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Introduction to Electron Structure

Student Activity Kit

Introduction

This simple and straightforward lab activity will help students to understand the basics of electron structure, a fundamental atomic concept.

Concepts

- Electron levels
- Electron structure
- Ions
- Atomic structure

Background

All atoms consist of protons, neutrons, and electrons. Protons and neutrons are clumped together to form a nucleus in the center of the atom. The electrons are very mobile and can be located anywhere from the center of the atom to its outer edge. (The electrons cannot be found in the nucleus, however.)

Two of these atomic particles have electrical charge. The proton has a positive (+) charge and the electron has a negative (–) charge. An atom has equal numbers of positively charged protons and negatively charged electrons. This makes the charge on the atom zero—the atom is said to be neutral. While the protons are only found in the nucleus, the electrons move around so much that they may be thought of as an "electron cloud" that surrounds the nucleus. Different electrons in the electron cloud have different amounts of energy. A model of electron structure would look like clouds within clouds. Each cloud represents the location of electrons that have a certain energy. The energy levels are numbered from one to seven, with level one being the closest to the nucleus and having the lowest energy and level seven being farthest from the nucleus and the highest energy (Figure 1).

Each energy level can contain more than one electron. However, the maximum number of electrons in each level is not the same, but increases as the energy level number increases. Energy level one can contain a maximum of two electrons; energy level two, eight electrons; energy level three, eighteen electrons; and energy level four, 32 electrons (Figure 2). These are the *maximum* number of electrons in each energy level. For levels 5, 6, and 7, the energy levels and orbital size increase, along with the number of possible electrons that can fill these energy levels. Figure 2 is a visual representation of the electrons and their energy levels. The electrons do pair up as they fill the energy levels, but they do *not* orbit in a ring. They move all over the area of the specific "electron cloud" or energy level.

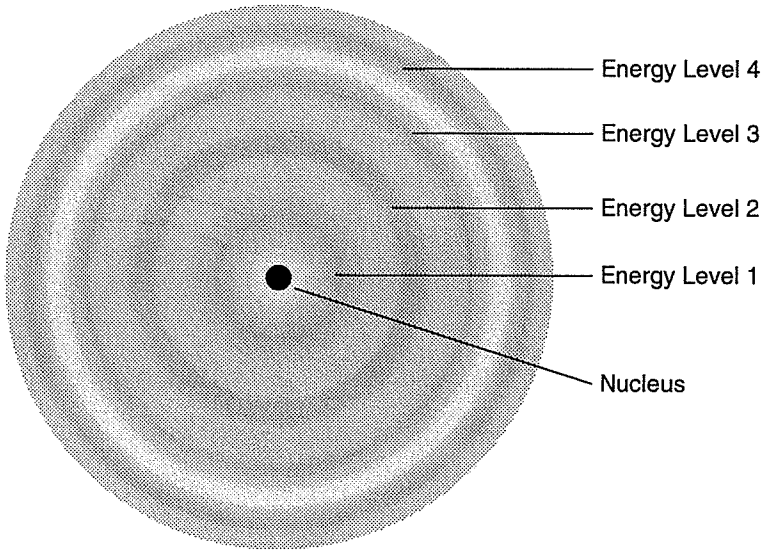

Figure 1. Electron Clouds (Energy Levels 5–7 omitted)

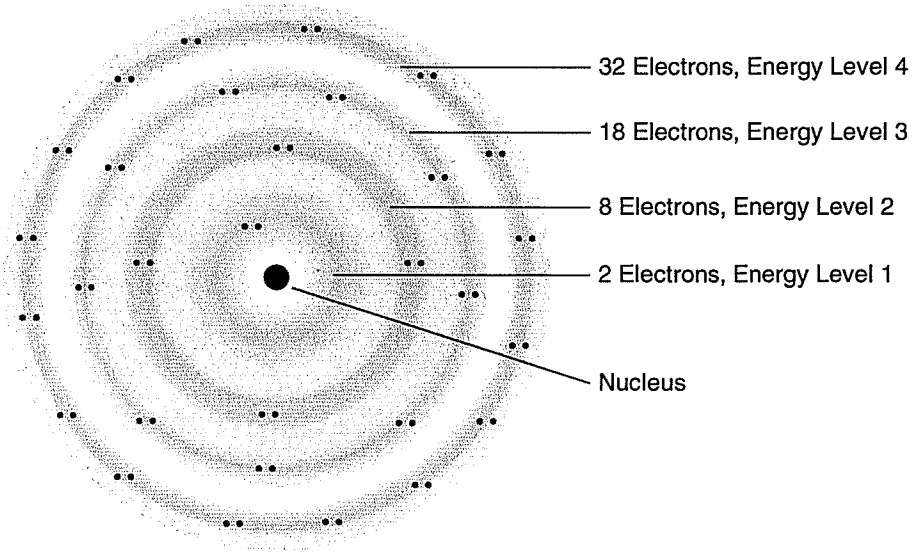

Figure 2. Energy Level Electrons

The elements may be arranged for convenience in a chart called the periodic table. The elements are listed in order of increasing atomic number, which is either the number of protons or the number of electrons in the element. Atomic numbers increase from left to right and from top to bottom. The periodic table used in this lab contains the element name, its one- or two-letter symbol, and its atomic number (Figure 3).

