DNA (deoxyribonucleic acid)

The DNA molecule and base pairs

The rungs of the DNA ladder are made up of pairs of **bases** connected to e the bases that carries the actual genetic code.

There are four different base molecules. Each is usually known by the Adenine (A), Cytosine (C), Guanine (G) Thymine (T

The way the bases join up in pairs is fixed: **A and T always join together, and C and G always join together.**

These are called **complementary base pairs**.

Exam

Just rem
straight-
and the

So, if the sequence of bases on one side of the DNA molecule is

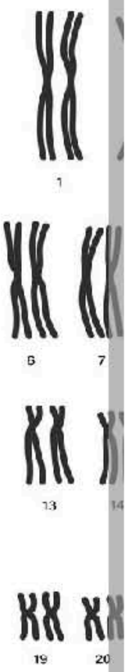
Then the sequence on the other side will be

C	**T**
G	**A**

The order of the bases controls the types of **proteins** that the cell makes. T their characteristics.

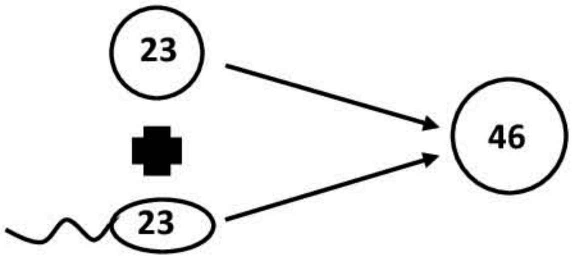
Chromosomes and genes

Humans have 46 chromosomes in our body cells, arranged in 23 pairs. When stained and photographed under a microscope, they look like this (see right):



We inherit one chromosome in each pair from our mother and one from our father.

Gametes (sperm and eggs) contain 23 single chromosomes. When the nucleus of the egg and the sperm fuse together in fertilisation, the new life has the full 46 chromosomes in its cells.



Notice that all the pairs are identical except for the 23rd pair. These are the
one is called an X chromosome, and the short one is called a Y chromosom
Females have XX, males have XY.

All normal eggs produced by a human ovary have an X chromosome.

In the case of sperm, however, half the sperm carry an X and half carry a Y.

A human baby's sex is determined when an X egg is fertilised by a sperm. T
fertilising sperm is an X sperm. The baby will be a boy if the fertilising sper

Since we inherit particular chromosomes from our parents through the eg
characteristics coded for by the **genes** on those chromosomes.

Mutations

Body cells divide to make other body cells and to make gametes. Sometim
there is a change in the order of the bases in a gene.

For example: the base sequence of a gene begins A C A G T C ....

If one of the bases got damaged, like this A C A G T C ....

The new base sequence would be A C A T C ....

This is called a **mutation**.

This gene will now produce a different protein, and this can result in a new

Mutations happen all the time; some happen spontaneously, and some are
factors such as radiation or toxic chemicals.

If a mutation happens in a gamete, the mutated gene will be passed on wh

Mutations increase the genetic **variation** between individuals of the same

Most mutations have no effect on survival or are harmful and die out, but
which produces a characteristic that helps the organism to survive.

Mutations that help the organism to survive will over time become more com
more organisms with the mutated gene will survive and reproduce. This is ca

For example: Most bluebell plants have blue flowers, but sometimes yo

If an insect was introduced to the habitat and that insect
then in a few years nearly all the bluebells would be white

Alleles

Because of mutations over many generations, many of our genes have mo
Different forms of the same gene are called **alleles**.

For example: The gene for flower colour in pea plants has two alleles:
A young plant grown from a seed will inherit one allele fr
plants, so it could inherit either:

Red and red or White and white or

The combination of alleles will determine whether the plant has red flower

Quick questions 3

1. Put these parts in order of size, starting with the smallest:
   nucleus gene cell chromosome
2. Copy and complete these sentences:
   The shape of the DNA molecule is called a ....
   The parts of the DNA molecule that carry the genetic code are called
3. The bases on one side of a section of DNA are **T C G A**. Write dow
   in the correct order.
4. In humans, how many chromosomes are there in the nucleus of:
   a) a muscle cell? b) a sperm cell? c) a fertilised egg?
5. Which pair of sex chromosomes is found in human males?

A4: Inheritance

For this section, it's important to understand these words and be able to us

Definitions

Genotype	the alleles that an individual has in their cells
Phenotype	the physical effect of an individual's alleles – their characte
Homozygous	a pair of alleles that are both the same
Heterozygous	a pair of alleles that are different from each other
Recessive	an allele that only shows in the phenotype if the individual
Dominant	an allele that shows up in the phenotype if it is present at one or two copies of the allele

Most of our characteristics are the result of several genes acting together, a by environmental factors such as nutrition. However, some characteristics a of **genes**, e.g. eye colour and the shape of the earlobe.

As stated in the previous section, these genes may have different forms, cal Alleles can be **dominant** or **recessive**:

- ★ The characteristic controlled by a **dominant** allele develops if the allele chromosomes in a pair.
- ★ The characteristic controlled by a **recessive** allele develops only if the a chromosomes in a pair.

The **genotype** of an individual tells you which alleles they have.

- ★ If both alleles are the same, we say the individual is **homozygous** for th
- ★ If the two alleles are different, we say the individual is **heterozygous** fo

Scientists use letters to show which alleles an individual has. The dominant letter, while the recessive allele is shown as a lower-case of the same letter.

For example, in humans the allele for brown eyes, **B**, is dominant, while the all

A person who inherits one or two alleles for brown eyes will have brown ey A person will only have blue eyes if they inherit two copies of the allele for

- ★ A person with brown eyes could have the genotype **BB** or **Bb**.
- ★ A person with blue eyes can only have the genotype **bb**.

Therefore, two brown-eyed parents could have a blue-eyed child, if they are both heterozygous with genotype **Bb**. If the child inherited a **b** allele from both parents, it would have the genotype **bb**.

However, it is impossible for two blue-eyed parents to have a brown-eyed child, because neither of them has the **B** allele to pass on.

There are various ways of showing the alleles involved and we can use them offspring of two individuals. You need to know about:

- ★ Genetic diagrams
- ★ Punnett squares
- ★ Pedigree diagrams, sometimes called family trees

Genetic diagrams

In a genetic diagram, all of the possible alleles for a particular characteristic offspring are shown.

- ★ Each parent can contribute two alleles, making four altogether.
- ★ You can draw lines to show all the possible combinations of these allele fertilisation, to give the alleles of all the possible offspring.
- ★ There will be four possible outcomes, but some or all of them could be

Example

In mice, the allele for grey fur, **G**, is dominant. The allele for white fur, **g**, is recess

Mickey is a homozygous grey mouse; Minnie is a white mouse. Their owner put t

Draw a genetic diagram and use it to explain why all of their offspring had grey f

First write down the parents' alleles. Mickey is a homozygous grey mo
Minnie is white, so she must have the alleles gg.

Now draw the diagram like this:

This row shows the alleles in the parents' gametes. All of Mickey's sperm will have the G allele, and all Minnie's eggs will have g.

The arrows show the possible fertilisations.

This row shows the alleles of possible offspring. They will all inherit Gg. You can write the phenotypes underneath, G is dominant, so Gg mice will have grey fur.

Finish with your explanation in words:
The offspring all have grey fur because they have all inherited the dom
their father.

Punnett squares

Punnett squares are a form of genetic diagram which works like a two-way

This is how it works for brown and blue eyes in humans:

The allele for brown eyes, **B**, is dominant. The allele for blue eyes, **b**, is rece
This means that:

- ★ A person with genotype **BB** will have **brown eyes**.
- ★ A person with genotype **Bb** will have **brown eyes**.
- ★ A person with genotype **bb** will have **blue eyes**.

This Punnett square shows what happens when one parent is homozygous
parent has blue eyes:

Diagram 1

father

	b	b
B	Bb	Bb
B	Bb	Bb

mother

The parents' possible gametes

Then you work out the fertilisa
down, just like using a times ta

For heterozygous individuals it
letter first.

All the children have brown eyes, and they all have the **heterozygous** geno

The next Punnett square shows what would happen if one of these offsprin
heterozygous person:

Diagram 2

father

	B	b
B	BB	Bb
b	Bb	bb

mother

About **¼** of the possible childr

That means the **probability** o
with blue eyes is **¼ or 25 %**.

The other **three quarters (75**
offspring have brown eyes but
or heterozygous.

The **ratio** of brown-eyed to blu

These are theoretical probabilit
vary in real families, but what it
for two brown-eyed parents to

The third Punnett square shows what would happen if one of the heterozyg
has children with a blue-eyed person:

Diagram 3

father

	B	b
b	Bb	bb
b	Bb	bb

mother

About **half** of the possible chi
half have brown eyes.

That means the **probability** o
with blue eyes is **½ or 50 %**.

The other **50 %** of the possibl
and are heterozygous.

The **ratio** of brown-eyed to bl

Exam tip

Practise drawing and completing Punnett squares – you often need to do th

Genetic disorders

Some medical conditions are caused by an allele, and that means they can I
are caused by a **recessive** allele.

An example that sometimes comes up in exams is **cystic fibrosis**.

Cystic fibrosis is an inherited disorder that affects the **cell membranes**; it ca
sticky mucus that blocks up the lungs. It is caused by a **recessive** allele. Th
inherited from **both** parents. Two healthy parents can have a child with the
heterozygous. The parents are carriers because they have the allele and ca

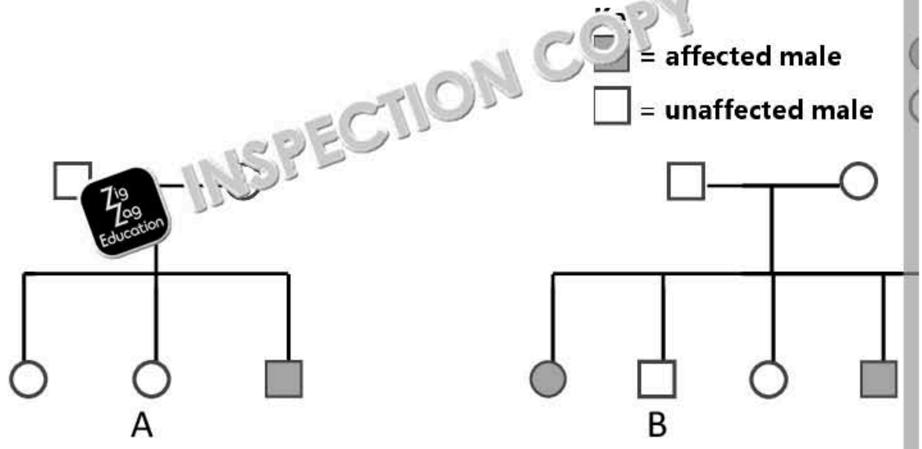
Pedigree diagrams (family trees)

Family trees are another way of showing the inheritance of alleles. They ca
many generations.

They use symbols to show the phenotypes. The symbols are explained in a
carefully. You don't always get given the genotypes, but you always have e
them out from the phenotypes.

Example

This pedigree diagram shows the inheritance of cystic fibrosis in two families. Cy
recessive allele, **f**. The healthy allele, **F**, is dominant.



a) What are the genotypes of the four parents?
b) Person A and person B want to get married and have children. They decide
see if they carry the allele for cystic fibrosis. Use a Punnett square to explain

a) *You can see from the diagram that both sets of parents are healt*
with cystic fibrosis. Therefore, they must all be carrying the recess
dominant allele. *All four parents are heterozygous with genot*

b) *A and B could have alleles FF or Ff. Draw your Punnett square fo*
parents, and then use the information in the Punnett square to a

		Parent 1	
		F	f
Parent 2	F	FF	Ff
	f	Ff	ff

A and B could be FF or Ff. If
they have a 25 % chance of
cystic fibrosis. If one of them
have a child with the disease.

Quick questions 4

1. What is meant by a recessive allele? Choose **one**.
   - A weak allele
   - An allele that only shows in the phenotype in homozygous indiv
   - An allele that determines the phenotype if it is present at all
   - An allele that comes from the mother

2. The gene for height in pea plants has two alleles, tall and dwarf. The
   a) Which symbol represents the dwarf allele?
   b) What is the genotype of a dwarf plant?
   c) A plant has genotype **Tt**. What is its phenotype?

3. In humans, the allele for black hair, **B**, is dominant, and the allele for

   Jerome has black hair like his dad. His mum has red hair.

   a) What is Jerome's genotype for hair colour?
   b) Explain your answer to part a).
   c) Jerome's wife, Serena, has red hair. They are expecting their firs

   Copy and complete the Punnett square below using the alleles

Jerome

Serena

   d) What is the probability that the child will have black hair?

Checklist – Cells, organs and ge

I can identify a nucleus, cell membrane, cytoplasm, mitochondrion, cell wall, chl
on a diagram and describe their functions.

I can identify neurones, red blood cells, white blood cells, sperm and egg cells a
are adapted for their functions in the human body.

I can identify root hair cells, guard cells, xylem cells and phloem cells, and explai
adapted for their function in a plant.

I understand the relationship between cells, tissues, organs and organ systems.

I can use the cardiovascular system to explain this relationship.

I can explain the function of roots, leaves, xylem vessels and phloem tubes in pla

I can describe the transpiration stream.

I can define transpiration and explain how it causes water to be sucked up from

I can describe the shape of the DNA molecule and identify the base pairs.

I can complete base pairs with the correct bases.

I understand the relationship between DNA, genes and chromosomes in the nuc

I can explain how genes code for individual characteristics.

I can define mutation and explain how mutations can produce new characteris

I can describe alleles as different forms of the same gene and explain the differe
homozygous and heterozygous genotypes.

I can describe how dominant and recessive alleles affect the phenotype in homo
heterozygous individuals.

I can draw and interpret a genetic diagram.

I can construct, complete and interpret a Punnett square.

I can obtain information from pedigree diagrams.

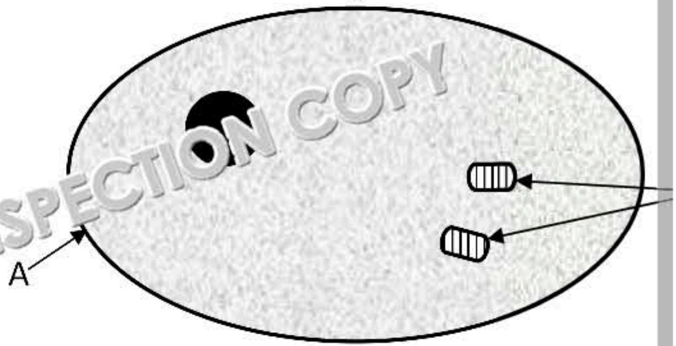
I can use genetic diagrams, Punnett squares and pedigree diagrams to determin
phenotypes of possible offspring.

I can calculate the probability, percentage or ratio of offspring displaying particu
characteristics from genetic crosses.

Exam-style questions

1. Figure 1 shows a generalised animal cell.

Figure 1



a) Copy Figure 1 and label the **nucleus** on the diagram.

b) Name part A and describe its function.

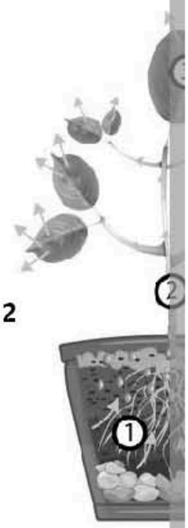
c) Complete the sentence by writing **one** word in each space:

The organelles labelled B are ...., and they release .... for t
chemical reaction called ....

2. Figure 2 shows how water travels through a plant.
Describe what takes place in steps 1, 2 and 3 of this process.

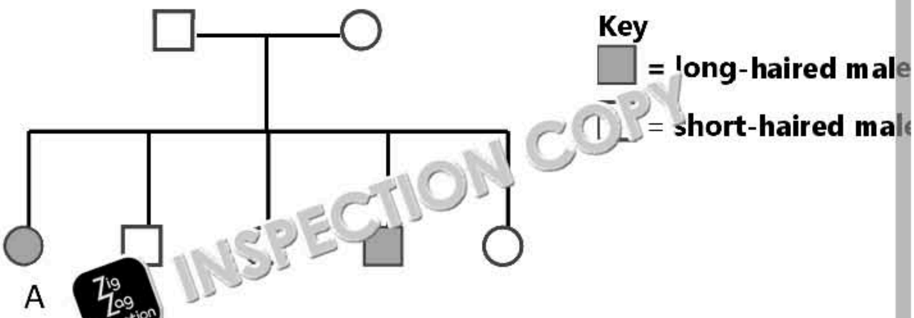
Total: 4 marks

Figure 2



3. Cats can be long-haired or short-haired.
The allele for short hair, **H**, is dominant. The allele for long hair, **h**, is recessiv
Figure 3 shows a pedigree diagram for two cats and their kittens.

Figure 3



a) What is the genotype of kitten A? **[1]**

b) Write down the phenotype of kitten B. **[1]**

c) Explain how coat length is inherited by kittens A and B. Use a Punnett squ

Chapter B: Homeostasis and comm

In this chapter you will learn about the body systems involved in homeosta responds to changes.

Our body systems need the right internal conditions for our cells to work p inside or outside the body can affect these conditions.

Homeostasis is the word that scientists use for the control systems which m for enzyme action and other functions.

Some conditions inside the human body need to be kept the same all the ti

These are:

- Body temperature
- Amount of glucose (sugar) in the blood
- Amount of water in the blood and body tissues
- Levels of salt and other mineral ions in the body

The two body systems that are involved in homeostasis are the **nervous sy** **hormonal system**.

B1: The nervous system

	Definitions
Neurone	a nerve cell
Impulse	an electrical signal that travels along a ne
Central nervous system (CNS)	the processing centre for nerve impulses. the **spinal cord**.
Receptor	a cell that detects changes in the internal
Effector	a muscle or a gland that makes a respons
Sensory neurone	a nerve cell that carries a signal from a re
Motor neurone	a nerve cell that carries a signal out of the
Relay neurone	connects sensory neurones to motor neur
Synapse	a tiny gap between two nerve cells
Neurotransmitter	a chemical that diffuses across a synapse

The nervous system allows humans to react to their surroundings.

It consists of:

- A **central nervous system (CNS)** which ***coordinates*** the information. of the **brain** and the **spinal cord**.
- A **peripheral nervous system (PNS)**. The PNS is made up of nerves – carry electrical signals in and out of the central nervous system.

Receptors and effectors

Receptors are groups of specialised cells which can detect energy changes **stimuli**, and turn them into electrical impulses. Receptors are often locate

The human body has a variety of **receptors**, each of which can detect a diff

- ★ Receptors in the **eyes** which detect light.
- ★ Receptors in the **ears** which detect sound (vibrations).
- ★ Receptors in the **ears** which detect changes in position and help us to k our balance.
- ★ Receptors in the **tongue** and inside the **nose** which detect chemicals a allow us to taste and to smell.
- ★ Receptors in the **skin** that detect touch, pressure and pain, and tempe

When a receptor detects a stimulus, it generates an electrical signal called a from receptors pass along nerve cells called **neurones** to the **CNS**.

The **CNS** processes the information coming in and sends signals back to th body's response to the stimulus.

An **effector** is any organ which has an effect – for example:

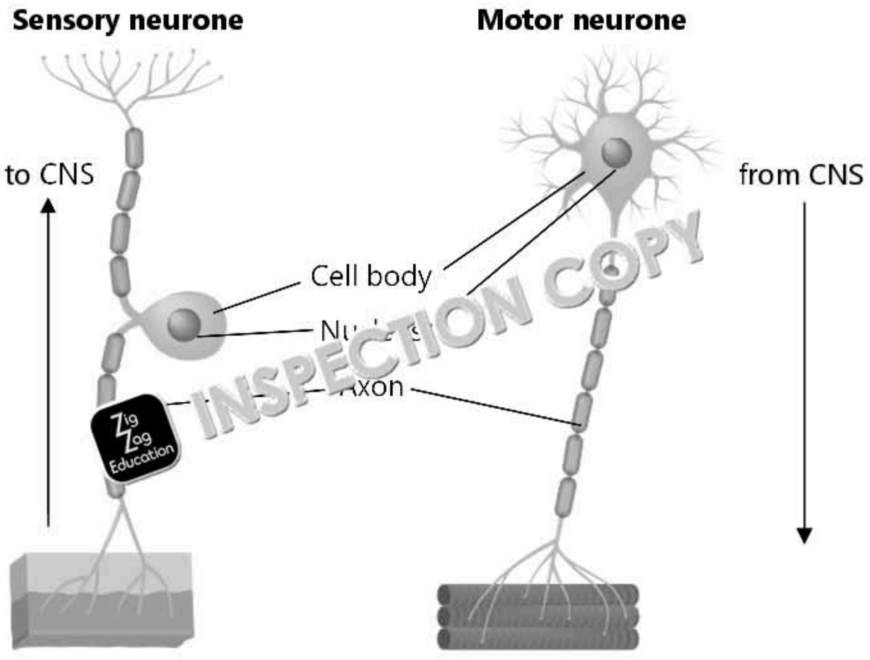
- ★ a **muscle** contracting to move your arm
- ★ a **gland** releasing sweat, tears or saliva

Neurones

All the electrical signals in the nervous system are transmitted by specialise **neurones**. There are three different types of neurones with slightly differe

1. **Sensory neurones** carry signals from receptors to the spinal cord and
2. **Relay neurones** carry signals from one part of the **CNS** to another.
3. **Motor neurones** carry signals from the CNS to muscles and other effe

The diagram below shows a sensory neurone and a motor neurone. The a nerve impulse.



