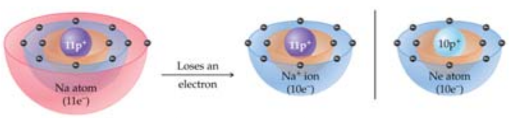
Stable Electron Configurations

- **Fact:** Noble gases, such as helium, neon, and argon are inert; they undergo few, if any, chemical reactions.
- **Theory:** The inertness of noble gases results from their electron structures; each (except helium) has an octet of electrons in its outermost shell.
- **Deduction:** Other elements that can alter their electron structures to become like those of noble gases would become less reactive by doing so.

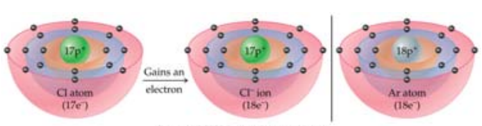
Stable Electron Configurations

- Sodium can lose a valence electron. In doing so, its core electrons are like the noble gas, neon.



Stable Electron Configurations

- Chlorine can gain an electron. In doing so, its electron structure becomes like argon.



Lewis (Electron Dot) Symbols

- G. N. Lewis developed a method of visually representing the valence electrons as dots around the symbol of an atom.

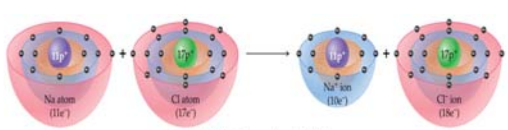
TABLE 5.1 Lewis Symbols for Selected Main Group Elements

Group 1A	Group 2A	Group 3A	Group 4A	Group 5A	Group 6A	Group 7A	Noble Gases
H·							He:
Li·	·Be·	·B·	·C·	:N·	:O·	:F·	:Ne:
Na·	·Mg·	·Al·	·Si·	:P·	:S·	:Cl·	:Ar:
K·	·Ca·				:Se·	:Br·	:Kr:
Rb·	·Sr·				:Te·	:I·	:Xe:
Cs·	·Ba·						

Sodium Reacts with Chlorine (Facts)

(a) (b) (c)

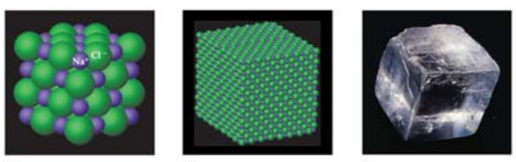
Sodium Reacts with Chlorine (Theory)



Sodium Reacts with Chlorine (Theory)

- Na^+ ions and Cl^- have opposite charges and attract each other.
- The resulting attraction is an **ionic bond**.
- Ionic compounds are held together by ionic bonds and exist in a **crystal**.

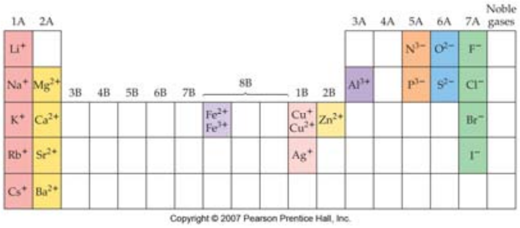
Sodium Reacts with Chlorine (Theory)



Octet Rule

- In reacting chemically, atoms tend to gain or lose or share electrons so as to have 8 valence electrons. This is known as the **octet rule**.

Octet Rule



Octet Rule

- **Metals** lose electrons to take on the electron structure of the previous noble gas. In doing so, they form positive ions (**cations**).

- **Nonmetals** tend to lose electrons to take on the electron structure of the next noble gas. In doing so they form negative ions (**anions**).

Octet Rule

TABLE 5.2 Symbols and Names for Some Simple (Monatomic) Ions

Group	Element	Name of Ion	Symbol for Ion
1A	Hydrogen	Hydrogen ion	H^+
	Lithium	Lithium ion	Li^+
	Sodium	Sodium ion	Na^+
	Potassium	Potassium ion	K^+
2A	Magnesium	Magnesium ion	Mg^{2+}
	Calcium	Calcium ion	Ca^{2+}
3A	Aluminum	Aluminum ion	Al^{3+}
5A	Nitrogen	Nitride ion	N^{3-}
6A	Oxygen	Oxide ion	O^{2-}
	Sulfur	Sulfide ion	S^{2-}
7A	Fluorine	Fluoride ion	F^-
	Chlorine	Chloride ion	Cl^-
	Bromine	Bromide ion	Br^-
	Iodine	Iodide ion	I^-
1B	Copper	Copper(I) ion (cuprous ion)	Cu^+
		Copper(II) ion (cupric ion)	Cu^{2+}
	Silver	Silver ion	Ag^+
2B	Zinc	Zinc ion	Zn^{2+}
8B	Iron	Iron(II) ion (ferrous ion)	Fe^{2+}
		Iron(III) ion (ferric ion)	Fe^{3+}

Formulas and Names of Binary Ionic Compounds

- **Cations**: The charge of a cation from the representative elements is the same as the family number.
- The names of cations are simply the name of the element.

