5.2.1.1 Chemical bonds

There are 3 types of strong chemical bonds:

Ionic Bonding: Between a metal and a non-metal. **Metal loses outer shell electrons**; becomes a **positively** charged ion (a **cation**). **Non-metal gains electrons** to fill its outer shell; becomes a **negatively** charged ion (an **anion**). Oppositely charged ions are **electro-statically attracted** to each other; this keeps them held closely together in the compound.

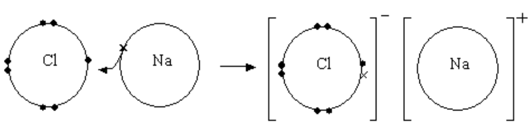
Covalent Bonding: Between most non-metals elements and in non-metals compounds. The atoms share pairs of outer shell electrons.

Metallic Bonding: In metallic elements & alloys. The atoms share delocalised electrons & so are described as positive metal ions surrounded by a sea of delocalised electrons.

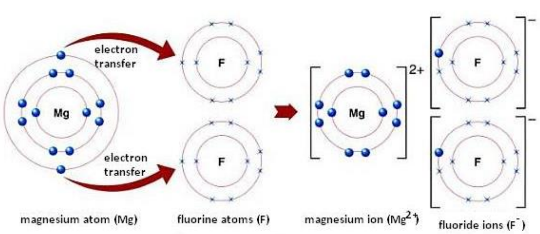
5.2.1.2 Ionic Bonding

Ions made by metals in Groups 1 & 2 and by non-metals in Groups 6 & 7 have the electronic structure of a noble gas (Group 0).

The electron transfer during the formation of an ionic compound can be represented by a dot and cross diagram, e.g. for NaCl.



and e.g. for $MgCl_2$



For atoms in the following groups, notice that:

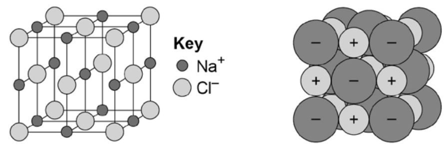
Group 1 → +1 cations. Group 2 → 2+ cations.

Group 6 → 2- anions. Group 7 → 1- anions.

5.2.1.3 Ionic compounds

An ionic compound is a giant structure of ions. Ionic compounds are held together by strong electrostatic forces of attraction between oppositely charged ions. These forces act in all directions in the lattice and this is called ionic bonding.

You need to know how the structure of Sodium chloride can be represented. It can be shown in these ways →



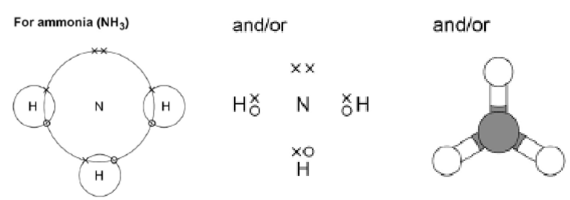
5.2.1.4 Covalent bonding

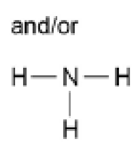
When atoms share pairs of electrons, they form covalent bonds. These bonds between atoms are strong.

Covalently bonded substances may consist of small molecules (e.g. Cl_2, H_2O, CO_2 and CH_4).

Some covalently bonded substances have very large molecules, such as polymers (e.g. PVC - $(C_2H_3Cl)_n$ and Polyethylene - $(C_2H_4)_n$).

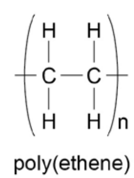
Some covalently bonded substances have giant covalent structures, such as diamond & SiO_2. The covalent bonds in molecules & giant structures can be represented in the following forms:





Polymers can be represented in the form:

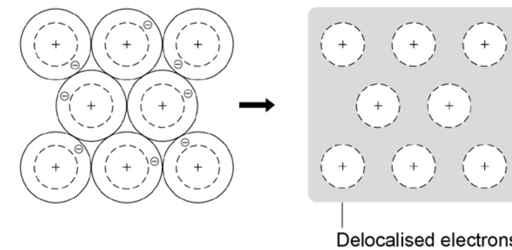
where n is a large number.



