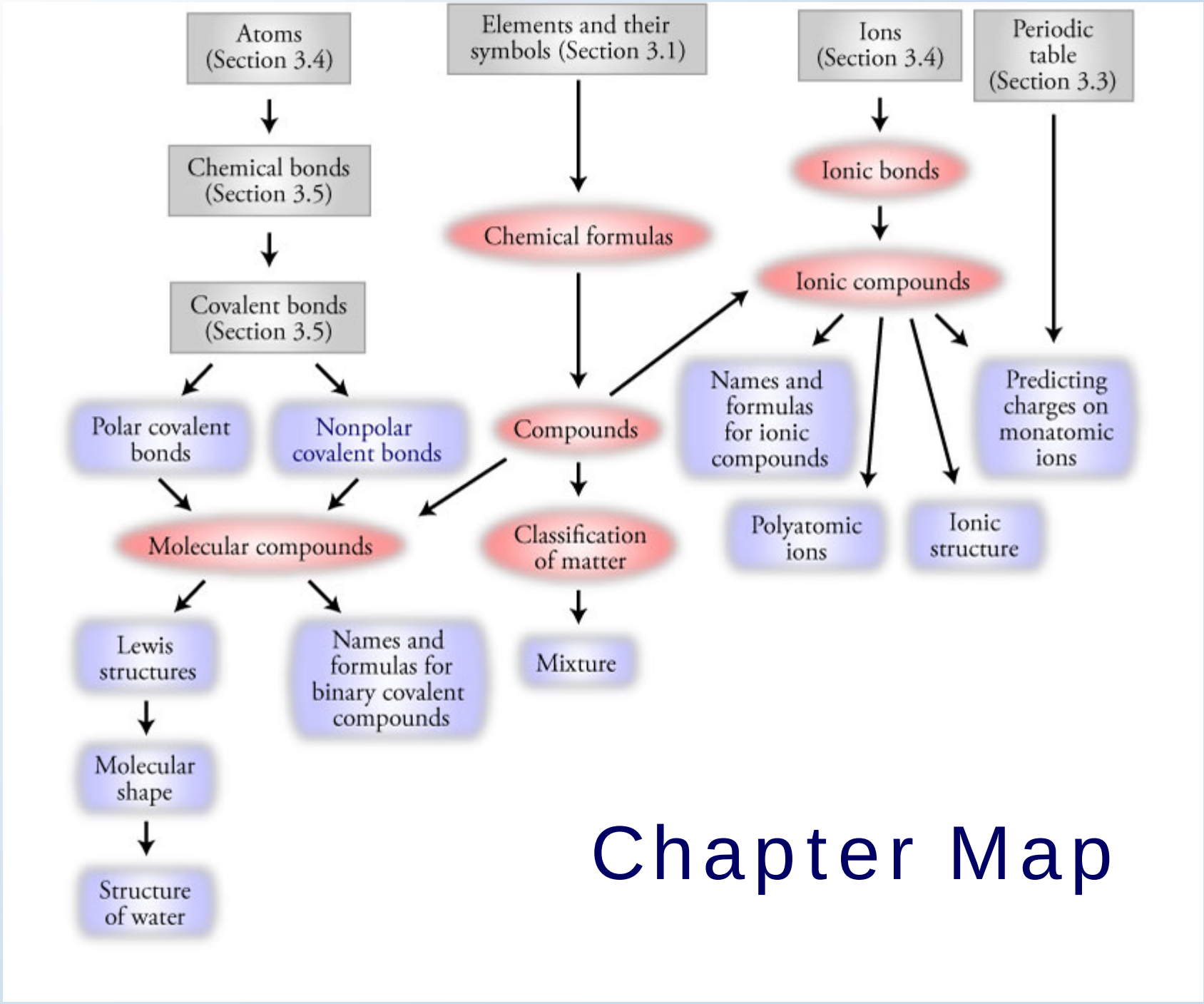
Chapter 4

Chemical Compounds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Ions (Section 3.4)
Periodic table (Section 3.3)
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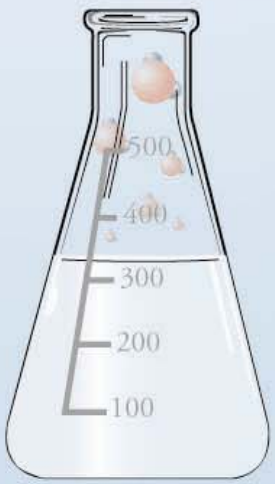
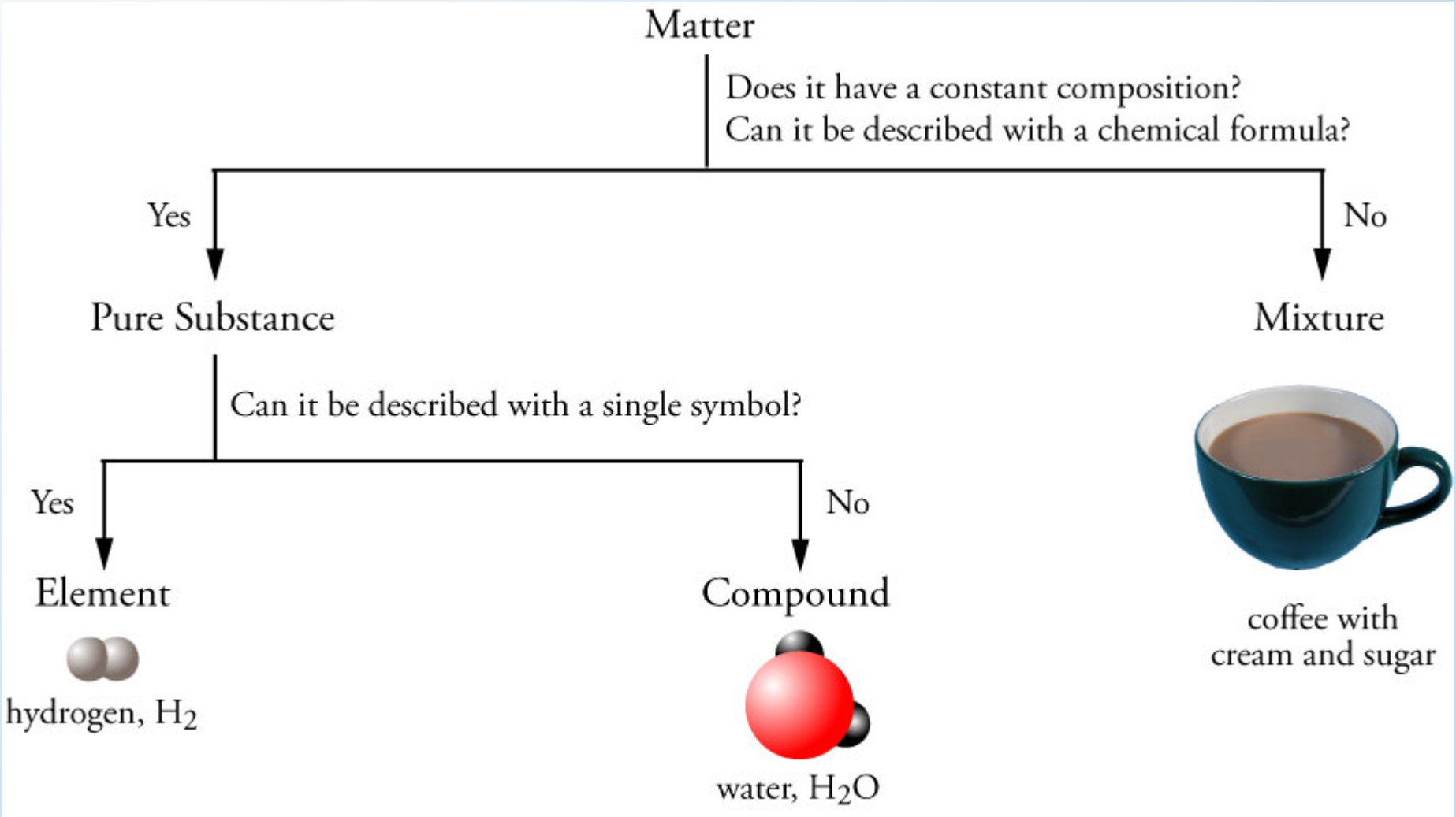
Chapter Map

Elements, Compounds, and Mixtures



- **Element:** A substance that cannot be chemically converted into simpler substances; a substance in which all of the atoms have the same number of protons and therefore the same chemical characteristics.
- **Compound:** A substance that contains two or more elements, the atoms of these elements always combining in the same whole-number ratio.
- **Mixture:** A sample of matter that contains two or more pure substances (elements and compounds) and has variable composition.

Classification of Matter



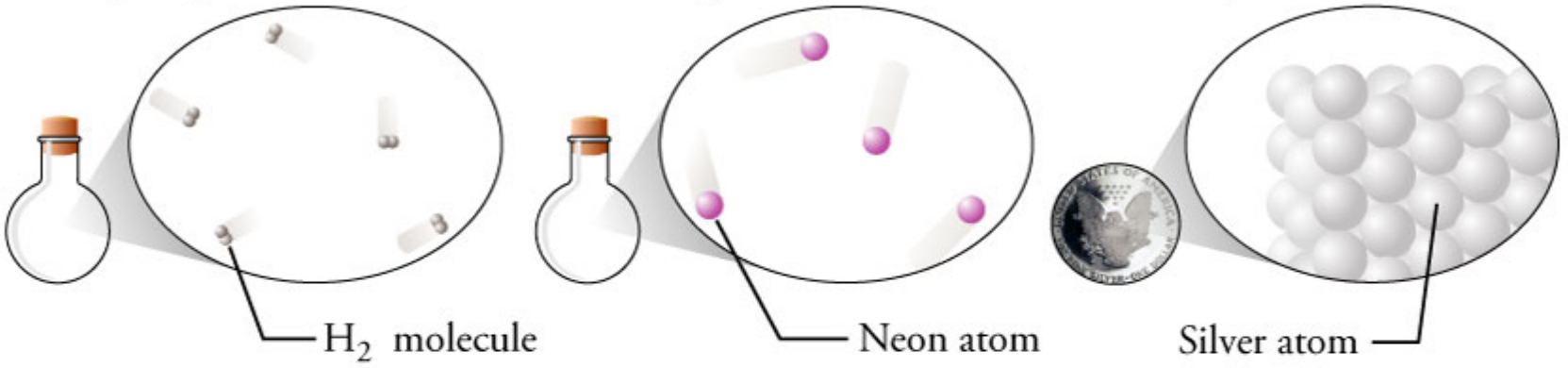
Elements and Compounds

ELEMENTS

Hydrogen is composed of molecules with 2 hydrogen atoms.

Neon is composed of independent atoms.

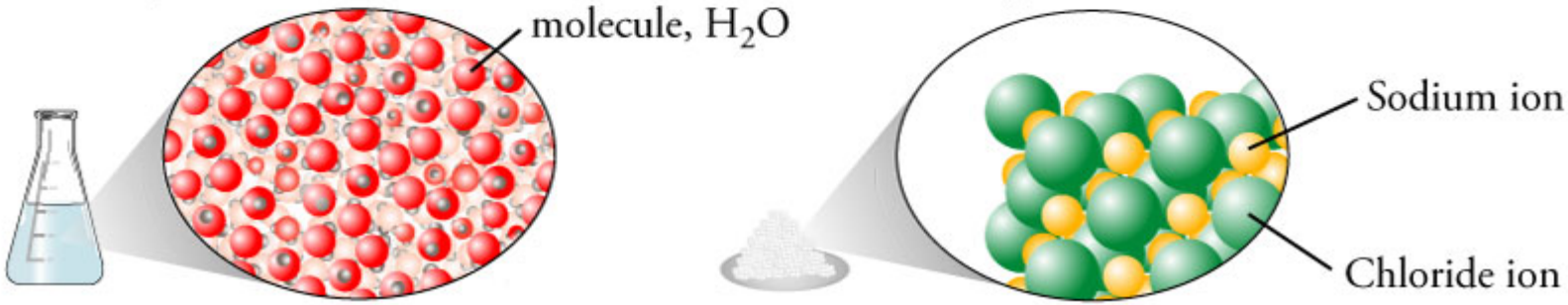
Silver exists as an assembly of silver atoms.



