2.3: The Atomic Number and Mass Number

Learning Objectives

- Define atomic number, mass number, and isotope.
- Use the atomic number and mass number to determine the number of protons, neutrons, and electrons in an atom.

The modern atomic theory states that atoms of one element are the same, while atoms of different elements are different. What makes atoms of different elements different? The fundamental characteristic that all atoms of the same element share is the *number of protons*. All atoms of hydrogen have one and only one proton in the nucleus; all atoms of iron have 26 protons in the nucleus. This number of protons is so important to the identity of an atom that it is called the **atomic number.** The number of protons in an atom is the atomic number of the element. Thus, hydrogen has an atomic number of 1, while iron has an atomic number of 26. Each element has its own characteristic atomic number.

Atoms are electrically *neutral*, meaning that the overall electric charge is zero. This is because the number of protons (positive charge) equals the number of electrons (negative charge). Therefore, the atomic number also provides the number of electrons. For example, helium has the atomic number 2, which tells us that there are 2 protons in the nucleus and 2 electrons outside of the nucleus. Sometimes atoms will gain or lose electrons resulting in a difference in the number of protons and electrons, which means the charge is no longer zero. Atoms that have a charge are called *ions* and will be discussed in more detail later.

As we learned previously, protons and neutrons, which are found in the nucleus of an atom, each have a mass of ~1 amu. Because an electron has negligible mass relative to that of a proton or a neutron, the majority of an atom's mass is in the nucleus. The **mass number** is defined as the total number of protons and neutrons in an atom:

mass number = protons + neutrons

Atoms of the same element always have the same number of protons, but often have different numbers of neutrons, therefore, different mass numbers. These atoms are called **isotopes** and will be discussed in more detail in the next chapter.

Example 2.3.1

a. The most common carbon atoms have six protons and six neutrons in their nuclei. What are the atomic number and the mass number of these carbon atoms?
b. An isotope of uranium has an atomic number of 92 and a mass number of 235. What are the number of protons and neutrons in the nucleus of this atom?

Solution

a. If a carbon atom has six protons in its nucleus, its atomic number is 6. If it also has six neutrons in the nucleus, then the mass number is 6 + 6, or 12.
b. If the atomic number of uranium is 92, then that is the number of protons in the nucleus. Because the mass number is 235, then the number of neutrons in the nucleus is 235 − 92, or 143.

Exercise 2.3.1

The number of protons in the nucleus of a tin atom is 50, while the number of neutrons in the nucleus is 68. What are the atomic number and the mass number of this isotope?

Answer

Atomic number = 50, mass number = 118

Example 2.3.2:

a. What is the symbol for an isotope of uranium that has an atomic number of 92 and a mass number of 235?
b. How many protons and neutrons are in $^{56}_{26}\mathrm{Fe}$

Solution

a. The symbol for this isotope is $^{235}_{92}\text{U}$
b. This iron atom has 26 protons and 56 − 26 = 30 neutrons.

? Exercise 2.3.2

How many protons are in $^{23}_{11}\text{Na}$

Answer

11 protons

Key Takeaways

- Each element has its own atomic number, which is equal to the number of protons in its nucleus.
- The mass number is the sum of the number of protons and neutrons.
- The number of neutrons in an atom can be determined by subtracting the atomic number from the mass number.

Contributors

- Lisa Sharpe Elles, University of Kansas