Year 10 Combined Science Paper 1 checklist

Biology

Cell Biology

Cells are individual units.
The nucleus controls the cell and contains DNA to create all the proteins.
The cytoplasm suspends all other organelles and where chemical reactions happen.
The cell membrane controls entry and exit in/out of the cell.
The mitochondria releases energy by aerobic respiration.
The ribosomes synthesis proteins.
The cell wall is made of cellulose and gives support to the cell.
The permanent vacuole fills with cell sap to keep the cell rigid.
The chloroplasts contain chlorophyll and carry out photosynthesis.
Algae, are protists not plants, even though they carry out photosynthesis.
Eukaryotic cells have genetic material enclosed in a nucleus.
Eukaryotes include: animals, plants, fungi, and Protista.
Prokaryote cells do not contain genetic material in a nucleus, can have additional pieces of DNA and are single celled.
Prokaryote cells are 1-2 orders of magnitude smaller than eukaryotes.
A plasmid is a small ring of DNA.
The cell wall of a prokaryote is not made of cellulose.
Some prokaryotes have a slime capsule, for additional protection.
A tail like structure is sometimes present on a prokaryote cell, called a flagellum/flagella.
Microscopes are used to magnify an object to allow it to be observed.
Microscopes use a range of methods to magnify, including light and electron beams.
Magnification is the process of making something bigger than it.
Magnify means to make something appear lager than it is.
Total magnification is calculated by multiplying the eyepiece lens magnification with the objective lens magnification.
Use the equation Magnification = Image size ÷ Real size
Resolution is the ability to distinguish between two separate points.
Resolving power refers to how much detail a magnifier can show.
Specialised cells have a specific shape and structures/organelles which enable them to carry out a specific function.
Differentiation is the process by which a cell becomes specialised.
Sperm cells are specialised for sexual reproduction.
Muscle cells are specialised for contraction and relaxation.
Nerve cells are specialised to carry electrical impulses.
Root hair cells are specialised to absorb water and mineral ions.
Phloem cells are specialised to transport sugars around the plant.
Xylem cells are specialised to transport water and mineral ions up the plant.
Diffusion is the spreading of particles of gas, or of any substance in solution, from a region of high concentration to a region of lower concentration.
The rate of diffusion is affected by: temperature of the particles, concentration of the particles, size of the particles.
Active transport is the movement of substances against the concentration gradient, from a lower concentration to a higher concentration.
A partially permeable membrane allows some substances through but not all substances.
A dilute solution contains a high concentration of water.
A concentrated solution contains a low concentration of water.
Osmosis is the movement of water particles from a dilute solution to a concentrated solution, across a partially permeable membrane.
An isotonic solution the concentration of solutes is the same inside and outside the cell.

In a hypertonic solution, the concentration of solutes is higher outside the cell than inside.
In a hypotonic solution, the concentration of solutes is lower outside the cell than inside.
Animal cells can be damaged if the concentration of water dramatically changes outside the cell.
Turgor pressure exists in cells with a cell wall, it makes a cell hard and rigid.
Plasmolysis occurs when water is lost from a plant cell causing the vacuole and cytoplasm to shrink, pulling the cell membrane away from the cell wall.
Surface area to volume ratio shows the size of the organisms surface compared to the volume of cells it contains.
The SA:Vol ratio falls as the object gets larger, meaning simple diffusion is not sufficient enough for adequate collection and removal of substances.
Several adaptations allow for more efficient exchange: large surface area, thin membranes, blood supply (where applicable), and steep concentration gradients.
Chromosomes carry the genes that contain the instructions for making new cells.
A gene is a section of DNA that contains the instructions to make one protein.
A human contains 46 chromosomes as 23 pairs. 23 from the mother and 23 from the father.
Mitosis is the process of cell division, which produces two identical cells, mainly for growth and repair of cells/tissues/organs.
The cell cycle varies in length from less than 24hours to more than several years.
The cell cycle has 3 stages, the first stage is the longest and where DNA and organelles are replicated, stage 2 is mitosis and stage 3 is the final division of the cell into 2 identical daughter cells.
Differentiation (already encountered)
Stem cells are unspecialised cells, able to become any type of cell.
Plants have specific locations of stem cell dense areas called the meristem, which remains undifferentiated for the plant's entire life.
Asexual reproduction involves the parent plant producing offspring using mitosis.
When identical offspring are produced from a single parent, this is called cloning.
A zygote is a single new cell produced from the fusion of an egg and sperm nucleus.
Embryonic stem cells are the inner cells within the embryo just after it has started dividing.
Adult stem cells are partially differentiated cells, able to become any type of cell within the tissue they are located.
Stem cells can be cloned and made to differentiate into many different cell types.
Plant meristems allow for plants to be quickly cloned for research, horticultural, and agricultural uses.
Stem cell treatments are being developed to help conditions like diabetes.
Progress with using stem cells has been extremely slow and expensive.
Therapeutic cloning involves using cells from an adult to create an early embryo of themselves as a source of perfectly matched cells, reducing rejection.
Stem cell use has risks as well as ethical and religious implications.

Organisation

Cells are the basic building blocks of all living organisms.
A tissue is a group of cells with a similar structure and function.
Organs are collections of tissues performing specific functions.
Organs are organised into organ systems, which work together to form organisms.
Both animals and plants have organ systems which each perform a role within the organism.
An example of an organ system would be the nervous system, which consists of the brain, spinal cord, nerves, receptors and effectors.
The digestive system is another example of an organ system in which several organs work together to digest and absorb food.
Digestive enzymes convert food into small soluble molecules that can be absorbed into the bloodstream.
The small intestine is adapted for efficient absorption of digestive products by being lined with small projections called villi, which are in turn lined with cells called microvilli.
Villi and microvilli increase the surface area of the small intestine allowing for fast absorption of the products of digestion.
Carbohydrates, lipids, and proteins are the main compounds that make up the structure of a cell. They are large molecules made up by smaller molecules joined together as part of cell metabolism.

Carbohydrates are made of long chains of sugars, such as glucose.
Proteins are made of chains of amino acids folded into 3D shapes.
Lipids are made of 3 fatty acid chains attached to one glycerol molecule.
Qualitative reagents are used to test for a range of carbohydrates, lipids and proteins.
Benedict's test is to identify if simple sugars are present in the food. A positive test is a change from blue to brick-red.
Iodine test is to identify if starch is present in the food. A positive test is a change from yellow/brown to blue/black.
Biuret reagent is to identify if protein is present in the food. A positive test is a change from blue to lilac/purple.
The emulsion test identifies lipids by turning the solution cloudy.
Enzymes control metabolism (the chemical reactions that occur daily in our body), this includes building molecules as well as breaking some down.
Enzymes are proteins.
Enzymes catalyse specific reactions in living organisms due to the shape of their active site.
The model of enzyme action we use is called the "lock and key" hypothesis.
Enzymes are chemicals, if their active site shape changes the enzyme cannot work and it is said to be "denatured".
Enzymes speed up reactions, as they are biological catalysts.
Their rate of reaction is influenced by temperature and pH changes.
Rate of reaction can be calculated using the formula: rate = 1÷time.
Know how to investigate the effect of pH on the rate of reaction of amylase enzyme.
A continuous sampling technique is used to determine the time taken to completely digest a starch solution at a range of pH values. Iodine reagent is used to test for starch.
Temperature is able to be controlled by the use of a water bath or electric heater.
Amylase is produced by the salivary glands and the pancreas.
Proteases are produced by the lining of the stomach and in the pancreas.
Lipases are produced by the pancreas.
Carbohydrase's break down carbohydrates into simple sugars. Amylase is a carbohydrase which breaks down starch.
Proteases break down proteins to amino acids.
Lipases break down lipids (fats) to glycerol and fatty acids.
The products of digestion are used to build new carbohydrates, lipids and proteins. Some glucose is used in respiration.
Bile is made in the liver and stored in the gall bladder.
Bile is alkaline to neutralise hydrochloric acid from the stomach. Bile also emulsifies lipids to form small droplets which increases the surface area allowing enzymes to work faster to digest lipids.
The heart is an organ that pumps blood around the body in a double circulatory system.
The right ventricle pumps deoxygenated blood via the pulmonary artery to the lungs where gas exchange takes place.
The left ventricle pumps oxygenated blood to the rest of the body via the aorta.
The vena cava brings deoxygenated blood back from the body to the right side of the heart.
The pulmonary vein brings oxygenated blood back to the left side of the heart.
The coronary arteries supply the heart with the oxygen and glucose it needs for respiration.
The natural resting heart rate is controlled by a group of cells located in the right atrium that act as a pacemaker.
Artificial pacemakers are electrical devices used to correct irregularities in the heart rate.
The body contains three different types of blood vessel: • arteries • veins • capillaries.
Arteries carry blood away from the heart at high pressure and speed. They have thick muscular and elastic layers with narrow lumens.

