Biology 1: Cell Biology

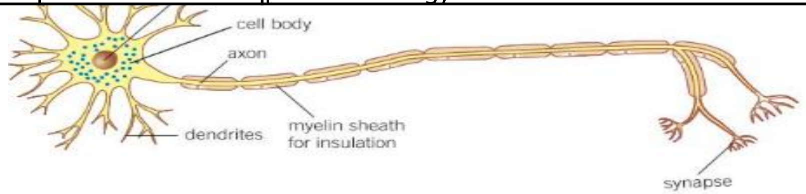
Section 1: Cell Structure

Cell Structure	Function	Eukaryotic (Nucleus) Animal Cells	Eukaryotic (Nucleus) Plant Cells	Prokaryotic (No Nucleus) Bacterial Cells
1 Nucleus	Contains **genetic material** controlling functions of cell	Y	Y	
2 Cell membrane	Controls what **enters** and **leaves** the cell	Y	Y	Y
3 Cytoplasm	Gel in which cells' **chemical reactions** occur	Y	Y	Y
4 Mitochondria	Provides **energy** from **aerobic respiration**	Y	Y	
5 Ribosome	**Synthesises** (makes) **proteins**	Y	Y	Y
6 Chloroplast	Contain chlorophyll for **photosynthesis**		Y	
7 Permanent vacuole	Contains **cell sap** to keep cell rigid and support plant		Y	
8 Cell wall	**Strengthens** and **supports** cell (made of **cellulose** in plants and algae but not in bacteria)		Y	Y
9 DNA loop	A loop of **DNA**, not enclosed within a nucleus.			Y
10 Plasmid	**Small ring of DNA**, sometimes with **genes** enabling antibiotic resistance.			Y
	Relative sizes	10-30µm	10-100µm	1-2µm

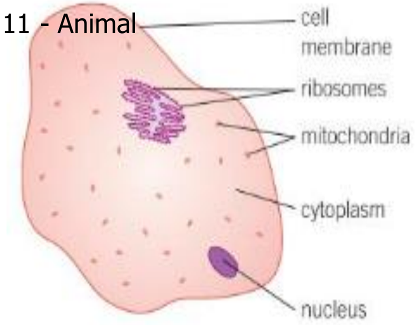
Section 2: Cell specialisation and differentiation

Type	Differentiation	Specialised Cell	How structure relates to function
ANIMAL CELLS	Cells differentiate in **early stage** of animal's development. Once mature, cell division only for **repair** & **replacement**	14 Sperm cell	**Acrosome** contains **enzyme** to break into egg; many **mitochondria** to provide **energy** for **tail** to swim to egg
		15 Nerve cell	**Long axon** to transmit electrical impulses over distance. To connect to other cells there are **dendrites** & **neurotransmitters** produced with energy supplied by mitochondria
		16 Muscle cell	Many mitochondria provide **energy** for **protein fibres** that can **contract** allowing movement**.** Store **glycogen** (chemical energy)
PLANT CELLS	Many plant cells can **differentiate** throughout life (ie **acquire different sub-cellular structures to carry out a particular function**)	17 Root hair cell	Root hair **increases surface area** for water & mineral uptake; permanent vacuole accelerates osmosis, mitochondria provide energy for active transport of minerals
		18 Xylem cell	**Hollow** to allow water & minerals to move up plant. **Lignin** in cell walls strengthen to withstand water pressure and support stem
		19 Phloem cell	Cell walls between phloem cells **sieve-like** to allow dissolved food made by photosynthesis up & down plant. **Companion cells** provides energy as few mitochondria.

