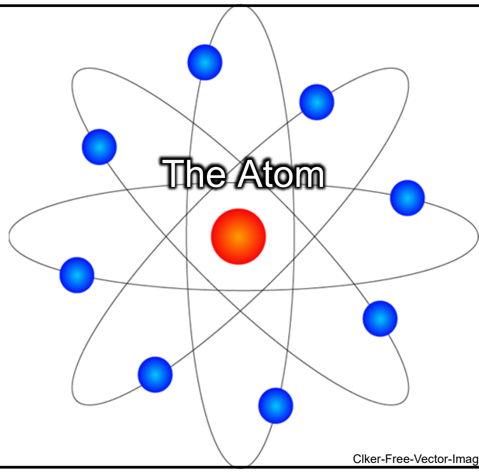
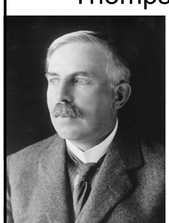


Clker-Free-Vector-Images (Pixabay)

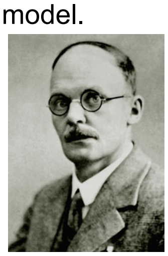
- 1904: J. J. Thompson (British) introduced the "plum pudding" model of the atom.
  - A spherical ball of positive charge, with negatively charged electrons scattered evenly throughout.

J. J. Thomson – unknown (Public Domain)

- 1909: Ernest Rutherford (English-New Zealand), Hans Geiger (German), Ernest Marsden (English-New Zealand) designed an experiment to test J. J. Thompson's model.



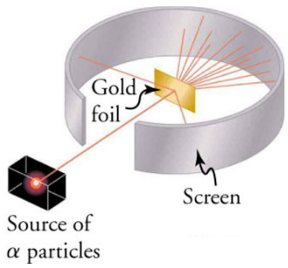
Ernest Rutherford – Bain News Service, Library of Congress Prints and Photographs Division, Digital ID ggbain.36570 (Public Domain)



Hans Geiger – unknown (Public Domain)

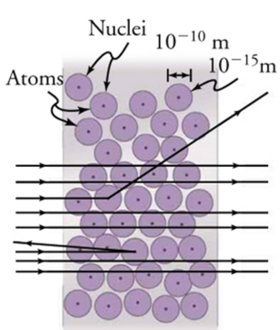
Ernest Marsden – S P Andrew Ltd (Public Domain)

- A beam of alpha particles was directed at a thin gold foil sheet.
- When the high-energy alpha particles passed through the gold foil, they were scattered.
- The scattering was observed from the bright spots they produced when they struck the phosphor screen.

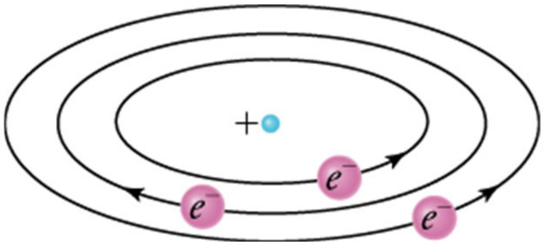


- The alpha particles should have passed through the thin foil.
  - Any deflection was expected to be minor, and due primarily to the electrostatic Coulomb force between the alpha particles and the foil's interior electric charges.
- However, while the majority of alpha particles passed through the foil unobstructed, occasionally some were scattered to large angles.
  - Some even came back in the direction from which they came.

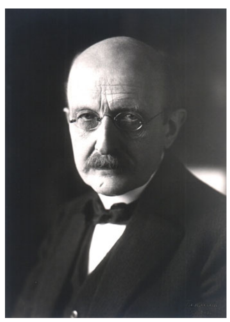
- The result, called Rutherford scattering, implied that the gold nuclei were actually very small when compared with the size of the gold atom.
  - 10^{-15} m



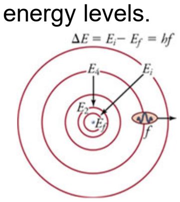
- This result led to Rutherford proposing a model of the atom that had the nucleus in the center and the electrons in orbits around it.

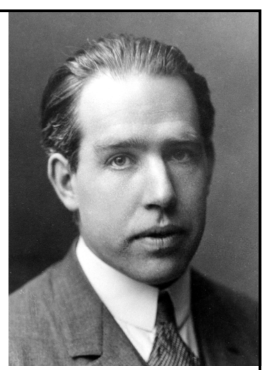


- 1900: Max Planck (German) recognized that all energy radiated from a source is emitted by atoms in quantum states.
  - Each element has a unique line spectrum.



- 1913: Niels Bohr (Danish) published his model of the atom combining the works of Planck and Rutherford.
  - The electrons orbited the nucleus in distinct energy levels.





- There are limits to Bohr's theory.
  - It does not work with atoms with more than one electron.
  - According to the theory of electromagnetism, an accelerated charge should radiate electromagnetic waves and thus lose energy.
    - Since the electrons are accelerating, they should lose energy and thus spiral into the nucleus.
  - It does not explain that some spectral lines are doublets or split into two when examined closely.

