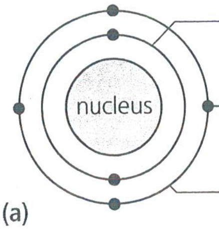
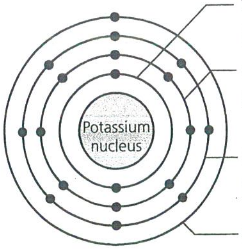


(a)



(b)

Figure 3 The number of shells (orbits) in an atom depends on the number of electrons in the atom

If you would like to learn more about the atomic theory of matter, go to **www.science.nelson.com** GO

The Atomic Theory of Matter

The development of the atomic theory required new technologies and discoveries to be made in order for it to advance. In the 1920s and later, the atomic theory was again modified as more discoveries were made about the behaviour of electrons in atoms. There are a maximum number of electrons that can occupy any one shell. The first shell can only contain a maximum of two electrons, and the second shell can contain a maximum of eight. The electrons fill the shells starting with the first or innermost shell and work outward. For example, an element with six electrons has two electrons in the first shell and four electrons in the second (Figure 3(a)).

The Number of Shells for an Element

The number of shells that an element will need is related to which row of the Periodic Table it is found in. First-row elements have electrons in the first shell. Second-row elements have electrons in the first and second shells. Third-row elements have electrons in the first, second, and third shells, and so on. For the first 20 elements, the third shell can only contain a maximum of eight electrons. Therefore potassium, in the fourth row, has one electron in its fourth shell (Figure 3(b)). Calcium will have two electrons in its fourth shell. (For elements beyond number 20, the arrangement of the electrons becomes more complicated.) As you will learn in Chapter 8, it is the arrangement of the electrons that determines the characteristics and chemical behaviour of an element.

To summarize, the atomic theory we will use is as follows: GO

The Atomic Theory of Matter

- All matter is made of atoms.
- Atoms are the smallest pieces of an element.
- Elements combine to form compounds. The atoms in the compound are held together by electrical attractions.
- An atom is composed of a nucleus surrounded by electrons.
- The nucleus is composed of positively charged protons and uncharged neutrons.
- All the atoms of an element have the same unique number of protons.
- All the nucleus contains most of the mass of the atom and all of the positive charge.
- There is only empty space between the electrons and the nucleus.
- Electrons have a negative charge and very little mass.
- Electrons orbit the nucleus only in specific, allowed shells.
- For the first 20 elements, the first shell contains a maximum of two electrons, the second shell contains a maximum of eight electrons, and the third shell contains a maximum of eight electrons.
- Electrons absorb or emit specific amounts of energy to change shells.

Standard Atomic Notation

As described earlier, elements give off an emission spectrum when energized. The light emitted is visible light, ultraviolet light, and X-ray energy (all are part of the electromagnetic spectrum). In 1913, Henry Moseley studied the X-ray part of the emission spectra of elements, and noted that a characteristic energy peak increased by one unit for each element in order of increasing atomic mass, with a few exceptions. (You will learn more about atomic mass in the next section.) Thus, the elements could each be given a specific number, called the **atomic number**. Scientists now know that the atomic number is the number of protons in the nucleus. The Periodic Law can now be stated as: *The properties of the elements are a periodic or regularly repeating function of their atomic number.* It is the atomic number (not the atomic mass) that determines the order of the elements in the modern Periodic Table.

The total number of protons and neutrons in the nucleus of an atom is called the **mass number**. The mass number of an element is often written after the element name, as in chlorine-35. The mass number, along with the chemical symbol for an element and the atomic number, can also be written in standard atomic notation (Figure 4). Like the symbols for the elements, standard atomic notation allows scientists to communicate and share their ideas efficiently.

LEARNING TIP

What does Figure 4 tell you? Atomic number is the number of protons in the nucleus of an atom. What is the atomic number for chlorine? An element's mass number is the number of protons and neutrons in its atom. What is the mass number for chorine? What is the symbol for chlorine?

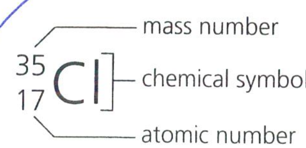


Figure 4 The standard notation for chlorine

Standard Notation for Ions

Normally, an atom has the same number of electrons as protons. Chlorine, atomic number 17, normally has 17 electrons. An atom obtains a charge when electrons are either added or removed. For example, heating a metal drives off electrons from the metal atoms, and friction between a piece of wool and vinyl plastic transfers electrons to the vinyl from the wool.

When an atom becomes charged, there are more or fewer electrons than protons in the atom. A charged atom is called an **ion**. When there are more electrons than protons, the atom has a negative charge and is called a **negative ion**. When there are fewer electrons than protons, the atom has a positive charge and is called a **positive ion**. For example, if there are 2 fewer electrons than protons, the ion has a charge of 2+. If there are 3 more electrons than protons, the ion has a charge of 3−. The charge of an ion, whether positive or negative, is called the **ion charge**. In standard atomic notation the ion charge is written above and to the right of the symbol (Figure 5). If the charge is 1+ or 1−, the "1" is not usually written. It is important to note that, when an atom becomes charged, the number of protons in the atom does not change. The ion charge is due *only* to a change in the number of electrons in the atom.

Figure 5 The standard notations for a chlorine ion and a magnesium ion