Veins bring blood back to the heart under low pressure and speed. They have less muscles and elastic tissue with large lumens.
Capillaries are where diffusion of nutrients and wate products in and out of the blood occurs. They are one cell thick to allow for efficient diffusion.
Blood is a tissue consisting of plasma, in which red blood cells, white blood cells and platelets are suspended.
Plasma is the liquid portion of the blood which carries dissolved nutrients and waste substances, as well as larger proteins such as hormones.
Red blood cells transport oxygen and contain a chemical called haemoglobin which converts to oxyhaemoglobin when oxygen is present.
White blood cells are part of the immune system which fights pathogens.
Platelets allow for the blood to clot when needed, preventing blood loss out of exposed vessels.
The lungs are large organs which allow for gas exchange to occur.
Breathing is a mechanical process, also called ventilation.
Gas exchange is the movement of oxygen from the air into the blood stream and carbon dioxide from the blood stream into the air.
The trachea is a large tube that has rings of cartilage around it in a C shape to prevent the trachea from closing.
The trachea divides into two, called the bronchi.
The bronchi divide further eventually leading to billions of tiny air sacs called alveoli.
Alveoli are one cell thick and surrounded by capillaries to allow for efficient gas exchange.
The roots, stem and leaves form a plant organ system for transport of substances around the plant.
Epidermal tissue covering the leaf provides a protective covering and is transparent to allow light to pass through. Sometimes it is also covered in a waxy waterproof layer.
The palisade mesophyll contains the palisade cells which are specialised to photosynthesise.
The spongy mesophyll contains air spaces to allow for gas exchange to occur within the plant.
The xylem and phloem are transport vessels, carrying water and minerals and sugars.
The meristem tissue found at the growing tips of shoots and roots is a site of undifferentiated cells.
Guard cells surround an opening called the stomata, which allows for gases to enter and exit as well as water vapour.
Root hair cells create a large surface area for increased osmosis of water and active transport of minerals into the root.
Transpiration is the movement of water through the xylem vessels which then evaporates out of the stomata in the leaf.
Factors affecting the rate of transpiration include: temperature, humidity, air movement and light intensity.
Xylem tissue transports water and mineral ions from the roots to the stems and leaves. It is composed of hollow tubes strengthened by lignin adapted for the transport of water in the transpiration stream.
Phloem tissue transports dissolved sugars from the leaves to the rest of the plant for immediate use or storage.
The movement of food molecules through phloem tissue is called translocation.
Phloem is composed of tubes of elongated cells. Cell sap can move from one phloem cell to the next through pores in the end walls.
Diseases, both communicable and non-communicable, are major causes of ill health.
Many other factors including diet, stress and life situations may have a profound effect on both physical and mental health. These are called “risk factors”.
Correlation does not necessarily mean causation. Many risk factors increase the risk of disease but may not directly cause a disease.
Describe the relationship between health and disease and the interactions between different types of disease.
Evaluate the human and financial cost of disease.

Different types of disease may interact. •• Defects in the immune system mean that an individual is more likely to suffer from infectious diseases. •• Viruses living in cells can be the trigger for cancers. •• Immune reactions initially caused by a pathogen can trigger allergies such as skin rashes and asthma. •• Severe physical ill health can lead to depression and other mental illness.
Translate disease incidence information between graphical and numerical forms and discuss the use of sampling in data.
A causal mechanism has been proven for some risk factors, but not in others. •• The effects of diet, smoking and exercise on cardiovascular disease. •• Obesity as a risk factor for Type 2 diabetes. •• The effect of alcohol on the liver and brain function. •• The effect of smoking on lung disease and lung cancer. •• The effects of smoking and alcohol on unborn babies. •• Carcinogens, including ionising radiation, as risk factors in cancer.
Many diseases are caused by the interaction of a number of factors.
Evaluate the advantages and disadvantages of treating cardiovascular diseases by drugs, mechanical devices or transplant.
In coronary heart disease layers of fatty material build up inside the coronary arteries, narrowing them. This reduces the flow of blood through the coronary arteries, resulting in a lack of oxygen for the heart muscle.
Stents are used to keep the coronary arteries open.
Statins are widely used to reduce blood cholesterol levels which slows down the rate of fatty material deposit.
In some people heart valves may become faulty, preventing the valve from opening fully, or the heart valve might develop a leak.
Faulty heart valves can be replaced using biological or mechanical valves.
In the case of heart failure a donor heart, or heart and lungs can be transplanted.
Artificial hearts are occasionally used to keep patients alive whilst waiting for a heart transplant, or to allow the heart to rest as an aid to recovery.
Cancer is the result of changes in cells that lead to uncontrolled growth and division.
Benign tumours are growths of abnormal cells which are contained in one area, usually within a membrane. They do not invade other parts of the body.
Malignant tumour cells are cancers. They invade neighbouring tissues and spread to different parts of the body in the blood where they form secondary tumours.
Scientists have identified both lifestyle and genetic risk factors for various types of cancer.

Ecology

An ecosystem is the interaction of a community of living organisms (biotic) with the non-living (abiotic) parts of their environment.
Organisms do not live in isolation, even if they are solitary individuals.
Organisms require materials from their surroundings and other living organisms to survive and reproduce.
A community is made up of the populations of different species of animals, plants, Protista, fungi, bacteria and archaea that are all interdependent in a habitat.
Within a community, each species depends on the other species for food, shelter, pollination, seed dispersal and more.
If one species is removed from the community it can affect all of the species, this is called interdependence.
A stable community is one where all the species and environment are in balance so that population sizes remain fairly constant.
Abiotic (non-living) factors which can affect a community are: • light intensity • temperature • moisture levels • soil pH and mineral content • wind intensity and direction • carbon dioxide levels for plants

• oxygen levels for aquatic animals.
Biotic (living) factors which can affect a community are: • availability of food • new predators arriving • new pathogens • one species outcompeting another so the numbers are no longer sufficient to breed.
The abundance and distribution of organisms in an ecosystem can depend on living and non-living factors.
A quadrat is a simple device used to estimate the number of organisms in a habitat.
When counting a population, sample size is important to consider as well as random sampling methods, such as random number generation to produce a set of coordinates at which to place the quadrat on the ground.
Quantitative sampling means you take multiple readings at different locations within the defined sample area and then calculate a mean.
Quantitative sampling is useful for comparing the same organism in different locations. A transect is a linear line across a habitat.
Transects are not random and are used to look at how a changing habitat affects the distribution of organisms within it.
The best-adapted individuals are most likely to win the competition for resources.
These organisms are more likely to survive and reproduce.
Competition exists between members of the same species and members of different species.
Animals compete with each other for food, territories, and mates.
Plants compete with each other for light, space, water, and mineral ions from the soil.
All organisms, including microorganisms, have features (adaptations) that enable them to survive in the conditions in which they normally live.
These adaptations could be structural, behavioural or functional.
Plant adaptations involve: • ways in which they spread their seeds • size and position of their leaves • methods of pollination • collection and retention of water
Animal adaptations involve: • Size and type of teeth • Bodily functions such as special salt glands to remove excess sea salt • Chemicals in their bodies which prevent freezing. • Changing their fur/coat to cope with varying temperatures • Camouflage techniques • Water retention
An extremophile is an organism that can survive in the most difficult conditions on the planet.
Most extremophiles are in the archaea domain, some are bacteria, plants or animals with special adaptations to certain environments.
Photosynthetic organisms are the producers of biomass for life on Earth.
Feeding relationships within a community can be represented by food chains.
All food chains begin with a producer which synthesises new molecules.
Producers are eaten by primary consumers, which in turn may be eaten by secondary consumers and then tertiary consumers.
Consumers that eat other animals are often predators and those that are eaten are prey.
In a stable community the numbers of predators and prey rise and fall in cycles.
All materials in the living world are recycled to provide the building blocks for future organisms.
The carbon cycle returns carbon from organisms to the atmosphere as carbon dioxide to be used by plants in photosynthesis.
The water cycle provides fresh water for plants and animals on land before draining into the seas. Water is continuously evaporated and precipitated.
Microorganisms are essential to the recycling of materials through an ecosystem by returning carbon to the atmosphere as carbon dioxide and mineral ions to the soil.
Biodiversity is the variety of all the different species of organisms on Earth, or within an ecosystem.
Biodiversity ensures the stability of ecosystems by reducing the dependence of one species on another for food, shelter and the maintenance of the physical environment.
The future of the human species on Earth relies on us maintaining a good level of biodiversity. Many human activities are reducing biodiversity and only recently have measures been taken to try to stop this reduction.
Rapid growth in the human population and an increase in the standard of living mean that increasingly more resources are used and more waste is produced.

