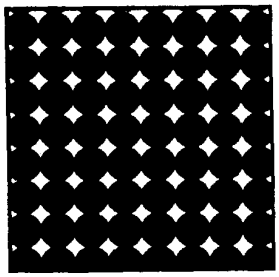
STATES OF MATTER

The particles in all types of matter are thought to be in constant motion.
The states of matter – solid, liquid, and gas – can be explained by the relative movement and the arrangement of particles in each state.

Solids



Solid

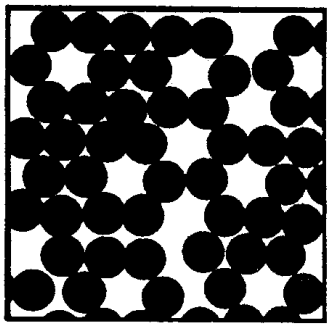
Solids such as ice, iron, and carbon:

- Hold their own shape (rigid)
- Are not able to be compressed.

The particles in a solid are closely packed and usually in a regular pattern with little space between them Even though a solid may appear motionless, There is constant movement of its particles as they vibrate about their fixed positions.

Liquids

1. Liquids such as water, mercury, and alcohol:



Liquid

- are incompressible,
- assume the shape of their containers'
- diffuse slowly
- evaporate from open containers

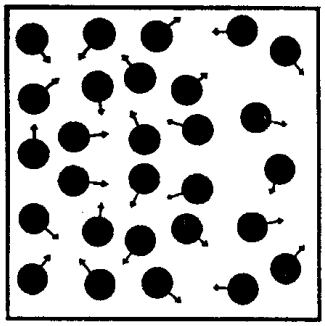
The particles in a liquid are able to move past each other in all directions. There is no regular arrangement but still little space between particles.

Gases

2. Gases such as steam, oxygen, and chlorine:

- assume the shape of their containers
- diffuse quickly,
- are able to be compressed

The particles in a gas move independently of each other at great speeds and occupy much more space. To confine a gas, it needs to be enclosed on all sides.



Gas

Summary

Chemistry is a valuable subject for fire fighters to know because it gives an understanding of combustion and the properties of other substances they may deal with.

- All matter is made of atoms,
- An element contains one type of atom only,
- A compound contains two or more elements chemically combined
- A molecule is the smallest portion of a substance, which can exist by itself and still retain the properties of that substance.
- A formula gives the numbers and types of atoms in a molecule.
- A mixture contains more than one element and/or compound physically combined.

- Matter can exist in one of three states – solid, liquid or gas.
- The particles in all states of matter are in continuous motion.
- The degree of movement increases from solid, to liquid, to gas.
- The particles in a solid are able to vibrate, but are closely packed in a regular arrangement.
- The particles in a liquid are able to move past each other, but are still closely packed.
- The particles in a gas are independent of each other – they are far apart and move at high speeds.

Structure of Atoms

Introduction

Atoms are the smallest parts of an element that can take part in a chemical change.
Atoms themselves are made up of smaller particles again.
At the centre of an atom is the nucleus – a small dense core made up of protons and neutrons. Each proton carries a positive electrical charge; the neutrons have no charge.
Tiny, Very light electrons are found some distance from the nucleus, They move at very high speeds in 3-dimensional orbits ("electron shells") around the nucleus. Each electron carries a negative charge
Atoms are electrically neutral, so the number of protons must be the same as the number of electrons.
The number of protons in the nucleus is called the atomic number.
This number differs for each different element.

For example:

Element	Atomic No.	Protons	Electrons
hydrogen	1	1	1
helium	2	2	2
Carbon	6	6	6

The number of neutrons in the nucleus is usually close to the number of protons, but this may vary. An element may have several isotopes, which differ in the number of neutrons in the nucleus.
The number of protons + neutrons is called the mass number.

For example:

Isotopes of carbon (atomic no = 6) may have 6, 7 or 8 neutrons. These isotopes are known as carbon – 12. Carbon – 13, carbon –14. (The number given to each isotope is the mass number).

	Mass No.	Protons	Neutrons
	12	**6**	**6**
Carbon Isotopes (atomic no. =6)	**13**	**6**	**7**
	14	**6**	**8**

An isotope with a high number of neutrons is often unstable; that is, the nucleus tends to disintegrate.
Such isotopes are called radioactive, and the break-up is called a Nuclear reaction.
For example: cobalt-60, carbon-14, uranium-238 are radioactive.
Radioactive materials give off one or more types of "radiation".
- Alpha particles (made up of 2 protons + 2 neutrons)
- Beta particles (the same as a single electron)
- Gamma rays (high energy electromagnetic waves - similar to x-rays)

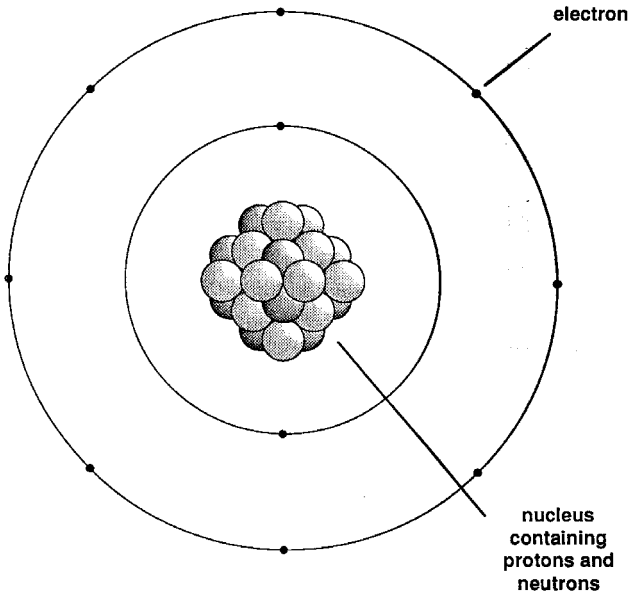
These radiations, and the energy they p0ssess, come from the break-up of the nucleus.

