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PhotoMaster Format

Elements & Compounds

Year 8 Chemical Sciences

KISS topic number — Year level designation in Nat.Curriculum

Topic 10.8C

Science Understanding Strand
B = Biological Sciences
C = Chemical Sciences
E = Earth & Space Sciences
P = Physical Sciences

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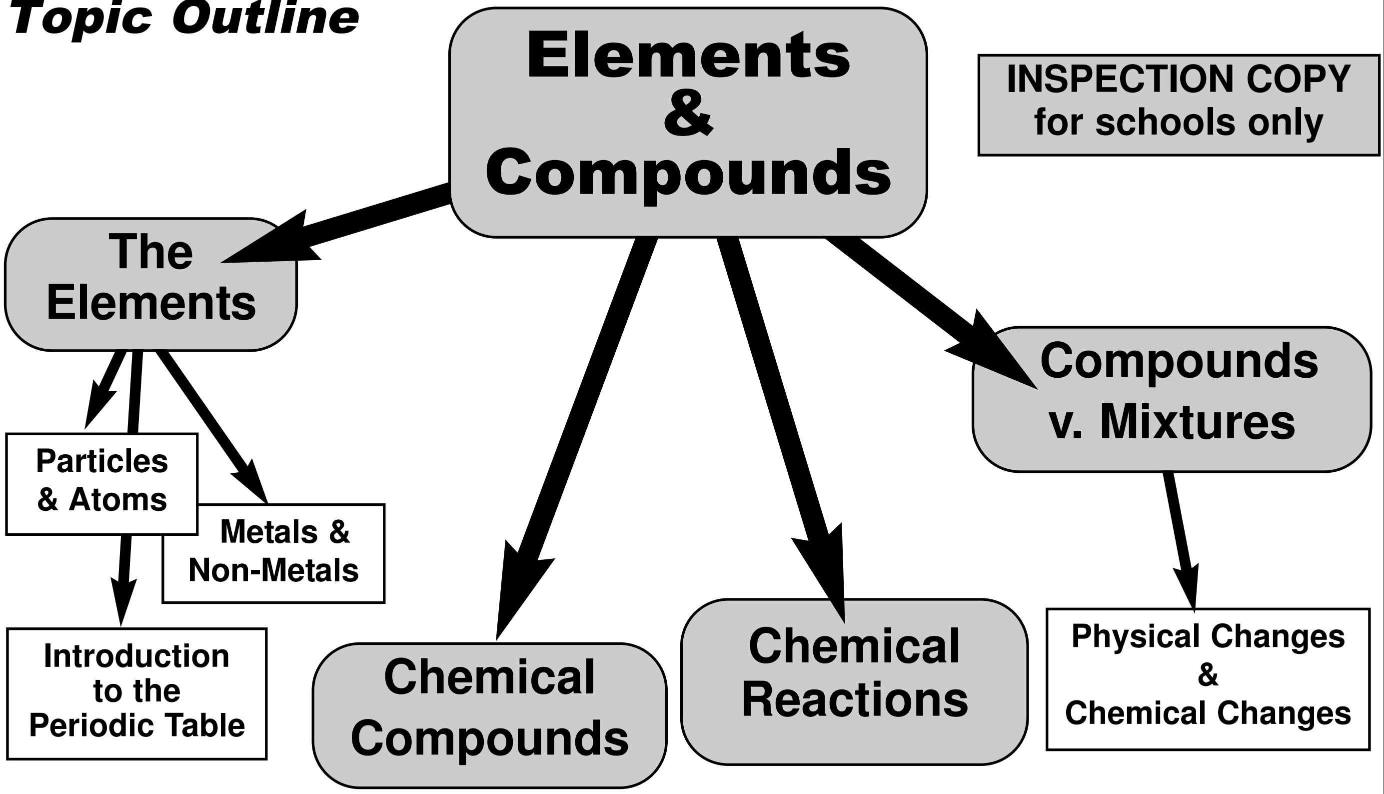
Topic Outline



What is this topic about?

To keep it as simple as possible, (K.I.S.S. Principle) this topic covers:

WHAT ARE THE ELEMENTS?

Introduction to the chemical elements, atoms and the Periodic Table. Metals & Non-metals.

CHEMICAL COMPOUNDS

Introduction to compounds.

CHEMICAL REACTIONS

Signs of a chemical change.

COMPOUNDS v. MIXTURES

How are they different? Physical changes v. Chemical changes.

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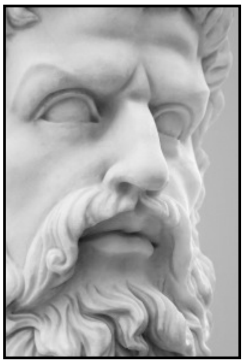
What Are the Chemical "Elements"?

To answer that, you must know about some history...

The Ancient Greeks

Much of our civilization's foundations such as government, democracy, citizenship, education and schools, (blame them!) drama, law, public health and medicine, etc, can be traced back to the Greek civilization which flourished over 2,000 years ago.



One of the most influencial thinkers of the time was Aristotle (384-322 BCE). He was one of the first people (that we know of) to try to answer the question "what is everything made of?".

He decided that everything was made of just 4 basic constituents, or "elements"; earth, water, air and fire.