Humans reduce the amount of land available for other animals and plants by building, quarrying, farming and dumping waste.
Pollution can occur: • in water, from sewage, fertiliser or toxic chemicals • on land, from landfill and from toxic chemicals.
Pollution kills plants and animals which can reduce biodiversity.
Pollution levels in water can be measured by oxygen and pH content. Pollution can also be measured by looking at bioindicators – these are a range of organisms found in different levels of polluted water.
Pollution can occur in the air from smoke and acidic gases.
Acidic gases are produced from the burning of fossil fuels: • Carbon reacts with oxygen to make carbon dioxide • Sulfur impurities reacts with oxygen to form sulfur dioxide • Nitrogen in the atmosphere reacts with oxygen inside the hot engine to form nitric acid
Acidic gases dissolve in rain water to form acid rain.
Acid rain causes damage to buildings, trees, lakes and soil.
Smoke pollution refers to small unburnt carbon particles called "particulates". These cause cooling and reduced light levels.
Smog is caused by a mixture of all these gases and particulates. It causes a brownish haze above a city. Smog is very dangerous to organisms, especially those with respiratory illnesses.
Large scale deforestation in tropical areas has occurred to provide land for cattle and for rice fields and to grow crops for biofuels.
The destruction of peat bogs and other areas of peat to produce garden compost reduces the area of this habitat and thus the biodiversity associated with it.
"Peat free" composts reduce carbon emissions and conserve peat bogs and peatlands as habitats for biodiversity.
The decay or burning of peat releases carbon dioxide into the atmosphere further fuelling global warming.
Levels of carbon dioxide and methane in the atmosphere are increasing and contribute to global warming.
The greenhouse effect is the warming of the Earth when solar radiation is absorbed by gases in the atmosphere, such as carbon dioxide and methane, keeping the Earth at an average temperature suitable for life on Earth to thrive.
Global warming happens due to excessive levels of carbon dioxide and methane entering the atmosphere, increasing the amount of solar radiation that is absorbed and heating the Earth up more than it needs.
Climate change is a consequence of global warming and it means the climate will become unpredictable.
Consequences of global warming include: • Loss of low-lying habitats due to flooding • Changes in the distribution patterns of species • Changes to the migration patterns of animals
These consequences will lead to unstable communities.
Scientists and concerned citizens have put in place programmes to reduce the negative effects of humans on ecosystems and biodiversity.
These include: • breeding programmes for endangered species • protection and regeneration of rare habitats • reintroduction of field margins and hedgerows in agricultural areas where farmers grow only one type of crop • reduction of deforestation and carbon dioxide emissions by some governments • recycling resources rather than dumping waste in landfill.

Bioenergetics

Photosynthesis is an endothermic chemical reaction.
Photosynthesis needs light energy to catalyse the reaction of carbon dioxide with water.
The reaction produces oxygen and glucose.
The word equation is: water + carbon dioxide ---light energy---> oxygen + glucose.
The symbol equation is: $6H_2O + 6CO_2$ ----light energy---> $6O_2 + C_6H_{12}O_6$
Leaves are adapted for photosynthesis by: • Containing palisade cells: elongated cells packed with chloroplasts (where green chlorophyll is present and absorbs light energy so that photosynthesis can take place). • Large surface area: leaves are wide or long and in abundance (e.g. millions of leaves on 1 tree). • Thin diffusion pathway: leaves are thin so gases can diffuse quickly.

• Large vascular network: xylem transporting water to the leaf and phloem transporting sugar away from the leaf. • Waxy layer: reduces evaporation of water during transpiration.
The leaf is composed of many tissues: • Epithelium – transparent cells lining the leaf surface. • Palisade mesophyll – site of photosynthesis • Spongy mesophyll – site of gas exchange • Guard cells + stomata – controls entry and exit of gases and transpiration of water.
How fast a plant is photosynthesising is called "the rate of photosynthesis".
The rate of photosynthesis can be measured by collecting oxygen over a unit of time, or by measuring the distance an air bubble moves over a unit of time.
Limiting factors are factors that limit the rate of photosynthesis.
The rate of photosynthesis is limited by: • low temperature • shortage of CO_2 • shortage of light • shortage of chlorophyll.
(HT) Limiting factors interact with each other, so any one of them could be limiting photosynthesis.
(HT) Light intensity is spread out equally over an area, as the distance away from the light source increases, the light intensity weakens. The Inverse Square Law shows us that the intensity of the light is inversely proportional the to the square of the distance.
A method details step by step what should be done to investigate a factor affecting the rate of photosynthesis.
Variables are factors that can influence the outcome of the practical work done to investigate the rate of photosynthesis.
Independent variable is the factor changed during the practical work to investigate its effect on the rate of photosynthesis.
Dependent variable is the factor we have chosen to measure to allow us to calculate the rate of photosynthesis.
Control variables are all the factors that may cause the results to become altered when we repeat the practical work. These variables must be kept the same as much as possible.
Graphs look at the rate of photosynthesis over time when plants are exposed to certain conditions. This allows us to make quick conclusions over the effectiveness of each limiting factor we are investigating.
Plants store excess glucose as starch, which can easily be tested using iodine.
Iodine turns blue-black in the presence of starch.
If plants are photosynthesising they convert the glucose they make into starch, if they are not photosynthesising they convert starch into glucose for use in respiration.
Other ways plants use glucose are: • converted into starch for storage • used to produce fats and oils for storage or cellulose to strengthen cell walls • used to produce amino acids for protein synthesis.
To produce proteins plants also use nitrate ions from the soil
Leaves must have the chlorophyll removed before they can be tested for starch otherwise the colour change is not visible.
Oxygen is a waste product of photosynthesis and is released by the leaf into the atmosphere.
The test for oxygen is a glowing splint: if it relights then oxygen is present.
(HT) Limiting factors can be used to identify how to increase the productivity of plant species to produce more food for humans.
(HT) Greenhouses are used to prevent limiting factors reducing growth.
(HT) If it is cost effective adding heat, light or carbon dioxide to greenhouses can optimise growth.
(HT) Understand there are both advantages and disadvantages to manipulating the environment within a greenhouse or polytunnel.
(HT) Hydroponics is a way of utilising the needs of plant growth against the space needed to house and grow plants.
Respiration is an exothermic chemical reaction that occurs in all living cells to release energy.
Mitochondria are the site of aerobic respiration.
There are two types of respiration in cells: aerobic (with oxygen) and anaerobic (without oxygen).

