Atomic model

History of the Atomic Model

The atomic model is not a concrete, one-hundred percent accurate depiction of the atom or description of what the atom is like. We can't base our model on actual observations of atoms, because they are too small to be seen with our most sensitive instruments. Instead, we must come up with a model of an atom that can account for and explain observations that we can actually see. As new observations are made over time, by scientists Democritus, Dalton, Thomson, Rutherford and Bohr, the model of the atom has evolved over time.

Democritus is credited with coming up with the term atom in 400 BC. He wanted to know what would happen if you kept breaking down something into smaller and smaller pieces. Could you keep breaking it down into smaller and smaller pieces? Democritus determined that if you kept breaking down the object, you would get it to a size that could no longer be broken. This was called the indivisible piece by the Greeks. In Greek, " atomos" meant indivisible. Thus, the indivisible piece became termed " the atom" for short (CompSoc). In the late 1700s, multiple scientists studied reactions and conducted controlled experiments, leading to new ideas that set the foundation for the development of more accurate atomic theories and models

In the early 1800s, John Dalton, an observer of weather and discoverer verify of the Law of Conservation of Mass among other things, was one of those scientists who performed controlled experiments and came up with a different atomic theory. He proved that matter cannot be created or destroyed by ordinary chemical or physical reactions and devised a conjecture in an attempt to explain how and why elements would combine with one another in fixed ratios and sometimes also in multiples of those ratios. He noted that oxygen and carbon combined to make two compounds. He discovered that for the same amount of carbon, one had exactly twice as much oxygen as the other (De Leon, N). This led him to propose the Law of Multiple Proportions, which states that when two or more elements form more than one compound, the ratio of the weights of one element that combine with a given weight of another element in the different compounds is a ratio of small whole numbers. For example, C and O can form both CO and CO2. The Law of Multiple Proportions can be regarded as an extension of the early Law of Definite Proportions, which states that the proportions by weight of the elements present in any pure compound are always the same. For example, NaCl will always be 39. 3 percent Sodium and 60.! Percent Chlorine.

His atomic theory, stated that elements consisted of tiny particles called atoms. He said that the reason an element is pure is because all atoms of an element were identical and that in particular they had the same mass. He also said that the reason elements differed from one another was that atoms of each element were different from one another; in particular, they had different masses (De Leon, N). This finding, however, was later proved wrong by further studies that demonstrated how atoms of the same element could differ: atoms could be either isotopes or ions. He also said that compounds consisted of atoms of different elements combined together in whole number ratios. Compounds are pure substances because the atoms of different elements are bonded to one another somehow, perhaps by hooks, and are not easily separated from one another. In fact, he stated that atoms cannot be subdivided, created or destroyed. Later experiments however, also proved this finding wrong in that nuclear reactions can split an atom. Compounds have constant composition because they contain a fixed ratio of atoms and each atom has its own characteristic weight, thus fixing the weight ratio of one element to the other. In addition he said that chemical reactions involved the combination, separation and rearrangement of combinations of those atoms (Doblecki). In other words, Dalton's model was that the atoms were tiny, indivisible, indestructible particles and that each one had a certain mass, size, and chemical behavior that was determined by what kind of element they were

Dalton did not convince everyone right away, however. Although a number of chemists were quickly convinced of the truth of the theory, JJ Thomson believed otherwise. In 1897, he accidentally discovered the electron through a series of experiments designed to study the nature of electric discharge in a high-vacuum cathode-ray tube—an area being investigated by numerous scientists at the time.

Thomson had an inkling that the ' rays' emitted from the electron gun were inseparable from the latent charge, and decided to try and prove this by using a magnetic field. His first experiment was to build a cathode ray tube with a metal cylinder on the end. This cylinder had two slits in it, leading to electrometers, which could measure small electric charges. He found that by applying a magnetic field across the tube, there was no activity recorded by the electrometers and so the charge had been bent away by the magnet.

This proved that the negative charge and the ray were inseparable and intertwined (Encyclopedia Britannica)

He did not stop there, and developed a second stage to the experiment, to prove that the rays carried a negative charge. To prove this hypothesis, he attempted to deflect them with an electric field. Earlier experiments had failed to back this up, but Thomson thought that the vacuum in the tube was not good enough, and found ways to greatly improve the quality. For this, he constructed a slightly different cathode ray tube, with a fluorescent coating at one end and a near perfect vacuum. Halfway down the tube were two electric plates, producing a positive anode and a negative cathode, which he hoped would deflect the rays. As he expected, the rays were deflected by the electric charge, proving beyond doubt that the rays were made up of charged particles carrying a negative charge (Doblecki). He discovered the electron!

