Ch 2Atoms and Elements AND Ch 3 Molecules & Compounds

Historical Development of the Atomic Model

Greeks (~400 B.C.E.)

-- Democritus, Leucippus, and others

Matter is discontinuous (i.e., "grainy").

-- Plato and Aristotle disagreed, saying that matter was continuous.

Hints at the Scientific Atom

-- Antoine Lavoisier: law of conservation of mass

-- Joseph Proust (1799)

law of definite proportions: every compound has a fixed proportion by mass

e.g., water = 8 g O, 1 g H chromium (II) oxide = 13 g Cr, 4 g O

-- John Dalton (1803)

law of multiple proportions: When two different compounds have same two elements, equal mass of one element results in integer multiple of mass of other.

e.g., water = 8 g O, 1 g H; hydrogen peroxide = 16 g O, 1 g H

e.g., chromium (II) oxide = 13 g Cr, 4 g O; chromium (VI) oxide = 13 g Cr, 12 g O

John Dalton's Atomic Theory (1808)

1. Elements are made of indivisible particles called atoms.
2. Atoms of the same element are exactly alike; in particular, they have the same mass.
3. Compounds are formed by the joining of atoms of two or more elements in fixed, whole number ratios, e.g.,

Dalton's was the first atomic theory that had evidence to support it.

Law of Electrostatic Attraction:

-- William Crookes (1870s): "Rays" causing a shadow were emitted from the cathode.

-- J.J. Thomson (1897) discovered that "cathode rays" are deflected by electric and magnetic fields. He found that "cathode rays" were particles (today, we call them electrons) having a charge-to-mass ratio of 1.76×10^8 C/g.

-- Robert Millikan (1909) performed the “oil drop” experiment. Oil drops were given negative charges of varying magnitude. Charges on oil drops were found to be integer multiples of 1.60×10^{-19} C. He reasoned that this must be the charge on an electron. He then found the electron’s mass:

-- William Thomson (a.k.a., Lord Kelvin)

Since atom was known to be electrically neutral, he proposed the plum pudding model.

-- Equal quantities of (+) and (–) charge distributed uniformly in atom.

-- (+) is ~2000X more massive than (–).

-- Ernest Rutherford (1910): Gold Leaf Experiment

A beam of α-particles (+) were directed at a gold leaf surrounded by a phosphorescent (ZnS) screen.

Most α-particles passed through, some angled slightly, and a tiny fraction bounced back.

Conclusions:

1.

2.

3.

-- James Chadwick discovered neutrons in 1932.

Purpose of n^0 =

electronic charge =

-- In chemistry, charges are expressed as unitless multiples of this value, not in C.

e.g.,

-- atomic mass unit (amu): used to measure masses of atoms and subatomic particles

1 p^+ = 1.0073 amu; 1 n^0 = 1.0087 amu; 1 e^- = 0.0005486 amu

Conversion:

Angstroms (A) are often used to measure atomic dimensions.   Conversion:

atomic number:

-- the whole number on Periodic Table; determines the identity of an atom

mass number:

isotopes: different varieties of an element's atoms

--

-- some are radioactive; others aren't

-- An atom of a specific isotope is sometimes called a nuclide.

All atoms of an element react the same, chemically.

The Periodic Table

group: a vertical column; elements in a group share certain phys. and chem. properties

-- group 1 = alkali metals

-- group 2 = alkaline earth metals

-- group 16 = chalcogens

-- group 17 = halogens

-- group 18 = noble gases

Most molecular compounds contain only nonmetals.

molecular formula:

empirical formula:

structural formula:

Also...   perspective drawing   ball-and-stick model   space-filling model

Nomenclature of Binary Molecular Compounds

Use Greek prefixes to indicate how many atoms of each element, but don't use "mono" on first element.

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

EXAMPLES:

carbon dioxide N_2O_5

CO | carbon tetrachloride

dinitrogen trioxide | NI_3

Ions and Ionic Compounds

ion: a charged particle (i.e., a charged atom or group of atoms)

anion: a (–) ion
-- more e^- than p^+
-- formed when atoms lose e^-

cation: a (+) ion
-- more p^+ than e^-
-- formed when atoms gain e^-

polyatomic ion: a charged group of atoms

Ionic compounds are also called salts, and they consist of oppositely-charged species attracted to each other by electrostatic forces. You can simplify ionic compounds as "metal-nonmetal," but "cation-anion" is a little better.