Voluntary and involuntary actions

The central nervous system coordinates all your thoughts and actions. You
between **voluntary** and **involuntary** actions.

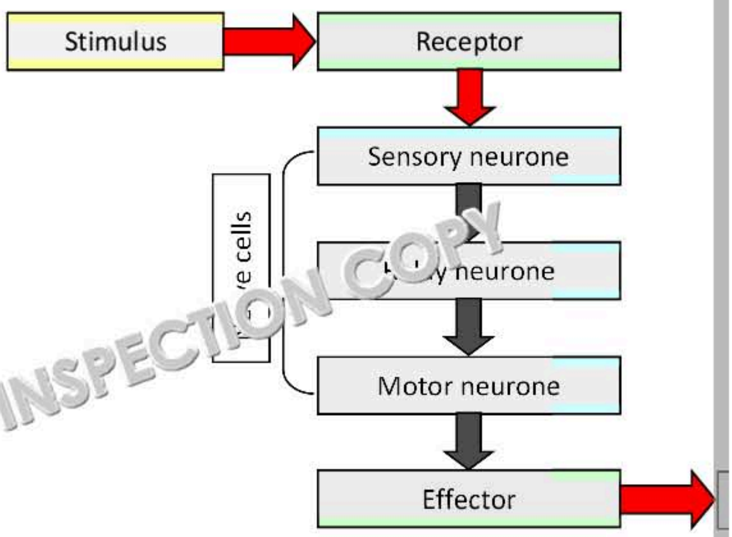
- **Voluntary actions** are movements you ***choose*** to do, e.g. walking and thinking part of your brain.
- **Involuntary actions** are movements that happen ***without thinking***, e. of food through your intestines.

Reflex response

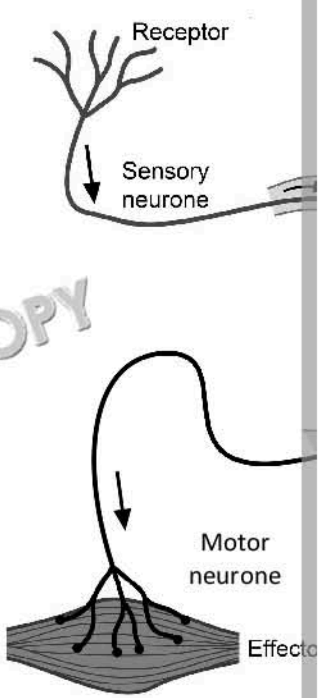
Reflexes are very fast **involuntary** responses that protect your body from h
something very hot, you will automatically pull your hand away.

Reflex actions do not involve the thinking part of the brain, because thinki
just three nerve cells and are usually coordinated by the **spinal cord**.

- A reflex arc works like this:



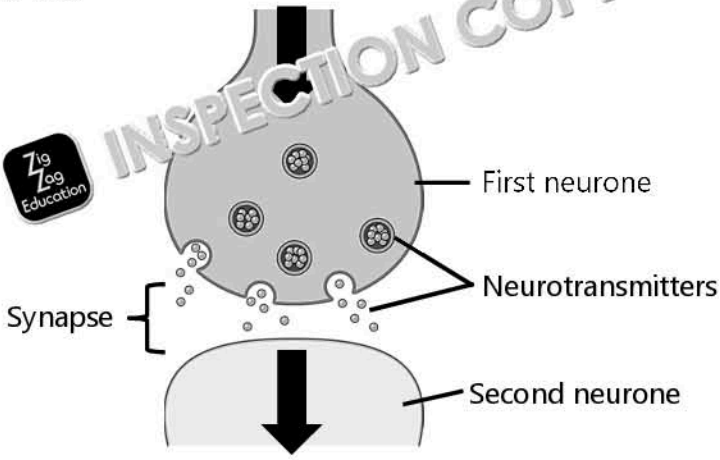
- Simple reflex actions involve an electrical impulse passing from the receptor, along a **sensory neurone** to the spinal cord, then along a **motor neurone** to a muscle or a gland. The muscle or gland brings about the response.
- The spinal cord contains **relay neurones** which link the sensory neurones with the motor neurones.
- The muscle or gland producing the response is called the **effector**. A muscle responds by contracting, a gland by releasing (secreting) chemical substances.



Synapses

Where two neurones meet there is a tiny gap called a **synapse**. The nerve i gap to continue on its journey to or from the CNS. Electrical impulses can't done by chemical substances which diffuse across the gap.

It works like this:



- ★ The electrical signal travels along an axon and stimulates the nerve enc chemicals called **neurotransmitters**.
- ★ The chemical molecules diffuse across the synapse and stimulate neurc electrical signal.
- ★ Synapses make sure that the signal always travels in the right direction.

Quick questions 1

1. What travels along neurones?
2. What is the name given to the muscles or glands that make respons
3. Which of these is a **voluntary** action? Choose ***one***.
    - Sneezing
    - Eating
    - Breathing
    - Yawning
4. Which of these is a **reflex** action? Choose ***one***.
    - Laughing
    - Catching a ball
    - Shading your eyes with your hand in bright sunlight
    - Blinking when some dust blows into your eye
5. a) Put the following words into the order that electrical impulses fl

    effector **motor neurone** **receptor** **sensory neurone**

    b) Which one of the neurones in part a) is the smallest?

B2: Thermoregulation

Human **enzymes** work best at about 37 °C (normal body temperature). Th chemical reactions work best at 37 °C, so we need to keep our core body te everything to work properly.

If the core temperature gets much lower or much higher than 37 °C the per

	Definitions
Core temperature	the temperature of the blood and internal orga
Enzymes	chemical substances that control the chemical
Vasodilation	blood vessels get wider and let more blood thr
Vasoconstriction	blood vessels get narrower and let less blood f
Thermoregulatory centre	the part of the brain that contains receptors wh temperature of the blood
Respiration	the chemical reaction that releases energy from

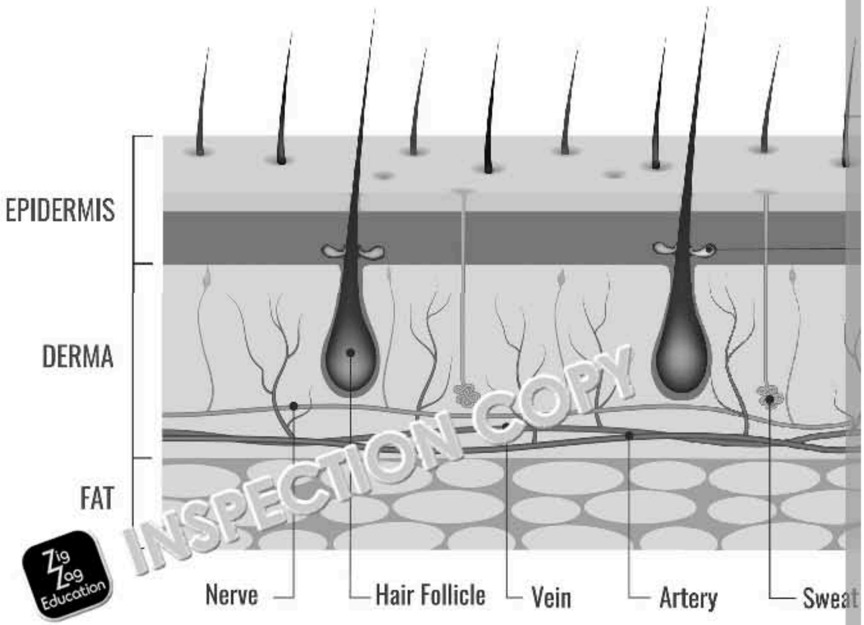
Thermoregulation is the process of keeping the body at a constant tempe

- ★ We release heat in our body cells through **respiration**.
- ★ We lose heat to the environment through our **skin**, a bit like a radiator
- ★ The blood carries heat around the body.

Body temperature is monitored and controlled by the **thermoregulatory c**

- ★ The thermoregulatory centre contains receptors that detect changes to the blood.
- ★ The skin contains receptors that detect skin temperature and send ner thermoregulatory centre.

If you are too hot or too cold the hypothalamus sends **nerve impulses** to t

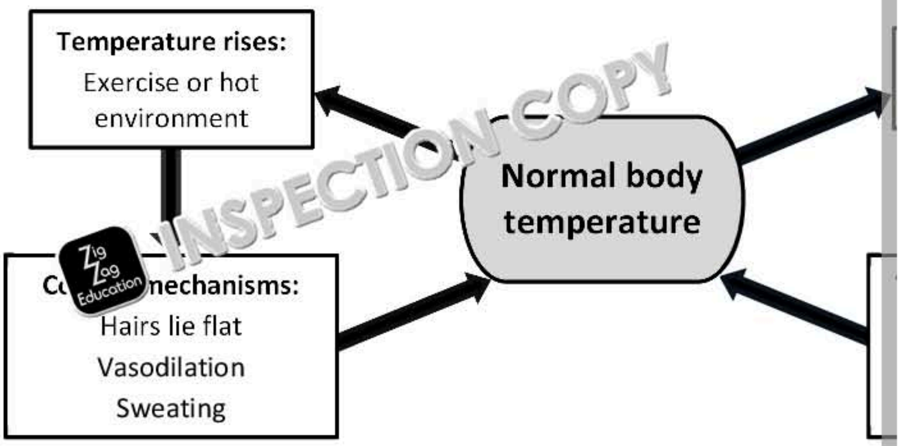


The skin has three ways to either increase or decrease heat loss from the b body temperature to normal levels.

	When you're too hot	Whe
1. Hairs	Hairs on the skin lie flat, so that heat can escape more easily.	Hairs stand up insulates the bo heat in. Tiny m pull the hairs u
2. Sweat glands	Sweat glands secrete sweat onto the skin surface. The **evaporation** of sweat takes heat from the skin.	No sweat releas
3. Blood vessels	The arteries that take blood to the skin get wider (**vasodilation**). More blood flows close to the surface of the skin, where it can lose heat to the air.	The arteries tha narrower (**vaso** flows to the su heat is kept insi

As well as the skin, your **muscles** also receive nerve impulses from the brai respond by **shivering**, which warms you up because the movement of the

These control mechanisms stop automatically when the core body tempera



Quick questions 2

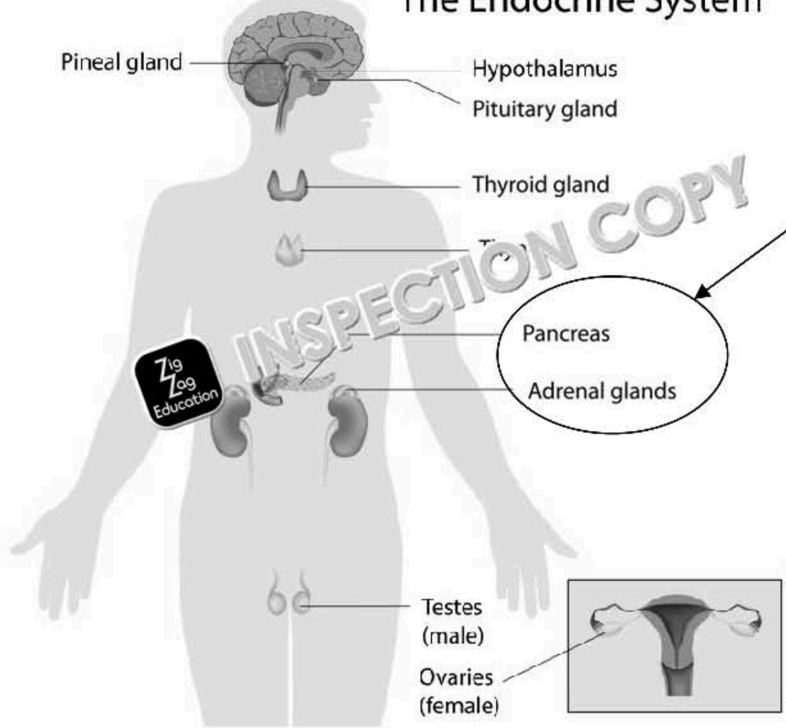
1. Copy and complete the sentence:
   Body temperature is monitored and controlled by the .... centre,
2. Why does human body temperature need to remain constant at abo
3. How does sweating help the body to lose heat?
4. Explain **three** ways the body responds to keep our internal organs w

B3: The endocrine system

The nervous system transmits electrical impulses throughout the body. The
chemical signals through **hormones**.

	Definitions
Hormone	a chemical messenger that affects the action of its targe
Gland	an organ that releases a substance. Endocrine glands re the blood
Pancreas	organ that controls the level of sugar in the blood
Glucose	a simple sugar that cells use for respiration, to release e
Carbohydrates	sugary or starchy foods. They break down to glucose in
Glycogen	a starch that the liver and muscle cells make to store ex
Insulin	the hormone that reduces blood sugar
Glucagon	the hormone that raises blood sugar
Adrenaline	the 'fight or flight' hormone. It's produced by the adre body for action by increasing the heart rate.

The Endocrine System



Exam tip
You need to
these two gl
hormones th

Hormones

- are released (**secreted**) by an endocrine gland into the bloodstream
- are transported in the blood around the body until they reach the orga
- are picked up by **receptors** in the cells of the target organs
- have an effect on the **target organ**

Other organs are not affected because their cells do not have the right rece

Hormones play an important part in **homeostasis**, to maintain constant inte

You already know that body temperature is controlled by nerve signals. Ho
and blood **water** levels. If these are not kept within narrow limits, body cell

Comparing the endocrine and nervous syste

Compared to the nervous system the effects of hormones are slower, but th

	Nervous system	
Method of transmission	Electrical impulses are carried along the axons of neurones.	Hormo transp glands
Speed of transmission	Instant: nerve impulses travel very fast.	Can ta target
Duration of the response	The response stops as soon as the signal stops.	The res

Controlling blood glucose levels

Glucose is a simple sugar that our cells need for respiration, to release ener and we use it up in our daily activities. We use more glucose when we exer respire faster.

When you have eaten **carbohydrates** your digestive system releases large food. This glucose is absorbed into the blood.

Too much glucose in the blood causes problems such as high blood pressu and dehydration.

Therefore, the glucose must be absorbed into the body's cells as soon as p blood sugar levels quickly returning to normal.

- ★ Blood glucose levels are monitored and controlled by the **pancreas**.
- ★ It detects when blood glucose is too high or too low and produces **ho** to normal.
- ★ The pancreas produces two hormones: **insulin** and **glucagon**.

When the blood sugar level rises, the **pancreas** releases insulin into the blood.

Insulin causes glucose to move from the blood into the cells. In **liver and muscle cells** excess glucose is converted to a starch called **glycogen** for storage. This brings the blood sugar level down.

Exa
Make
functi
Reme
gluco
gluca

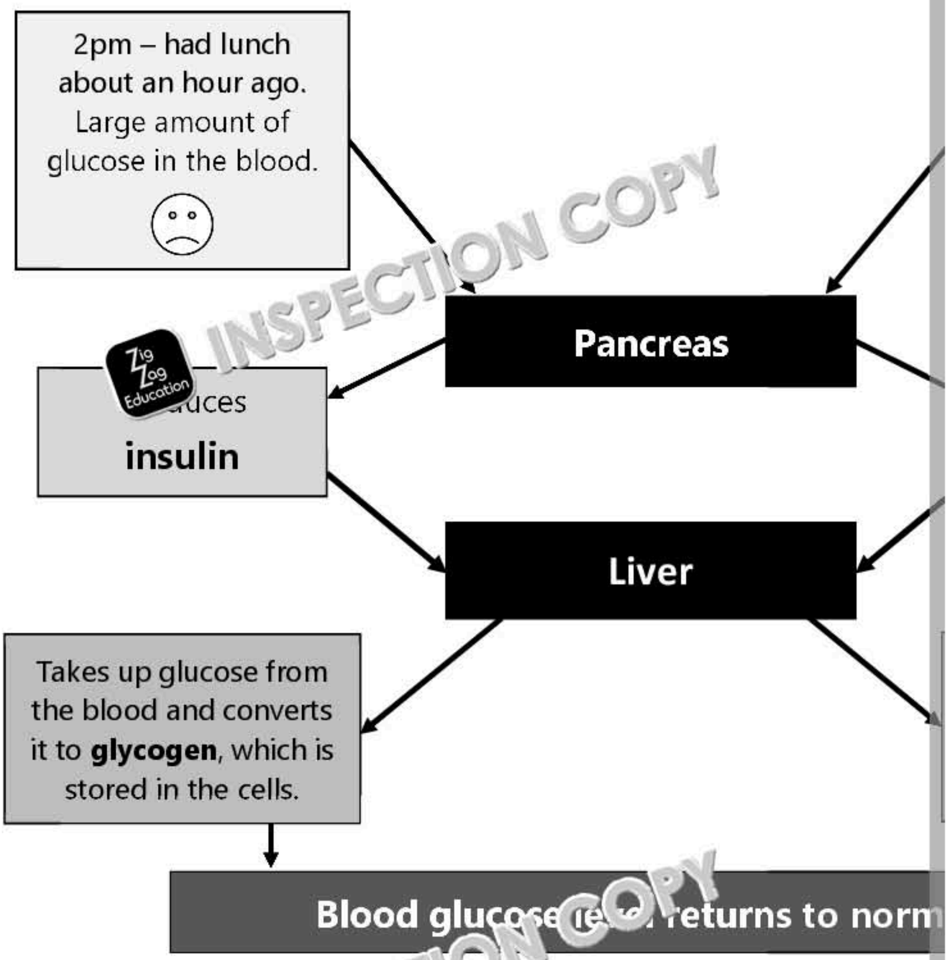
At other times, for example during the night, when you haven't eaten for se may be lower than you need – remember your body cells still respire even w

When blood sugar levels are too low, the pancreas stops producing insulin by the **liver** and blood sugar levels rise again.

The pancreas also produces another hormone called **glucagon**, which mak glycogen back into glucose when we need it.

People with **diabetes** are not able to control their blood sugar levels in this

How your blood glucose level is regulate



Quick ions 3

1. What is a hormone?
2. Give **two** ways in which hormones are different from nerve impulses
3. Copy and complete the table:

Name of hormone	Gland that makes it	What
		Lowers blood sugar – co
		Raises blood sugar – con
	Adrenal glands	Prepares the body for act

4. Samera is eating her lunch. Explain what will happen to her blood s few hours.

Checklist – Homeostasis and comm

I can explain what homeostasis is.

I know which organs make up the central nervous system, and the function of th

I can identify a sensory neurone and a motor neurone and describe what each o

I can explain how nerve impulses are transferred between receptors, effectors a

I can explain what happens at a synapse.

I can give examples of voluntary and involuntary responses.

I can explain what a reflex is and why we have reflex actions.

I can describe the steps in a reflex arc, from stimulus to response.

I can explain why body temperature needs to be controlled.

I can describe three responses that occur when the body temperature is too low happen when the body temperature is too high.

I can explain what hormones are and what they do.

I can compare the action of the nervous system and the endocrine system in ter transmission, speed, and duration.

I can describe the function of insulin and glucagon.

I can explain how insulin and glucagon regulate blood sugar levels.

I can describe the role of the liver and pancreas in controlling blood glucose.

Exam-style questions

1. a) What is a **reflex** action?

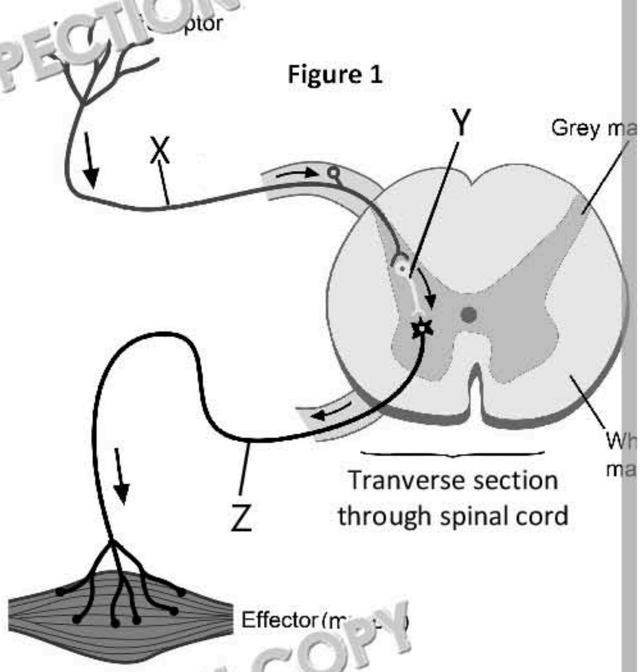
Yasmin is in the kitchen. *She accidentally touches a hot pan.* She immediatel

b) What is the **stimulus**?

c) Which body part makes the **response**?