"Element" means the most basic, simple thing.

About 1,000 years later, some great thinkers in the Islamic cultures carried on developments in Mathematics and Science. Among other things, they invented "Alchemy".

Alchemy in Middle Ages

Alchemy was partly practical experimenting & partly mystical magic.

The basic aim of alchemy was to "transmute" common metals into gold, and to find chemicals which could make someone immortal. From the alchemists we get our legends of sorcerers like Merlin the Magician.

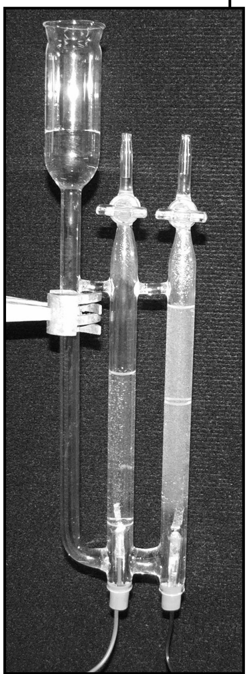
Many alchemists were crooks who used various "magical" tricks to fool people into giving them money. From this, alchemy got a very bad name.

However, the alchemists did discover many facts about solids, liquids and gases. They invented processes like distillation, filtration and crystallisation and discovered new dyes and other useful substances.

One of the important processes they developed was decomposition. This means to break a substance down into simpler, more basic parts.

Alchemy becomes Chemistry

The Alchemists discovered ways to decompose chemical substances into simpler parts and separate and collect them. However, some substances could never be decomposed any further, no matter what was done to them. These became known as "chemical elements"... the most basic substances of all matter.



For example, when electricity was discovered, it was found that water (one of Aristotle's elements) could be decomposed into simpler substances.

You might see the equipment (at right) demonstrated in class.

water ⟶ hydrogen + oxygen

Using electricity, water can be broken down into 2 gases, hydrogen and oxygen. No matter what you do, hydrogen and oxygen cannot be decomposed into anything else. This means that water is NOT and element, but hydrogen and oxygen ARE chemical elements... they are 2 of the simplest, basic chemical substances.

By about 1750, Alchemy had became the modern science of Chemistry.

No more magic. Chemistry is based on the idea that there are certain substances which are the simplest and most basic. These "elements" can be understood scientifically in terms of particles, forces and energy, and chemical reactions.

That's what this topic is about.

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The Chemical Elements

How Many Elements?

We now know that about 90 chemical elements occur naturally on Earth. Another 20 (or so) can be made artificially in nuclear reactors.

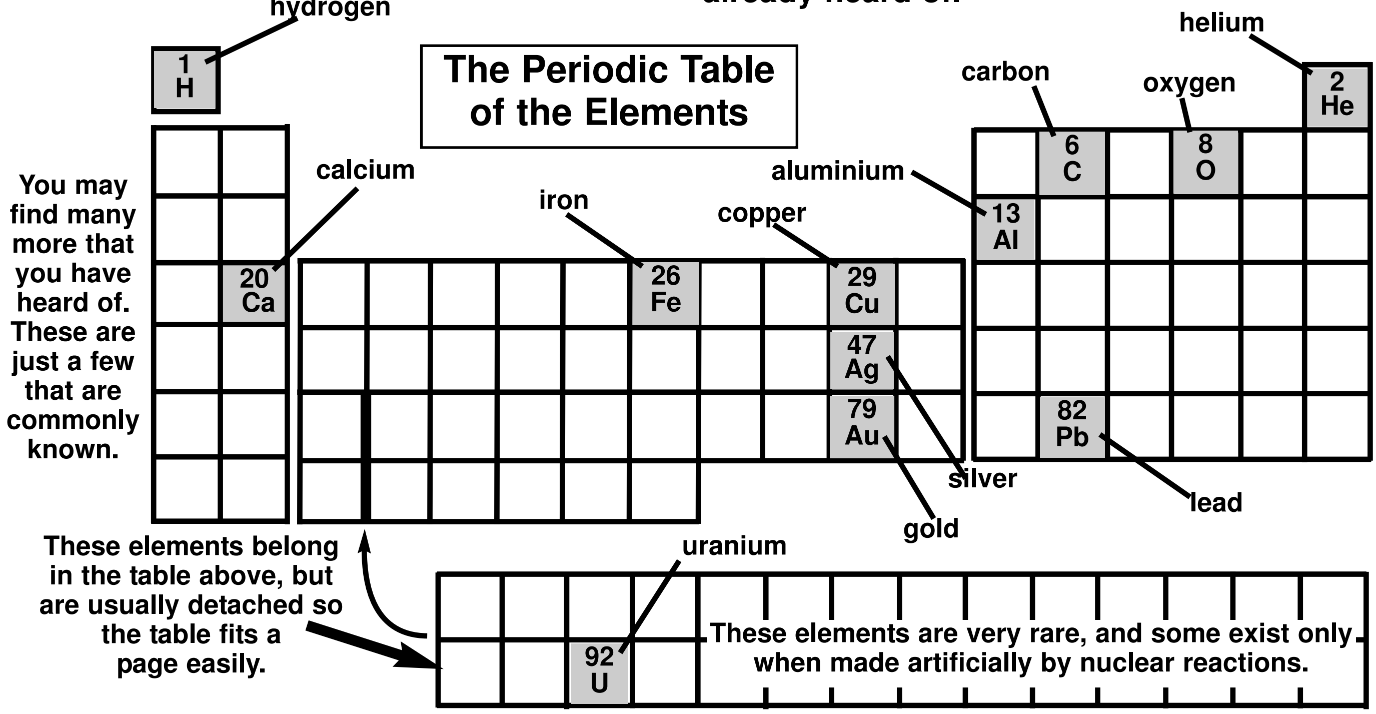
Of these elements, many are very rare. Most familiar substances on Earth are made from only about 20 or 30 of the most common elements.