Examples:

Na^{+} = sodium ion

Mg^{2+} = magnesium ion

Formulas and Names of Binary Ionic Compounds

- **Anions**: The charge of an anion from the representative elements is equal to the family number – 8.
- The names of anions are the root name of the element plus the suffix –ide.

Examples:

Cl^{-} = chloride ion

O^{2-} = oxide ion

Formulas and Names of Binary Ionic Compounds

- To name the compounds of simple binary ionic compounds, simply name the ions.

Examples:

NaCl = sodium chloride

MgO = magnesium oxide

Formulas and Names of Binary Ionic Compounds

- Many transition metals can exhibit more than one ionic charge. Roman numerals are used to denote the charge of such ions.

  Examples:

  Fe^{2+} = iron II ion

  Fe^{3+} = iron III ion

  Cu^{2+} = copper II ion

  Cu^{+} = copper I ion

Covalent Bonds

- Many nonmetallic elements react by **sharing electrons** rather than by gaining or losing electrons.
- When two atoms share a pair of electrons, a **covalent bond** is formed.
- Atoms can share one, two, or three pairs of electrons; forming **single, double**, and **triple bonds**.

Names of Binary Covalent Compounds

Binary covalent compounds are named by using a prefix to denote the number of atoms.

TABLE 5.3 Prefixes that Indicate the Number of Atoms of an Element in a Covalent Compound

Prefix	Number of Atoms
Mono-	1
Di-	2
Tri-	3
Tetra-	4
Penta-	5
Hexa-	6
Hepta-	7
Octa-	8
Nona-	9
Deca-	10

Names of Binary Covalent Compounds

- Binary covalent compounds have two names:

first name = prefix + name of 1st element
(note: If the first element has only one atom, prefix mono is dropped.)

second name = prefix + root name of second element + suffix –ide.

Names of Binary Covalent Compounds

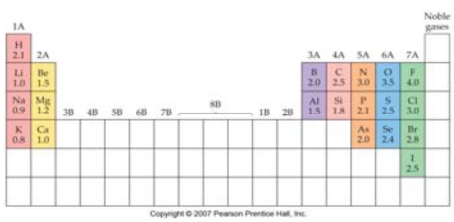
- Examples:

SBr_4
sulfur tetrabromide

P_2O_3
diphosphorus trioxide

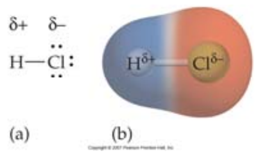
Electronegativity

Electronegativity is a measure of an atom's attraction for the electrons in a bond.



Polar Covalent Bonds

When two atoms of differing **electronegativity** form a bond, the bonding electrons are drawn closer to the atom with the higher electronegativity. Such a bond exhibits a separation of charge and is called a **polar covalent bond**.



Bond Polarity

The difference in electronegativity between two bonded atoms can be used to determine the type of bond. As a rule of thumb:

ΔEN	Type of Bond
<0.5	nonpolar covalent
between 0.5 and 2.0	polar covalent
greater than 2.0	ionic

Polyatomic Ions

Polyatomic ions are groups of covalently bonded atoms with a charge.

TABLE 5.4 Some Common Polyatomic Ions

Charge	Name	Formula
1+	Ammonium ion	NH_4^+
	Hydronium ion	H_3O^+
1−	Hydrogen carbonate (bicarbonate) ion	HCO_3^-
	Hydrogen sulfate (bisulfate) ion	HSO_4^-
	Acetate ion	$CH_3CO_2^-$ (or $C_2H_3O_2^-$)
	Nitrite ion	NO_2^-
	Nitrate ion	NO_3^-
	Cyanide ion	CN^-
	Hydroxide ion	OH^-
	Dihydrogen phosphate ion	$H_2PO_4^-$
	Permanganate ion	MnO_4^-
2−	Carbonate ion	CO_3^{2-}
	Sulfate ion	SO_4^{2-}
	Chromate ion	CrO_4^{2-}
	Monohydrogen phosphate ion	HPO_4^{2-}
	Oxalate ion	$C_2O_4^{2-}$
	Dichromate ion	$Cr_2O_7^{2-}$
3−	Phosphate ion	PO_4^{3-}

Writing Formulas Using Polyatomic Ions

When writing formulas for compounds containing polyatomic ions, it may be necessary to use parentheses to denote the proper number of the ion.

