Chapter 3: Chemical Compounds

Sept 7, 2022

Chemistry Department, Cypress College

Class Announcements

- Inputted grades for up to the quiz
- When uploading assignments, be certain that the file is in a readable format e.g. docx, png, jpeg, and pdf
- Everyone performed pretty well on the quiz; average 4.1 and standard deviation 0.84
- This week only, any late assignments will not be penalized 50%; submit late assignments by the Sept 7th at 11:59pm
- Quiz #2 released this Thurs, Sept 8 at 11am and due Mon, Sept 12 at 11am
- Homework #2 released this Fri, Sept 9 at 11am and due Fri, Sept 16 at 11am

Lecture and Lab Weekly Agenda

Lab Section

- Finish Exp 1 - Laboratory Techniques
- There is no need to cut glassware and fire polishing
- Be familiarize with evaporation and filtration techniques
- Submit the lab worksheet due Sept 14 at 11:59pm; 50% late penalty

Lecture Section

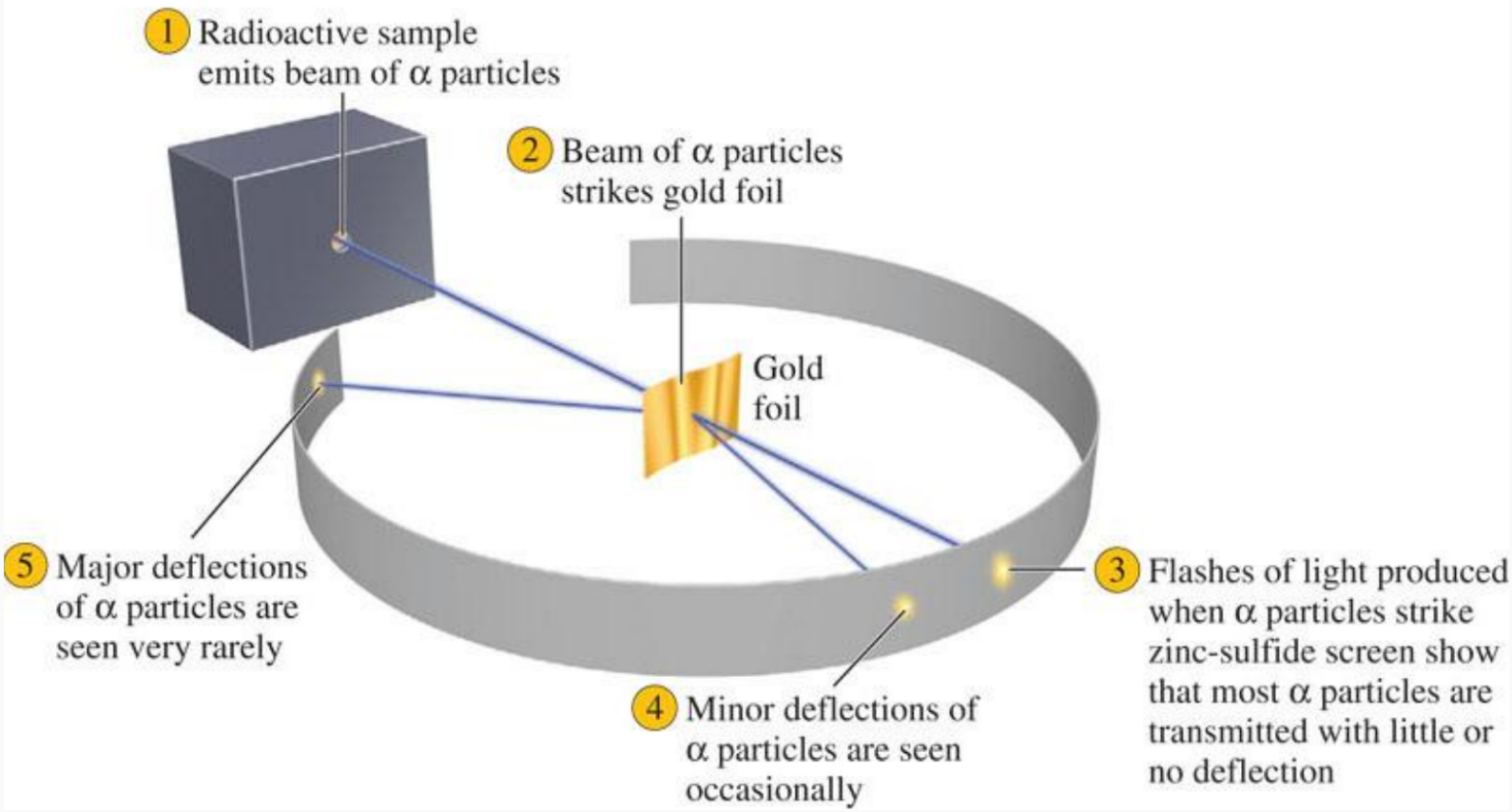
- Go over homework assignment; present your work for 1pt EC
- Review Ch 2 - Atoms, Ions, and the Periodic Table
- Begin lecture on Ch 3 - Chemical Compounds and Ch 8.1 - 8.2 - Types of Bonding

