

Atomic Structure

Textbook References:

- Addison-Wesley *Chemistry*, Chapter 4 *Atomic Structure*, and Chapter 11 *Electrons in Atoms*
- Merrill *Chemistry A Modern Course*, Chapter 7 *Atomic Structure*, and Chapter 8 *Electron Clouds and Probability*
- Heath *Chemistry: Experiments and Principles*, Chapter 8 *The Structure of the Atom*, and Chapter 9 *Models of Atomic Structure*

This unit begins by reviewing concepts covered in grades nine and ten science.

Greek Model - Fourth and Fifth Centuries BC

- The word **atom** is from the Greek word **atomos**, which means indivisible or uncut
- This was the original model of the atom
- It viewed the atom as the smallest indivisible particle of matter
- This theory was never verified by experiments and was discarded

Introductory/Review Assignment

1. Define the following terms:

a. atom

- An atom is the smallest particle of an element that retains all the properties of the element.
- the smallest portion into which an element can be divided and still retain its properties, made up of a dense, positively charged nucleus surrounded by a system of electrons.

b. electron

- a very small negatively charged particle found within the atom, outside of the nucleus

c. proton

- small, stable positively charged particle found within the nucleus of an atom

d. neutron

- small particle, with no electrical charge, found within the nucleus of an atom

e. nucleus

- the central region of an atom
- a very small, dense region where all of the positive charge and most of the mass is located in an atom

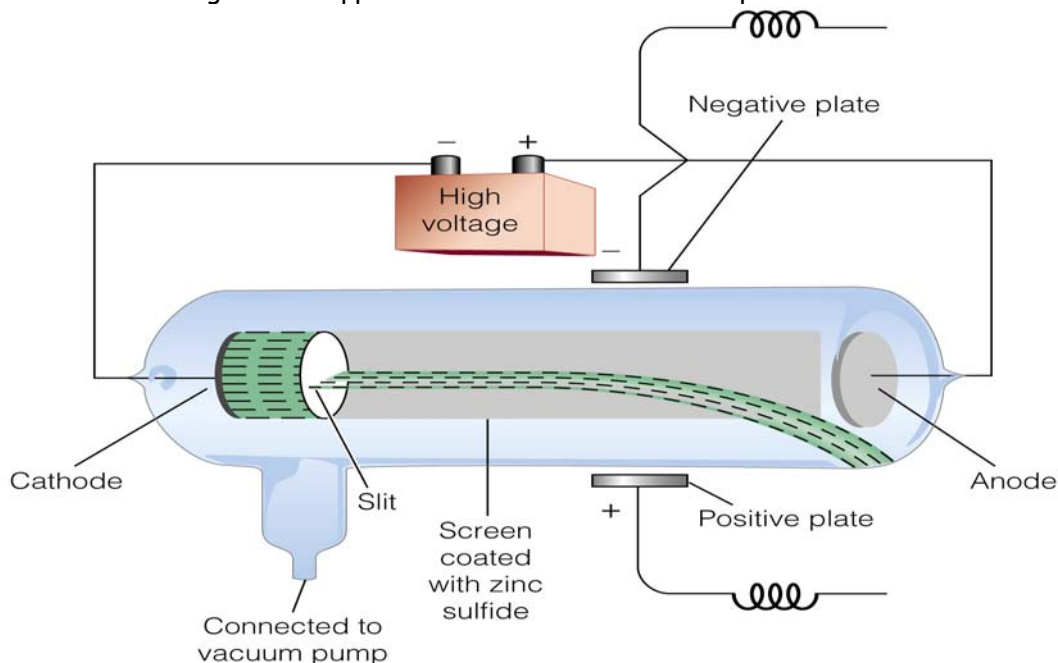
- f. nucleon
 - a proton or neutron
 - a particle found within the nucleus
 - g. isotope
 - atoms of the same element that have the same atomic number (protons) but a different atomic mass due to different number of neutrons
 - h. average atomic mass
 - the weighted average of all naturally occurring isotopes of an element based on their relative abundance on earth
 - i. mass number
 - the total number of protons and neutrons within an atom
 - j. atomic number
 - the number of protons in the nucleus of an atom of an element. The atomic number of all the isotopes of an element is the same and determines that element's position in the periodic table.
 - k. ion
 - an electrically charged atom, or group of atoms
 - an atom or group of atoms that has acquired an electric charge by losing or gaining one or more electrons
2. Dalton's Atomic Theory - John Dalton (1766-1844)
- a. State the main ideas of Dalton's Atomic Theory (4)
 1. All elements are composed of tiny indivisible particles called atoms.
 2. Atoms of the same element are identical. The atoms of any one element are different from those of any other element.
 3. Atoms of different elements can combine with another in simple whole number ratios to form compounds.
 4. Chemical reactions occur when atoms are separated, joined, or rearranged. However, atoms of one element cannot be changed into atoms of another element by a chemical reaction.

b. Which parts of Dalton's theory are still considered to be true?