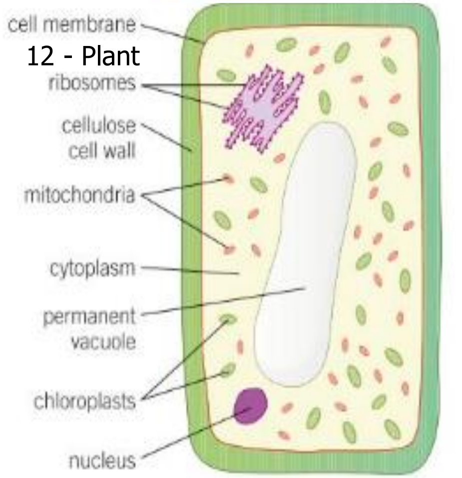
15 – Nerve cell



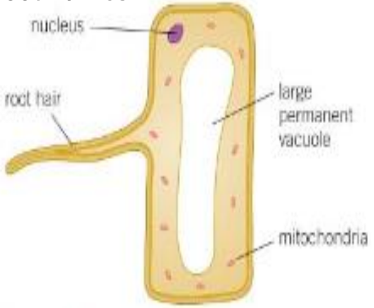
11 - Animal

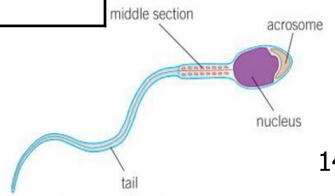


12 - Plant



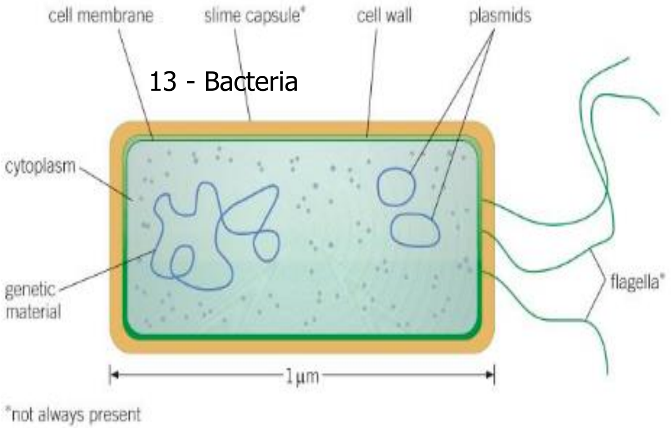
17 – Root hair cell



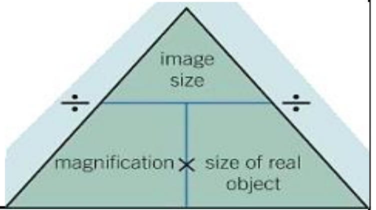


14– Sperm cell

13 - Bacteria



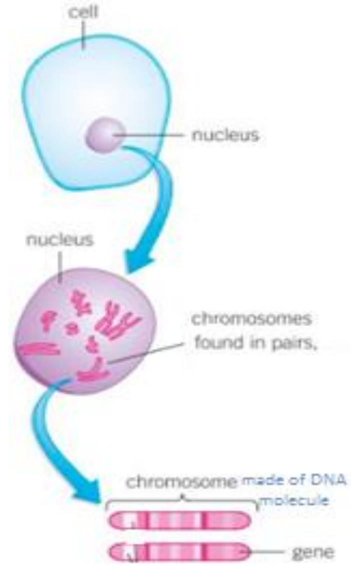
Section 3: Microscopy

20 Magnification	How much bigger an object looks	
21 Resolving Power	Minimum distance between two objects where you can still see them as separate	
22 Light microscope	Invented in 17th century with lower magnification and resolving power.	
23 Electron microscope	Invented in 1930s with much higher magnification and resolution. Allowed study of cells in finer detail and **exploration of subcellular structures**	

Section 4: Orders of Magnitude

Unit Prefix	Size in metres	Standard Form	Context
24 Centimetre (cm)	0.01m	10^{-2}m	
25 Millimetre (mm)	0.001m	10^{-3}m	
26 Micrometre (µm)	0.000001m	10^{-6}m	**Cell size**
27 Nanometre (nm)	0.000000001m	10^{-9}m	

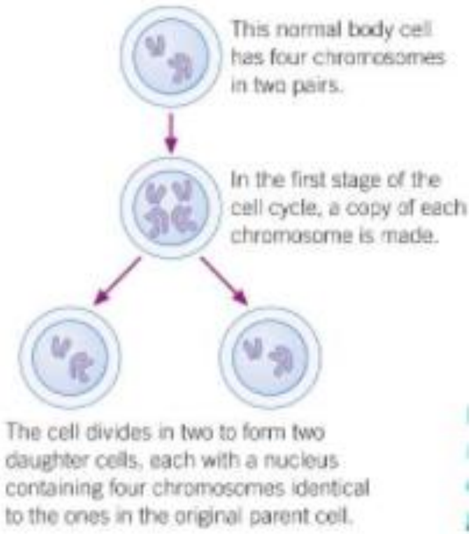
28 – Chromosomes



Section 5: Mitosis and the Cell Cycle

29	Mitosis (**cell division**) is important in the growth & development of multicellular organisms	
30	Stage 1 (longest)	Number of **sub-cellular structures** (e.g. **ribosomes** and **mitochondria**) **increase. DNA replicates** creating two copies of each chromosome
31	Stage 2	One set of **chromosomes** is **pulled** to each end of the cell and then the **nucleus divides**
32	Stage 3	**Cytoplasm** and **cell membranes divide** to form two **identical** cells

