

# **Chapter 3: Chemical Compounds**

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Sept 13, 2022

Chemistry Department, Cypress College

## Class Announcements

- Go over homework assignment; present your work for 1pt EC
- Begin Ch 3 - Chemical Compounds and Types of Bonding
- Quiz #3 released this Fri, Sept 16 at 3pm and due Tues, Sept 20 at 11:59pm
- Homework #3 released this Fri, Sept 16 at 3pm and due Fri, Sept 23 at 11:59pm

## Lecture Weekly Agenda

- 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 Nomenclature
- Nomenclature Lab assignments due Sept 19 at 11:59pm

# Outline

## Review: Chapter 2 Highlights

Ionic and Molecular Compounds

Monoatomic and Polyatomic Ions

Formulas for Ionic Compounds

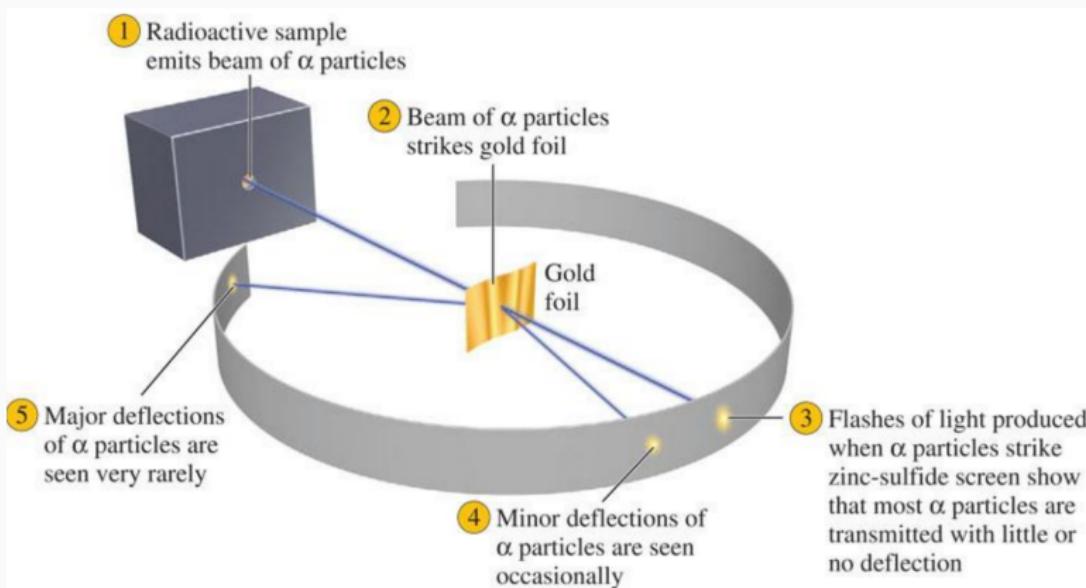
Naming and Writing Formulas

Ionic Compounds

Molecular Compounds

Acids and Bases

# J.J. Thompson's Plum Pudding Model



# Review: Modern Periodic Table

Temperature: 0 °C | 32 °F | 273 K

32	2	8	18	4															
<b>Ge</b>																			
Germanium	72.630																		
Series	Metalloids																		
Write-up	<a href="#">Germanium</a>	<a href="#">Wikipedia</a>																	
State at	0 °C	Solid																	
Weight	72.63	u																	
Energy levels	2, 8, 18, 4																		
Electronegativity	2.01																		
Melting point	938.25 °C	v																	
Boiling point	2,820 °C	v																	
Electron affinity	119 kJ/mol	v																	
Ionization, 1st	762 kJ/mol	v																	
Radius, calculated	125 pm	v																	
Hardness, Brinell	N/A MPa	v																	
Modulus, bulk	N/A GPa	v																	
Density, STP	5,323 kg/m³	v																	
Conductivity, thermal	0.0103 W/mK	v																	

For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.

57	58	59	60	61	62	63	64	65	66	67	68	69	70	71			
La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu			
Lanthanum (138.91)	Cerium (140.12)	Neodymium (140.91)	Praseodymium (144.24)	Neptunium (145)	Samarium (150.96)	Europium (151.96)	Terbium (157.29)	Dysprosium (158.93)	Holmium (162.59)	Thulium (168.93)	Erbium (167.26)	Terbium (168.93)	Ytterbium (173.05)	Lucentium (174.57)			
6																	
89	90	91	92	93	94	95	96	97	98	99	100	101	102	103			
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Ee	Md	No	Lu				
Actinium (227)	Thorium (232.04)	Protactinium (231.04)	Uranium (238.03)	Neptunium (237)	Plutonium (244)	Americium (243)	Curium (247)	Berkelium (247)	Fergusonium (251)	Einstenium (252)	Fermium (257)	Mendelevium (258)	Neobium (259)	Lawrencium (266)			
7																	

