Atomic Theory

John Dalton (1766-1844) is the scientist credited for proposing the atomic theory. This theory explains several concepts that are relevant in our world today. This includes what a pure gold necklace is made of, what makes the pure gold necklace different than a pure silver necklace, and what occurs when pure gold is mixed with copper. After reading this text you will know the answers to all of those questions. Before discussing the Atomic Theory we will explain the theories that Dalton used as a basis for his theory: the law of conservation of mass and the law of constant composition.

Law of Conservation of mass: (1766-1844)

The law of conservation of mass states that the total mass present before a chemical reaction is the same as the total mass present after the chemical reaction; thus, **mass is conserved**. The law of conservation of mass was formulated by Antoine Lavoisier (1743-1794). This law was a result of his combustion experiment where he observed that the mass of his original substance –a glass vessel, tin, and the air in the sealed vessel- was equal to the mass of the produced substance- the glass vessel, “tin calx”, and the remaining air.

Historically, this was a difficult concept for scientists to grasp. If this law was true then how was it that a large piece of wood was reduced to a small pile of ashes. Obviously the wood has a greater mass than the ashes. From this observation scientists concluded that mass had been lost. However, the illustration below depicts the fact that the burning of word does follow the law of conservation of mass. Scientists did not take into account the gases that play a critical role in this reaction.

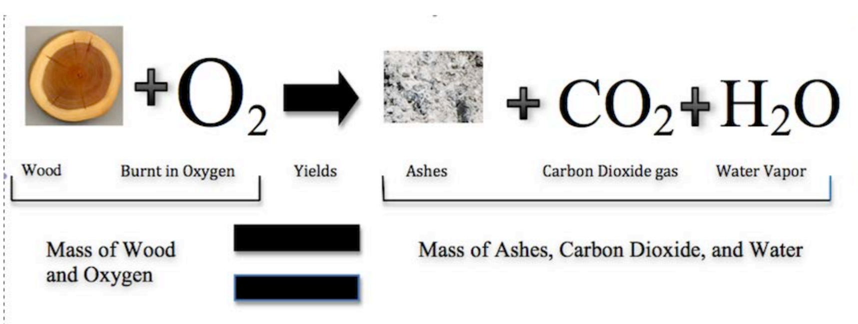
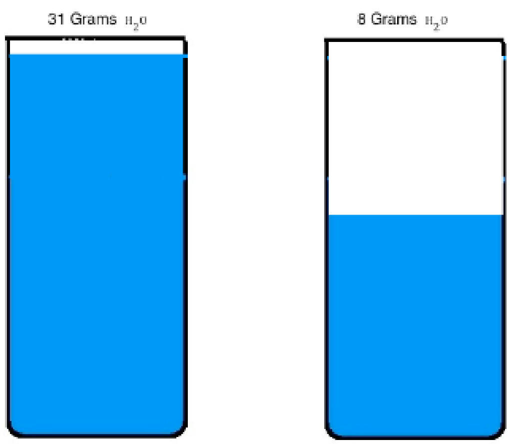


Figure 1: Image of the wood courtesy of Ehamberg and Stannered on Wikimedia Commons, available under Creative Commons Attribution 2.5 Generic license. Image of ashes courtesy of Walter Siegmund under the creative commons-share alike 3.0 unported license. Figure one as a whole constructed by Jessica Thornton using Microsft word and Preview (UCD).

Law of Constant Composition

Joseph Proust (1754-1826) came up with the law of constant composition (also called the **law of definite proportions**). This law states that if a compound is broken down into its constituent elements, the masses of the constituents will always have the same proportions, regardless of the quantity or source of the original substance. Joseph Proust based this law primarily on his experiments with basic copper carbonate. The illustration below depicts this law; 31 grams of H_2O and 8 grams of H2O are made up of the same percent of Hydrogen and Oxygen.



Compound	Grams of H	Grams of O	Percent H	Percent O
31 grams H_2O	3.469	27.53	11.19%	88.81%
8 grams H_2O	.8951	7.105	11.19%	88.81%

Figure 2: Constructed by Jessica Thornton (UCD)

Dalton's Atomic Theory

1. Each chemical element is composed of extremely small particles that are indivisible and cannot be seen by the naked eye, calledatoms. Atoms can neither be created nor destroyed. Pictured below is a Helium atom. The purple and red dots represent the neutrons and protons in the nucleus. The black area around the nucleus represent the electron cloud. In the following sections we will discussion this further.