Nomenclature of Ionic Compounds

chemical formula: has neutral charge; shows types of atoms and how many of each

To write an ionic compound's formula, we need:

1. the two types of ions
2. the charge on each ion

Na^+ and F^-
Ba^{2+} and O^{2-}
Na^+ and O^{2-}
Ba^{2+} and F^-

Parentheses are required only when you need more than one "bunch" of a particular polyatomic ion.

Ba^{2+} and SO_4^{2-}
Mg^{2+} and NO_2^-
NH_4^+ and ClO_3^-
Sn^{4+} and SO_4^{2-}
Fe^{3+} and $Cr_2O_7^{2-}$
NH_4^+ and N^{3-}

Single-Charge Cations with Elemental Anions

For this class, the single-charge cations are groups 1, 2, 13, and...

Ag^+, Zn^{2+}, Cd^{2+}, Sc^{3+}, Y^{3+}, Zr^{4+}, Hf^{4+}, Ta^{5+}.

A. To name, given the formula:

1. Use name of cation.
2. Use name of anion (it has the ending "ide").

NaF

BaO

Na_2O

BaF_2

B. To write formula, given the name:

1. Write symbols for the two types of ions.
2. Balance charges to write formula.

silver sulfide

zinc phosphide

calcium iodide

Multiple-Charge Cations with Elemental Anions

For this class, the multiple-charge cations are Pb^{2+}/Pb^{4+}, Sn^{2+}/Sn^{4+}, and all transition elements not listed above.

A. To name, given the formula:

1. Figure out charge on cation.
2. Write name of cation.
3. Write Roman numerals in ( ) to show cation's charge.
4. Write name of anion.

FeO

Fe_2O_3

$CuBr$

$CuBr_2$

B. To find the formula, given the name:

1. Write symbols for the two types of ions.
2. Balance charges to write formula.

cobalt (III) chloride

tin (IV) oxide

tin (II) oxide

Traditional System of Nomenclature

…used historically (and still some today) to name compounds w/multiple-charge cations

To use: 1. Use Latin root of cation.

2. Use ***-ic*** ending for higher charge; use ***-ous*** ending for lower charge.

3. Then say name of anion, as usual.

Element	Latin root	***-ic***	***-ous***	Write formulas.	Write names.
gold, Au	aur-	Au^{3+}	Au^{+}	cuprous sulfide	Pb_3P_4
lead, Pb	plumb-	Pb^{4+}	Pb^{2+}		
tin, Sn	stann-	Sn^{4+}	Sn^{2+}	auric nitride	Pb_3P_2
copper, Cu	cupr-	Cu^{2+}	Cu^{+}		
iron, Fe	ferr-	Fe^{3+}	Fe^{2+}	ferrous fluoride	$SnCl_4$

Compounds Containing Polyatomic Ions

Insert name of ion where it should go in the compound's name.

But first... oxyanions: polyatomic ions containing oxygen

Common oxyanions:

BrO_3^{1-}	NO_3^{1-}	CO_3^{2-}
IO_3^{1-}	PO_4^{3-}	
ClO_3^{1-}	SO_4^{2-}	

Above examples show "most common" forms of the oxyanions. If an oxyanion differs from the above by the # of O atoms, the name changes are as follows:

one more O	=	per_____ate
"most common" # of O	**=**	**_____ate**
one less O	=	_____ite
two fewer O	=	hypo_____ite

Write formulas:	Write names:
iron (III) nitrite	$(NH_4)_2S_2O_3$
ammonium phosphide	$AgBrO_3$
ammonium chlorite	$(NH_4)_3N$
zinc phosphate	$U(CrO_4)_3$

lead (II) permanganate $Cr_2(SO_3)_3$

Acid Nomenclature

binary acids: acids w/H and one other element

Binary Acid Nomenclature

1. Write "hydro."
2. Write prefix of the other element, followed by "-ic acid."

HF

HCl

HBr

hydroiodic acid

hydrosulfuric acid

oxyacids: acids containing H, O, and one other element

Oxyacid Nomenclature

For "most common" forms of the oxyanions, write prefix of oxyanion, followed by "-ic acid."

$HBrO_3$

$HClO_3$

H_2CO_3

sulfuric acid

phosphoric acid

If an oxyacid differs from the above by the # of O atoms, the name changes are:

one more O	=	per_____ic acid
"most common" # of O	**=**	**_____ic acid**
one less O	=	_____ous acid
two fewer O	=	hypo_____ous acid

$HClO_4$

$HClO_3$

$HClO_2$

HClO

phosphorous acid