5.2.1.5 Metallic bonding

Metals consist of giant structures of atoms arranged in a regular pattern.

The electrons in the outer shell of metal atoms are delocalised and so are free to move through the whole structure. The sharing of delocalised electrons gives rise to strong metallic bonds. The bonding in metals may be represented in the following form:



5.2.2.1 The three states of matter

In a **solid**, the particles are fixed in position and only vibrate – they can't flow around.

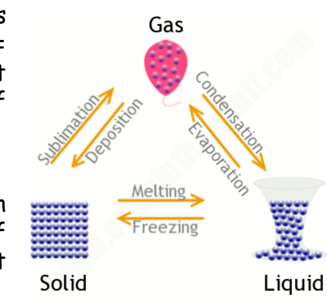
In a **liquid**, the particles are still very close together but they can flow past each other.

In a **gas**, the particles move randomly and there is empty space between them.

Amount of energy to change from solid to liquid & from liquid to gas depends on strength of forces between particles.

Stronger the forces between particles = higher melting point and boiling point of the substance.

Make sure you can name each change of state & describe what happens during each.



5.2.2.2 State symbols

In chemical equations, the 3 states of matter are shown as (s), (l) & (g), with (aq) for aqueous solutions.

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5.2.2.3 Properties of ionic compounds

Ionic compounds have regular structures (giant ionic lattices) in which there are strong electrostatic forces of attraction in all directions between oppositely charged ions.

These compounds have high melting points and high boiling points because of the large amounts of energy needed to break the many strong bonds.

When melted or dissolved in water, ionic compounds conduct electricity because the ions are free to move and so charge can flow.

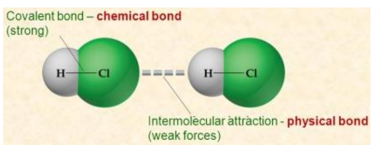
5.2.2.4 Properties of small molecules

Substances that consist of small molecules are usually gases or liquids that have relatively low melting points and boiling points.

These substances do not conduct electricity because the molecules do not have an overall electric charge.

These substances have only weak forces between the molecules (intermolecular forces).

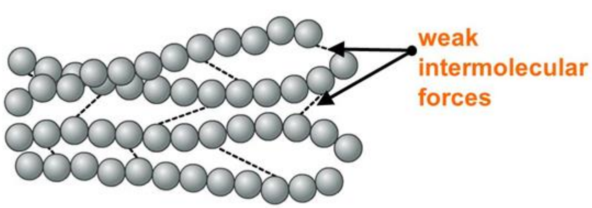
It is these intermolecular forces that are overcome, not the covalent bonds, when the substance melts or boils.



The intermolecular forces increase with the size of the molecules, so larger molecules have higher melting and boiling points. For example, longer polymers tend to have higher m.p. and b.p.

5.2.2.5 Polymers

Polymers have very large molecules. The atoms in the polymer molecules are linked to other atoms by strong covalent bonds. The intermolecular forces between polymer molecules are relatively strong and so these substances are solids at room temperature.



5.2.2.6 Giant covalent structures

Substances that consist of giant covalent structures are solids with very high melting points.

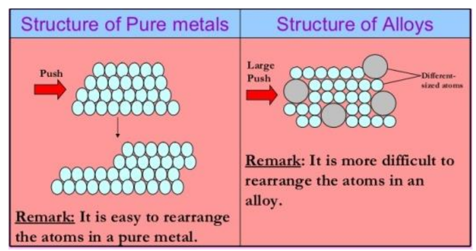
All of the atoms in these structures are linked to other atoms by strong covalent bonds. These bonds must be overcome to melt or boil these substances.

Diamond, Graphite and Silicon dioxide (Silica) are examples of giant covalent structures.