The energy released is called ATP.
The word equation for aerobic respiration is: glucose + oxygen -----> carbon dioxide + water (+energy)
The symbol equation for aerobic respiration is: $C_6H_{12}O_6 + 6O_2$ -----> $6CO_2 + 6H_2O$
Organisms need energy for chemical reactions, movement (including transport of substances within the organism) and to maintain a constant internal temperature.
The products of respiration can be tested for: • The test for carbon dioxide is to bubble the gas through limewater, which then turns cloudy. • The test for water is to use cobalt chloride paper, it turns from blue to pink if water is present.
During exercise the heart and breathing rates increase and breath volume increases to supply oxygen to muscle cells faster.
Graphs can be used to interpret the effects of exercise on the body.
Can you design an investigation to look at the effects of exercise on the body?
Anaerobic respiration is the incomplete breakdown of glucose, so much less energy is released compared with aerobic respiration.
The word equation for anaerobic respiration is: Glucose ----> Lactic acid
When anaerobic respiration occurs during exercise, it creates an “oxygen debt” and the creation of lactic acid causes muscle fatigue due to the inefficient contraction of muscle cells.
The oxygen debt is the amount of oxygen needed to react with lactic acid and remove it from cells.
The oxygen debt is repaid by the continuation of deep breathing after exercise has finished.
(HT) Lactic acid is transported to the liver where it is converted back into glucose.
Anaerobic respiration in yeast cells is called fermentation
The word equation for fermentation is: glucose ---> ethanol + carbon dioxide
Fermentation is an economically important chemical reaction in the manufacture of bread and alcoholic drinks.
Metabolism means all the chemical reactions happening in a living organism.
Metabolism includes: • the conversion of glucose to starch, glycogen or cellulose (long chain natural polymers). • the formation of lipids (glycerol bonding to three chains of fatty acids). • the formation of amino acids and proteins (glucose is joined with nitrate ions to form amino acids. Long chains of amino acids form a protein). • Respiration. • the breakdown of excess proteins to form urea for excretion.

Chemistry

Atomic Structure and the Periodic Table

• All substances are made of atoms. An atom is the smallest whole part of an element that can exist.
• Atoms of each element are represented by a chemical symbol, eg O represents an atom of oxygen, Na represents an atom of sodium.
• There are over 100 different elements.
• Elements are shown in the periodic table.
• An element is made up of atoms of one type, eg gold contains only gold atoms.
• Compounds are formed from elements by chemical reactions.
• Chemical reactions always involve the formation of one or more new substances.
• Compounds contain two or more difference elements chemically combined in fixed proportions.
• Compounds can be represented by formulae using the symbols of the atoms from which they were formed.
• Compounds can only be separated into elements by chemical reactions.
• Chemical reactions can be represented by word equations or equations using symbols and formulae.
• A molecule is made up of 2 or more atoms and can be an element or a compound. It is the smallest identifiable unit that retains the same properties.
• A mixture consists of two or more elements or compounds not chemically combined together.
• The chemical properties of each substance in the mixture are unchanged.
• A solvent is something that dissolves something else

- A solute is the substance that is dissolved in a solvent to make a solution.
- Mixtures can be separated by physical processes such as: filtration, crystallisation, simple distillation, fractional distillation, chromatography.
- These physical processes do not involve chemical reactions and no new substances are made.
- Filtration works by separating an insoluble solid from a liquid
- Distillation works by separating mixtures of liquids that have different boiling points
- Crystallisation separates a soluble salt from a solution.
- Chromatography separates mixtures based on their solubility
- Rf = distance travelled by sample/distance travelled by solvent
- New experimental evidence may lead to a scientific model being changed or replaced
- Before the discovery of the electron, atoms were thought to be tiny spheres that could not be divided
- The discovery of the electron led to the plum pudding model of the atom. The plum pudding model suggested that the atom is a ball of positive charge with negative electrons embedded in it
- Ernest Rutherford did an experiment called the gold foil experiment. He fired alpha particles at a thin sheet of gold foil. Some bounced back, some were deflected and some went straight through.
- The results from the alpha particle scattering experiment led to the conclusion that the mass of an atom was concentrated at the centre (nucleus) and that the nucleus was charged. This model was called the nuclear model and it replaced the plum pudding model.
- Niels Bohr adapted the nuclear model, suggesting that electrons orbit the nucleus at specific distances.
- Later experiments led to the idea that the positive charge of any nucleus could be subdivided into a whole number of smaller particles, with each particle having the same amount of positive charge. These particles were called protons
- James Chadwick discovered the existence of neutrons in the nucleus of the atom about 20 years after the nucleus was accepted
- The nucleus of an atom contains two types of subatomic particles; the proton and the neutron
- Protons have a mass of one and a charge of +1.
- Neutrons have a mass of 1 and a charge of 0.
- The third type of subatomic particle is called the electron. These are found around the outside of the nucleus.
- The electron has a mass of 0 and a charge of -1.
- In an atom, the number of electrons is equal to the number of protons in the nucleus.
- The number of protons in an atom is its atomic number. All atoms of the same element have the same number of protons.
- Atoms of different elements have different numbers of protons.
- Atoms are very small, having a radius of about 0.1nm ($1x10^{10}$m)
- The radius of a nucleus is less than 1/10000 of that of an atom (about $1x10^{14}$)
- The sum of the protons and neutrons in an atom is its mass number
- Atoms of the same element can have different numbers of neutrons.
- An atom with the same number of protons but different numbers of neutrons are called isotopes.
- The relative atomic mass of an element is an average value that takes into account the abundance of the isotopes of the element
- The electrons in an atom occupy the lowest available energy levels (the innermost available shells)
- The electronic structure can be represented by numbers or by a diagram
- The lowest energy level can hold a maximum of 2 electrons
- The second and third energy level can hold a maximum of 8 electrons
- For example, the electronic structure of sodium is 2, 8, 1
- Before the discovery of subatomic particles, scientists attempted to classify the elements by arranging them in order of their atomic weights.
- The early periodic tables were incomplete, and some elements were placed in inappropriate groups if the strict order of atomic weights was followed.
- Mendeleev overcame some of the problems by leaving gaps for elements that he thought had not been discovered and in some places changed the order based on atomic weights.
- Elements with properties predicted by Mendeleev were discovered and filled the gaps.
- Knowledge of isotopes made it possible to explain why the order based on atomic weights was not always correct

•	The modern periodic table has elements ordered by atomic number.
•	The group number shows the number of electrons in the outer shell.
•	The rows are called periods. Each period shows another full shell of electrons
•	Metals are found on the left of the periodic table and non-metals are found on the right
•	Metals are malleable, electronic conductors, thermal conductors
•	Non-metals are brittle, electronic insulators and thermal insulators
•	Elements that react to form positive ions are metals
•	Elements that react to form negative ions are non-metals
•	Elements in group 0 are called Noble gases. They are unreactive and do not easily form molecules. They have stable arrangements of electrons
•	The boiling points of the noble gases increase down the group
•	Group 1 metals are also known as alkali metals. They form an alkaline solution when reacting with water.
•	Group 1 metals form +1 ions and have low densities.
•	The reactivity of group 1 metals increases down the group. This is because it is easier to lose an electron when the outer shell is further from the nucleus.
•	The elements in group 7 are also known as the halogens. They have seven electrons in the outer shell.
•	Group 7 elements are non-metals and consist of molecules of pairs of atoms.
•	The reactivity of group 7 elements decreases as you go down the group. This is because it is more difficult to gain an electron when the outer shell is further from the nucleus.
•	A more reactive halogen can displace a less reactive halogen from an aqueous solution of its salt.
•	The transitions metals are found in the centre block of the periodic table. They form ions with different charges, form coloured compounds and are useful as catalysts
•	They have a higher density than group 1 metals and are less reactive