## Relative Atomic Mass

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

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

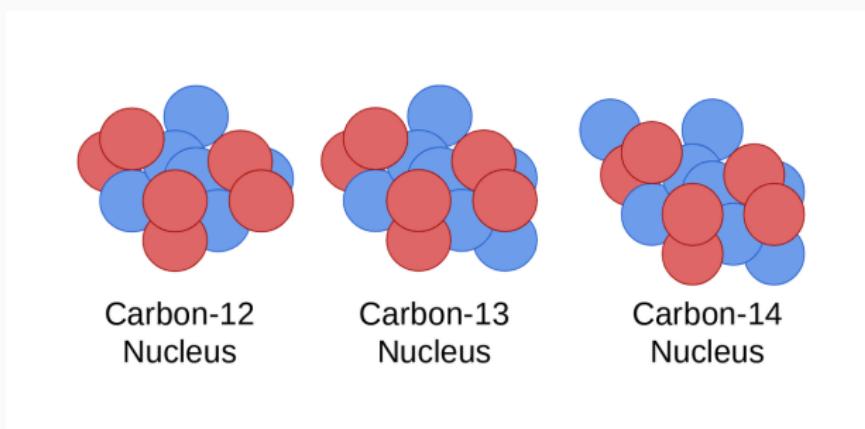
## Defining Atomic Number and Mass

$$^{A_Z}X^C \quad (2)$$

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

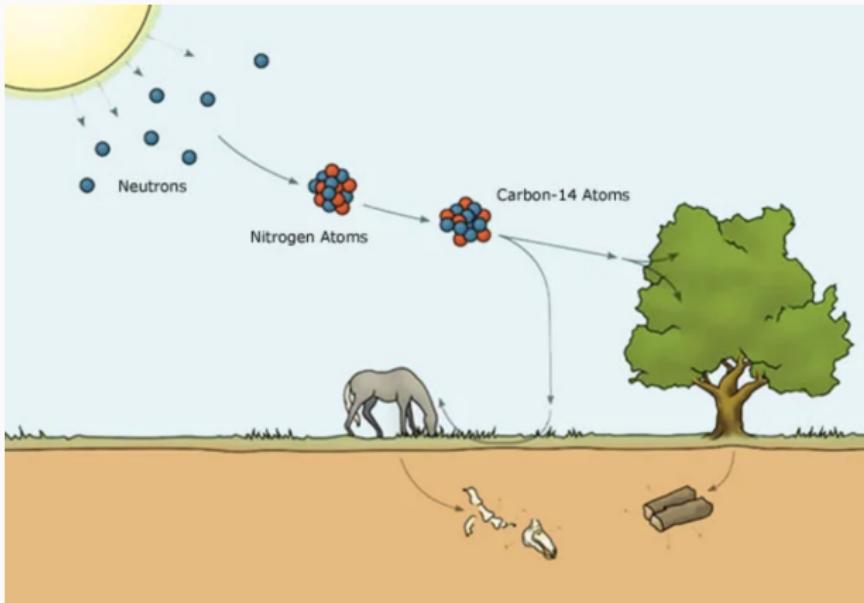
**Isotopes** - chemically same atom (same number of protons) but physically different (different number of neutrons)

# Hydrogen Isotopes and Applications



- Carbon-12, carbon-13, and carbon-14 have relative abundances of 98.9%, 1.1%, and 0.1%, respectively
- **Q:** Which carbon isotope is the highest in abundance?

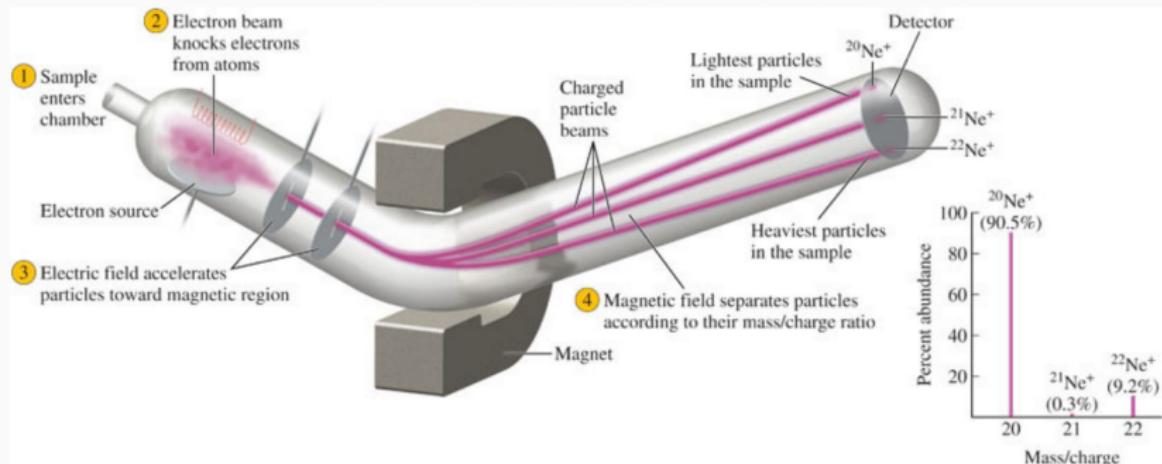
# Carbon-14 Dating



## Applications

- Rough estimation of fossils because known half-life  $\sim 5,730$  years

# 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

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Monoatomic and Polyatomic Ions