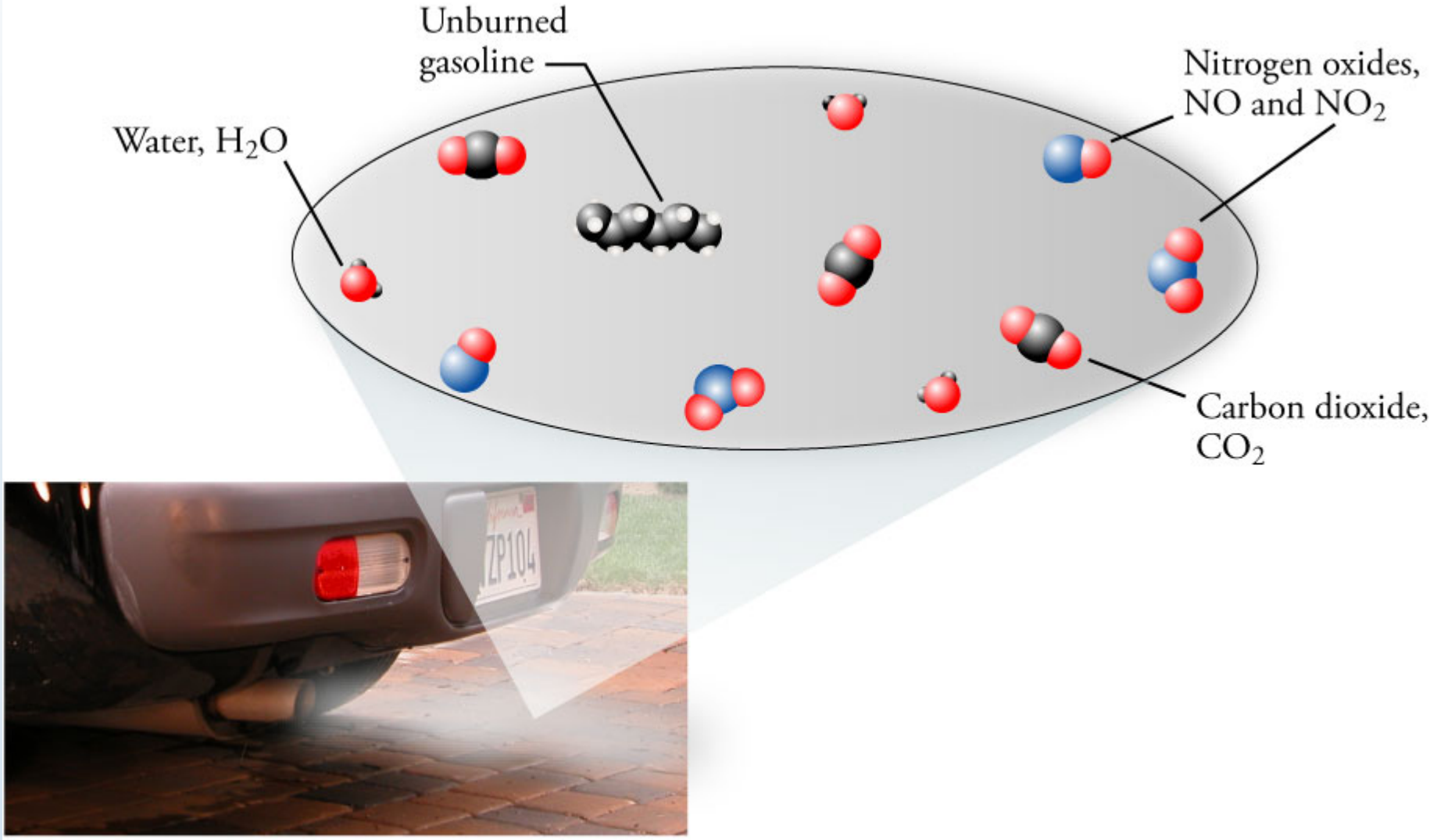
COMPOUNDS

Water is composed of molecules that contain one oxygen atom and two hydrogen atoms.

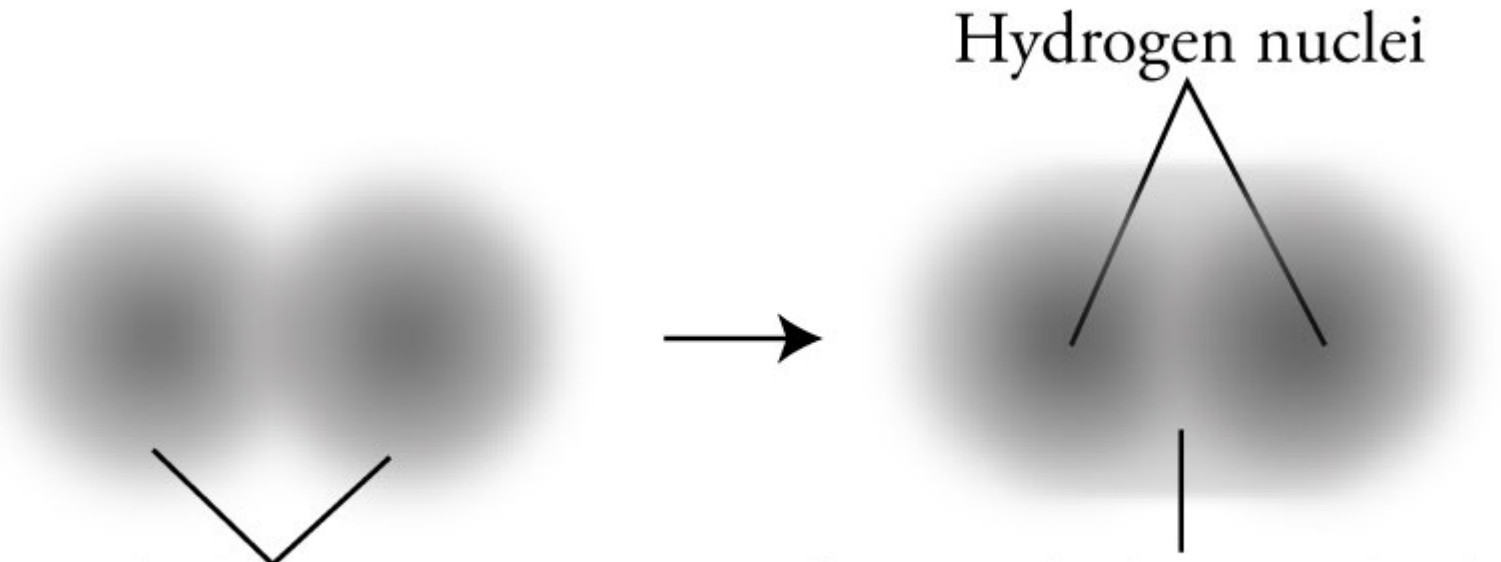
Sodium chloride exists as an assembly of sodium and chloride ions, always in a one-to-one ratio.



Exhaust – a Mixture



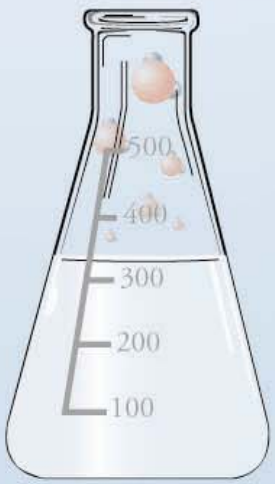
Covalent Bond Formation



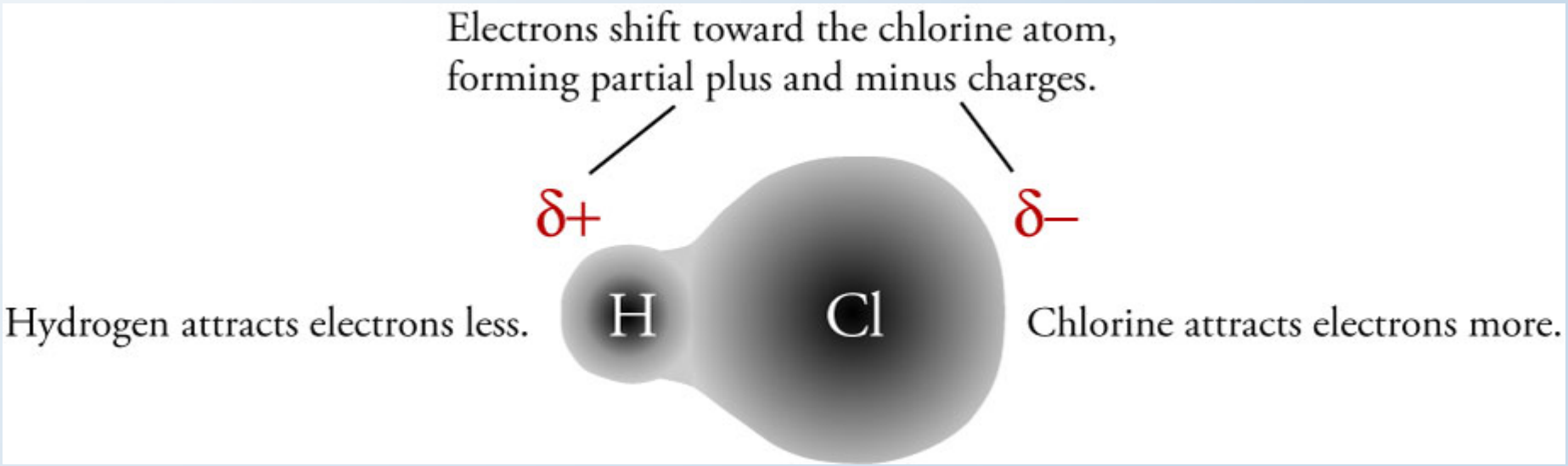
Two hydrogen atoms interact to form one hydrogen molecule

Covalent Bond

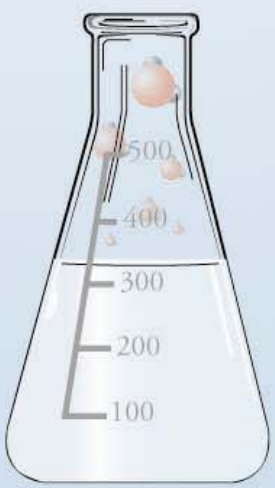
- A link between atoms due to the sharing of two electrons. This bond forms between atoms of two nonmetallic elements.
  - If the electrons are shared equally, there is a even distribution of the negative charge for the electrons in the bond, so there is no partial charges on the atoms. The bond is called a ***nonpolar covalent bond***.
  - If one atom in the bond attracts electrons more than the other atom, the electron negative charge shifts to that atom giving it a partial negative charge. The other atom loses negative charge giving it a partial positive charge. The bond is called a ***polar covalent bond***.



