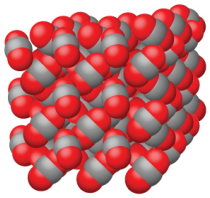
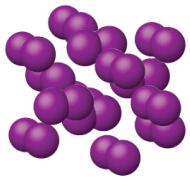
# 2.5 - 2.8 - Isotopes, Ions, Nomenclature



carbon dioxide



iodine

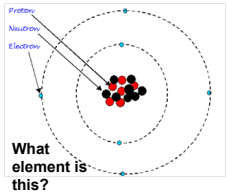
May 20-7:09 AM

## Atomic Number (Z)

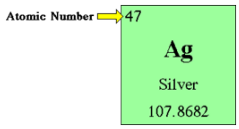
Def: Number of protons in an atom.
Symbol = Z: "Zahl" is "number", in German.

Elements are defined by their number of protons.

Also equals the number of electrons in electrically neutral atom.




What element is this?

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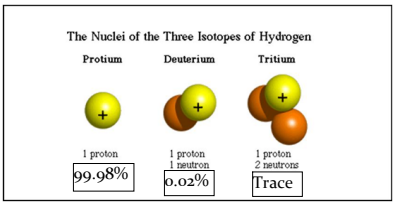
## Isotope

Atoms of the same element with different numbers of neutrons.
Elemental isotopes have different abundance.




Isotopes have the same chemical properties, but some different physical ones: mass, boiling point.

Sep 25-6:47 AM

## Mass Number

Def: Number of protons + neutrons of an isotope.

1. What is the mass number of a sodium isotope that has 13 neutrons in the nucleus?

Sodium has 11 protons, so the mass number will be:

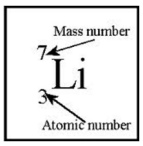
11 protons + 13 neutrons = mass number = 24

Sep 25-6:48 AM

## Isotope Notation

There are two ways of symbolically writing isotopes:

Superscript/Subscript method: mass number is superscripted, atomic number is subscripted.




Element - Mass Number method: Element's name/ symbol is followed by the mass number.

**Lithium - 7**
**OR Li - 7**

Oct 2-10:51 AM

$$^{15}_{7}\mathrm{N}$$

What element is this? Nitrogen
How many electrons, protons, and neutrons does it have?
Electrons = Protons = 7
Neutrons = Mass Number – Atomic Number = 8

Write this isotope in element - mass number notation.
N-15.

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## 3. More Isotopes

Write the following elements in both forms of isotope notation.

Protons = 33
Neutrons = 38

$^{71}_{33}As$

Arsenic - 71

Neutrons = 11
Protons = 9

$^{20}_{9}F$

Fluorine - 20

Apr 7-3:09 PM

## Atomic Mass Unit (amu)

**(also called a Dalton (Da))**

Scientists realized the importance of standardizing atomic masses in chemistry.
In 1803, John Dalton proposed using hydrogen's mass as a standard. Later, oxygen was used.
With the discovery of isotopes in 1912, the original standards became invalid.
Finally, in 1961, carbon-12 was adopted.
AMU Definition: the mass of 1/12th of a carbon-12 atom.

Sep 25-6:53 AM

## Atomic Mass

Since it's impossible to weigh every atom of an element on Earth and find the average, a weighted average mass of an element's isotopes is made.

22
Ti
Titanium
47.867(1)

← Weighted Average Atomic Mass

Sep 25-6:54 AM

## Average Mass Process

A. Multiply isotope's atomic mass by % abundance (as decimal) for every isotope to determine each contribution.
B. Add contributions.

4. Guided Example:
Chlorine: $^{37}_{17}Cl$ Mass = 36.97 amu
% = 24%
= (36.97 amu)(0.24) = 8.87 amu

$^{35}_{17}Cl$ Mass = 34.97 amu
% = 76%
= (34.97 amu)(0.76) = 26.58 amu

Weighted average mass: 8.87 amu + 26.58 amu
= 35.45 amu

Sep 25-7:02 AM

## 5. Changing Abundance

If isotopic abundance changes, the weighted average mass does too.