The Periodic Table

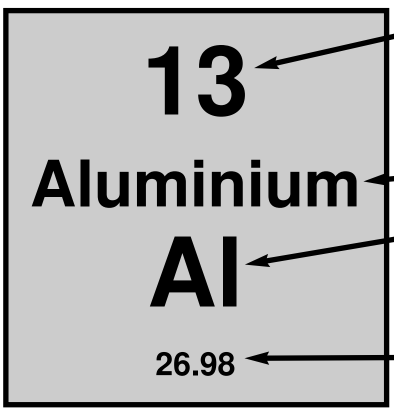
The best way to learn about the elements is to study the "Periodic Table", which is a special list of all the elements.

Your teacher may give you a copy, or show you a wall chart.

The first thing to do is to look through it and see how many elements you have already heard of.



How to Read the Information



"Atomic Number"
Each element is numbered, in order, across each row and then down the table. This puts the elements in a numerical order, but it also gives information about atoms... details later.

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Name of the Element

Chemical Symbol
Each element has a short-hand symbol. It is always one capital letter, OR if 2 letters, always a capital followed by a lower case letter.

"Atomic Mass"
This number gives the mass, or weight, of an atom of this element.

Why is the table such an odd shape?

Why not put the elements in a simple rectangular box table?
The Periodic Table has this shape so that elements that are similar to each other are under each other, or in "groups" and "blocks'.
It is called "periodic" because it has patterns that re-occur in a regular pattern.
You will learn these patterns as you learn more about Chemistry.

Some Elements & Their Uses

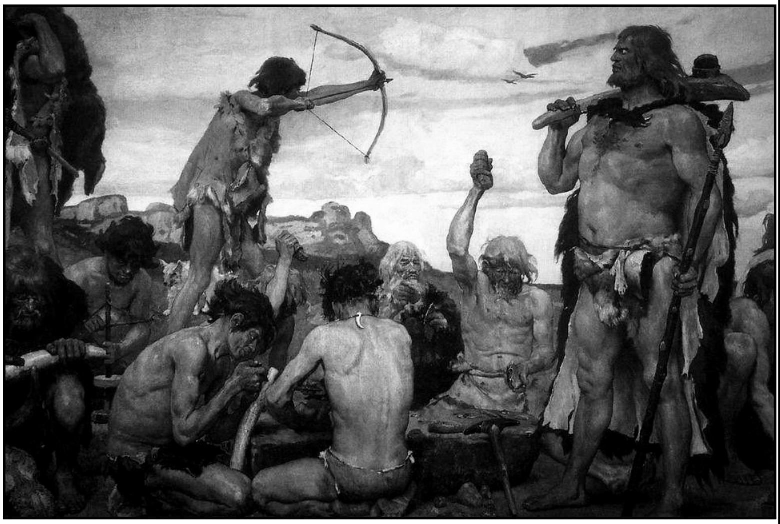
Every element has it own unique properties, such as colour, density, electrical conductivity and so on. It is these properties which make some elements particularly useful to us. For example:

Element	Used for	Properties which make it useful
Copper	Electrical wires.	Excellent conductor of electricity.
Helium	Inflating weather balloons & airships.	Lower density than air, so lifts balloon. Non-flammable, so safe.
Aluminium	Drink cans, window frames, small boats, aircraft frames.	Light, strong, does not corrode easily.
Carbon (diamond state)	Jewellery. Drill tips for rock drilling.	Attractive sparkle. Extremely hard.

Notice, in every case, it is the particular, special properties of the element which make it suitable for the way(s) it is used. Actually, this is always true for all useful substances... think about it: you don't choose UNsuitable things to do a job!

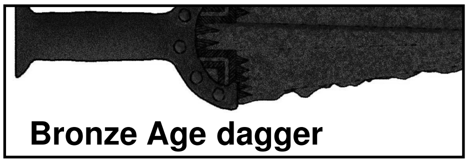
Uses of Materials Through History

People have always applied this idea that substances with special properties can be used for appropriate purposes.



Even the very earliest humans understood this & gathered certain rocks or timbers to make the best tools and certain skins or plant fibres for warmth, baskets, etc.

Later, new materials were discovered (e.g. metals) and in modern times we have added plastics, various ceramics, fabrics and much more.


Bronze Age dagger

The changes to human society have often been made possible by the discovery and invention of new, useful substances.