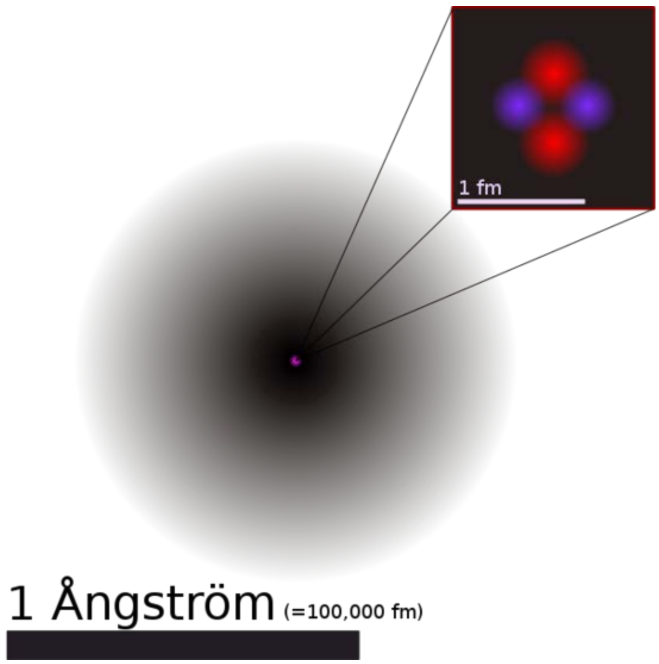


Figure 3: Courtesy of Yzmo on Wikimedia commons, available under Creative Commons-Share Alike 3.0 Unported

2. All atoms of an element are alike in mass (weight) and other properties, but the atoms of one element differ from all other elements. For example, gold and silver have differnt atomic masses and differnt properties.

Gold

Silver

Atomic Mass: 196.97

Atomic Mass: 107.87

Figure 4 (Gold): Courtesy of Chris Ralph that released this image into the public domain.
Figure 5 (silver): Courtesy
of http://resourcescommittee.house.gov/subcommittees/emr/usgsweb/photogallery/

3. For each compound, different elements combine in a simple numerical ratio. The illustration below describes this rule. The second equation for the reaction is incorrect because their cannot be half of an atom.

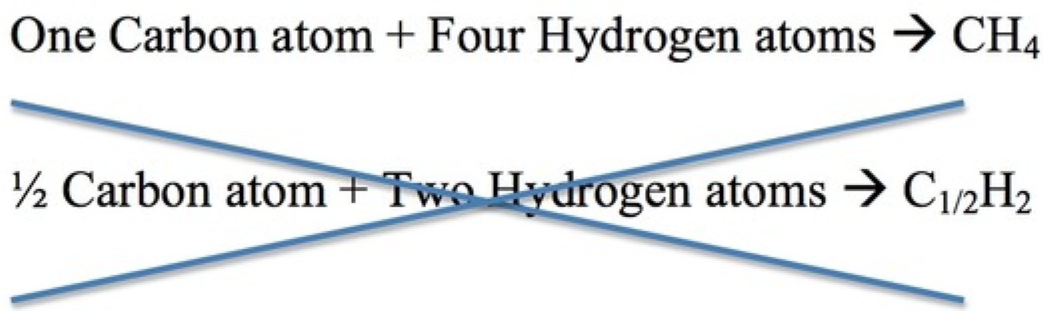


Figure 6: Created by Jessica Thornton

We can use the atomic theory to answers the questions presented above. A pure gold necklace is made up of atoms. A pure gold necklace and a pure silver necklace are different because they have different atoms. When we mix pure gold with pure copper we get rose gold. This is simply the gold and copper combining in a simple numerical ratio.

Dalton's theory has not proven to be one hundred percent correct. The first rule was proven to be incorrect when scientist were able to divide atoms in a process called nuclear fission. The second rule was proven to be incorrect by the discovery that not all atoms of the same element have the same mass, there are isotopes. However, these failures should not cause us to throw away the atomic theory. It correctly explains the law of conservation of mass: if atoms of an element are indestructible, then the same atom must be present after a chemical reaction as before and their mass remains constant. Dalton’s atomic theory also explains the law of constant composition: if all the atoms of an element are alike in mass and if atoms unite in fixed numerical ratios, the percent composition of a compound must have a unique value without regards to the sample analyzed. The atomic theory led to the creation of the law of multiple proportions.

Law of Multiple Proportions

The law of multiple proportions states that if two elements form more than one compound between them, the masses of one element combined with a fixed mass of the second element form in ratios of small integers. The illustration of the third rule of the atomic theory correctly depicts this law.