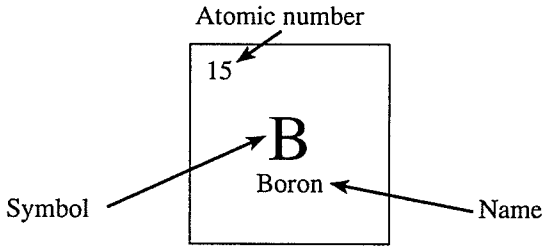

Figure 3.

As the atomic numbers of the elements increase, the electrons fill in the energy levels, starting from the lowest energy level to the next higher energy level, and so forth, until the number of electrons in the atom equals the number of protons in the nucleus.

For example, the atomic number of fluorine is nine—a neutral fluorine atom has nine protons and nine electrons. Two electrons are paired and fill energy level one. The remaining seven electrons fill energy level two. Six of the electrons are paired in level two, with one lone unpaired electron (Figure 4).

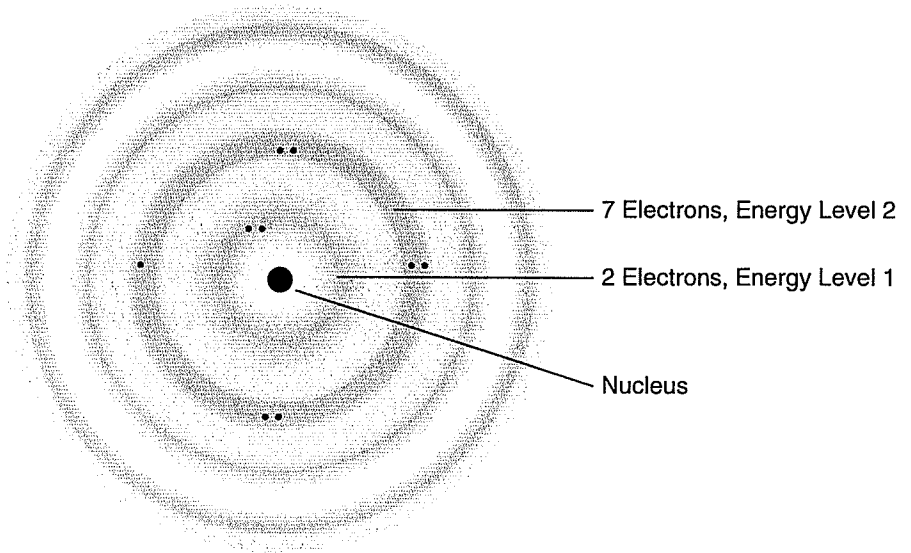

Figure 4. Electron Energy Level Diagram for Fluorine

In chemical reactions, atoms tend to gain or lose electrons. Atoms in which the number of protons is not equal to the number of electrons are called *ions*. The magnesium ion, for example, has twelve protons and ten electrons.

Ions are written using the element symbol, with the number of extra or deficient electrons at the top and right of the symbol. If the ion has fewer electrons than protons, a + sign is put after the number; if the ion has more electrons than protons, a – sign is used. For every ion, the number of electrons changes. The number of protons remains constant. The number of protons in a neutral atom always equals the number of protons in the ion. If the ion has only one extra or deficient electron, the number 1 is omitted from the ion symbol.

The magnesium ion with two less electrons than protons, is written

$$Mg^{2+}$$

If the atom has 9 protons and 10 electrons, then the ion is a fluorine ion and is written;

$$F^-$$

When the electrons are filled in the correct energy level for both Magnesium, Mg, and the magnesium ion, Mg^{2+}, the electron changes are:

	Level 3 — 2 electrons				Level 3 — 0 electrons
Mg	Level 2 — 8 electrons	– 2 electrons	=	Mg^{2+}	Level 2 — 8 electrons
	Level 1 — 2 electrons				Level 1 — 2 electrons

Magnesium loses two electrons from the third energy level, leaving the Mg^{2+} ion with only the first two energy levels filled.

If a fluorine atom gains an extra electron (nine protons and ten electrons), it forms a fluorine ion, F^-. When the electrons are filled in, the extra electron completes energy level two, and the fluorine ion has the first two energy levels completely filled.

F	Energy Level 2 — 7 electrons	+ 1 electron	=	F^-	Energy Level 2 — 8 electrons
	Energy Level 1 — 2 electrons				Energy Level 1 — 2 electrons

In these two examples, both Mg^{2+} and F^- have identical electron structures. However, the nuclei of these two ions contain different numbers of protons and thus the two ions are still very different elements. One of the reasons that atoms react with each other is for each atom to have completely filled energy levels.

Pre-Lab Questions

1. How are the energy levels filled with electrons for a phosphorus atom?
2. How are the energy levels filled with electrons for an oxygen ion, O^{2-}?

Materials

Periodic table	Energy level diagrams, A–R
Data table	Chips

Procedure

1. At each workstation, there is an energy level diagram, a symbol for a neutral atom or an ion, and chips representing electrons. Record the symbol for the neutral atom or ion in the Data Table.
2. Determine the number of protons contained in the atom or the ion. (Refer to the Periodic Table.) Record this number in the Data Table.
3. Determine the number of electrons in the atom or ion. Record this number in the Data Table.
4. Count out this number of electrons (chips).
5. Fill the electron energy levels with the correct number of electrons, from lowest energy level to highest. Record the number of electrons in each energy level in the Data Table.
6. Remove the chips from the energy level diagram and proceed to the next workstation.

Name: _____

Data Table

Station	Atom or Ion	Number of Protons	Number of Electrons	Number of Electrons Level 1	Number of Electrons Level 2	Number of Electrons Level 3	Number of Electrons Level 4
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							