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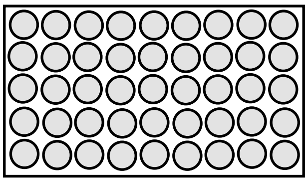
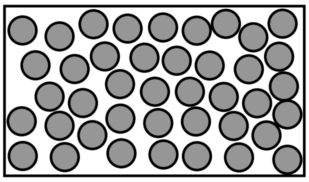
The Elements & Particle Theory

One Type of Particle = Element

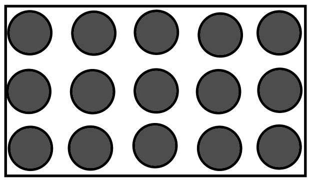
An element is a substance made entirely of identical particles.



Element 1



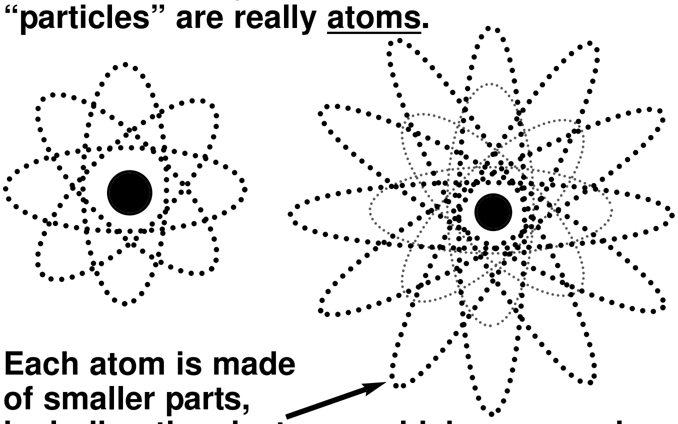
Element 2



Element 3

The particles within each element are all the same.
The particles of one element are different to the particles of another element.
What is the difference between the particles of different elements?

You are already aware that these "particles" are really <u>atoms</u>.



Each atom is made of smaller parts, including the <u>electrons</u>, which you may have learnt about when you studied electricity.

You will learn more about the parts of atoms, and the structure of atoms at a later stage. For now, just know that every atom of a particular element contains a fixed number of electrons.

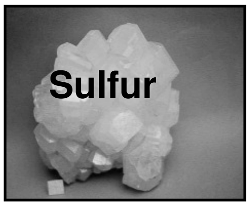
Number of Electrons = Atomic Number

The <u>Atomic Number</u> shown in the Periodic Table tells you how many electrons each type of atom has. So, hydrogen has 1, helium has 2, uranium has 92, and so on.

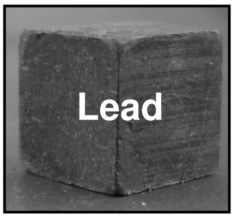
Definitions for What is an "Element"

To summarise some important ideas covered so far, you should note that we now have a variety of ways to define "element".

An element is a pure substance which cannot be decomposed into anything simpler.



An element is a substance entirely made up of identical atoms.



At this stage, you should learn <u>both</u> the definitions above.
The information below is also very useful.

Each element has atoms which have the <u>same number of electrons</u>.
The number of electrons is equal to the element's <u>Atomic Number</u>.
Different elements have atoms with different Atomic Numbers and different numbers of electrons.

Please complete Worksheets 1-4 before going on.

Technological Inventions Affect Science

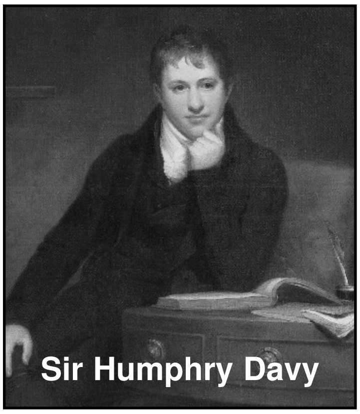
Starting about 200 years ago, the new Science of Chemistry went through a period of rapid development. One of the main areas of progress was the discovery of many new chemical elements.
These discoveries were made possible by a new technology... Electricity.

Volta's Pile

The Italian scientist Alessandro Volta had discovered that the strange energy called electricity could be made using metal plates layered with paper soaked in salt solution. The device was called "Volta's Pile".

In fact, he had invented the electrical battery. No-one had any idea why it worked or what electricity was.

Humphry Davy (English, 1778-1829) experimented with this new technology and found that it could decompose chemicals.



Sir Humphry Davy

Davy's Discoveries

Using the new and mysterious forces of electricity, Davy began decomposing chemical substances.

Some substances were thought to be elements, but Davy decomposed them. Therefore, they were really compounds, and he discovered new elements within them. Eventually, he almost doubled the count of known chemical elements and set Chemistry on a new course.

Davy died relatively young, probably from the effects of breathing toxic fumes from his experiments.

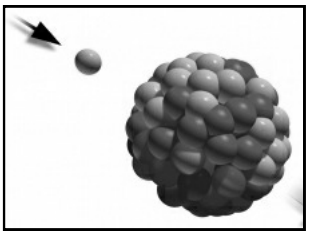
Modern Research to Find New Elements

If you read a Science text from 50 years ago, it will probably state that there are exactly 92 chemical elements. However, a modern Periodic Table lists well over 100.

Trans-Uranium Elements

The largest atoms which occur naturally on Earth are those of uranium. For many years it was believed that atoms larger than uranium could not exist.

