Chemical Particles

Name: ____________________________

AP Chemistry Lecture Outline

Video 203 (8:43)

Historical Development of the Atomic Model

Greeks (~400 B.C.E.)

-- Democritus, Leucippus, and others

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

Greek model of atom

-- 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…………………. chromium(II) oxide……..

-- 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…………………. chromium(II) oxide……..

hydrogen peroxide…. chromium(VI) oxide…….

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…

Dalton's model of atom

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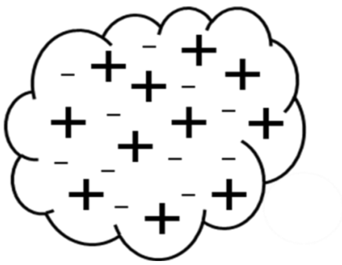
Law of Electrostatic Attraction:

-- 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.

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 (–).

-- 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 a single electron. He then found the electron’s mass:

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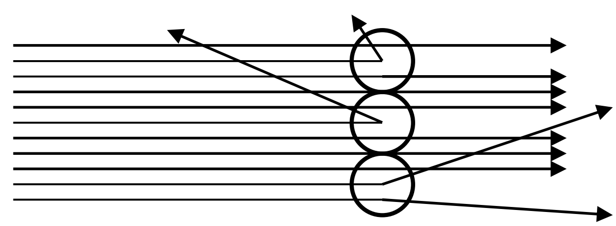
-- Ernest Rutherford (1910): Gold Leaf Experiment

A beam of α-particles (+) was 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 =

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electronic charge =

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

e.g.,

-- <u>atomic mass unit</u> (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:

<u>Angstroms</u> (Å) are often used to measure atomic dimensions.

Conversion:

<u>atomic number</u>:

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

<u>mass number</u>:

<u>isotopes</u>: different varieties of an element's atoms

--

-- some are radioactive; others aren't

-- A nucleus of a specific isotope is sometimes called a…

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Complete Atomic Designation

…gives precise info about an atomic particle

mass # **charge (if any)**
element
symbol
atomic #

$$^{125}_{53}\mathrm{I}^{-}$$

Protons	Neutrons	Electrons	Complete Atomic Designation
92	146	92	
11	12	10	
34	45	36	
			$^{59}_{27}\mathrm{Co}^{3+}$
			$^{37}_{17}\mathrm{Cl}^{-}$
			$^{55}\mathrm{Mn}^{7+}$

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Average Atomic Mass (a.k.a., Atomic Mass or Atomic Weight)

This is the weighted average mass of all atoms of an element, measured in a.m.u. For an element with isotopes A, B, etc.:

EX. Lithium has two isotopes. Li-6 atoms have mass 6.015 amu; Li-7 atoms have mass 7.016 amu. Li-6 makes up 7.5% of all Li atoms. Find AAM of Li.

** Decimal number on Table refers to…

EX. Complete the table.

Isotope	**Mass**	**% abundance**
Si-28	27.98 amu	92.23%
Si-29	28.98 amu	4.67%
Si-30		

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The Periodic Table

<u>group</u>: a vertical column; elements in a group share certain phys. and chem. properties

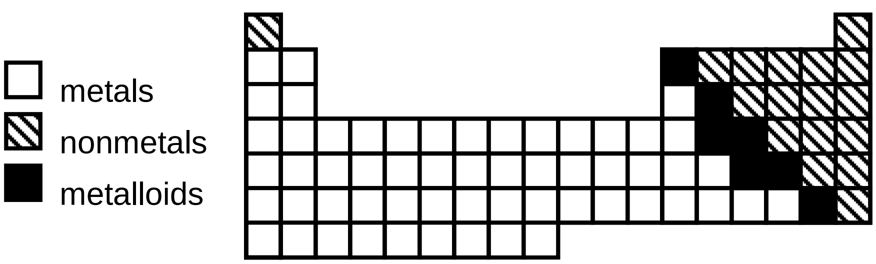
-- group 1 =

-- group 2 =

-- group 16 =

-- group 17 =

-- group 18 =



<u>Molecular compounds</u> contain only…

empirical formula: shows relative #s of each type of atom in m'cule

molecular formula: shows actual #s & types of atoms in m'cule

structural formula: shows which atoms are bonded to which

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 –	3 –	5 –	7 –	9 –
2 –	4 –	6 –	8 –	10 –

EX: carbon dioxide N_2O_5

CO carbon tetrachloride

dinitrogen trioxide NI_3

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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…

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

polyatomic ion: a charged group of atoms

Memorize:

NH_4^+	ammonium
CH_3COO^-	acetate
PO_4^{3-}	phosphate
MnO_4^-	permanganate

NO_3^-	nitrate
ClO_3^-	chlorate
BrO_3^-	bromate
IO_3^-	iodate

CO_3^{2-}	carbonate
HCO_3^-	bicarbonate
SO_4^{2-}	sulfate
HSO_4^-	bisulfate

CrO_4^{2-}	chromate
$Cr_2O_7^{2-}$	dichromate

CN^-	cyanide
OH^-	hydroxide

Ionic compounds, or salts, consist of oppositely-charged species bonded by electrostatic forces. You can describe salts as "metal-nonmetal," but "cation-anion" is 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 req'd only with multiple "bunches" 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 $N^{3–}$

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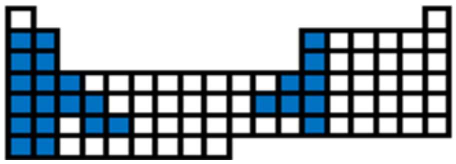
Fixed-Charge Cations with Elemental Anions



For this class, the fixed-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

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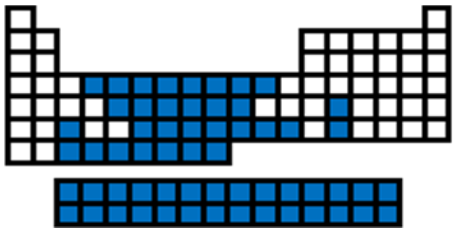
Variable-Charge Cations with Elemental Anions



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

A. To name, given the formula:

Stock System of nomenclature

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 $\qquad$ $CuBr$

Fe_2O_3 $\qquad$ $CuBr_2$

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

Video 233 (8:25)

Compounds Containing Polyatomic Ions

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

But first... oxyanions: polyatomic ions containing oxygen

"Most common" oxyanions:

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

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 fewer O	=	_____ite
two fewer O	=	hypo_____ite

Write formulas:	*Write names:*
iron (III) nitrite	$(NH_4)_2SO_4$
ammonium phosphide	$AgBrO_3$
ammonium chlorite	$(NH_4)_3N$
zinc phosphate	$U(CrO_4)_3$
lead (II) permanganate	$Cr_2(SO_3)_3$

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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 fewer O	=	_____ous acid
two fewer O	=	hypo_____ous acid

$HClO_4$

$HClO_3$

$HClO_2$

$HClO$

phosphorous acid

hypobromous acid

persulfuric acid