In his third experiment, he used scientific deduction by performing a series of interconnected experiments, gradually accumulating data and proving a hypothesis. He decided to try to work out the nature of the particles. They were too small to have their mass or charge calculated directly, but he attempted to deduce this from how much the particles were bent by electrical currents, of varying strengths. Thomson found out that the mass to charge ratio was so high that the particles either carried a huge charge, or were a thousand time smaller than a hydrogen ion. He decided upon the latter and came up with the idea that the cathode rays were made of particles that emanated from with the atoms themselves.

Thomson took the idea of the atom and tried to incorporate the evidence for the electron. In the diagram on the right, the electrons are the small things and the rest of the stuff is some positive matter. This is commonly called the plum pudding model because the electrons are like things in positive pudding. The plums were negative because cathode rays deflected towards the positive end. The pudding was defined by Thomson as the empty space that surrounded electrons because the overall charge of the atom had to be neutral, so he deductively reasoned that this space had to be positive

In 1911, Ernest Rutherford, under the theory that atoms are uniform in structure, said “ hey, I think I will shoot some stuff at atoms.” So he did. He fired radioactive particles through minutely thin metal foils (notably gold) and detected them using screens coated with zinc sulfide (a scintillator). He thought to himself, “ If you shoot these positive alpha particles at this positive pudding atom, they should mostly bounce off, right?” Well, that is not what happened. Although some of them did bounce back, Rutherford found that most of the alpha particles— one in eight-thousand— went right through the foil (Chemical Heritage Foundation). He said, “ It was as if you fired a 15 inch artillery shell at a piece of tissue paper and it bounced back and hit you”. His experiment became famously known as the gold foil experiment. How could that be if the plumb pudding model was correct? Rutherford’s experiment prompted a change in the atomic model. After two years of contemplating the results of his experiment, he came up with a new atomic theory. His atomic theory described the atom as having a densely packed central positive nucleus surrounded by negative orbiting electrons (Chemical Heritage Foundation). He concluded that the center repelled the electrons. This model suggested that most of the mass of the atom was contained in the small nucleus, and that the rest of the atom was mostly empty space (Doblecki).

Niels Bohr proposed yet another atomic model in 1915, which was a simplified picture of an atom known as the Bohr Model that stemmed from previous studies by Max Planck and Albert Einstein. Max Planck presented a theoretical explanation of the spectrum of radiation emitted by an object that glows when heated. He argued that the walls of a glowing solid could be imagined to contain a series of resonators that oscillated at different frequencies. These resonators gain energy in the form of heat from the walls of the object and lose energy in the form of electromagnetic radiation (Doblecki). The energy of these resonators at any moment is proportional to the frequency with which they oscillate . Albert Einstein extended Planck's work to the light that had been emitted. Einstein suggested that light behaved as if it was a stream of small bundles, or packets, of energy (MacTutor). In other words, light was quantized, or countable

Bohr then took Planck's and Einstein's findings on energy and developed an atomic theory that is similar to quantum mechanics, the correct theory of the atom, but is much simpler. In the Bohr Model the neutrons and protons, symbolized by red and blue balls, occupy a dense central region called the nucleus, and the electrons orbit the nucleus much like planets orbiting the Sun. He found that electrons travel in stationary orbits defined by their angular momentum. This led to the calculation of possible energy levels for these orbits and the postulation that the emission of light occurs when an electron moves into a lower energy orbit (MacTutor). Calculations based on

Bohr's model determined that the shapes of the orbitals of the electrons vary according to the energy state of the electron. Bohr discovered that different electrons have different energies. The lowest energy state is generally termed the ground state. The states with successively more energy than the ground state are called the first excited state, the second excited state, and so on. Then, when an electron moves back to its normal energy level, it releases electromagnetic energy

Finally, we have reached the electron cloud model, which the current atomic model used today in scientific, educational and research settings. The electron cloud model is a model of the atom where the electrons are no longer depicted as particles moving around the nucleus in a fixed manner, like in the Thomson, Rutherford and Bohr models. Instead, the electron cloud model does not illustrate exactly where electrons are—their probable location can only be described as around the nucleus only as an arbitrary ' cloud' (Science Encyclopedia). The nucleus contains both protons and neutrons, while the electrons float about outside of the nucleus. Within the nucleus, the probability of finding an electrons is . 00, but within the electron cloud there is a high probability of finding electrons

As I stated earlier, however, the atomic model is not a concrete, one-hundred percent accurate depiction of the atom or description of what the atom is like. We cannot base our model on actual observations of atoms, because they are too small to be seen even with our most sensitive instruments. Thus, this current atomic model is most likely to change in the future, as technology advances and scientists continue in-depth research and experimentation. Most likely, students' papers a few years from now will need to be twelve pages instead of six to outline the history of the ever-changing atomic model.