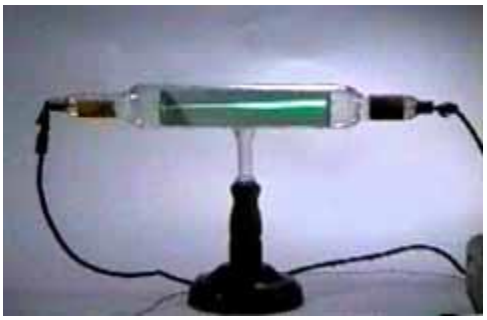
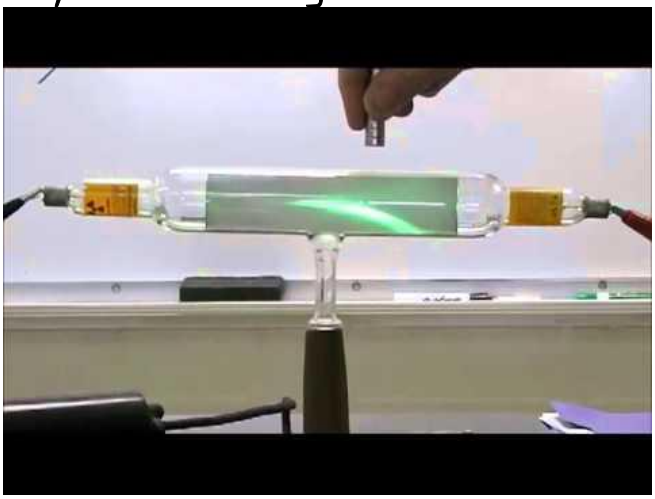
Chemistry Lecture #17: Electrons, Protons, and Neutrons

Dalton's atomic theory states that atoms are indestructible and could not be separated into smaller pieces. This is not correct. It was later discovered that atoms are made of electrons, protons, and neutrons.

Electrons were discovered with a device called a cathode ray tube. This is a glass tube filled with gas. Inside the tube at each end are metal plates. The metal plates are attached to a battery or voltage source. When you turn on the voltage, a beam appears between the plates. The beam is called a cathode ray.



If you hold a magnet near the beam, the beam will bend.



The fact that the cathode ray is deflected by a magnet indicates that it is composed of charged particles. By the end of the 1800s, it was known that the particles had a negative charge.

English physicist J.J. Thompson (1856-1940) performed experiments and determined that a cathode ray particle had a mass that was less than that of a hydrogen atom. Hydrogen is the smallest atom. Thus, the cathode ray particle is not an atom, but another type of particle smaller than the atom.. This is how the electron was discovered.

Thompson did not find the exact mass of the electron. He found its charge to mass ratio. American physicist Robert Millikan (1868-1953) performed a famous experiment with tiny droplets of oil to determine the mass of the electron.. Using Thompson's data, the mass of the electron was found to be 1/1837 the mass of a hydrogen atom. The point of all this is that the electron is very small compared to an atom.

Discovery of the proton was based on experiments involving hydrogen. At the time, it was believed that hydrogen could be the building block of all atoms. Hydrogen is the lightest atom. All other atoms could be made by fusing hydrogen atoms together to make bigger and bigger atoms.

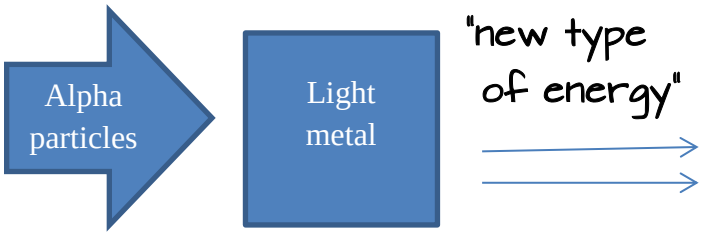
Ernest Rutherford (1871-1937) conducted an experiment that produced hydrogen where none existed. He combined two elements, helium (also called an alpha particle) and nitrogen, and ended up with oxygen and hydrogen.

alpha particle + nitrogen = oxygen + hydrogen

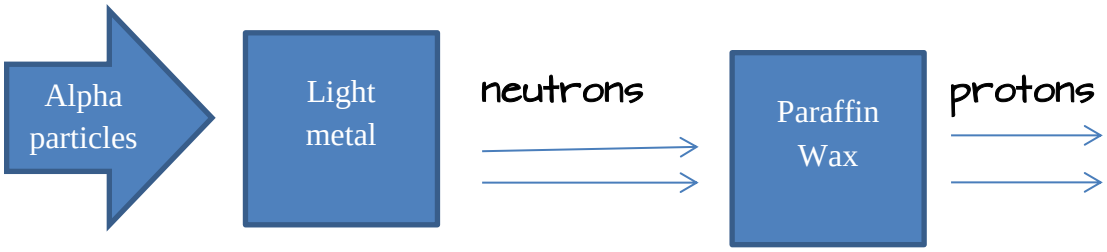
Rutherford reasoned that the alpha particle and nitrogen atom combined, and then ejected the hydrogen atom. The hydrogen atom was originally inside the nitrogen atom. The ejected hydrogen atom was different from a regular, neutral hydrogen atom - it had a positive charge. Rutherford named this special hydrogen atom the proton.

If atoms were made of only protons, then there was a discrepancy between the actual mass of an atom and the predicted mass. Rutherford suggested that atoms also contained neutral particles that also contributed to the mass of the atom.

Evidence for existence of the neutron occurred when Walther Bothe (1891-1957) conducted an experiment where light metals (beryllium, boron, and lithium) were exposed to alpha particles. The exposed elements seemed to emit some new type of energy or radiation.



James Chadwick (1891-1974) replicated Bothe's experiment, and exposed the new radiation to paraffin wax. The wax then emitted protons. By measuring the speed of the emitted protons, Chadwick determined that the protons were not being hit by a new type energy, but by neutral particles of almost the same mass. Thus, Chadwick proved the existence of neutrons.



In summary, atoms are composed of electrons, protons and neutrons.

Particle	Charge	Relative Mass
Electron	negative (-)	very small (1/1837 mass of proton)
Proton	positive (+)	large
Neutron	neutral (0)	large (slightly larger than the proton)