

Chemistry Unit 2 - Chemical Bonding

Over 31 million known chemical compounds exist, but there are fewer than 100 naturally occurring elements. Through chemical bonding, atoms of elements can combine in many ways to form chemical compounds. This process is called **bonding**. Chemical bonds are classified as **covalent**, **ionic**, or **metallic** depending on what happens with the valance electrons involved in the bond.

What are ions?

Atoms either gain or lose electrons to become **ions**. Stable **atoms** of an element have the same number of protons and electrons, but if atoms gain or lose electrons they become **ions** since they would no longer have equal amounts of positive and negative charges.

Atom $\rightarrow P = E$
Ion $\rightarrow P \neq E$

Examples:

- By **losing** an electron, a sodium atom becomes a sodium **ion**.
 - It would have 11 protons, but only 10 electrons, which gives it a charge of +1.
 - Positive ions are called **cations**.
- By **gaining** an electron, a chlorine atom becomes a chloride **ion**.
 - It would have 18 electrons and 17 protons, which gives it a charge of -1.
 - Negative ions are called **anions**.

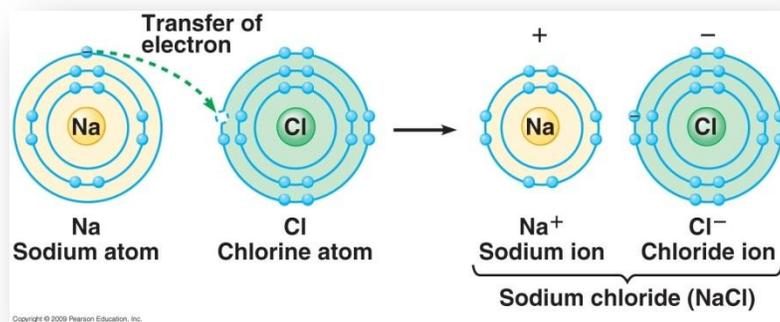
An element's **oxidation number** is equal to the number of electrons it would gain or lose in order to form a bond. In the examples shown above, sodium would lose one electron and have an oxidation number of 1+. A chlorine atom would gain one electron and have an oxidation number of 1-. The oxidation number is often written as a superscript after an element's chemical symbol, such as Na^{1+} or Cl^{1-} .

How do ionic bonds form?

An **ionic bond** is the force of attraction that holds together positive and negative ions. It forms when atoms of a **metal** give up electrons to atoms of a **nonmetal**.

Using the example from above, an atom of sodium (Na) **transfers** (or donates) an electron to an atom of chlorine (Cl). When this electron is transferred, the sodium atom becomes a positive ion with a charge of +1 and the chlorine atom becomes a negative ion with a charge of -1.

Sodium and chloride **ions** have **equal** but **opposite** charges. Opposite electric charges attract each other, so When ionic bonds hold ions together, they form an **ionic compound**. The compound formed from sodium and



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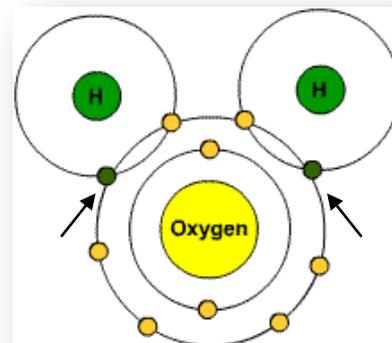
chloride ions is named **sodium chloride**, which is commonly called table salt and represented by the formula NaCl.

How do covalent bonds form?

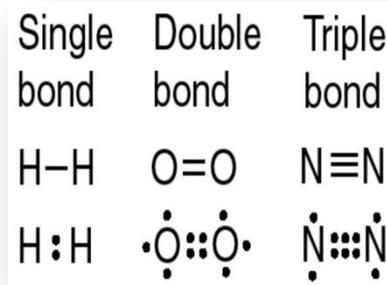
A **covalent bond** is the force of attraction that holds together two **nonmetal** atoms that **share** a pair of valence electrons. The shared electrons are attracted to the nuclei of both atoms, which holds the atoms together in a bond. This forms a **molecule**, which is the smallest particle of a covalent compound that still has the properties of the compound.

Example:

- Each hydrogen atom has 1 valence electron and each one needs 1 more to fill up its outer shell.
- The oxygen atom has 6 valence electrons and needs 2 more electrons to fill up its outer shell.
- With oxygen sharing one electron with each hydrogen atom, all three atoms are able to fill up their outer shells.
- The chemical formula for this molecule is H_2O , which shows it is composed of 2 atoms of hydrogen and one atom of oxygen.



The type of covalent bond depends on how many electron pairs are shared between atoms. A molecule created by the sharing of one pair of electrons is called a **single bond**, such as the H_2 molecule shown at right. The O_2 molecule is created by two oxygen atoms sharing two pairs of electrons and is called a **double bond**. If a compound has three pairs of electrons being shared, such as the N_2 molecule, it would be called a **triple bond**.



Oxygen normally occurs as **diatomic** ("two-atom") molecules, which are covalent bonds formed between two atoms of the same element. Several other elements also occur as diatomic molecules: hydrogen, nitrogen, fluorine, chlorine, bromine, and iodine.

How do metallic bonds form?

Metallic bonds are forces of attraction between positive metal ions and the valence electrons that are constantly moving around them. The valence electrons include their own and those of other, nearby ions of the same metal. The valence electrons of metals move freely in this way because metals have relatively low **electronegativity**, or attraction to electrons. The positive metal ions form a lattice-like structure held together by all the metallic bonds.

The valence electrons surrounding metal ions are constantly moving and often referred to as a "sea" of electrons. This makes metals good **conductors** of electricity and heat. The lattice-like structure of metal ions is strong but quite flexible, which allows metals to bend without breaking. Metals are both **ductile** (can be shaped into wires) and **malleable** (can be shaped into thin sheets).