Figure 1 shows what is happening in Yasmin's nervous system.

Figure 1



d) Name the structures labelled X, Y and Z.

e) Between X and Y there is a small gap called a synapse. Explain how the ner

2. Ali is playing in a football match.

As he runs for the ball, his body temperature increases.

a) Why does Ali's body temperature increase?

b) Explain how Ali's body responds to prevent his temperature from gettin

c) During the match, Ali's blood sugar level starts to fall. A hormone is rele bring it back to normal.

  (i) What is the name of the hormone?
  (ii) Which gland releases this hormone?
  (iii) How does it raise Ali's blood sugar?

Chapter C: Atoms, elements and the p

Every living thing is made from cells. Living and non-living things are all ma chapter you will learn about the structure of atoms, and how to use the per information about them.

C1: What is an atom?

	Definitions
Atom	the smallest unit of a chemical substance that can exist
Nucleus	the central core of an atom
Proton	a positively charged subatomic particle in the nucleus o
Neutron	a subatomic particle in the nucleus of an atom with no e
Electron	a very tiny negatively charged subatomic particle that is
Atomic number	the number of protons in a specific atom
Mass number	the number of protons *plus* the number of neutrons in a

Atoms are the basic building blocks of all matter. An atom is the smallest p own, and atoms can't be broken down any further by ordinary chemical rea

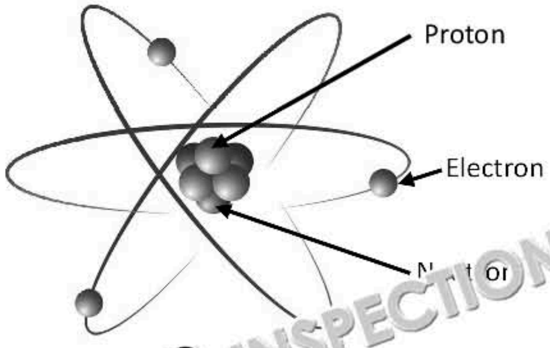
They can combine together in millions of different ways to make up every chen

An **element** is a pure substance that is made up of only **one** type of atom, e elements. Pure gold contains only gold atoms and pure oxygen contains o

The structure of an atom

Most of an atom is empty space. The rest of it consists of **subatomic parti** subatomic particle:

- ★ **Proton**
- ★ **Neutron**
- ★ **Electron**



The diagram shows a lithi

It has 3 protons, 3 neutro

- ★ The protons and neu which is the central p
- ★ The electrons orbit ar

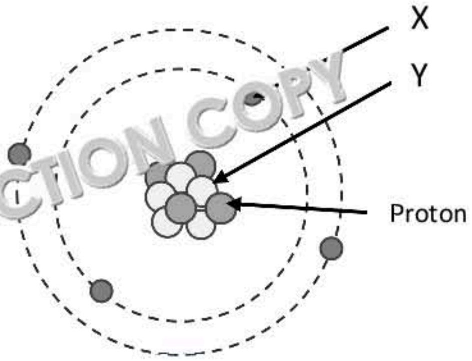
Only lithium atoms have Other elements have diffe in their atoms.

In any atom (note: not ions):

- ★ The number of electrons is **always** equal to the number of protons.
- ★ The number of neutrons can be the same or it can be different, e.g. so and 12 neutrons in their nucleus.

Example

The diagram below shows an atom of beryllium (Be).



Name particles X and Y.

Particle X is orbiting the nucleus of the atom, so therefore it must be

Particle Y is part of the nucleus. The proton is already labelled, so it w

Relative mass and charge of subatomic parti

Most of an atom is empty space; the nucleus and electrons make up just a s

Protons, neutrons and electrons are all very tiny, so we talk about their mas

- ★ Protons and neutrons are the same size; they both have a relative mass
- ★ Electrons are much smaller. They have a relative mass of approximately

Protons and electrons carry an electrical charge.

- ★ Each proton has a **positive** charge of **+1**.
- ★ Neutrons are **neutral**; their electrical charge is **0**.
- ★ Each electron has a **negative** charge of **-1**.

There are always the same number of protons and electrons in an atom, an of an atom is zero because the positive and negative charges cancel each o

Atomic number and mass number

Every element has its own unique **atomic number**. The atomic number of a **protons** it has in its nucleus.

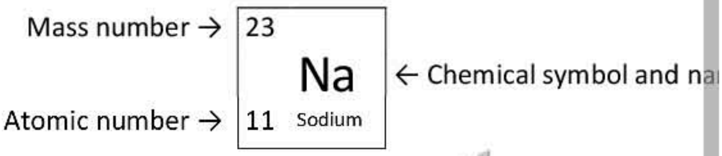
It is also the number of electrons.

The number of particles in the nucleus of an atom is called the **mass numb** **protons and neutrons** in the atom

In the example above, you can see that the beryllium atom in the diagram h because it contains four protons.

The nucleus also contains 5 neutrons, so the mass number is 4 + 5 = **9**

In the periodic table and in exam questions you will often see elements rep



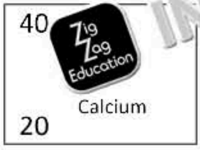
The **atomic number** is always the smaller of the two numbers.

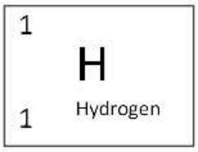
This sodium atom has an atomic number of 11, so it has 11 protons and 11

You can work out the number of neutrons: **mass number – atomic numbe**

Quick questions 1

1. Name the particles that make up the **nucleus** of an atom.
2. Which ***two*** of these statements about electrons are correct?
   - They have the same mass as neutrons
   - They have a much smaller mass than protons
   - They are negatively charged particles
   - They are positively charged particles
3. A carbon atom has 6 electrons. How many protons does it contain?
   - 12
   - 3
   - 6
   - Not enough information to tell
4. Three elements are shown below:





Copy and complete this table:

Element	Number of protons	Number of neutrons
Calcium		
Hydrogen		
Iron		

C2: The periodic table of elem

	Definitions
Symbol	one or two letters that represent a chemical el
Periodic table	a table showing all of the elements that exist
Period	a horizontal row in the periodic table
Group	a vertical column in the periodic table
Properties	the physical features of a substance, and how it
Electron shell	a layer of electrons orbiting the nucleus of an a
Electronic configuration	a representation of the number of electron she number of electrons in each shell. This can be as a series of numbers separated by full stops,

More about elements

You already know that an element is a pure substance, made up of just one has a unique **atomic number** and is represented by a chemical **symbol**. Th

- a single capital letter, e.g. the symbol for carbon is **C**, and the symbol fo
- a capital letter followed by a lower-case letter, e.g. the symbol for chlor sodium is **Na**

Each element has its own **properties**, both physical and chemical.

- **Physical properties** of a substance include appearance, melting point,
- **Chemical properties** of a substance are related to how the substance r reactions, e.g. how it reacts when mixed with an acid.

The periodic table

The periodic table is used by scientists all over the world. It organises elem and their chemical properties.

There are 94 elements that occur naturally, and a further 24 are made by nu

You will see many versions of the periodic table. All versions show the cher and many versions contain additional information.

The table given below shows the symbol, name and atomic number of eac

						H Hydrogen 1						
Li Lithium 3	Be Beryllium 4											B Boron 5
Na Sodium 11	Mg Magnesium 12											Al Aluminium 13
K Potassium 19	Ca Calcium 20	Sc Scandium [illegible]	Ti [illegible] 22	[illegible] Vanadium 23	Cr Chromium 24	Mn Manganese 25	Fe Iron 26	Co Cobalt 27	Ni Nickel 28	Cu Copper 29	Zn Zinc 30	Ga Gallium 31
Rb Rubidium 37	Sr Strontium 38	Y Yttrium 39	Zr Zirconium 40	Nb Niobium 41	Mo Molybdenum 42	Tc Technetium 43	Ru Ruthenium 44	Rh Rhodium 45	Pd Palladium 46	Ag Silver 47	Cd Cadmium 48	In Indium 49
Cs Caesium 55	Ba Barium 56	La Lanthanum 57	Hf Hafnium 72	Ta Tantalum 73	W Tungsten 74	Re Rhenium 75	Os Osmium 76	Ir Iridium 77	Pt Platinum 78	Au Gold 79	Hg Mercury 80	Tl Thallium 81
Fr Francium 87	Ra Radium 88	Ac Actinium 89	Rf Rutherfordium 104	Db Dubnium 105	Sg Seaborgium 106	Bh Bohrium 107	Hs Hassium 108	Mt Meitnerium 109	Ds Darmstadtium 110	Rg Roentgenium 111		

Many versions also include the mass number or relative atomic mass.

Metals and non-metals

Most elements are metals.

Metals appear on the left and in the middle of the table, while non-metals a
a zig-zag line starting at B (boron).

Metals and non-metals have different physical properties. Metals tend to h
points, high density and be good conductors of heat and electricity.

Non-metals have much lower melting and boiling points, lower density, an

Periods and groups

★ The horizontal **rows** in the periodic table are called **periods**. All of the
have the same number of **electron shells** in their atoms. They are in o
number and have different chemical properties.

★ The vertical columns are called **groups**. Elements in the same group h
properties. This means they react in the same way to the same substa
react with water. The strength of the reaction increases as you go dow
when it's placed in water, while potassium bursts into flames.

← **Group number** →

1	2											3
						H Hydrogen 1						
Li Lithium 3	Be Beryllium 4											B Boron 5
Na Sodium 11	Mg Magnesium 12											Al Aluminium 13
K Potassium 19	Ca Calcium 20	[illegible]	[illegible] Titanium 22	V Vanadium 23	Cr Chromium 24	Mn Manganese 25	Fe Iron 26	Co Cobalt 27	Ni Nickel 28	Cu Copper 29	Zn Zinc 30	Ga Gallium 31
Rb Rubidium 37	Sr Strontium 38	Y Yttrium 39	Zr Zirconium 40	Nb Niobium 41	Mo Molybdenum 42	Tc Technetium 43	Ru Ruthenium 44	Rh Rhodium 45	Pd Palladium 46	Ag Silver 47	Cd Cadmium 48	In Indium 49
Cs Caesium 55	Ba Barium 56	La Lanthanum 57	Hf Hafnium 72	Ta Tantalum 73	W Tungsten 74	Re Rhenium 75	Os Osmium 76	Ir Iridium 77	Pt Platinum 78	Au Gold 79	Hg Mercury 80	Tl Thallium 81
Fr Francium 87	Ra Radium 88	Ac Actinium 89	Rf Rutherfordium 104	Db Dubnium 105	Sg Seaborgium 106	Bh Bohrium 107	Hs Hassium 108	Mt Meitnerium 109	Ds Darmstadtium 110	Rg Roentgenium 111		

For example:

- ★ Calcium (Ca) is in period 4 and group 2.
- ★ Oxygen (O) is in period 2 and group 6.

Electron shells

- ★ The **nucleus** of an atom is made up of **protons** and **neutrons**. The pos
  the number of protons, or **atomic number**. For example, the nucleus o
  charge of +14.
- ★ Negatively charged electrons orbit the nucleus. The total number of el
  number of protons, so the whole atom has no overall electric charge.
- ★ Electrons orbit the nucleus in layers called **electron shells**. The shells c
  levels, and are given numbers, with shell 1 closest to the nucleus. Shell
  and the amount of energy increases with each layer.

Electron shells are filled in a specific order, and the arrangement of electron
electron structure or **electronic configuration**.

This can be shown in a schematic diagram like this, or as numbers.
The diagram tells you that this atom has two electron shells, with two
electrons in shell 1 and six electrons in shell 2.

As numbers, you would write it as 2,6

You need to know the rules for filling electron shells:

First shell

The first shell is filled first, and it can only hold a maximum of **two** electrons

Figure 1 shows a helium (He) atom. It only has one electron shell, and that

When the first shell is full, electrons start to fill up shell 2.

Second shell

The second shell can hold up to **eight** electrons.

Figure 2 shows an atom of neon (Ne), atomic number 10.
It has two electrons in shell 1 and eight in shell 2.

Its electronic configuration is 2.8

Third and fourth shells

When shell 2 is full, electrons start to fill up shell 3.

Figure 3 shows an atom of silicon (Si), atomic number 14.
It has two electrons in shell 1, eight in shell 2 and four in shell 3.

Its electronic configuration is 2.8.4

When there are eight electrons in shell 3, then shell 4 starts to fill up.

Figure 4 shows a potassium (K) atom, atomic number 19. It has two electrons in shell 1, eight in shell 2, eight in shell 3 and one in shell 4.

Its electronic configuration is 2.8.8.1

You need to be able to write the electronic configuration and draw schema diagrams for all the elements from **hydrogen**, atomic number 1, up to **calcium**, atomic number 20.

Exam tip

In schematic diagrams of electron structure, the electrons can be shown as dot

When you draw schematic diagrams in your exam, it's better to draw them as because [illegible] be easier for the marker to read.

Don't forget to bring compasses to your exam so that you can draw the electro

If you know the atomic number of an element, you can work out the electro
Fill up each electron shell according to the rules until you get up to the ato

Example

Write down the electronic configuration of an atom of **magnesium (Mg)**.

First look up magnesium in the periodic table to get the atomic numb
Now use the rules to fill up the electron shells, like this:

$$\left.\begin{array}{ll}\text{Shell 1} & 2\\ \text{Shell 2} & 8\end{array}\right\}\ 2 + 8 = 10$$

That leaves two electrons to go in shell 3
Therefore the electronic configuration of magnesium is **2.8.2**

Electron shells and groups

The vertical columns in the periodic table are groups.

The group number of an element is the same as the number of electrons i electrons are available for chemical reactions.

For example, magnesium has two electrons in its outer shell, so it's in grou

It's in period 3 because it has three electron shells altogether; two shells ar

Quick Questions 2

Part of the periodic table is shown below.

						H Hydrogen 1						
Li Lithium 3	Be Beryllium 4											B Boron 5
Na Sodium 11	Mg Magnesium 12											Al Aluminiu 13
K Potassium 19	Ca Calcium 20	Sc Scandium 21	Ti Titanium 22	V Vanadium 23	Cr Chromium 24	Mn Manganese 25	Fe Iron 26	Co Cobalt 27	Ni Nickel 28	Cu Copper 29	Zn Zinc 30	Ga Galliu 31

1. What name is given to the vertical columns in the periodic table?
2. Which of these elements are in the same period?
   - Beryllium and magnesium
   - Sulfur and oxygen
   - [illegible] and chlorine
   - [illegible] and carbon
3. A carbon atom has six protons. How many electron shells does it ha
   - 6
   - 2
   - 1
   - 3
4. Use the periodic table to find the chemical symbols for copper, iron
5. Describe the position of nitrogen (N) in the periodic table.
6. Show the electronic configuration of the following elements in a sch number form:
   a) Sulfur
   b) Calcium
   c) Oxygen

C3: Isotopes

	Definitions
Isotope	a different variety of the same element, with the same but a different number of neutrons
Mass number	the mass of one atom of an isotope. This is the total n neutrons in the atom.
Relative atomic mass	the average mass of all the atoms of an element. It use
Percentage abundance	the percentage of a particular isotope in the whole popu

What are isotopes?

- ★ Every element can be found in different forms, and these different form
- ★ Some elements have many isotopes, but most have just two or three.

Isotopes of an element have the same properties and the same atomic num isotopes, chlorine-35 and chlorine-37.

They are both chlorine – they look the same, they behave in the same way they have an **atomic number** of 17.

However, they have different mass numbers because they have different numb

Isotope	Atomic number	Number of protons	Number of electrons	Mass
Chlorine-35	17	17	17	
Chlorine-37	17	17	17	

When you write about an isotope

you can either:

- ★ use the name and mass number, e.g. chlorine-37 or carbon-13...

... **or write it in the form:**

Atomic mass of the isotope →

Atomic number →

Isotopes and atomic mass

The existence of isotopes means that not every atom in an element has the

- ★ Atoms of chlorine-37 are slightly heavier than atoms of chlorine-35 becau
- ★ Three quarters of chlorine atoms have a mass of 35 and one quarter ha
- ★ This means that the **average** mass of a chlorine atom will be more than
- ★ This average is called the **relative atomic mass**, and it is not always a w
- ★ The symbol for relative atomic mass is $\mathbf{A_r}$

Many versions of the periodic table include the relative atomic mass in addi shown in the following extract:

					4.00 **He** Helium 2	← relativ ← symbo ← name ← atomic
10.80 **B** Boron 5	12.01 **C** Carbon 6	14.01 **N** Nitrogen 7	16.00 **O** Oxygen 8	19.00 **F** Fluorine 9	20.18 **Ne** Neon 10	
26.98 **Al** Aluminium 13	28.09 **Si** Silicon 14	30.97 **P** Phosphorus 15	32.06 **S** Sulfur 16	35.45 **Cl** Chlorine 17	39.95 **Ar** Argon 18	

Calculating relative atomic mass

In the case of elements which have isotopes, you can calculate the relative atomic mass of the element if you know:

- ★ the mass number of each isotope
- ★ the **percentage abundance** of each isotope

Ex
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wit
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Percentage abundance means what percentage of each isotope you would find in a large sample of atoms.

There is a formula for calculating relative atomic mass:

$$A_r = \frac{\overset{\text{isotope 1}}{(\text{Mass number} \times \text{percentage})} + \overset{\text{isotope 2}}{(\text{Mass number} \times \text{percentage})} + (\text{M}}{100}$$

Example

The element **boron (B)** has two isotopes, **boron-10** and **boron-11**:

Isotope	Mass number	Percentage
Boron-10	10	20
Boron-11	11	80

Calculate the relative atomic mass of boron.

In 100 boron atoms 20 have a mass of 10, and 80 have a mass of 1

To work out the average:

1. *Find the total mass of each isotope.*
   Boron 10 20 × 10 = 200 Boron 11 80 x 11 =
2. *Add [illegible] together to get the total mass for 100 atoms.*
   *200 + 880 = **1080***
3. *Divide by 100 to obtain the average mass for one atom 10*
   The relative atomic mass of boron is 10.8

Quick questions 3

1. Copy and complete the following sentences:

   Isotopes are different versions of the same .... They h
   .... but a different number of .... in their at

2. The element **magnesium (Mg)** has three isotopes.

   a) Copy and complete the table.

Isotope	Atomic number	Number of neutrons	Mass number
magnesium-24	12		
magnesium-25			
magnesium-26			

   b) Calculate the relative atomic mass of magnesium. Give your an

Checklist – Atoms, elements and the p

I can identify elements as metals or non-metals using their position in the perioc

I can describe the structure of an atom in terms of its nucleus, electron shells an in between.

I can identify protons, neutrons and electrons on a diagram.

I understand the relationship between the number of protons and the number o

I can define the terms atomic number and mass number.

I can use the atomic number and mass number to work out how many protons, an atom has.

I can describe the relative charge and relative mass of protons, neutrons and ele

I understand that all atoms of a particular element have the same number of pro and that number is unique to that one element.

I can describe the arrangement of elements in the periodic table in terms of peri

I understand and can use the rules about filling electron shells.

I can predict the electronic configuration of the first 20 elements in the periodic

I can represent the electronic configuration of the first 20 elements in diagram f

I can explain the relationship between the number of outer electrons and the po in the periodic table.

I can define an isotope of an element in terms of its protons and neutrons.

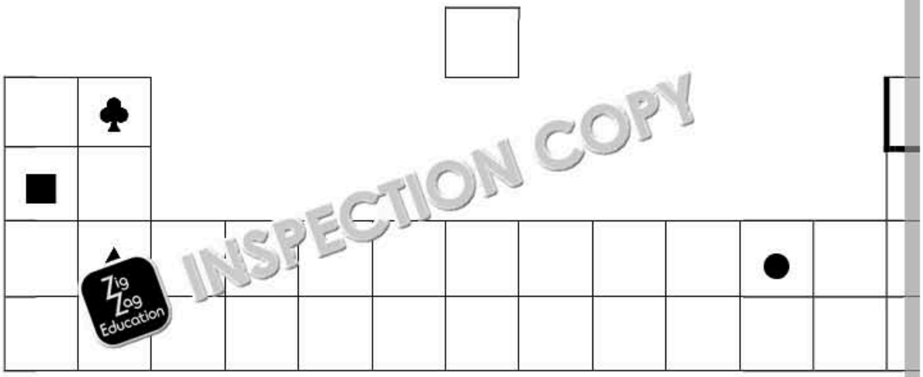
I can define the term relative atomic mass.

I can explain why the relative atomic mass of an element is not always a whole n

I can calculate the relative atomic mass of an element from the relative masses a abundance of its isotopes.

