ATOMIC MODELS

What is an atom?

Atoms are the basic units of matter and the defining structure of elements. The term "atom" comes from the Greek word for indivisible, because it was once thought that atoms were the smallest things in the universe and could not be divided. We now know that atoms are made up of three particles: Protons, neutrons and electrons.

How were these three particles found?

Protons and neutrons are heavier than electrons and reside in the nucleus at the center of the atom. Electrons are extremely lightweight and exist in a cloud orbiting the nucleus. The electron cloud has a radius 10,000 times greater than the nucleus. Protons and neutrons have approximately the same mass. However, one proton weighs more than 1,800 electrons. Atoms always have an equal number of protons and electrons, and the number of protons and neutrons is usually the same as well. Adding a proton to an atom makes a new element, while adding a neutron makes an isotope, or heavier version, of that atom.

There are several theories to understand the structure of the atom:

1. *Dalton atomic theory*
2. *Thomson atomic model*
3. *Rutherford atomic model*
4. *Bohr atomic model*
5. *Quantum atomic model*
6. *Vector model of atom*

DALTON ATOMIC THEORY

1. *Each compound is composed of atoms.*
2. *The atom combines in certain proportions to form molecules.*
3. *All atoms of a certain element are identical and have the same shape, size and mass.*
4. *Atom cannot be destroyed and created.*

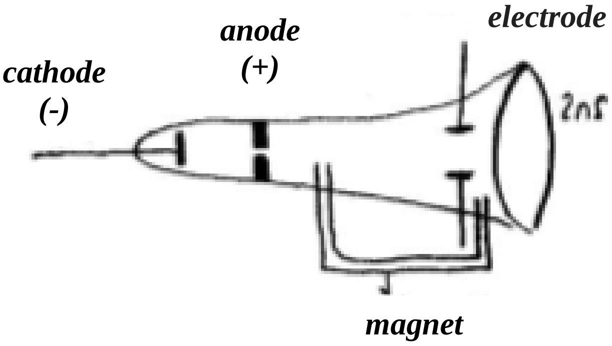
These substances have changed over time. The third one lost its validity with the discovery of the isotope and the forth one lost also its validity with the atomic disintegration. Dalton atomic theory is not a model. John Dalton, a British chemist, had ideas about the atom. Each element has its own atoms. Atoms are protected in chemical reactions and the compounds are formed by the incorporation of elements.

THOMSON ATOMIC MODEL

Thomson, the British physicist who discovered the electron, in 1897 argued that the electrons formed by passing a high electrical potential through a gas were present in the atom. The electron model for the first time in the atom was used by Thomson. Thomson defined the atom as a sphere system in which (+) charges and (-) charges balance each other. Thomson proposed a model where the (+) charge within an atom is uniformly distributed within a sphere of appropriate size, with the electrons somehow localized within this volume; this is the so-called "plum-pudding" model. He also likened the atom to watermelon or grape cake. The grapes or cores represent the (-) charge, while the fleshy part or the dough part represents (+) charge. The structure of the atom is not really exactly this way. He said that there were electrons (or - charges) in the atom and that there is enough charge to balance the electrons. Thomson theorized that when the atom is heated up the electrons are randomly accelerated and responsible for the emission of radiation. The electrons' lower mass implied that their motion would be more important than the heavier (+) charges.

What did make Thomson?

He was able to determine the existence of the negatively charged particles by studying properties of electric discharge in cathode-ray tubes.



Electron spread from the cathode. These electrons emitted were accelerated to the right in an air evacuated or vacuum tube. Some of these accelerated electrons shined on the ZnS by passing through the hole on the electrode (anode) and falling on the ZnS. When a magnet is placed under and above the tube, electrons are deviated from the magnetic field, which proved that there is something that was negatively charged within the vacuum tube.