What if: $^{37}_{17}Cl$ Mass = 36.97 amu
% = 85%
= (36.97 amu)(0.85) = 31.42 amu

$^{35}_{17}Cl$ Mass = 34.97 amu
% = 15%
= (34.97 amu)(0.15) = 5.25 amu

Average: 31.42 amu + 5.25 amu = 36.67 amu.
Heavier than 35.44 amu from the earlier distribution.

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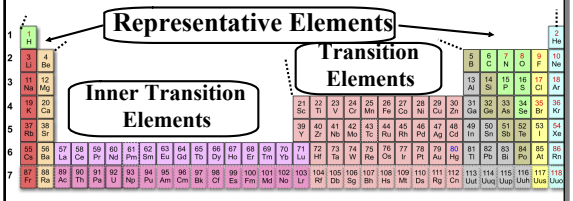
## 6. Label the Terms of the Table

Group (Family) - Vertical column of elements.
Period - Row of elements.
Representative Elements – Groups 1 & 2, 3 - 8: Correspond to the number of valence (outermost) electrons.
Transition Elements – Between 2 and 3 (B series)
Inner Transition Elements - Lanthanides & Actinides.




Mar 5-12:38 PM

## Types of Elements: Metals

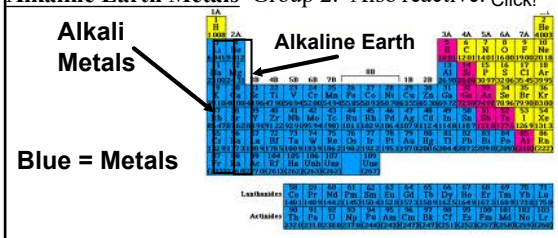
Metals are found on the left side of the periodic table.

**Metals**: Generally shiny, solid @ room temperature, good conductors of heat & electricity.

**Alkali Metals** Group 1 elements except H. Very reactive!

**Alkaline Earth Metals** Group 2. Also reactive. Click!

Click!

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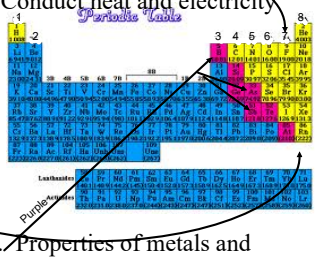
## Non-Metals

Non-Metals: Upper right side of table (and hydrogen). Brittle solids or gases (one liquid). Conduct heat and electricity poorly.

Halogens Group 7. Very reactive.

Noble Gases Group 8. Very unreactive.




Metalloids Semi-metals. Properties of metals and nonmetals. Ex: Si and Ge used in microchips.

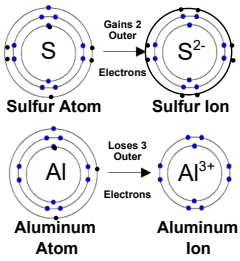
Mar 5-12:38 PM

## Octet Rule

Ions with eight electrons in their valence shells are chemically stable - they won't react more.
Atoms end up with eight electrons by sharing, losing, or gaining them (whichever is easiest).

Ex. 1: sulfur has 6 V. E.; by obtaining two more, it will have 8 (easier than losing 6).

Ex. 2: aluminum has 3 V. E.; by losing all three, the next energy level down will have 8 (easier than gaining 5).




Oct 24-7:33 AM

## Octet Rule Exceptions

Helium is a noble gas with only two electrons.

H, Li, Be, and B will form ions that mimic helium's electron configuration: $1s^2$, because they have too few electrons to end up with eight.

Carbon is also an exception, it can form a 4+ ion that mimics helium.

Oct 24-7:33 AM

## Covalent Bonds

Covalent Bonds form in non-ionic compounds where pairs of electrons are shared, not lost or gained.

Single, Double, or Triple Bonds are possible.