Exam-style questions

1. The diagram below shows part of the periodic table. The symbols represent e



   a) Which **two** elements are both metals? Choose one of the options.

   ♥ and ♣ ▲ and ♣ ▲ and ♦

   b) Give a reason for your choice.

   c) Which **two** elements are in the same **period**? Choose one of the options.

   ▲ and ♣ ● and ♠ ♣ and ♦

   d) Which of these elements has the **smallest** number of **electrons**? Choose

   ♥ ♦ ▲

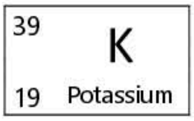
   e) Write down **two** differences between an electron and a proton.

2. The entry in the periodic table for the element sodium is shown below.

   a) Copy the image and fill in the spaces to complete the entry.

   b) How many **neutrons** does a sodium atom contain?

   This is the entry for potassium.



   c) Describe the atomic structure of potassium, including its electronic confi

   d) Describe the position of potassium in the periodic table.

3. Part of the periodic table is shown below.

56	59	59	63.5	65
Fe	**Co**	**Ni**	**Cu**	**Zn**
iron	cobalt	nickel	copper	zinc
26	27	28	29	30

Key
← relative atomi
← symbol
← name
← atomic numbe

   a) Explain what is meant by ***relative atomic mass***.

   b) Explain why the relative atomic mass of copper is not a whole number.

   c) The element bromine (Br) has the atomic number 35.
   50.7 % of bromine atoms have mass number 79, the rest have mass num
   Calculate the relative atomic mass of bromine. Give your answer to two s

Chapter D: Substances and chemica

In this chapter you will learn about how elements combine to form compou and how compounds behave in chemical reactions. You will also learn how reactions in words and in symbols.

D1: Elements and compoun

	Definitions
Molecule	a particle made up of two or more atoms that are bo
Molecular element	an element that naturally occurs in the form of two c atoms bonded together
Compound	two or more elements that are chemically bonded to new substance
Mixture	two or more substances that have been mixed toget chemical reaction
Hazard	a potential danger associated with a chemical substa
Flammable	will catch fire easily
Toxic	poisonous
Corrosive	will damage human tissue

Elements

You already know that an element is a pure substance, made up of just one

The **periodic table** lists the names and chemical symbols of the elements, and chemical properties:

						H Hydrogen 1						
Li Lithium 3	Be Beryllium 4											B Boron 5
Na Sodium 11	Mg Magnesium 12											Al Aluminium 13
K Potassium 19	Ca Calcium 20	Sc Scandium 21	Ti Titanium 22	V Vanadium 23	Cr Chromium 24	Mn Manganese 25	Fe Iron 26	Co Cobalt 27	Ni Nickel 28	Cu Copper 29	Zn Zinc 30	Ga Gallium 31
Rb Rubidium 37	Sr Strontium 38	Y Yttrium 39	Zr Zirconium 40	Nb Niobium 41	Mo Molybdenum 42	Tc Technetium 43	Ru Ruthenium 44	Rh Rhodium 45	Pd Palladium 46	Ag Silver 47	Cd Cadmium 48	In Indium 49
Cs Caesium 55	Ba Barium 56	La Lanthanum 57	Hf Hafnium 72	Ta Tantalum 73	W Tungsten 74	Re Rhenium 75	Os Osmium 76	Ir Iridium 77	Pt Platinum 78	Au Gold 79	Hg Mercury 80	Tl Thallium 81
Fr Francium 87	Ra Radium 88	[illegible] 89	Rf Rutherfordium 104	Db Dubnium 105	Sg Seaborgium 106	Bh Bohrium 107	Hs Hassium 108	Mt Meitnerium 109	Ds Darmstadtium 110	Rg Roentgenium 111		

You can use the periodic table to look up the name of an element if you kn
if you know the name.

However, it will help you a lot if you can remember these common element

Metals: **sodium – Na**
calcium – Ca
magnesium – Mg
potassium – K
zinc – Zn
copper – Cu
iron – Fe

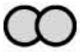
Non-metals: **hyd**
car
nitr
oxy
chlo
sulf

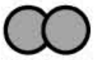
Molecular elements

A small number of non-metals naturally exist in the form of **molecules**, ma
same type of atom joined together.

Examples of molecular elements are hydrogen, nitrogen, oxygen and chlori

★ The chemical formula for a molecule of hydrogen is H_2 

★ The chemical formula for a molecule of nitrogen is N_2 

★ The chemical formula for a molecule of oxygen is O_2 

★ The chemical formula for a molecule of chlorine is Cl_2 

The **₂** tells you how many atoms are in the molecule. It always goes at the b
correct, O2 and O^2 are incorrect.

Compounds

Elements react with each other to form **compounds**.

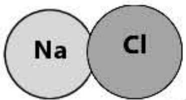
The molecules in a compound are made up of two or more ***different*** atom
together. They can **only** be separated by a chemical reaction.

The chemical formula of a compound shows the atoms it contains and how

For example:

The formula for water is **H_2O**. Each water molecule contains tw
and one oxygen atom.

The formula for carbon dioxide is **CO_2**. A molecule of carbon dioxide conta
atom and two oxygen atoms.



The chemical name for everyday cooking salt is sodium chl
formula is **NaCl**. Each molecule of salt contains one sodiu

Mixtures

A mixture is made up of two or more substances that have been combined chemically bonded.

- ★ The substances in a mixture can be quite easily separated by physical m
- ★ A mixture of salt crystals and iron filings can be separated using a mag iron, and the salt is left behind.
- ★ A mixture of sugar and water can be separated by pouring it into a sha in a warm place – the water will evaporate, leaving the sugar.

Hazardous chemicals

During your work in the laboratory, you will see that some of the bottles of chemicals are labelled with a symbol, like the ones in the picture.

These are **hazard signs**, and they are the same all over the world. Hazard signs warn you about the dangers of a substance. They tell you the of risk and how severe it is.

You need to know the following signs and what they mean:

	This sign indicates a **moderate hazard**. That mea but not severely harmful. The dilute acids and alkalis you work with in the la can make your skin and eyes red, sore and itchy, a You should wear gloves and goggles when workin
	Substances with this sign are **corrosive**. Example and alkalis. Corrosive substances can destroy living tissue, so don't come into contact with the skin or eyes. Always wear hand and eye protection.
	This sign indicates that a chemical is **toxic**. You s substances like bleach and weedkiller, not just in t Toxic chemicals can cause death or serious dama swallowed, or absorbed through the skin.
	Substances labelled with this sign are **flammable**. They catch fire very easily and should be kept wel Flammable chemicals should be stored in fire-resi
	This sign shows that a substance poses an enviro The chemical can cause short- or long-term dama that make up an ecosystem. Chemicals labelled with this sign may need to be

When you plan an experiment, you need to do a **risk assessment**. This wil

- ★ Identifying any potential sources of harm in the equipment, method an
- ★ Planning **precautions** to reduce the risk of anyone being hurt by these

Quick questions 1

1. Copy and complete this table:

Name of element	Chemical symbol
Sodium	
	Cu
Carbon	
	Mg
	S

2. Nitrogen is a molecular element. State the chemical formula for nitr

3. For each of the following substances, write down whether it is an ele mixture:
   a) Potassium
   b) Calcium carbonate
   c) Water
   d) Salt solution
   e) Sulfuric acid

4. Explain the difference between a mixture and a compound.

5. The formula for sulfuric acid is **H_2SO_4**. Copy and complete the table make up a sulfuric acid molecule.

Name of element	Number of atoms

6. Write down the meaning of these hazard signs:


a)


b)

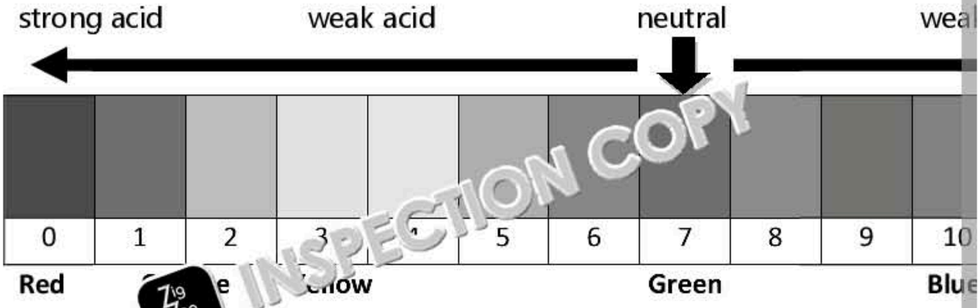

c)

Elements react with each other and combine together to form a huge range
These compounds have various chemical properties; they include **acids**, **ba**

	Definitions
pH scale	a scale from 0 to 14 that measures the acidity of a subst
Indicator	a substance that changes colour in the presence of cert
Acid	a compound that contains hydrogen and has a pH less th
Base	a substance that has a pH of more than 7 and reacts wit
Alkali	a base that will dissolve in water
Neutral	a neutral substance has a pH of 7 and is neither acid no
Neutralisation	when an acid reacts with a base to produce a neutral su
Salt	a compound that is produced by a neutralisation reactio

Acidity and the pH scale

All chemical compounds are either acids, bases, or neutral substances.
The **pH scale** measures how acidic or alkaline a substance is on a scale of 0



The colours are shown using **universal indicator**. Universal indicator come
and it changes colour from red for strong acids, through to dark blue/purpl

Exa
If yo
thin
rain

Neutral substances have a pH of 7 and are harmless.
They will turn universal indicator green. Water is an example of a neutral substance.

Acids have a pH of less than 7 and they will turn universal indicator yellow, orange or red.

- ★ Strong acids have pH between 0 and 3. These include the sulfuric, hyd
use in the laboratory. They will turn universal indicator red or orange.
- ★ Weak acids have pH between 4 and 6. The acid in oranges and lemon
turn universal indicator yellow or light green.

Bases have a pH of more than 7 and they turn universal indicator blue or pu

- ★ Strong bases have pH between 11 and 14. They include sodium hyd
bleach. They will turn universal indicator dark blue or purple.
- ★ Weak bases have pH 8 to 10, and they will turn universal indicator blue
up liquid has a pH of 8.

Bases are metal oxides, hydroxides, and carbonates. **Alkalis** are bases that

Alternative indicator – litmus

Litmus is a chemical indicator that usually comes in the form of red and blu
whether a substance is an acid or an alkali, but not how strong it is.

- **Acids** turn blue litmus red.
- **Alkalis** turn red litmus blue.
- **Neutral** substances don't change the colour of litmus – red stays red a

Neutralisation

Acids and bases will react together, and this reaction will produce a neutral

For example:

- Hydrochloric acid has a pH of 1. Sodium hydroxide has a pH of 11.
- If you gradually add sodium hydroxide to hydrochloric acid the pH of t when you have added the right amount, it will increase to pH 7. You h
- If you continued to add sodium hydroxide after this point the pH of the increase and it will become alkaline, because all the acid has already be

Products of neutralisation

When an acid and a base react together, the products are always a **salt** and

$$\underbrace{\text{acid + base}}_{\text{reactants}} \rightarrow \underbrace{\text{salt + water}}_{\text{products}}$$

In the example above:

hydrochloric acid + sodium hydroxide → sodium chlor

Salts get the first part of their name from the metal in the base, and the sec

If you change the acid:

nitric acid + sodium hydroxide → sodium nitrate

sulfuric acid + sodium hydroxide → sodium sulfate

- Hydrochloric acid produces **chlorides**.
- Nitric acid produces **nitrates**.
- Sulfuric acid produces **sulfates**.

If you change the base:

hydrochloric acid + copper oxide → copper chlorid

hydrochloric acid + zinc oxide → zinc chloride +

Chemical formulae

You need to know the formulae for the acids and bases you use in chemica

Acids	Bases
	Oxides/hydroxides
Hydrochloric acid HCl	Sodium hydroxide NaOH
Nitric acid HNO_3	Calcium hydroxide $Ca(OH)_2$
Sulfuric acid H_2SO_4	Copper oxide CuO
	Zinc oxide ZnO
	Magnesium oxide MgO

Uses of neutralisation

The neutralisation reaction is used in everyday life for many purposes, and few examples:

- ★ **Treatment of acid indigestion**. The stomach contains hydrochloric a helps us digest our food. However, if too much acid is produced a per indigestion and heartburn.

  Indigestion remedies contain bases such as magnesium carbonate and neutralise the excess acid and relieve the symptoms. Insoluble bases a dissolve in acid, not in water, so there is no risk of the digestive system person takes too much.

- ★ **Soil treatment**. When we burn fossil fuels (coal, oil or gas) gases such dioxide are released into the air; these gases dissolve in rainwater to fo falls on fields it makes the soil more acidic.

  Some food crops don't grow well in acid soil, and this could affect the powdered lime (calcium oxide) or chalk (calcium carbonate) to neutrali

- ★ **Water treatment**. When acid rain falls in rivers and lakes it can decrea Industrial chemicals released from factories can do the same thing. If t it will kill underwater plants and animals.

  Lime is sometimes added to river water to neutralise excess acid and pre

Quick questions 2

1. Copy and complete this table:

Name of compound	**Chemical formula**
Sodium hydroxide	
	CuO
Nitric acid	
	$MgCO_3$
	H_2SO_4

2. Give ***two*** chemical properties of an acid.
3. Sodium hydroxide and copper oxide are both bases. Explain why so alkali, but copper oxide is not.
4. Water is a neutral substance. Write down the pH of water.
5. Vinegar is a weak acid. Which of these is likely to be the pH of vineg
   a) 2 b) 5 c) 7 d) 10
6. Copy and complete this word equation:
   nitric acid + copper oxide ________________ + ______
7. Copy and complete this word equation:
   ________ acid + ____________ hydroxide → calcium chloride

D3: Reaction of acids with metals and

Definitions

Hydrogen	a flammable gas with the formula H_2
Splint	a long, thin piece of wood that can be placed in a test tu
Carbonate	a salt that contains metal, carbon and oxygen atoms
Carbon dioxide	a non-flammable gas with the formula CO_2
Lime water	a calcium hydroxide solution that turns cloudy in the pr

Acids and metals

Most metals will react with acids to form salts. The exceptions are copper, s which don't react with acids at all.

When an acid reacts with a metal the products are a salt and hydrogen gas.

$$\underbrace{\text{acid + metal}}_{\text{reactants}} \rightarrow \underbrace{\text{salt + hydrogen}}_{\text{products}}$$

For example, if you add a strip of magnesium tape to a test tube of sulfuric

sulfuric acid + magnesium → magnesium sulfate + h

If you change the acid:

nitric acid + magnesium → magnesium nitrate + hy

hydrochloric acid + magnesium → magnesium chloride

If you change the metal:

sulfuric acid + zinc → zinc sulfate + hydroge

sulfuric acid + aluminium → aluminium sulfate + hy

Testing for hydrogen gas

When an acid is added to a metal the mixture will bubble and fizz. This tells you that a gas is being produced, but it doesn't tell you which gas.

To confirm that the gas is hydrogen, and not oxygen or carbon dioxide, you need to perform the following test.

Light a wooden splint and insert it into the neck of the test tube, above the liquid.

If the gas is hydrogen, then the gas will burn and make a sound that is usually described as a **squeaky pop**. The popping sound indicates that a small explosion has occurred.

Acids and carbonates

Carbonates are metal compounds that contain one carbon atom and three

The formula for a carbonate ends in **CO_3**, e.g. sodium carbonate has the fo

When an acid reacts with a carbonate there are three products: a salt, wate

$$\underbrace{\textbf{acid + carbonate}}_{\text{reactants}} \rightarrow \underbrace{\textbf{salt + water + carbon}}_{\text{products}}$$

For example, if you add sulfuric acid to calcium carbonate, the reaction will

sulfuric acid + calcium carbonate → calcium sulfate + water

If you change the acid:

nitric acid + calcium carbonate → calcium nitrate + water

hydrochloric acid + calcium carbonate → calcium chloride + wa

If you change the metal:

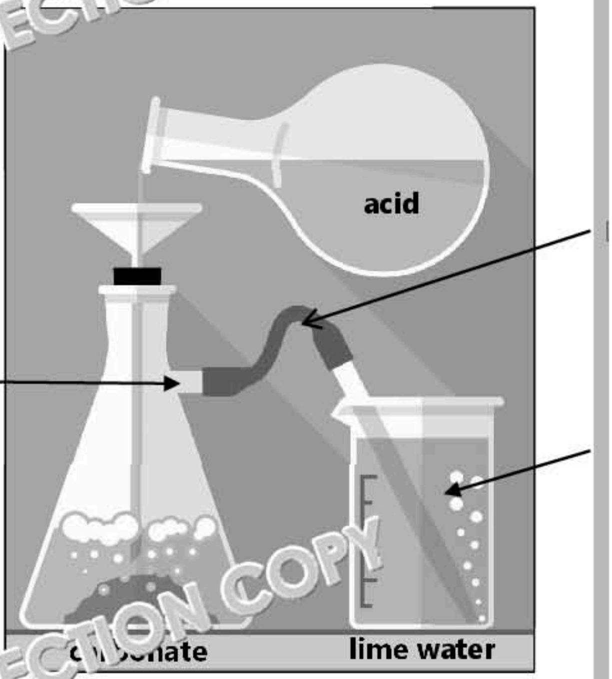
sulfuric acid + zinc carbonate → zinc sulfate + water + c

sulfuric acid + aluminium carbonate → aluminium sulfate + wa

Testing for carbon dioxide gas

When an acid is added to a carbonate the mixture will bubble and fizz, like same way, the fizzing tells you that a gas is being produced, but it doesn't

To confirm that the gas is carbon dioxide you need to perform the followin



Gas produced by the reaction leaves the flask through here.

Collect the gas as shown in the diagram above and bubble it through an in

Lime water is a solution of calcium hydroxide, and it reacts with carbon dio

Lime water is normally a clear, colourless solution, but in the presence of c and cloudy.

Writing balanced chemical equations

So far in this chapter we have used word equations to describe chemical re

sulfuric acid + magnesium → magnesium sulfate +

You also need to use the chemical formulae of substances to write chemica
In the example above:

sulfuric acid + magnesium → magnesium sulfate + hy

$\mathbf{H_2SO_4 + Mg \rightarrow MgSO_4 + H_2}$

This is a balanced chemical equation because the number and type of atom
of the equation like this:

$\mathbf{H_2SO_4 + Mg \rightarrow MgSO_4 + H_2}$

2 hydrogen atoms 1 sulfur atom 4 oxygen atoms 1 magnesium atom	2 hydrogen ato 1 sulfur atom 4 oxygen atom 1 magnesium a

No atoms have disappeared, and none have appeared from nowhere, they

In that example the equation is already balanced. One molecule of sulfuric
mercury to produce one magnesium sulfate molecule and one molecule of

However, it doesn't always work that way. The same reaction with nitric aci

nitric acid + magnesium → magnesium nitrate + hy

Using chemical symbols, this is:

$\mathbf{HNO_3 + Mg \rightarrow MgNO_3 + H_2}$

However, the equation does not balance, because hydrogen is a molecular
two hydrogen atoms to make a molecule of hydrogen gas.

At the moment you have

$\mathbf{HNO_3 + Mg \rightarrow MgNO_3 + H_2}$

1 hydrogen atom 1 nitrogen atom 3 oxygen atoms 1 magnesium atom	**2 hydrogen at** 1 nitrogen ato 3 oxygen atom 1 magnesium a

You need to find another hydrogen atom from somewhere to balance the e
problem, double the number of nitric acid molecules and then count up the

$\mathbf{2HNO_3 + Mg \rightarrow MgNO_3 + H_2}$

2 hydrogen atoms **2 nitrogen atom** **6 oxygen atoms** 1 magnesium atom	2 hydrogen ato **1 nitrogen ato** **3 oxygen atom** 1 magnesium a

However, you now have twice as many nitrogen and oxygen atoms, so you number of magnesium atoms to combine with them, like this:

$$2HNO_3 + 2Mg \rightarrow 2MgNO_3 + H_2$$

2 hydrogen atoms 2 nitrogen atoms 6 oxygen atoms 2 magnesium atoms	2 hydrogen ato 2 nitrogen aton 6 oxygen atom 2 magnesium a

The chemical equation is now balanced.

Two molecules of nitric acid react with two magnesium atoms to produce t nitrate and one molecule of hydrogen gas.

Example

a) Write a word equation for the chemical reaction that would produce calciu carbon dioxide.

b) The formula for calcium chloride is **$CaCl_2$**. Write a balanced chemical equati

a) *If a salt, water and CO_2 are produced, that means the reaction i a carbonate.*

The salt is calcium chloride; that means the carbonate is calcium hydrochloric acid.