Bonding, Structure and the Properties of Matter

By the end of this topic you should know and understand:	
•	There are 3 types of strong bond: Ionic, Covalent and metallic
•	Ionic bonding is when oppositely charged ions are held together by electrostatic forces of attraction
•	Covalent bonding is when atoms share pairs of electrons
•	Metallic bonding is when atoms share delocalised electrons
•	Ionic bonding is the transfer of outer shell electrons between metals and non-metals
•	Metals lose electrons to become positively charged ions; Non-metals gain electrons to become negatively charged
•	Groups 1&2 and 6&7 transfer electrons to obtain a noble gas electronic structure
•	Dot-and-Cross diagrams are used to show the transfer of electrons to produce ions
•	Ionic compounds are giant structures of ions, held together by electrostatic forces of attraction
•	Electrostatic forces act in all directions to form a lattice structure
•	Limitations of the 3D models representing ionic compounds, including forces being represented as lines
•	Covalent bonding is between mostly non-metal atoms sharing electrons to form elements or compounds
•	Covalent substances can consist of small molecules, these can be deduced from their chemical formula; Some covalent substances have large molecules, such as polymers; Some covalent substances are giant structures such as diamond and silicon dioxide
•	These can be represented by dot-and-cross diagrams, ball and stick models and as repeating unit diagrams
•	Covalent substances can form single bonds, sharing one pair of electrons and represented by a single line on diagrams; can form double bonds, sharing two pairs of electrons and represented by double lines on diagrams
•	Metallic bonding occurs in metal elements and alloys
•	Metals consist of giant structures of atoms arranged in a regular pattern
•	The electrons in the outer shell of metal atoms are delocalised, so are free to move through the structure
-	The sharing of delocalised electrons gives rise to strong metallic bonds, the more electrons delocalised from the outer shell, the stronger the bond and the better the metal is at conducting electricity. This occurs due to the electrostatic attraction between the positive metal ions and the negative electrons

- Metallic bonding can be represented by the diagram of a positive nucleus surrounded by a sea of delocalised electrons
- The three states of matter are solid, liquid and gas and state symbols are used to represent these in symbol equations (s) (l) (g) respectively, with (aq) for aqueous solutions
- Melting and freezing happen at the melting point of a substance; evaporation and condensation happen at the boiling point of a substance
- States of matter can be represented by a simple particle model, representing the atoms as solid spheres
- Particle theory can help explain changes in state
- The amount of energy needed to change state depends on the strength of forces between particles in the substance
- The nature of the particles depends on the type of bonding and the structure of the substance
- The stronger the forces between particles, the higher the melting and boiling points
- **HT** Limitations of the model include: no forces shown between particles, all particles represented as solid spheres
- Ionic compounds have a regular giant ionic lattice structure with strong bonds in all directions, leading to high melting and boiling points as large amounts of energy are needed to break them
- Ionic compounds conduct electricity when melted (molten) or dissolved in water (aqueous), as ions are free to move and charge can flow e.g. Sodium Chloride
- Covalent compounds that consist of small molecules are usually gases or liquids at room temperature as they have relatively low melting and boiling points due to weak intermolecular forces
- Intermolecular forces are weak forces between molecules that are overcomes when substances melt or boil, NOT covalent bonds
- Larger the molecule, the more intermolecular forces so larger molecules have higher melting and boiling points
- Small molecules do not conduct electricity as there is no overall electric charge
- Polymers are very large molecules, with the atoms linked by strong covalent bonds
- HDPE (high density poly ethene) is made from straight chained polymers. LDPE (low density poly ethene) is made from branched chains
- Thermosoftening polymers can be heated and remoulded, whereas thermosetting polymers cannot be remoulded.
- Intermolecular forces between polymer molecules are relatively strong and so polymers are solid at room temperature
- Giant covalent structures are solids with very high melting and boiling points
- All the atoms are linked to other atoms by strong covalent bonds and these require a lot of energy to overcome them
- Examples of giant covalent structures are diamond and graphite and silicon dioxide
- Metals have giant structures of atoms with strong metallic bonding
- Metals are good conductors of electricity because of the delocalised electrons carrying the electrical charge
- Metals are good conductors of thermal energy because energy is transferred by the delocalised electrons
- Most metals have high melting and boiling points
- Atoms are arranged in layers in pure metals, allowing them to be bent and shaped (malleable)
- Pure metals are too soft for many uses so are mixed with other metals to form alloys which are harder
- Diamond is made up of carbon atoms and each carbon atom forms 4 covalent bonds with other carbon atoms in a giant covalent structure and so is very hard with a very high melting point and does not conduct electricity
- Graphite is made up of carbon atoms and each carbon atom forms 3 covalent bonds with 3 other carbon atoms, forming layers of hexangonal rings with no covalent bonds between layers
- The 4th electron of each carbon becomes delocalised, allowing graphite to conduct electricity
- Graphene is a single layer of graphite and has properties that make it useful in electronics and composites.
- Fullerenes are molecules of carbon atoms with hollow shapes. The structure of fullerenes is based on hexagonal rings of carbon atoms but they may also contain rings with five or seven carbon atoms.
- The first fullerene to be discovered was Buckminsterfullerene (C_{60}) which has a spherical shape
- Carbon nanotubes are cylindrical fullerenes with very high length to diameter ratios. Their properties make them useful for nanotechnology, electronics and materials.

Quantitative Chemistry

By the end of this topic you should know and understand:
• The law of conservation of mass states that no atoms are lost or made during a chemical reaction, so the mass of the products equals the mass of the reactants.
• Chemical reactions can be represented by symbol equations which are balanced in terms of the numbers of atom of each element involved on both sides of the equation
• Some reactions may appear to involve a change in mass but this can usually be explained because a reactant or product is a gas and its mass has not been taken into account.
• For example, when a metal reacts with oxygen the mass of the oxide produced is greater than the mass of the metal.
• In thermal decomposition of metal carbonate, carbon dioxide is produced and escapes into the atmosphere leaving the metal oxide as the only solid product.
• The relative formula mass (M_r) of a compound is the sum of the relative atomic masses of the atoms in the numbers shown in the formula
• In a balanced chemical equation, the sum of the relative formula masses of the reactants in the quantities shown equals the sum of the relative formula masses of the products shown.
• Percent by mass tells us how much of the mass of a compound is made by one of the elements. It is calculated by: (Mr of element/Mr of compound) x 100
• Whenever a measurement is made there is always some uncertainty about the result obtained
• A systematic error causes readings to differ from the true value by the same amount each time. This could be caused by environmental conditions, methods of observation or the equipment used.
• A random error causes readings to be spread about the true value, with results varying in an unpredictable way. The effect of random errors can be reduced by taking more measurements and calculating a mean.
• A zero error is caused when a measuring device does not read zero when nothing is measured. It could result in systematic uncertainty.
• Chemical amounts are measured in moles. The symbol for the unit mole is mol.
• The mass of one mole of a substance in grams is numerically equal to its relative formula mass
• One mole of a substance contains the same number of the stated particles, atoms, molecules or ions as one mole of any other substance.
• The number of atoms, molecules or ions in a mole of a given substance is the Avogadro constant. This is $6.02x10^{23}$ per mole.
• The masses of reactants and products can be calculated from balanced symbol equations.
• Chemical equations can be interpreted in terms of moles. For example: $Mg + 2HCl \rightarrow 2MgCl_2 + H_2$ shows that one mole of magnesium reacts with two moles of hydrochloric acid to produce one mole of magnesium chloride and one mole of hydrogen gas.
• The balancing numbers in a symbol equation can be calculated from the masses of reactants and products by converting the masses in grams to amounts in moles and converting the numbers of moles to simple whole number ratios
• In a chemical reaction involving two reactants, it is common to use an excess of one of the reactants to ensure all of the other reactant is used. The reactant that is completely used up is called the limiting reactant because it limits the amount of products
• Many chemical reactions take place in solutions.
• The concentration of a solution can be measured in mass per given volume of solution eg. grams per dm^3 (g/dm^3)

Chemical Changes

By the end of this topic you should know and understand:
• Acids produce hydrogen ions (H+) in aqueous solutions.
• Aqueous solutions of alkalis contain hydroxide ions (OH–).
• The pH scale, from 0 to 14, is a measure of the acidity or alkalinity of a solution, and can be measured using universal indicator or a pH probe (wide range indicators)
• A solution with pH 7 is neutral. Aqueous solutions of acids have pH values of less than 7 and aqueous solutions of alkalis have pH values greater than 7.