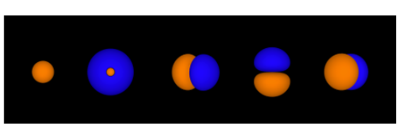
- 1924: Louis de Broglie (French) postulated the wave nature of electrons and suggested that all matter has wave properties.
  - The electron levels are quantized because of the electrons are behaving as waves.

Louis de Broglie – unknown (Public Domain)

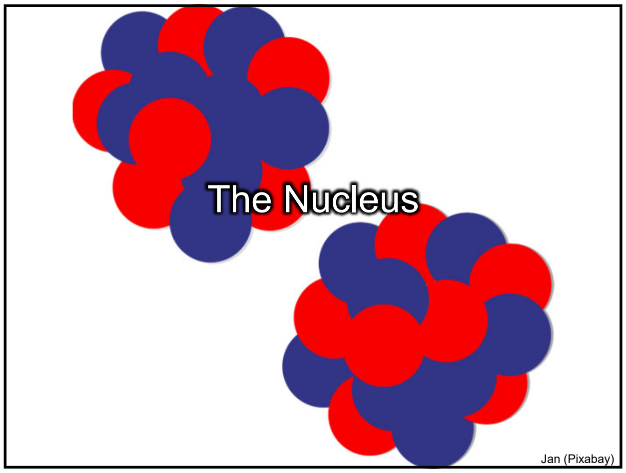
- 1926: Werner Heisenberg (German) and Erwin Schrödinger (Austrian) postulated that the electrons are in probability regions called orbitals.

Werner Heisenberg – German Federal Archive (CC BY-SA 3.0)

Erwin Schrodinger – Nobel Foundation (Public Domain)



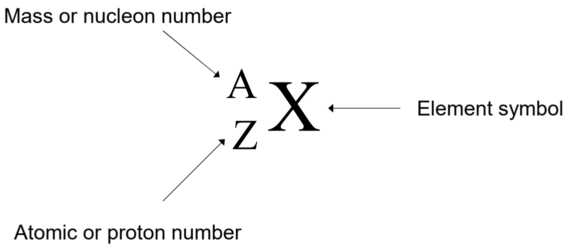
Orbitals – Rakudaniku (Public Domain)



- The particles that make up the nucleus of the atom are called **nucleons**.
  - protons and neutrons
- The **atomic number**, Z, represents the number of protons within a nucleus.
- The **mass number**, A, represents the total number of nucleons in an atom.
  - The mass number is used to differentiate between **isotopes** of an atom.

- The term **isotope** refers to the variation of atoms based upon the number of neutrons within their nucleus.
  - Most carbon atoms, for example, have 6 protons and 6 neutrons. However, some carbon atoms have 7 neutrons (carbon-13), and some have 8 (carbon-14).

- To more easily identify various atoms, their atomic number and mass number are typically written in a form of representation called the **nuclide**.



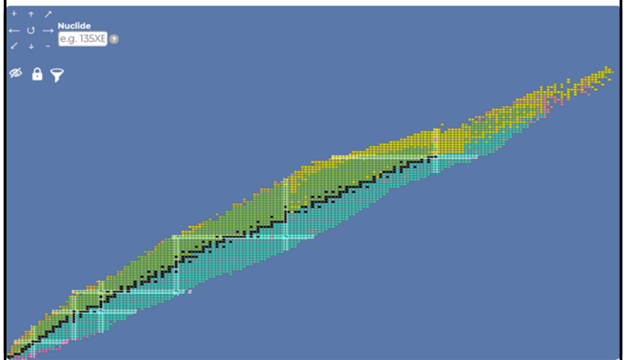
- Examples
  - $^{1}_{1}\mathrm{H}$ - Hydrogen (1 proton, 0 neutrons)
  - $^{2}_{1}\mathrm{H}$ - Deuterium (1 proton, 1 neutron)
  - $^{3}_{1}\mathrm{H}$ - Tritium (1 proton, 2 neutrons)

  - $^{238}_{92}\mathrm{U}$ - Uranium (92 protons, 146 neutrons)
  - $^{235}_{92}\mathrm{U}$ - Uranium (92 protons, 143 neutrons)

  - $^{39}_{19}\mathrm{K}$ - Potassium (19 protons, 20 neutrons)
  - $^{40}_{19}\mathrm{K}$ - Potassium (19 protons, 21 neutrons)

- There is some redundancy in the symbols A, X, Z, and N.
- Thus, the simpler notation for nuclides is ^{A}X, which is sufficient and is most used.
- For example, the three isotopes of hydrogen are ^{1}H, ^{2}H, and ^{3}H.

Chart of the Nuclides



https://www-nds.iaea.org/relnsd/vcharthtml/VChartHTML.html