Polar Covalent Bond

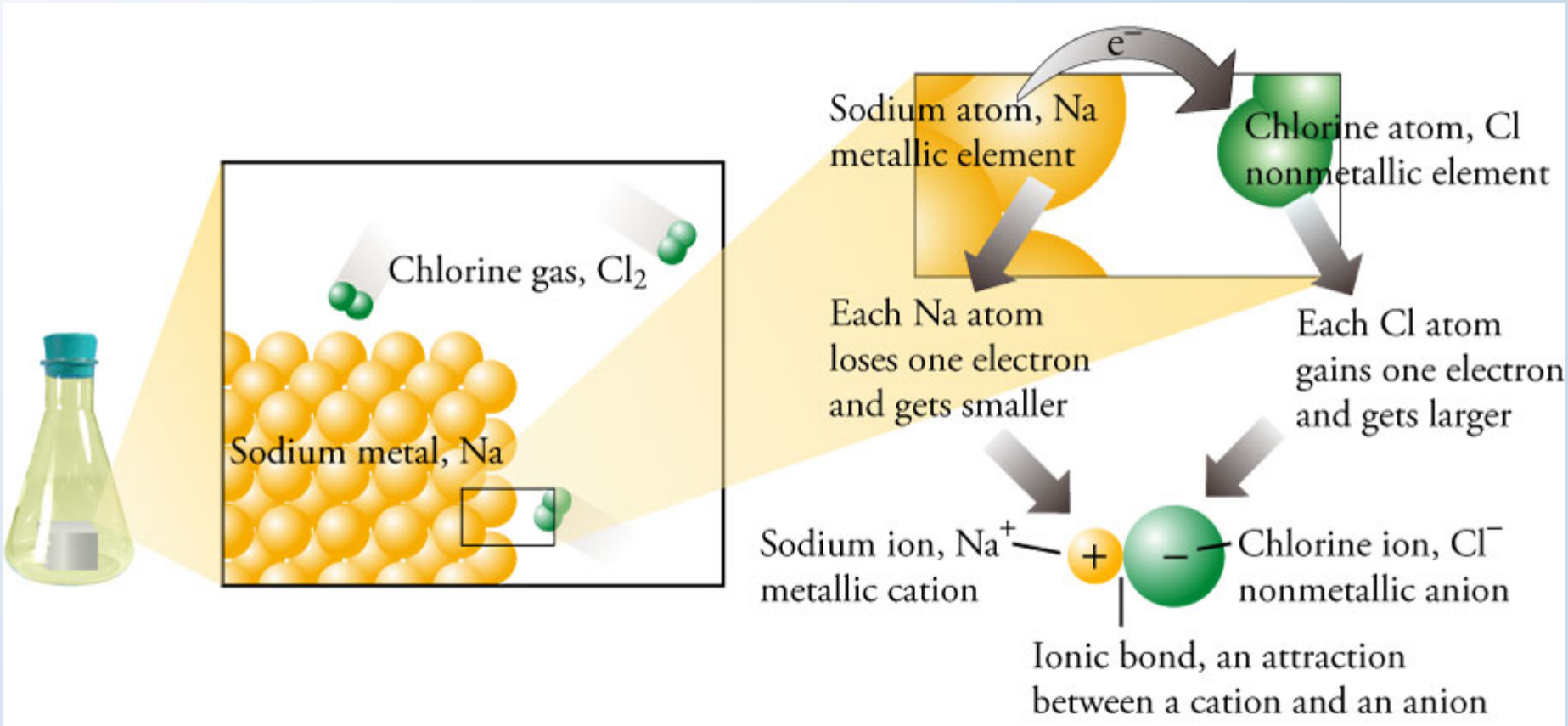


Ionic Bond

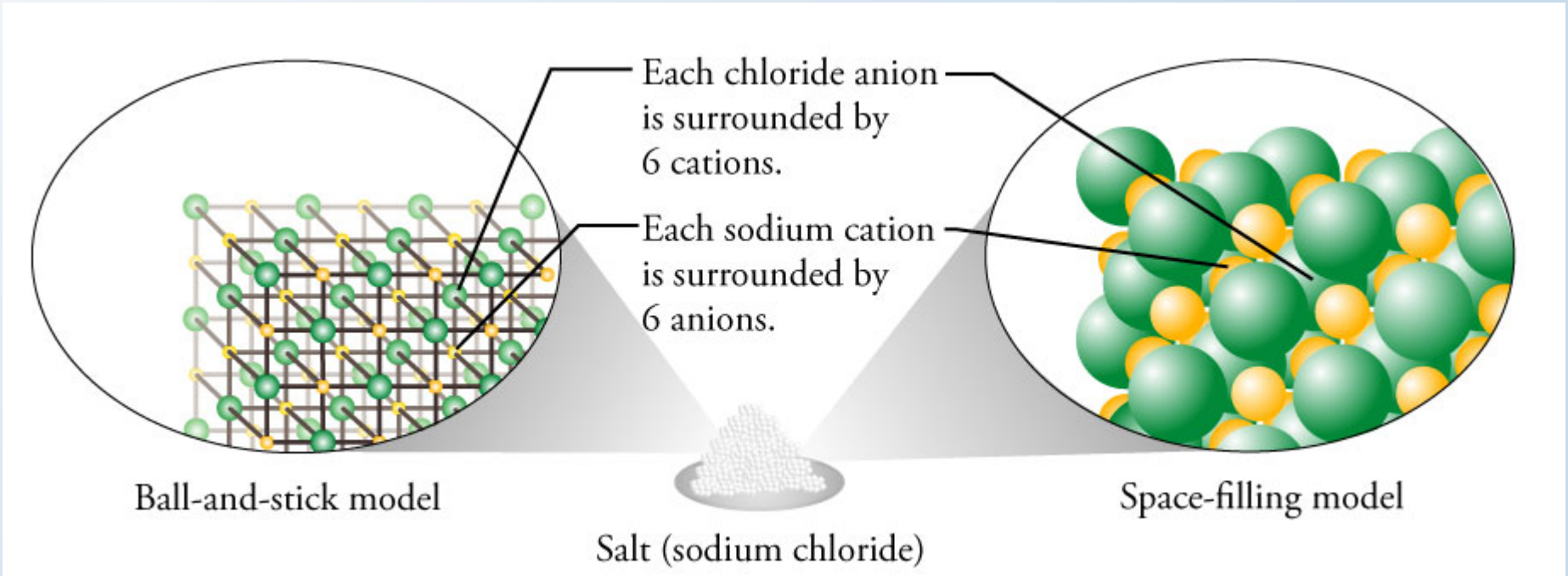


- The attraction between cation and anion.
- Atoms of nonmetallic elements often attract electrons so much more strongly than atoms of metallic elements that one or more electrons are transferred from the metallic atom (forming a positively charged particle or ***cation***), to the nonmetallic atom (forming a negatively charged particle or ***anion***).
- For example, an uncharged chlorine atom can pull one electron from an uncharged sodium atom, yielding Cl^- and Na^+.

Ionic Bond Formation



Sodium Chloride, NaCl, Structure

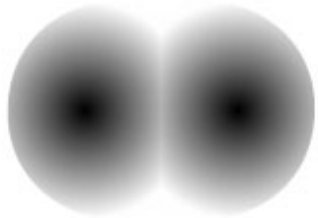


Bond Types

Nonpolar Covalent Bond

Equal sharring of electrons

Both atoms attract electrons equally (or nearly so).

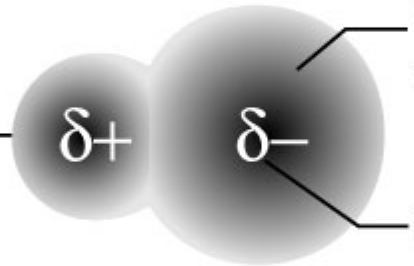


No significant charges form.

Polar Covalent Bond

Unequal sharing of electrons

Partial positive charge



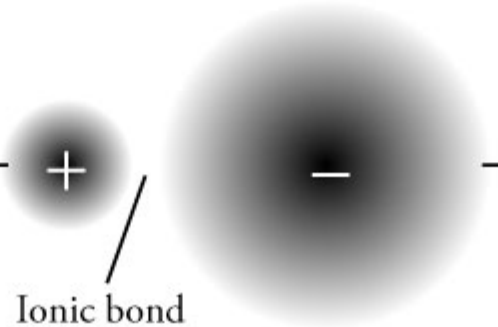
This atom attracts electrons more strongly.

Partial negative charge.

Ionic Bond

Strong attraction between positive and negative charges.

This atom loses one or more electrons and gains a positive charge.

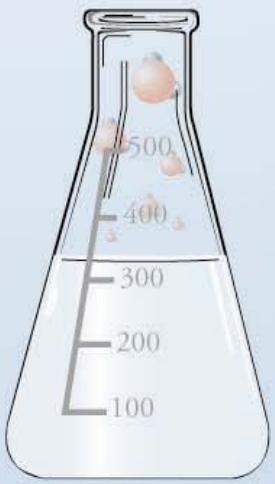


Ionic bond

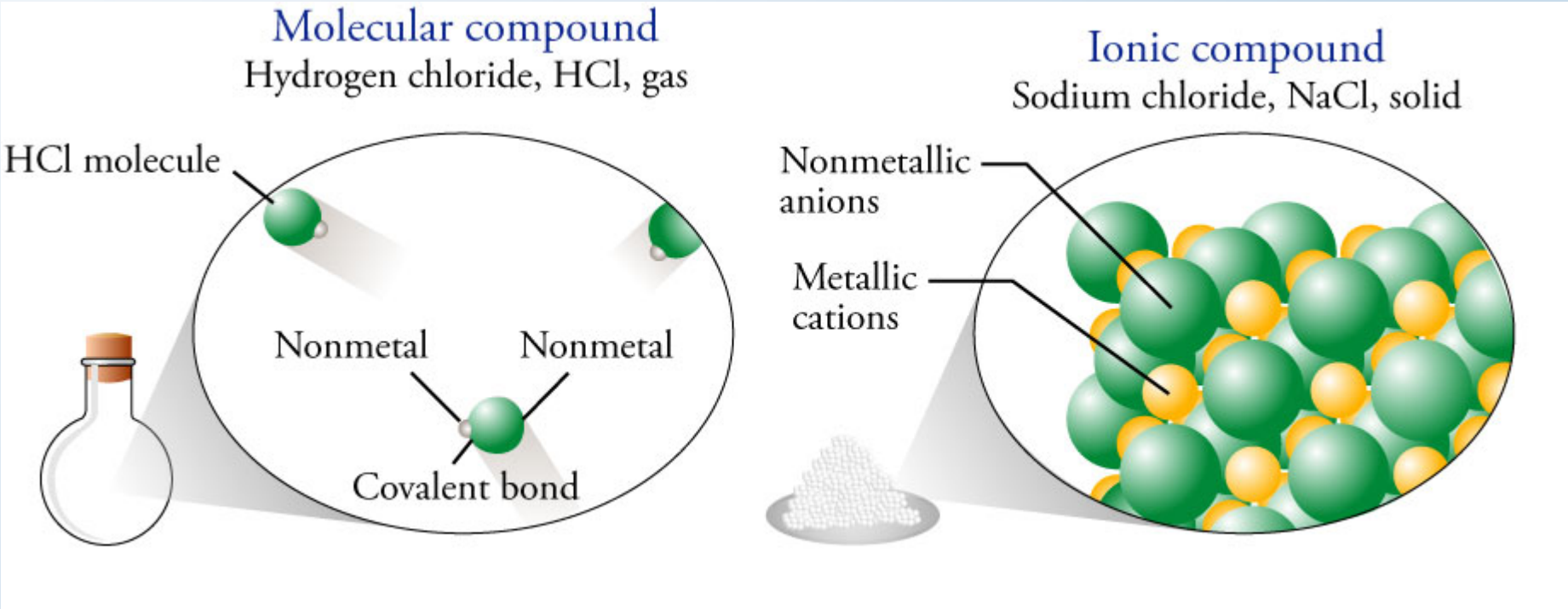
This atom attracts electrons so much more strongly than the other atom that it gains one or more electrons and gains a negative charge.