Molecule: A group of covalently-bonded elements.
(Ionic compounds = formula unit)

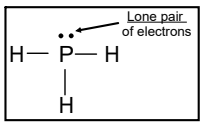
Example: How many electrons gained in:

| O? | Cl? | P? |
|---|---|---|
| **2** | **1** | **3** |

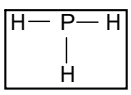
Nov 1-9:18 PM

## Five ways Show Structure: Ex. = Phosphorous Trihydride

1. Molecular formula: $PH_3$
2. Lewis structure:




3. Structural formula – no lone electrons ($e^-$):

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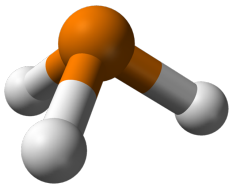
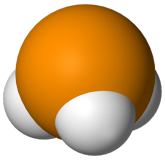
## Phosphorous Trihydride

4. Ball and stick model:





5. Space filling model:

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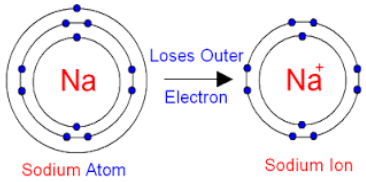
## Ion Definition

**Ion:** atom that has lost or gained one or more valence electrons by reacting with another atom.
In forming ions, elements become stable (unreactive).

Ions mimic nearest noble gas's electron configuration.

Noble gases already have a full outer shell, so are unlikely to form bonds with other elements.

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## 7. You Do!

How many electrons will these elements gain or lose to satisfy the octet rule?

Nitrogen = 3 electrons gained

Chlorine = 1 electron gained

Calcium = 2 electrons lost

Carbon = 4 electrons gained or lost

Oct 24-7:35 AM

## 8. Details

Positive ion – called cation (cat-ion)

Negative ion – called anion (an-ion)

The **charges** of ions appear as **superscripted** numbers beside the symbol:

$K^{+}$ $S^{2-}$ $Al^{3+}$ $Cl^{-}$

Nov 1-9:18 PM

## Cations

Metals lose electrons.

Group 1 metals form 1+ ions,
Group 2 metals form 2+ ions.

Transition metals lose s electrons, and may lose d electrons also, depending on what they react with.

Look at Resources 5 for metal ions with multiple charges: those are listed with Roman Numerals.

## Anions

Nonmetals gain electrons.

Group 5 elements gain 3 electrons: charge = 3-.
Group 6 elements gain 2: charge = 2-.

Group 7 (halogens) elements gain one: charge = 1-

Nov 1-9:18 PM

## Singles vs. Groups

Look at your Ions Resource (Page 5).
Monatomic Ion – A single atom with a charge.
Ex: $I^{-}$ (iodide ion),
$Al^{3+}$ (aluminum ion),
$O^{2-}$ (oxide ion).

Polyatomic Ion – A group of atoms with a charge.
Ex: $NO_3^{-}$ (nitrate ion),
$NH_4^{+}$ (ammonium ion),
$C_2H_3O_2^{-}$ (acetate ion).

Nov 1-9:18 PM

## Some Formula Definitions

Formula Unit: Simplest ratio of the ions in a compound, with an overall charge of **zero.**

Oxidation number: the charge of an ion.
Some metals have multiple oxidation numbers.

Oxyanions: **Negative** ion with **oxygen** atoms connected to another element.

Nov 1-9:18 PM

## Monkeys vs. Wizards

Two ways to determine formulas for ionic compounds, BOTH start by writing down what ions are involved.

The Wizard Method: Add ions until charges balance:

Example: Aluminum Chloride:
If you have three negative chloride ions, they cancel the 3+ charge of the aluminum ion.

$AlCl_3$.

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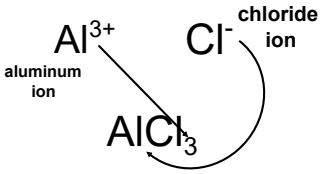
## Monkeys vs. Wizards

The Monkey Method: swap charge values between ions, and write the formula:




(Implied subscripted 1 behind Al)
Caution: The formula must be reduced if possible:
Ex: $Pb_2O_4$ becomes $PbO_2$.

Nov 1-9:18 PM

## 9. Formula Examples

Memorize all the ions on page 5 over the first quarter - next quarter you won't be able to use this list on tests and quizzes.
Be sure that charges balance as you solve these!

| | |
|---|---|
| calcium nitrite: | $Ca(NO_2)_2$ |
| lead (IV) chloride: | $PbCl_4$ |
| chromium (II) borate: | $Cr_3(BO_3)_2$ |
| silver sulfate: | $Ag_2SO_4$ |
| beryllium cyanide: | $Be(CN)_2$ |

Nov 1-9:18 PM

## Polyatomic Ion Formulas

If multiple polyatomic ions (a group of atoms with a charge) are needed to balance a formula, write the ion in parenthesis, with the number as a subscript.