Formulas for Ionic Compounds

Naming and Writing Formulas

Ionic Compounds

Molecular Compounds

Acids and Bases

# Ionic and Molecular Compounds

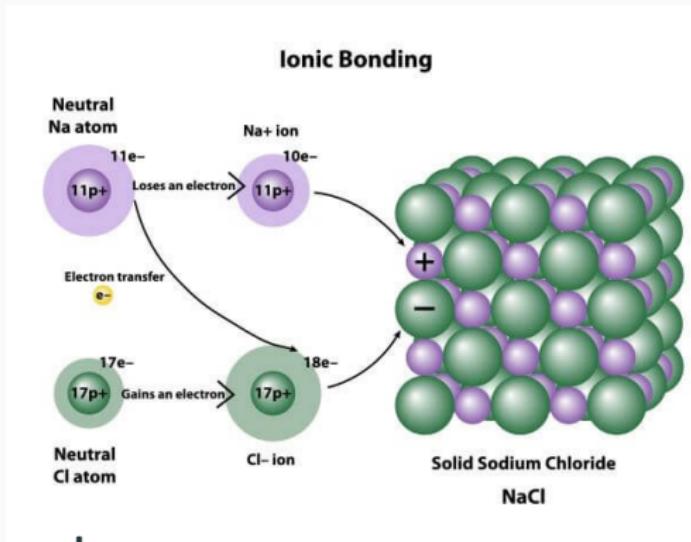
## Ionic Compounds

- Consists of oppositely charged cations and anions such that the overall charge is neutral e.g  $\text{CaCl}_2(\text{s})$ ,  $\text{BaF}(\text{s})$ , and  $\text{Fe}_2\text{O}_3(\text{s})$
- Electrolyte - substances that separate into the ions e.g.  $\text{NaCl}(\text{aq})$  dissociates into  $\text{Na}^+$  and  $\text{Cl}^-$
- Forms ionic bonds (purely electrostatic interactions)

## Molecular Compounds

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

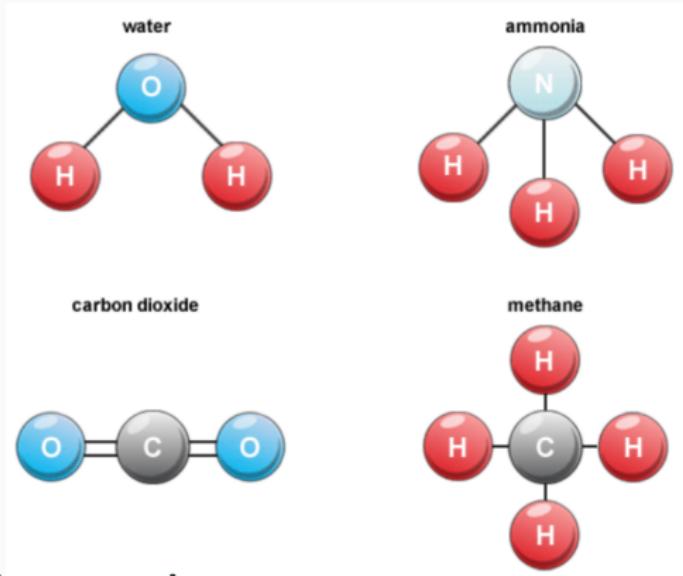
# Properties of Ionic and Molecular Compounds



## 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

# Monoatomic Ions

	IA (1)	IIA (2)											VIIIA (18)	
1														
2	$\text{Li}^+$	$\text{Be}^{2+}$												
3	$\text{Na}^+$	$\text{Mg}^{2+}$	IIIB (3)	IVB (4)	VB (5)	VIB (6)	VIIIB (7)	VIIIB (8) (9) (10)		IB (11)	IIB (12)	$\text{Al}^{3+}$		
4	$\text{K}^+$	$\text{Ca}^{2+}$									$\text{Zn}^{2+}$		$\text{Se}^{2-}$	$\text{Br}^-$
5	$\text{Rb}^+$	$\text{Sr}^{2+}$								$\text{Ag}^+$	$\text{Cd}^{2+}$		$\text{Te}^{2-}$	$\Gamma^-$
6	$\text{Cs}^+$	$\text{Ba}^{2+}$												
7														
Transition metals typically form ions with variable charges.														

