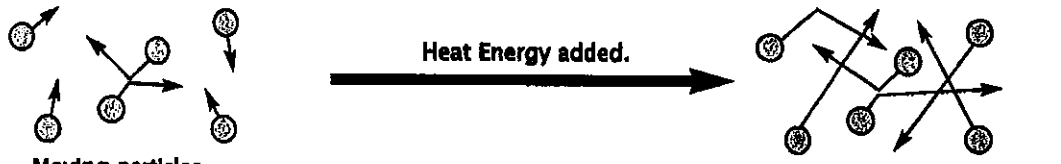
Moving Particles? What Makes Them Move?

The answer is "Heat Energy".

When you add heat energy to any substance, the particles in it do not get hotter... they get faster.
When something cools down, the particles do not get any colder... they go slower.



Moving particles in a substance.

Particles move faster. Temperature has increased.

The measurement we call "temperature" is actually a measure of how fast (on average) the particles are moving.

In a solid substance the particles cannot move around, but only vibrate.
When a solid is heated, the particles vibrate faster, but still stay in their fixed place.

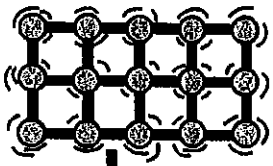
Note: The energy of a moving thing is called "Kinetic Energy".
The Moving-Particle Model is sometimes called the "Kinetic Theory (Model) of Matter".

Changes of State... Again

With a knowledge of what heat energy does to particles, we can explain what happens in a change of state.

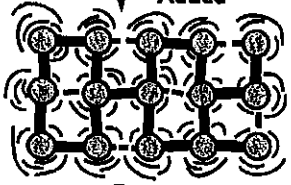
Melting

Particles in a solid are vibrating, but are held in place by forces of attraction.



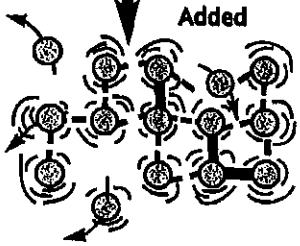
Heat Added

Adding heat makes the particles vibrate faster. The forces between them are still there, but the particles have more energy so the forces are almost overcome.



More Heat Added

At a certain temperature (the "melting point") the particles break free from their positions and begin moving around. The forces are still there, but unable to hold them. The particles are still close together, but moving among each other.



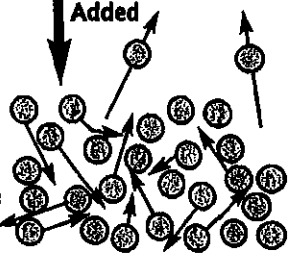
The solid has melted!

Evaporation

Particles in a liquid are close together, but move around among each other.

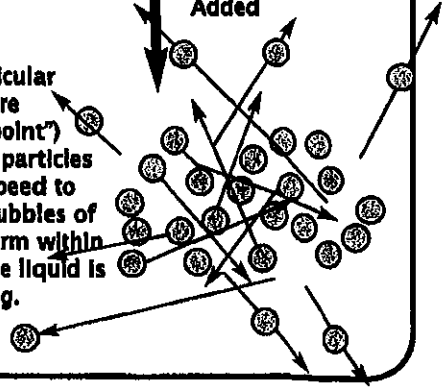
Heat Added

When heated, the particles move faster. Even at relatively low temperatures, a few particles have enough energy to fly off into the gas state. Some of the liquid is evaporating.



More Heat Added

At a particular temperature (the "boiling point") many of the particles reach the speed to evaporate. Bubbles of gas vapour form within the liquid... the liquid is boiling.

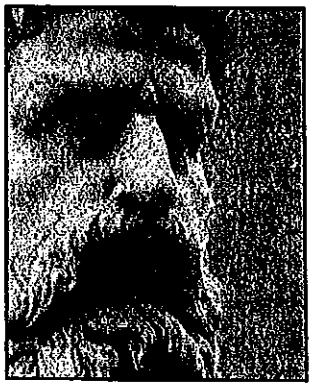


What Are the Chemical "Elements"?

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 the Middle Ages

Alchemy was partly practical experimenting and 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.