Types of Compounds

- All nonmetallic atoms usually leads to all covalent bonds, which from molecules. These compounds are called ***molecular compounds***.
- Metal-nonmetal combinations usually lead to ionic bonds and ***ionic compounds***.

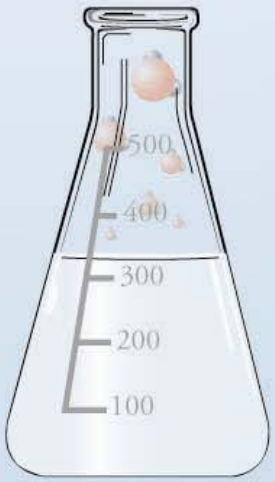


Classification of Compounds



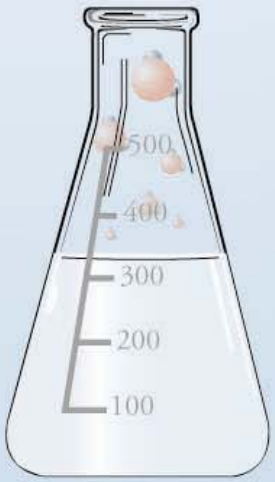
Summary

- **Nonmetal-nonmetal** combinations (e.g. HCl)
  - Covalent bonds
  - Molecules
  - Molecular Compound
- **Metal-nonmetal** combinations (e.g. NaCl)
  - Probably ionic bonds
  - Alternating cations and anions in crystal structure
  - Ionic compound

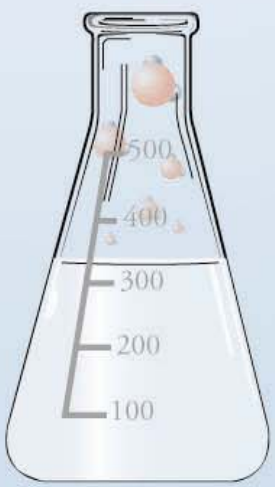


Valence Electrons

- The valence electrons for each atom are the most important electrons in the formation of chemical bonds.
- The number of valence electrons for the atoms of each element is equal to the element's A-group number on the periodic table.
- Covalent bonds often form to pair unpaired electrons and give the atoms of the elements other than hydrogen and boron eight valence electrons (an octet of valence electrons).



Valence Electrons and A-Group Numbers



One valence electron

Number of valence electrons equals the A-group number

					8A
1 H	3A	4A	5A	6A	7A	2 He
	5 B	6 C	7 N	8 O	9 F	10 Ne
			15 P	16 S	17 Cl	18 Ar
			33 As	34 Se	35 Br	36 Kr
				52 Te	53 I	54 Xe

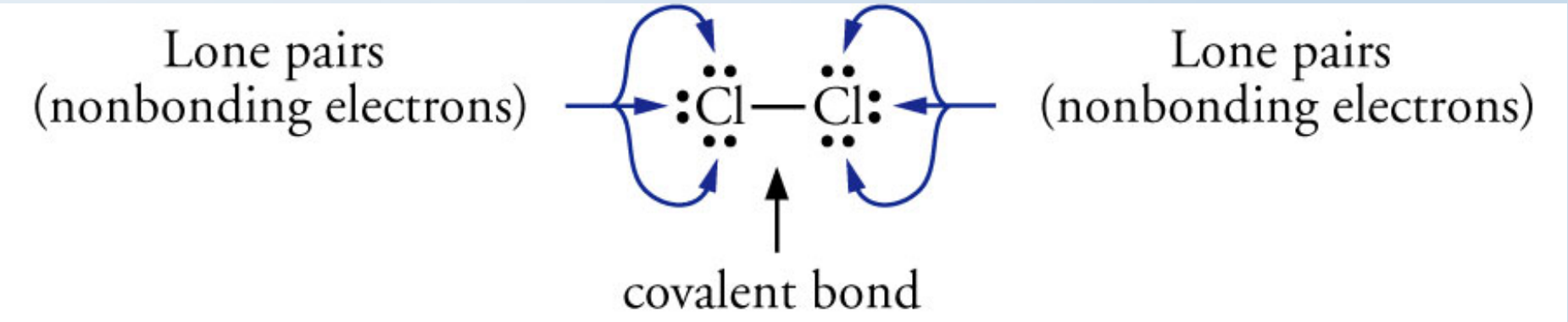
Electron-Dot Symbols and Lewis Structures

- **Electron-dot symbols** show valence electrons.

- Nonbonding pairs of valence electrons are called ***lone pairs***.

Lewis Structures

- ***Lewis structures*** represent molecules using element symbols, lines for bonds, and dots for lone pairs.

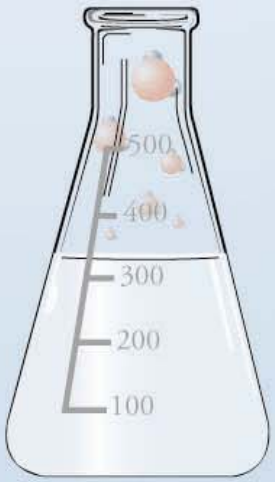


Most Common Bonding Patterns for Nonmetals

Element	# Bonds	# lone pairs
H	1	0
C	4	0
N, P	3	1
O, S, Se	2	2
F, Cl, Br, I	1	3

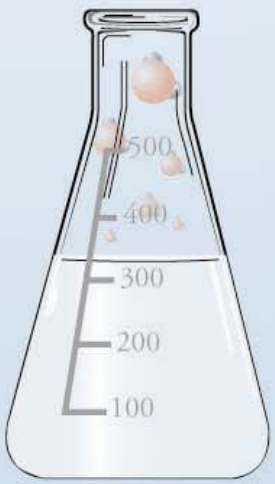
Drawing Lewis Structures

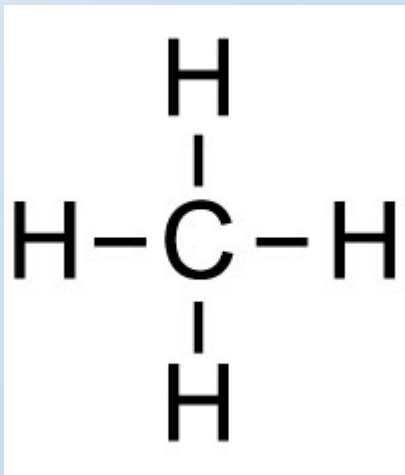
- Chapter 12 describes procedure that allows you to draw Lewis structures for many different molecules.
- Many Lewis structures can be drawn by attempting to give each atom in a molecule its most common bonding pattern.



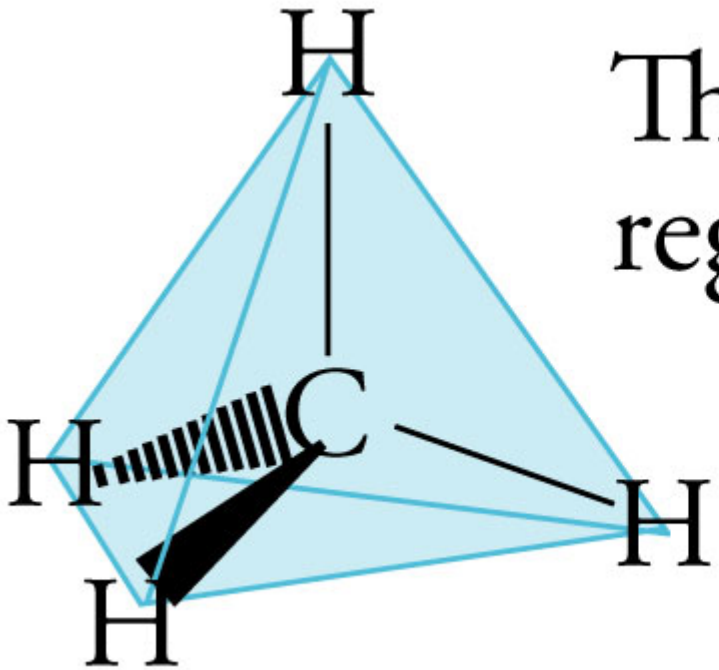
Lewis Structure for Methane, CH_4

- Carbon atoms usually have 4 bonds and no lone pairs.
- Hydrogen atoms have 1 bond and no lone pairs.



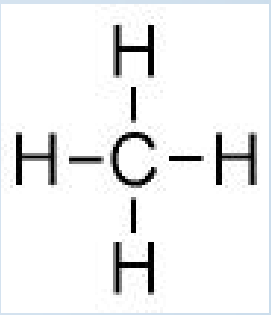


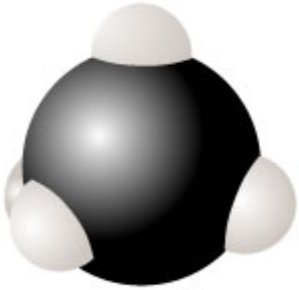
Tetrahedral Geometry



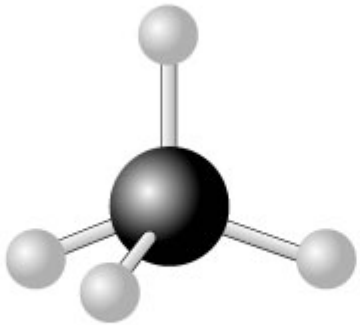
The blue shape is a regular tetrahedron.

Methane, CH_4

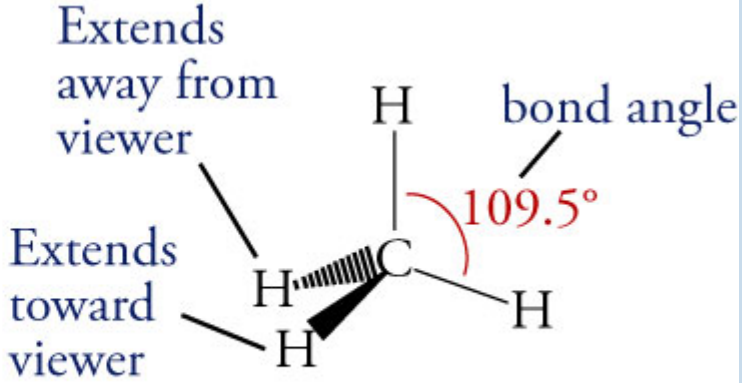




Space-filling model



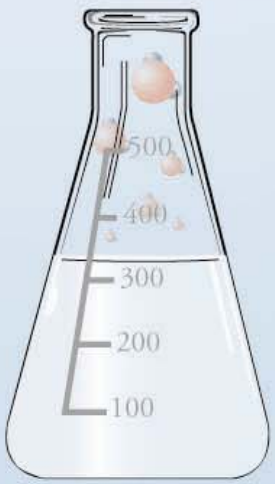
Ball-and-stick model

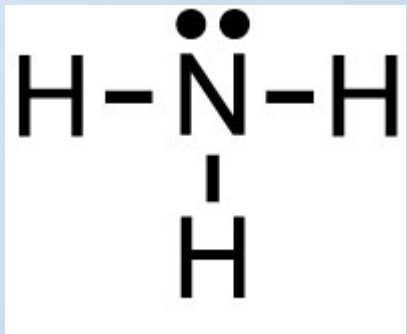


Geometric Sketch

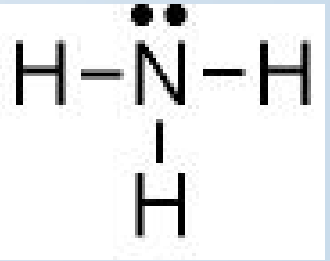
Lewis Structure for Ammonia, NH_3

- Nitrogen atoms usually have 3 bonds and 1 lone pair.
- Hydrogen atoms have 1 bond and no lone pairs.