Relative atomic mass ("atomic weight")

The relative masses of atoms of different elements can be compared by taking the mass of the carbon-12 isotope to be equal to 12.00.
The average, mass of atoms of each element is measured on this scale.

For example:	H	=	1.01
	O	=	16.00
	C	=	12.01

Combinations of Atoms



Model of an atom

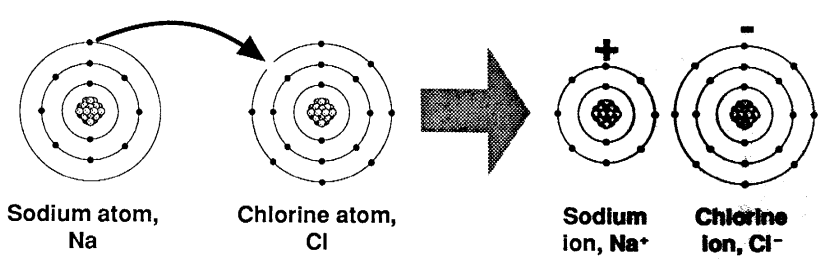
The way an element behaves depends on the number of electrons in the outer "electron shell" of its atoms.

Atoms, which have a full outer shell, are very unreactive,
For example: helium, argon etc.,
Atoms which have less than a full shell react more easily, and do so in order to gain a full outer electron shell.

Ways Atoms Combine

By transfer of electrons

The sodium atom has one electron in its outer shell and the chlorine atom has seven electrons.



Sodium combining with chlorine to make sodium chloride

Sodium gives up one electron to chlorine so both atoms now have a full outer shell.

Sodium now has a net positive charge Na^+; chlorine has a net negative charge Cl^-. These charged atoms are called ions. The positive and negative ions attract each other to form an ionic bond. The result is sodium chloride – an ionic compound.
Salts, acids and bases are all tonic compounds. With the exception of some acids, they are all crystalline solids. This is due to the strong electrical forces, which attract the ions to each other.

Table of Some Common ions

Positive Ions		Negative Ions	
Na^+	sodium ion	Cl^-	chloride ion
K^+	potassium ion	OH^-	hydroxide ion
NHG_4^+	ammonium ion	NO_3^-	nitrate ion
H^+	hydrogen ion	NO_3^-	nitrate ion
Ag^+	silver ion	HCO_3^-	hydrogen carbonate ion (bicarbonate ion)
Mg^{2+}	magnesium ion	MnO_4^-	permanganate ion
Ca^{2+}	calcium ion	CN^-	cyanide ion
Zn^{2+}	zinc ion	ClO_3^-	chlorate ion
Fe^{2+}	iron (II)ion	O^{2-}	oxide ion
Pb^{2+}	lead ion	S^{2-}	sulphide ion
Cu^{2+}	copper ion	SO_3^{2-}	sulphite ion
Al^{3+}	aluminium ion	SO_4^{2-}	sulphate ion
Fe^{3+}	iron (III)ion	CO_3^{2-}	carbonate ion
		Pb_4^{3-}	phosphate ion

- The charge on each ion shows how many electrons have been lost or gained.
- Some groups of atoms form ions (e.g.) SO_4^{2-}, the sulphate ion. These groups act as a single unit with a charge and are sometimes called radicals.
- In an ionic compound the positive and negative charges are always balanced.

For example:

Magnesium Oxide

- ions formed Mg^{2+} O^{2-}
- balance charges: +2 -2
- formula MgO

Sodium Sulphate

- ions formed: Na^+ SO_4^{2-}
- balance charges +1 -2

  +1
- formula Na_2SO_4

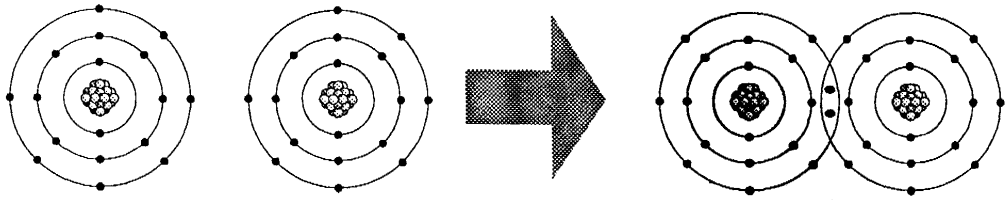
Magnesium nitrate

- Ions formed Mg^{2+} NO_3^-

- Balance charges +2 -1
  -1
- Formula $Mg(NO_3)_2$

By sharing electrons

Another way atoms gain a full outer shell is by sharing electrons with another atom. (This may be with an identical atom)



Chlorine atom (Cl) Chlorine atom (Cl) Chlorine molecule (Cl_2)

Each chlorine atom now has eight electrons in its outer shell, two of which are shared between the two atoms. This shared pair of electrons constitutes a covalent bond.