Biology Content (Separate only)

Culturing microorganisms.

Bacteria multiply by simple cell division (binary fission) as often as once every 20 minutes if they have enough nutrients and a suitable temperature.

Bacteria can be grown in a nutrient broth solution or as colonies on an agar gel plate.

Uncontaminated cultures of microorganisms are required for investigating the action of disinfectants and antibiotics.

Students should be able to describe how to prepare an uncontaminated culture using aseptic technique.

They should be able to explain why: • Petri dishes and culture media must be sterilised before use • inoculating loops used to transfer microorganisms to the media must be sterilised by passing them through a flame • the lid of the Petri dish should be secured with adhesive tape and stored upside down • in school laboratories, cultures should generally be incubated at 25°C.

Students should be able to calculate cross-sectional areas of colonies or clear areas around colonies using πr^2.

Students should be able to calculate the number of bacteria in a population after a certain time if given the mean division time.

(HT only) Students should be able to express the answer in standard form

The brain

The brain controls complex behaviour. It is made of billions of interconnected neurones and has different regions that carry out different functions.

Students should be able to identify the cerebral cortex, cerebellum and medulla on a diagram of the brain, and describe their functions.

(HT only) Students should be able to explain some of the difficulties of investigating brain function and treating brain damage and disease.

(HT only) Neuroscientists have been able to map the regions of the brain to particular functions by studying patients with brain damage, electrically stimulating different parts of the brain and using MRI scanning techniques. The complexity and delicacy of the brain makes investigating and treating brain disorders very difficult.

Chemistry Content (Separate only)

Yield and atom economy of chemical reactions

Percentage yield

Even though no atoms are gained or lost in a chemical reaction, it is not always possible to obtain the calculated amount of a product because:

• the reaction may not go to completion because it is reversible

• some of the product may be lost when it is separated from the reaction mixture • some of the reactants may react in ways different to the expected reaction.

The amount of a product obtained is known as the yield. When compared with the maximum theoretical amount as a percentage, it is called the percentage yield.

$$\% \ Yield = \frac{Mass \ of \ product \ actually \ made}{Maximum \ theoretical \ mass \ of \ product} \times 100$$

Students should be able to: • calculate the percentage yield of a product from the actual yield of a reaction • (HT only) calculate the theoretical mass of a product from a given mass of reactant and the balanced equation for the reaction.

Atom economy

The atom economy (atom utilisation) is a measure of the amount of starting materials that end up as useful products. It is important for sustainable development and for economic reasons to use reactions with high atom economy.

The percentage atom economy of a reaction is calculated using the balanced equation for the reaction as follows:

$$\frac{Relative \ formula \ mass \ of \ desired \ product \ from \ equation}{Sum \ of \ relative \ formula \ masses \ of \ all \ reactants \ from \ equation} \times 100$$

Students should be able to: • calculate the atom economy of a reaction to form a desired product from the balanced equation • (HT only) explain why a particular reaction pathway is chosen to produce a specified product given appropriate data such as atom economy (if not calculated), yield, rate, equilibrium position and usefulness of by-products.

Reactions of alkenes and alcohols

Structure and formulae of alkenes

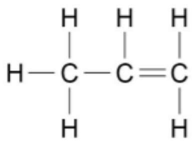
Alkenes are hydrocarbons with a double carbon-carbon bond. The general formula for the homologous series of alkenes is C_nH_{2n}

Alkene molecules are unsaturated because they contain two fewer hydrogen atoms than the alkane with the same number of carbon atoms.

The first four members of the homologous series of alkenes are ethene, propene, butene and pentene. Alkene molecules can be represented in the following forms:

C_3H_6

or



Students do not need to know the names of individual alkenes other than ethene, propene, butene and pentene.

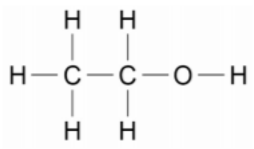
Alcohols

Alcohols contain the functional group –OH. Methanol, ethanol, propanol and butanol are the first four members of a homologous series of alcohols.

Alcohols can be represented in the following forms:

CH_3CH_2OH

or



Students should be able to:

- describe what happens when any of the first four alcohols react with sodium, burn in air, are added to water, react with an oxidising agent
- recall the main uses of these alcohols.

Aqueous solutions of ethanol are produced when sugar solutions are fermented using yeast.

Students should know the conditions used for fermentation of sugar using yeast.