Discovering Electrons

The first cathode-ray tube (CRT) was invented by Micheal Faraday (1791-1867). Cathode rays are a type of radiation emitted by the negative terminal, the cathode, and was discovered by passing electricity through glass tubes from which the air was mostly evacuated. The radiation crossed the evacuated tube to the positive terminal, the anode. Cathode rays produced by the CRT are invisible and can only be detected by light emitted by the materials that they strike, called phosphors. Phosphorous are painted at the end of the CRT to reveal the path of the cathode rays.

Through this it was discovered that cathode rays travel in straight lines and have properties independent of the cathode material (whether it is gold, silver, ect.). Another significant property of cathode rays is that they are deflected by magnetic and electric fields in a manner that is identical to negatively charged material. Due to theses observations J.J. Thompson(1856-1940) concluded that cathode rays are negatively charged particles that are located in all atoms. It was George Stoney that first gave the term electrons to the cathode rays. The below figures depict the way that the cathode ray is effected by magnetics. The cathode ray will always be attracted by the postive magnetic and deflected by the negative magnets.

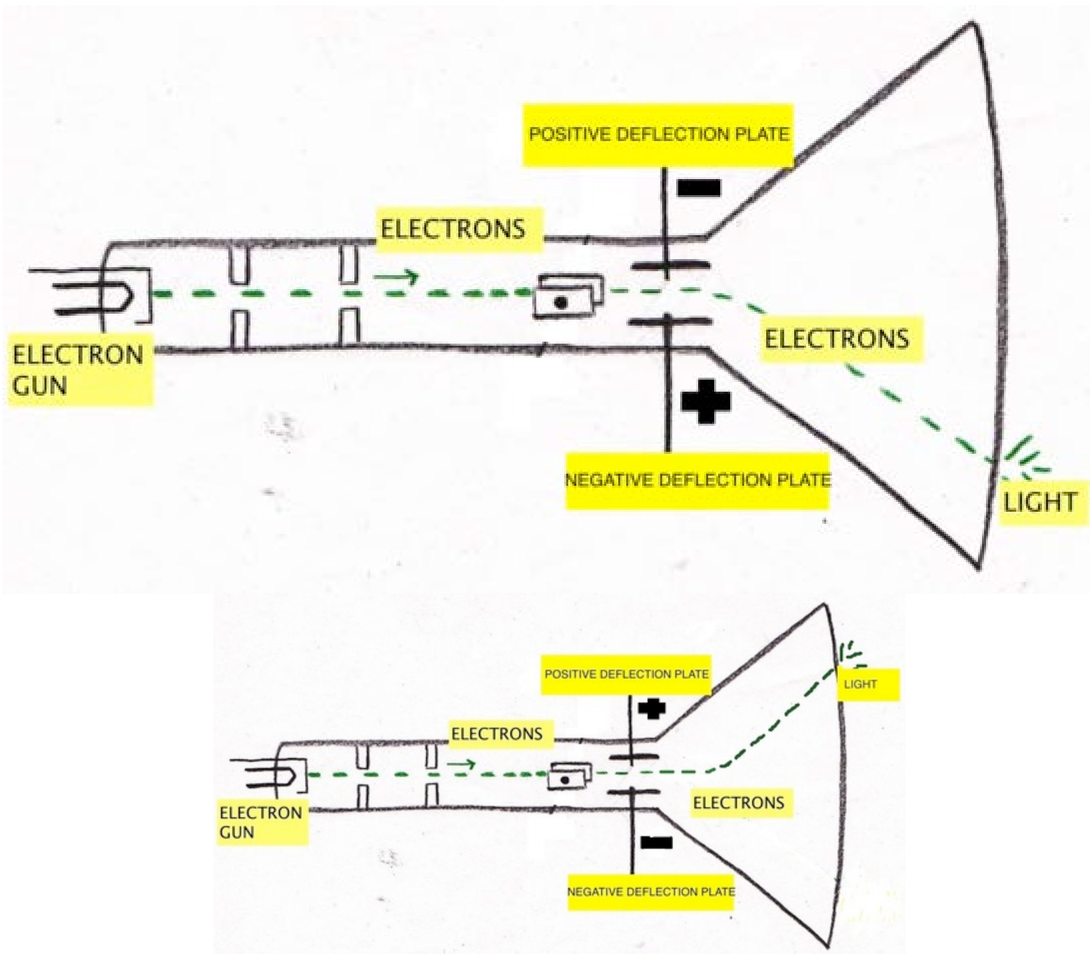


Figure 7 and 8:

The Plum Pudding Model

After Thomson's discovery of the electron, Thompson proposed the plum pudding model of an atom that stated that the electrons float in material that is positively charged. This model was named after the plum-pudding dessert.