30 – 32 Stages of cell cycle



Section 6: Stem Cells

Stem Cells	Type	Properties	Uses
33 **Undifferentiated** cell of an organism which is capable of giving rise to many more cells of same type, or other specialised cells can arise from differentiation	34 **Embryonic** stem cell	These are in a ball of cells that divide from fertilised egg. Can divide into **most types** of human cell.	Can be **cloned** and researchers are trying to differentiate into insulin producing cells to helps **diabetes** or spinal nerve cells to help **paralysis**
	35 Adult stem cell	Can divide into a **limited number of cells** e.g. bone marrow stem cells can form blood cells.	
	36 Meristem	Can differentiate (divide) into **any type** of **plant** cell throughout plant's life	**Clone** rare species to **prevent extinction**. **Crops** with **special features** can be cloned eg disease resistance

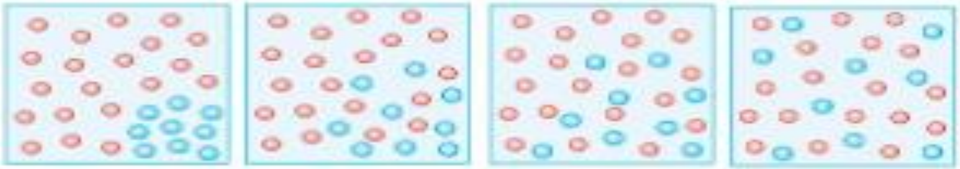
Pros and Cons of Using Embryonic Stem Cells

37 Pros	**Treatment** of above conditions. **Therapeutic cloning** can produce embryo cells with the same genes as the patient's cells so they are not **rejected**
38 Cons	**Ethical** and **religious** objections as often come from aborted/unused embryos. Can **transfer viruses** held within cells.

Section 7: Transport Across Cell Membranes: Diffusion

Definition	Uses	Factors Affecting Rate	Factor Explanation	Specialisation of multicellular organisms to allow fast enough diffusion
39 **Spreading** out of particles (gas/solution) resulting in a **net movement** from an area of **higher concentration** to an area of **lower concentration**	**Oxygen** and **carbon dioxide** in **gas exchange** (leaves & alveoli). **Urea** from **cells** into **blood plasma** for excretion in kidney	40 Difference in concentrations (**concentration gradient**)	The greater the difference in concentrations, the faster the rate of diffusion down gradient	43 **Large exchange surface areas** eg small intestine & lung in mammals, gills in fish, roots and leaves in plants
		41 **Temperature**	Particles move more quickly at higher temperatures, so rate of diffusion increases	44 **Thin membrane** to provide a **short diffusion path**
		42 **Surface area** of membrane	The greater the surface area the quicker the rate of diffusion (single cell organisms have large enough surface area to volume ratio to keep sufficient transport Multicellular don't)	45 **Ventilation** (in animals for gas exchange – maintains a steep concentration gradient)
				46 **Efficient blood supply as a transport system** (in animals – maintains a concentration gradient)

39 – Diffusion Model



42 – Surface area to volume ratio

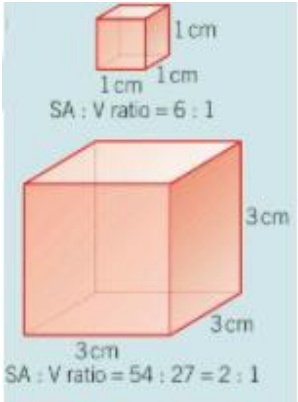


Figure 1 Relationship of surface area to volume

Section 8: Transport Across Cell Membranes: Osmosis

Transport	Definition	Uses
47 Osmosis	Diffusion of water from a dilute solution to a concentrated solution through a partially permeable membrane.	Movement of water into and out of cells.

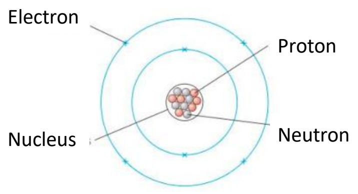
Section 9: Transport Across Cell Membranes: Active transport

Transport	Definition	Uses
48 Active Transport	The movement of substances from a more dilute solution to a more concentrated solution (against a concentration gradient). Requires energy from respiration.	**Absorption** of **mineral ions** (low concentration) from soil into **plant roots**. **Absorption** of **sugar molecules** from lower concentrations in the **gut** into the **blood** which has a higher sugar concentration.