Outline

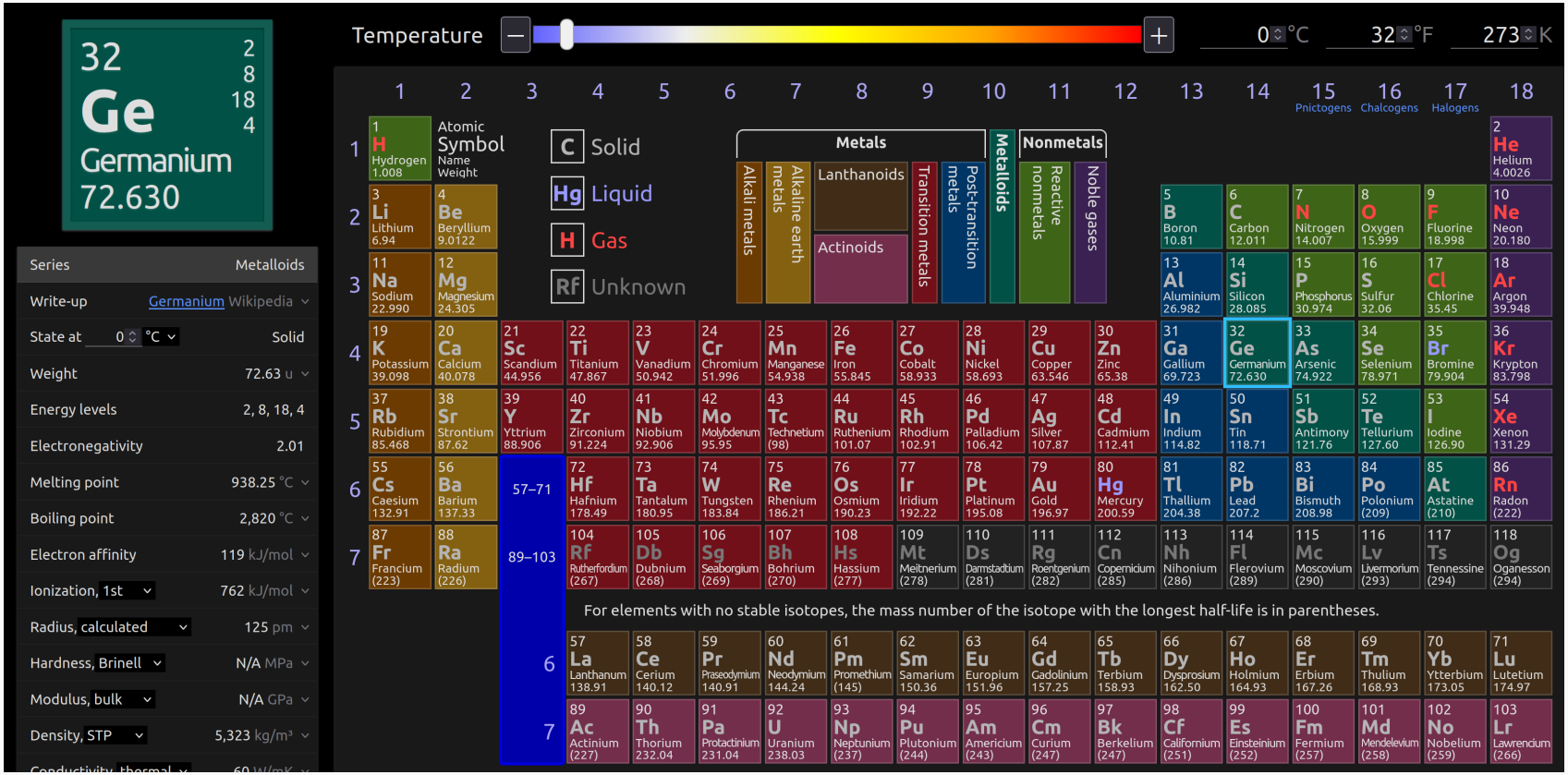
Atoms and Ions

- Conservation of mass and conservation of energy
- Anions (gain electron) and cations (lose electron)
- Made up of protons, neutrons, and electrons

J.J. Thompson's Plum Pudding Model



Review: Modern Period Table



Relative Atomic Mass

$$\text{Relative Atomic Mass} = (I_1 \times A_1) + (I_2 \times A_2) + \ldots \qquad (1)$$

where I is the mass of the isotope, and A is the relative abundance between 0 and 1

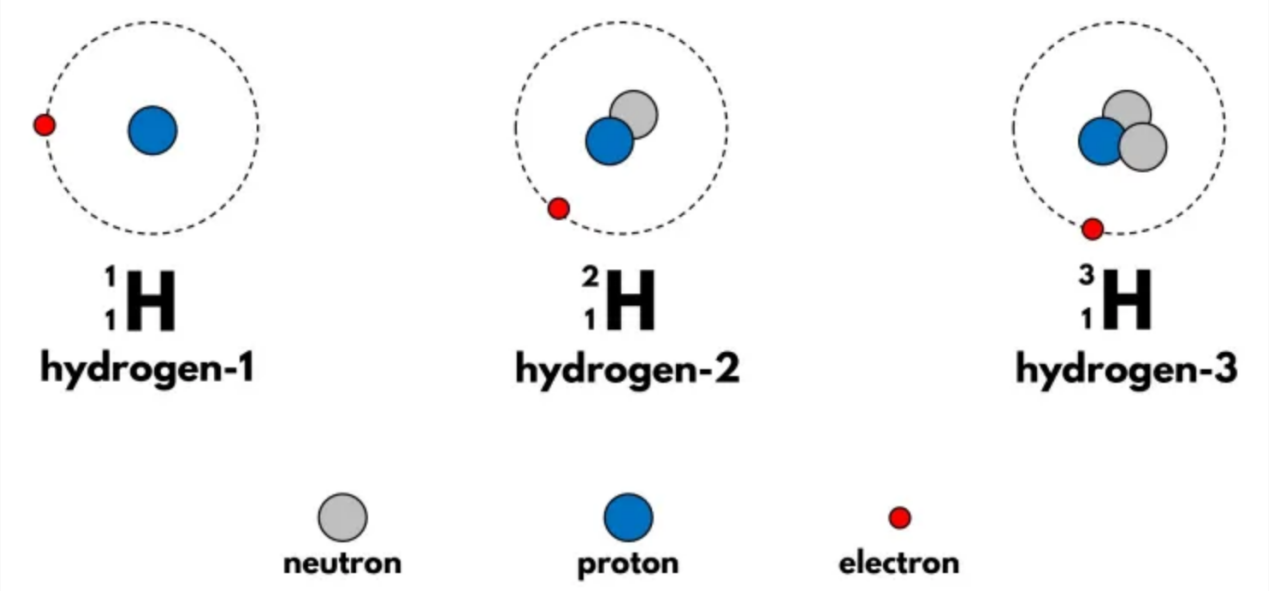
Defining Atomic Number and Mass

$$^{A}_{Z}X^{C} \tag{2}$$

where A is the atomic mass, Z is the atomic number, X is atomic symbol, and C is the overall charge