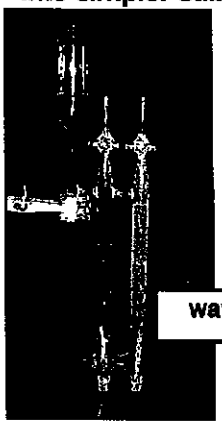
However, the alchemists did discover many facts about solids, liquids and gases. They invented processes like distillation, filtration and crystallisation and discovered new dyes and other useful substances.

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

Alchemy becomes Chemistry

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 this equipment demonstrated in class.

Using electricity, water can be broken down into 2 gases, hydrogen and oxygen.

water ⟶ hydrogen + oxygen

No matter what you do, hydrogen and oxygen cannot be decomposed into anything else.

By about 1800, 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.

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.

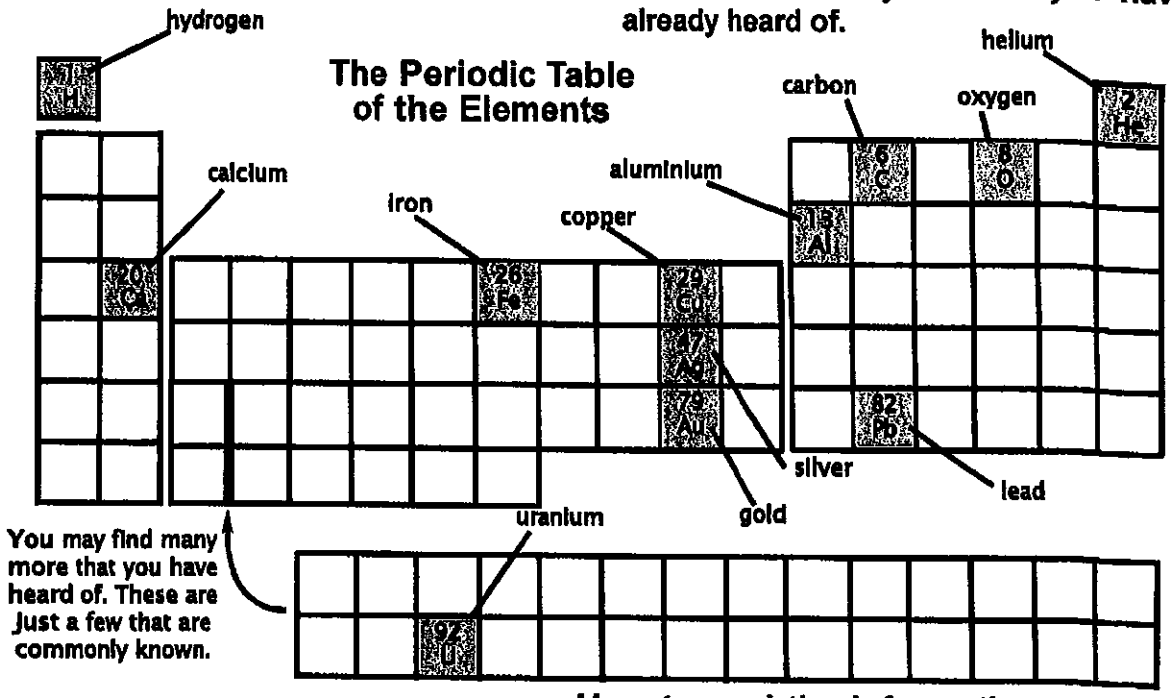
Of these elements, many are very rare. All the familiar substances on Earth are composed of only about 20-30 of the most common elements.

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.

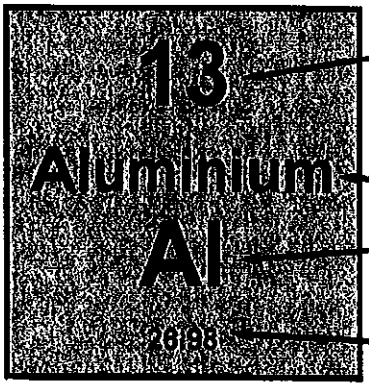
Your teacher may give you a copy, or show you a wall chart.

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



You may find many more that you have heard of. These are just a few that are commonly known.

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.

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.