Students should be able to recognise alcohols from their names or from given formulae. S

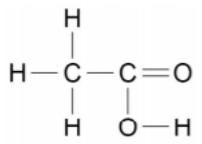
students do not need to know the names of individual alcohols other than methanol, ethanol, propanol and butanol.

Carboxylic acids

Carboxylic acids have the functional group –COOH. The first four members of a homologous series of carboxylic acids are methanoic acid, ethanoic acid, propanoic acid and butanoic acid. The structures of carboxylic acids can be represented in the following forms:

CH_3COOH

or



Students should be able to:

• describe what happens when any of the first four carboxylic acids react with carbonates, dissolve in water, react with alcohols •

Students should be able to recognise carboxylic acids from their names or from given formulae.

Students do not need to know the names of individual carboxylic acids other than methanoic acid, ethanoic acid, propanoic acid and butanoic acid.

Physics Content (Separate only)

Gas Pressure

A gas can be compressed or expanded by pressure changes. The pressure produces a net force at right angles to the wall of the gas container (or any surface).

Students should be able to use the particle model to explain how increasing the volume in which a gas is contained, at constant temperature, can lead to a decrease in pressure.

For a fixed mass of gas held at a constant temperature

$$pressure \times volume = constant$$

$$[\ p\ V = constant\ ]$$

pressure, p, in pascals, Pa volume, V, in metres cubed, m3

Students should be able to calculate the change in the pressure of a gas or the volume of a gas (a fixed mass held at constant temperature) when either the pressure or volume is increased or decreased.

Work is the transfer of energy by a force. Doing work on a gas increases the internal energy of the gas and can cause an increase in the temperature of the gas.

Students should be able to explain how, in a given situation eg a bicycle pump, doing work on an enclosed gas leads to an increase in the temperature of the gas.

Pressure in a fluid

A fluid can be either a liquid or a gas. The pressure in fluids causes a force normal (at right angles) to any surface. The pressure at the surface of a fluid can be calculated using the equation:

$$\text{pressure} = \frac{\text{force normal to a surface}}{\text{area of that surface}}$$

$$\left[p = \frac{F}{A}\right]$$

pressure, p, in pascals, Pa

force, F, in newtons, N

area, A, in metres squared, m^2

The pressure due to a column of liquid can be calculated using the equation:

pressure = height of the column × density of the liquid × gravitational field strength

$$[p = h \rho g]$$

pressure, p, in pascals, Pa

height of the column, h, in metres, m

density, ρ, in kilograms per metre cubed, kg/m^3

gravitational field strength, g, in newtons per kilogram, N/kg (In any calculation the value of the gravitational field strength (g) will be given.)

Students should be able to explain why, in a liquid, pressure at a point increases with the height of the column of liquid above that point and with the density of the liquid.

Students should be able to calculate the differences in pressure at different depths in a liquid. A partially (or totally) submerged object experiences a greater pressure on the bottom surface than on the top surface. This creates a resultant force upwards. This force is called the upthrust. Students should be able to describe the factors which influence floating and sinking.

The atmosphere is a thin layer (relative to the size of the Earth) of air round the Earth. The atmosphere gets less dense with increasing altitude.

Air molecules colliding with a surface create atmospheric pressure. The number of air molecules (and so the weight of air) above a surface decreases as the height of the surface above ground level increases. So as height increases there is always less air above a surface than there is at a lower height. So atmospheric pressure decreases with an increase in height.

Students should be able to: • describe a simple model of the Earth's atmosphere and of atmospheric pressure • explain why atmospheric pressure varies with height above a surface.

Sound waves

Sound waves can travel through solids causing vibrations in the solid.

Within the ear, sound waves cause the ear drum and other parts to vibrate which causes the sensation of sound. The conversion of sound waves to vibrations of solids works over a limited frequency range. This restricts the limits of human hearing.

Students should be able to: • describe, with examples, processes which convert wave disturbances between sound waves and vibrations in solids. Examples may include the effect of sound waves on the ear drum

• explain why such processes only work over a limited frequency range and the relevance of this to human hearing.

Students should know that the range of normal human hearing is from 20 Hz to 20 kHz.

Waves for detection and exploration

Students should be able to explain in qualitative terms, how the differences in velocity, absorption and reflection between different types of wave in solids and liquids can be used both for detection and exploration of structures which are hidden from direct observation.

Ultrasound waves have a frequency higher than the upper limit of hearing for humans. Ultrasound waves are partially reflected when they meet a boundary between two different media. The time taken for the reflections to reach a detector can be used to determine how far away such a boundary is. This allows ultrasound waves to be used for both medical and industrial imaging.