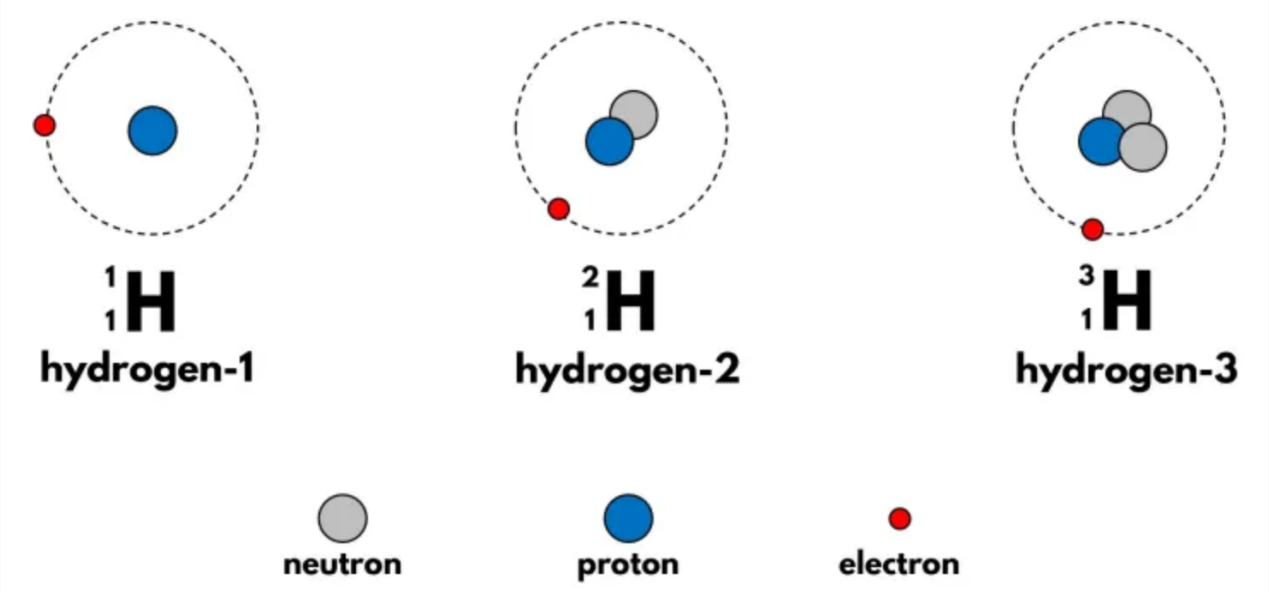
Isotopes - chemically same atom (same number of protons) but physically different (different number of neutrons)

Hydrogen Isotopes and Applications



- Hydrogen ($^{1}_{1}\mathrm{H}$), deuterium ($^{2}_{1}\mathrm{D}$), and tritium ($^{3}_{1}\mathrm{T}$) have relative abundances of 99.84%, 0.0156%, and trace amounts, respectively
- **Q:** Which hydrogen isotope is the highest in abundance?

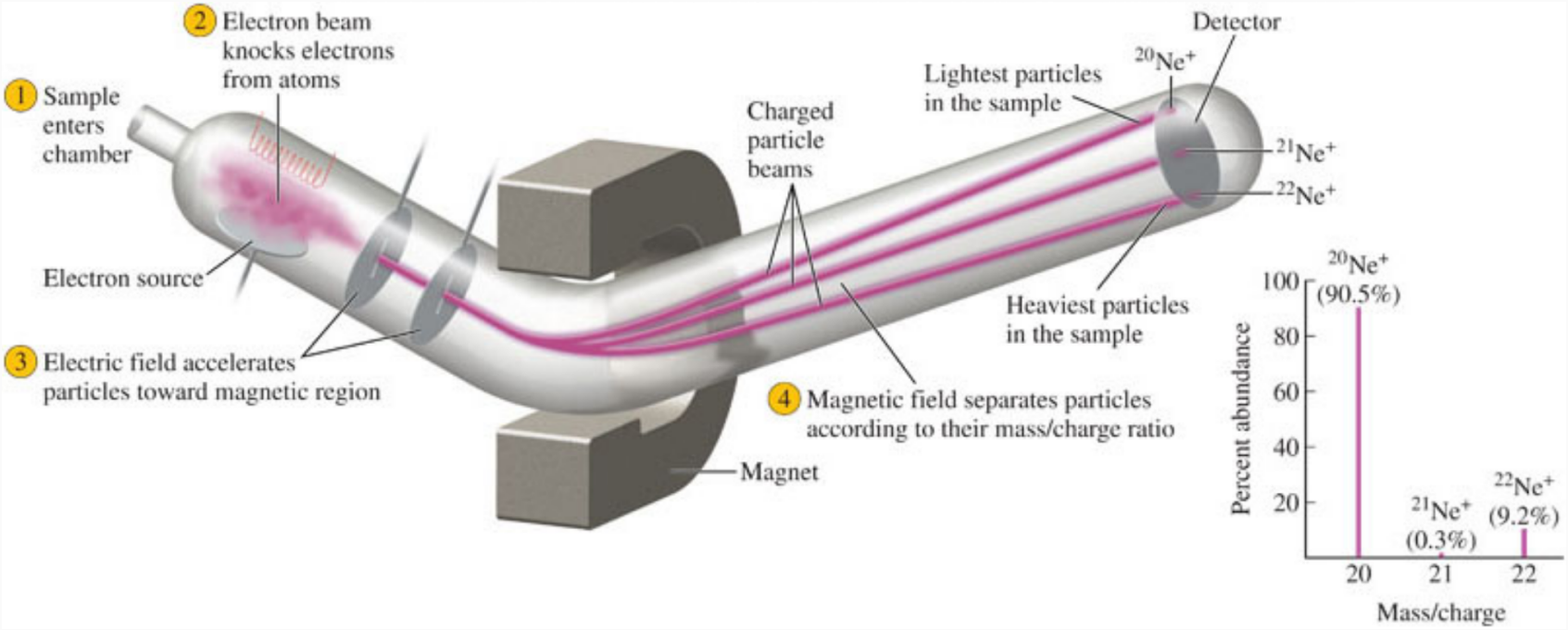
Hydrogen Isotopes and Applications



Applications

- Semiconductor production enhancing Si-H bond by preventing chemical erosion and Hot Carrier Effect
- Chemical labeling to track chemical reactions
- Medicinal chemistry - FDA approved the first deuterium-labeled drug (reference)

Experiment: Mass Spectroscopy



- Ionizes the atom and electric field accelerates atoms
- Time of flight - heavier atoms will travel slower than lighter ones
- Weighted average of atomic masses

