

### Topic 3 What Are Elements

The original 'elements' were earth, air, fire and water.



**Ancient Greek philosophers** thought matter was made out of these four 'elements'. They thought all things were made from these four elements with varying degrees of hotness, coldness, dryness and wetness.

**Alchemists** (part pharmacist and part mystic) developed many useful procedures, including distillation, and they described the properties of many different materials. They also thought they could change lead and copper into gold. They used special symbols to prevent others from finding out their secrets.

The current view of matter began with **Sir Francis Bacon**, who stated that all science should be based on experimental evidence, rather than thought. **Robert Boyle** recognized that elements could combine to form compounds. Bacon and Boyle motivated others to search for elements.

#### Taking Apart Matter

Scientists began using heating, burning, mixing, and cooling to take matter down until it could not be broken down any further, to determine if a substance was a pure substance or a mixture. Antoine Lavoisier defined elements as pure substances that could not be decomposed into simpler substances by means of a chemical change. In this way he identified 23 pure substances as elements. Lavoisier was one of the first chemists to use a balanced view of chemical change, which we now call ...

#### **The Law of Conservation of Mass**

*In a chemical reaction, the total mass of the reactants, is always equal to the total mass of the products.*

This law ties in well with the atomic theory, which states that atoms are never created or destroyed. In a chemical reaction the atoms and molecules are simply rearranged. This law of conservation of mass however does not apply to nuclear reactions, because there is some loss of mass: **the mass is changed into energy**. This was first suggested by **Albert Einstein** in his famous equation:

$$E = MC^2$$

(**E** is Energy, **M** is Mass, **C<sup>2</sup>** is a large number)

A very tiny amount of mass is equal to a very large amount of energy  
In an **open system** some of the mass seems to disappear, when it is in the form of a gas.

Other scientists followed up on the law of conservation of mass by stating the ...

#### **Law of Definite Composition**

*Compounds are pure substances that contain two or more elements combined together in fixed (or definite) proportions.*

Water is an example of this law. Pure water always contains 11% Hydrogen and 89% Oxygen.

Chemistry Tutorials <http://www.chemistrycoach.com/tutorials-2.htm>

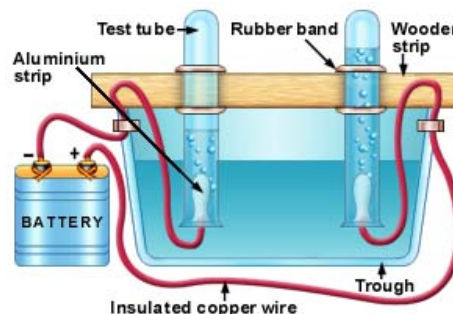
**Law of Multiple Proportions** *states that the masses of one element, which combine with a fixed mass of the second element, are in a ratio of whole numbers.*

Pure substances have constant composition and properties. An unknown substance can be identified by measuring a property of the substance (eg. density) and compare it to known values of other substances. If the test property matches a known value, it is likely that substance, because each substance has its own distinguishing properties unique to that substance.

## New Discoveries

Allesandro Volta made the first practical battery (the voltaic pile) around 1800, by piling zinc and copper plates on top of each other, separating them with electrolyte-soaked paper discs.

When this voltaic pile was hooked up to transfer the electricity through water, they discovered hydrogen and oxygen gases could be produced and the water level dropped slightly. Using electricity to split molecules into their elements was a process called **electrolysis**. Scientists used electrolysis to isolate the elements potassium, sodium, magnesium, calcium, strontium, and barium.



## Dalton's Atomic Theory

John Dalton developed a theory that helped explain what happened in the electrolysis of water and was a new way to explain chemical facts and laws. His Atomic Theory was widely accepted.

- All matter is made up of tiny particles called atoms
- Atoms cannot be created, destroyed, or divided into smaller particles.
- All atoms of the same element are identical in mass and size. Atoms of one element are different in mass and size from the atoms of other elements.
- Compounds are created when atoms of different elements link together in definite proportions

An **element** is a pure substance made up of only one type of particle, or atom. Each element has its own unique set of distinguishing properties and cannot be broken down into simpler substances by means of a chemical change.

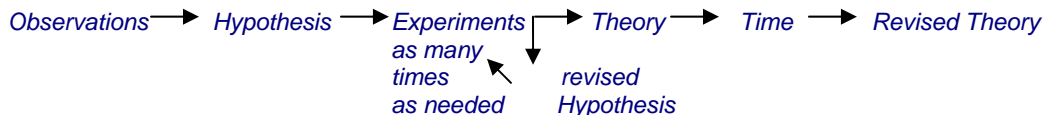
A **compound** is a pure substance made up of 2 or more elements chemically combined together. Compounds can be broken down into the elements that they are composed of.

## Laws, Theories, Models, and Observations

In science, **laws** do not explain anything. They simply describe and summarize what happens.

**Theories** are imaginative ways to explain why something happens the way it does.

Theories are developed over the course of many observations and hundreds of experiments before other scientists will accept it.



Scientific ideas may change over time as more evidence is gathered. Most of Dalton's atomic theory has stood the test of time, however, smaller particles (subatomic) have been discovered and Dalton's Theory needed to be revised.

**Scientific models** help others to visualize structures or processes that cannot be seen directly.

Some of the atomic models are illustrated on p. 113 in the Science Focus 9 textbook.

### A Brief Timeline of Atomic Theory

Year	Evolving Theory of Matter	3D Model
8000 B.C.	<i>(Stone Age) Matter was made up of solid material, which could be fashioned into tools.</i>	Stone implements
6000-1000 B.C.	<i>Chemists investigated the properties of only those materials that were of high value to humans. (gold and copper)</i>	Metals
4500 B.C.	<i>(Bronze Age) The effect of heat on copper, lead to the creation of a strong material (bronze) for use as tools.</i>	Bronze tools
1200 B.C.	<i>(Iron Age) Iron combined with carbon to make steel, for even stronger tools.</i>	Steel
350 B.C.	<i>Everything was made out of Air – Water - Earth – Fire (atomos particles)</i>	Earth/Wind/Fire/Ice
1500	<i>Theory of Matter was based more on experimentation. (History of Alchemy)</i>	States of Matter
1660	<i>Particles can be compressed. (Boyle)</i>	Particles
1770	<i>System for the naming of chemicals was developed. (Lavoisier)</i>	Molecule
1780	<i>Air is necessary for combustion to occur.</i>	Molecules
<b>A Brief History Atomic Models (p. 113 SF9)</b>		
1808	<i>Observation principles during experimentation.</i>	Dalton's Atomic Theory (billiard ball model)
1897	<i>Raisin bun model with charged particles.</i>	JJ Thomson Raisin bun (plum pudding model)
(1904) 1911	<i>Negatively charged particles orbiting around nucleus.</i>	Ernest Rutherford (planetary model)
1913 (1922)	<i>Electrons rotate randomly around the nucleus.</i>	Niels Bohr (atomic model)
Today	<i>the atom is a cloud of electrons around a nucleus</i>	'quantum model'