Therefore, the word equation for this reaction is

hydrochloric acid + calcium carbonate → calcium chloride + water

b) *First write down the unbalanced chemical equation, and then cou each side:*

$$HCl + CaCO_3 \rightarrow CaCl_2 + H_2O + CO_2$$

1 hydrogen atom *1 chlorine atom* *1 calcium atom* *1 carbon atom* *3 oxygen atoms*	*2 hydrogen atoms* *2 chlorine atoms* *1 calcium atom* *1 carbon atom* *1 + 2 = 3 oxygen atoms*

You need one more hydrogen atom and one more chlorine atom

Double the HCl and you will balance the equation, like this:

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

Quick questions 3

1. a) A chemical reaction produces zinc sulfate and hydrogen gas. N
   b) Describe the test that you would perform to confirm that the ga
   c) The formula for zinc sulfate is **$ZnSO_4$**. Write a balanced chemica
2. a) An acid is added to a carbonate. Name the **products** of this rea
   b) Write down the word equation for the reaction between hydroc sodium carbonate.
   c) Write a balanced chemical equation for the reaction in part b).

Checklist – Substances and chemical

I can use the periodic table to recognise elements and the formulae of simple co

I can explain the meaning of the words element, compound, mixture, molecule a

I can define acids, bases and alkalis.

I understand the relationship between pH and acidity.

I can test [illegible]lkalis and neutral substances using universal indicator and litmu

I can identify the hazard symbols for mild hazard/irritant, corrosive, toxic, flamm to the environment.

I can predict the outcome of neutralisation reactions using hydrochloric acid, nitr with a metal oxide and sodium hydroxide.

I understand that chemicals react to form products with different properties, inc and salts.

I can explain how neutralisation reactions are used to treat indigestion in human chemicals used.

I can explain how neutralisation reactions are used in the environment to reduce to reduce the acidity of rivers and lakes, caused by acid rain.

I can predict the outcome of chemical reactions using hydrochloric acid, nitric ac with metals.

I can predi[illegible]utcome of chemical reactions using hydrochloric acid, nitric ac with carbonates.

I can describe how to test for the presence of hydrogen gas.

I can describe how to test for the presence of carbon dioxide using lime water.

I can recall the formulae for the acids and bases named in this chapter.

I can write word equations to describe the chemical reactions outlined in this ch

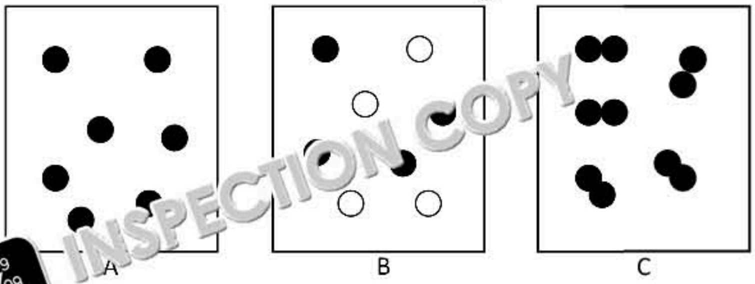
I can write balanced chemical equations to describe the chemical reactions outli

I can balance a chemical equation and explain the reason for any changes I need

Exam-style questions

1. a) Figure 1 shows four substances, labelled A, B, C and D.

Figure 1



Which of these substances:

(i) is a compound? (ii) is a mixture? (iii) could be

b) Explain what is meant by the term ***compound***.

c) Some chemical substances carry hazard warning labels.
For both the symbols below, select one word to represent the hazards th

(i)

(ii)

T

Cor

Fla

2. a) Yasmin adds hydrochloric acid to universal indicator solution in a test tub

(i) What is the chemical formula for hydrochloric acid?

(ii) What colour will the indicator be after adding the acid? Choose one

Orange/red Yellow/green Green/

b) Yasmin then adds an equal amount of sodium hydroxide to the test tube.

(i) What is the most likely colour of the indicator after adding the sodi
Choose one option.

Blue Red Yellow

(ii) Sodium hydroxide is an **alkali**. Write down **two** chemical properties

c) An acid will react with an alkali to form two new compounds.

(i) Copy and complete this word equation to show the products that ar
hydrochloric acid and sodium hydroxide react together.
Hydrochloric acid + sodium hydroxide → .... + ...

(ii) Copy and complete the sentence:
The chemical reaction between an acid and a base is called ....

(iii) Bases such as magnesium hydroxide are often used to treat indigesti
Explain how this treatment works.

3. a) Za[illegible]s dilute nitric acid with sodium carbonate in a flask. A gas is pro

(i) What is the name of the gas?

(ii) How would you test this gas to confirm its identity?

b) The formula for sodium carbonate is Na_2CO_3. The formula for sodium nit
Write a balanced chemical equation for the reaction between sodium car

Chapter E: Energy and how we

Energy is what makes things happen. In physics it is defined as the capacit chapter you will learn about the different forms of energy, how we store it, transferred between its various forms.

E1: Energy and energy store

	Definitions
Thermal energy	heat energy from hot objects
Kinetic energy	the energy in a moving object
Mechanical energy	includes kinetic energy and potential energy
Potential energy	energy that is stored in an object because it is high
Nuclear energy	energy that is stored in an atom and released by nu
Chemical energy	energy that is stored in food, fuels and batteries
Battery	a store of chemical energy that can be converted t

Forms of energy

Energy comes in many different forms, and it can be transferred from one f

Light energy is energy that our eyes can detect.

- ★ Light energy comes from the Sun. It is also emitted by light bulbs, lasers, and LEDs.
- ★ It can travel through liquids, gases or a vacuum.
- ★ We use it to see, and to generate electricity (solar power).
- ★ Plants use it to make food by photosynthesis.

Sound energy

- ★ Sound energy is the energy in a sound wave.
- ★ Sound waves are produced when objects vibrate.
- ★ They can travel through solids, liquids and gases.
- ★ We use sound to communicate information.

Thermal energy

- ★ Thermal energy is **heat** energy.
- ★ It flows from hot objects to colder objects.
- ★ Hot objects include the Sun and hot water.
- ★ We use it for cooking and heating, and also to generate electricity.

Kinetic energy

- ★ Kinetic energy is the energy of a moving object. It is a type of **mechan**
- ★ The amount of kinetic energy depends on the mass of the object and h it is moving.
- ★ It is used to move things and to generate electricity.

Electrical energy

- ★ Electrical energy comes from moving electric charges.
- ★ Lightning is an example of electrical charges in nature.
- ★ Electrical energy can't be stored; it must be generated by a power stati battery, or solar cell.
- ★ Electrical appliances transform electrical energy into other forms of energy, such as light, sound, and thermal energy.

Nuclear energy

- ★ Energy is stored in the nucleus of an atom and released in nuclear reac
- ★ It is released when large radioactive atoms split apart, called **nuclear fi** and also when small atoms join together, called **nuclear fusion**.
- ★ Nuclear energy can be used to make nuclear weapons and to generate electricity.

Storing energy

Some forms of energy can be stored, and then used when we need it.

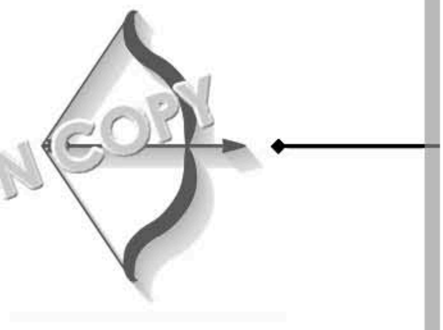
- ★ **Light** and **sound** energy **cannot** be stored.
- ★ **Electrical** energy **cannot** be stored.

Sources of stored energy are:

- ★ **Thermal energy** can be stored in hot water tanks if the tanks are insul escape. We insulate our homes to prevent warm air from escaping.
- ★ **Chemical energy** is the energy stored in the bonds that connect atom Our most common sources are food and fuels.
  - o Food stores chemical energy, which is released in our cells when transform the energy in food into kinetic energy for movement, th warm, and sound when we communicate.
  - o Plants use light energy to make their own food store.
  - o **Fuels** like coal, oil, natural gas and wood contain chemical energy fuel is burned. The thermal energy that is produced when fuels ar and heating, and also to power engines and generate electricity.
  - o **Batteries** store chemical energy, which is converted to electrical e connected to an electrical appliance.
- ★ **Mechanical potential energy** is kinetic energy that is stored in an object when it is **not** moving. There are two types:
  - o **Gravitational potential energy** is stored in an object because it is high up. When it falls, the potential energy is transformed so that the moving water now stores kinetic energy.
  - o At the top of the waterfall the water has gravitational potential energy.
  - o On the way down, the water has kinetic energy.
  - o At the bottom kinetic energy keeps the river flowing, and some energy is transformed into sound and thermal energy.

- **Elastic potential energy** is stored in an object that is stretched, lik compressed, like a spring. When it is released, the potential energ kinetic energy.

The string of the bow is pulled back and stretched tightly, storing elastic potential energy



★ **Nuclear energy** is the energy stored in atoms. See above for more de

Quick questions 1

1. Which forms of energy are generated by the following objects in the
   a) A gas fire
   b) A vacuum cleaner
   c) A CD player
2. Which of the following shows the **two** forms of energy that can be s
   - Light and thermal energy
   - Chemical and electrical energy
   - Mechanical and chemical energy
   - Electrical and nuclear energy
3. Which form of energy is stored in a mobile phone battery?
   - Electrical energy
   - Sound energy
   - Thermal energy
   - Chemical energy
4. Write down **two** uses of nuclear energy.
5. Jamal throws a ball straight upwards from point A. The diagram sh how the ball travels. Which form of energy does the ball have:
   a) at point B?
   b) at point C?
   c) Jamal uses a spring-loaded ball-throwing device to throw the b Name the type of energy that is stored in the spring.

E2: Transferring energy

	Definitions
Joule (J)	the unit for measuring energy
Conservation of energy	the basic principle that energy cannot be cre be transferred
Energy transfer	the change of energy from one form to anot energy to kinetic energy. Also called **transfo**
Sankey diagram	a diagram that shows the proportion of energ
Energy efficiency	the proportion of energy that is transferred a
Thermal energy transfer	the ways in which heat is transferred from o **conduction**, **convection** and **radiation**
Power	the rate at which energy is transferred
Watt (W)	the unit for measuring the power of a device

Measuring energy

Energy is measured in joules (J).

One **joule** is a very small amount of energy. The chemical energy in our fo kilojoules (kJ). A small tin of baked beans contains about 170 kJ.

★ The important thing about energy is that it can never be created or de

★ The total energy at the end of an energy transfer is always the same as

Total energy in (J) = Total energy out (J)

This is called the principle of conservation of energy, or the first law of the

Transferring energy

Whenever something happens, energy is transferred, either from one form to another.

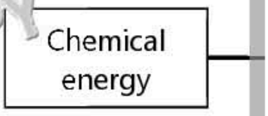
Energy can be transferred in various ways:

★ **Mechanical transfer (work)** happens when an object is moved throu or lifting.

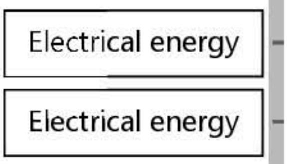
The amount of energy transferred depends on the weight of the object

For example, if you are carrying a bag of rice home from the shop, you carry a 10 kg bag of rice than a 5 kg bag.

The energy to carry the rice comes from the chemical energy in your food. This energy transfer can be shown as a flow chart like this →



★ **Electrical work** happens when electrical devices transfer electrical energy into a range of other forms, such as:



- o Thermal energy when you boil a kettle.
- o Light energy when you turn a lamp on.
- o Kinetic energy in the motor of a washing machine or food mixer.
- o Sound energy in a speaker.

Useful energy and wasted energy

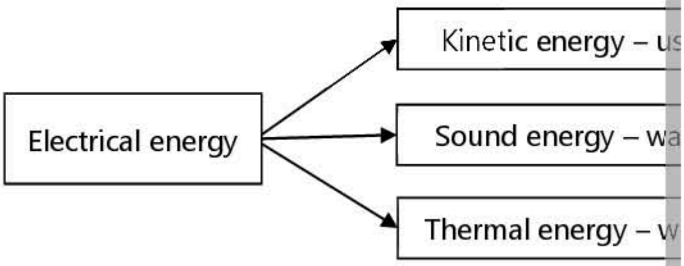
Usually when electrical appliances transfer energy, more than one form of e

For example: a vacuum cleaner transfers kinetic energy to work the motor, gets warm during use, so sound energy and thermal energy are also transfe

The kinetic energy is **useful energy** because it makes the vacuum cleaner s

However, we don't need it to be noisy or get warm, so the sound and therm The wasted energy is transferred to the surroundings.

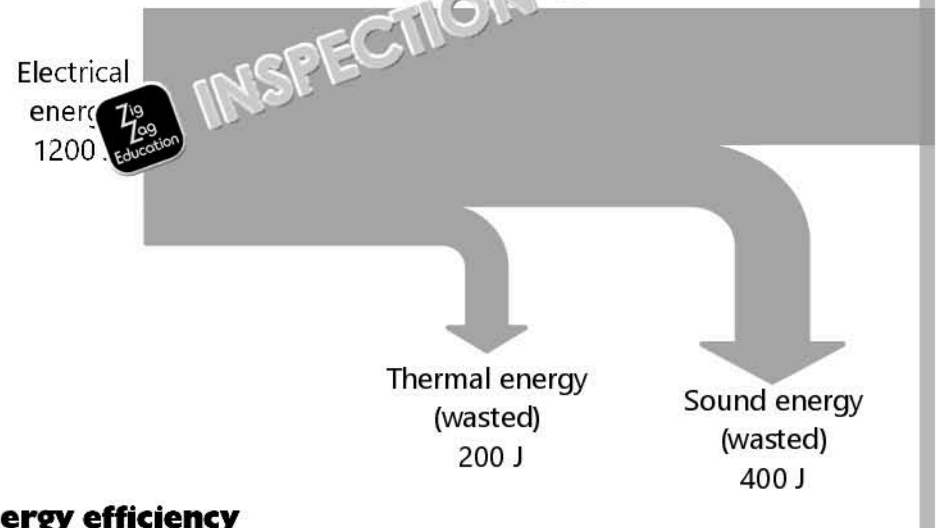
You can show this in an energy transfer flow chart, like this:



Alternatively, if you know the amounts of energy involved you can draw a **S**

This starts off as a large arrow and splits up into smaller arrows. The thickn proportional to the amount of energy transferred.

For example: if a vacuum cleaner transfers 1200 J of energy, and out of thi 600 J are kinetic energy, 400 J are sound energy and 200 J are heat energy, the Sankey diagram would look like this:



Energy efficiency

The energy efficiency of an electrical appliance is the percentage of **useful** e appliance produces.

You can calculate energy efficiency using the following equation:

$$\text{energy efficiency} = \frac{\text{amount of useful energy output}}{\text{total energy input}} \times 100$$

So, the energy efficiency of the vacuum cleaner in the Sankey diagram is:

$$\frac{\text{useful energy output}}{\text{total energy input}} \times 100 = \frac{600}{1200} \times 100 = \mathbf{50\ \%}$$

If you are given the percentage energy efficiency, you can calculate the out

Example

a) A light bulb is 80 % energy efficient. If it uses 1500 J of electrical energy, how m

The bulb is 80 % efficient, so that means the useful output, light, i

$80\ \% \text{ of } 1500 = \frac{80}{100} \times 1500 = 1200$ *Light energy = 1200 J*

b) A different light bulb is only 60 % energy efficient. How much electrical ene produce 1200 J of light energy

In this case 1200 J [illegible] output is only 60 % of the input. To calcu

$\frac{100}{60} \times 1200 = 2000$ J *Electrical energy input = 2000 J*

It is impossible to make an appliance that is 100 % energy efficient; some h surroundings. However, manufacturers work on making products more effi LED light bulbs are much more energy efficient than the old-style bulbs, wh

Thermal energy transfer

Whenever there is a temperature difference between an object and its surro transferred from the warmer place to the cooler place.

For example, if you put a hot drink and an iced drink at normal room tempe down over time and the ice will melt in the cold drink.

Transfer of thermal energy is important for cooking, heating, and all other a is transferred in the following ways:

- **Conduction**

  Conduction happens between solid objects that are in contact with eac

  When solids are heated, the particles next to the heat source start to vibrate against each other, although the object does not move. The vibrations are passed to neighbouring particles, which also then heat up.

  In this picture the hotplate is the heat source. Vibrations in the element are conducted to the pan, and to the food inside.

  Notice that the pan is made of metal because metals are good conductors of heat.

  Non-metals like wood and plastic are poor conductors of heat. They a so that you won't burn yourself when you touch them.

  A poor conductor of heat is also called an **insulator**.

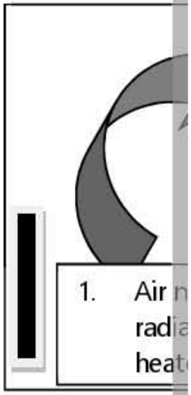
  Liquids and gases are poor conductors of heat.

- **Convection**

  Convection happens in fluids. A fluid is a liquid or a gas, e.g. water an

  When particles in a fluid are heated, they have more energy, and they

  This makes the fluid expand. It becomes less dense, so it rises. The co replaces it. This process is called a **convection current**.



  The diagram shows the convection current in a room that is heated by a radiator.

  The same thing happens when you boil water in a pan. Water at the bottom gets heated first, and then it rises to the top, and is replaced by cooler water.

  This continues until all of the water boils.

- **Radiation**

  Radiation is the transfer of heat energy directly from a hot object, such as the Sun, to a cooler region that can absorb it.

  Unlike conduction and convection, radiation does not involve moving waves, called **infrared** waves.

  Infrared waves are part of the electromagnetic spectrum. See Chapter electromagnetic waves. They can travel through a vacuum, such as spa feel the heat of the Sun even though it is 150 million kilometres away f

  Objects which take in radiated heat are called absorbers of heat. Obje radiation are called emitters of heat. Black matt surfaces are the best a radiation. Solar panels are black for this reason.

  Shiny white surfaces are poor absorbers and emitters of heat radia back. White clothes are cooler on hot sunny days than black clothes.

Power

Your muscles have power, and so do appliances and engines.
Power is the amount of energy which is transferred in a specific time.

For example, if you move your body 100 metres, you transfer the same am run or walk, because you are moving the same weight through the same di

However, it takes more muscle power to run, because you are transferring t

Calculating power

Power is measured in **watts** (W).

1 watt is 1 joule per second. A [illegible] W microwave oven is more powerful th because it transfers more energy every second it is in use, so the food will t

The equation for calculating power is:

$$\text{power (W)} = \frac{\text{energy (J)}}{\text{time (s)}}$$

You can rearrange this equation to calculate energy or time if you know the

Example

a) Calculate the power of a motor that transfers 9000 J of energy in 1 minute.

Use the equation and substitute the values you know:

$$\text{power (W)} = \frac{\text{energy (J)}}{\text{time (s)}} = \frac{9000}{60} \text{ (1 minute = 60 seconds)}$$

Power = 9000 ÷ 60 = **150 watts**

b) How much energy is transferred by a 750 W microwave oven in 2 minutes c

The microwave has 750 watts of power. That means that every s

750 J of energy.

2 minutes = 120 seconds, therefore energy transferred = **750 × 1**

c) How long does it take for a 60 watt light bulb to transfer 3000 joules of ener

60 watt bulb transfers 60 joules in 1 second:

$$60\text{ (W)} = \frac{3000\text{ (J)}}{\text{time (s)}} \qquad \text{time} = 3000 \div 60 = 50 \text{ seconds}$$

Many appliances have a power rating that is given in kilowatts (kW).

1 kilowatt = 1000 watts, so a 2 kW hairdryer will transfer 2000 joules of ene

Paying for electricity

When electricity companies calculate how much electricity to charge us for, the unit they use is the **kilowatt-hour (kWh)**.

1 kWh is the amount of energy that is used by running a 1 kW appliance for 1 hour.

The cost per kilowatt-hour is set by the suppliers and is called the **unit cost**.

Exa
You
all t

Alw
you'
espe

To calculate the cost of running an electrical appliance:

cost = power of appliance (kW) × running time (hours) × u

For example, an electric oven has a power rating of 2400 W. Calculate the c
90 minutes if the cost of electricity is 25 p per kilowatt-hour.

★ First turn the power from watts to kilowatts – divide by 1000 2400

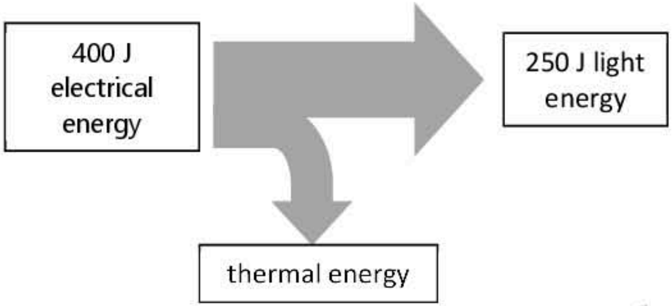
★ Then turn the time from minutes to hours – divide by 60 90 ÷

★ Now do the multiplication **2.4** ×

Quick questions 2

1. State the law of conservation of energy.
2. Maya eats her lunch and then goes for a run. Draw a flow chart to s which takes place.
3. A torch uses batteries. Copy and complete this flow chart to show th happen when the torch is switched on.