5.2.2.7 Properties of metals and alloys

Metals have giant structures of atoms with strong metallic bonding, allowing most metals to have high melting and boiling points.

In pure metals, atoms are arranged in layers, which allows metals to be bent and shaped. Pure metals are too soft for many uses and so are mixed with other metals to make alloys which are harder.



Alloys are harder than pure metals due to the distortion to the layers of atoms in the structure, by the addition of other differently sized atoms.

5.2.2.8 Metals as conductors

Metals are good conductors of electricity because the delocalised electrons in the metal carry electrical charge through the metal.

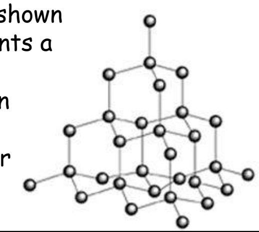
Metals are good thermal conductors as their delocalised electrons can transfer the energy.

5.2.3.1 Diamond

Diamond is an allotrope (different structural form) of carbon. In diamond, each carbon atom forms four covalent bonds with other carbon atoms in a giant covalent structure, so diamond is very hard, has a very high melting point and does not conduct electricity.

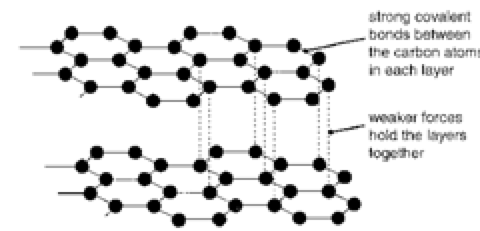
5.2.3.1 Diamond (continued).

Diamond's structure is shown here. Each ball represents a Carbon atom.
The single lines between each Carbon atom represents 1 shared pair of electrons (a single covalent bond).



5.2.3.2 Graphite

Graphite is an allotrope (different structural form) of carbon. In graphite, each carbon atom forms 3 covalent bonds with 3 other carbon atoms, forming layers of hexagonal rings which have no covalent bonds between the layers. In graphite, 1 electron from each C atom is delocalised.



5.2.3.3 Graphene and fullerenes

Graphene is a single layer of graphite. It Is stronger than steel & a better conductor than Copper, making 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 5 or 7 carbon atoms. The first fullerene to be discovered was Buckminsterfullerene (C_{60}) which has a spherical shape. Fullerenes are used as drug delivery systems, lubricants and catalysts.

Carbon nanotubes are cylindrical fullerenes with very high length to diameter ratios. Their properties make them useful for nanotechnology, electronics and materials.

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4.2 Organisation: 4.2.1 Principles of Organisation

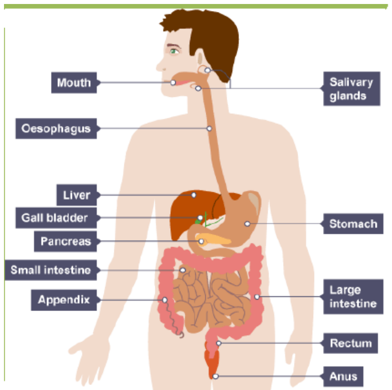
Cells: the basic building blocks of all living organisms. **Tissue**: a group of cells with a similar structure and function. **Organ**: a group of different types of tissues performing a specific function. **Organ system**: Organs working together to do a particular job. **Organism**: Organ systems working together to form a living thing.

4.2.2.1 The human digestive system

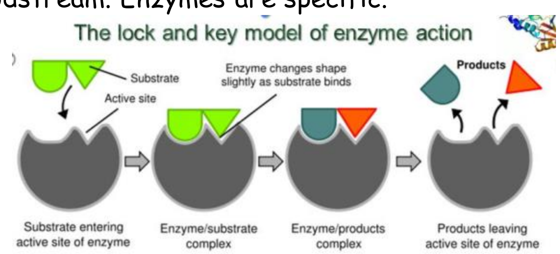
An organ system in which several organs work together to digest and absorb food.