# Polyatomic Ions

<b>B</b> $\text{BO}_3^{3-}$ borate	<b>C</b> $\text{CO}_3^{2-}$ carbonate	<b>N</b> $\text{NO}_3^-$ nitrate $\text{NO}_2^-$ nitrite $\text{N}^{3-}$ nitride	<b>O</b> $\text{O}_2^{2-}$ peroxide $\text{O}^{2-}$ oxide	<b>F</b> No oxoanions $\text{F}^-$ fluoride
<b>Si</b> $\text{SiO}_4^{4-}$ silicate	<b>P</b> $\text{PO}_4^{3-}$ phosphate $\text{P}^{3-}$ phosphide	<b>S</b> $\text{SO}_4^{2-}$ sulfate $\text{SO}_3^{2-}$ sulfite $\text{S}^{2-}$ sulfide	<b>Cl</b> $\text{ClO}_4^-$ perchlorate $\text{ClO}_3^-$ chlorate $\text{ClO}_2^-$ chlorite $\text{ClO}^-$ hypochlorite $\text{Cl}^-$ chloride	
<b>As</b> $\text{AsO}_4^{3-}$ arsenate $\text{AsO}_3^{3-}$ arsenite $\text{As}^{3-}$ arsenide	<b>Se</b> $\text{SeO}_4^{2-}$ selenate $\text{SeO}_3^{2-}$ selenite $\text{Se}^{2-}$ selenide	<b>Br</b> $\text{BrO}_4^-$ perbromate $\text{BrO}_3^-$ bromate $\text{BrO}_2^-$ bromite $\text{BrO}^-$ hypobromite $\text{Br}^-$ bromide		
	<b>Te</b> $\text{TeO}_4^{2-}$ tellurate $\text{TeO}_3^{2-}$ tellurite $\text{Te}^{2-}$ telluride	<b>I</b> $\text{IO}_4^-$ periodate $\text{IO}_3^-$ iodate $\text{IO}_2^-$ iodite $\text{IO}^-$ hypoiodite $\text{I}^-$ iodide		

## Additional Polyatomic Ions

$\text{SCN}^-$	thiocyanate
$\text{NH}_4^+$	ammonium
$\text{H}_3\text{O}^+$	hydronium
$\text{O}_2^{2-}$	peroxide
$\text{OH}^-$	hydroxide
$\text{CN}^-$	cyanide
$\text{C}_2\text{H}_3\text{O}_2^-$	acetate
$\text{MnO}_4^-$	permanganate
$\text{C}_2\text{O}_4^{2-}$	oxalate
$\text{CrO}_4^{2-}$	chromate
$\text{Cr}_2\text{O}_7^{2-}$	dichromate

# 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

- $\text{CaCO}_3$
- $\text{BaCl}_2$
- $\text{FeCl}_3$
- $\text{Ca}(\text{NO}_3)_2$

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# 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
$\text{F}^-$	fluoride ion
$\text{Cl}^-$	chloride ion
$\text{Br}^-$	bromide ion
$\text{I}^-$	iodide ion
$\text{O}^{2-}$	oxide ion
$\text{S}^{2-}$	sulfide ion
$\text{P}^{3-}$	phosphide ion
$\text{N}^{3-}$	nitride ion

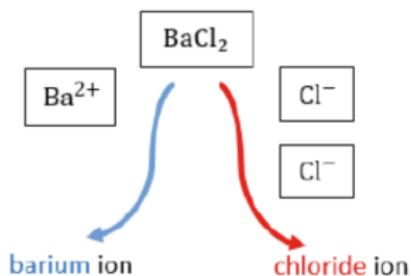
## Practice: Name Each Ion

- $\text{Fe}^{2+}$
- $\text{F}^-$
- $\text{Ba}^+$
- $\text{S}^{2-}$

# Naming Binary Ionic Compounds

The metal cation is named first, followed by the nonmetal anion.  
The word ion is dropped from both parts.

Name of cation (metal) + Base name of anion (nonmetal) and *-ide*



Remove the word “ion”



barium + chloride

barium chloride

## Practice: Name the Ionic Compound

- $\text{CaCl}_2$
- $\text{Ca}_3\text{P}_2$
- $\text{MgO}$
- $\text{FeCl}_2$
- $\text{Co}_2\text{O}_3$

# 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

- $\text{H}_2\text{O}$
- $\text{N}_2\text{O}_4$
- $\text{CO}$
- $\text{CH}_4$

# 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<sub>3</sub>
- H<sub>2</sub>CO<sub>3</sub>
- H<sub>2</sub>SO<sub>3</sub>