Ionic Bonding

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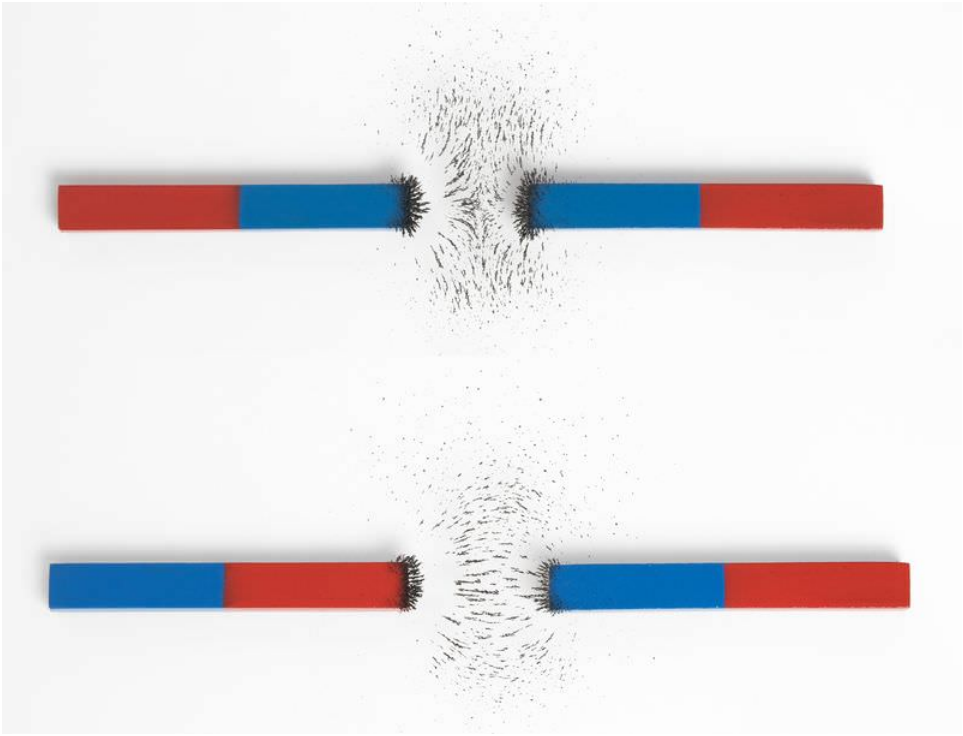
CHAPTER 1 Ionic Bonding

- State how ionic bonds form.
- Explain why ionic bonds form.
- Describe the role of energy in the formation of ionic bonds.



Look at the photos of bar magnets in the opening image. At first glance, the two photos look very similar, but they differ in one important way. In the top photo, the north (blue) poles of both magnets are placed close together. In the bottom photo, the north pole of one magnet is placed close to the south (red) pole of the other magnet. Now look closely at the iron filings in the two photos. The ion filings show the force of repulsion between the two north poles in the top photo and the force of attraction between the north and south poles in the bottom photo. Like the poles of magnets, electric charges repel or attract each other. Two positive or two negative charges repel each other, and two opposite charges attract each other. The attraction of opposite electric charges explains how ionic bonds form.

How Ionic Bonds Form

An **ionic bond** is the force of attraction that holds together positive and negative ions. It forms when atoms of a metallic element give up electrons to atoms of a nonmetallic element. The **Figure** 1.1 shows how this happens.

In row 1 of the **Figure** 1.1, an atom of sodium (Na) donates an electron to an atom of chlorine (Cl).

- By losing an electron, the sodium atom becomes a sodium ion. It now has more protons than electrons and a charge of +1. Positive ions such as sodium are given the same name as the element. The chemical symbol has a plus sign to distinguish the ion from an atom of the element. The symbol for a sodium ion is Na^{+}.
- By gaining an electron, the chlorine atom becomes a chloride ion. It now has more electrons than protons and a charge of -1. Negative ions are named by adding the suffix *-ide* to the first part of the element name. The symbol for chloride is Cl^{-}.

