

COMBINING ATOMS

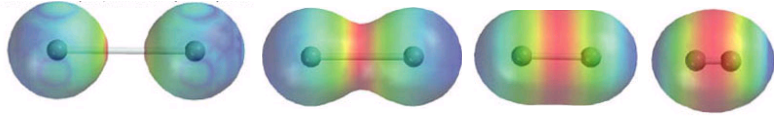
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- ◉ Recall that all things are made of matter and all matter is composed of atoms.
- ◉ Elements are made of only one kind of atom.
- ◉ How can just 118 elements form all the substances that exist?
- ◉ Atoms of elements combine with one another to form new and different substances called compounds.
- ◉ Compounds contain more than one kind of atom chemically joined together.
- ◉ Let's take a look at how this happens.....

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Chemical Bonds



- A chemical bond is a strong force of attraction that holds the atoms together
- Chemical bonds “glue” atoms together to make compounds

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Electrons

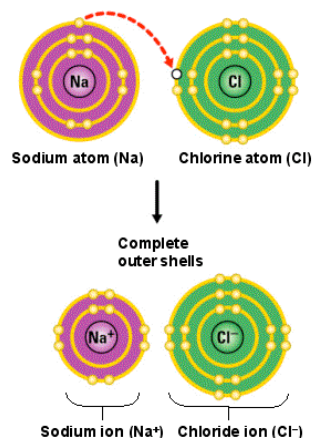
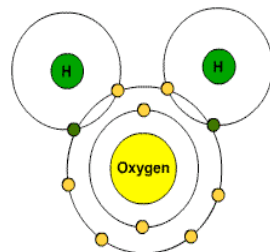
- The forces of bonds are based on electrons
- The higher the energy level, the better the chance for bonding
- Valence electrons (electrons in the outer shell) determine how an atom bonds with other atoms



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Give and Take

- Atoms give electrons
- Atoms take electrons
- Atoms share electrons



- Atoms with few valence electrons tend to lose electrons
- Atoms with more valence electrons tend to take electrons

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Octet Rule



The octet rule

Atoms are most stable if they have a filled or empty outer layer of electrons.

Except for H and He, a filled layer contains 8 electrons - **an octet**.

Atoms will

gain or lose (ionic compounds)
share (covalent compounds)

electrons to make a filled or empty outer layer.

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Noble Gases

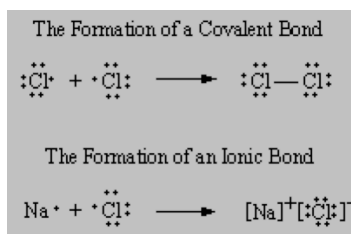
- Elements in group 18 have a full outer shell
- These are known as Noble gases
- They will NOT combine with other elements under normal circumstances



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The name is Bond...

- There are several types of chemical bonds.
- We'll look at 2 of them.
 - Ionic
 - Covalent

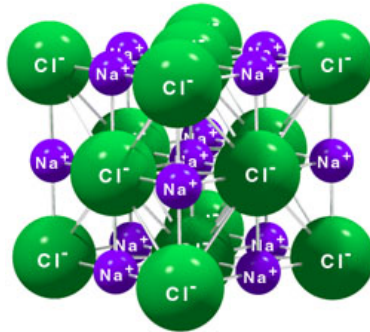


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Ionic Bonds

- ⦿ An ionic bond is the force of attraction between oppositely charged ions.
- ⦿ Recall that ions are atoms with a charge.
- ⦿ These bonds form when atoms pull electrons away from other atoms.