Outline

Ionic and Molecular Compounds

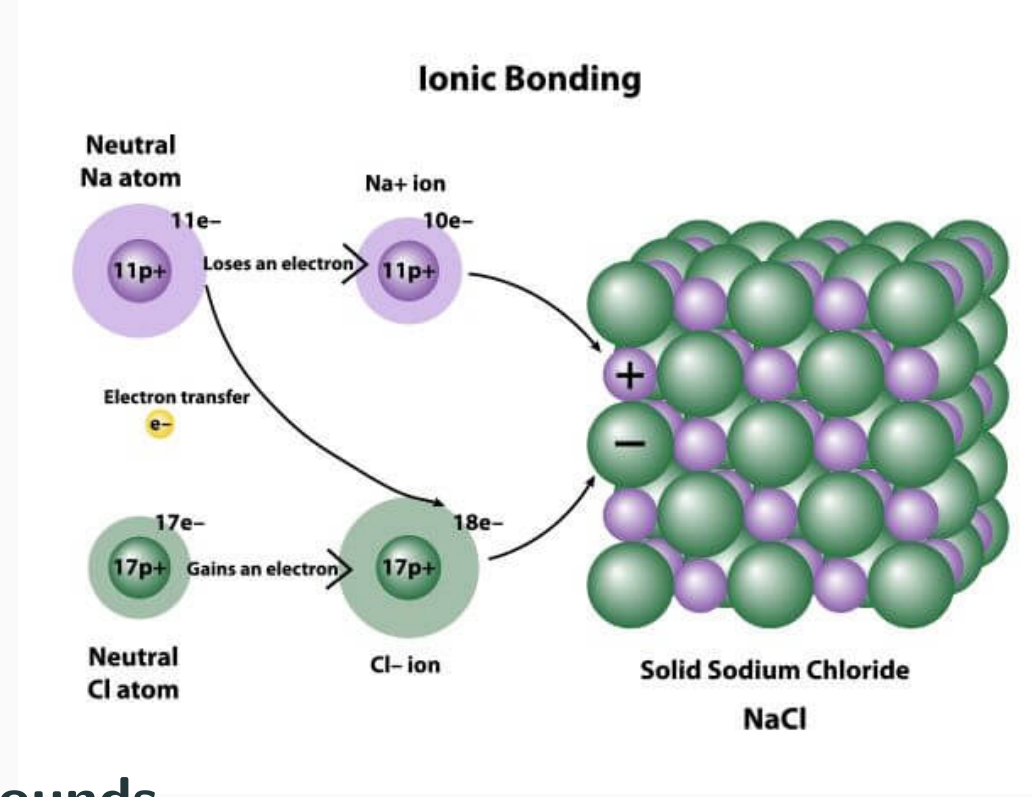
Ionic Compounds

- Consists of oppositely charged cations and anions such that the overall charge is neutral e.g $CaCl_2(s)$, BaF(s), and $Fe_2O_3(s)$
- Electrolyte - substances that separate into the ions e.g. NaCl(aq) dissociates into Na^+ and Cl^-
- Forms ionic bonds (purely electrostatic interactions)

Molecular Compounds

- Composed of atoms from two or more nonmetals
- Forms covalent bonds (sharing of electrons)

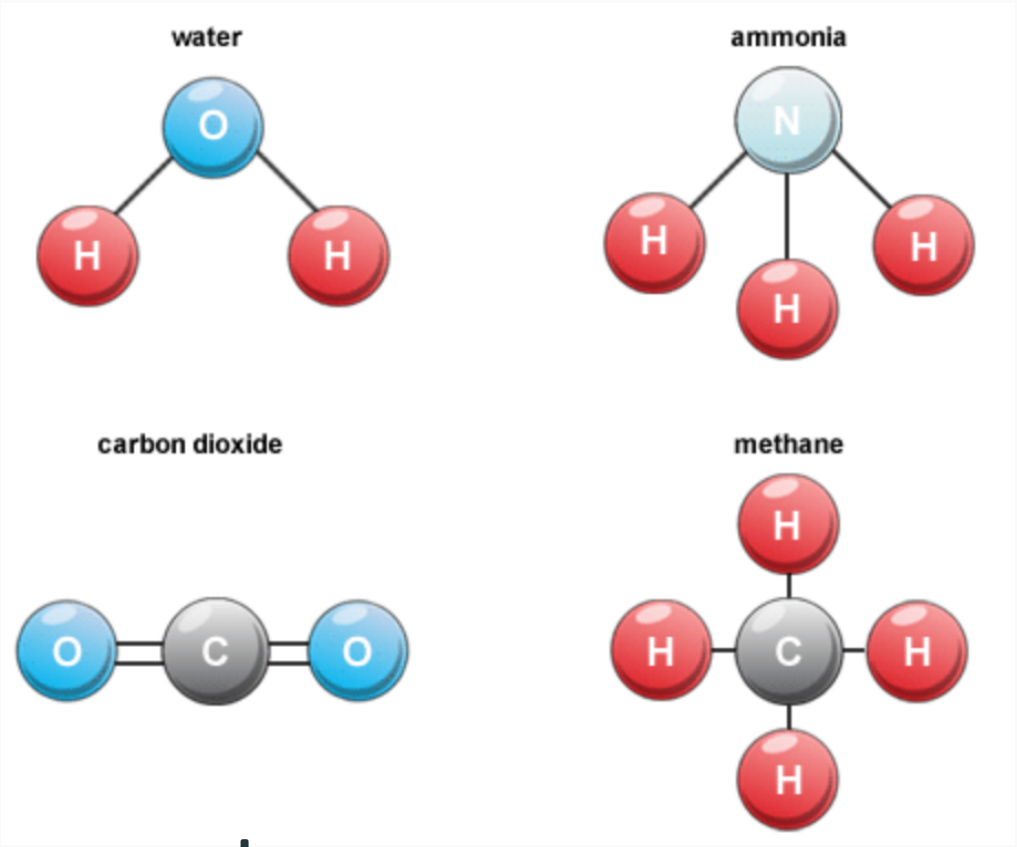
Properties of Ionic and Molecular Compounds



Ionic Compounds

- Highly conductive and strong electrolyte - ability to carry electricity (electrons)
- High melting and boiling points, high density

Properties of Ionic and Molecular Compounds



Molecular Compounds

- Not conductive and weak electrolyte
- Low melting and boiling points, low density