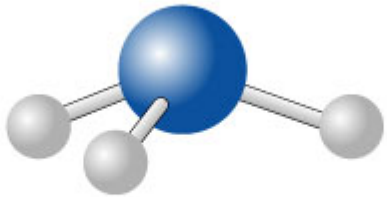




Ammonia, NH_3



Space-filling model

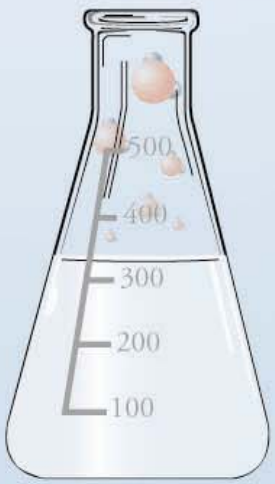


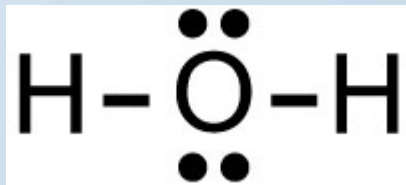
Ball-and-stick model

Geometric sketch

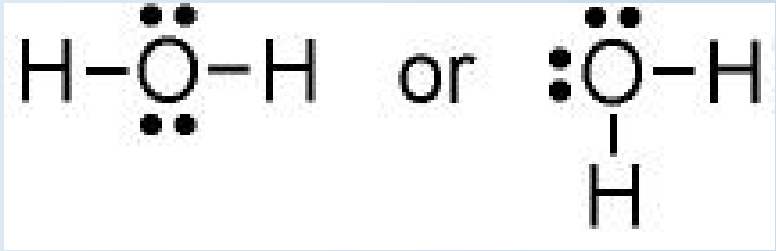
Lewis Structure for Water, H_2O

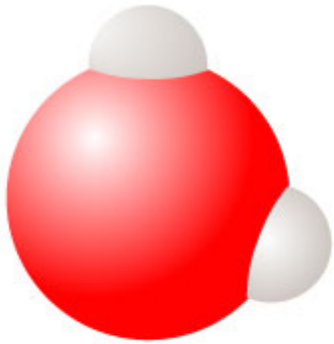
- Oxygen atoms usually have 2 bonds and 2 lone pairs.
- Hydrogen atoms have 1 bond and no lone pairs.



