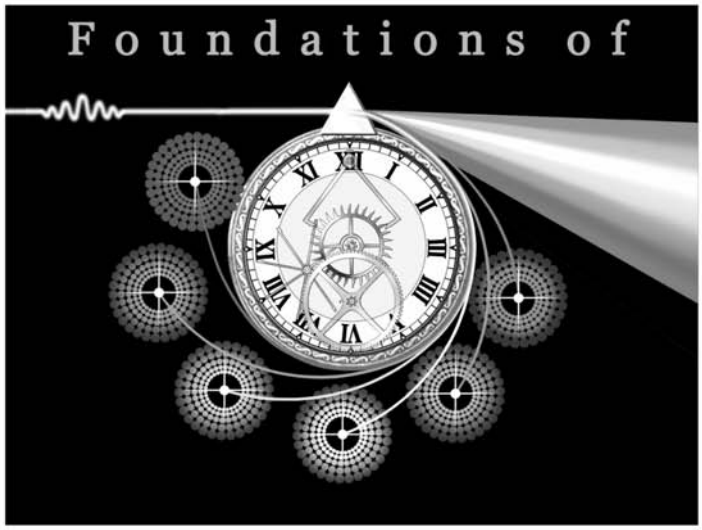

Physical Science Investigations

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19.1 Bonding and Molecules

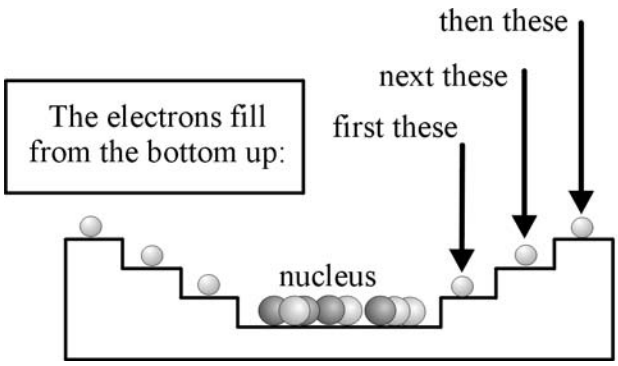
Question: Why do atoms form chemical bonds?

In this Investigation, you will:

1. Build models of atoms to gain an understanding of the arrangement of electrons.
2. Identify how atoms form chemical bonds and the role of electrons in bonding.

Most of the matter on Earth is in the form of compounds. Even when a substance exists as a pure element, it tends eventually to combine with other elements. For example, if you leave an iron nail outside in the rain, it will quickly combine with the oxygen in the air to form iron oxide, better known as rust. In this Investigation, you will build models of atoms and discover one of the fundamental ideas in chemistry: how electrons are involved in the formation of chemical bonds.

1 Reviewing atomic structure



Let's review what you already know about atoms:

- A neutral atom has the same number of electrons and protons.
- The electrons occupy energy levels surrounding the nucleus.
- Since electrons are attracted to the nucleus, they fill the lower energy levels first.

Once a given level is full, electrons start filling the next level.

2 How many electrons are in the outermost level?

Using the atom building game, build each element in the table. For each element, record the number of electrons in the outermost energy level and the number of unoccupied spaces in the outermost energy level.

element	atomic number	electrons in outermost level	unoccupied spaces in outermost level
hydrogen			
helium			
lithium			
fluorine			
neon			
sodium			
chlorine			
argon			
potassium			

3 What are valence electrons?

Examine the table you just completed and record the answers to the following questions:

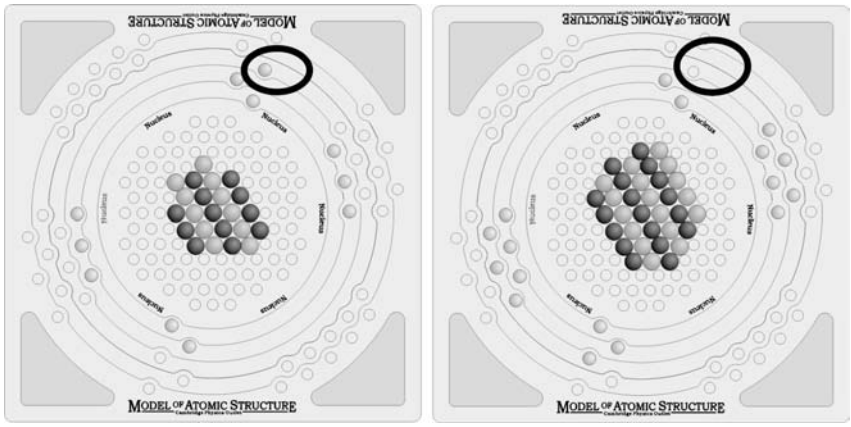
a. What do lithium, sodium, and potassium have in common?

b. What do fluorine and chlorine have in common?

c. What do neon and argon have in common?

The electrons in the outermost energy level of an atom are called **valence electrons**. These are the electrons involved in chemical bonds. Lithium, sodium, and potassium each have one valence electron.

4 Modeling a chemical bond



Atoms that have a complete outermost energy level are stable. If there are empty holes, an atom will either gain, lose, or share electrons with another atom in order to complete its outermost level and become stable. When atoms gain, lose, or share electrons with another atom, they form **chemical bonds**.

Using two atom building games, build a sodium atom and a chlorine atom. Put them next to each other and answer the questions below.

a. In order to complete its outermost energy level, do you think sodium will tend to lose its only valence electron, or gain seven? Explain your answer.

b. In order to complete its outermost energy level, do you think chlorine will tend to lose all of its valence electrons or gain one electron? Explain your answer.

c. Why might these two atoms bond together to form a molecule? In your answer, describe what you think might happen when sodium and chlorine form a chemical bond.

5 Determining oxidation numbers

An element's **oxidation number** is equal to the charge an atom has when it **ionizes**, that is, gains or loses electrons.

Use your models of sodium and chlorine to answer the questions below.

a. Remove the valence electron from sodium. What has happened to the balance of positive and negative charges? What is sodium's oxidation number?

b. Move the electron you took from sodium into the chlorine. What happens to chlorine's charge when it gains the electron from the sodium atom? What is chlorine's oxidation number?

c. When sodium and chlorine form a chemical bond, what is the overall charge of the molecule? Why do you think sodium and chlorine combine in a 1:1 ratio?

The cover is an evocative montage of historical and scientific achievements that demonstrate the incredible persistence of the human intellect. Around the border, daVinci's graphics reflect an evolving tapestry of conceptual thinking as they interweave with more contemporary themes. DaVinci's fantastical mechanisms become the modern bicycle, a quintessential machine, which rolls into a graphical interpretation of wavelength division multiplexing on a fiber optic. The images follow 500 years of scientific and technological innovation. The Earth and DNA symbolize the interdependence of the built world and the natural world. The exquisite blend of form and function revealed in the elegant geometry of the chambered nautilus folds into a spiral defined by the Golden Rectangle. The interplay of organic and architectural forms represents the balance we seek between the power of technology and the fragility of our lives and our world. I hope this colorful interplay of images will inspire interest and excitement about the discovery of science.

Bruce Holloway - Senior Creative Designer

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