Bile:

- Made in the liver
- Stored in the gall bladder.
- Alkaline to neutralise HCl acid from stomach.
- Emulsifies fat to form small droplets, increasing the surface area & rate of fat breakdown.



Digestive Enzymes: Biological catalysts that speed up the conversion of food into small soluble molecules that can be absorbed into the bloodstream. Enzymes are specific.



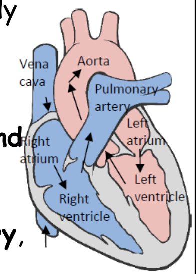
Optimal conditions: Certain conditions in which an enzyme works best. If the pH or temperature are not optimal, the enzyme's active site can become misshapen, causing the enzyme to lose its specificity. We call this "denaturation" & say the enzyme has been "**denatured**".

More on enzymes:

Enzyme type:	Example:	Found in the…	Breaks down…	Into…	Used for…
Carbohydrase	Amylase	Mouth	Carbohydrates	Simple sugars	Energy
Lipase	Pancreatic lipase	Small intestine	Lipids (Fats)	Fatty acids and glycerol	Energy & Insulation (keeping warm)
Protease	Pepsin	Stomach	Proteins	Amino acids	Growth & Repair

4.2.2.2 The heart and blood vessels

Human heart: An organ that pumps blood around the body in a double circulatory system. **Right ventricle** pumps blood **to lungs**. **Left ventricle** pumps blood **around body**. Make sure you can identify & label the **aorta**, **vena cava**, **pulmonary artery**, pulmonary vein & **coronary arteries**.



Pacemaker Cells: Natural resting heart rate is controlled by this group of cells located in the right atrium.

Blood Vessels:

Arteries: Thick, elastic walls to carry blood under high pressure.

Veins: Contain valves to prevent back-flow of blood. Only need thin walls as they carry blood under low pressure.

Capillaries: Only 1 cell thick, to allow for faster rate of diffusion & gas exchange.

Human lungs: The lungs are adapted for gas exchange. At the alveoli, O_2 diffuses out of your inhaled air & diffuses into your blood. Meanwhile, CO_2 diffuses out of your blood & into your alveoli to be exhaled by the lungs.

4.2.2.3 Blood - A tissue consisting of:

Plasma – Liquid part, mostly made of water, but has substance such as Glucose & CO_2 dissolved in it & the following parts suspended in it.

RBCs – Disc-shaped & dimpled (no nucleus) so they have a large surface to carry more O_2. Contain haemoglobin which binds the O_2.

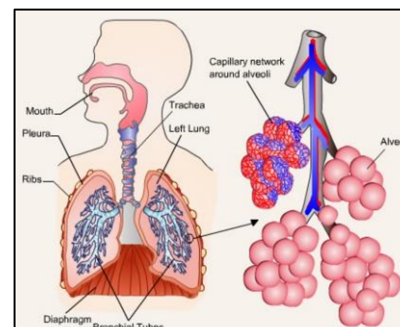
WBCs – Fight infections. Can change shape to engulf pathogens. Contain enzymes & make antibodies to destroy pathogens.

Platelets – Fragments of cells that clot blood at a wound, reducing blood loss.

4.2.2.4 Coronary heart disease

A non-communicable disease where layers of fatty material build up inside the coronary arteries, narrowing them. This reduces the flow of blood through them, resulting in a lack of O_2 for the heart muscle.

- **Stents**: used to keep coronary arteries open. **Statins** are widely used to reduce blood cholesterol levels which slows down the rate of fatty material deposit.
- Heart valves may be faulty & prevent the valve from opening fully, or the heart valve might develop a leak. Faulty heart valves can be replaced using biological or mechanical valves. If a heart failure, a donor heart can be transplanted.



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4.2.2.5 Health issues

Health: The state of physical & mental wellbeing. Diseases, both communicable and non-communicable, are major causes of ill health. Other factors including diet, stress and life situations may have a profound effect on both physical and mental health.

