Learn

Electron shells

Bohr proposed that electrons that have the same energy are at the same distance from the nucleus. The more energy the electron possesses, the further the energy orbit can be from the nucleus. This means that the atom is made up of a set of possible energy levels, which Bohr called **electron shells**. Electrons with the least amount of energy occupy the shell closest to the nucleus, electrons with the next highest amount of energy occupy the next shell and so on.

Interestingly, the further they are from the nucleus, the closer the electron shells are to one another. Electron shells are numbered from the nucleus outwards, with the one closest to the nucleus being shell number 1, the next shell is number 2 and so on (Figure 1.6).

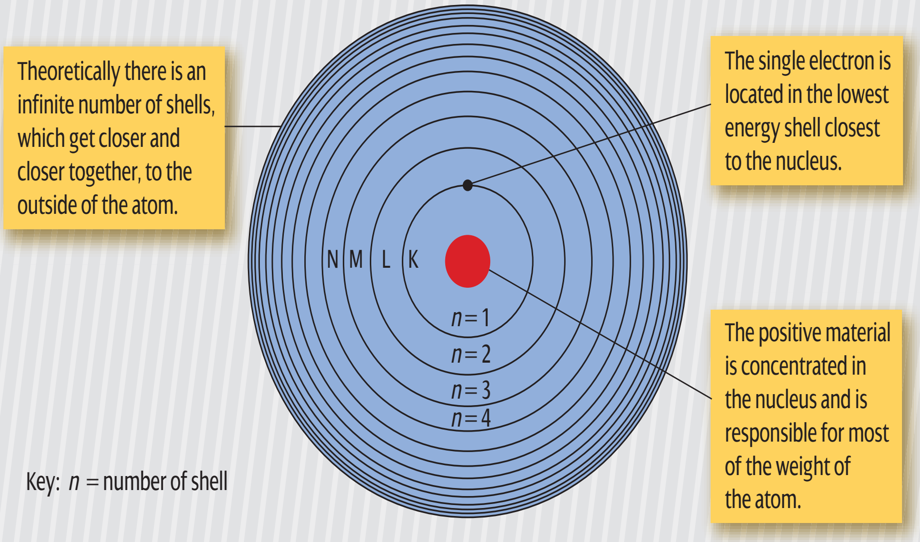

Figure 1.6 The Bohr model of the hydrogen atom, the simplest atom of all

Rules

Bohr said that unless you give an atom extra energy by heating it or shining light on it, the electrons will always be located at the lowest possible energy levels. However, each shell has a limit to how many electrons it can take. These limits are shown in Table 1.2.

Table 1.2 The maximum possible number of electrons in the first five electron shells

Shell number *n* (from nucleus outwards)	Maximum number of electrons
1	2
2	8
3	18
4	32
5	50

WOW

Bohr suggested that the electrons of the atom cannot be just anywhere. They only have certain amounts of energy and can only be found at certain distances from the nucleus. Electrons travel around the nucleus at high speed, tracing out circular paths called **orbits**. Extraordinarily, unlike normal-sized objects, they do not use up any energy as they move and so they do not get pulled into the nucleus, despite the electrostatic attraction between the electrons and the nucleus. This attraction, however, is the reason that the fast-moving electrons stay orbiting the nucleus instead of flying away.

The idea that particles on the atomic scale could behave differently from normal-sized objects was considered to be very radical at the time. It was a huge leap in thinking! But Bohr argued that this was the only way in which you could explain the spectra of the elements and other evidence.

There is also one further restriction: the shell furthest from the nucleus that contains any electrons, which we describe as the **outermost occupied shell**, can never have more than 8 electrons. (The reason for this only becomes clear when you study the Schrödinger model of the atom in senior chemistry.)

The outermost occupied shell determines the volume of the atom. Although it is hard to believe when you touch substances such as steel, atoms are almost entirely empty space. This is because the electrons and nuclei of the atom are minute compared with the space traced out by the moving electrons. This is rather like an electric fan. The blades appear to take up far more space than they really do, due to their very rapid movement.

BLM 1.4 Bohr explains spectra

>>skillbox<<

Electron configuration

Now that you have learned the rules for the location of electrons in the Bohr model of the atom, you can deduce the electron arrangement of the first 20 elements.

Example 1 Carbon

From the Periodic Table on the inside front cover of this book, you can see that carbon is element number 6. This tells us that it has 6 protons in its nucleus.

In the uncharged atom, there must be one electron for each proton, because the total positive charge must equal the total negative charge, so we have 6 electrons to locate.

These electrons must be placed in the lowest energy levels possible. From Table 1.2, we see that the first 2 electrons can fit in shell number 1, the shell with the lowest energy. This leaves 4 electrons. These can all fit into the next shell. Figure 1.7 demonstrates how we show the electron arrangement. (This is also termed the **electron configuration**.)

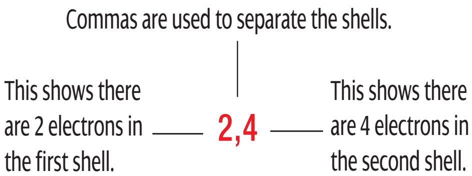

Figure 1.7 The electron arrangement of carbon

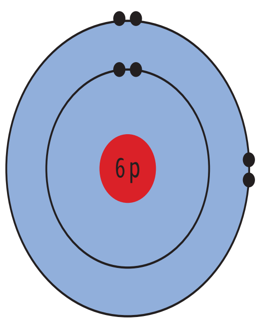

Figure 1.8 A model of the carbon atom

Figure 1.8 shows how we model the carbon atom. Notice that, for convenience, we write the number of protons in the nucleus; we do not attempt to draw the particles in the nucleus. For the same reason, we generally only show the occupied electron shells.

WOW

>>If you were to remove all the electrons from the atoms that make up the Sydney Opera House, so that you were left with just their nuclei, the Opera House would be about the size of a die! However, you would never be able to pick it up, because this die would be almost as heavy as the Opera House itself!

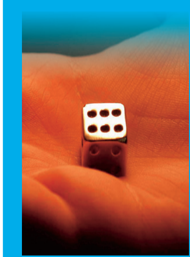

Figure 1.9 The Sydney Opera House could be this big?