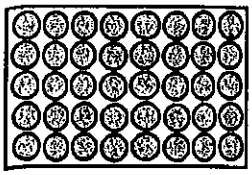
Why is the table such an odd shape?

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.

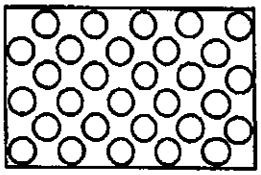
The Elements & Particle Theory

One Type of Particle = Element

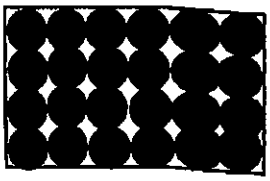
An element is a substance made entirely of identical particles.



Element 1



Element 2

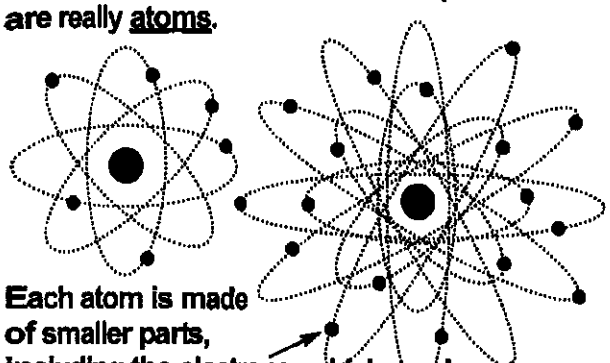


Element 3

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 atoms.



Each atom is made of smaller parts, including the electrons, which you 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 Atomic Number 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 naturally made up of identical particles.

At this stage, you should learn both the definitions above.

The information below is also very useful.

Each element is composed of atoms which have the same number of electrons.

The number of electrons is equal to the element's Atomic Number.

Different elements have atoms with different Atomic Numbers and different numbers of electrons.

Technological Inventions Affect Science

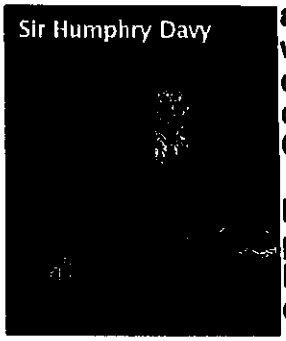
Starting about 200 years ago, the new Science of Chemistry went through a period of rapid development. One of the main areas of progress was the discovery of many new chemical elements. These discoveries were made possible by a new technology... Electricity.

Volta's Pile

The Italian scientist Alessandro Volta had discovered that the strange energy called electricity could be made using metal plates separated by 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.



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 very definitely that there are exactly 92 chemical elements. Look at a modern Periodic Table and it will list 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. All trans-uranium elements are radioactive.

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

Elements up to No.118 have been confirmed to exist, but they have not been named above No.111 because only about 3 single atoms of some have ever been made.

Warning label on a household smoke detector

The 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 all 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 which we get "plumber", a lead-pipe worker)

Worksheet 1
The Elements

Fill in the blanks

Student Name.....

The ancient Greek, a)..... believed that everything was made of 4 "elements"; earth, air, b)..... and .....

The aim of Alchemy was to turn ordinary metals into c)..... and to find a chemical which could make a person d).....

While searching for these impossible chemicals, the alchemists discovered many new chemicals and invented equipment and processes such as filtration and e).....

By learning to break chemicals down into the simplest parts ("f).....") the true concept of a chemical element was finally discovered.

We now know there are about g)..... naturally occurring elements. These are listed on the h)..... Table. Each element has its own unique i)..... and j)..... number.

An element can be defined as a substance composed of atoms which are k)..... ..... It can also be defined as a substance which cannot be l)..... into anything simpler.

Each element's atoms have the same number of m)..... This number is equal to the n)..... ..... shown on the Periodic Table.

Boiling and melting points

☞ 1 Read the following passage and circle the correctly spelt word in each pair.

The (boiling/boling) point of a substance is the (temperatur/temperature) at which a substance changes state from a (liquid/liqid) to a gas. The melting point of a substance is the temperature at which a substance changes state from a (soilid/solid) to a liquid. Different substances have different melting and boiling points. For (pure/prue) water, the melting point is 0°C and the boiling point is 100°C.