Introduction to Bonding

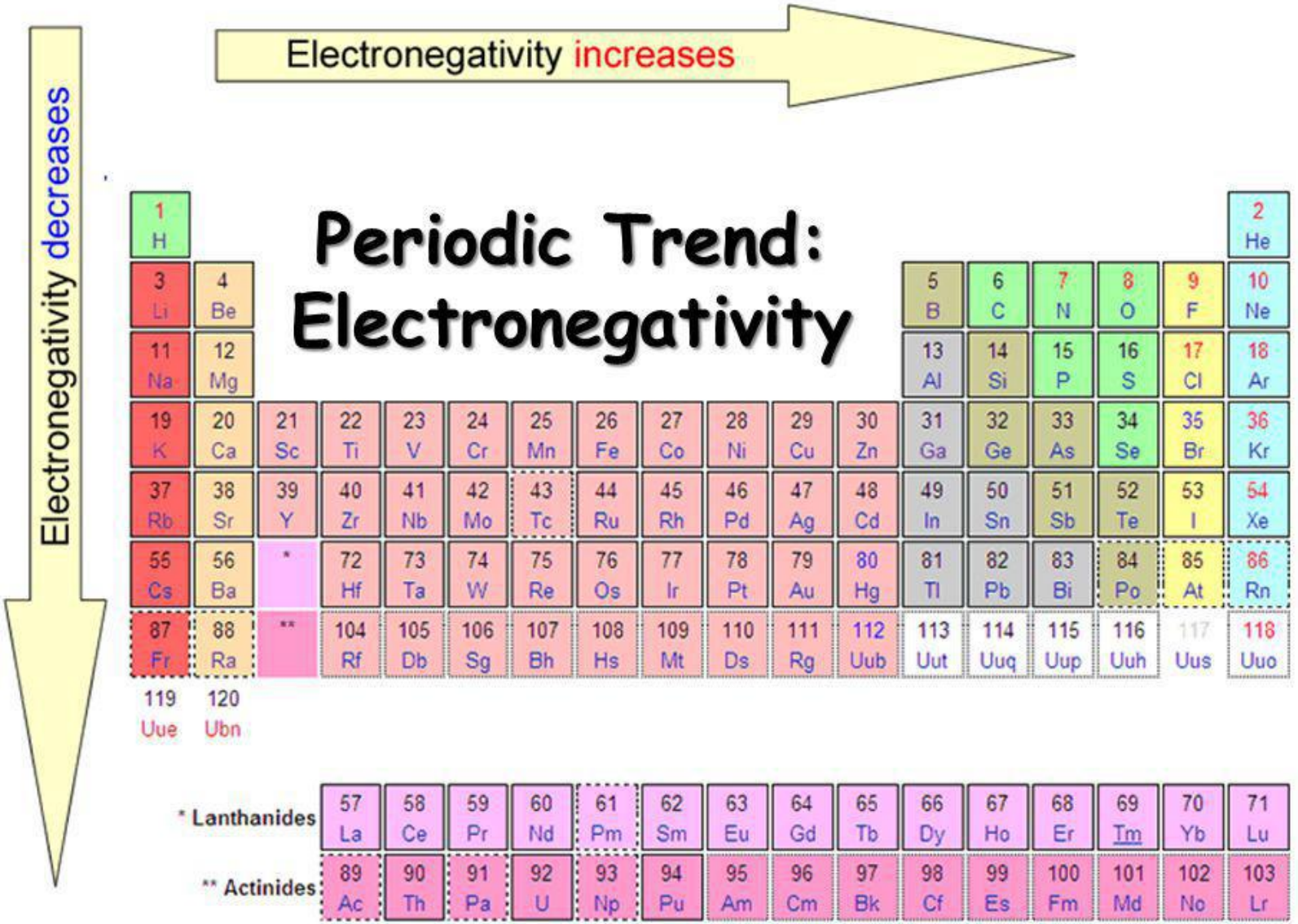
Ionic Bonding

- Electrons transferred from metal to nonmetal
- Ionized atoms and electrostatic interactions

Covalent Bonding (CB)

- Sharing of electrons between atoms (usually look at as pairs)
- Generally occurs between nonmetals in molecular elements, molecular compounds, and polyatomic ions

CB: Consideration of Electronegativity



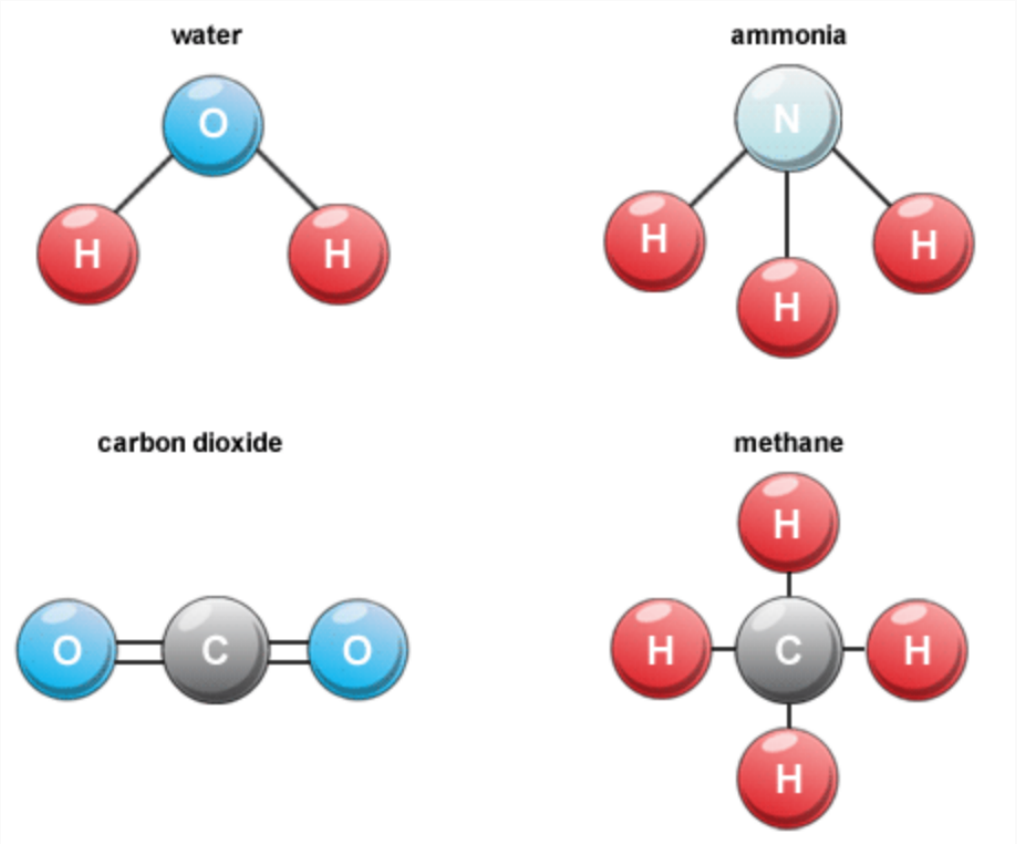
Pauling Electronegativity

Linus Pauling was the first one to describe electronegativity using bond energies. Determine the relative polarities of bonds or atoms tugging on the electrons