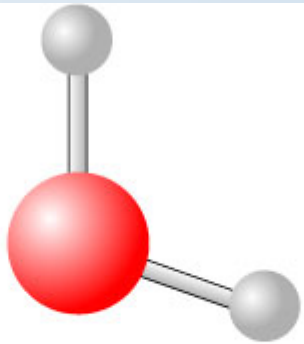


Water, H_2O

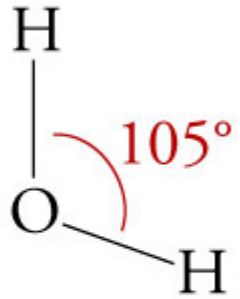




Space-filling model

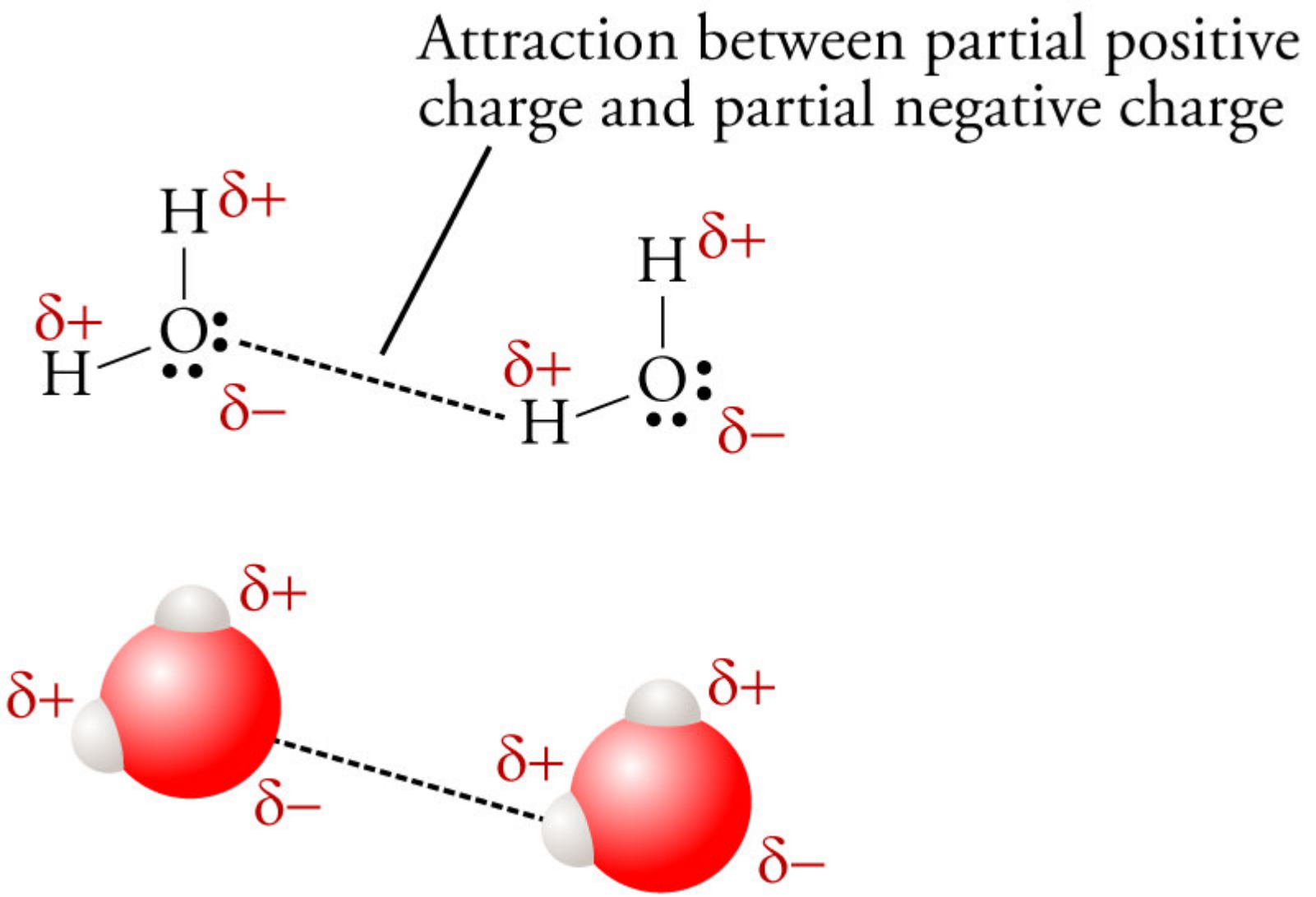


Ball-and-stick model

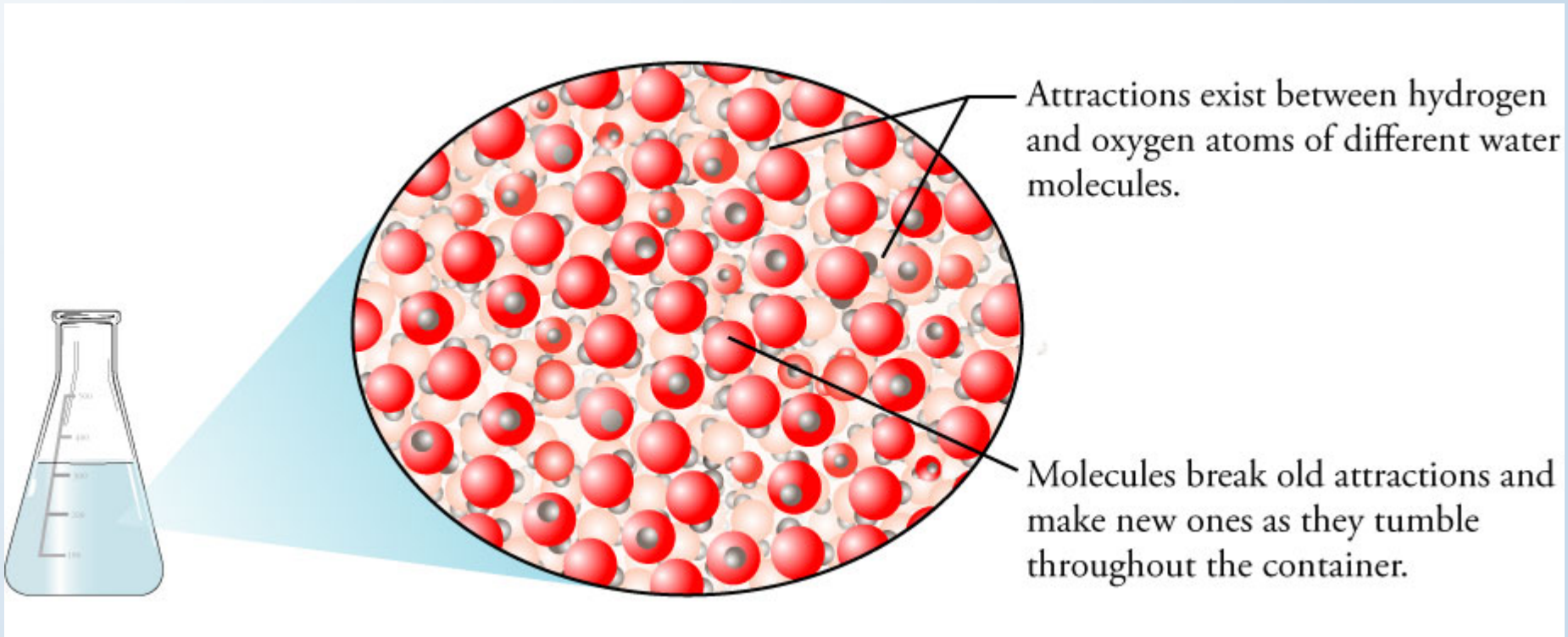


Geometric Sketch

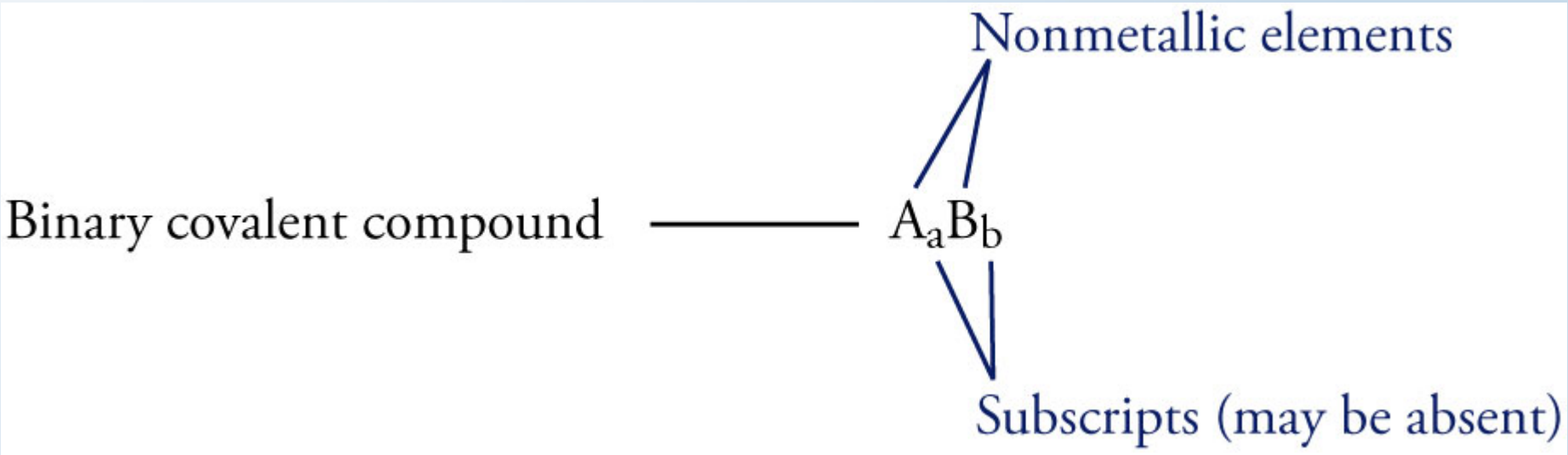
Water Attractions



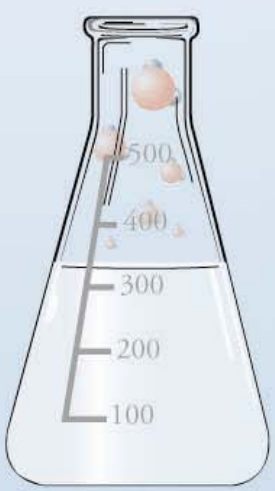
Liquid Water



Binary Covalent

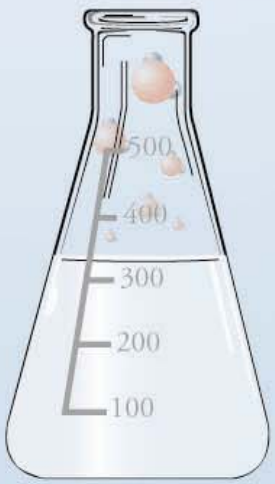


Common Names



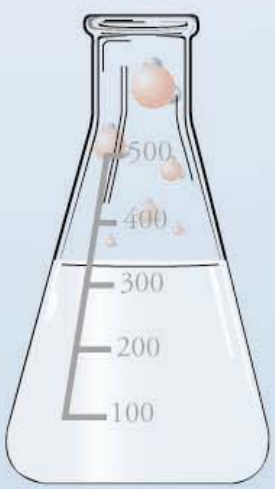
- H_2O, water
- NH_3, ammonia
- CH_4, methane
- C_2H_6, ethane
- C_3H_8, propane

Naming Binary Covalent Compounds



- If the subscript for the first element is greater than one, indicate the subscript with a prefix.
  - We do not write mono- on the first name.
  - Leave the "a" off the end of the prefixes that end in "a" and the “o” off of mono- if they are placed in front of an element that begins with a vowel (oxygen or iodine).
- Follow the prefix with the name of the first element in the formula.

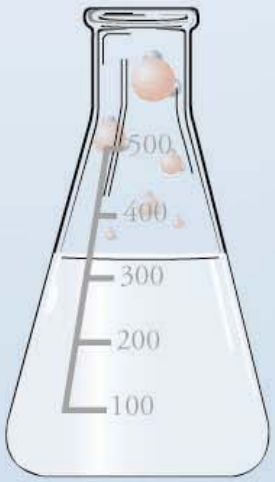
Naming Binary Covalent Compounds



- Write a prefix to indicate the subscript for the second element.
- Write the root of the name of the second symbol in the formula.
- Add -ide to the end of the name.

Prefixes

mon(o)	hex(a)
di	hept(a)
tri	oct(a)
tetr(a)	non(a)
pent(a)	dec(a)



Roots of Nonmetals

H hydr-

C carb-

N nitr-

P phosph-

O ox-

S sulf-

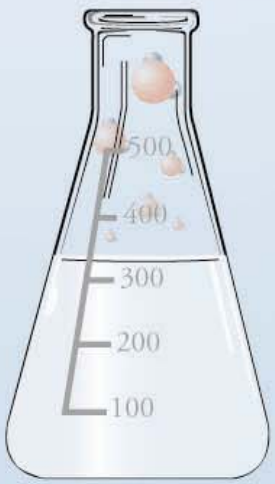
Se selen-

F fluor-

Cl chlor-

Br brom-

I iod-

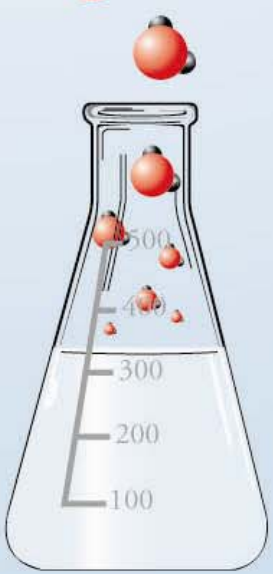


Forms of Binary Covalent Names

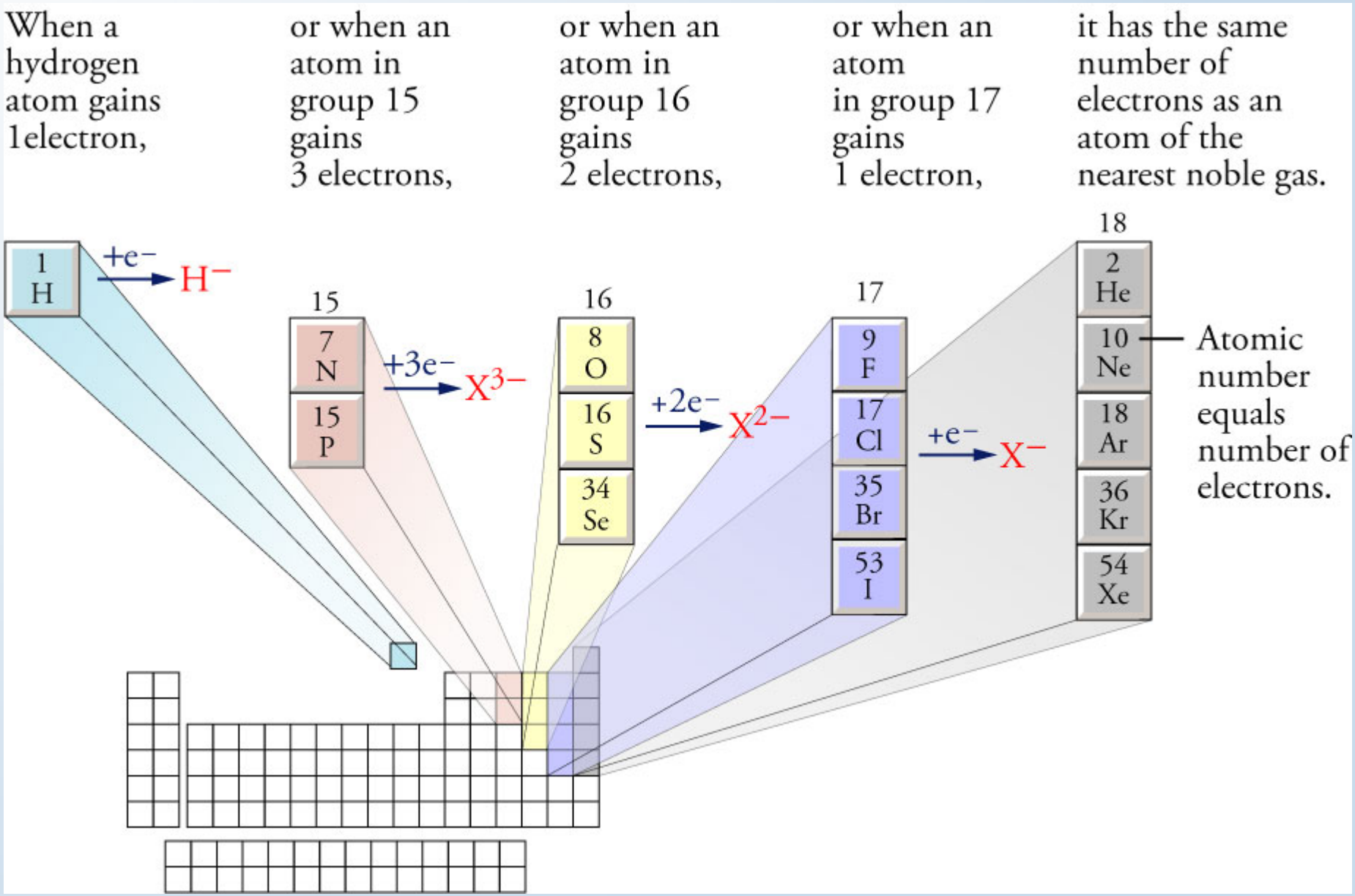
- prefix(name of nonmetal) prefix(root of name of nonmetal)ide
- (for example, dinitrogen pentoxide)
- or (name of nonmetal) prefix(root of name of nonmetal)ide
- (for example, carbon dioxide)
- or (name of nonmetal) (root of nonmetal)ide
- (for example, hydrogen fluoride)