Different types of disease may interact:

- If person has disease of their immune system they will be left more open to infection by a pathogen causing infectious diseases.
- Viruses living in cells can be the trigger for cancers and immune reactions caused by a pathogen can trigger allergies, such as skin rashes & asthma.
- Severe physical ill health can lead to depression and other mental illness.

4.2.2.6 The effect of lifestyle on some non-communicable diseases (NCDs)

Human & financial cost of NCDs:

- Lower quality of life or a shorter lifespan = a human cost.
- Researching and treating disease = a financial cost to wider society.
- Moving home or adapting your home because of your disease = financial cost to an individual.

Risk factors: Things that are linked to an increased chance of getting a certain disease. Doesn't mean that someone will definitely get the disease.

They can be:

- Aspects of a person's lifestyle, e.g. diet, exercise
- Substances in the person's body or environment, e.g. air pollution.

4.2.2.6 (continued).

Not all risk factors can directly cause disease, but the following have been proven:

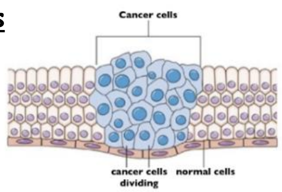
- Obesity - risk factor for Type 2 diabetes.
- Effects of diet, smoking & exercise on cardiovascular disease.
- Effect of alcohol on liver & brain function.
- Effect of smoking on lung disease & lung cancer.
- Effects of smoking & alcohol on unborn babies.
- Carcinogens, including ionising radiation, as risk factors in cancer.

4.2.2.7 Cancer

Cancer: The result of changes in cells that lead to uncontrolled growth and division.

Benign tumours are growths of abnormal cells, contained in one area within a membrane. Don't invade other parts of 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.



Lifestyle risk factors: Smoking, obesity, viral infection, UV exposure

Genetic risk factors: Faulty genes that lead to cancer can be inherited, making a person more likely to get cancer.

Cancer survival: Now more likely because treatments have improved, diagnoses are made earlier, more people are screened (tested) and we know more about the risk factors for cancer.

4.2.3.1 Plant tissues

The leaf is a plant organ consisting of the following tissues:

Upper epidermis: transparent to allow light through to the palisade layer.

Palisade mesophyll: Layer of rectangular-shaped cells, near the upper-side of the leaf, containing lots of chloroplasts.

Spongy mesophyll: This layer contains air spaces which increase the rate of diffusion of gases.

Xylem & phloem: Bring water & nutrients to the leaf & take away the glucose the leaf makes by photosynthesis. They also support the leaf.

Meristem tissue: Found at the growing tips of shoots and roots.

4.2.3.2 Plant organ system

Roots, stem & leaves form a plant organ system for the transport of substances around the plant.

Stomata: Tiny pores on the underside of the leaf.

Guard cells: Guard cells surround stomata and control their opening and closing.

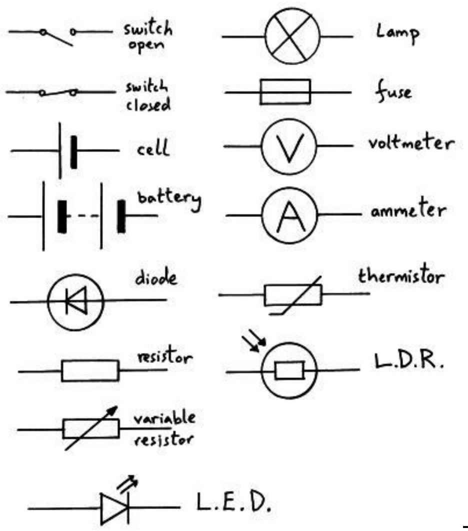
Transpiration: Loss of water from the plant by diffusion at the leaves. High temps, low humidity & high light intensity will increase the rate of transpiration.

Xylem tissue: Transports water and mineral ions from roots to stems & leaves.