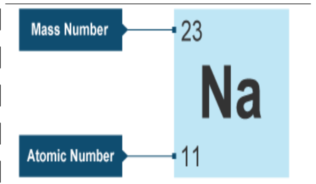
Chemistry 1: Atomic structure and the periodic table

Atoms

Atoms are tiny, too small to see. They have a radius of 0.1 nanometres (1 x 10 $^{-10}$ m)
Atoms have no charge because they have the same number of **protons** and **electrons.**



Type of sub-atomic particle	Relative charge	Relative mass
proton	+1	1
neutron	0	1
electron	−1	very small (it would take almost 2000 electrons to have the same mass as one proton or neutron)

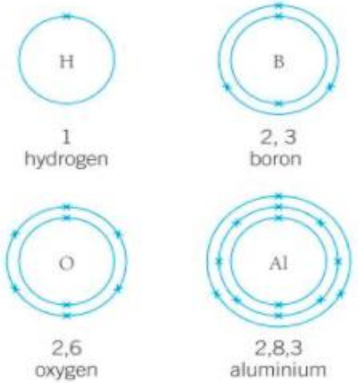


Mass Number :
protons + neutrons
Atomic number:
Protons

Electron - Orbit around nucleus in shells
Proton - Found in the nucleus
Neutron - Found in the nucleus

Electronic Structure

- 1st **shell**– Lowest energy level and can hold <u>**2 electrons**</u>
- 2nd **shell**– Energy level can hold up to <u>8 **electrons**</u>
- 3rd **shell** onwards– Can hold up to <u>8 **electrons**</u>.



<u>**Electron** structure and the **periodic table**</u>
Elements in the same **group** have the same number of **electrons** on their outer **shell.**

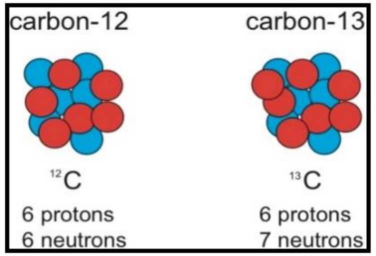
Proton number = **Electron** Number
Number of **neutrons**=
Mass number—Atomic number

Ions

An **ion** is an atom that has lost or gained electrons.
In an i**on** the number of protons is not equal to the number of **electrons** so the atom has an overall charge.

Isotopes

An **isotope** is an atom that has the same number of **protons** but a different number of **neutrons**.
They have the same **atomic number** but different **atomic mass** numbers.



Relative atomic mass (A$_r$)

An average mass of an **element** that has a number of different **isotopes.**

Relative atomic Mass (Ar) = <u>sum of (i**sotope** abundance x **isotope** mass number)</u> / sum of abundance of all the **isotopes**

Chemical Equations

Chemical reactions are shown using:
- **Word equations**

Magnesium + Oxygen → *Magnesium Oxide*
(reactants) *(product)*

- ***Symbol equations**—Show the **atoms** on both sides*

2Mg + O2 → *2MgO*

<u>**Balancing equations:**</u>
- There must always be the same number of **atoms** on both sides of a **symbol equation**.
- Atoms can't just disappear.
- You **balance** equations by putting numbers <u>**in front**</u> of the nu

$$CH_4 + 4Cl_2 \longrightarrow CCl_4 + 4HCl$$

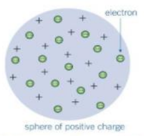
C = 1
H = 4
Cl = ~~2~~ 8

C = 1
H = ~~1~~ 4
Cl = ~~5~~ 8

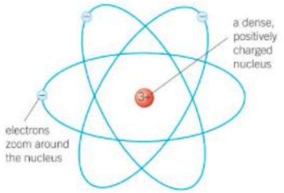
History of the atom

*Ideas about **atoms** have change over time.*

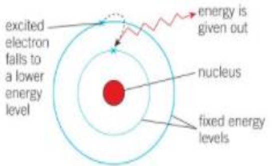
Plum pudding model
An **atom** was a ball of positive charge with **electrons** scattered in the ball.



Rutherford's nuclear model
Electrons orbiting the **nucleus** which contains very dense positively charged **protons.**



Bohr's model
Electrons orbit the **nucleus** at set distances in fixed energy levels **(shells).**



The Periodic table

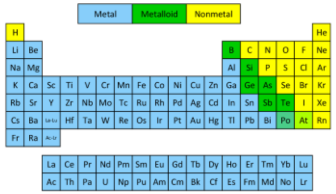
The arrangement of the periodic table has changed.

Early 1800s
- Arranged my **relative atomic mass**.
- Scientists had not yet discovered proton, neutrons or electrons.
- There were gaps for missing elements that had not been found yet.

Dimitri Mendeleev
- Ordered mainly by **atomic mass**.
- Elements with similar properties in the same **group**.
- Gaps left for **elements** that hadn't been found yet.