•	In neutralisation reactions between an acid and an alkali, hydrogen ions react with hydroxide ions to produce water. This reaction can be represented by the equation: $H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$
•	Acids are neutralised by alkalis (soluble metal hydroxides) and bases (insoluble metal hydroxides and metal oxides) to produce salts and water, and by metal carbonates to produce salts, water and carbon dioxide.
•	The particular salt produced in any reaction between an acid and a base or alkali depends on: the acid used (hydrochloric acid produces chlorides, nitric acid produces nitrates, sulfuric acid produces sulfates) and the positive ions in the base, alkali or carbonate.
•	Formulae of common ions can predict the formulae of salts
•	A strong acid is completely ionised in aqueous solution. Examples of strong acids are hydrochloric, nitric and sulfuric acids.
•	A weak acid is only partially ionised in aqueous solution. Examples of weak acids are ethanoic, citric and carbonic acids.
•	For a given concentration of aqueous solutions, the stronger an acid, the lower the pH.
•	As the pH decreases by one unit, the hydrogen ion concentration of the solution increases by a factor of 10.
•	Concentration relates to the amount of substance in a given volume. High concentration has a large amount of substance and low solution has a small amount of substance in given volume.
•	Solutions can be diluted to decrease concentration.
•	As acids react, the hydrogen ions react to form water molecules reducing the concentration of the acid and increasing neutrality.
•	Metals react with oxygen to produce metal oxides. The reactions are oxidation reactions because the metals gain oxygen.
•	Acids react with some metals to produce salts and hydrogen.
•	Metals react with hydrochloric acid to form chloride salts.
•	Metals react with sulphuric acid to form sulphate salts.
•	Soluble salts can be made from acids by reacting them with solid insoluble substances, such as metals, metal oxides, hydroxides or carbonates.
•	The solid is added to the acid until no more reacts and the excess solid is filtered off to produce a solution of the salt.
•	Salt solutions can be crystallised to produce solid salts.
•	When metals react with other substances the metal atoms form positive ions.
•	The reactivity of a metal is related to its tendency to form positive ions.
•	Metals can be arranged in order of their reactivity in a reactivity series.
•	The metals potassium, sodium, lithium, calcium, magnesium, zinc, iron and copper can be put in order of their reactivity from their reactions with water and dilute acids, at room temperature.
•	The non-metals hydrogen and carbon are often included in the reactivity series.
•	A more reactive metal can displace a less reactive metal from a compound.
•	Unreactive metals such as gold are found in the Earth as the metal itself but most metals are found as compounds that require chemical reactions to extract the metal.
•	Metals less reactive than carbon can be extracted from their oxides by reduction with carbon. Reduction involves the loss of oxygen.
•	Oxidation is the loss of electrons and reduction is the gain of electrons.
•	Half equations are used to show which species has been oxidised and which species has been reduced.
•	Ionic equations are used to show the reacting species in a reaction.
•	Metals lose electrons and acids gain electrons as redox reactions (HT) Metals are oxidised and acids are reduced (HT)
•	When an ionic compound is melted or dissolved in water, the ions are free to move about within the liquid or solution.
•	These liquids and solutions are able to conduct electricity and are called electrolytes.
•	Passing an electric current through electrolytes causes the ions to move to the electrodes.
•	Positively charged ions move to the negative electrode (the cathode), and negatively charged ions move to the positive electrode (the anode). Ions are discharged at the electrodes producing elements. This process is called electrolysis.

•	Half equations are used to show the reactions occurring at the electrodes during electrolysis.
•	When a simple ionic compound (eg lead bromide) is electrolysed in the molten state using inert electrodes, the metal (lead) is produced at the cathode and the non-metal (bromine) is produced at the anode.
•	Metals can be extracted from molten compounds using electrolysis
•	Electrolysis is used if the metal is too reactive to be extracted by reduction with carbon or if the metal reacts with carbon. Large amounts of energy are used in the extraction process to melt the compounds and to produce the electrical current.
•	Aluminium is manufactured by the electrolysis of a molten mixture of aluminium oxide and cryolite to lower the melting point, using carbon as the positive electrode (anode). Carbon dioxide is produced as the oxygen reacts with the positive electrode and so the carbon electrode must be continually replaced.
•	The ions discharged when an aqueous solution is electrolysed using inert electrodes depend on the relative reactivity of the elements involved. At the negative electrode (cathode), hydrogen is produced if the metal is more reactive than hydrogen. At the positive electrode (anode), oxygen is produced unless the solution contains halide ions, when the halogen is produced.
•	This happens because in the aqueous solution water molecules break down producing hydrogen ions and hydroxide ions that are discharged.
•	During electrolysis, at the cathode (negative electrode), positively charged ions gain electrons and so the reactions are reductions. At the anode (positive electrode), negatively charged ions lose electrons and so the reactions are oxidations.
•	Reactions at electrodes can be represented by half equations, for example: $2H^+ + 2e- \rightarrow H_2$ and $4OH^- \rightarrow O_2 + 2H_2O + 4e-$ or $4OH^- - 4e- \rightarrow O_2 + 2H_2O$

Energy Changes

•	Energy is conserved in chemical reactions.
•	The amount of energy in the universe at the end of a chemical reaction is the same as before the reaction takes place.
•	An exothermic reaction is one that transfers energy to the surroundings so the temperature of the surroundings increases.
•	Everyday uses of exothermic reactions including self-heating cans and hand warmers.
•	An endothermic reaction is one that takes heat in from the surroundings so the temperature of the surroundings decreases.
•	Endothermic reactions include thermal decompositions and the reaction of citric acid and sodium hydrogencarbonate. Some sports injury packs also use endothermic reactions.
•	Chemical reactions can occur only when reacting particles collide with each other and with sufficient energy.
•	Activation energy is the minimum amount of energy that particles must have to react.
•	Reaction profiles can be used to show the relative energies of reactants and products, the activation energy and the overall energy change of a reaction.
•	During a chemical reaction energy must be supplied to break bonds in the reactants.
•	During a chemical reaction energy is released when bonds in the product are formed.
•	The energy needed to break bonds and the energy released when bonds are formed can be calculated from bond energies.
•	The difference between the sum of the energy needed to break bonds in the reactants and the sum of the energy released when bonds in the products are formed is the overall energy change of the reaction.
•	In an exothermic reaction, the energy released from forming new bonds is greater than the energy needed to break existing bonds.
•	In an endothermic reaction, the energy needed to break existing bonds is greater than the energy released from forming new bonds.