Phloem tissue: Transports dissolved sugars from leaves to rest of plant. Movement of food molecules through phloem tissue is called translocation.

Root hair cells: Adapted for the efficient uptake of water by osmosis, and mineral ions by active transport, as they have a large surface area

Symbols



Charge and Current

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 × time

[$Q = I\,t$]

charge flow, Q, in coulombs, C

current, *I*, in amperes, A (amp is acceptable for ampere)

time, *t*, in seconds, s

A current has the same value at any point in a single closed loop.

Current, Resistance, Potential difference.

The current (*I*) through a component depends on both the resistance (*R*) of the component and the potential difference (*V*) across the component. The greater the resistance of the component the smaller the current for a given potential difference (pd) across the component.

Questions will be set using the term potential difference. Students will gain credit for the correct use of either potential difference or voltage.

Current, potential difference or resistance can be calculated using the equation:

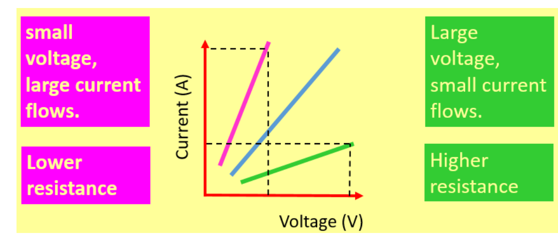
potential difference = current × resistance

[$V = I\,R$]

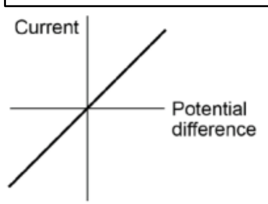
potential difference, *V*, in volts, V

current, *I*, in amperes, A (amp is acceptable for ampere)

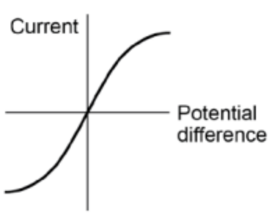
resistance, *R*, in ohms, Ω



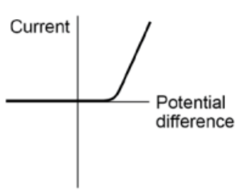
Resistors



Resistance of a Ohmic Conductor – Constant Temperature.

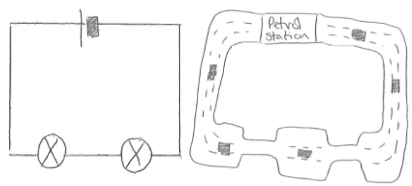


Resistance of a Filament Lamp

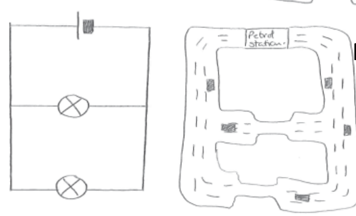


Resistance of a diode

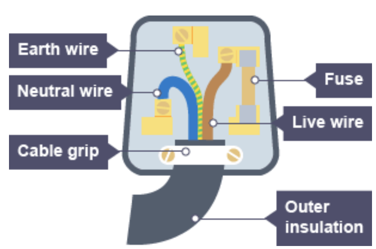
Series and Parallel



Series Circuit.



Parallel Circuit



Energy Transfers

The energy transferred by a component

E = energy – measured J (Joules)
I = current – measured in A (Amps).
V = voltage – measured in V (Volts)
t = time – measured in s (seconds)

$$E = V \times I \times t$$

The energy transferred by a component

E = energy – measured J (Joules)
Q = charge – measured in C (Coulombs)
V = voltage – measured in V (Volts)

$$E = Q \times V$$

The power of a component

P = power = measured in W (Watts)
E = energy – measured J (Joules)
t = time – measured in s (seconds)

$$P = \frac{E}{t}$$

The power of a component

P = power = measured in W (Watts)
I = current – measured in A (Amps).
t = time – measured in s (seconds)

$$P = i^2 \times t$$