Atoms, Elements and Compounds

Pure substances are made up of one type of **atom**

An **element** is a pure substance that cannot decompose into simpler substances

Compounds are formed by joining 2 or more elements; they can be broken down into simpler substances

Atoms of the **same element** are exactly alike

Atoms cannot be created, destroyed, or divided into smaller particles

Seperating mixtures

Sieving	Separates based on particle size
Filtration	One substance is a solid, other is a solution or liquid; particle size
Vapori-sation	Liquid has a much lower boiling point than the solid
Distillation	Big difference in boiling points
Fractional distillation	Significant but small difference in boiling points
Separating funnel	Components are immiscible liquids; different densities
Adding a solvent	One sunbstance is soluble in the chose solvent, while the others are insoluble

Physical vs Chemical Change

Chemical	Physical
At least one new substance formed	No new substance formed
Difficult to reverse (hard to 'unboil' an egg)	Easily reversed (melt a solid; freeze again)

Physical vs Chemical Change (cont)

Generally large input and output of energy (burn natural gas)	Relatively small energy changes involved (evaporate alcohol, dissolve sugar in water)

In a chemical reaction the starting substances are called **reactants** and the substances that are formed are called the **products**.

The Periodic Table

Metals are elements that:	are solids at room temperature
	have a shiny or lustrous appearance
	are good conductors of heat and electricity
	are malleable and ductile

Most other elements are called **non-metals**

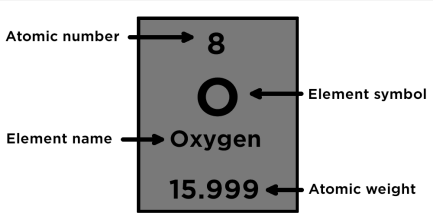
The **periodic table** is a chart of the elements arranged so that those with similar properties fall into the same vertical column

The vertical columns are called **groups**, They are numbered from 1 to 18.

The elements in groups 3 to 12 are called **transition elements**. The other elements (in group 1, 2 and 13 to 18) are called **main-group elements**

The horizontal rows are called **periods** and they are numbered 1 to 7

Periodic Table cont.



Periodicity

The trends of the periodic table can be seen clearly in the image above.

The **screening effect** is the *decrease* in electrostatic force between a nucleus and an outermost electron brought about by completely filled electron shells between the nucleus and the outermost electron.

When an atom *loses or gains* an electron it becomes an **electrically charged species** because the numbers of *protons and electrons are no longer in balance*; becoming **ions**

First ionisation energy, IA, of an element is the **energy required to remove an electron** from a neutral gaseous atom of the element.

Electronegativity of an element is a measure of the *ability of an atom of that element to attract bonding electrons* towards itself in compounds.

The **higher** the electronegativity the **stronger the attraction** of the atom for bonding electrons.

Bohr vs Schrödinger

Bohr	Considered electrons as particles orbiting the nucleus
	Successful in interpreting the hydrogen spectrum
	Failed on more complicated ones.
Schrödinger	Much more successful in interpreting atomic and molecular properties.
	Showed that electrons move at extremely high speeds *randomly* in **orbitals**

Schrödinger equation uses wave properties and quantum theory to calculate the **probability of finding an electron at a particular location**

Planck's quantum theory proposes that in atoms energy is not continuously variable but exists in discrete packages.

Atoms

An **atom** is the smallest particle of an element that is still recognisable as that element

The **formula of a compound that exists as molecules** is a combination of symbols of the elements in the compound, with subscripts denoting how many atoms of each element are in the molecule

An atom consists of an extremely **small dense nucleus** or core, which contains the **bulk of the mass of the atom** and carries **positive electrical charges**

This nucleus is surrounded by an **electron cloud** of rapidly moving and extremely light **negatively charged** particles.

Atoms (cont)

Atomic number, Z, of an element is the **number of protons** in the nucleus of an atom of that element.

The **mass number, A**, is the number of **protons plus neutrons in the nucleus** of an atom of the species concerned. Sometimes called the nucleon number

Number of electrons in the electron cloud is *equal* to the **number of protons** in the nucleus

Isotopes

Isotopes are atoms of one element that have **different numbers of neutrons in their nuclei** (although the same number of protons).

