

Chapter 3: Chemical Compounds

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

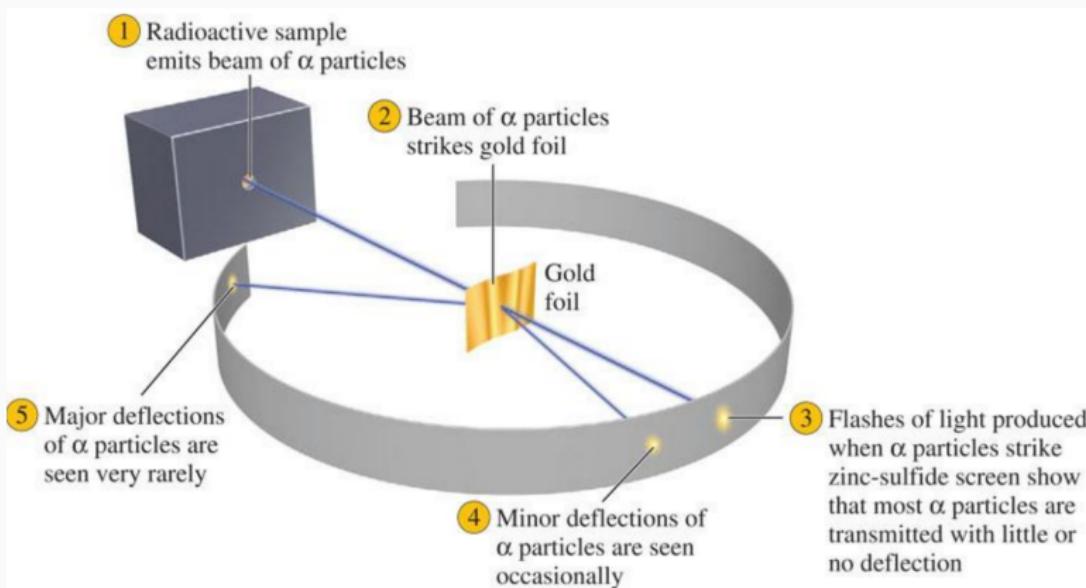
Naming and Writing Formulas

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															
Ge																			
Germanium	72.630																		
Series	Metalloids																		
Write-up	Germanium	Wikipedia																	
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)	Nocturnium (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

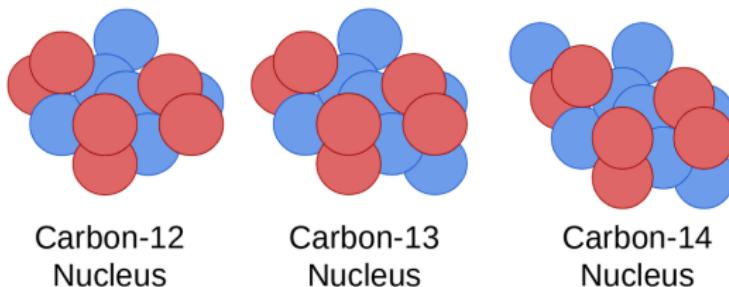
Defining Atomic Number and Mass

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

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

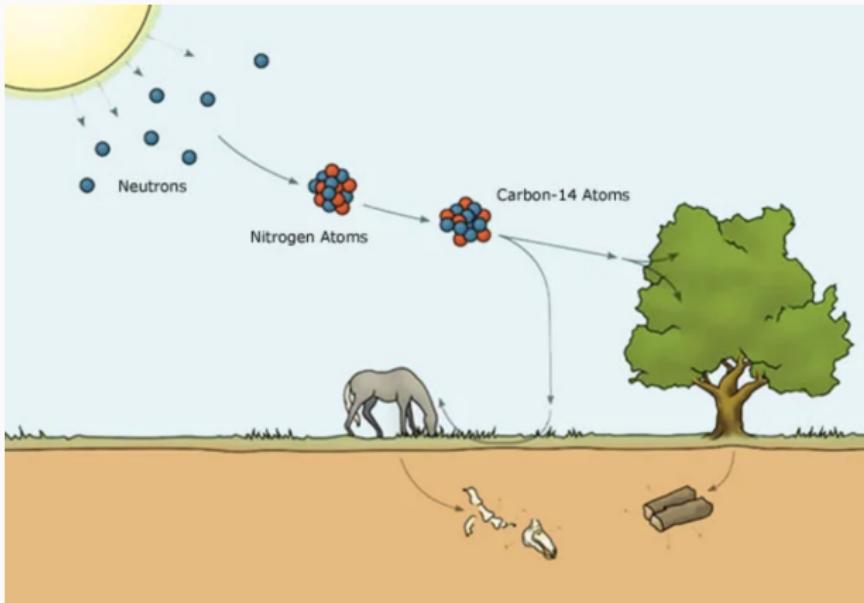
Isotopes - chemically same atom (same number of protons) but physically different (different number of neutrons)

Hydrogen Isotopes and Applications



- Carbon-12, carbon-13, and carbon-14
- **Q:** Which carbon isotope is the highest in abundance?