Writing Binary Covalent Formulas

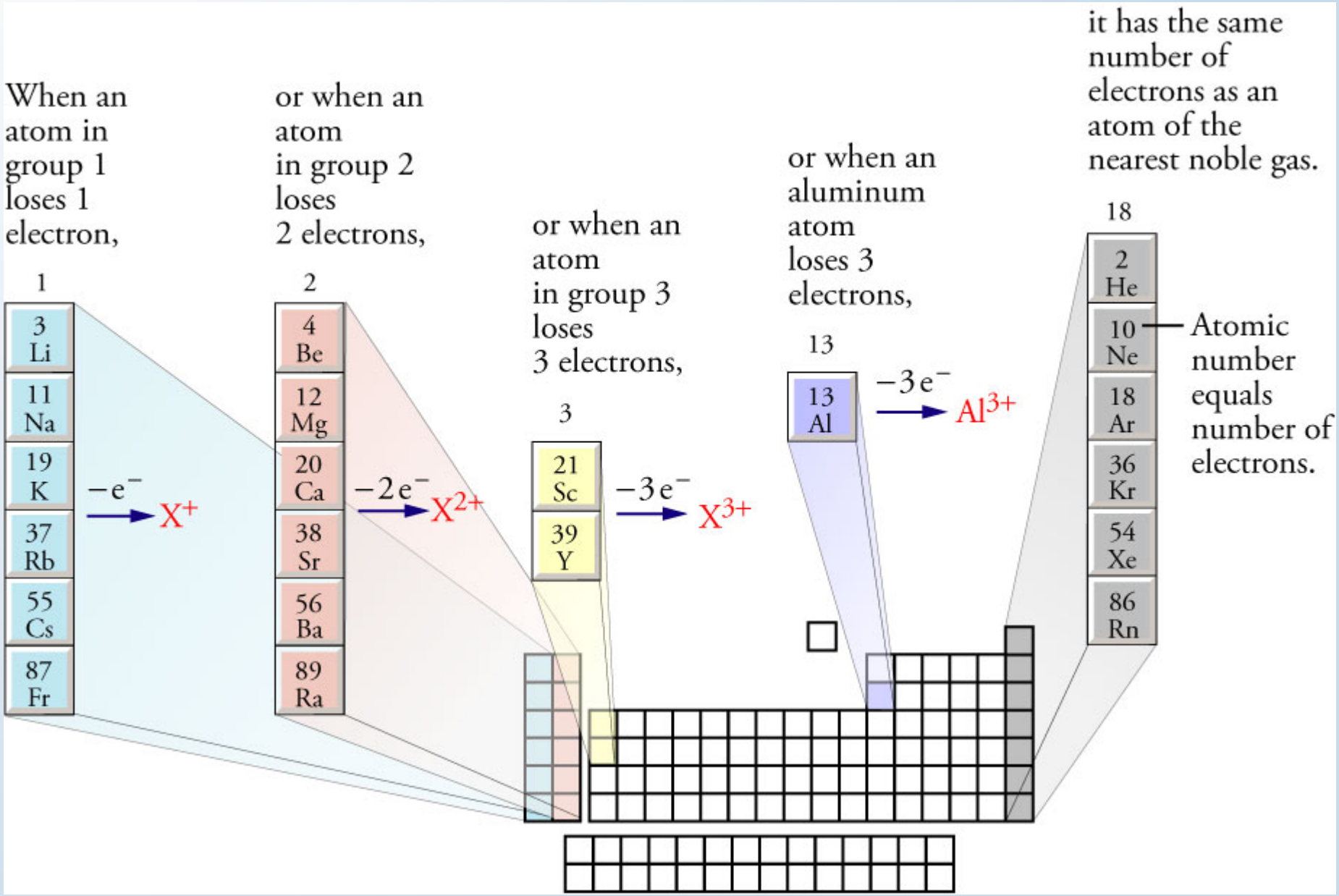
- Write the symbols for the elements in the order mentioned in the name.
- Write subscripts indicated by the prefixes. If the first part of the name has no prefix, assume it is mono-.



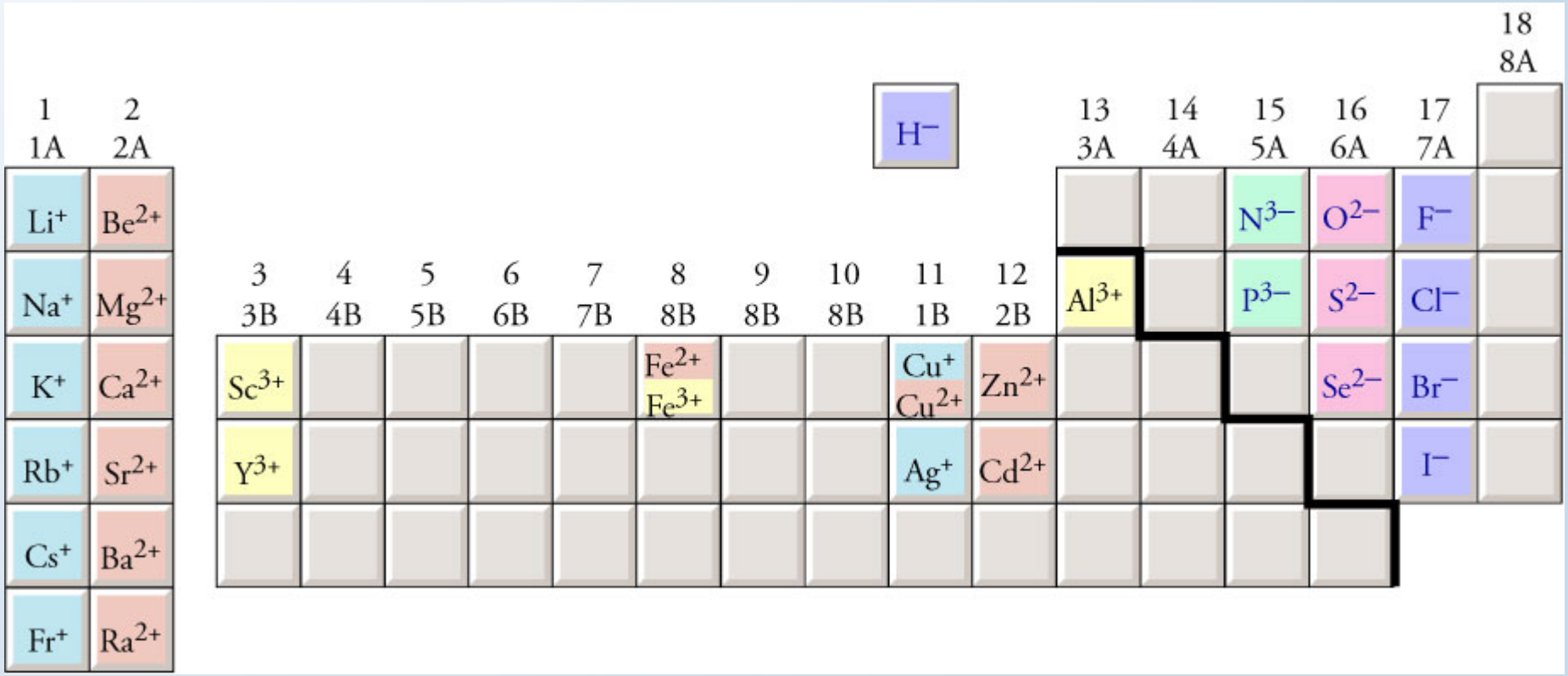
The Making of an Anion



The Making of a Cation

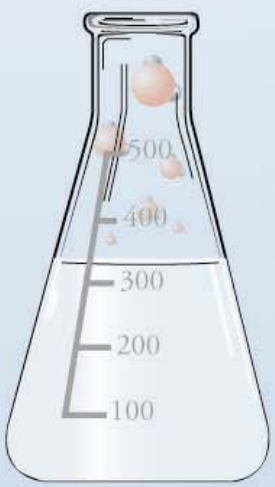


Monatomic Ions



Monatomic Ion Names

- Monatomic Cations
  - (name of metal)
    - Groups 1, 2, and 3 metals
    - Al^{3+}, Zn^{2+}, Cd^{2+}, Ag^{+}
  - (name of metal)(Roman numeral)
    - All metallic cations not mentioned above
- Monatomic Anions
  - (root of nonmetal name)ide