If the temperature is above a substance's boiling point, the substance is a (gas/gase). If the temperature is between a substance's melting and boiling point, the substance is a liquid. Below its melting point, a substance is a solid. Substances that have a (mealting/melting) and boiling point below room temperature (around 20°C) are usually gases.

2 Use the information in the following table to answer the questions below.

Substance	Melting point °C	Boiling point °C
Iron	1535	2750
Mercury	–39	357
Pure water	0	100
Oxygen	–218	–183

a What state of matter is oxygen at 25°C? _____

b At 25°C, what state of matter is mercury? _____

c Is 25°C above or below the melting point of iron? _____

d What temperature must iron be heated to before it will change from a gas to a liquid? _____

e What temperature does oxygen have to be before it will change from a gas to a liquid? _____

f Is 25°C above the melting point but below the b_____ p_____ for water? _____

g Which substance listed in the table has the lowest melting point? _____

Achieve!

Atoms and elements

☞ 1 Use the words in the word bank to complete the passage below.

Word bank
living
particles
atom
Elements
one
carbon
materials
same

Everything around us, and all the things we use are made of m _____. All materials are made up of tiny p_____ called **atoms.** Although there are millions of different materials that exist, they are made up of just over 100 different elements. An element is a substance that cannot be split into anything simpler. E_____ contain only o_____ type of a_____. For example, iron is an element made up of iron atoms. Carbon, which is found in all l_____ things, is made up of c_____ atoms. Marble is not an element, because the atoms in marble are not all the s_____.

2 Unscramble these important words used in the passage above.

mstao _____ mtseenel _____

tmlareasi _____ rsceaptil _____

3 Circle the correct answer.

Instead of saying particle, sometimes scientists use the word element / material / atom / carbon.

4 Look at the diagrams below and decide which is an element and which is a mixture of elements. Label them.

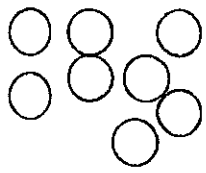


Diagram 1

_____

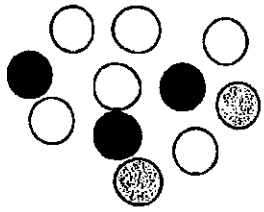


Diagram 2

_____

5 Diagram 1 is made up of _____ type of element.

6 Diagram 2 is made up of _____ different elements.

Naming elements

☞ Use the Resource sheet 'The periodic table (1)', the periodic table on the inside front cover, and the word bank below to help you solve the riddles and complete the table below. Each riddle gives a clue about what the name of the element sounds like.

For each riddle:

1 Write down the element's full name and its symbol.

2 Classify it as a metal or non-metal.

Word bank

Po	He	Li	Es	B	Au	Br
Hg	Cu	Sn	Fe	Eu	Ar	Ba

Riddle	Element name	Symbol	Metal or non-metal
What you hope a doctor can do			
What a weightlifter does			
Male sibling of someone			
What a gravedigger has to do			
A kind of sausage, also known as devon			
Closest planet to the sun			
Once someone leaves they ...			
Rhymes with what you put rubbish in			
What you get when you win			
Used to remove wrinkles from clothes			
Dull and unexciting			
A very clever element			
What you do with a lasso			
A slang name for a policeman			

What is matter?

☞ **1** Use the words in the word bank to complete the passage below.

Everything in the world belongs to two groups: e_____ or m_____. Energy makes things happen. Different forms of energy include l_____, s_____ and h_____. Matter is anything that can be w_____ and that takes up s_____. All material objects are made up of matter.

Living o_____ like plants and a_____ are also made up of matter.

Matter can be either a s_____, l_____ or g_____. These are known as the three s_____ of matter. Water can exist in all three of these states.

Word bank

light
solid
matter
heat
gas
energy
sound
organisms
states
space
liquid
weighed
animals

2 Decide which of the following are matter and which are forms of energy. Write them in the table below.

car	electricity	iPad	thunder
petrol	heat	oxygen	lightning

Matter	Energy

3 Water can be a solid, a liquid or a gas. Match each form of water to the correct state.

solid	water vapour
liquid	ice
gas	liquid water