Example: calcium nitrate

Ca^{2+} NO_3^-

$Ca(NO_3)_2$

Naming Compounds with Polyatomic Ions

When naming compounds with polyatomic ions, simply name the ions in order.

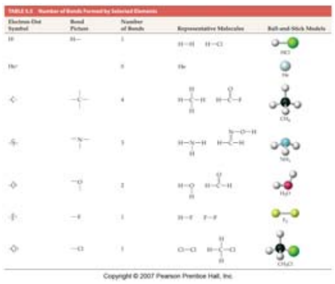
Example: $(NH_4)_2SO_4$

ammonium sulfate

Rules for Sketching Lewis Structures

1. Count valence electrons.
2. Sketch a skeletal structure.
3. Place electrons as lone pairs around outer atoms to fulfill the octet rule.
4. Subtract the electrons used so far from the total number of valence electrons. Place any remaining electrons around the central atom.
5. If the central atom lacks an octet, move one or more lone pairs from an outer atom to a double or triple bond to complete an octet.

Sketching Lewis Structures



Odd Electron Molecules: Free Radicals

An atom or molecule with an unpaired electron is known as a **free radical**.

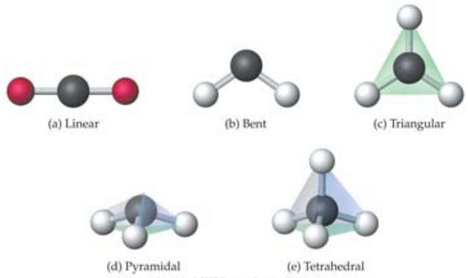
Examples include:

NO NO_2 ClO_2

Molecular Shapes: The VSEPR Theory

The **V**alence **S**hell **E**lectron **P**air **R**epulsion (**VSEPR**) Theory predicts the shape of molecules and polyatomic ions based on repulsions of electron pairs on central atoms.

Molecular Shapes: The VSEPR Theory



Molecular Shapes: The VSEPR Theory

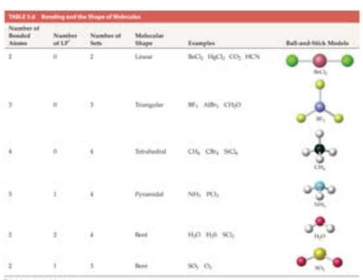


TABLE [illegible] Bonding and the Shape of Molecules

Number of Bonded Atoms	Number of LP*	Number of Sets	Molecular Shape	Examples	Ball-and-Stick Models
2	0	2	Linear	$BeCl_2$ $HgCl_2$ CO_2 HCN	$BeCl_2$
3	0	3	Triangular	BF_3 $AlBr_3$ CH_2O	BF_3
4	0	4	Tetrahedral	CH_4 CBr_4 $SiCl_4$	CH_4
3	1	4	Pyramidal	NH_3 PCl_3	NH_3
2	2	4	Bent	H_2O H_2S SCl_2	H_2O
2	1	3	Bent	SO_2 O_3	SO_2

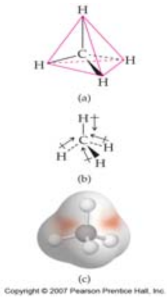
*LP: Lone pair(s) of electrons.

Shapes and Properties: Polar and Nonpolar Molecules

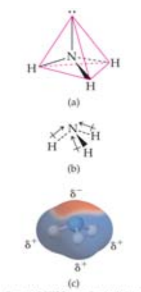
In order for a molecule to be polar, two conditions must be met:

1. It must have polar bonds.
2. The bonds must be arranged such that a separation of charge exists.

Shapes and Properties: Polar and Nonpolar Molecules



Shapes and Properties: Polar and Nonpolar Molecules



Shapes and Properties: Polar and Nonpolar Molecules