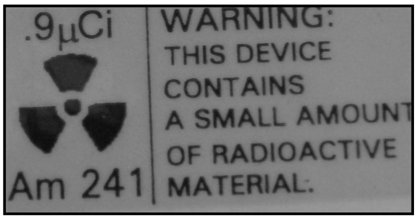
When nuclear reactors were first built (tight military secrets to start with) it was discovered that atoms larger than uranium could be made artificially by bombarding large atoms with neutrons in the nuclear reactor.



These were called "Trans-Uranium Elements".

All trans-uranium elements are radioactive. This means they give off invisible rays. This can be dangerous, but it can also be very useful.

The manufacture of some "trans-uranium" elements is now routine. Element 95, Americium, is made for use in everyday devices such as smoke detectors.



Warning label on a household smoke detector. "Am 241" tells you that the element Americium is present.

Elements up to No.118 have been confirmed to exist, but they have not all been named because only a few atoms of some have ever been made.

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Classifying the Elements:
Metals & Non-Metals

You might do some Practical Work in the laboratory to investigate the different properties of substances which we call "metals" and those which are not.

The important questions are:

Is the substance shiny, or dull?

Is it a conductor of electricity?

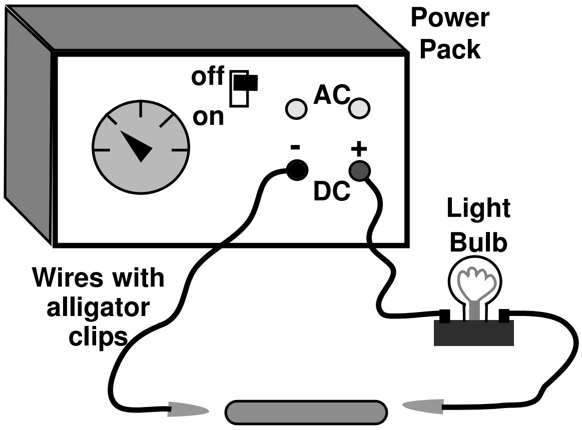
Can it be flattened into flexible sheets, or drawn out into flexible wires, or not?

Basically, if the answer to all 3 questions is "YES", then the substance is a metal.

If 2 or more answers are "NO", then it is a non-metal.

You might do the test on each substance to find out if it conducts electricity.
The equipment to do this is shown below.

If the bulb lights up, then the test item is an electrical conductor. If not, it's not.



Properties of Metals & Non-Metals

If you have examined some elements in the laboratory, you will now have a good idea of the differences between metals and non-metals.

Metals	Non-Metals
Shiny appearance	Most not shiny (some exceptions)
All solids (except liquid mercury)	Some solids, many gases, 1 liquid
All are good conductors of electricity	Most are poor conductors of electricity (important exception = carbon)
All are good conductors of heat	Most are poor conductors of heat
All are malleable, and ductile **	Brittle, not malleable nor ductile

**Malleable means it can be hammered or pressed by rollers and flattened into sheets.
Ductile means it can be pulled out so it will stretch into wires, especially if hot.
Try this with a solid non-metal and it will shatter or snap.

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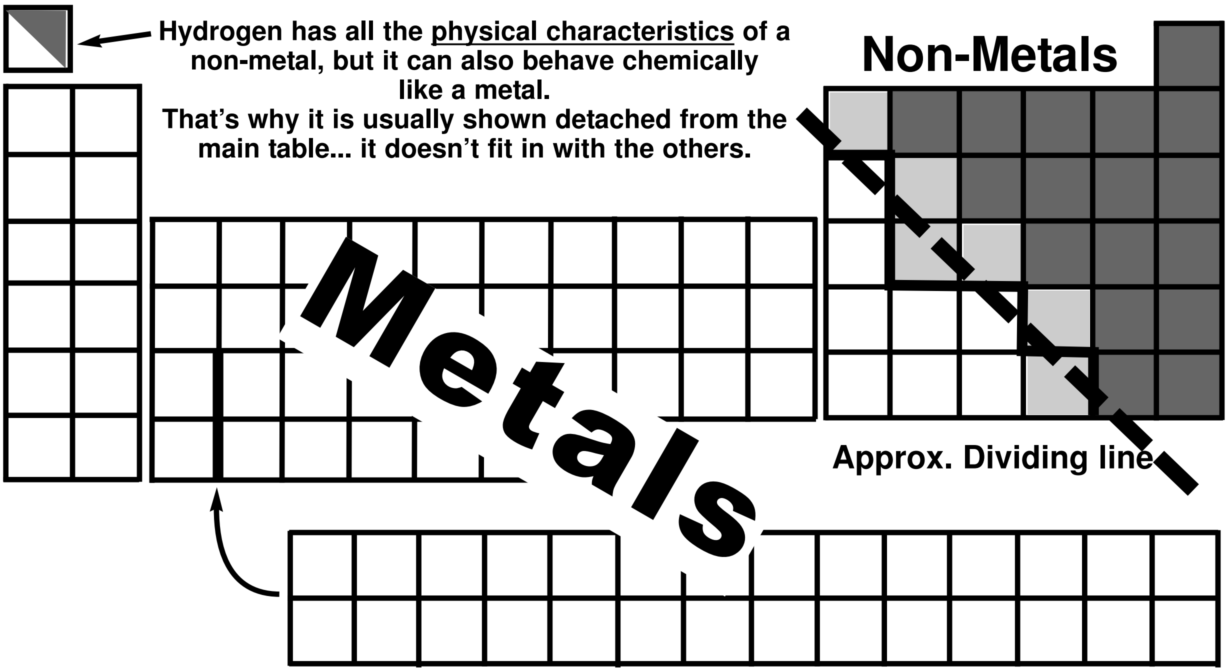
Metals & Non-Metals in the Periodic Table

In the Periodic Table, the metals and non-metals are in different parts of the table as shown below. The dotted line is the approximate dividing line. You can see that most of the elements are metals. The non-metals are clustered in the top-right corner.