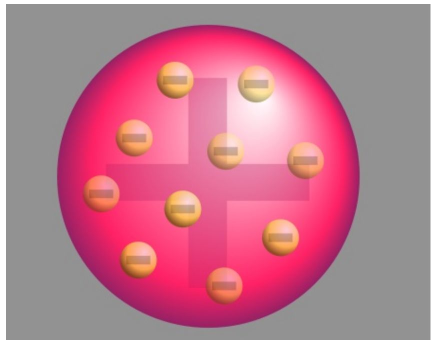


Figure 9: Provided courtesy of the Wikipedia Commons

Discovery of the Proton

In 1909, Ernest Rutherford (1871-1937) performed a series of experiment studying the inner structure of atoms. Using the plum-pudding model for reference, Rutherford predicted that particles in an alpha beam would pass through matter unaffected with a tiny amount of particles slightly deflected. The particles would only be deflected if they happen to come into contact with electrons. According to the plum pudding model, this occurrence would be very unlikely. In order to test his hypothesis, Rutherford shot a beam of alpha particles at a thin foil of gold. Around the gold foil Rutherford placed sheets of zinc sulfide. These sheets produced a flash of light when struck by an alpha particle. However, this experiment produced results that contradicted Rutherford's hypothesis. Rutherford observed that a great majority of the alpha particles went through the foil, some particles were slightly deflected,a small amount were greatly deflected, and another small amount were thrown back in the same direction that they had came. Figure 10 shows Rutherford's prediction based off of the plum-pudding model (pink) and the observations he observed of the large deflections of the alpha particles (gold).

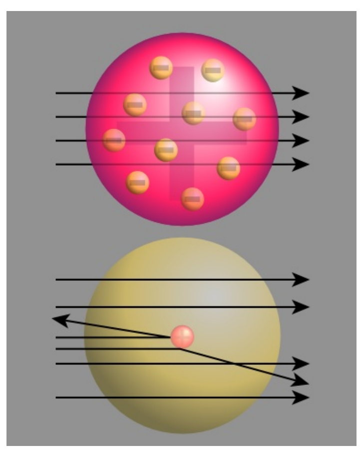
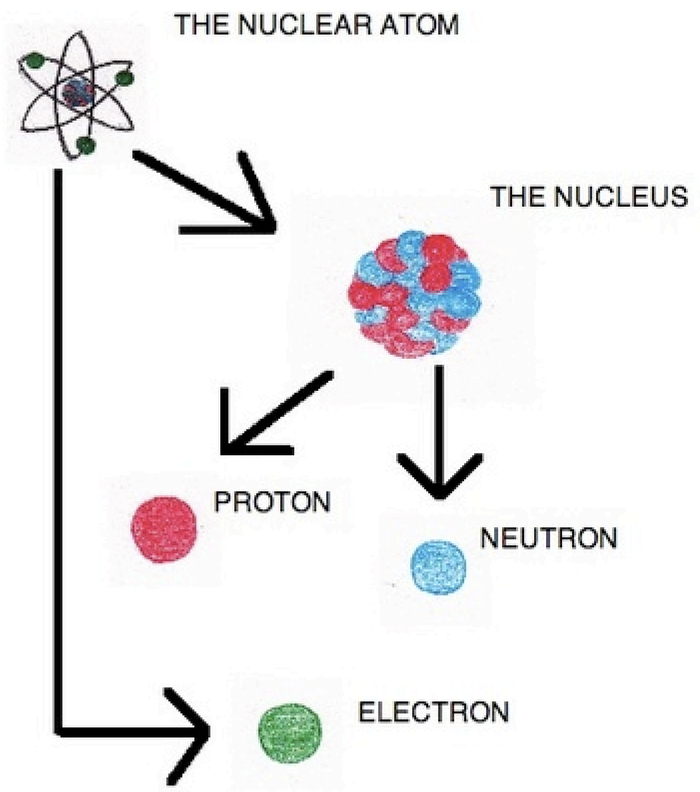


Figure 10: Provided courtesy of the Wikipedia Commons

To account for these observations Rutherford came up with a model called the nuclear atom. In this model the positive charge is held in the nucleus, located in the middle of the atom. Outside of the nucleus the atom is largely composed of empty space. This model stated that there was positive particles within the nucleus but failed to define what these particles were. It was Rutherford that discovered these particles in 1919. Rutherford conducted an experiment that scattered alpha particles against nitrogen atoms. When the alpha particles and nitrogen atoms collided protons were released.

The Discovery of the Neutron

In 1933, James Chadwick (1891-1974) discovered a new type of radiation that consisted of **neutral** particles. It was discovered that these neutral atoms came from the nuclei of the atom. This last discovery completed the atomic model.



Source: http://chemwiki.ucdavis.edu/Physical_Chemistry/Atomic_Theory/Atomic_Theory