The **relative abundance** of an isotope is the **percentage of that isotope in the naturally occurring element**.

Isotopes of one element have the **same chemical properties** and very **similar physical ones.**

Radioactivity

Radioactive isotopes or radioisotopes **spontaneously** emit radiation. They are also called **unstable isotopes**

Radioisotopes emit three types of radiation:

alpha (α) rays	which are helium nuclei
beta (β) rays	which are electrons
gamma (γ) rays	which are a type of electromagnetic radiation like light and X-rays

Radioactivity (cont)

A **nuclear equation** shows the disintegration of a radioisotope into a new nucleus and a helium atom or an electron; the atomic and mass numbers **must balance** in nuclear equations.

The **half-life** of a radioisotope is the time required for half the atoms in a given sample to undergo radioactive decay.

Half-life is independent of the initial amount of the isotope present.

Spectroscopy

Electrons in an atom can be given extra energy and so be raised from its **ground state** into an **excited state**

When electrons in **excited states *fall back* to their ground states**, **energy is released** in the form of **ultraviolet, visible and infrared radiation**

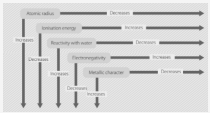
This radiation can be analysed with a **spectroscope**

Measuring and studying the emission spectra of elements is called atomic emission spectroscopy.

Some elements produce **distinctive flame colours** because one particular **electron transition** occurs much more frequently than any other.

So a **flame test** can also be used to detect their presence in a sample

Periodicity



Chemical Bonding

Ionic Outright transfer of electrons from one atom to another.

Electrostatic attran is between positive and negative ions

Ions are present in ratios, the total # of positive charges is equal to the total # negative charges

Formulaes (e.g. NaCl, CaF2) specify the ratios in which the ions are present, not the composition of discrete molecules.

Ionic binary compounds are named positive ion then negative ion.

The positive ion has the same name as the element (e.g. ‘sodium’, ‘calcium’)

Negative ion the ending of the element name is changed to -ide.

High melting and boiling points

A polyatomic ion is an ion formed from two or more atoms joined together.

Electron Shells and Arrangements

Electrons orbit (move around) the nucleus in a circle called an **electron shell.**

These electrons exist in discrete energy levels

1st shell: holds 2 e-

2nd shell: holds up to 8 e-

3rd shell: holds up to 8 e-

Octet Rule: atoms are stable when their outer electron shell holds 8 electrons.

There are 2 exceptions to the octet rule.

Electron Shells and Arrangements (cont)

1. The cases in which there are fewer than 8 electrons in the outer shell.

2. The cases in which there are more than 8 electrons in the outer shell. Exception: H and He.

Valence electrons: **electrons in outer most shell** of an atom that can participate in **forming chemical bonds** with other atoms

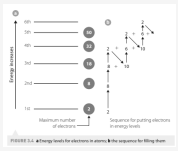
Atoms with a relatively **empty outer shell** will want to **give up electrons**

Atoms with a relatively **full outer shel**l will want to **gain electrons** to fill up the outer shell

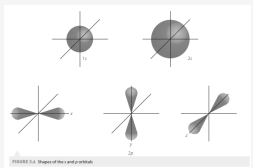
The arrangement of electrons in energy levels is called the **electron configuration** of the atom.

The ‘driving force’ behind chemical reactivity is that an atom tends to lose, gain or share electrons in order to achieve the stable electron configuration of the nearby noble gas.

Filling energy levels



Orbitals



Orbitals

Orbitals are a volume of space surrounding the nucleus of an atom through which one or two **electrons may randomly move.**

Each main energy level of an atom (except the first) is made up of a set of energy sublevels called the **s, p, d and f sublevels.**

Each orbital can accommodate a **maximum of two electrons.**

Ions

Ions are atoms with **extra electrons or missing electrons**

Ions are positively or negatively charged particles

Missing electrons results in a **positive charge**

Extra electrons results in a **negative charge**

Postive ions are called **cations**; negative ions are called **anions**

An **ionic lattice** is an orderly array of positive and negative ions

The **formula of a compound that is made up of ions** is a combination of symbols of the atoms involved, with subscripts giving the ratio in which the elements are present in the compound (since there are no molecules of ionic compounds).