Example: ammonium sulfate.
Ammonium has 1+ charge, sulfate has 2- charge: it takes two ammonium ions to counter one sulfate ion.

$(NH_4)_2SO_4$

Nov 1-9:18 PM

## Naming Binary Compounds

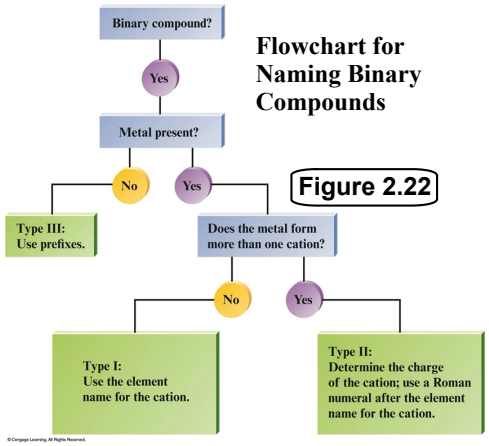
Binary compound: Two elements bonded ionically or covalently in some ratio.

Type I: Binary Ionic. Two different monatomic elements bound ionically, only one cationic charge.

Type II: Binary Ionic. Two monatomic elements bound ionically, multiple cationic charges possible.

Type III: Binary molecular. Two different nonmetallic elements bound covalently.

Nov 1-9:18 PM




**Flowchart for Naming Binary Compounds**

**Figure 2.22**

Aug 29-4:36 PM

## Naming Ionic Compounds Process

1. Write cation's name first.

2. Name anion.

Note: If cation has multiple oxidation numbers (Type II), determine which one is in the formula, and parenthesize the number using Roman Numerals.

Ex: $PbCl_2$ - Lead can be 2+ or 4+, but chloride has only a 1- charge. There are two chloride ions, for a total charge of 2-. Lead must be 2+ for balance. $PbCl_2$ is **lead (II) chloride**.

Note: chemical names NEVER have super/subscripts.

Nov 1-9:18 PM

## 10. Naming Examples

$Na_3N$: sodium nitride

FeO: iron (II) oxide

$Fe_2O_3$: iron (III) oxide

KOH: potassium hydroxide

Note: Group 1 and 2 elements only have one oxidation number: don't write "potassium (I) hydroxide"

Nov 1-9:18 PM

## 11. More Naming Examples:

Name these:

$LiNO_3$ = lithium nitrate

$Cr_3(PO_4)_2$ = chromium (II) phosphate

$Sn(SO_3)_2$ = tin (IV) sulfite

Nov 1-9:18 PM

## Binary Molecular Compounds

Def: covalently bonded compound formed from ratios of two different elements.

Three naming rules: *Ex: $SeCl_2$*

1. Name 1st element. *Ex: selenium*
2. Name 2nd element, with –IDE ending. *Ex: chloride*
3. Use prefixes to indicate *how many* of each element there are. Prefix Rabbit Hole!

Note: 1st element never gets "mono-"

*Ex: selenium dichloride*

4. Reverse process determines formulas from names. Vowel Rabbit Hole!

Nov 1-9:18 PM

## Prefix Rabbit Hole! (Resources Page 6)

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

Back to Reality!

Nov 1-9:18 PM

## Vowel Rabbit Hole!

Sometimes, vowel clusters (groups of vowels) **involving oxygen** result in slightly altered names, to make words sound better:

1. monooxide is: ***mon*oxide**

2 and 3. di, tri are unchanged

4, 5, 6, 7, 8, 9 and 10: the prefix's last *a* is dropped: tetroxide, pentoxide, heptoxide, octoxide, nonoxide, decoxide.

