SNC1D CHEMISTRY

ATOMS, ELEMENTS, & COMPOUNDS
☞ Atomic Theory
(P.168-175)

Atomic Theory

Thousands of years ago Greek philosophers were asking themselves questions like, "If you take a gold bar and cut it into smaller and smaller pieces, what is the smallest piece of gold that you can get?" and "Would the piece of gold ever become so small that, if you cut it further, it would no longer be gold?"

February 8, 2013 1DCHEM - Atomic Theory 1

Atomic Theory

Their answers, and those of many curious minds, have shaped our theories about the structure of matter.

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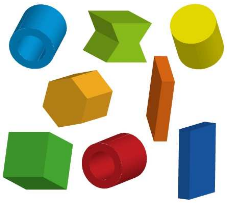
Democritus – The Atom

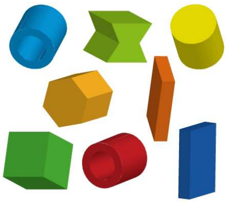
*Around 400 BCE (Before Common Era), the Greek philosopher Democritus proposed that all matter can be divided into smaller and smaller pieces until a single indivisible particle is reached. He named this particle the **atom**, which means "cannot be cut."*



Democritus – The Atom

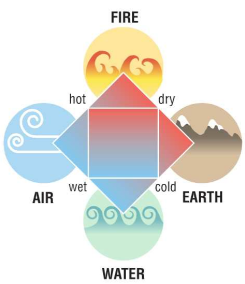
Without any experimental evidence, he proposed that atoms are:

- *of different sizes*
- *in constant motion*
- *separated by empty spaces (the void)*



Aristotle – Earth, Water, & Fire

Around 450 BCE, another famous Greek philosopher, Aristotle, rejected the idea of the atom. He supported an earlier theory that all matter is made up of four basic substances: earth, water, air, and fire. These substances were thought to have four specific qualities: dry, wet, cold, and hot. Because of Aristotle's reputation, this theory of the structure of matter was accepted for almost 2000 years.



Dalton – The Billiard Ball Model

In 1807, John Dalton, an English scientist and teacher, revived Democritus' theory of the indivisible atom. He imagined that all atoms were like small spheres (or billiard balls) but that they could have different properties – they might vary in size, mass, or colour.

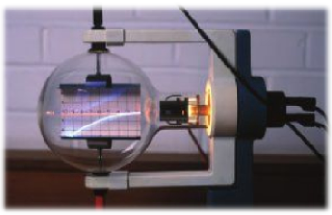
Dalton – The Billiard Ball Model

Dalton proposed that:

- *all matter is made up of tiny, indivisible particles called atoms*
- *all atoms of an element are identical*
- *atoms of different elements are different*
- *atoms are rearranged to form new substances in chemical reactions*
- *atoms are never created or destroyed*

Thomson – The Electron

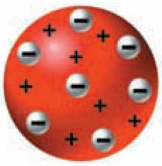
*In 1897, J.J. Thomson discovered that extremely small negatively charged particles could be emitted by very hot materials. These particles were attracted to the positive end of a circuit. Positive charges and negative charges were known to attract each other, so Thomson concluded that the particles must be negatively charged. These particles were later called **electrons**.*

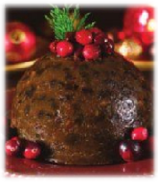


Thomson – The Electron

Thomson theorized that:

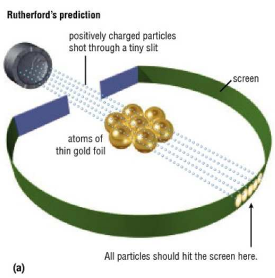
- *atoms contain negatively charged electrons*
- *since atoms are neutral, the rest of the atom is a positively charged sphere*
- *negatively charged electrons are evenly distributed throughout the atom (resembles plum pudding)*





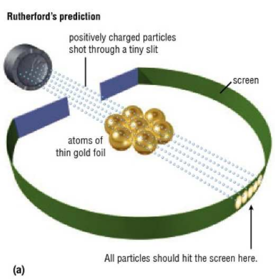
Rutherford – The Nucleus & Proton

In 1909, Ernest Rutherford supervised an experiment to test Thomson's model of the atom. He predicted that if positive and negative charges were uniformly distributed throughout atoms, then tiny positively charged particles shot at a thin piece of gold foil would pass through the foil. Some of the particles might be slowed down or deflected at very small angles.



