learning_objectives

• To become familiar with the components and structure of the atom.

To date, about 115 different elements have been discovered; each is chemically unique. That means that they behave differently in forming molecules and reacting with other elements and molecules. To understand why they are unique, you need to understand the structure of the atom (the fundamental, individual particle of an element) and the characteristics of these components.

Atoms consist of electrons, a light, subatomic particle with a negative charge that resides around the nucleus of all atoms protons and neutrons. This is an oversimplification that ignores the other subatomic particles that have been discovered, but it is sufficient for our discussion of chemical principles. Some properties of these subatomic particles are summarized in Table 1.1.1, which illustrates three important points.

1. Electrons and protons have electrical charges that are identical in magnitude but opposite in sign. No particle with any fractional charge has ever been discovered although many have tried. For historical reasons having to do with the earliest studies of electricity we assign charges of −1 and +1 to the electron and proton, respectively.

2. Neutrons have approximately the same mass as protons but no charge. They are electrically neutral.

3. The mass of a proton or a neutron is about 1836 times greater than the mass of an electron. Protons and neutrons constitute by far the bulk of the mass of atoms.

The discovery of the electron and the proton was crucial to the development of the modern model of the atom. This will be discussed in our General Physics course.

Table 1.1.1 Properties of Subatomic Particles*
The Atomic Model

Ernest Rutherford proved that all of the positive charge and almost all of the mass each atom was found in a small core, called the nucleus. Although Rutherford could not explain why repulsion between the positive charges in nuclei that contained more than one positive charge did not cause the nucleus to disintegrate, he reasoned that repulsion between the positively charged nucleus and the negatively charged electrons would cause the electrons to be distributed throughout the atom’s volume. Today we know that strong nuclear forces, which are much stronger than electrostatic interactions, hold the protons and the neutrons together in the nucleus. For this and other insights, Rutherford was awarded the Nobel Prize in Chemistry in 1908.

Subsequently, Rutherford established that the nucleus of the hydrogen atom was a positively charged particle, for which he coined the name proton in 1920. He also suggested that the nuclei of elements other than hydrogen must contain electrically neutral particles with approximately the same mass as the proton. The neutron, however, was not discovered until 1932, when James Chadwick (1891–1974, a student of Rutherford discovered it. For this he won the Nobel Prize in Physics in 1935.

Rutherford's model of the atom is essentially the same as the modern one, except that we now know that electrons are not uniformly distributed throughout an atom's volume. Instead, they are distributed according to a set of principles described in Chapter 2.

A more detailed discussion of how the atomic model was established can be found in the companion textbook at Howard University. In 1913 Nels Bohr created a simple model of Rutherford's hydrogen atom. You can follow his work in this LibreTexts book and read more about it in this other LibreTexts book.

Summary

Atoms, the smallest particles of an element that exhibit the properties of that element, consist of negatively charged electrons around a central nucleus composed of more massive positively charged protons and electrically neutral neutrons. Radioactivity is the emission of energetic particles and rays (radiation) by some substances.

Key Takeaway

- The atom consists of discrete particles that govern its chemical and physical behavior.
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