

Atomic Theory Development

Democritus 460 BC and Dalton 1803 AD



Thomson



Rutherford



Bohr













Born as early as 400 BC, it took <u>more than 2000 years</u> before Science was ready <u>to accept the idea</u> of atomic structure of matter...<u>and another 150 years to develop a good model</u>!

What is a Model?

In Science, a <u>model</u> is a physical, mathematical, or conceptual (abstract) <u>representation of a real phenomenon</u> that is difficult to observe directly – that is, a *convenient substitute*.



Scientific models are used in a variety of scientific disciplines to explain and predict the behavior of real objects or systems.

Model is Never Perfect



all models are wrong, but some are useful

George E. P. Box

(one of the most influential statisticians of the 20th century)



Scientific models are approximations of the objects and systems that they represent!

Scientists are constantly working to *improve and refine* models.

Democritus ~400 BC

Nothing exists except atoms

and empty space;

everything else is opinion"

"atomos"="not to be cut"

Democritus (ca. 460 BC - ca. 370 BC)

- Matter could not be divided into smaller and smaller pieces forever, eventually the smallest possible piece would be obtained.
- This piece, atomos (atom), would be indivisible.
- Between atoms, there would be empty space.
- To Democritus, atoms were small, hard particles of different shapes and sizes that were all made of the same material.
- Atoms were <u>infinite in number</u>, <u>always moving</u> and capable of <u>joining together</u>.

John Dalton early 1800s

The first truly scientific theory of the atom: conclusions were reached by <u>experimentation</u> and examination of the results in an <u>empirical fashion</u>.

Η



- All elements are composed of atoms.
- Atoms are <u>indivisible</u> and <u>indestructible</u> particles.
- <u>Atom model</u>: a *billiard ball* or a *marble*.
- Atoms of the same element are exactly alike.
- Atoms of different elements are different.
- Compounds are formed by the joining of atoms of two or more elements.



Discovery of Electron



Joseph John Thomson



<u>1897</u>: Thomson detected charged particles that were around <u>1800 times lighter than the lightest</u> atom, hydrogen. Therefore they were not atoms, but a new particle, the first subatomic particle to be discovered. Originally it was called "corpuscle" but was later named *electron*.

- many elements were shown to emit electrons...
- …all atoms must contain electrons as universal building blocks
- atoms are neutral, so there must be balancing "cloud" of opposite charge



Plum Pudding Model, 1904 1906 Nobel prize in Physics **Discovery** of the **Nucleus** Rutherford (Geiger–Marsden), 1908-1913: Gold Foil Experiment

- "Father of nuclear physics"
- Bombarded a <u>thin metal foil</u> with <u>alpha particles</u>. A majority of the particles passed through the sheet but a <u>small percentage</u> were deflected.





 Rutherford's conclusion: "the greater part of the mass of the atom was concentrated in a minute nucleus... carrying a charge".



Planetary Model Niels Bohr, 1913

<u>Electrons</u> move in <u>definite orbits</u> around the nucleus, <u>much like</u> planets circle the Sun.

- These <u>circular</u> orbits, or <u>energy</u> <u>levels</u>, are located at <u>certain</u> <u>distances</u> from the nucleus.
- Electrons can jump between levels emitting (or absorbing) energy.









Chemical Bond Explained

Gilbert Newton Lewis, 1916:

a covalent bond between two atoms is maintained by a pair of electrons shared between them.



never won the Nobel Prize in Chemistry...

Summary: Structure of Matter



enough to explain all experimental observations?

Inside a Nucleus

- <u>Rutherford, 1920</u>: discovery of a proton (Greek: "first"), a positively charged subatomic particle.
- 1920-1932: search for a *neutral* particle.
- Chadwick, 1932: detected zero charged particles with about the same mass as the proton, eventually called neutron (1935 Nobel Prize in Physics).



Atom ~10⁻¹⁰m

Nucleus ~10⁻¹⁴m Proton ~10⁻¹⁵m Neutron ~10⁻¹⁵m

Atomic Nucleus Structure