Physics

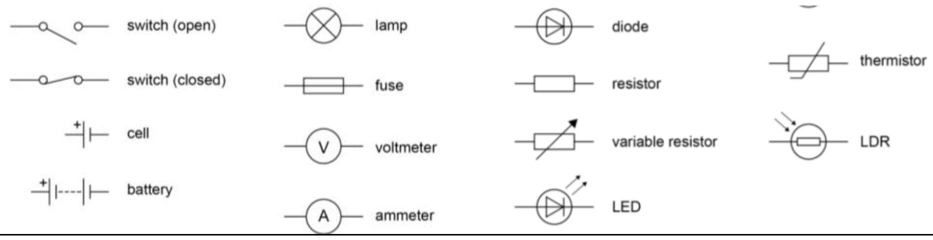
Energy

By the end of this topic you should know and understand:
• A **system** is an object or group of objects
• When a system changes, the energy stored in that system changes as well
• The following are the different stores of energy: **chemical, kinetic, gravitational potential, elastic potential, thermal, magnetic, electrostatic, nuclear**
• Energy can be transferred usefully, stored or **dissipated**, but cannot be created or destroyed.
• Where energy is transferred in a closed system, there is no net change in the total energy.
• All energy transfers have some energy dissipated so that it is stored in less useful ways.
• Energy is transferred via one of the following pathways: **heating, electrical, radiation** or **mechanical.**
• Energy that is not transferred usefully is said to be wasted
• Unwanted energy transfers can be reduced through **lubrication** or **insulation**
• Energy for humans comes from the food that we eat
• Different people have different energy requirements
• **Anomalies** – a result that does not fit the pattern
• **Control** – it may, in addition to the independent variable, affect the outcome of the investigation and should therefore be kept constant
• **Dependent** – the value is measured for each change in the independent variable
• **Independent** – values are changed or selected by the investigator
• **Accurate** – a measurement is considered accurate if it is judged to be close to the true value
• **Precise** – precise measurements are ones in which there is very little spread around the mean value.
• **Resolution** – the smallest change in the quantity being measured by a measuring instrument.
• **Uncertainty**- the interval within which the true value can be expected to lie
• **Random error** – cause readings to be spread about the true value, due to results varying in an unpredictable way. They cannot be corrected. They can be reduced by taking more measurements and calculating a mean
• **Systematic error** – cause readings to differ from the same amount each time. They cannot be dealt with by repeats.
• **Reproducible** – the same results can be obtained if the investigation is repeated by another person
• **Repeatable** – the same results are obtained if the investigation is repeated by the same investigator using the same method
• The energy in food can be transferred from the chemical store to the thermal store by burning.
• Energy can be lost to the surroundings
• When a force causes an object to move through a distance, work is done on the object
• **Work done** (energy used to move the object) is measured in Joules (J)
• Work done can be calculated using the equation: Work done (J) = Force (N) x displacement (m) [W = F x s]
• One **joule** of work is done when a force of one newton causes a displacement of one metre.
• **Power** is defined as the rate at which energy is transferred or the rate at which work is done
• Power = energy transferred/time; Power = work done/time
• An energy transfer of 1 joule per second is equation to a power of 1 watt
• Efficiency is a measure of how good a device is at changing energy (or power) from one form to another
• **Efficiency** can be calculated using the equation: Efficiency = useful energy out/total energy in Or Efficiency = useful power out/total power in
• Efficiency can be turned into a percentage by multiplying it by 100.
• The kinetic energy of a moving object can be calculated using the equation: Kinetic energy = 0.5 x mass x $(\text{speed})^2$ [$E_k = ½\ m\ v^2$] Where E_k in J, m in kg, v in m/s
• The amount of gravitational potential energy gained by an object raised above ground level can be calculated using the equation: g.p.e. = mass x gravitational field strength x height [E_p = mgh] Where E_p is in Joules, m in kg, g in N/kg and h in metres
• The amount of elastic potential energy stored in a stretched spring can be calculated using the equation: Elastic potential energy = 0.5 x spring constant x $(\text{extension})^2$ [$E_e = ½\ k\ e^2$] Where E_e in J, k in N/m and e in m
• During heat transfer, energy always moves from hot to cold
• Heat can be transferred through 3 process; **conduction** (mostly in solids), **convection** (in liquids and gases) and **radiation** (EM radiation that can travel through a **vacuum**)

•	**Thermal conductivity** (in units of W/m°C) tells you how well a material conducts heat. The higher the thermal conductivity of a material, the higher the rate of energy transfer by conduction across the material
•	The thicker the material, the lower the thermal conductivity, thus a thicker wall on a house will conduct less heat away.
•	**Infrared** radiation is radiation of shorter wavelength than red light
•	An object emits infrared radiation when it cools.
•	A perfect **black body** is an object which absorbs all of the radiation incident on it. It does not reflect or transmit any radiation
•	A body at a constant temperature is absorbing radiation at the same rate as it is emitting radiation
•	Putting the same amount of heat energy into some materials gives a bigger temperature rise than in other materials due to **specific heat capacity** • The specific heat capacity (c) is the amount of energy needed to increase the temperature of 1 kg of a substance by 1°C
•	Energy can be calculated using the equation: $\Delta E = mc\Delta\theta$. Where: ΔE = change in energy (J), m = mass (kg), c = specific heat capacity (J/kg°C), $\Delta\theta$ = change in temperature (°C)
•	In a house, heat is lost through the walls, windows, roof and floor
•	Drafts can enter a house through gaps in doors/windows and lose heat through convection currents
•	Heat loss is bad because using energy to heat a house costs money
•	We can reduce heat loss from a house using draft excluders, loft insulation, double glazing, carpets or cavity wall insulation
•	The main energy resources available for use on Earth include: fossil fuels, nuclear fuel, **biofuel**, wind, **hydroelectricity**, **geothermal**, the tides, the Sun and water waves
•	A **renewable** resource is one that is replenished as it is used
•	The uses of energy resources include transport, electricity generation and heating
•	**Fossil fuels** are formed from plant and animal matter under pressure and heat for millions of years. They are reliable. They produce greenhouse gases and are not renewable, they will run out.
•	Nuclear fuel relies on energy being released when large, unstable radioactive atoms split. It does not release greenhouse gases, and releases a lot more energy compared to other energy types. Radioactive waste is difficult to store safely, and the power stations are expensive to build.
•	Solar energy relies on energy from the sun which is captures by solar panels and is converted into electricity. It allows houses to have their own energy supply, but they can be expensive and rely on sunny weather.
•	Wind turbines turn wind into electricity. They can be used on their own but are often in groups on wind farms. Some people object to wind farms, arguing that it spoils the countryside. They rely on windy weather.
•	The movement of tides can drive turbines. A tidal barrage is built across estuaries, forcing water through the gaps. These are useful on islands with large coastal areas, and have the potential to generate a lot of electricity. They can be expensive to build and can have a negative impact on wildlife.
•	Wave power uses the movement of sea water to drive a turbine. Again, they are useful for islands. They are more likely to be small, local operations. They can be expensive and might be opposed by environmental groups.
•	Geothermal uses the natural heat of the Earth. Steam can be used for heating or to power turbines. These can be expensive to set up and only work in areas of volcanic activity
•	Hydroelectric power uses the movement of water through rivers, lakes and dams. This helps to create water reserves as well as energy supplies. They are expensive and can cause flooding of the surrounding areas
•	Biomass/biofuels use the chemical energy stored in organic materials that is released when burned. They are carbon neutral. They are only renewable if the crops are replanted.
•	The UK uses a combination of all energy types to meet energy demand in the future.
•	Burning fossil fuels releases **greenhouse gases**, which cause global warming
•	Burning coal can also release sulfur dioxide which leads to acid rain, and carbon particulates which causes global dimming
•	Carbon capture is likely to be needed in the future to trap the CO_2 gases that are released when fossil fuels are burned.

Electricity

- Circuit components are represented by the following standard symbols.



- For electrical charge to flow through a closed circuit the circuit must include a source of potential difference.
- Electric current is a flow of electrical charge. The size of the electric current is the rate of flow of electrical charge.
- Charge flow, current and time are linked by the equation: charge flow = current x time (Q=It)
- A current has the same value at any point in a single closed loop.
- Potential difference is measured in volts and is measured with a voltmeter connected in parallel.
- Potential difference is a measure of energy transferred between two points in a circuit.
- The current through a component depends on both the resistance of the component and the potential difference across the component.
- The greater the resistance of the component the smaller the current for a given potential difference across the component.
- Potential difference = current x resistance (V = IR)
- The resistance of a wire depends on temperature; the higher the temperature the higher the resistance
- The longer the wire the higher the resistance.
- The thinner the wire the higher the resistance
- For some resistors, resistance remains constant regardless of the current (at a constant temperature). This is called an ohmic conductor.
- For other resistors, resistance is not constant when changing current. This is called a non-ohmic conductor.
- The resistance of components such as lamps, diodes, thermistors and LDRs is not constant, it changes with the current through the component.
- The resistance of a filament lamp increases as the temperature of the filament increases.
- The current through a diode flows in one direction only. The diode has a very high resistance in the reverse direction.
- The resistance of a thermistor decreases as the temperature increases.
- Thermistors can be used in thermostats
- The resistance of an LDR decreases as light intensity increases.
- LDRs can be used in circuits to switch lights on when it gets dark
- Components connected in series have the same current through each component
- The total potential difference of the power supply is shared between the components in series
- The total resistance of the components in the circuit is the sum of the resistance of each component ($R_{total} = R_1 + R_2 + R_3...$)
- The potential difference of each component connected in parallel is the same
- The total current through the whole circuit is the sum of the currents through the separate components
- The total resistance of multiple resistors is less than the resistance of the smallest individual resistor.
- Power transferred in a circuit is related to potential difference and current, and to the energy changes over time.
- Power = potential difference x current (P = VI)
- Power = $(\text{current})^2$ x resistance ($P=I^2 \times R$)
- Every day appliances are designed to bring about energy transfers.
- The amount of energy an appliance transfers depends on how long it is switched on for and the power of the appliance
- Work is done when charge flows in a circuit
- The amount of energy transferred by electrical work is calculated using the equation: Energy = power x time (E = Pt)
- It can also be calculated by: energy = charge flow x potential difference (E =QV)

