Summary

4.1 Studying Atoms

The ancient Greek philosopher Democritus believed that all matter consisted of extremely small particles that could not be divided. He called these particles atoms from the Greek word *atomos*, which means "uncut" or "indivisible." Aristotle did not think there was a limit to the number of times matter could be divided.

By the 1800s, scientists had enough data from experiments to support an atomic model of matter. The English scientist John Dalton developed a theory to explain why the elements in a compound always join in the same way. Dalton proposed that all matter is made up of individual particles called atoms, which cannot be divided. The main points of Dalton's theory are as follows.

- All elements are composed of atoms.
- All atoms of the same element have the same mass, and atoms of different elements have different masses.
- Compounds contain atoms of more than one element.
- In a particular compound, atoms of different elements always combine in the same way.

In the model of atoms based on Dalton's theory, the elements are pictured as solid spheres. Each type of atom is represented by a tiny, solid sphere with a different mass.

J. J. Thomson used an electric current to learn more about atoms. Before Thomson's experiments, the accepted model of atoms was a solid ball of matter that could not be divided into smaller parts. Thomson's experiments provided the first evidence that atoms are made of even smaller particles. In Thomson's model of the atom, negative charges were evenly scattered throughout an atom filled with a positively charged mass of matter.

In 1899, Ernest Rutherford discovered that uranium gives off fast-moving particles that have a positive charge. He named them alpha particles. From the results of experiments conducted by Rutherford's student, Ernest Marsden, Rutherford concluded that the positive charge of an atom is not evenly spread throughout the atom. It is concentrated in a very small, central area that Rutherford called the nucleus. The nucleus is a dense, positively charged mass located in the center of the atom.

Rutherford proposed a new model of the atom. According to Rutherford's model, all of an atom's positive charge is concentrated in its nucleus.

4.2 The Structure of an Atom

Protons, electrons, and neutrons are subatomic particles.

- A proton is a positively charged subatomic particle that is found in the nucleus of an atom. Each proton is assigned a charge of 1+.
- An electron is a negatively charged subatomic particle that is found in the space outside the nucleus. Each electron has a charge of 1–.
- A neutron is a neutral subatomic particle that is found in the nucleus of an atom.

Protons, electrons, and neutrons can be distinguished by mass, charge, and location in an atom. Protons and neutrons have almost the same mass. The mass of about 2000 electrons would equal the mass of a proton. Electrons have a charge that is equal in size to the charge of a proton, but the charges of electrons and protons are opposite.

The atoms of any given element always have the same number of protons. The atomic number of an element equals the number of protons in an atom of that element. Atoms of different elements have different numbers of protons. Each positive charge in an atom is balanced by a negative charge because atoms are neutral. So the atomic number of an element also equals the number of electrons in an atom.

The mass number of an atom is the sum of the protons and neutrons in its nucleus. Therefore, the number of neutrons in an atom equals the mass number minus the atomic number.

Isotopes are atoms of the same element that have different numbers of neutrons and different mass numbers. Isotopes of an element have the same atomic number but different mass numbers because they have different numbers of neutrons.

For example, every atom of oxygen has 8 protons. Some oxygen atoms have 8 neutrons and a mass number of 16. Some oxygen atoms have 9 neutrons and a mass number of 17. To distinguish one isotope from another, the isotopes are referred to by the mass number. The two oxygen isotopes, then, are referred to as oxygen-16 and oxygen-17.

With most elements, it is hard to notice any differences in the physical or chemical properties of their isotopes. Hydrogen is an exception.

4.3 Modern Atomic Theory

Niels Bohr, a Danish physicist, developed a model of the atom that focused on the electrons. A description of the arrangement of electrons in an atom is the centerpiece of the modern atomic model. In Bohr's model, electrons move with constant speed in fixed orbits around the nucleus, as planets move in fixed orbits around the sun.

Each electron in an atom has a certain amount of energy. The possible energies that electrons in an atom can have are called energy levels. An electron can move from one energy level to another when the atom gains or loses energy.

An electron can move up energy levels if it gains the right amount of energy. On the other hand, an electron can move down energy levels if it loses the right amount of energy. The size of the jump between energy levels determines the amount of energy gained or lost.

Scientists improved Bohr's model as new discoveries were made. Today, scientists know that electrons do not move like planets around the sun. An electron cloud is a visual model of the most likely locations for electrons in an atom. The cloud is denser where the chances of finding an electron are high. Scientists use the electron cloud model to describe the possible locations of electrons around the nucleus.

The electron cloud represents all the orbitals in an atom. An orbital is a region of space around the nucleus where an electron is likely to be found. An electron cloud is a good description of how electrons behave in their orbitals. The level in which an electron has the least energy has only one orbital. Higher energy levels have more than one orbital. The maximum number of electrons in an energy level is twice the number of orbitals of that energy level. Each orbital can contain two electrons at most.

A configuration is an arrangement of objects in a given space. An electron configuration is the arrangement of electrons in the orbitals of an atom. The most stable electron configuration is the one in which the electrons are in orbitals with the lowest possible energies. When all the electrons in an atom have the lowest possible energies, the atom is said to be in its ground state.