4. a) Write down three forms of energy that are transferred by a telev
   b) Which of these is wasted energy?
5. The Sankey diagram below shows the energy transfers that happen i



   a) How much energy is transferred as heat?
   b) Calculate the energy efficiency of the light bulb.
6. A ball bearing is attached to one end of a metal bar with some wax. heated up.

   a) What will happen to the ball after a few minutes?
   b) Which type of energy transfer is this? Choose **one**.
      Radiation / Conduction/ Convection
7. A motor transfers 750 joules of energy in 5 seconds. Calculate the p state the units of your answer.
8. a) Name the unit that electricity suppliers use to calculate your ene
   b) If electricity costs 30 p per unit how much will it cost to use a 1 30 minutes?

E3: Renewable and non-renewabl

	Definitions
Non-renewable energy	sources that are extracted from the earth and ca a human lifetime
Renewable energy	resources that can be replaced by nature in less
Turbine	a device with rotating blades that transfers the e steam or water into mechanical energy to drive
Generator	a machine that transfers other forms of energy i
Fuel cells	use hydrogen gas, which reacts with oxygen fro electrical energy

The modern world needs to generate a huge amount of electricity in order

Electricity must be generated from another form of energy, and these ener **non-renewable** and **renewable** sources.

In the past most of our electricity was generated by burning non-renewabl danger that these sources will run out, so there is a need to develop more

Non-renewable energy sources

Fossil fuels and nuclear power are non-renewable energy sources.

Fossil fuels

Fossil fuels were formed over millions of years from the fossilised remains They are:

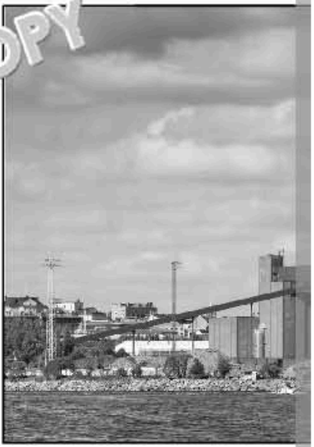
- ★ Coal
- ★ Oil, and oil derivatives such as petrol and diesel
- ★ Natural gas

Most UK electricity comes from power stations that burn fossil fuels. The fu they are burned to heat water and produce steam to drive **turbines** in a **ge**

We also burn fossil fuels for heating and cooking, and to power motor vehi

Disadvantages of fossil fuels:

- ★ They are likely to run out in the next 200 years if we keep using them a
- ★ Burning fossil fuels produces **carbon dioxide**. This is a greenhouse gas and contributes to global warming
- ★ Coal and oil contain sulfur. When burned they release sulfur dioxide, which dissolves in rain to form **acid rain**. Acid rain can kill plants and aquatic animals.
- ★ Burning fossil fuels produces smoke, which pollutes the air and can cause breathing difficulties.



Nuclear energy

Nuclear energy is non-renewable because it uses the fuels **uranium** and p they need to be mined and can't be replaced when they run out.

Nuclear power stations work in the same way as fossil-fuelled power statio

Advantages of using nuclear energy to generate electricity:

★ Unlike fossil fuels no carbon dioxide or other gases are released, so it d change, acid rain or air pollution.

Disadvantages:

★ Nuclear fuels will eventually run out.

★ They produce waste products which remain radioactive and harmful to This nuclear waste must be stored safely.

★ If there is an accident at a nuclear power plant large amounts of radioa released into the air, harming the environment and human health.

Renewable energy sources

Renewable energy sources are easily replaced.

Energy from biomass

Biomass is plant material and animal faeces. It can be used to produce ene

★ Wood and other plant materials can be burned to heat homes and to g

★ Plant materials can be fermented to make fuel for motor vehicles.

★ Human and animal waste can be fermented to produce methane gas, w heating or burned to generate electricity.

Advantages of generating electricity from biomass:

★ Burning biomass still produces carbon dioxide, but plant biomass is re because the plants took in carbon dioxide while they were growing.

★ Using up waste materials means that less waste goes into landfill, and thi

★ Biomass does not contain sulfur, so no sulfur dioxide is produced.

Disadvantages:

Growing plants to be burned for electricity takes up land which could be us

Solar energy

Solar cells transfer light energy from the Sun directly into electricity. A calc or two solar cells, whereas the panels on a roof contain thousands.

Advantages of using sunlight to generate electricity:

★ No fuel costs.

★ No harmful gases or carbon dioxide.

Disadvantages:

★ Solar cells only work when the Sun is shining, and that makes them unreliable in many places.

★ They can be expensive to set up.

★ The panels take up a lot of space; many people don't have enough suitable roof space to meet their energy needs.

Energy from wind

Wind is moving air. It has kinetic energy, which is a renewable resource.

Wind **turbines** have large blades mounted on tall towers. These capture the kinetic energy of the wind and transform it into electrical energy. A wind farm consists of a large number of wind turbines grouped together. Some of these are on land and some are offshore.

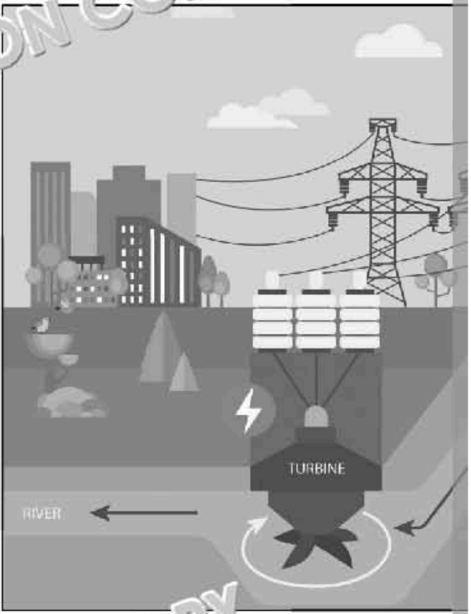
Advantages of using wind power to generate electricity
- No fuel costs.
- No harmful gases or carbon dioxide.
- Single turbines can be used in isolated places with no mains electricity.

Disadvantages:
- Wind turbines only work when the wind is strong enough to turn the blades, and that makes them unreliable in many places.
- They can be expensive to set up.
- Wind farms are noisy and ugly to look at.
- Birds and bats can be killed by turbine blades.

Energy from water

The kinetic energy of moving water can be used in various ways to drive tu

- **Wave power**. In the sea the water moves backwards and forwards in w this movement to turn turbines.
- **Tidal power**. Large amounts of water move in and out of rivers from t barrier is built across the mouth of a river, the water is forced through turbines at high pressure between spaces in the barrier.
- **Hydroelectric power**. This works by building a dam across a big river, which keeps the water contained at a high level, so it has a lot of gravitational potential energy. When the water is released, it rushes through tubes in the dam and drives turbines.



Advantages of using water to generate electricity.
- No fuel costs.
- No harmful gases or carbon dioxide.
- Tidal barriers and hydroelectric power stations are very reliable.

Disadvantages:
- These projects can be expensive to set up.
- Tidal barriers destroy the habitats of the fish and birds that live in river
- Large-scale hydroelectric power station developments involve flooding farms and villages.

Geothermal energy

In volcanic areas hot rocks deep underground heat water. The hot water tu drive turbines.

Advantages of using geothermal energy to generate electricity:

- No fuel costs.
- No harmful gases or carbon dioxide.

Disadvantages:

- Only a few places in the world have the right conditions to make use o

Fuel cell

Hydrogen fuel cells use hydrogen as a fuel to produce an electric current. T vapour. The hydrogen can be extracted from water, which is a renewable re energy to extract and store the hydrogen, and that energy could come from

Using energy efficiently

A large proportion of our energy in the UK and worldwide is obtained by b run out in the foreseeable future if we continue to use them up at the curre also produces gases which contribute to climate change and environmenta

Therefore, it's important that we use energy as efficiently as possible to ma longer and to reduce environmental damage.

Governments are investing in renewable energy, but we all need to be awa daily lives, and make sure we don't **waste** energy. We can do this by:

- Turning off lights and electrical appliances when we're not using them.
- Insulating our homes to reduce heat loss.
- Choosing energy-efficient light bulbs, motor vehicles and electrical app
- Reducing the temperature on our central heating system.
- Operating washing machines and dishwashers at a lower temperature.
- Reducing our use of cars.

Quick questions 3

1. What is meant by renewable energy?
2. For each of the energy sources below, state whether it is renewable
   a) Solar power
   b) Nuclear power
   c) Natural gas
   d) Hydro-electric power
3. Give **two** examples of fossil fuels.
4. In 2011 [illegible] of the UK's electricity was generated by burning fossil
   a) [illegible] **one** advantage of using fossil fuels to generate electricity.
   b) State **two** ways in which burning fossil fuels harms the environn
   c) Give **one other** disadvantage of using fossil fuels in power stati

Checklist – Energy and how we

I can define the following forms of energy and give examples of how they are us light energy, sound energy, kinetic energy, electrical energy, and nuclear energy

I can describe how energy is stored as chemical energy in food, fuels, batteries a give examples.

I can explain how energy is stored as gravitational or elastic potential energy.

I can name sources of renewable energy and explain their advantages and dis

I can identify fossil fuels and nuclear power as non-renewable energy sources an advantages and disadvantages.

I can evaluate the use of renewable or non-renewable energy in a given situatio

I can explain the importance of using energy stores effectively.

I understand how energy transfers from one place to another by means of elect

I understand how energy is transferred when a force moves through a distance

I can explain how thermal energy is transferred by conduction, convection and r give examples.

I can draw and interpret flow diagrams showing energy transfer.

I can explain the principle of conservation of energy.

I can use joules (J) as a unit of energy and watts (W) as a unit of power.

I can use the equation power = energy / time to calculate one of these variables

I can calculate the cost of running an electrical appliance for a given time.

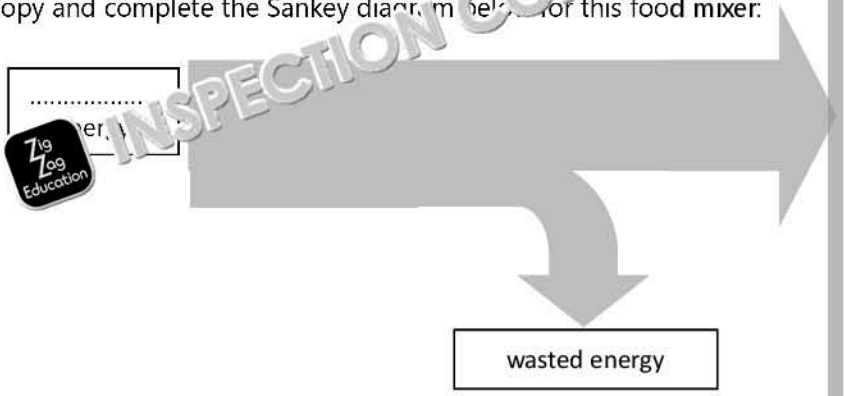
I can explain the difference between useful energy and wasted energy and give

I can draw and interpret a Sankey diagram to show useful and wasted energy.

I can calculate the percentage energy efficiency of a device.

Exam-style questions

1. The illustration on the right shows a food mixer. The motor turns the whisks t the food.
   a) Name the type of useful energy transferred by the motor.
   b) Give **two** forms of wasted energy produced by the motor.
   c) Copy and complete the Sankey diagram below for this food mixer:



   d) The energy efficiency of this mixer is 60 %. It produces 120 J of useful en mix pancake batter.

      Calculate the total energy input to the mixer.

      $$\text{Energy efficiency} = \frac{\text{useful energy output}}{\text{total energy input}} \times 100$$

2. Mrs Okambo has an electric fire in her living room.

   The power of the fire is 1800 watts.
   a) Explain what is meant by the **power** of an appliance.
   b) How much energy does this fire use in one hour? Show your working.
   c) Electricity costs 28 p per kilowatt-hour.

      Calculate the cost of running the fire for six hours every day for one week

      Show your working, and give your answer in pence to the nearest whole
   d) The electric fire heats the whole room by (choose **one**):

      Conduction Convection Radiation

3. Electricity can be generated using renewable or non-renewable sources of ene

   Wind power is a renewable energy source.
   a) Explain what is meant by a renewable source of energy.
   b) Give **one** other example of a renewable energy source.
   c) Evaluate the advantages and disadvantages of generating electricity from from burning fossil fuels.

Chapter F: Waves and the electromagn

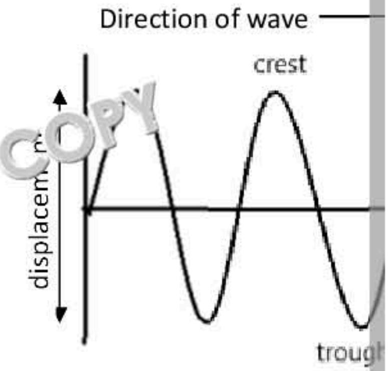
Waves transfer energy from one place to another without transferring matt learn about the main features of waves, and about the electromagnetic spe

F1: Characteristics of waves

	Definitions
Oscillation	up and down movement from a rest position
Crest	the highest point of a wave
Trough	the lowest point of a wave
Amplitude	the maximum displacement of a wave from the rest posit
Wavelength	the distance between corresponding points on a wave
Frequency	the number of complete waves that pass a set point in o
Hertz (Hz)	the unit for measuring frequency

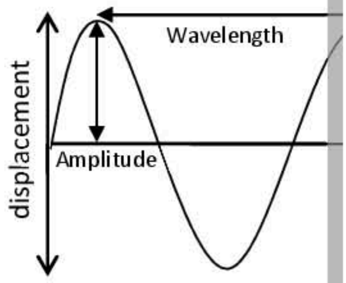
Features of waves

Waves are usually represented like this:



Energy is transferred by a series of **oscillations**, which are up and down movements relative to a rest position. They are also called vibrations.

Wave diagrams like this show **displacement**, which is how far above and below the rest position the wave goes.



- ★ The maximum displacement is called the **amplitude** of the wave and is measured in **metres (m)**. The higher the amplitude of a wave, the more energy it is carrying.
- ★ The **wavelength** is the distance covered by one single wave cycle. It's usually measured as the distance between two crests or between two troughs. Wavelength is measured in **metres (m)**. The symbol for wavelength is **λ**.

Waves are constantly moving:

- ★ A wave's **time period** is the amount of time in **seconds (s)** that it takes t
- ★ The **frequency (f)** is the number of waves that go through a set point i measured in **hertz (Hz)**.
- ★ 1 Hz = 1 wave per second   120 Hz means that 120 waves pass a poi
- ★ The wave speed is how fast the wave is travelling in **metres per secon** frequency and wavelength.

Wave calculations

Calculating frequency

If you know the time period for a wave, you can calculate the frequency usi

$$f = \frac{1}{T}$$

If you know the frequency, you can work out the time period:

$$T = \frac{1}{f}$$

If you don't know the time period but you know how many waves pass a po
you can calculate the frequency using this formula:

$$f = \frac{\text{number of waves to pass a point}}{\text{time taken in seconds}}$$

Example

a) Wave A takes 2 seconds to pass a point. Calculate the frequency of the wav
The time period is 2 seconds. Use the formula $f = 1 \div T = 1 \div$

b) A different wave, wave B, has a frequency of 50 hertz. How long does it take
a point?
In this case you need to work out the time period, T
Use the formula $T = 1 \div f = 1 \div 50 =$ **0.02 seconds**

c) 6000 cycles of wave C pass a sensor in 1 minute. Calculate the frequency of
$f = \frac{\text{number of waves}}{\text{time in seconds}} = 6000 \div 60 =$ **100 Hz**

Calculating wave speed

To calculate the speed of a wave in metres per second, multiply the wavelen

Wave speed (V) = wavelength (λ) × frequency (*f*)
Metres per second = metres per wave × waves per second

You can rearrange the wave speed equation to calculate wavelength and fr

$$\text{Wavelength} = \frac{\text{wave speed}}{\text{frequency}} \qquad \text{Frequency} = \frac{\text{wave speed}}{\text{wavelength}}$$

Example

a) Calculate the speed of a wave which has a wavelength of 30 cm and a frequ
Notice that the wavelength is in centimetres, so you must convert
30 cm = 0.3 m
Now do the multiplication $0.3 \times 250 =$ **75 m/s**

b) Calculate the frequency of a wave with a wave speed of 1500 m/s and a wav
$f = 1500 \div 7.5 =$ **200 Hz**

Calculations using standard form

Some of the calculations you need to do involve numbers in standard form

Standard form is a way of writing very large and very small numbers using

Powers of 10

Numbers like **one hundred**, **one thousand** or **one million** are often writte

Power of 10	Number in figures	Number in words
10^2	100	One hundred
10^3	1000	One thousand
10^6	1 000 000	One million
10^9	1 000 000 000	One billion

★ ***Notice that the power of ten is equal to the number of zeros.***

Example: ***Write the number one hundred thousand as a power of 10.***

Write the number out in figures, and then count the zeros to get the powe

Negative powers of 10

Negative powers of 10 are **fractions**. Very small numbers such as **thousan** usually written as negative powers of 10, like this:

Power of 10	Number in figures as a fraction	Number in figures as a decimal	Number in words
10^{-1}	$^1/_{10}$	0.1	One tenth
10^{-2}	$^1/_{100}$	0.01	One hundredth
10^{-3}	$^1/_{1000}$	0.001	One thousandth
10^{-6}	$^1/_{1\,000\,000}$	0.000001	One millionth
10^{-9}	$^1/_{1\,000\,000\,000}$	0.000000001	One billionth

A number written in standard form is made up of:

★ A number between 1 and 10, e.g. 2.5 multiplied by

★ 10 to the power of something **10^n**, where **n** means any n

Very big numbers have positive powers of 10; very small numbers have neg

The power of 10 you use is how many places you need to move the de number between 1 and 10.

Example 1: Write 253 000 000 in standard form.

Use the digits you have before the zeros to start to make a number between decimal point. Here the digits are 253 so the number is **<u>2.53.</u>**

Work out the power of 10 by counting how many places you have to move to get from 253 000 000 to 2.53, like this:

8 7 6 5 4 3 2 1
← ← ← ← ← ← ← ←
2 . 5 3 0 0 0 0 0 0 .

253 000 000 = 2.5

Example 2: Write 0.000067 in standard form.
Use the digits you have after the zeros finish to make a number between 1
point. Here the digits are **67**, so the number is **6.7.**

Work out the power of 10 by counting how many places you have to move
to get from 0.000067 to 6.7, like this:

$$\begin{array}{cccccccc} & & 1 & 2 & 3 & 4 & 5 & \\ & & \rightarrow & \rightarrow & \rightarrow & \rightarrow & \rightarrow & \\ 0 & . & 0 & 0 & 0 & 0 & 6 & 7 \end{array}$$

$\mathbf{0.000067 = 6.7 \times 10^{-5}}$

You will see numbers written in standard form during your science course,
how big or small they are. The words for the powers of 10 will help you.

Examples: You know that 10^9 is one billion, so therefore 2.5×10^9 is two
10^{-3} is one thousandth; therefore 4×10^{-3}seconds is four millis

If you need to convert a number in standard form back to an ordinary numb

Most scientific calculators have a button labelled $\boxed{\times 10^x}$ or $\boxed{\times 10^n}$ for this.

Example: Write 3.75×10^6 as a whole number.
On your calculator it's $3.75\ \boxed{\times 10^x}\ 6\ =$ the answer is 3 75

If your calculator doesn't have a standard form button, use the X^n button in

$$3.75 \times \boxed{\mathbf{10}}\ \boxed{\mathbf{x^n}}\ \boxed{\mathbf{6}}\ =$$

Alternatively, write down the number, move the decimal point six places to
spaces with zeros to maintain the value of the number.

$$\begin{array}{cccccccc} & & 1 & 2 & 3 & 4 & 5 & 6 \\ & & \rightarrow & \rightarrow & \rightarrow & \rightarrow & \rightarrow & \rightarrow \\ 3 & . & 7 & 5 & 0 & 0 & 0 & 0 \end{array}$$

$\mathbf{3.75 \times 10^6 = 3\ 750\ 000}$

Multiplying and dividing using standard form

When you multiply numbers in standard form, you **add** the powers of 10, li

$$10^3 \times 10^5 = 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10$$

Example: 2.3×10^5 multiplied by one thousand = $\mathbf{2.3 \times 10^5 \times 10^3 = 2.3}$
When you divide numbers in standard form, you **subtract** the

$$10^5 \div 10^3 = \frac{10 \times 10 \times \cancel{10 \times 10 \times 10}}{\cancel{10 \times 10 \times 10}} = 10^2$$

Example: 6×10^{-3} divided by one hundred = $\mathbf{6 \times 10^{-3} \div 10^2 = 6 \times 10^{-3-}}$

★ Use the $\boxed{\times 10^x}$ or $\boxed{\mathbf{x^n}}$ buttons on your calculator for complicated calculat

Example

A wave travels at a speed of 3×10^8 metres per second. It has a frequency of 2 m
Calculate the wavelength. Give the units of your answer.

