The beginning of atomic theory

Democritus (460 - 370 BC) - the beginning of atomic theory

Democritus, an ancient Greek philosopher who lived from 460BC - 370 BC, proposed the idea that you can't divide something in half forever. Eventually, he argued, you must reach a smallest indivisible part. He called this smallest piece of matter an *atom*. Democritus correctly deduced the existence of atoms, but he could go no further in discovering any of their properties. For the next 2000 years *atomism* was an interesting idea but there was no good scientific evidence to support its truth or falsehood.

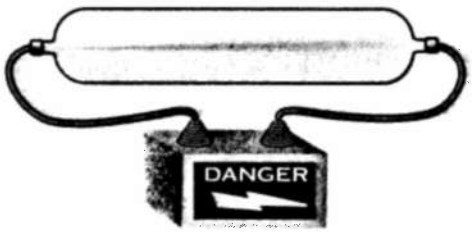
John Dalton (1768 - 1828) - first "modern" atomic theory

In 1808, John Dalton, an English school teacher, put together many ideas in his four postulates of the atomic theory. Daltons four postulates were a brilliant synthesis based on what little evidence there was at that time. They remain true today.

1. All elements are made of tiny indivisible particles called atoms.
2. All atoms of the same element are alike but different from atoms of every other element.
3. Chemical reactions rearrange atoms but do not create, destroy or convert atoms from one element to another.
4. Compounds are made from combining atoms in simple whole number ratios

Cathode rays

In the mid 1800's it was discovered that high voltage made a "glow" in a sealed glass tube from which most of the air had been pumped out. In 1870 William Crookes invented a tube in which virtually ALL of the gas was removed. Now, the glow inside the tube disappeared, but *the glass at one end of the tube was glowing*. Some kind of invisible "ray" was being emitted from the cathode end of the tube and striking the glass at the other end. These rays were called *cathode rays*, and a great debate occurred over the nature of them. Were they another kind of light? Where they a stream of particles?.

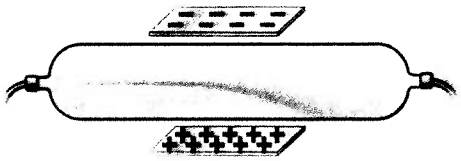


high voltage electricity creating cathode rays inside a Crookes tube

J.J. Thomson (1856 - 1940) - the discovery of the electron


Thomson

In 1897, J.J. Thomson was able to definitively resolve the debate. His experiments showed that cathode rays were deflected toward a positively charged plate and away from a negatively charged plate. Thomson deduced that cathode rays must be negative. He found they could be deflected by magnetic fields. No ordinary ray of light would behave this way. He tried using different metals, or starting with the tube filled with different gasses. None of those factors mattered. He always got the same cathode rays and they always were deflected in the same way


cathode rays deflected away from negative plate and toward positive plate

P. 49B

The discovery of the nucleus

Cathode rays are electrons

Thomson's discovery stunned the scientific world. Cathode rays were a stream of particles 2000 times lighter than the lightest known atom (H)! How there be a particle smaller than an atom? Because Thomson always got the same cathode rays regardless of whatever metals he used for the electrodes in his Crookes tube, he named the new particle an *electron* and proposed that electrons were inside ALL atoms.

The atom must have a structure inside

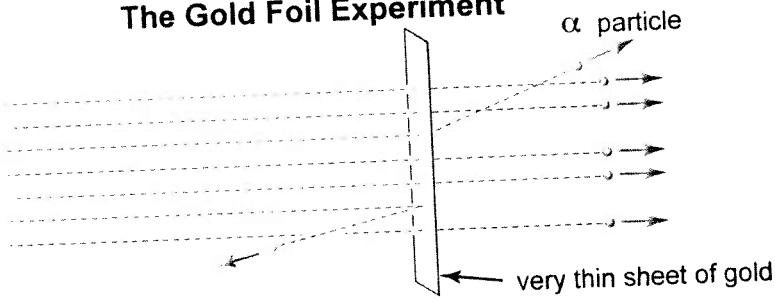
If electrons were inside atoms, then atoms could not be the most elementary particles of matter. Furthermore, electrons were *negative* and atoms were *neutral* so there had to also be something *positive* within atoms to cancel the charge of the electrons. The search was on to discover the *structure* inside the atom.

Ernest Rutherford - the gold foil experiment


Rutherford

In 1910, Ernest Rutherford designed and carried out the crucial experiments that provided the answer. Marie and Pierre Curie had discovered that uranium was radioactive and released energetic alpha particles at high velocity. Alpha particles were positively charged and had a mass about 8000 times that of an electron. Rutherford devised an experiment to shoot alpha particles through a thin gold foil and observe what happend as they collided with gold atoms. He expected most of the alpha particles to be deflected a little as they crashed through gold atoms.

The Gold Foil Experiment



Most α particles passed straight through, but a few were deflected to the side and once in a while one would bounce straight backwards!

Rutherford's discovery of the atomic nucleus

Rutherford's results were completely unexpected. Most of the alpha particles went straight through the gold foil with no deflection at all. A few were deflected slightly off their original path and about 1 of every 20,000 reversed direction, bouncing back from the foil! Rutherford determined that atoms have nearly all their mass concentrated in a very tiny, very dense, positively charged nucleus and this was his reasoning:

1. The deflected alpha particles were repelled by something with the same charge, so the nucleus must be positively charged.
2. Very few alpha particles were deflected so it must rare for one to come close to a nucleus. This meant the nucleus had to be tiny, about 1/10,000 the diameter of the atom.
3. The alpha particles were travelling at such high velocity that only something with significant mass could deflect them.