Seismic waves are produced by earthquakes. P-waves are longitudinal, seismic waves. P-waves travel at different speeds through solids and liquids. S-waves are transverse, seismic waves. S-waves cannot travel through a liquid. P-waves and S-waves provide evidence for the structure and size of the Earth's core.

Echo sounding, using high frequency sound waves is used to detect objects in deep water and measure water depth.

Students should be aware that the study of seismic waves provided new evidence that led to discoveries about parts of the Earth which are not directly observable

<u>Space Physics</u>

Our solar system

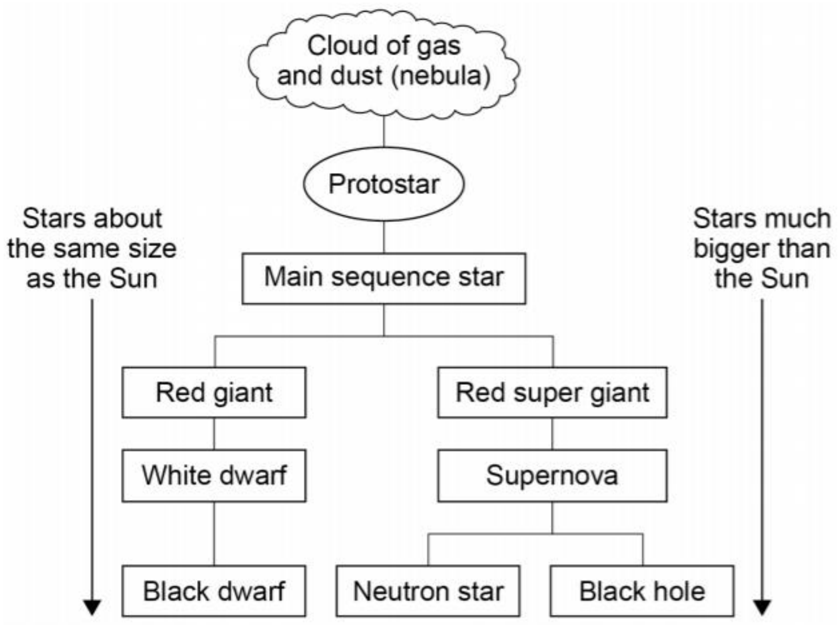
Within our solar system there is one star, the Sun, plus the eight planets and the dwarf planets that orbit around the Sun. Natural satellites, the moons that orbit planets, are also part of the solar system.

Our solar system is a small part of the Milky Way galaxy. The Sun was formed from a cloud of dust and gas (nebula) pulled together by gravitational attraction.

Students should be able to explain: • how, at the start of a star's life cycle, the dust and gas drawn together by gravity causes fusion reactions • that fusion reactions lead to an equilibrium between the gravitational collapse of a star and the expansion of a star due to fusion energy.

The life cycle of a star

A star goes through a life cycle. The life cycle is determined by the size of the star. Students should be able to describe the life cycle of a star: • the size of the Sun • much more massive than the Sun.



Fusion processes in stars produce all of the naturally occurring elements. Elements heavier than iron are produced in a supernova. The explosion of a massive star (supernova) distributes the elements throughout the universe. Students should be able to explain how fusion processes lead to the formation of new elements.

Orbital motion, natural and artificial satellites

Gravity provides the force that allows planets and satellites (both natural and artificial) to maintain their circular orbits.

Students should be able to describe the similarities and distinctions between the planets, their moons, and artificial satellites. (HT only) Students should be able to explain qualitatively how: • (HT only) for circular orbits, the force of gravity can lead to changing velocity but unchanged speed • (HT only) for a stable orbit, the radius must change if the speed changes.

Red-shift (physics only)

There is an observed increase in the wavelength of light from most distant galaxies. The further away the galaxies, the faster they are moving and the bigger the observed increase in wavelength. This effect is called red-shift. The observed red-shift provides evidence that space itself (the universe) is expanding and supports the Big Bang theory.

The Big Bang theory suggests that the universe began from a very small region that was extremely hot and dense. Since 1998 onwards, observations of supernovae suggest that distant galaxies are receding ever faster.

Students should be able to explain:

• qualitatively the red-shift of light from galaxies that are receding • that the change of each galaxy's speed with distance is evidence of an expanding universe • how red-shift provides evidence for the Big Bang model • how scientists are able to use observations to arrive at theories such as the Big Bang theory

• that there is still much about the universe that is not understood, for example dark mass and dark energy.