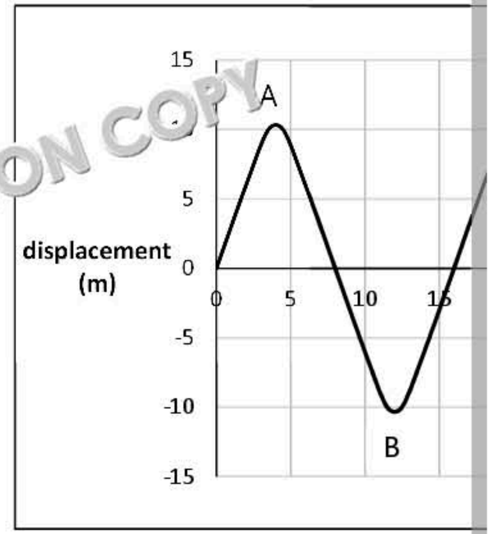
Wavelength = wave speed ÷ frequency

The frequency must be in ***hertz****. 2 megahertz = 2 million hertz = 2 ×*

On your calculator that's $3\ \boxed{\times 10^x}\ 8 \div 2\ \boxed{\times 10^x}\ 6 =$ *150 metres*

Quick questions 1

The diagram shows the progress of a wave.



1. Name the points labelled A and B.
2. What is the amplitude of this wave? State the units of your answer.
3. What is the approximate wavelength of this wave? State the units of your answer.
4. a) What is meant by the frequency of a wave?
   b) Write down the full name of the unit of frequency.
5. 4500 waves pass a sensor in 1.5 minutes. Calculate the frequency of
6. Calculate the speed of a wave which has a wavelength of 50 centime of 10 Hz.
7. The speed of light is 300 million metres per second. Write this value
8. Calculate the frequency of a wave which has a speed of 2.5×10^4 m/ 5×10^{-2} m. Give your answer in standard form.

F2: The electromagnetic spect

	Definitions
Electromagnetic waves	a group of transverse waves that transfer energy to an absorber,
Transverse waves	waves that oscillate up and down, at right angle
Vacuum	a space that contains nothing at all, not even ai
Genetic mutation	a change in the structure of the DNA in living ce

Electromagnetic waves are members of a family of waves with common pro **electromagnetic spectrum**.

All electromagnetic waves:
- ★ transfer energy from one place to another
- ★ are **transverse waves**
- ★ can travel through matter, air or through a **vacuum**
- ★ travel at exactly the same speed in a vacuum, the speed of light, 300 0
- ★ can be reflected or refracted by different materials

There are seven types of wave in the electromagnetic spectrum, and they h and wavelengths.

High	←		Wavelength	←
Radio waves	**Microwaves**	**Infrared**	**Visible light spectrum**	**Ultraviolet**
Low	→		Frequency	→

- ★ All the waves have the same speed, or velocity. Wave speed = frequen

Therefore, waves with high frequency have shorter wavelengths, and lower longer wavelengths.
- ★ The higher the frequency of a wave, the more energy it carries.

High frequency, high energy waves can penetrate and damage human tissu
- ★ Each of the seven types of wave in the spectrum has different uses, anc

Visible light

Visible light waves are the only part of the electromagnetic spectrum that can be detected by the receptor cells of the human eye.

The white light we see is actually made up of all the colours of the rainbow, and each colour has a slightly different frequency and wavelength.

Ex
Yo
or
ex
ha

Infrared ←	**Red**	**Orange**	**Yellow**	**Green**	**Blue**	**Indigo**

- ★ Red light has the lowest frequency and the highest wavelength.
- ★ Violet light has the highest frequency and the lowest wavelength.

Uses of visible light

We use visible light for seeing, lighting, photography, and visual communic emitted by lasers can be used to send Internet signals along optical fibres.

Hazards

Very bright light can damage the eyes. This can happen if you look directly a

Waves with a lower frequency and higher wavelength t

Radio waves

Radio waves have the lowest frequency of the electromagnetic spectrum an can have waves which are thousands of metres long.

Uses of radio waves

Radio waves are used for radio and TV broadcasts, satellite communication radio-controlled toys, and police radios.

Hazards

No known harmful effects due to their low frequency.

Microwaves

Microwave ovens cook food quickly by causing the water particles in the fo thermal energy, which is transferred throughout the food by conduction.

Uses of microwaves

In addition to cooking, microwaves are used for communication in mobile phones and laptop computers and also for satellite communication and weather forecasting.

Hazards

Microwaves can heat body tissues. This is why microwave ovens are made so that they won't work if the door is open. The microwave radiation in mobile phones is at a low level and has no proven harmful effe

Infrared

Infrared radiation is felt as heat and is emitted by hot objects.

Uses of infrared radiation

- ★ Cooking and heating – grills, cooker elements, toasters, and heat lamp
- ★ Thermal imaging cameras and some security systems detect infrared ra animals.
- ★ TV remote controls and optical fibres for high-speed Internet communi

Hazards

Excessive exposure to infrared waves can burn the skin if you get too close

Waves with a higher frequency and shorter wavelengt

Ultraviolet (UV) light

Ultraviolet light is emitted by the Sun, but we can't see it. It has a higher fr can penetrate the cells at the surface of the skin and kill microorganisms su

Uses of ultraviolet light

- ★ We need UV light for the skin to produce vitamin D
- ★ Fluorescent lights and sunbeds
- ★ Sterilising water and surgical equipment
- ★ Detecting forged banknotes and passports

Hazards

Excessive exposure to UV radiation can damage the skin and eyes. It can da producing harmful mutations which can lead to skin cancer.

X-rays

X-rays are high energy waves which can pass through human soft tissues, bu

Uses of X-rays

- ★ Detecting broken bones and dental problems
- ★ Sterilising medical equipment
- ★ Checking luggage at airports
- ★ Detecting broken pipes and other objects underground

Hazards

X-rays have high frequencies and can damage the DNA in cells, which can c only have occasional X-rays which is unlikely to cause a problem, but pregn advised not to have them in case they cause genetic mutations in the devel professionals who work with X-rays all the time use protective aprons and s prevent the X-rays from getting to them.

Gamma rays

Gamma rays are emitted by radioactive atoms. They have a very high frequ

Uses of gamma rays

- ★ Sterilising food and surgical equipment
- ★ Detecting cancer – the patient is given an injection of a radioactive sub more radioactivity than healthy cells, and this can be detected by a sca location of the cancer.
- ★ Gamma rays can also be used to treat cancer if they are carefully target kill the [illegible] This is called **radiotherapy**.

Hazards

Gamma rays damage the DNA in body cells, which can kill the cells or caus People who work with radioactive materials must wear protective clothing exposed to gamma rays.

Quick questions 2

1. Write down the electromagnetic spectrum in order, starting with the
2. Which colour of visible light has the highest frequency?
3. Explain why doctors recommend that people avoid spending too m
4. a) Give **one** way that X-rays are similar to radio waves.
   b) State **two** differences between X-rays and radio waves.
5. Write down **two** ways that we use infrared radiation.
6. A radio station broadcasts at a frequency of 80 megahertz. Calculat

✓ Checklist – Waves and the electromagne

I can define the following characteristics of a wave: wavelength, amplitude, freq

I can identify amplitude and wavelength on a diagram.

I can state the units for measuring wavelength, amplitude, frequency and wave

I can calculate frequency as 1 ÷ time in seconds.

I can calculate wave speed using the formula V = λf and rearrange the formula t

I can make calculations using standard form.

I can explain what is meant by the electromagnetic spectrum.

I can name the seven groups of waves in the electromagnetic spectrum.

I can place waves in the electromagnetic spectrum in order of frequency and wa

I can place colours in the visible spectrum in order of frequency and wavelength.

I can explain why there is an inverse relationship between frequency and wavele
electromagnetic spectrum.

I can describe the uses of each of the seven groups of waves in the electromagne

I can identify the harmful effects of exposure to microwaves, infrared, ultraviole

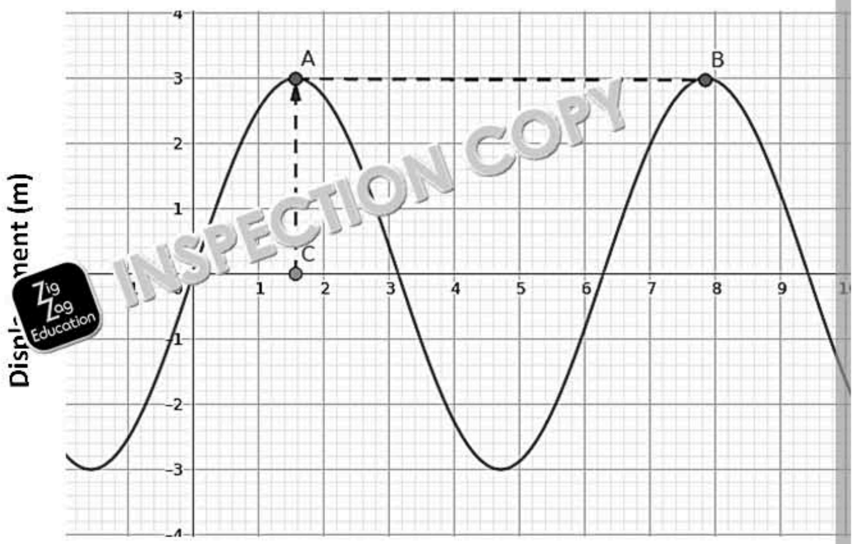
I can explain suitable safety precautions associated with these harmful effects.

I can compare different electromagnetic waves.

I can calculate the frequency and wavelength of electromagnetic waves.

Exam-style questions

1. The graph below shows a wave.

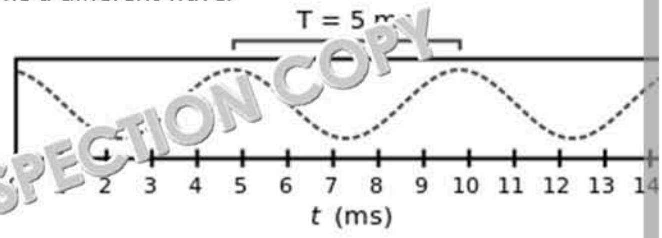


a) Copy and complete these sentences:
   (i) Point A on the graph is the .... of the wave.
   (ii) Line AB shows the .... of the wave.

b) What is the amplitude of this wave? Choose one option.

6 metres	6.2 metres	3 metres

c) This diagram shows a different wave.



The time is measured in milliseconds (ms). 1 millisecond = 0.001 sec
Calculate the frequency of this wave. Show your working and state the u

d) This wave travels at a speed of 400 m/s. Calculate its wavelength.
Wave speed = wavelength × frequency

2. The chart below shows the electromagnetic spectrum of waves:

Radio waves	Microwaves	....	Visible light	Ultraviol

a) Copy the table and fill in the missing waves.

b) Which of these waves:
   (i) has the highest frequency?
   (ii) has the longest wavelength?
   (iii) is used to detect smuggled goods at airports?

c) Many people have microwave ovens in their homes for cooking food qui
A microwave oven [illegible] start working when the door is closed. Explai

d) All electromagnetic waves travel at a speed of 300 million m/s.
A [illegible] microwave has a wavelength of 5×10^{-2}m.
Wave speed = wavelength × frequency
Calculate the frequency of this microwave. Give your answer in standard

e) Sami's cat is hit by a car and breaks his leg. The vet gives the cat an X-ra
The vet wears a lead apron while she takes the X-ray. Explain why she do

Answers

A: Cells, organs and genes

Quick questions 1

1. Any **three** from: nucleus, cytoplasm, cell membrane, mitochondria
2. Plant cells have a cell wall, anim[illegible] don't; plant cells have a (perm[illegible]) vacuole, animal ce[illegible] cells have chloroplasts, animal[illegible]on't
3. To ferti[illegible] egg / to swim towards the egg
4. cell, tissue, organ, organ system, organism

Quick questions 2

1. Water and mineral ions / minerals / nutrients
2. Evaporation of water vapour from the leaves
   Note: the word *transpiration* refers to evaporation from the leaves. The passage of water through the plant is called the *transpiration stream.*
3. Stomata
4. Any **one** from: heat, wind, dry air, light

Quick questio

[illegible] base, gene, chr

2. The shape of th
   double helix.
   The parts of the
   genetic code ar
3. **A G C T**
4. a) 46 b
5. XY

Quick questio

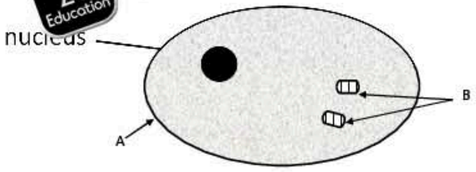
1. An allele that o
   homozygous in
2. a) **t** b
3. a) **Bb**
   b) Jerome's m
   bb. Theref
   b from her.
   must also h
   c)

Serena	b
	b

   d) ½ / 50 %

Exam-st[illegible]qu[illegible]ons

1. a)



[1]

1. b) Cell membr
   Controls th
   and out of
   c) mitochondr
   1 mark eac

2. Any **four** from:
   Water is absorbed by the roots (1)
   Root hair cells provide a large surface area for maximum absorption (1)
   Water is then transported up the stem to the leaves (1)
   In xylem vessels (1)
   Some of the water is used by the leaf cells for photosynthesis (1)
   Some of the water evaporates from the leaves (1)
   Through the stomata (1)
   This causes more water to be drawn up from [illegible] (1)
   To obtain full marks your answers [illegible]n a logical order **[4]**

3. a) hh **[1]** b) [illegible]ir (male) **[1]**
   c)

[illegible]e parent

		H	**h**
Female parent	**H**	**HH**	**Hh**
	h	**Hh**	**hh**

Up to 4 marks for correct Punnett square

Both parents must be heterozygous/Hh (1)
Kitten A has genotype hh; she inherited a recessive allele from both parer
Kitten B has short hair, so has inherited at least one dominant allele – co

Quick questions 1

1. Electrical signals / electrical impulses / nerve impulses
2. Effectors
3. Eating
4. Blinking when some dust blows into your eye
5. a) receptor → sensory neurone → relay neurone → motor neurone → effect
   b) relay neurone

Quick questions 2

1. Body temperature is monitored and controlled by the **thermoregulatory** cent
2. 37 °C is the best temperature for human enzymes / chemical reactions to wor
3. When the sweat evaporates it absorbs heat energy from the skin.
4. Any **three** from:
   The person stops sweating, and that reduces heat loss from the skin.
   Hairs stand up. This traps a layer of warm air next to the skin and reduces hea
   Blood vessels in the skin get narrower (vasoconstriction) so that less blood flo
   more heat is kept inside.
   Muscles shiver and release heat energy.

Quick questions 3

1. A chemical that affects a target organ / a chemical messenger / a chemical sig
2. Any **two** from:
   Hormones take longer to have an effect than nerve impulses
   The effects of hormones last for longer
   Hormones are transported by blood; nerve impulses are carried along neuron
   Your answer must include a comparison.
3.

Insulin	**Pancreas**	Lowers blood sugar – converts glucose to g
Glucagon	**Pancreas**	Raises blood sugar – converts glycogen to
Adrenaline	Adrenal glands	Prepares the body for action

4. Samera's blood sugar level will rise after eating because glucose is absorbed f
   this happens, her pancreas will produce insulin. Insulin removes glucose from
   glycogen), so her blood glucose level will return to normal.

Exam-style questions

1. a) Any **two** from:
      Very fast response
      Automatic/involuntary response
      Does not involve thinking
      Protects the body from harm/danger **[2]**
   b) Heat/pain **[1]**
   c) Arm muscle **[1]**
   d) X = sensory neurone Y = relay neurone Z = motor neurone (
   e) Chemicals (neurotransmitters) are released from the end of neurone X (1)
      They cross the synapse and are picked up by neurone Y (1) **[2]**
2. a) His muscles are respiring and releasing heat (thermal energy) **[1]**
   b) To obtain full marks you need to link statements – say what happens and
      Sweating (1)
      The sweat absorbs heat from the skin when it evaporates (1)
      Hairs lie flat (1)
      Sweat can evaporate more easily and heat can escape more easily (1)
      Vasodilation / blood vessels in the skin get wider (1)
      More blood flows to the surface of the skin where it can lose heat to the
   c) (i) Glucagon **[1]**
      (ii) Pancreas **[1]**
      (iii) It causes the liver to convert glycogen to glucose and release it into

C: Atoms, elements and the perio

Quick questions 1

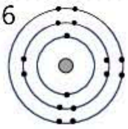
1. Protons and neutrons
2. They have a much smaller mass than protons **and** They are negatively charge
3. 6
4.

Element	Number of protons	Number of neutrons	Number c
Calcium	20	20	2
Hydrogen	1	0	
Iron	26	30	2

Quick questions 2

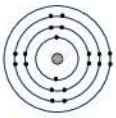
1. Groups
2. Sodium and chlorine
3. 2
4. Copper = Cu,
   Iron = Fe,
   Sodium = Na
5. Period 2, group 5

6. a) Sulfur: 2.8.6
   example



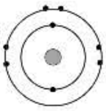
must have a to

b) Calcium: 2.8.8.2
   example



must have a

c) Oxygen: 2.6
   example



must have a tota

Quick questions 3

1. Isotopes are different versions of the same **element.** They have the same nu
   number of **neutrons** in their atoms.
2. a)

Isotope	Atomic number	Number of neutrons	Mass nu
magnesium-24	12	12	24
magnesium-25	12	13	25
magnesium-26	12	14	26

b) $\frac{(24 \times 79) + (25 \times 10) + (26 \times 11)}{100} = 24.32$

Exam-style questions

1. a) ▲ and ♣ **[1]**
   b) They are on the left of the periodic table **[1]**
   c) ♣ and ♦ **[1]**
   d) ♣ **[1]**
   e) Any **two** from:
   Electrons are much smaller than protons
   Protons are in the nucleus, electrons are in shells
   Protons have a positive charge; electrons have a negative charge **[2]**

2. a) Mass number → 23, Atomic number → 11 [1]
   b) 12 (23 – 11) **[1]**
   c) **Four** from:
   19 protons in the nucleus
   20 neutrons in the nucleus
   19 electrons in shells
   4 electron shells
   Electronic configuration is 2.8.8.1 **[4]**
   d) It is in period 4 (because it has four electron shells) (1)
   It is group 1 (because it has one electron in the outer shell) (1) **[2]**

3. a) The mean/av
   number/sam
   b) Some elemen
   (1) with the s
   different num
   c) (50.7 × 79) +
   10

D: Substances and chemical rea

Quick questions 1

1.

Name of element	Chemical symbol
Sodium	Na
Copper	Cu
Carbon	C
Magnesium	Mg
Sulfur	S

2. N_2
3. a) element b) compound
   c) compound d) mixture
   e) compound
4. In a compound the atoms are chemically bonded together, in mixtures they are not.
5.

Name of element	Number of atoms
Hydrogen	2
Sulfur	1
Oxygen	4

6. a) Moderate hazard / irritant / harmful
   b) Toxic / poison / can cause death or serious damage to health
   c) Flammable

Quick questions 2

1.

