Chemistry – C2

The Periodic Table

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States of Matter

There are three main states of matter: solids, gases, and liquids. Solids have a fixed shape and volume and cannot be compressed. Liquids have a fixed volume, but they can still flow and change shape. They also take up slightly more space than solids (except water). Gases have no fixed shape or volume and can be compressed.

To explain the properties of solids, liquids, and gases, the particle theory is used. It’s based on the fact that all matter is made up of tiny particles and describes the movements of particles, and the average distances between them.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| State | Fixed Shape | Fixed Volume | Compressible | Particle Movement | Distance between Particles |
| Solid | Yes | Yes | No | Vibrates on the spot. | Touching its nearest neighbours, remains in a fixed arrangement. |
| Liquid | No | Yes | No | Constantly changing arrangement of particles. | Particles are close together but can flow past each other. |
| Gas | No | No | Yes | Moves at high speed in any direction. | Particles are separate from each other. |

Changing State

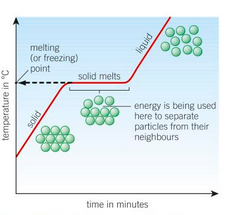
As the temperature of a substance increases, the particles move faster and faster. As substances melt (solid -> liquid), the vibrations experienced by the solid are so powerful that the particles can break free and become a liquid.

As substances boil (liquid -> gas) the particles in the liquid move faster, and eventually break free from each other, becoming a gas. Every state change is a reversable reaction – they can be undone. They are an example of a physical change – no new substances are produced in the process.

Energy Transfers during Changes of State

If the temperature of a substance is measured over time as it melts or boils, you will be able to see that the temperature stops rising until all the substance has changed state. As a substance changes state, energy is transferred from the surrounding (which are being heated) to the particles. This causes their speed to increase, which eventually allows them to break free.

This also works in reverse for freezing and condensing – the cooling of the substance stops whilst it changes state and continues once all the substance has changed.



Limitations of the Particle Model – Higher

The simple particle model is limited in a few ways. The model assumes that particles are made up of solid sphere with no forces acting between each other. However, the particles which make up substances are atoms, molecules, and ions. They can also all vary in size, from the small helium atoms to the polymers in plastics.

Whilst this model is useful for comparing the properties of solids, liquids, and gases, the model is not very accurate, and makes assumptions about particles that we know not to be true.

Atoms into Ions

Whilst some substances can be mixed together without reacting (for example iron filings and sand), some substances react chemically, which forms a compound. This is an irreversible action – it is very hard to separate them again. In order for substances to react with each other, they need to not be stable.

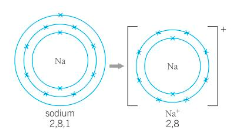
Substances with a full outer shell of electrons (like the noble gases) are stable. This means that they are very unreactive. However, most atoms are not stable. When they react, they take part in changes which give them a stable structure. They can become stable two ways:

* Sharing electrons – called covalent bonding.
* Transferring electrons – ionic bonding.

Losing Electrons (Positive ions)

When atoms lose electrons to become stable (for example Group 1 elements), they form charged atoms called ions. This is because they have an overall charge, unlike normal atoms.

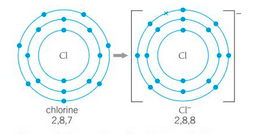
For example, if a sodium atom (with the structure of 2,8,1) loses an electron, making it stable (with a structure of 2, 8), it will end up having more protons than electrons, which gives the atom an overall positive charge, making the atom a positively charged ion. This atom can be written as Na+



Gaining Electrons (Negative ions)

When non-metals (such as the elements in Group 7) react with metals, the non-metals gain electrons to make them stable. This will create an atom with a positive overall charge, called a positive ion.

For example, chlorine (Cl with an electronic structure of 2,8,7) reacts to become stable by gaining an additional electron (giving it a structure of 2,8,8). However, there is 1 more electron than there are protons, meaning that the atom has an overall negative charge. It can be written as Cl –



Forming Compounds

Metals atoms, which often lose electrons, can react well with Non-Metals, which normally gain electrons. When these react with each other, they both form stable ions, with the metal becoming a negative ion, and the non-metal becoming a positive ion.

The electrostatic attraction between these ions is called ionic bonding. These two ions are attracted, forming a compound. In our example of Sodium (Na) and Chlorine (Cl), they combine to form Sodium Chloride (2NaCl2), also known as table salt.

Representing Ionic Bonding

Ionic Bonding can be represented using a dot and cross diagram. In this diagram, the electrons of one atom are drawn as dots, and the other are drawn as crosses. This helps us to keep track of which atom the electrons came from when they form a compound. Dot and cross diagrams can also just show the outermost shell, as that is the only one that changes.

A diagram showing the full reaction where sodium (Na) and chlorine (Cl) form a compound (2NaCl^2).
The electron that the sodium loses to become stable goes across to the chlorine atom, making it stable as well. A picture containing text, clock, gauge

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