Modern Day
- In order of increasing **atomic mass**.
- Repeating patterns in the properties of the **elements**.
- **Metals** are on the left and **non– metals** are on the righ

You will need to know the first 20 **element** names and their **symbols**

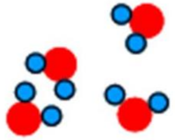


Properties of **metals** - **Ductile** - **Malleable**
- High **melting** and **boiling** point
- **Conduct** heat - **Conduct** electricity

Properties of **non- metals** - Brittle
- **Insulators** of heat and electricity
- Not always **solids** - lower **density**

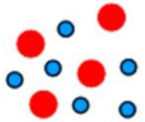
Compounds

- Have a fixed composition
- Can be separated by a **chemical reaction**
- Chemical bonds between **atoms**



Mixtures

- No fixed composition
- Can be separated by physical means
- No chemical **bonds** between **atoms**



Separating Mixtures

Filtration
*Separates **insoluble solids** from **liquids.***
- Put filter paper in a funnel and pour the **solution** through it. The liquid passes through and the solid is caught in the filter paper.

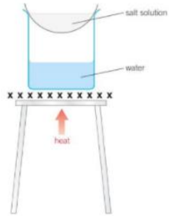
Evaporation
*Used to separate a **soluble** salt from a **solution.***
- Heat the **solution** until the **solvent evaporates**.

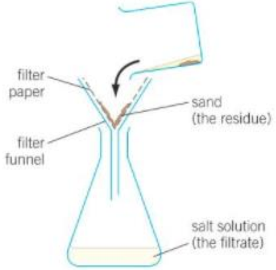
Crystallisation
*Used to separate a **soluble** salt from a **solution.***
- Heat the **solution** and then leave to cool until crystals form.

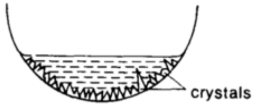
Distillation
*Used to separate **liquid** from a **solution.***
Heat **solution** and the part with the lowest **boiling** point **evaporates** and is **condensed** back into a **liquid.**

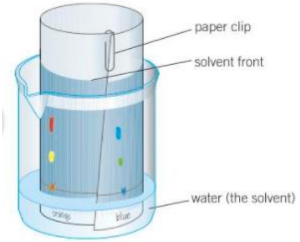
Fractional Distillation
*Used to separate a mixture of **liquids** from a **solution.***

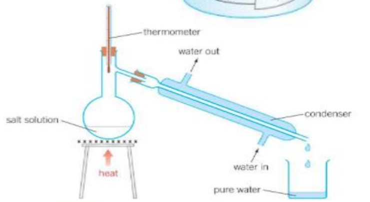
Paper chromatography
Can be used to separate different dyes in an ink.
- **Compounds** are **dissolved** by using filter paper and a **solvent**, in which the **compounds** are placed.











Group 1– Alkali metals

- *One **electron** on outer shell*
- *Very **reactive***
Reactivity** increases down the **group.

Li
Na
K
Rb
Cs
Fr

Group 7– Halogens

- Seven **electrons** on outer shell
- Less **reactive** down the group
- Higher **melting** and **boiling** points down the group

F
Cl
Br
I
At

Group 0– Noble gases

- Eight **electrons** on outer shell
- **Unreactive** as they have a full outer shell and are stable
- Colourless gases

He
Ne
Ar
Kr
Xe
Rn

5.2 - Bonding, Structure and Properties of Matter

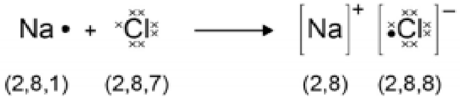
Section 1 – Key Definitions

1. Ionic bond – the electrostatic force of attraction between positively and negatively charged ions.
2. Dot and cross diagram – a drawing to show only the arrangement of the outer shell electrons of the atoms or ions in a substance.
3. Covalent bond – the bond between two atoms that share one or more pairs of electrons.
4. Metallic bond –
5. Alloy – a mixture of two or more elements, at least one of which is a metal.
6. Delocalised electrons – bonding electron that is no longer associated with any one particular atom.
7. Fullerene – form of the elements carbon that can exist as large cage-like structures, based on hexagonal rings of carbon atoms.
8. Giant covalent structure – a huge 3D network of covalently bonded atoms.
9. Giant structure/lattice – a huge 3D network of atoms or ions.
10. Polymer – a substance made from very large molecules made up of many repeating units.

Section 2 - Ionic

2A - Ionic Bonding

1. Bonds between metal positive ions and non-metal negative ions.
2. The outer-shell electron of the metal ion transfers to the non-metal ion.
3. Can be represented with dot and cross diagrams.