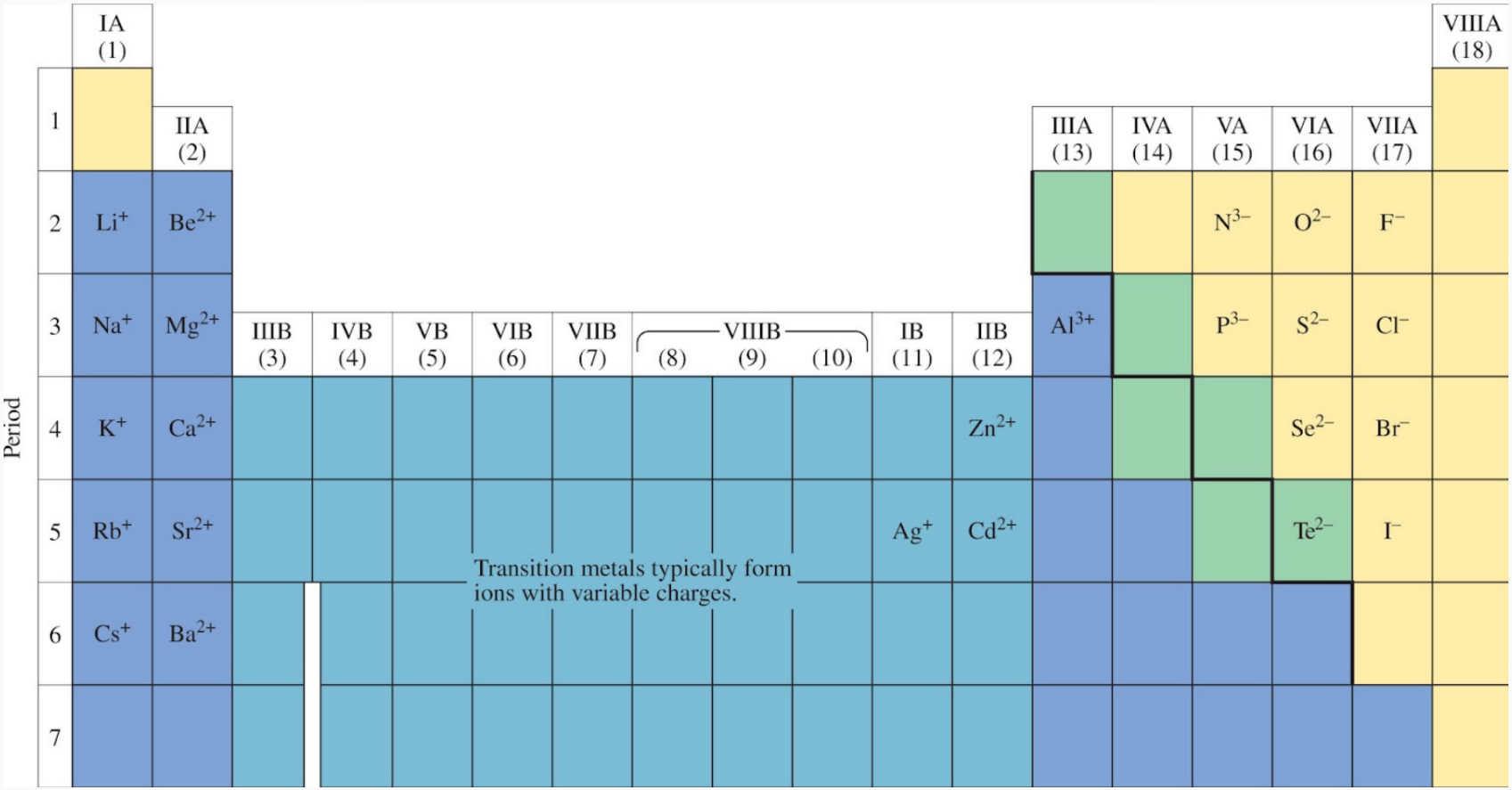
Examples: Determine which atom does the electron gets pulled toward

- O-H
- C-H
- C-O

Practice: Bond Polarity within a Molecule



Monoatomic and Polyatomic Ions



Monoatomic and Polyatomic Ions

B BO_3^{3-} borate	**C** CO_3^{2-} carbonate	**N** NO_3^- nitrate NO_2^- nitrite N^{3-} nitride	**O** O_2^{2-} peroxide O^{2-} oxide	**F** No oxoanions F^- fluoride
	Si SiO_4^{4-} silicate	**P** PO_4^{3-} phosphate P^{3-} phosphide	**S** SO_4^{2-} sulfate SO_3^{2-} sulfite S^{2-} sulfide	**Cl** ClO_4^- perchlorate ClO_3^- chlorate ClO_2^- chlorite ClO^- hypochlorite Cl^- chloride
		As AsO_4^{3-} arsenate AsO_3^{3-} arsenite As^{3-} arsenide	**Se** SeO_4^{2-} selenate SeO_3^{2-} selenite Se^{2-} selenide	**Br** BrO_4^- perbromate BrO_3^- bromate BrO_2^- bromite BrO^- hypobromite Br^- bromide
			Te TeO_4^{2-} tellurate TeO_3^{2-} tellurite Te^{2-} telluride	**I** IO_4^- periodate IO_3^- iodate IO_2^- iodite IO^- hypoiodite I^- iodide

Additional Polyatomic Ions

SCN^-	thiocyanate
NH_4^+	ammonium
H_3O^+	hydronium
O_2^{2-}	peroxide
OH^-	hydroxide
CN^-	cyanide
$C_2H_3O_2^-$	acetate
MnO_4^-	permanganate
$C_2O_4^{2-}$	oxalate
CrO_4^{2-}	chromate
$Cr_2O_7^{2-}$	dichromate