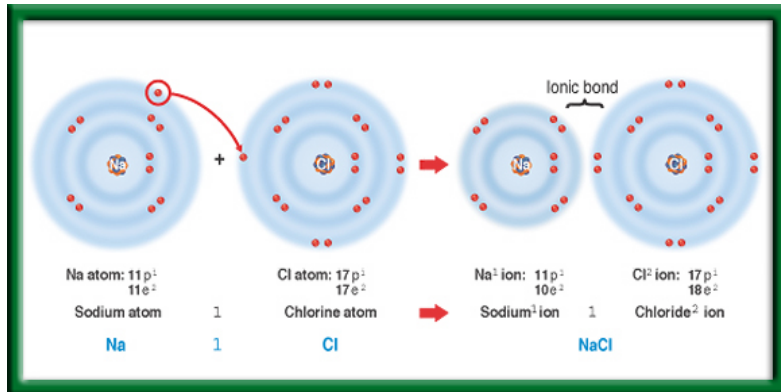
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Three steps in an ionic bond

- ⦿ Step 1: Formation of ions
 - Electrons are transferred from one atom to another
 - Formation of positive ion (cation)
 - Metals lose electrons
 - If fewer than four electrons in outer shell, more likely to lose an electron (positive charge, Na^+)
 - Formation of a negative ion (anion)
 - Non metals tend to “steal” electrons
 - If more than four electrons in outer shell, less likely to lose electron and more likely to gain one (negative charge, Cl^-)
 - The same number of electrons is lost by the metal as is gained by the nonmetal.

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- By giving up an electron, sodium's valence shell is now full.
- By gaining an electron, chlorine's valence shell is now full.



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Three steps in an ionic bond

- Step 2: Attraction of opposites
 - Na⁺ is attracted to Cl⁻ because of opposite charges
- Step 3: Formation of ionic bond
 - The association of Na and Cl ions form the ionic compound NaCl (sodium chloride)

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Ionic Compounds

- ⦿ solid at room temperature
- ⦿ many are water-soluble
- ⦿ conduct current when melted or dissolved in H₂O
- ⦿ high melting point
- ⦿ examples: KCl, NaCl, NaOH

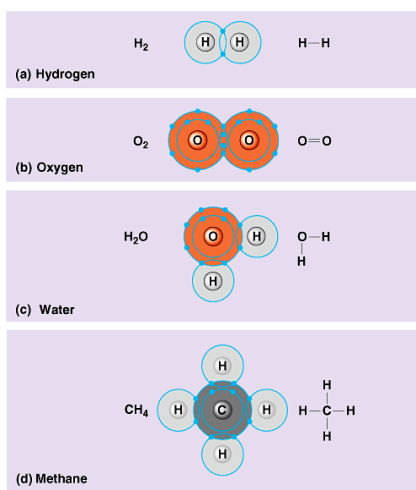
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Covalent bonds

- ⦿ When electrons are shared between atoms, rather than transferred, you have a covalent bond.
- ⦿ The combination of atoms joined by covalent bonds are called *molecules*.
- ⦿ Covalent bonds usually form between non-metals.
- ⦿ Covalent bonding often takes place between atoms of the same element.

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Covalent Bonds



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- Sharing electrons is another way to fill up the valence shell.
- Electron are in the valence shell of both atoms at the same time.

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Covalent Compounds

- solid, liquid or gas at room temperature
- soluble or insoluble in H_2O
- low melting points
- examples: HCl , H_2O , CH_4 ,

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Check for understanding

- ⦿ What is an ionic bond?
- ⦿ How does an atom become a negative ion? A positive ion?
- ⦿ What is covalent bonding?
- ⦿ What is a molecule?
- ⦿

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Predicting Types of Bonds

- ⦿ The number of electrons in the outermost energy level of an atom, the valence electrons, determines how an atom will combine with other atoms.
- ⦿ Compounds formed between elements that lose electrons easily and those that gain electrons easily will have ionic bonds.
 - Elements at the left and center (metals) of the periodic table tend to lose valence electrons
 - Elements at the right (nonmetals) tend to gain electrons readily.