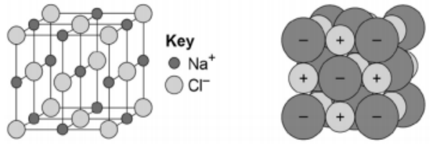
2B - Ionic Compounds

1. Ionic compounds are held together by strong forces of attraction between their oppositely charged ions.
2. These forces act in all directions in the compound.
3. Giant regular structure of ions.
4. They have high melting and boiling points, due to large amounts of energy being needed to break the strong bonds.
5. When melted or dissolved in water, ionic compounds conduct electricity due to free moving ions.

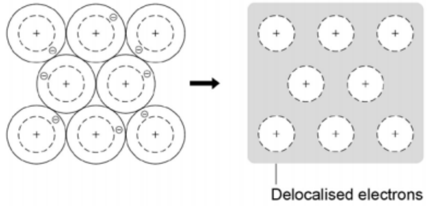
Section 3 – Metals and Alloys

3A - Metallic Bonding

1. Giant structures of atoms arranged in a regular pattern.
2. Delocalised outer shell electrons are free to move through the whole structure.
3. Sharing of delocalised electrons gives rise to strong metallic bonds.



Sodium chloride lattice structure



Metal bonding with delocalised electrons

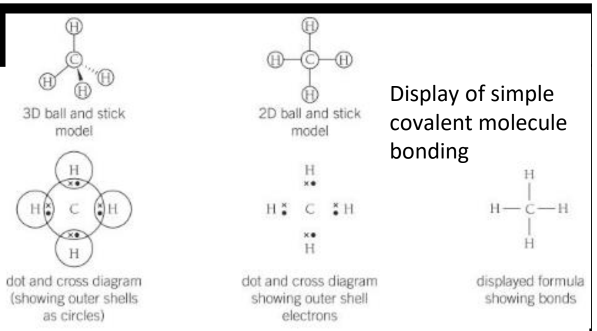
3B - Metal Properties

1. High melting and boiling points.
2. Atoms are arranged in layers which allows metals to be bent and shaped.
3. Pure metals are too soft for many uses. They are mixed with other metals to make alloys which are harder.
4. Metals conduct electricity because of the delocalised electrons carrying charge through the metal.
5. Good thermal energy conductors because energy is transferred by delocalised electrons.

Section 4 - Covalent

4A - Covalent Bonding

1. Between non-metal atoms.
2. Atoms share pairs of electrons.



Display of simple covalent molecule bonding

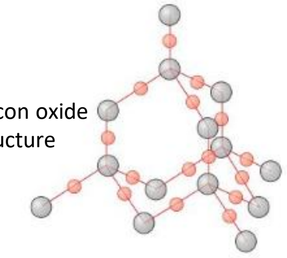
4B - Small Covalent Molecules

1. Gases or liquids with low melting and boiling points.
2. Weak intermolecular forces that break when the substance melts or boils.
3. Intermolecular forces increase with the size of the molecules.
4. Do not conduct electricity.
5. Examples – water, ammonia, carbon dioxide

4C - Giant covalent structures

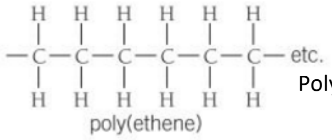
1. Solids with high melting points.
2. All atoms linked to other atoms by strong covalent bonds.
3. Examples – diamond, silicon dioxide

Silicon oxide structure



4D - Polymers

1. Very large molecules.
2. Atoms in the polymer are linked by strong covalent bonds.
3. Strong intermolecular forces.
4. Solid at room temperature.

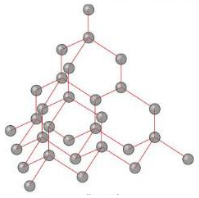


Polymer structure

Section 5 – Carbon Compounds

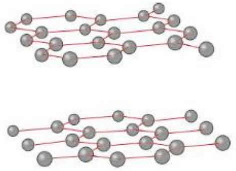
5A - Diamond

1. Carbon atoms form four covalent bonds with other carbon atoms in a giant covalent structure.
2. Very hard
3. Very high melting point.
4. Does not conduct electricity.



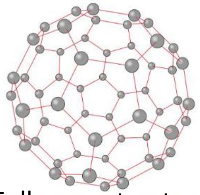
5b - Graphite

1. Carbon atoms form three covalent bonds with three other carbon atoms; forming layers of hexagonal rings.
2. No covalent bonds between layers.
3. One electron from each carbon atom is delocalised which behave like delocalised electrons in metals.