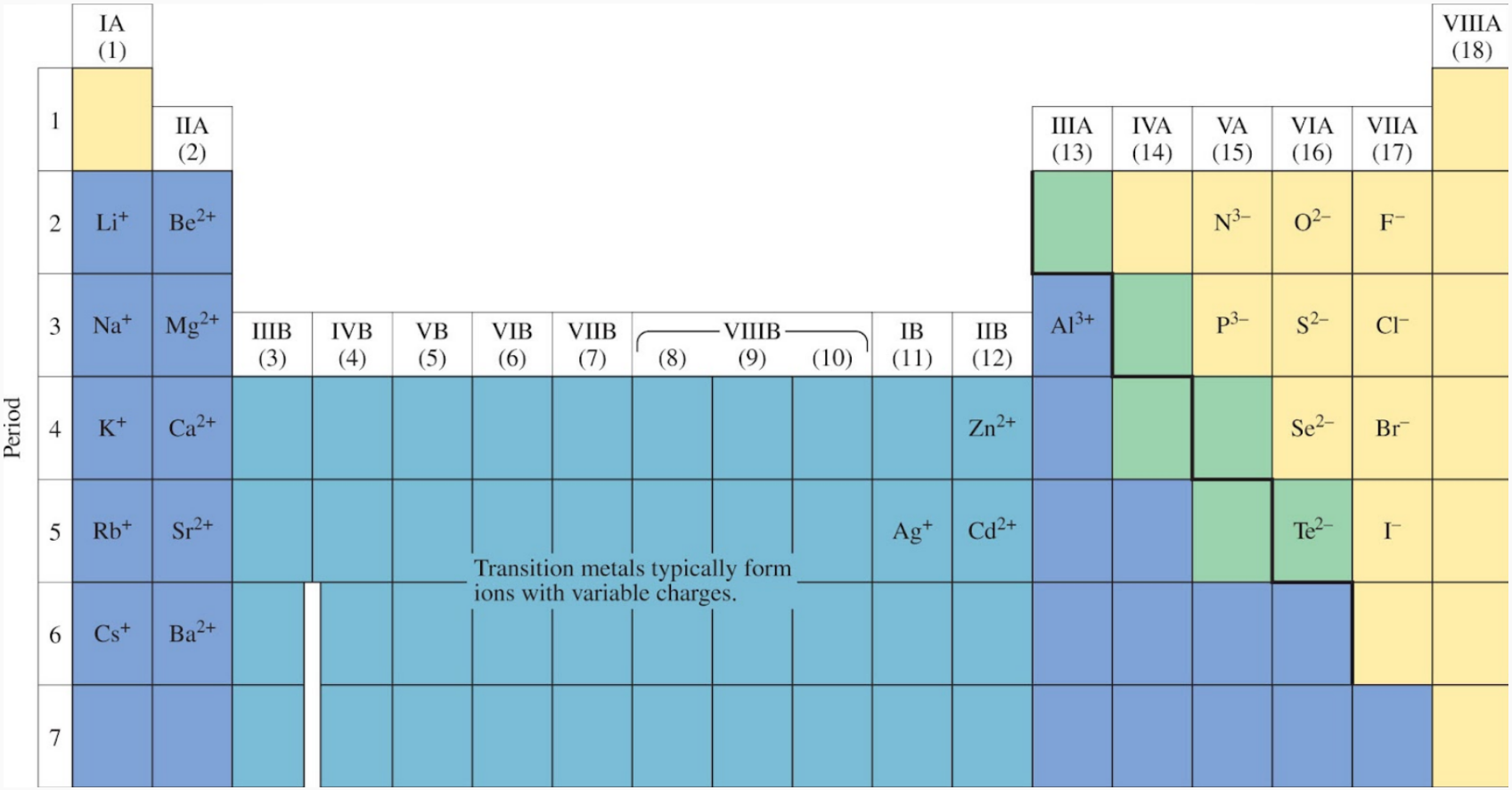
Q: How is the overall charge determined?

This is based on the oxidation state of the atoms within the molecule. The total charge of the molecule is the sum of the atom oxidation state.

Oxidation States Rules

1. The oxidation state of an element is zero e.g Xe, Cl_2, and S_8.
2. The sum of the oxidation states of all the atoms or ions in a neutral compound is zero.
3. The sum of the oxidation states of all the atoms in an ion is equal to the charge on the ion.
4. The more electronegative element in a substance is assigned a negative oxidation state. The less electronegative element is assigned a positive oxidation state.
5. Fluorine always has an oxidation state of -1
6. Oxygen atoms normally have an oxidation state of -2

Practice: Monoatomic and Polyatomic Ions



Practice: Monoatomic and Polyatomic Ions

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			Te TeO_4^{2-} tellurate TeO_3^{2-} tellurite Te^{2-} telluride	**I** IO_4^- periodate IO_3^- iodate IO_2^- iodite IO^- hypoiodite I^- iodide

Molecular Formulas for Ionic Compounds

The sum of the cations and anions equals to zero. The cation is written first then anion.

Examples: Practice determining the oxidation states

- $CaCO_3$
- $BaCl_2$
- $FeCl_3$
- $Ca(NO_3)_2$

Outline

Naming Ions

Metals - start with the element and end with ion

Element	Stem	Charge	Modern Name	Common Name
iron	ferr-	2+	iron(II) ion	ferrous ion
		3+	iron(III) ion	ferric ion
copper	cupr-	1+	copper(I) ion	cuprous ion
		2+	copper(II) ion	cupric ion
tin	stann-	2+	tin(II) ion	stannous ion
		4+	tin(IV) ion	stannic ion
lead	plumb-	2+	lead(II) ion	plumbous ion
		4+	lead(IV) ion	plumbic ion
chromium	chrom-	2+	chromium(II) ion	chromous ion
		3+	chromium(III) ion	chromic ion
gold	aur-	1+	gold(I) ion	aurous ion
		3+	gold(III) ion	auric ion

Naming Nonmetal Ions

Nonmetals - replace suffix with -ide and end with ion

Ion	Name
F^-	fluoride ion
Cl^-	chloride ion
Br^-	bromide ion
I^-	iodide ion
O^{2-}	oxide ion
S^{2-}	sulfide ion
P^{3-}	phosphide ion
N^{3-}	nitride ion