Some of the elements near the dividing line (shown here in lighter shading) have some characteristics of metals, and are a bit "in-between". For now, consider themnon-metals.



Please complete Worksheets 5 & 6 before going on.

Chemical Symbols for the Elements

It will help future learning if you begin to learn the chemical symbols for some of the common elements.

As you study them, you may notice something that needs to be explained.

Some Logical Symbols

Most elements have chemical symbols that match their name:
e.g. Ca = calcium, N = nitrogen, etc.

Some Make No Sense

What about Na = sodium, Pb = lead, or Fe = iron.
These seem to make no sense.
What is the reason for this?

It is a Matter of History

The elements with "nonsense" symbols are mostly those that were known to the alchemists, and used to have different names.

Their modern symbols still refer to their old names. (Mostly Latin) Examples:

Element	Old Name	Symbol
iron	ferrum	Fe
silver	argentum	Ag
copper	cuprum	Cu
gold	aurum	Au
lead	plumbum	Pb

(From the old name for lead we get the word "plumber". Originally, all metal pipes were made from lead.)

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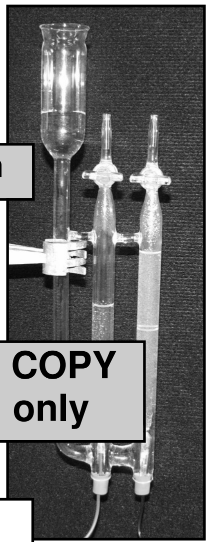
Chemical Compounds



It was previously mentioned that water can be decomposed into the elements hydrogen and oxygen.

water ⟶ hydrogen + oxygen

You may also be aware that scientists use the chemical formula H_2O to describe water. Does this mean that water is a mixture of hydrogen and oxygen? NO !!

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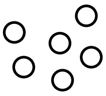
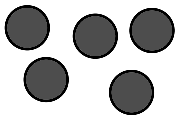
If the element hydrogen is represented by this particle diagram:



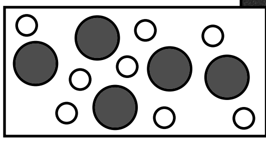
particles (atoms) of hydrogen

and oxygen is represented by:



particles (atoms) of oxygen

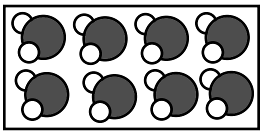
then a mixture of hydrogen and oxygen would be:



But this is not water!

The diagram for water would be:

H_2O molecules



Each "particle" of water is made of an oxygen atom with 2 hydrogen atoms strongly attached to it.

Particles like this, made of 2 or more atoms joined together, are called "molecules".

The atoms are not just mixed. They are "chemically bonded" together in a fixed ratio of 2:1. You will learn later how chemical bonding works... for now think of it as a strong force which joins the atoms together.

Compounds Have Different Properties Compared to Their Elements

If you mix 2 substances together, the mixture usually has characteristics of both of its parts.

For example, if you mix salt and water, the mixture still looks like water and it still tastes like salt... it is like both things.

When 2 elements combine to make a compound, it is a totally new substance.

Example

Hydrogen = explosive, low-density gas.
Oxygen = gas which we need to breathe.

Water = clear liquid, good solvent. Won't explode! Don't try to breathe it!

This is how just a few dozen common elements can make many thousands of different substances around us. Each combination of elements makes a substance with totally new and different properties.

Example

"Salt" is the compound "sodium chloride", with chemical formula NaCl.

Sodium = soft, shiny, silver-grey metal.
Chlorine = yellow-green, poisonous gas.

Salt = white crystals. Good on chips!

The compound is a new substance, totally different to the elements that are combined to make it.

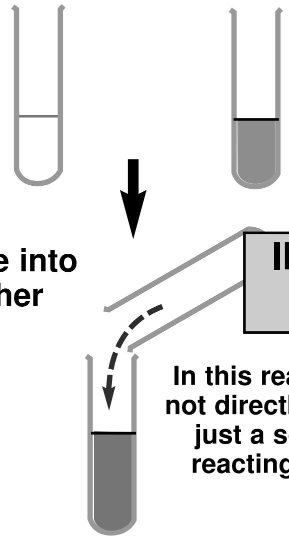
Notice that many compounds have a common name, and a chemical name which describes the elements within. e.g. "salt" is sodium chloride, "water" is hydrogen oxide.