Rutherford – The Nucleus & Proton

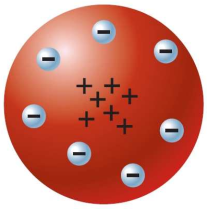
When the experiment was performed, most of the particles passed through the foil unaffected. Also, a small number of particles were deflected at very large angles, as though something very massive but very small was repelling them.



Rutherford – The Nucleus & Proton

In Rutherford's revised model:

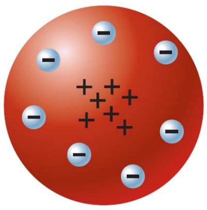
- *the centre of the atom has a positive charge and is called the **nucleus** (contains most of atom's mass but occupies very small space)*
- *the nucleus is surrounded by a cloud of negatively charged electrons*
- *most of the atom is empty space*



Rutherford – The Nucleus & Proton

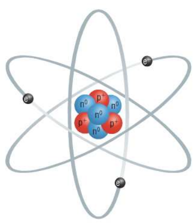
NOTE!

Rutherford calculated that if an atom were the size of a football field, the nucleus would be the size of a single pea located in the centre.



Chadwick – The Neutron

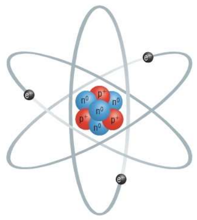
In 1932, James Chadwick, Rutherford's student, found a particle that could penetrate and disintegrate atoms with extraordinary power. Unlike positively charged protons, these particles have zero charge – they must be neutral. Therefore, there must be other undetected particles in the atom.



Chadwick – The Neutron

Based on this discovery, Chadwick proposed:

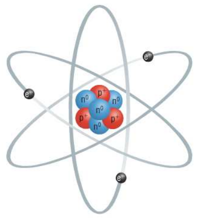
- *an atom must be an empty sphere with a tiny dense central nucleus (that contains positively charged* ***protons*** *and neutral particles called* ***neutrons****)*
- *the mass of the neutron is about the same as a proton*
- *electrons circle rapidly through empty space around the nucleus*
- *a neutral atom has the same number of protons as electrons*



Chadwick – The Neutron

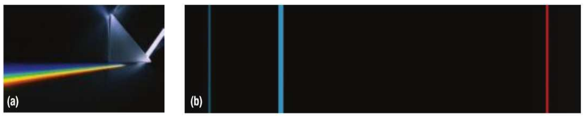
NOTE!

This model is commonly referred to as the "planetary model".



Bohr – Electron Orbits

Niels Bohr, a Danish scientist, studied the hydrogen atom and the light that it produces when it is excited by thermal energy or electricity. For example, when white light is shone through a prism (a) a full rainbow of colours is seen. However, when light produced by hydrogen is examined in the same way (b), only a few lines of colour are seen.



Bohr – Electron Orbits

In 1913, Bohr used this evidence to propose the following:

- *electrons orbit the nucleus much like planets orbit the Sun*
- *each electron in an orbit has a definite amount of energy*
- *electrons cannot be located between orbits, but they can jump between orbits (and release energy in the form of light when they drop from higher to lower orbits)*
- *each orbit can hold a certain maximum number of electrons (2 in the first orbit, and 8 in the second and third orbit)*

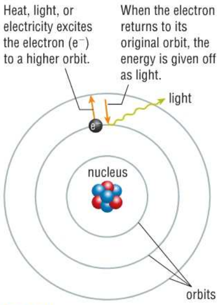


Figure 11 The Bohr–Rutherford model of the atom

Bohr & Rutherford

NOTE!

The Bohr-Rutherford model – a combination of both Bohr & Rutherford's theories – is useful for explaining and predicting the properties of first 20 elements. Because of its simplicity, many people still use this model to describe the particles that make up the atom.

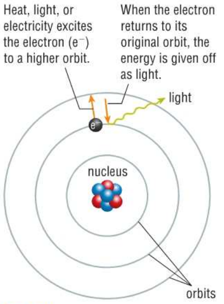
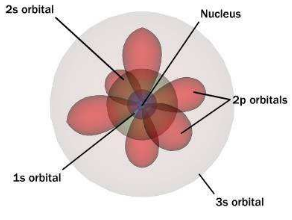


Figure 11 The Bohr–Rutherford model of the atom

The Quantum Mechanical Model – DYK?

The most advanced and accurate model of the atom, and the one in use today by physicists and chemists, is called the quantum mechanical model. In this model, electrons do not exist as tiny points inside an atom. Electrons exist in specific energy levels, but they surround the positively charged nucleus in a form resembling a cloud.



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