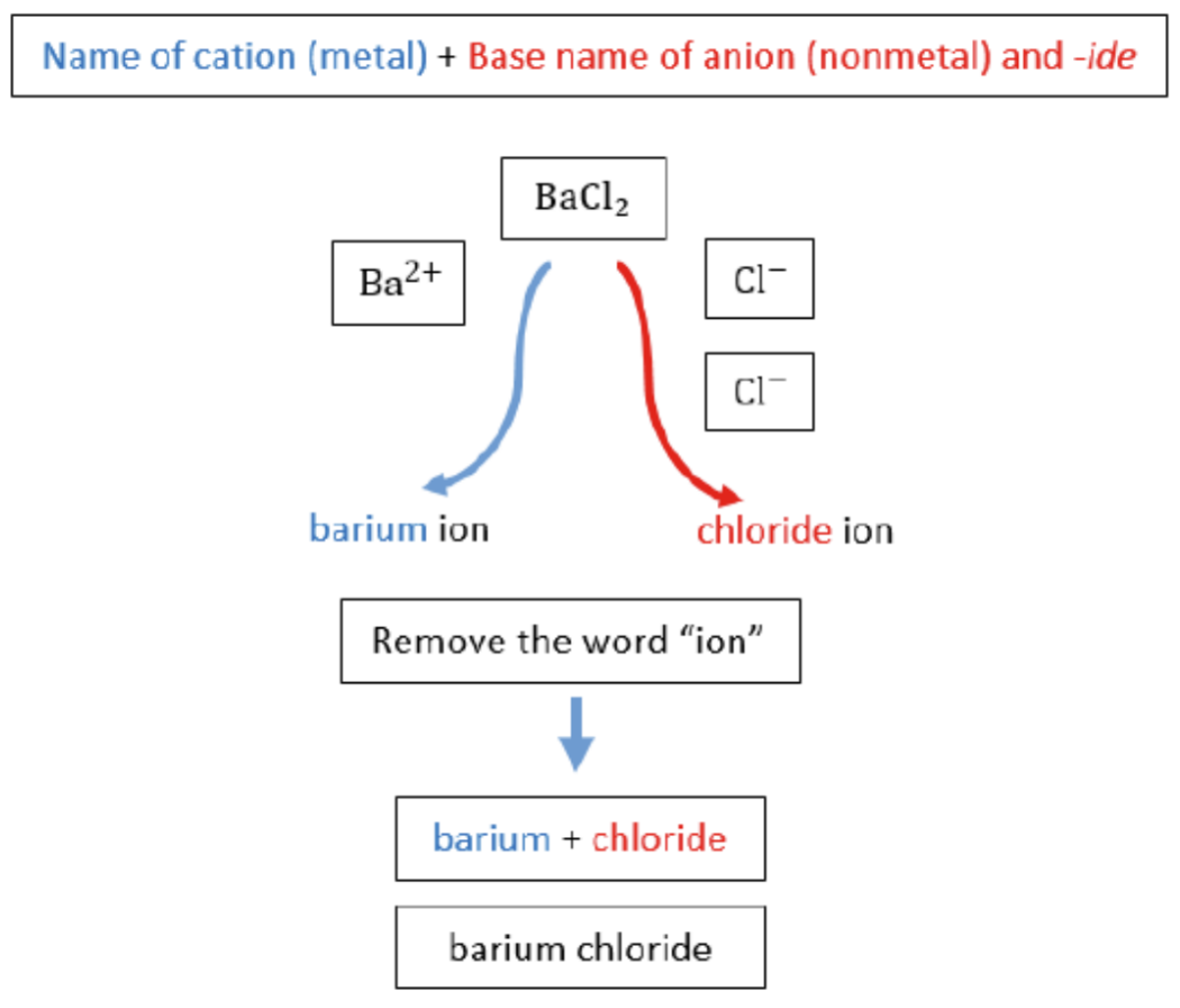
Practice: Name Each Ion

- Fe^{2+}
- F^{-}
- Ba^{+}
- S^{2-}

Naming Binary Ionic Compounds

The metal cation is named first, followed by the nonmetal anion.

The word ion is dropped from both parts.



Practice: Name the Ionic Compound

- $CaCl_2$
- Ca_3P_2
- MgO
- $FeCl_2$
- Co_2O_3

Naming Molecular Compounds

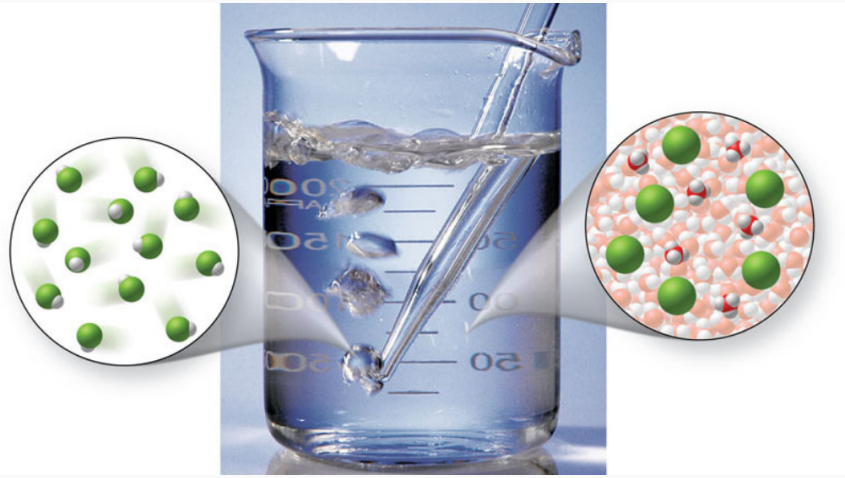
Prefix	Number	Prefix	Number	Prefix	Number
mono-	1	penta-	5	octa-	8
di-	2	hexa-	6	nona-	9
tri-	3	hepta-	7	deca-	10
tetra-	4				

1. Use numerical prefix for the element (usually ignore the first when using "mono")
2. Add "-ide" to the second element

Naming Binary Molecular Compounds

- H_2O
- N_2O_4
- CO
- CH_4

Naming Acids and Bases



1. If anion ends in "-ide," add "hydro" before the root of the anion name followed by "-ic acid"
2. If anion ends in "-ate," use the root of the anion name followed by "-ic acid"
3. If anion ends in "-ite," use the root of the anion name followed by "-ous acid"

Practice: Naming the Acid

- HCl
- HNO_3
- H_2CO_3
- H_2SO_3

Definition(s) of an Acid

Arrhenius Acid - dissociation of acid in water to yield the ions
e.g. $HCl(aq) \rightarrow H^+(aq) + Cl^-(aq)$

Brønsted Acid - any species that can donate a proton H^+

Lewis Acid - donation of a pair of electrons