Nov 1-9:18 PM

## 12. Binary Molecular Compounds Practice

$CO_2$ = carbon dioxide

$CCl_4$ = carbon tetrachloride

$H_2O$ = dihydrogen monoxide

$N_2O_3$ = dinitrogen trioxide

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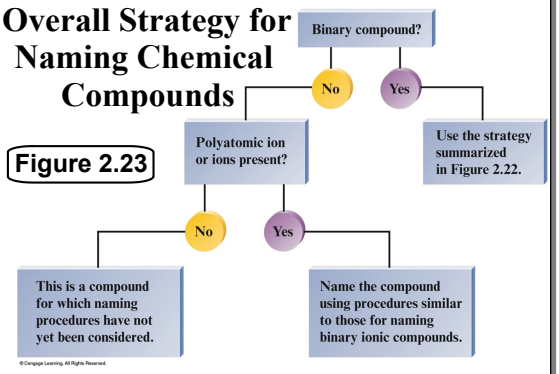
## Overall Strategy for Naming Chemical Compounds

Figure 2.23

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## Naming Binary Acids Process

Acid - Ionic compounds that release hydrogen ions ($H^+$) in aqueous solution.

Binary Acids- hydrogen and non-oxygen element(s).

Naming Process:

1. Write name of ionic compound.
   Ex: HCl – hydrogen chloride.
2. Remove *gen* and *ide* endings.
3. Combine word parts, add ending *ic acid'*.
   Ex: Hydrochloric acid
4. Check your name: Resources Page 6.

Nov 1-9:18 PM

## 13. Name These Binary Acids

HBr = hydrobromic acid

HI = hydroiodic acid

$H_2S$ = hydrosulfuric acid

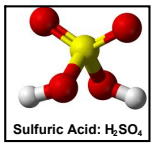
HCN = hydrocyanic acid

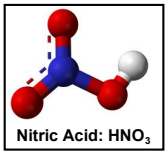
Nov 1-9:18 PM

## Naming Oxyacids Process

Oxyacids contain hydrogen and an oxyanion.

1. Write ionic compound name.
2. Remove the word 'hydrogen', then
   A. Replace *-ite* ending with *-ous acid.*
      Ex: - $HNO_2$ = hydrogen nitrite = **nitrous acid.**
   B. Replace *-ate* with *–ic acid.*
      Ex: - $HNO_3$ = hydrogen nitrate = **nitric acid.**
3. Check the name: Resources Page 6.

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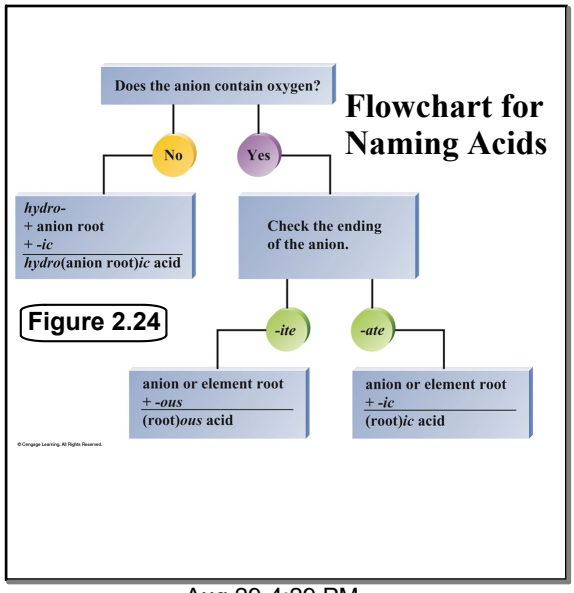


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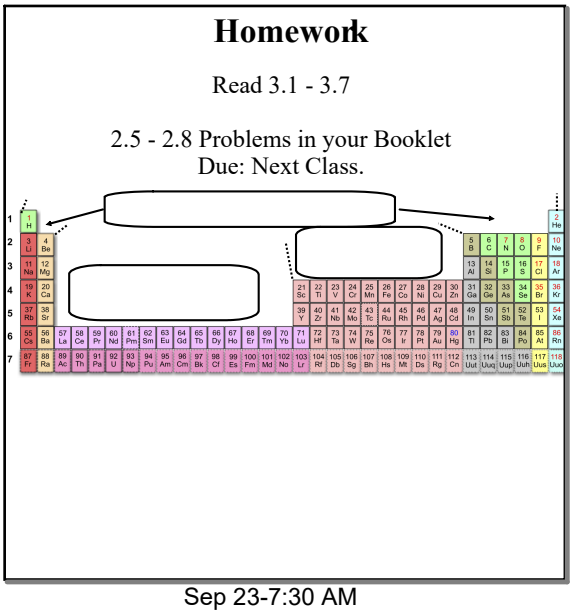


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