Name of compound
Sodium hydroxide
Copper oxide
Nitric acid
Magnesium carbonate
Sulfuric acid

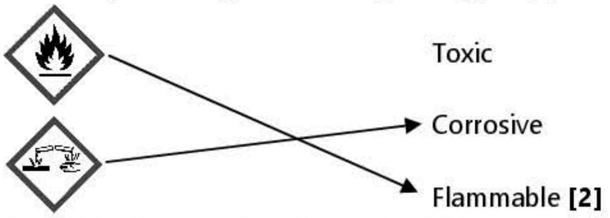
2. Any **two** from: pH less t
   litmus red / reacts with
3. Sodium hydroxide dissol
4. 7
5. b) 5
6. nitric acid + copper oxi
7. hydrochloric acid + calciu

Quick questions 3

1. a) Sulfuric acid and zi
   b) Put a lighted splint
   hydrogen is preser
   squeaky pop.
   c) $\mathbf{H_2SO_4 + Zn \rightarrow Zn}$
2. a) A salt, water and ca
   b) hydrochloric acid +
   chloride + water +
   c) $\mathbf{2HCl + Na_2CO_3 \rightarrow}$

Exam-style questions

1. a) (i) [illegible] (ii) B (iii) C (1 mark each) **[3]**
   b) Two or more elements (1)
   that are (chemically) bonded together (1) **[2]**
   c)



2. a) (i) HCl **[1]** (ii) Orange/red **[1]**
   b) (i) *Green* **[1]**
   (ii) Any **two** from:
   Has a pH of more than 7
   Turns universal indicator blue/purple
   Turns red litmus blue
   Dissolves in water **[2]**
   c) (i) sodium chloride + water (either order) **[2]**
   (ii) neutralisation / neutralising **[1]**
   (iii) Indigestion/heartburn is caused by (excess) stomach acid (1)
   Magnesium hydroxide reacts with the acid and neutralises it (1) **[2**
3. a) (i) Carbon dioxide / CO_2 **[1]**
   (ii) Collect the gas and bubble it through lime water (1)
   If CO_2 is present the lime water will turn cloudy/white (1) **[2]**
   b) $Na_2CO_3 + 2HNO_3 \rightarrow 2NaNO_3 + CO_2 + H_2O$
   (1) (1) (1) (1) **[4]**

E: Energy and how we use i

Quick questions 1

1. a) thermal/heat (and light) b) mechanical/kinetic and sound (and he
2. Mechanical and chemical energy
3. Chemical energy
4. Making nuclear weapons and generating electricity. Also medical applications
   diagnostic imaging and cancer treatment
5. a) Gravitational potential energy b) Kinetic energy c) Elastic pot

Quick questions 2

1. Energy cannot be created or destroyed, only transferred / energy input = ener
2. chemical energy → kinetic energy
3. chemical energy → electrical energy → light energy
4. a) Light, sound, and thermal/heat energy b) Thermal/heat ene
5. a) 400 – 250 = 150 joules/J b) (250 ÷ 400) × 1
6. a) The wax will melt and the ball will fall off b) Conduction
7. 750 ÷ 5 = 150 watts
8. a) kilowatt-hours / kWh b) 1.6 × 0.5 × 30 =

Quick questions 3

1. Energy sources that can be easily replaced / can be replaced in a human lifeti
2. a) renewable b) non-renewable c) non-renewable
3. Any **two** from: coal, oil, (natural) gas
4. a) It is reliable / currently easy to obtain
   b) Any **two** from: produces carbon dioxide / linked to global warming / con
   produces sulfur dioxide / causes acid rain; produces smoke / air pollution
   c) Non-renewable / it will run out

Exam-style questions

1. a) Kinetic/mechanical energy **[1]**
   b) Sound energy (1)
   Thermal (heat) energy (1) **[2]**
   c)

   d) $60 = \frac{120}{\text{total energy input}} \times 100$ energy input = (100 ÷ 60) × 120 = 200

2. a) The amount of energy transferred (1) in 1 second / per second / in a spec
   b) 1800 × 60 × 60 = 6 480 000 J = 6.48 MJ **[2]**
   c) 1800 W = 1.8 kWh 1 week = 7 days
   28 p × 1.8 kWh × 6 hours × 7 days = 2116.9 p = 2117 p **[3]**
   d) Convection **[1]**

3. a) Can be replaced / can be easily replaced / does not run out **[1]**
   b) Solar / Sunlight / Waves / Tides / Hydroelectric power / Geothermal / Bio
   c) Any four from the list below, must have at least one advantage and at lea
   Advantages – No fuel costs, so cheaper to run once it's set up
   Does not produce CO_2 / does not contribute to climate
   Does not produce sulfur dioxide / does not contribute t
   Sustainable – will not run out
   Helps to conserve fossil fuel supplies
   Disadvantages – Not always reliable, because there needs to be enough
   High start-up costs
   Wind turbines are noisy / ugly to look at
   Wind turbines can kill/harm birds **[4]**

F: Waves and the electromagnetic s

Quick questions 1

1. A = crest/peak   B = trough
2. 10 metres/m
3. 16 metres/m (any answer between 15 and 17 metres is acceptable)
4. a) The number of waves that pass a point every second / waves per second
   b) Hertz
5. 4500 waves ÷ 90 seconds = 50 [illegible]
6. 0.5 m × 10 Hz = 5 metres per second / m/s
7. 3 × 10^8 m/[illegible]
8. 2.5 $\boxed{\times 10^x}$ [illegible] $\boxed{\times 10^x}$ -2 = 5 × 10^5 Hz

Quick questions 2

1. Gamma rays, X-rays, Ultraviolet, Visible light, Infrared, Microwaves, Radio wave
2. Violet
3. Sunlight contains ultraviolet radiation, which can cause skin cancer
4. a) Any **one** from: both travel at the speed of light (300 000 000 m/s) / same both electromagnetic waves / both transverse waves
   b) Any **two** from: X-rays have higher frequency / X-rays have lower wavelen frequency / radio waves have longer wavelength / radio waves have no h damage body cells / radio waves are used for communication, X-rays are detection
5. Any **two** from: cooking, thermal imaging, optical fibres, television remote cont
6. 80 megahertz = 80 000 000 Hz, speed = 300 000 000 m/s
   Wavelength = 300 000 000 ÷ 80 000 000 = 3.75 m

Exam-style questions

1. a) (i) crest/peak (1)   (ii) wavelength (1) **[2]**
   b) 3 metres **[1]**
   c) T [illegible] 5 seconds   f = 1/T = 200 (1) hertz/Hz (1) **[2]**
   d) 40 [illegible] 0 (1) = 2 (m) (1) **[2]**

2. a) **[2]**

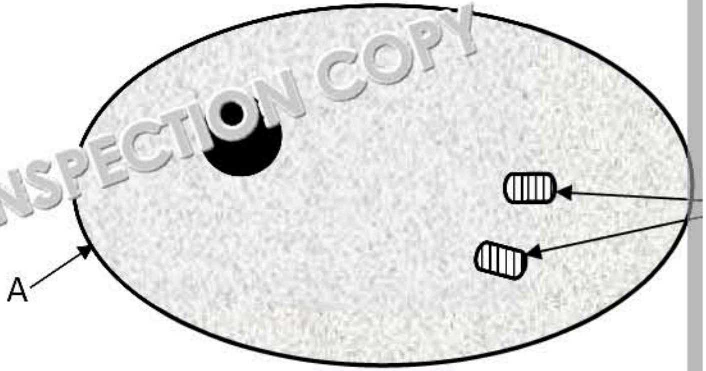
Radio waves	Microwaves	Infrared (1)	Visible light	Ultra-violet

   b) (i) Gamma rays **[1]**   (ii) Radio waves **[1]**   (iii) X-rays **[1]**
   c) A microwave oven can heat up the water inside human cells (1) and this c chemical reactions in cells (1) **[2]**
   d) Frequency = wave speed ÷ wavelength (1)
   300 million = 3 × 10^8 (1)
   3 $\boxed{\times 10^x}$ 8 ÷ 5 $\boxed{\times 10^x}$ -2 = **6 × 10^9** (1) Hz (1)
   Or 3 ÷ 5 × $10^{8-(-2)}$ = 0.6 × 10^{10} = 6 × 10^9 Hz **[4]**
   6 000 000 000 Hz or 6000 MHz gains 3 marks
   e) X-rays can penetrate human tissue (because they are high frequency / hi and can damage the DNA inside cells / cause genetic mutations / cause c

Exam-style questions:
Chapter A: Cells, organs and ge

1. Figure 1 shows a generalised animal cell.

Figure 1



a) Label the **nucleus** on the diagram.

b) Name part A and describe its function.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

c) Complete the sentence by writing **one** word in each space:

The organelles labelled B are ……………………………………, and they relea

for the cell by means of a chemical reaction called ……………………………

2. Figure 2 shows how water travels through a plant.

Describe what takes place in steps 1, 2 and 3 of this process.

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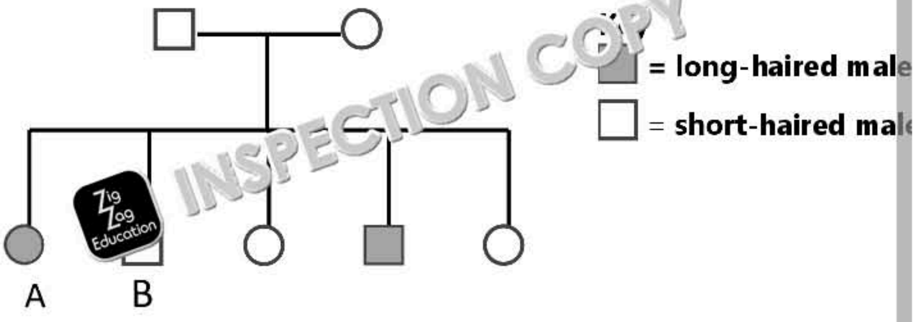
3. Cats can be long-haired or short-haired.

The allele for short hair, **H**, is dominant. The allele for long hair, **h**, is recessive

Figure 3 shows a pedigree diagram for two cats and their kittens.

Figure 3



a) What is the genotype of kitten A? ……………………………………………

b) Write down the phenotype of kitten B. ……………………………………………

c) Explain how coat length is inherited by kittens A and B. Use a Punnett sq

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Exam-style questions:
Chapter B: Homeostasis and comm

1. a) What is a **reflex** action?

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Yasmin is in the kitchen. She accidentally touches a hot pan. She immediatel

b) What is the **stimulus**?

....

c) Which body part makes the **response**?

....

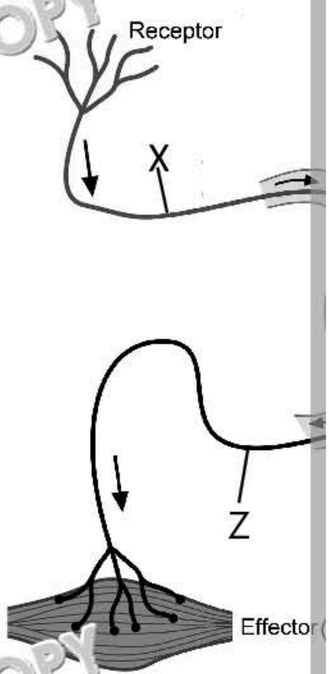
Figure 1 shows what is happening in Yasmin's nervous system.

d) Name the structures labelled X, Y and Z.

X ....

Y ....

Z ....



e) Between X and Y there is a [illegible] called a synapse. Explain how the n

....

....

....

....

2. Ali is playing in a football match.
As he runs for the ball, his body temperature increases.

a) Why does Ali's body temperature increase?

....

....

b) Explain how Ali's body responds to prevent his temperature from gettin

....

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....

c) During the match, Ali's blood sugar level starts to fall. A hormone is relea
to normal.

(i) What is the name of the hormone? ....

(ii) Which gland releases this hormone? ....

(iii) How does it raise Ali's blood sugar?

....

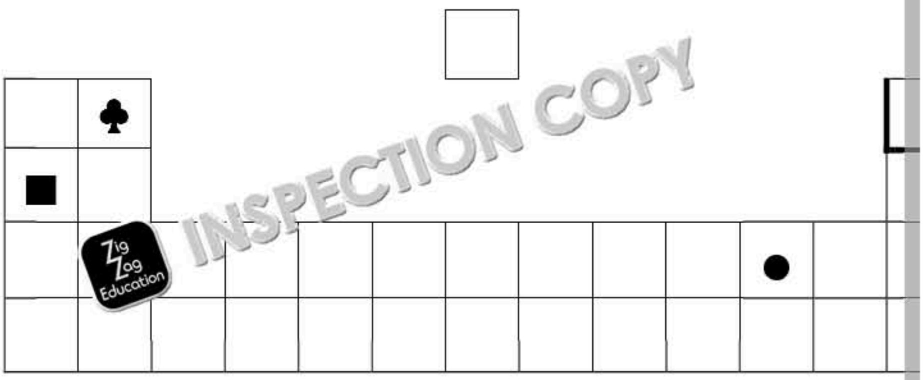
....

....

....

Exam-style questions:
Chapter C: Atoms, elements and the pe

1. The diagram below shows part of the periodic table. The symbols represent el



a) Which **two** elements are both metals?

☐ ♥ and ♣ ☐ ▲ and ♣ ☐ ▲ and ♦

b) Give a reason for your choice.

....

....

c) Which **two** elements are in the same **period**?

☐ ▲ and ♣ ☐ ● and ♠ ☐ ♣ and ♦

d) Which of these elements has th[illegible]est number of **electrons**?

☐ ♥ ☐ ♦ ☐ ▲

e) Write down **two** differences between an electron and a proton.

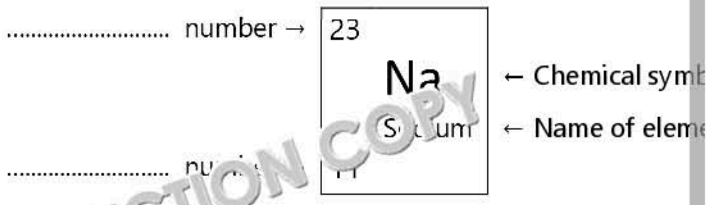
....

....

....

....

2. The entry in the periodic table for the element sodium is shown below.



a) Fill in the spaces to complete the entry.

b) How many **neutrons** does a sodium atom contain? ....

This is the entry for potassium.

39	K
19	Potassium

c) Describe the atomic structure of potassium, including its electronic config

d) Describe the position of potassium in the periodic table.

3. Part of the periodic table is shown below.

56	59	59	63.5	65	← relative atomic
Fe	**Co**	**Ni**	**Cu**	**Zn**	← symbol
iron	cobalt	nickel	copper	zinc	← name
26	27	28	29	30	← atomic numbe

Key

a) Explain what is meant by ***relative atomic mass***.

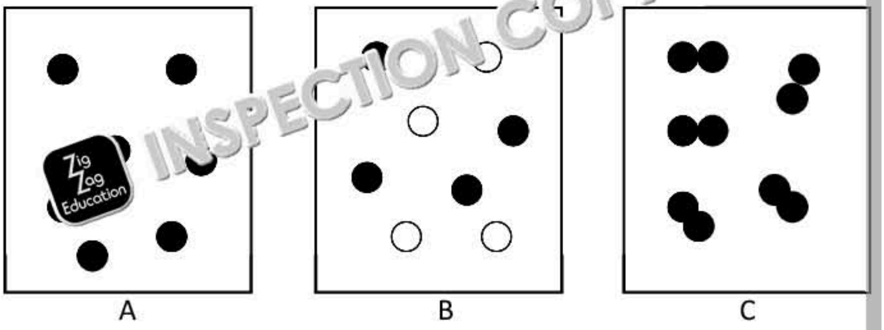
b) Explain why the relative atomic mass of copper is not a whole number.

c) The element bromine (Br) has the atomic number 35.
50.7 % of bromine atoms have a mass number 79, the rest have mass numb
Calculate the relative atomic mass of bromine. Give your answer to two s

Exam-style questions:
Chapter D: Substances and chemical

1. a) Figure 1 shows four substances, labelled A, B, C and D.

Figure 1



Which of these substances:

(i) is a compound? ....

(ii) is a mixture? ....

(iii) could be oxygen? ....

b) Explain what is meant by the term ***compound***.

....

....

....

....

c) Some chemical substances carry hazard warning labels.
Draw straight lines to match these symbols to the hazards they represent

Toxic
Corrosive
Flammable

2. a) Yasmin adds hydrochloric acid to universal indicator solution in a test tub

(i) What is the chemical formula for hydrochloric acid? ……………………………

(ii) What colour will the indicator be after adding the acid?

☐ Orange/red ☐ Yellow/green ☐ Green/blue

b) Yasmin then adds an equal amount of sodium hydroxide to the test tube.

(i) What is the most likely colour of the indicator after adding the sodiu

☐ Blue ☐ Red ☐ Yellow

(ii) Sodium hydroxide is an **alkali**. Write down **two** chemical properties

……………………………………………………………………………………

……………………………………………………………………………………

c) An acid will react with an alkali to form two new compounds.

(i) Complete this word equation to show the products that are formed sodium hydroxide react together.

Hydrochloric acid + sodium hydroxide → ……………………………… +

(ii) Complete the sentence:

The chemical reaction between an acid and a base is called ………………

(iii) Bases such as magnesium hydroxide are often used to treat indigesti

Explain how this treatment works.

……………………………………………………………………………………

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3. a) Zak mixes dilute nitric acid with sodium carbonate in a flask. A gas is pro

(i) What is the name of the gas? ……………………………………………………

(ii) How would you test this gas to confirm its identity?

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

b) The formula for sodium carbonate is Na_2CO_3. The formula for sodium nit

Write a balanced chemical equation for the reaction between sodium car

……………………… + ……………………… → ……………………… + ……………………… +

Exam-style questions:
Chapter E: Energy and how we

1. The illustration below shows a food mixer. The motor turns the whisks to mix

a) Name the type of useful energy transferred by the motor.

....

[1]

b) Give **two** forms of wasted energy produced by the motor.

1. ....

2. ....

[2]

c) Complete the Sankey diagram below for this food mixer:

d) The energy efficiency of this mixer is 60 %. It produces 120 J of useful en
mix pancake batter.

Calculate the total energy input to the mixer.

$$\text{Energy efficiency} = \frac{\text{useful energy output}}{\text{total energy input}} \times 100$$

Show your working.

....

....

....

....

2. Mrs Okambo has an electric fire in her living room.

The power of the fire is 1800 wat

a) Explain what is meant by the **power** of an appliance.

....

....

....

....

b) How much energy does this fire use in one hour? Show your working.

c) Electricity costs 28 p per kilowatt-hour.

Calculate the cost of running the fire for six hours every day for one wee

Show your working, and give your answer in pence to the nearest whole

d) The electric fire heats the whole room by (select **one**):

☐ Conduction ☐ Convection ☐ Radiation

3. Electricity can be generated using renewable and non-renewable sources of en

Wind power is a renewable energy source.

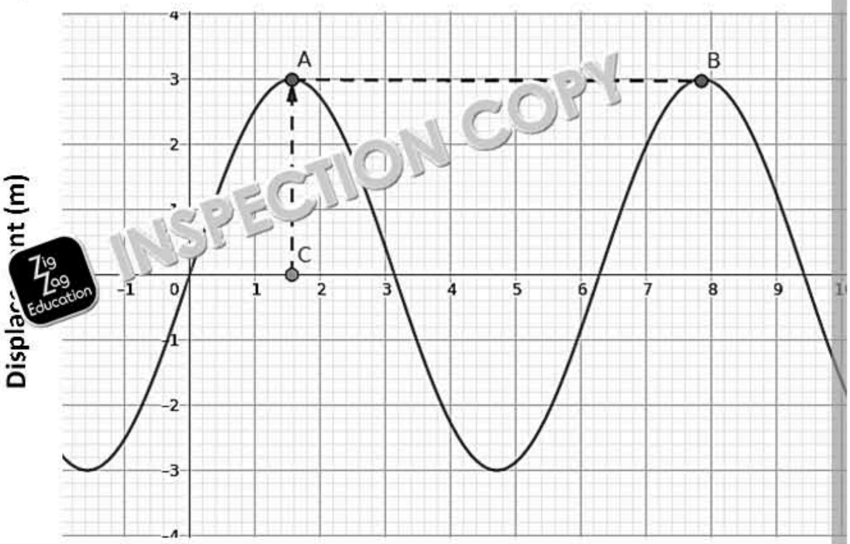
a) Explain what is meant by a renewable source of energy.

b) Give **one** other example of a renewable energy source.

c) Evaluate the advantages and disadvantages of generating electricity fro burning fossil fuels.

Exam-style questions:
Chapter F: Waves and the electromagne

1. The graph below shows a wave.



a) Complete these sentences:

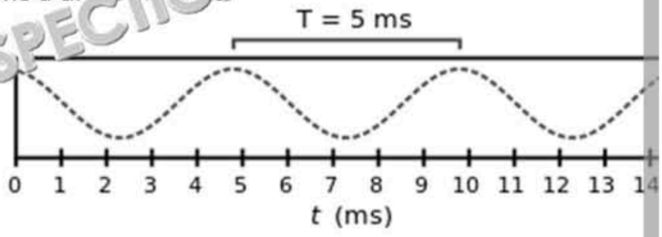
(i) Point A on the graph is the .... of the wave.

(ii) Line AB shows the .... of the wave.

b) What is the amplitude of this wave?

☐ 6 metres ☐ 6.2 metres ☐ 3 metres

c) This diagram shows a different wave.



The time is measured in milliseconds (ms). 1 millisecond = 0.001 sec

Calculate the frequency of this wave. Show your working and state the u

....

....

....

....

d) This wave travels at a speed of 400 m/s. Calculate its wavelength.

Wave speed = wavelength × frequency

....

....

....

....

2. The chart below shows the electromagnetic spectrum of waves:

Radio waves	**Microwaves**	………………	**Visible light**	**Ultraviolet**

a) Fill in the missing waves.

b) Which of these waves

(i) has the highest frequency? ……………………………

(ii) has the longest wavelength? ……………………………

(iii) is used to detect smuggled goods at airports? ……………………………

c) Many people have microwave ovens in their homes for cooking food quic
A microwave oven will only start working when the door is closed. Explai

……………………………………………………………………………………………………

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d) All electromagnetic waves travel at a speed of 300 million m/s.
A typical microwave has a wavelength of 3×10^{-2}m.
Wave speed = wavelength × frequency
Calculate the frequency of this microwave. Give your answer in standard

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e) Sami's cat is hit by a car and breaks his leg. The vet gives the cat an X-ray
The vet wears a lead apron when she takes the X-ray. Explain why she do

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