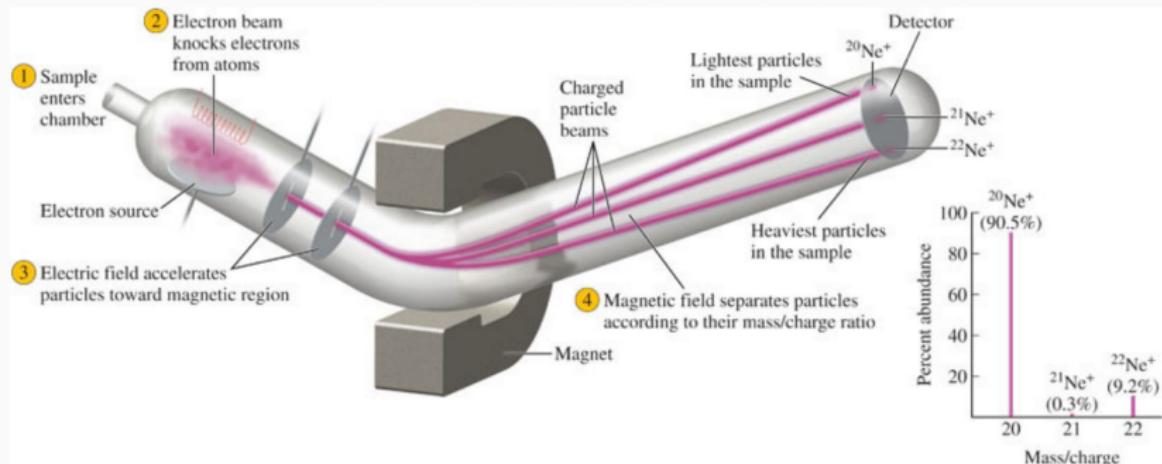
Carbon-14 Dating



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

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

Ionic and Molecular Compounds

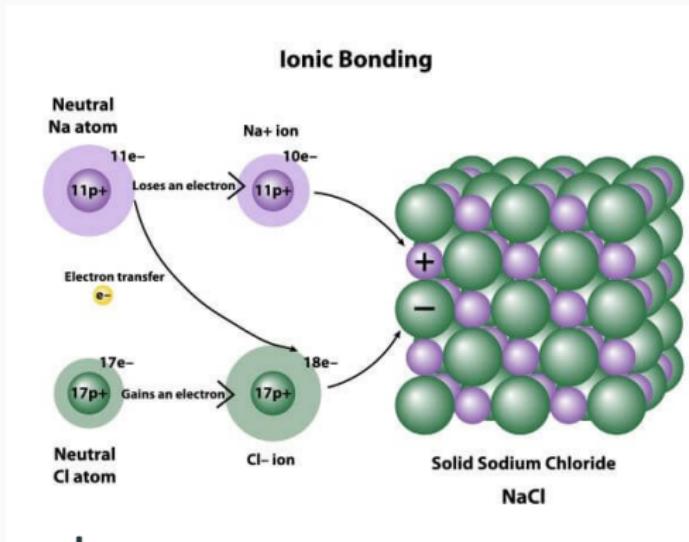
Ionic Compounds

- 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 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)

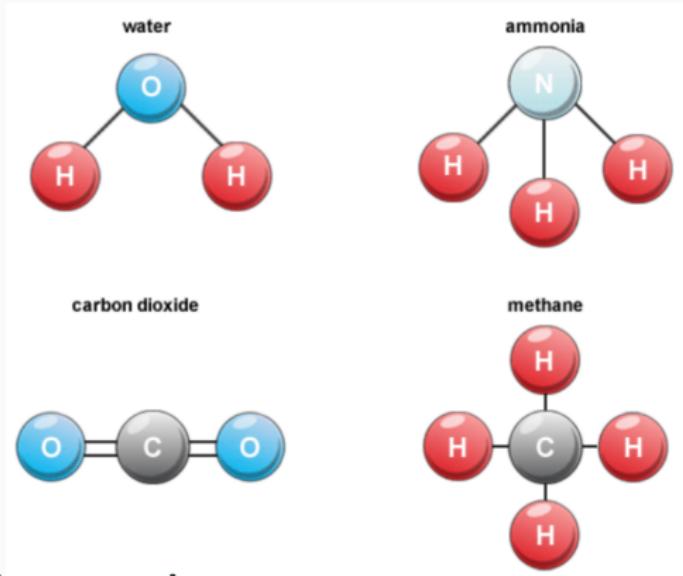
Properties of Ionic and Molecular Compounds



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

Monoatomic Ions

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

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
$\text{C}_2\text{H}_3\text{O}_2^-$	acetate
MnO_4^-	permanganate
$\text{C}_2\text{O}_4^{2-}$	oxalate
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

- CaCO_3
- BaCl_2
- FeCl_3
- $\text{Ca}(\text{NO}_3)_2$

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

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

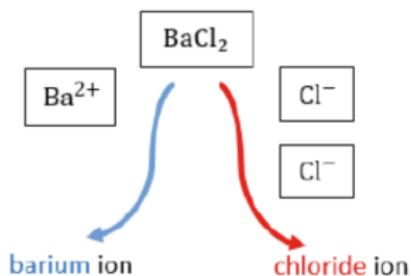
Practice: Name Each Ion

- 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.

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



Remove the word “ion”



barium + chloride

barium chloride

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
- HNO₃
- H₂CO₃
- H₂SO₃