Chemical Reactions

**A chemical reaction alters the way atoms are bonded together.
The atoms are re-combined in new ways, and new substances are made.
The numbers of atoms, types of atoms and the total weight of material is still exactly the same as it was before the reaction, but new substances have been made by changing the way the atoms are bonded together.**

**How do you know when a chemical change has occurred?
The best way to learn that is to observe some chemical reactions.
You might do, or see, these reactions, or others similar.**

Mixing 2 Dissolved Chemicals

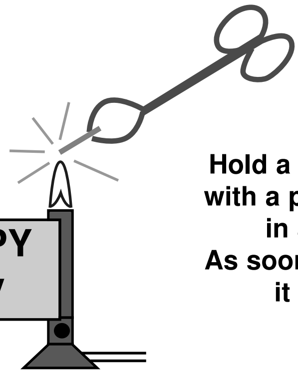


In this reaction, water is not directly involved. It is just a solvent for the reacting compounds.

Observed Changes

Change of colour. Clear solutions become a cloudy suspension.

Burning Magnesium



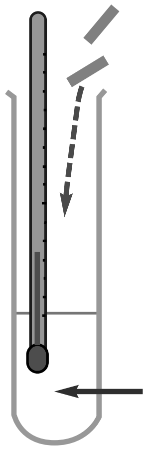
Hold a piece of magnesium with a pair of tongs. Ignite it in a bunsen flame. As soon as it lights, remove it from the flame.

Observed Changes

Hot, bright flame.
Magnesium is replaced by a new substance... a white powder.

Follow all Safety Directions your teacher gives you.

Acid Reacts With Magnesium



Measure the temperature of the acid first.

Drop in one or two pieces of magnesium.

Check the temperature again at the end.

Observed Changes

Temperature rises.
Bubbles form, because a gas is produced.
Magnesium is "eaten away" and disappears.

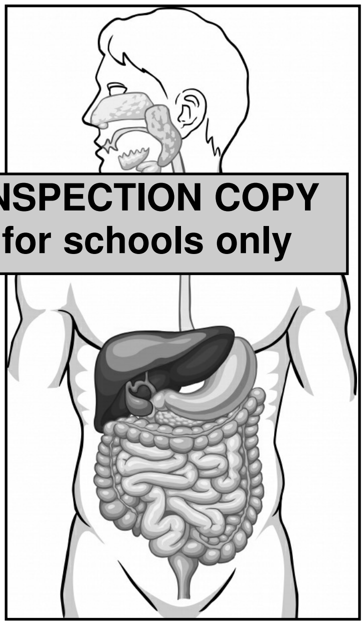
Signs of a Chemical Change

If you observe a number of chemical reactions, you will see that the same sorts of changes happen again and again.

- Original substance(s) disappear.
- New substance(s) appear.
  This may involve:
  - changes of colour.
  - gas is made which causes bubbles.
  - change from solution to suspension.
- The temperature changes. In some cases there may be flames, as a substance burns.

Chemical Reactions Around Us

Many chemical reactions are constantly going on around us and in our bodies.



Digestion & Respiration

When you eat anything, your digestive system carries out chemical reactions which break down (decompose) the food compounds into smaller, simpler molecules. These can be absorbed into the blood stream and carried throughout the body.

One of the most important reactions of digestion is:

Starch ⟶ Glucose

(Starch contains huge molecules.
It is the main nutrient in bread, rice, vegetables, cereals, etc.)
(Glucose is a small "sugar" molecule; formula $C_6H_{12}O_6$)

Once carried to all the body cells, the glucose reacts with oxygen in a process called cellular respiration.

Glucose + Oxygen ⟶ Carbon Dioxide + Water + Energy released

This process releases energy in a form which all your cells use to power your muscle movements, nerves, growth and so on.

Photosynthesis

All the plants are able to make their own food from the very simple compounds carbon dioxide (CO_2) and water (H_2O) and the energy of sunlight.

The chemical chlorophyll (which colours plant leaves green) is essential for "catching" the sunlight energy to drive the reaction:

Carbon Dioxide + Water $\xrightarrow{\text{+ Light Energy}}$ Glucose + Oxygen

We can write this in chemical symbols:

$$6\,CO_2 + 6\,H_2O \longrightarrow C_6H_{12}O_6 + 6\,O_2$$

This means that it takes 6 molecules each of CO_2 & H_2O to make 1 molecule of glucose. Six molecules of oxygen are also made & released into the air. All the oxygen in the air has been made this way.

Weathering of Rocks

All over the world, the rocks are constantly being "weathered" or broken down by reaction with the air, water and other natural chemicals. Part of this process involves chemical reactions which change the rock minerals into new forms.
For example, some hard minerals in rock are turned into "clay" which we use for pottery. Clay mixed with sand and rotted plant material forms fertile soil, essential to grow forests, grasslands and our crops.

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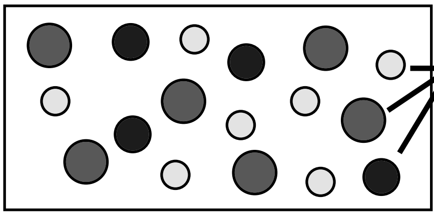
Compounds v. Mixtures

What's the difference?