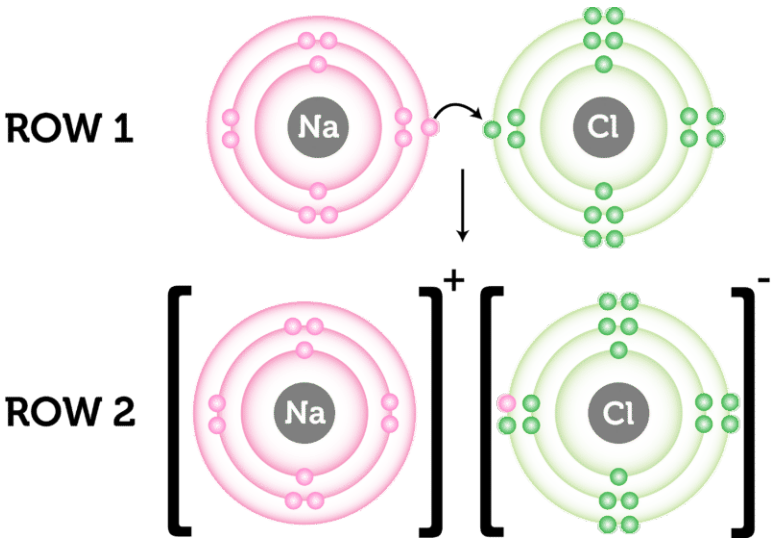


FIGURE 1.1

Sodium and chloride ions have equal but opposite charges. Opposite electric charges attract each other, so sodium and chloride ions cling together in a strong ionic bond. You can see this in row 2 of the **Figure** 1.1. (Brackets separate the ions in the diagram to show that the ions in the compound do not actually share electrons.) When ionic bonds hold ions together, they form an ionic compound. The compound formed from sodium and chloride ions is named sodium chloride. It is commonly called table salt.

Why Ionic Bonds Form

Ionic bonds form only between metals and nonmetals. That's because metals "want" to give up electrons, and nonmetals "want" to gain electrons. Find sodium (Na) in the **Figure** 1.2. Sodium is an alkali metal in group 1. Like all group 1 elements, it has just one valence electron. If sodium loses that one electron, it will have a full outer energy level, which is the most stable arrangement of electrons. Now find fluorine (F) in the periodic table **Figure** 1.2. Fluorine is a halogen in group 17. Like all group 17 elements, fluorine has seven valence electrons. If fluorine gains one electron, it will also have a full outer energy level and the most stable arrangement of electrons.

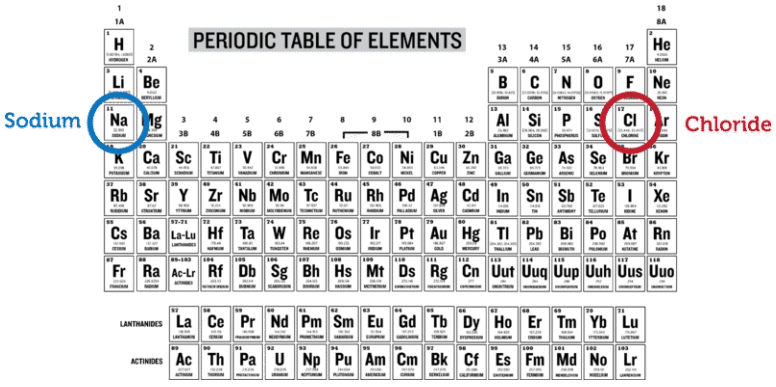


FIGURE 1.2

Q: Predict what other elements might form ionic bonds.

A: Metals on the left and in the center of the periodic table form ionic bonds with nonmetals on the right of the periodic table. For example, alkali metals in group 1 form ionic bonds with halogen nonmetals in group 17.

Energy and Ionic Bonds

It takes energy to remove valence electrons from an atom because the force of attraction between the negative electrons and the positive nucleus must be overcome. The amount of energy needed depends on the element. Less energy is needed to remove just one or a few valence electrons than many. This explains why sodium and other alkali metals form positive ions so easily. Less energy is also needed to remove electrons from larger atoms in the same group. For example, in group 1, it takes less energy to remove an electron from francium (Fr) at the bottom of the group than from lithium (Li) at the top of the group (see the **Figure** 1.2). In bigger atoms, valence electrons are farther from the nucleus. As a result, the force of attraction between the valence electrons and the nucleus is weaker.

Q: What do you think happens when an atom gains an electron and becomes a negative ion?

A: Energy is released when an atom gains an electron. Halogens release the most energy when they form ions. As a result, they are very reactive elements.

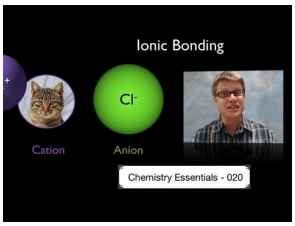
Summary

- An ionic bond is the force of attraction that holds together positive and negative ions. It forms when atoms of a metallic element give up electrons to atoms of a nonmetallic element.
- Ionic bonds form only between metals and nonmetals. That's because metals "want" to give up electrons, and nonmetals "want" to gain electrons.
- It takes energy to remove valence electrons from an atom and form a positive ion. Energy is released when an atom gains valence electrons and forms a negative ion.

Review

1. What is an ionic bond? How does it form?
2. Why do metals lose electrons and nonmetals gain electrons in the formation of ionic bonds?
3. Atoms of lithium (Li) and cesium (Cs) both lose electrons and become positive ions when they from ionic bonds. Which type of atom requires more energy to become an ion? Why?

Resources



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References

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