Monatomic Anions

Hydride H^-

Nitride N^{3-}

Phosphide P^{3-}

Oxide O^{2-}

Sulfide S^{2-}

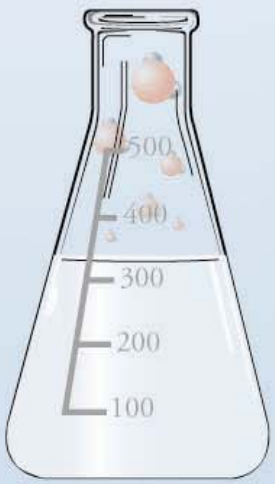
selenide Se^{2-}

fluoride F^-

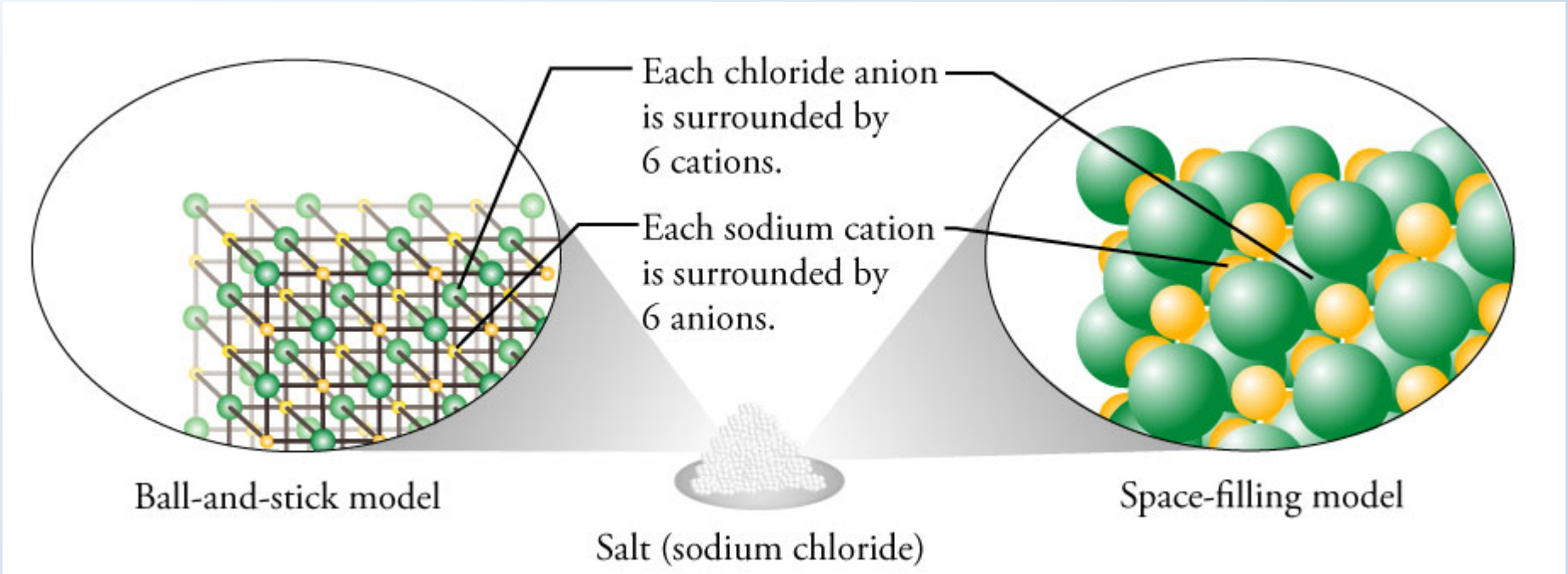
chloride Cl^-

bromide Br^-

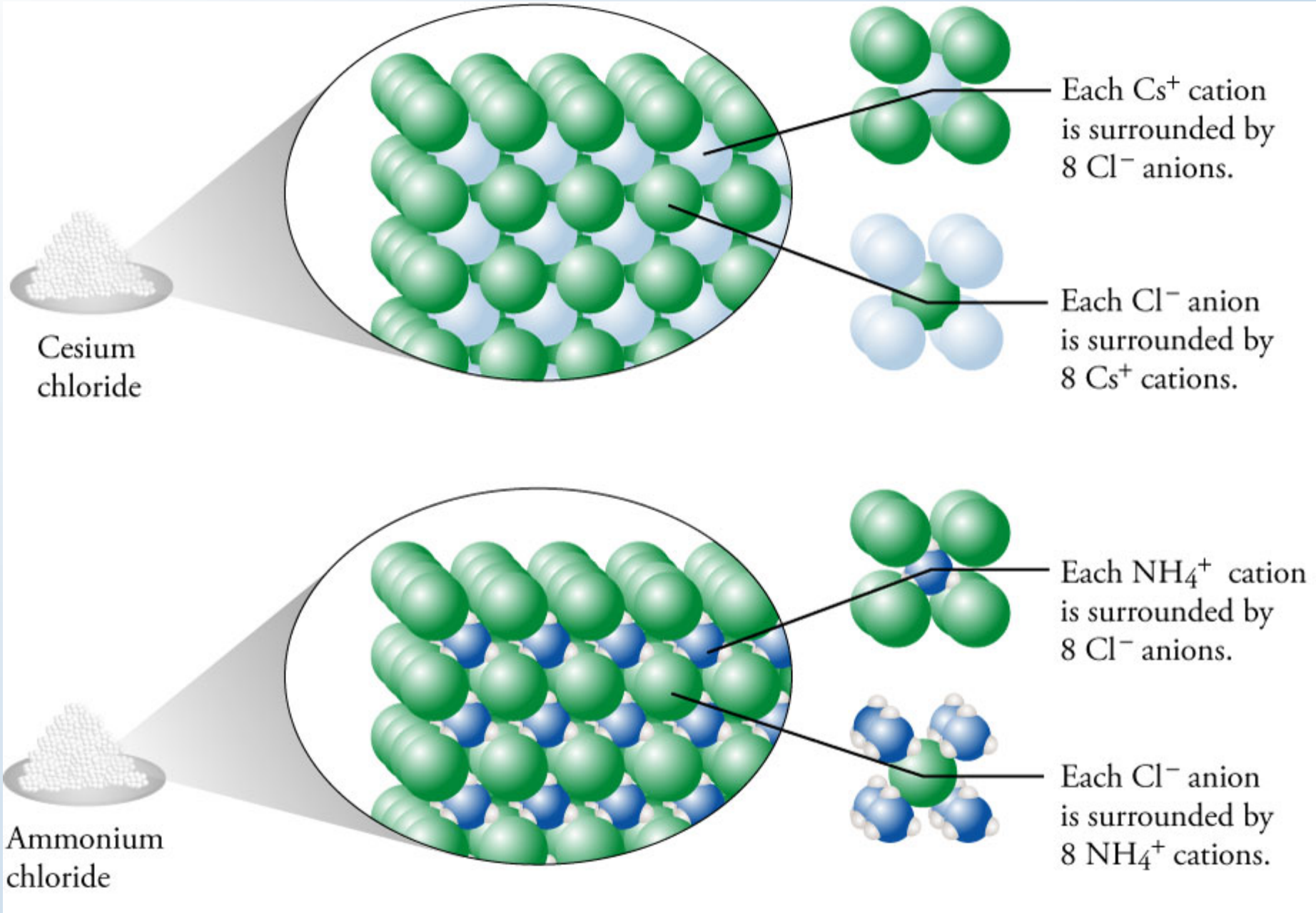
iodide I^-



Sodium Chloride, NaCl, Structure

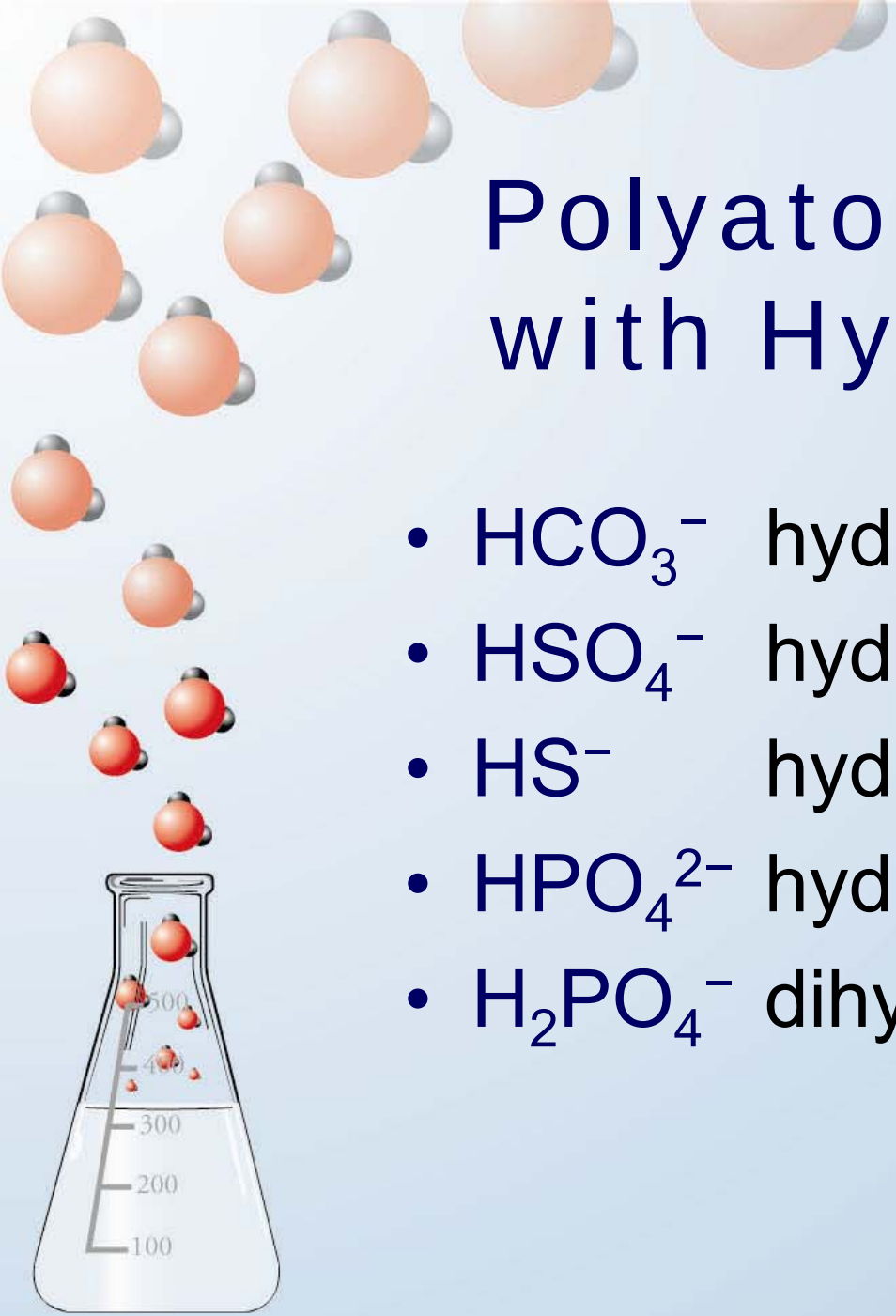


CsCl and NH_4Cl structure



Polyatomic Ions

Ion	Name	Ion	Name
NH_4^+	ammonium	NO_3^-	nitrate
OH^-	hydroxide	SO_4^{2-}	sulfate
CO_3^{2-}	carbonate	$C_2H_3O_2^-$	acetate
PO_4^{3-}	phosphate		

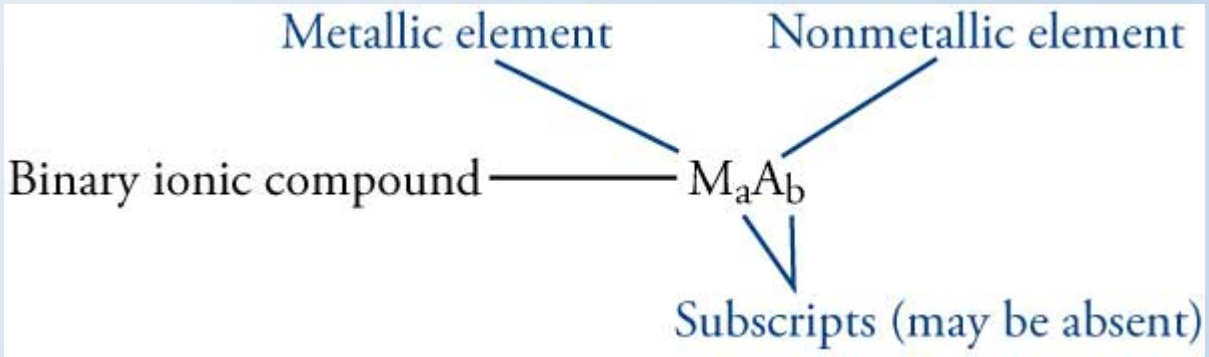


Polyatomic Ions with Hydrogen

- HCO_3^- hydrogen carbonate
- HSO_4^- hydrogen sulfate
- HS^- hydrogen sulfide
- HPO_4^{2-} hydrogen phosphate
- $H_2PO_4^-$ dihydrogen phosphate

Recognizing Ionic Compounds

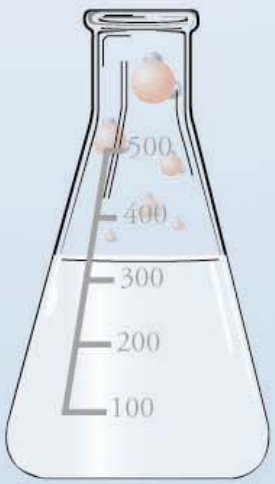
- Metal-nonmetal…binary ionic compound



- Metal-polyatomic ion
- Ammonium-nonmetal or ammonium polyatomic ion

Converting Ionic Formulas to Names

- Name
  - (name of cation) (name of anion)

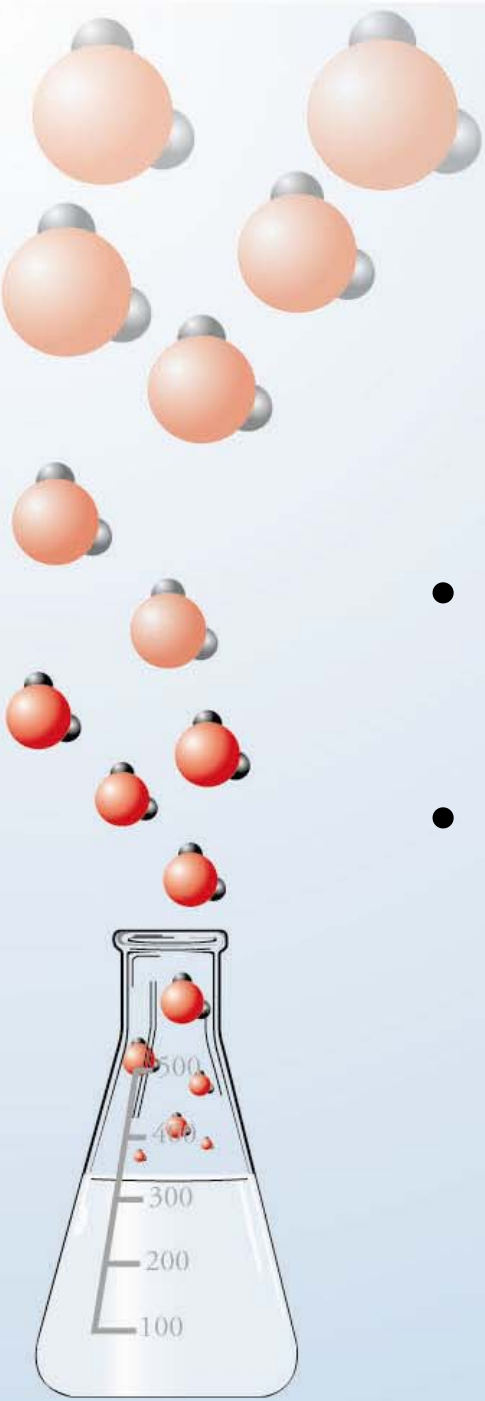


Cation Names

Metals with one possible charge (Al, Zn, Cd, and Groups 1, 2, 3)	name of metal
Metals with more than one possible charge (the rest)	name(Roman numeral)
polyatomic cations (e.g. ammonium)	name of polyatomic ion

Anion Names

monatomic anion	(root of nonmetal name)ide
polyatomic anion	name of polyatomic ion



Converting Ionic Names to Formulas

- Determine the formula, including charge, for the cation and anion.
- Determine the ratio of the ions that yields zero overall charge.