Thomson found e/m for an electron in1897 e/m=-1.7589.10^{11} C.kg^{-1}.
Thomson found e/m_p for a proton in 1906 e/m_p=9.5791.10^{7} C.kg^{-1}.

$$F = H.q_E.V \qquad F = \frac{mV^2}{r} \Rightarrow \frac{q_E}{m} = \frac{V}{H.r}$$

$$F_{my} = F_{el} \Rightarrow H q_E V = E.q_E \Rightarrow V = \frac{E}{H} \qquad \frac{q_E}{m} = \frac{E}{H^2.r}$$

H: *Magnetic field*

V: *Speed*

q_E: *Charge of the electron*

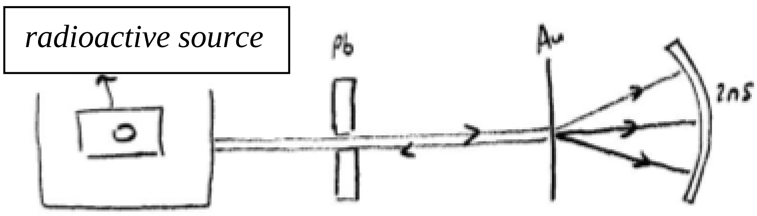
m: *Mass of electron*

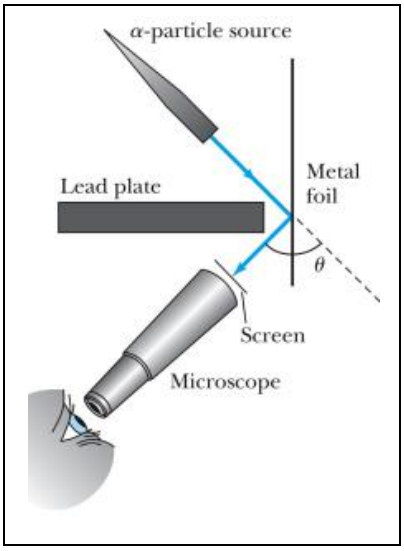
r: *Distance*

In 1909, Milikan found the charge of the electron to be e = -1.6.10^{-19} C with the famous oil drop experiment. In other words, Milikan calculated e and m separately in the e/m ratio found by Thomson.

RUTHERFORD ATOMIC MODEL

The next scientist to further modify and progress the atomic model was Rutherford, who studied under Thomson. Rutherford objected to Thomson atomic model and Rutherford is exploring the core. In 1911, Rutherford conducted the α-scattering experiment to determine if the Thomson atomic model was correct. In this experiment, Rutherford sent high-energy α-rays (helium core $^{4}_{2}He^{2+}$) onto a very thin (~10^{-4} cm) sheets of gold (An alpha particle is made up of two protons and two neutrons, all held together by the same strong nuclear force that binds the nucleus of any atom). If the Thomson model was true, the high energy α-particles would pass the gold plate without deviating from their paths. However, in the experiment, it was observed that the α-particles deviated from the path and some of them returned. Upon this observation, Rutherford thought that the atom was composed of a heavily (+) charged nucleus and a number of electrons which are around the nucleus and can neutralize the nucleus. That is, atom includes a positively charged nucleus that is orbited by electrons. There are gaps in the atom since α-particles cross the gold plate. α-Particles return when they encounter the nucleus of the atom. α-Particles are scattered to the original direction of motion when they encounter the electrons in the atom. The Rutherford atomic model is called the solar system model. The neutron prevents that the (+) charges in the nucleus repulses each other.





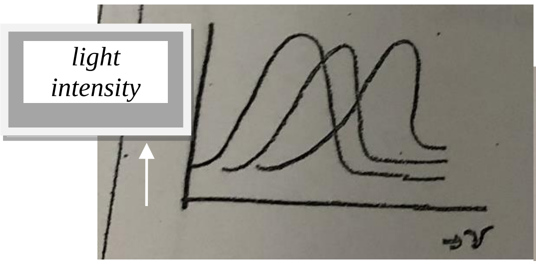
Rutherford was able to find approximate the size of the nucleus of the gold atom to be at least 10,000 times smaller than the size of the entire atom with much of the atom being empty space. Rutherford's model of the atom is still the basic model that is used today, despite its limitations.