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Predicting Types of Bonds

- ⦿ Compounds formed between elements that have similar tendencies to gain will have covalent bonds.
 - Bonds between two nonmetals

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Practice

- ⦿ What type of bonding would you expect between the following atoms?
 - Mg and F
 - O and Cl
 - In a sample of Zn

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Chemical Formulas

- ⦿ Compounds and molecules can be represented with a chemical formula.
- ⦿ A chemical formula shows the exact number of atoms of each element involved in the bond.
 - Example: CO₂
- ⦿ The small numbers placed to the lower right of symbols are called subscripts.
- ⦿ Subscripts show the number of atoms of each element.
- ⦿ Where there is only one atom of an element the subscript 1 is not written.

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Chemical Formulas

- ⦿ CO₂
- ⦿ How many atoms of carbon are there?
 - 1
- ⦿ How many atoms of oxygen are there?
 - 2

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Chemical formulas

- ⦿ What would be the formula for a molecule that has 1 carbon (C) atom and 4 chlorine (Cl) atoms?

- CCl_4

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Check for understanding

- ⦿ What does the chemical formula a molecule tell you?
- ⦿ What elements and how many of each are represented in the following formulas:

- Na_2CO_3
- $\text{Ca}(\text{OH})_2$
- $\text{Mg}(\text{C}_2\text{H}_3\text{O}_2)_2$
- $\text{Ba}_3(\text{PO}_4)_2$

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Oxidation Numbers

- ⦿ The number of electrons that an atom gains, loses, or share when bonding with another atom is called its **oxidation number**.
- ⦿ An atom of sodium (Na) has 1 valence electron.
- ⦿ It loses this electron when it combines with another atom.
- ⦿ In doing this it forms an ion with a 1+ charge, Na^{1+} .
- ⦿ The oxidation number of sodium is 1+.

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Oxidation Numbers

- ⦿ A magnesium (Mg) atom has 2 valence electrons, which it will lose when it forms a chemical bond.
- ⦿ The magnesium ion is Mg^{2+} .
- ⦿ The oxidation number of magnesium is 2+.
- ⦿ The small numbers placed to the upper right of symbols are called superscripts.
- ⦿ Superscripts indicate the charge of the ion (like subscripts, we don't write 1)

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Oxidation Numbers

- ⦿ An atom of chlorine has 7 valence electrons.
- ⦿ It will gain 1 electron when it bonds with another atom.
- ⦿ The ion formed will have a 1- charge, Cl^{1-} .
- ⦿ The oxidation number of chlorine is 1-.

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Oxidation Numbers

- ⦿ Oxygen has 6 valence electrons.
 - How many electrons will it gain?
 - 2
 - What is the oxidation number of oxygen?
 - 2

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Oxidation Numbers

[illegible]

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Check for understanding

- ⦿ Determine the oxidation number of the underlined element using the clue provided.
- ⦿ CaBr₂ (Br 1-)
- ⦿ CH₄ (H 1-)
- ⦿ H₂S (S 2-)
- ⦿ NaNO₃ (Na 1+, O 2-)
- ⦿ MgSO₄ ((SO₄) 2-)

Using oxidation numbers

- ⦿ You can use the oxidation numbers of atoms to predict how atoms will combine and what the formula for the resulting compound will be.
- ⦿ The sum of the oxidation numbers of the atoms in a compound **must** be zero.

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- ⦿ Sodium has an oxidation number of 1+.
- ⦿ Chlorine has an oxidation number of 1-.
- ⦿ One atom of sodium will bond with 1 atom of chlorine to form NaCl.
- ⦿ Magnesium has an oxidation number of 2+.
- ⦿ How many atoms of chlorine are needed to combine with magnesium to form the compound magnesium chloride?
 - 2
- ⦿ What is the chemical formula of magnesium chloride?
 - MgCl_2

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Check for understanding

1. What is an oxidation number?
2. How can the oxidation number of an atom be determined?
3. How is the oxidation number related to bond type?
4. What rule of oxidation numbers must be followed in writing chemical formulas?