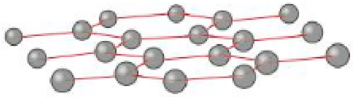


5C - Graphene and Fullerenes

1. Graphene is a single layer of graphite and has properties that make it useful in electronics and composites.
2. Fullerenes are molecules of carbon atoms with hollow shapes.
3. The structure of fullerenes is based on hexagonal rings of carbon atoms but they may also contain rings of five or seven carbon atoms.
4. The first fullerene to be discovered was Buckminsterfullerene (C60) which has a spherical shape.
5. Carbon nanotubes are cylindrical fullerenes with very high length to diameter ratios.
6. Nanotubes are useful for nanotechnology, electronics and materials.



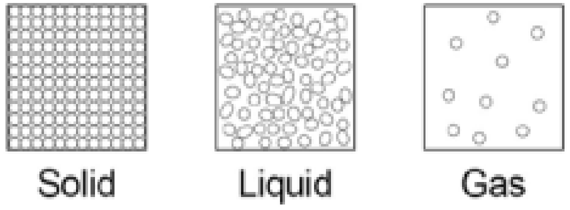
Fullerene structure



Graphene structure

Section 6 – States of Matter

1. Solid to liquid state change is melting. Liquid to solid state change is freezing. Happens at the melting point.
2. Liquid to gas state change is boiling. Gas to liquid state change is condensing. Happens at the boiling point.
3. The amount of energy needed to change state from solid to liquid and liquid to gas depends on the strength of the forces between the particles of the substance.
4. The nature of the particles involved depends on the type of bonding and the structure of the substance.
5. The stronger the forces between the particles the higher the melting point and boiling point of the substance.
6. Particle model limited by the fact there are no forces, all particles are represented as spheres and that the spheres are solid.
7. States are represented by state symbols in chemical equations, (s), (l) and (g). (aq) for aqueous solutions.



Physics 1 – 6.1 Energy

Section 1: Energy Stores

Energy Store	Definition / Example
Chemical	Energy in bonds of chemicals
Thermal /Internal	Heat. Increases with as temperature increases
Kinetic	Movement.
Gravitational Potential	Distance from the ground. Increases as height increases
Electrostatic	Attraction or repulsion of charges
Elastic Potential	Stretching / Bending / Moulding
Magnetic	Attraction or repulsion of Magnetic Poles
Nuclear	Within a nucleus

Section 2: Energy Transfers

Energy Transfer: The movement of energy from one store to another.

Energy Transfer	How it transfers
Mechanical Working	Physical movement
Electrical Working	Movement of charge in electrical currents
Heating	Via conduction or convection
Radiation	Light, sound or heat

Section 3: Conservation and Dissipation

Theory	Definition
Conservation of energy	Energy cannot be created or destroyed Energy can only change store within a system
Dissipation of energy	Energy if lost from a system, spreads out, often as heat
System	Is an object or group of objects
Wasted energy	Energy that is not usefully transferred

Section 4: Calculating Energy Stores

Useful Energy output in a system (J) = **Total energy input**(J) **– wasted energy** (J)
Gravitational Potential Energy (J) = **mass** (kg) **x gravitational field strength** (J) **x height** (m)
Kinetic Energy (J) = **0.5 x mass** (kg) **x speed^2** (m/s)
Work Done (J) = **force applied** (N) **x distance in the same direction** (m)
Change in Thermal Energy (J) = **mass** (kg) **x specific heat capacity** (J/Kg°C) **x temperature change** (°C)
Elastic Potential Energy (J) = **0.5 x spring constant** (N/m) **x extension^2** (m) ← You will be given this

Section 5: Electrical Appliances

Power: The rate of energy transfer or rate of work done

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

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

An energy transfer of 1 joule per second is equal to a power of 1 watt.

Efficiency: The amount of useful energy compared to wasted energy

$$\textbf{Efficiency} = \frac{\text{Useful output energy transfer}}{\text{Total input energy transfer}}$$