•	Direct current flows in one direction
•	Alternating current flows in both directions.
•	Mains electricity is an ac supply
•	In the UK, domestic energy supply has a frequency of 50Hz and is about 230V
•	Most electrical appliances are connected to the mains using three-core cable
•	The live wire is brown and carries the alternating potential difference from the supply. It can be dangerous even when the switch is open. • The neutral wire is blue and completes the circuit.
•	The earth wire is green and yellow stripes. It is a safety mechanism that stops the appliance becoming live.
•	The potential difference between the live wire and the earth wire (0V) is about 230V.
•	The neutral wire is at, or close to, earth potential (0V)
•	The earth wire is at 0V and only carries a current if there is a fault.
•	The fuse is designed to melt if too high a current flows through, to prevent fires.
•	A correct amp rating of fuse must be used for an appliance.
•	Efficiency = (output power/input power) x 100
•	The national grid is a system of cables and transformers linking power stations to consumers
•	Step-up transformers are used to increase the potential difference from the power station to the transmission cables.
•	This reduces the current which reduces heat loss, making the transmission more efficient.
•	Step-down transformers are used to decrease the potential difference to a safer level for domestic use
•	A charged object creates an electric field around itself.
•	The electric field is strongest close to the charged object. The further away from the charged object the weaker the field
•	A second charged object placed in the field experiences a force. The force gets stronger as the distance between the objects decreases.
•	When certain insulating materials are rubbed against each other they become electrically charged.
•	Negatively charged electrons are rubbed off one material and on to another
•	The material that gains electrons becomes negatively charged. The material that loses electrons is left with an equal positive charge
•	When two electrically charged objects are brought close together they exert a force on each other.
•	Two objects of the same charge repel. Two objects of opposite charge attract.
•	Attraction and repulsion between two charged objects are examples of non-contact forces.

Particle Model of Matter

By the end of this unit you should know and understand:	
•	The density of a material is defined by the equation *density=mass/volume* [ρ=m/v]
•	Volume of an irregular solid can be determined using a eureka can and measuring cylinder, using water displacement.
•	Particles in a solid vibrate around a fixed point
•	Particles in a liquid move over each other whilst remaining in contact. They move to take the shape of their container.
•	Particles in a gas move rapidly and randomly, and are spread over a large area. They move to fill the container they are in.
•	Changes of state are physical changes which differ from chemical changes because the material recovers its original properties if the change is reversed
•	When substances change state (melt, freeze, boil, evaporate, condense or sublimate) mass is conserved
•	The melting point of a substance is the temperature at which it changes from a solid to a liquid and vice versa
•	The melting and boiling point of a pure substance are fixed
•	Evaporation can happen at any temperature, and it happens at the surface of the substance
•	Boiling only happens at the boiling point, and occurs throughout the liquid.
•	Internal energy is the total kinetic energy and potential energy of all the particles (atoms and molecules) that make up a system

• Heating changes the energy stored within the system by increasing the energy of the particles that make up the system. This either raises the temperature of the system or produces a change of state.
• If the temperature of the system increases, the increase in temperature depends on the mass of the substance heated, the type of material and the energy input to the system
• Change in thermal energy = mass x specific heat capacity x temperature change
• The specific heat capacity of a substance in the amount of energy required to raise the temperature of one kilogram of the substance by one degree Celsius.
• The energy needed for a substance to change state is called latent heat. When a change of state occurs, the energy supplied changes the energy stored (internal energy) but not the temperature
• The specific latent heat of a substance is the amount of energy required to change the state of one kilogram of the substance with no change in temperature
• Energy for a change of state = mass x specific latent heat [E=mL]
• Specific latent heat of fusion is the change of state from solid to liquid
• Specific latent heat of vaporisation is the change of state from liquid to vapour
• The molecules of a gas are in constant random motion so they store kinetic energy.
• The temperature of the gas is related to the average kinetic energy of the molecules. The higher the temperature, the more kinetic energy they have, so they move faster on average.
• Changing the temperature of a gas held at constant volume, changes the pressure exerted by the gas

Atomic Structure

• Atoms are very small, having a radius of about $1x10^{-10}$ metres
• An atom has a positively charged nucleus made of protons and neutrons surrounded by negatively charged electrons
• The radius of a nucleus is less than 1/10000 of the radius of an atom.
• Most of the mass of an atom is concentrated in the nucleus
• The electrons are arranged at different distances from the nucleus (energy levels)
• The electron arrangement may change with the absorption of electromagnetic radiation (move to a higher energy level or further from the nucleus) or by the emission of electromagnetic radiation
• In an atom the number of electrons is equal to the number of protons
• Atoms have no overall electrical charge
• All atoms of a particular element have the same number of protons This is called its atomic number
• The total number of protons and neutrons in an atom is called its mass number
• Atoms of the same element can have different numbers of neutrons; these atoms are called isotopes of the element
• Ions are formed if an atom loses or gains electrons.
• New experimental evidence may lead to a scientific model being changed or replaced
• Before the discovery of the electron, atoms were thought to be tiny spheres that could not be divided
• The discovery of the electron led to the plum pudding model of the atom. This suggested that the atom is a ball of positive charge with negative electrons embedded in it
• The results from the alpha particle scattering experiment led to the conclusion that the mass of an atom was concentrated at the centre and that the nucleus was charged.
• Niels Bohr adapted the nuclear model by suggesting that electrons orbit the nucleus at specific distances. The theoretical calculations of Bohr agreed with experimental observations
• Later experiments led to the idea that the positive charge of any nucleus could be subdivided into a whole number of smaller particles, with each particle having the same amount of positive charge. These were called protons.
• The experimental work of James Chadwick provided the evidence to show the existence of neutrons within the nucleus. This was about 20 years after the nucleus became an accepted scientific idea.
• Some atomic nuclei are unstable.
• The nucleus gives out radiation as it changes to become stable.
• This process is random and is called radioactive decay.

•	Activity is measured in becquerels (Bq) and is the rate at which a source of unstable nuclei decays
•	Count rate is the number of decays recorded each second by a detector (for example the Geiger-Muller tube)
•	Nuclear radiation may be alpha, beta or gamma.
•	An alpha particle consists of two neutrons and two protons. It is the same as a helium nucleus.
•	Alpha radiation is highly ionising but is the least penetrating type of radiation. It is absorbed by a thin sheet of paper and travels 5cm in air.
•	A beta particle is a high speed electron ejected from the nucleus as a neutron turns into a proton
•	Beta radiation is less ionising than alpha radiation, but is more penetrating. It will be stopped by a thin sheet of aluminium and travels 1m in air.
•	A gamma ray is a type of electromagnetic radiation from the nucleus.
•	Gamma rays are highly penetrating but have a low ionising power. It is stopped by 3-5cm of lead, or 1m of concrete. It can travel an unlimited distance in air.
•	Radiation has many uses. Each use has its own advantages and disadvantages, and sources have to be selected carefully to be safe
•	Nuclear equations are used to represent radioactive decay
•	In a nuclear equation an alpha particle may be represented by the symbol: $^{4}_{2}He$
•	A beta particle may be represented by: $^{0}_{-1}e$
-	The emission of different types of nuclear radiation may cause a change in the mass and/or the charge of the nucleus
•	An example of alpha decay causing both the mass and charge of the nucleus to decrease is: $^{219}_{86}$radon → $^{215}_{84}$polonium + $^{4}_{2}He$
•	An example of beta decay is: $^{14}_{6}$carbon → $^{14}_{7}$nitrogen + $^{0}_{-1}e$
•	The emission of a gamma ray does not cause the mass or the charge of the nucleus to change
•	Radioactive decay is random
•	The half life of a radioactive isotope is the time it takes for the number of nuclei of the isotope in a sample to halve, or the time it takes for the count rate or activity from a sample containing the isotope to fall to half its initial level.
•	Radioactive contamination is the unwanted presence of materials containing radioactive atoms on other materials
•	The hazard from contamination is due to the decay of the contaminating atoms
•	The type of radiation emitted affects the level of hazard
•	Irradiation is the process of exposing an object to nuclear radiation. The irradiated object does not become radioactive.
•	It is important for the findings of studies into the effects of radiation on humans to be published and shared with other scientists so that the findings can be checked by peer review