A Mixture of 3 Elements



Contains different, separate particles

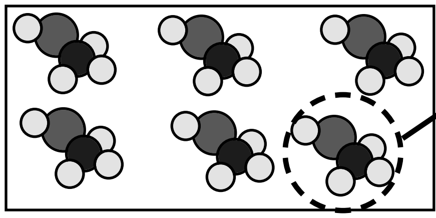
A mixture is not "pure" because it contains a variety of types of particles.

In a mixture, the parts may be mixed in any proportions, so its composition can vary.

The properties of a mixture are a "blend" of the properties of the parts of the mixture.

A mixture can be separated by physical means (e.g. filtering, distilling)

A Compound of 3 Elements



1 particle (molecule) of this compound

A compound is "pure" because there is only one type of particle present.

In a compound, the elements are "bonded" together in a definite, fixed ratio. This ratio is shown in the chemical formula. e.g. CH_4O

A compound has unique properties which are different to those of its elements.

A compound cannot be separated into parts by any physical process. It can be separated into its elements by chemical decomposition.

Please complete Worksheets 7 & 8.

Physical & Chemical Changes

Physical Changes

Physical changes are those which change only the shape, size, or the state of a substance, or the way things are mixed.

The "particles" in the substance are not changed, and no new substances are formed.

The change is usually easily reversed. e.g. melted ice can be re-frozen. Things mixed together can be easily separated again.

Physical Changes include:

- changes of state. → melting, evaporation condensation, etc
- breaking something into bits. (e.g. smashing a rock into powder)
- separating a mixture or mixing things together. → sieving, filtration, distillation, etc

Chemical Changes

Chemical changes involve chemical reactions which create new substances.

The atoms are re-combined in new arrangements, forming new molecules. (Note that exactly the same atoms are still there, just re-combined.)

Chemical bonds within molecules are broken, and new bonds are formed.

The change is usually difficult, or impossible, to reverse. e.g. if you burn a piece of paper it is impossible to turn the ash & smoke back to paper.

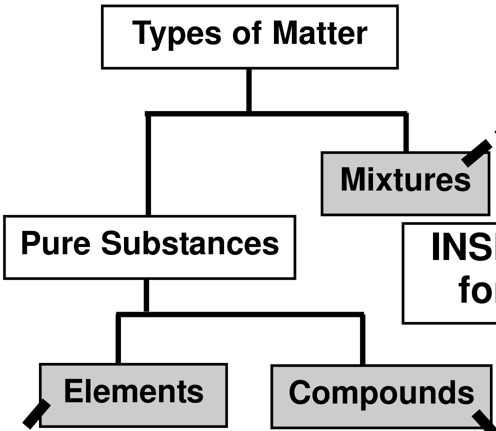
Chemical Changes include:

- combustion (burning)
- decomposition (breaking down)
- changes that cause colour changes, release of heat, bubbles of gas, etc.

A Final Summary: Elements, Compounds & Mixtures

The information on this page is absolutely vital to your future education in the area of Chemical Science. Do yourself a favour and learn it now!

Every substance is either an element, a compound, or a mixture



It is essential for you to understand the differences!

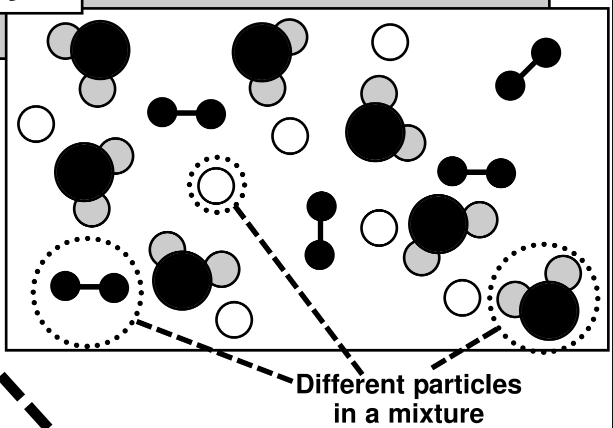
Mixtures

Not pure.
(Different particles within.)

Variable composition and properties.

Can be separated into parts by physical processes.
(filtering, distilling, etc)

May contain elements and/or compounds within the mix.



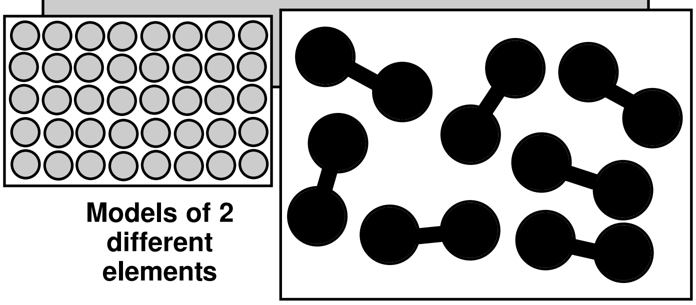
Elements

Pure.
Only one type of atom present.

Each has a unique set of properties.

Listed on the Periodic Table, with its own symbol and Atomic Number.

Cannot be separated into parts by any physical or chemical process.



Models of 2 different elements

Compounds

Pure.
Only one type of particle present.

Each has a unique set of properties.

Contains 2 or more elements, chemically bonded together in a fixed ratio.

Cannot be separated into parts by any physical process.

Can be separated into its elements by chemical decomposition.