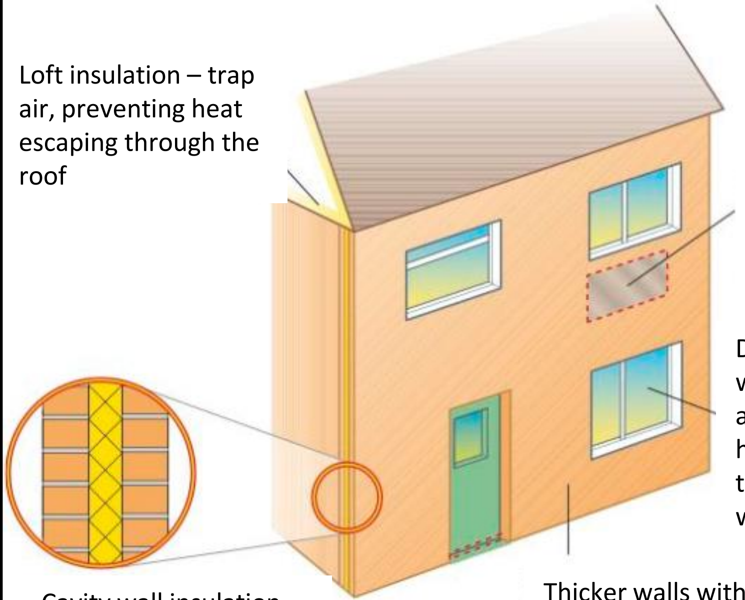
$$\textbf{Efficiency} = \frac{\text{Useful power output}}{\text{Total power input}}$$

To calculate a percentage efficiency you times by 100

Section 6: Transfers by Heat

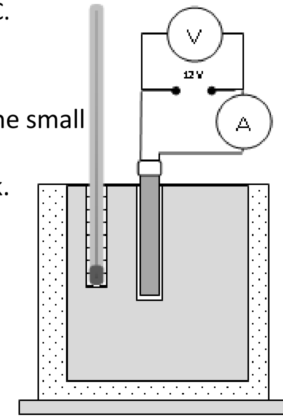
Thermal conductivity: the higher the thermal conductivity, the higher the rate of energy transfer.
Conduction: When particles vibrate in a solid, they bump into one another passing the kinetic/internal energy along.
To reduce unwanted heating transfers - Use an insulator to prevent the transfer of heat.
To reduce unwanted mechanical transfer - Use lubrication to reduce friction.

Section 7: Heating in the Home



Section 8 : Required Practical: Specific Heat Capacity

Specific heat capacity – the amount of energy required to raise the temperature of 1kg of the substance by 1°C.



Required Practical Method:

1. Measure and record the mass of the copper block in kg.
2. Place a heater in the larger hole in the block and thermometer with a pipette drop of water, in the small hole.
3. Connect the ammeter, power pack and heater in series and the voltmeter across the power pack.
4. Switch the power pack to 12 V. Switch it on.
5. Record the ammeter and voltmeter readings. These shouldn't change during the experiment.
6. Measure the temperature and switch on the stop clock every minute for 10 minutes.
7. Calculate work done and power.
8. The specific capacity of the block = $\frac{\text{Energy}}{\text{Mass x temperature rise}}$

Why is expected specific heat capacity always higher than the actual specific heat capacity in this experiment?

As thermal stores of energy can dissipate into the surroundings.

Why do we use an insulation during the practical?

To minimise the amount of energy escaping the system.

Section 9: Energy Resources

Non- Renewable

The non-renewable fossil-fuels are:

- Coal
- Gas
- Oil

Non-renewable: they cannot be replenished

Fossil Fuels: Fuel from dead animals and plants which have been crushed together. They are burnt to release their energy store.

Advantages: Cheap, no start-up costs, easy to work with, efficient

Disadvantage: Pollution, contribute to global warming, limited supply,

Renewable

Renewable energy resources – is being (or can be) replenished as it is used.

Every resource can generate electricity.

Advantages: Replenishable, don't damage environment

Disadvantages: expensive to set up and maintain, less efficient, wastes space, eyesores,

Energy Resource	Definition / Example	Reliable?	Use
Nuclear	Energy released due to nuclear fission in a nuclear reactor.	Yes – as long as there is a supply of uranium or plutonium	
Biofuel	Any fuel taken from living, or recently living, materials. E.g. Animal Waste, vegetable oil.	Yes – sources can regrow (vegetation) or is continually produced (sewage and rubbish)	As a fuel
Wind	Force of the wind drives a turbine around.	No – dependent on wind amount and speed	
Hydro-electricity	Rainwater that is collected, flows downhill driving a turbine.	No – dependent on rain volume	
Geothermal	Energy is released by radioactive substances deep within the earth, heating the surrounding rock and Earth's surface.	Yes – consistent heating of rocks via radioactive substances	Heats water and houses
Tidal	Traps water from tides which can be released into the sea via turbines	No – dependent on high tides	
Solar	Solar radiation heats water in solar panels or generates electricity in solar cells	No – dependent on radiation from the sun	Heats water
Wave	Waves make a floating generator move up or down	No – depends on wave levels and has to withstand storms.	