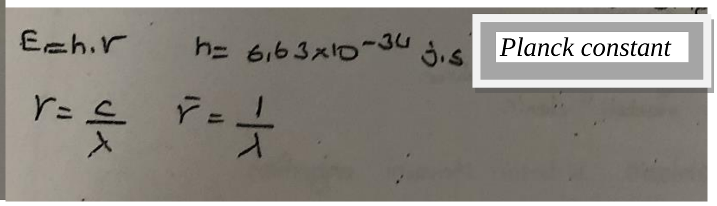
Black Body Radiation

The inside and outside of a sphere were covered with black carbon and a small hole was drilled. When this sphere was heated to 1000-2000 °C, light is emitted from that hole. Plank made the most comments about this issue.

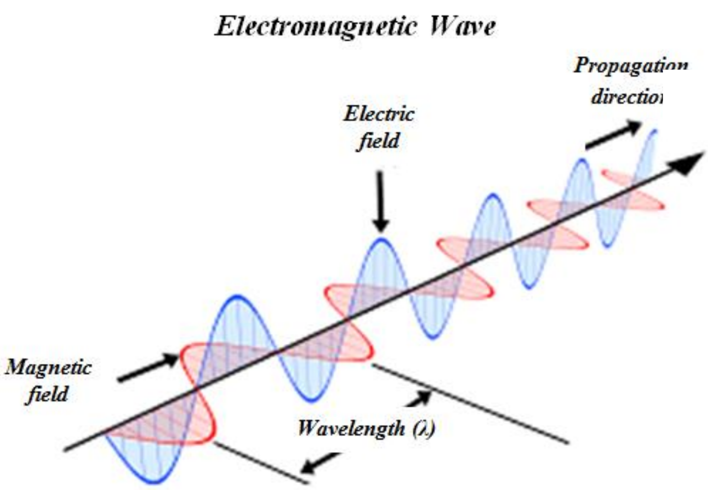
E=n.h.γ

Planck said energy is not continuous like a substance. The formula E=h.γ has emerged.