2. The atoms of any one element are different from those of any other element.
3. Atoms of different elements can combine with another in simple whole number ratios to form compounds.
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c. Which parts of Dalton's theory are no longer believed to be true? Explain why.

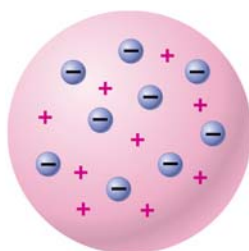
1. All elements are composed of tiny indivisible particles called atoms.
 - We now know that atoms are divisible, there are particles found within the atom: protons, neutrons, and electrons.
 2. Atoms of the same element are identical.
 - Isotopes are atoms of the same element that have different mass numbers because of different numbers of neutrons, therefore, all atoms of the same element are NOT identical.
3. Thomson's Model of the Atom - Joseph John Thomson (1856 - 1940)
- a. Describe and diagram the apparatus Thomson used in his experiments



- b. What did Thomson conclude about electrons?

Thomson determined that electrons were a fundamental particle of matter, that all electrons were identical regardless of the element, and that they carry a negative charge.

- c. Briefly describe Thomson's model of the atom.

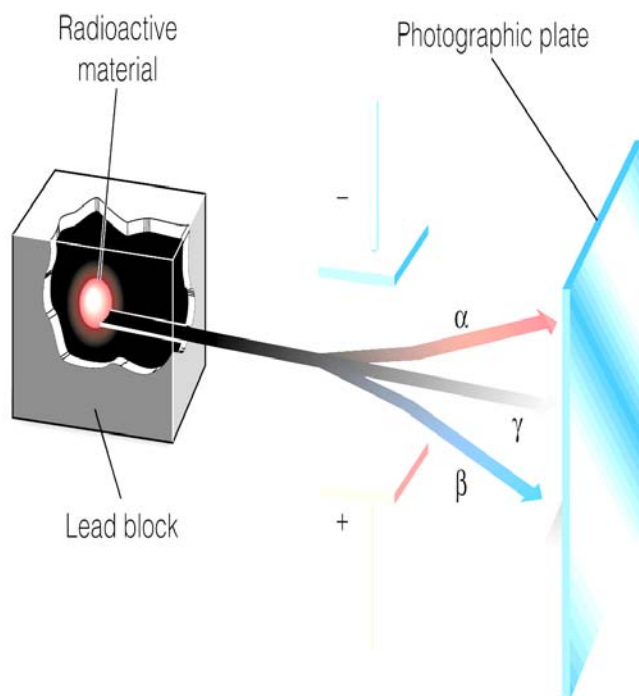


Thomson viewed the atom as a sphere of uniform positive charge with negative electrons embedded throughout.

4. Rutherford's Model of the Atom - Ernest Rutherford (1871 - 1937)
a. Who discovered radioactivity?

In 1896 Henri Becquerel discovered radioactivity.

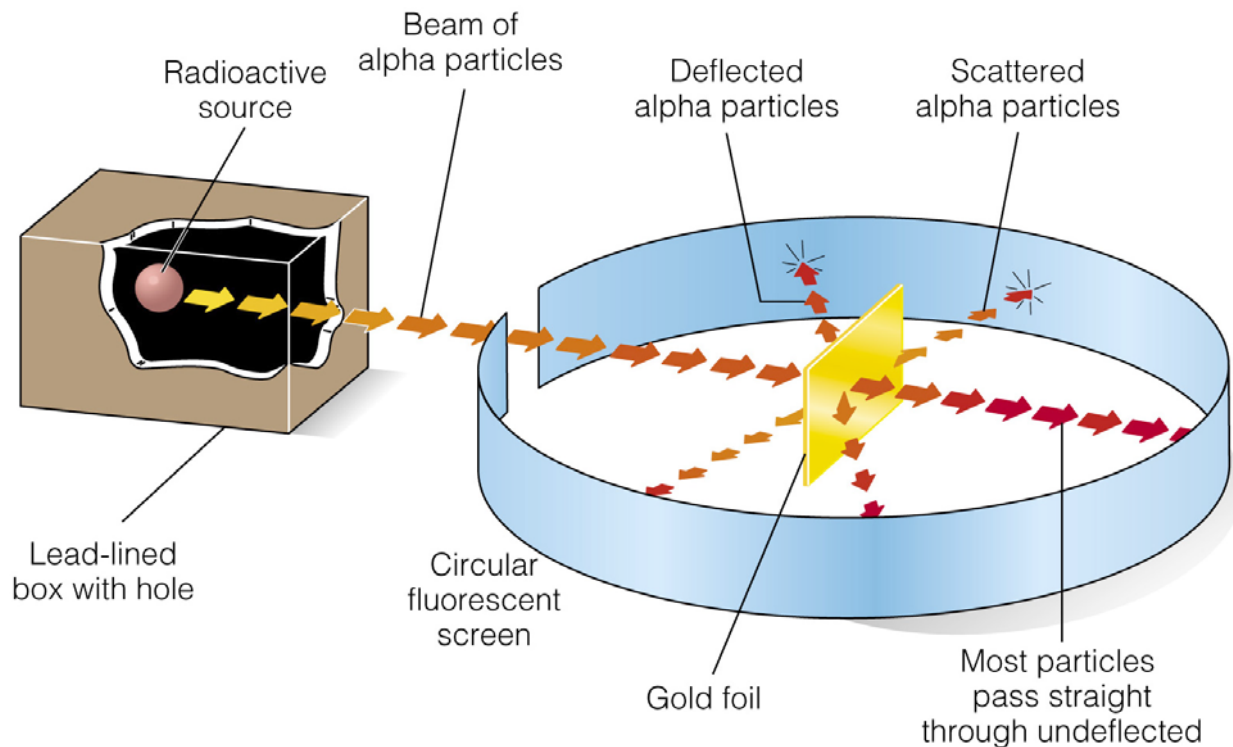
- b. What are alpha, beta, and gamma rays?



Working with radium (a radioactive element) Rutherford discovered that the invisible rays were actually composed of three different rays: alpha (positively charged), beta (negatively charged), and gamma (uncharged) rays.

- c. Diagram and describe the Gold Foil Experiment.

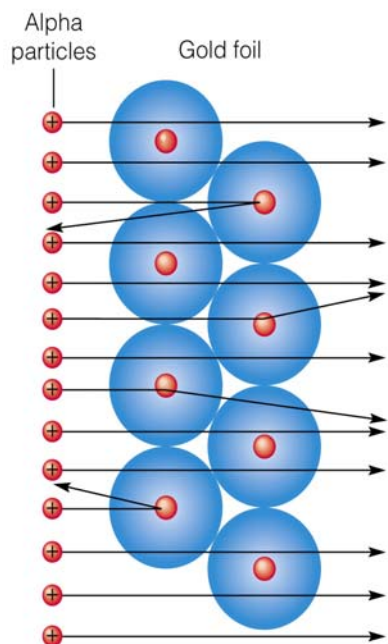
Using alpha particles, Rutherford investigated the scattering of these particles by thin sheets of gold foil.



- d. What were the expected results of the Gold Foil Experiment, and how did the actual results differ from expected?

Rutherford expected all of the alpha particles to go straight through the gold foil without any change in direction. This is not what occurred. Most of the alpha particles did not have any change in direction, but some were deflected and some were reflected.

- e. How did Rutherford account for these unexpected results, i.e., explain how Rutherford used these results to design his own model of the atom.



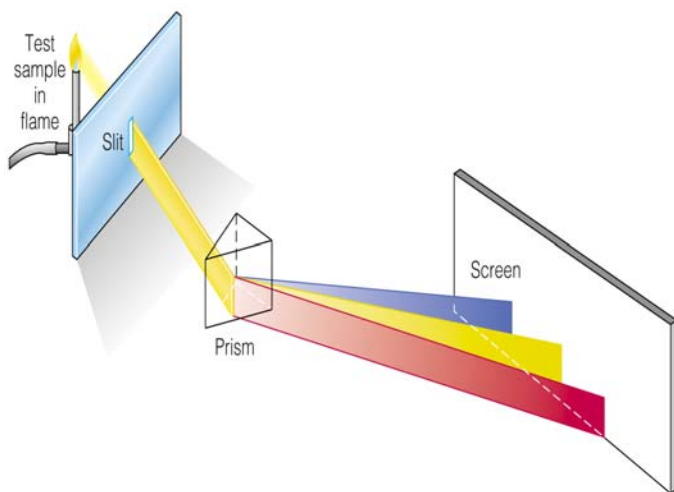
Rutherford assumed that there must be something within the atom, which caused the alpha particles to be deflected or reflected. Rutherford suggested that an atom had a **nucleus** or centre in which the positive charge and most of the mass were located. This nucleus occupied only a tiny portion of the volume of the entire atom. The electrons were located outside the nucleus. This model of the atom is often called the "nuclear" atom.

- f. What parts of Thomson's model of the atom are still retained?

The negatively charged electrons are still part of the Rutherford model of the atom. Their location has changed.

5. The Bohr Model of the Atom - Niels Bohr (1885 - 1962)

- a. What types of experiments did Bohr perform with hydrogen? What were the results of these experiments?



Bohr investigated the spectra of hydrogen. He determined that hydrogen produced a line spectra with four distinct lines in the visible spectrum.

- b. What does the term *quantized (quantum)* mean?

A quantum is a unit of electromagnetic energy. If something is quantized, then it can only gain or lose energy in discrete unit of energy.

- c. What is an energy level?

An energy level is a region around the nucleus of an atom where an electron is in motion.

- d. How did Bohr relate the results of these experiments to a model of the atom?

Because hydrogen produced line spectra, Bohr explained that the energy of these lines corresponded to the energies released when an electron at a higher energy level returned to a lower energy level. The difference in energy between two energy levels was emitted as electromagnetic radiation with a specific wavelength.

- e. What parts of Rutherford's model of the atom are still retained?

The central nucleus, with electrons in motion around the nucleus, is still retained in the Bohr model of the atom. Bohr provided more information about the motion of the electrons.