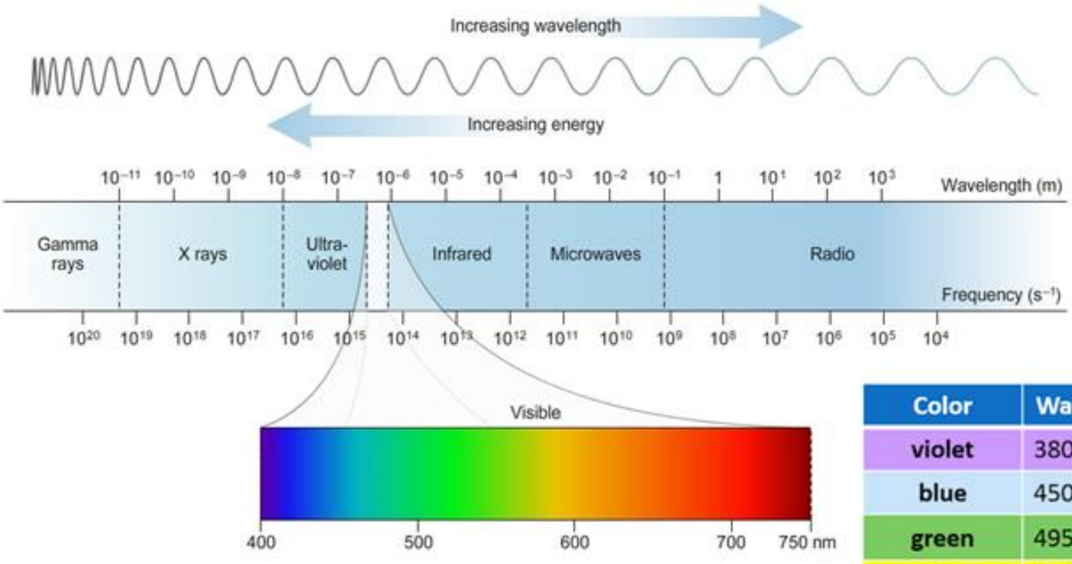




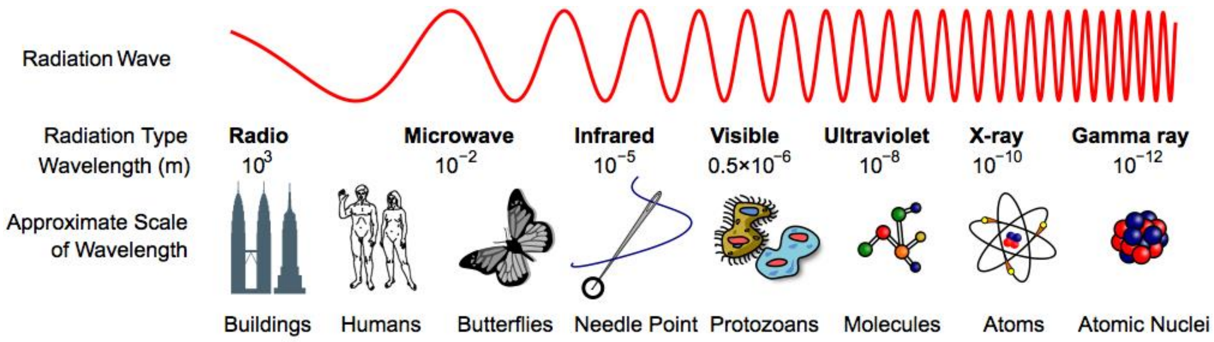
Electromagnetic Spectrum



*A **wavelength** is a measure of distance between two identical peaks (high points) or troughs (low points) in a wave.*



Color	Wavelength
violet	380–450 nm
blue	450–495 nm
green	495–570 nm
yellow	570–590 nm
orange	590–620 nm
red	620–750 nm



used to broadcast radio and television

used in cooking, radar, telephone and other signal

transmits heat from sun, fires, radiators

makes things able to be seen

absorbed by the skin, used in flurescent tubes

used to view inside of bodies and objects

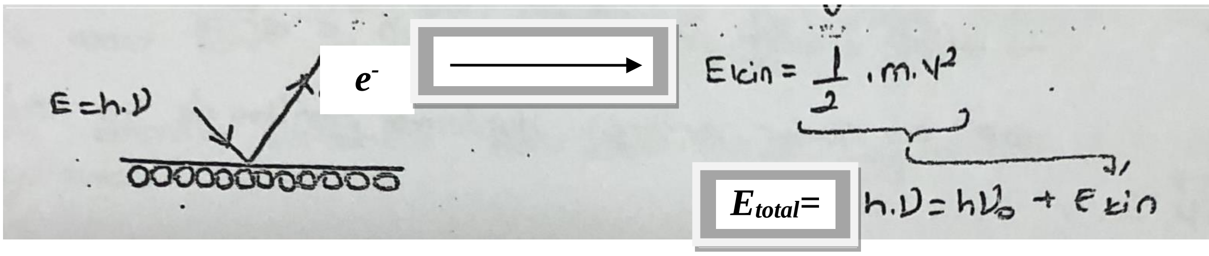
used in medicine for killing

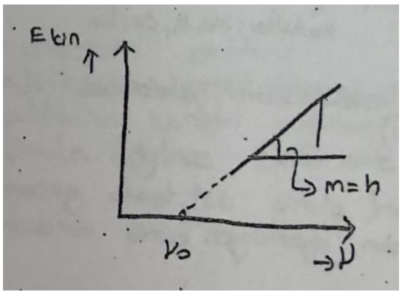
The Photoelectric Effect

When photons are sent to the surface of the metals, the ejection of electrons from the metal surface are called ''photoelectric effect''. The ray sent to the metal surface must be at a certain threshold frequency or at a higher frequency than this threshold frequency in order to breakout electrons from the metal.

The number of electrons emitted depends on the intensity, kinetic energy and thus the frequency of the ray used. Increasing the intensity of the ray increases, the number of electrons ejected increases but does not change their energies.

Einstein found the Planck constant ''h'' with a high degree of precision from the slope of the line obtained from his work on the photoelectric event. So, in 1923, he was awarded the Nobel Prize in Physics on the photoelectric event. Alkali metals show a strong photoelectric effect. Particularly, Cs emits electrons even with visible ray effect and so, it is used in photoelectric cells due to this feature. The photoelectric event proves the particle character of the electron.





$E_o = h.\nu_o$

E_o= *threshold energy;* ν_o= *threshold frequency*

The number of electrons released depends on the intensity of the incoming ray. The kinetic energy of the electron emitted depends on the frequency of the ray.