

Chapter 2

Atoms, Molecules, and Ions

Jim Geiger

Cem 151

Atomic Theory of Matter



The theory of atoms:

Original to the Greeks

Leucippus, Democritus and Lucretius
(around 50 B.C.)

(Aristotle thought they were nuts)

Believed that one never came up with a piece of matter that could not be further divided.

He suggested that everything in the world was made up of some combination of four elements: earth, fire, water, and air.

The elements were acted upon by the two forces: gravity and levity.
Gravity was the tendency for earth and water to sink, and levity the tendency for air and fire to rise.

John Dalton (1805-1808)

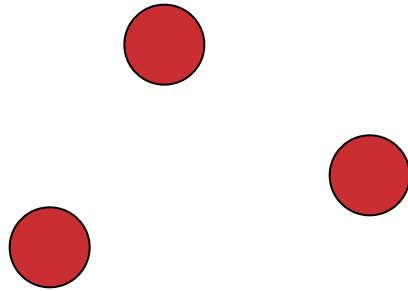
Revived the idea and made it
science by **measuring** the
atomic weights of 21 elements.



*That's the key thing
because then you can see
how elements combine.*

Dalton's Postulates

Each element is composed of extremely small particles called atoms.



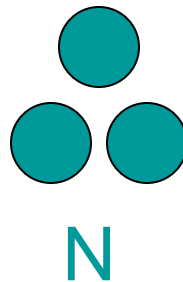
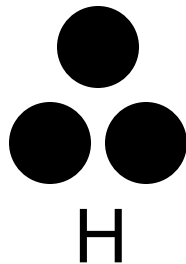
Tiny balls make up the world



Dalton's Postulates

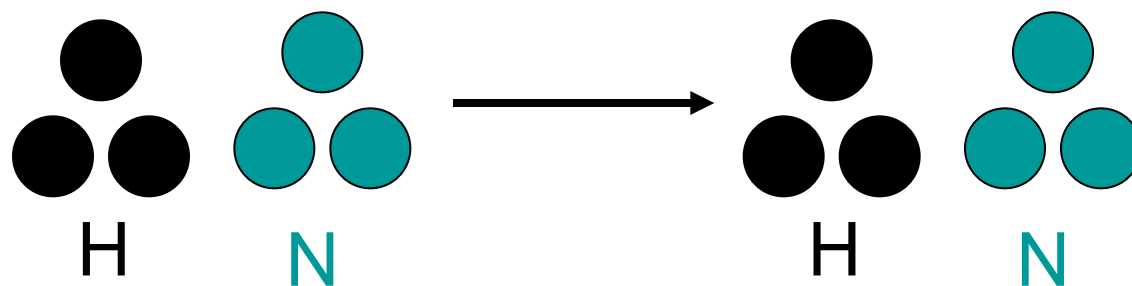
All atoms of a given element are *identical* to one another

The atoms of one element are *different* from the atoms of all other elements.



Dalton's Postulates

Atoms cannot be changed, created or destroyed in chemical reactions. (As far as Dalton knew, they couldn't be changed at all).

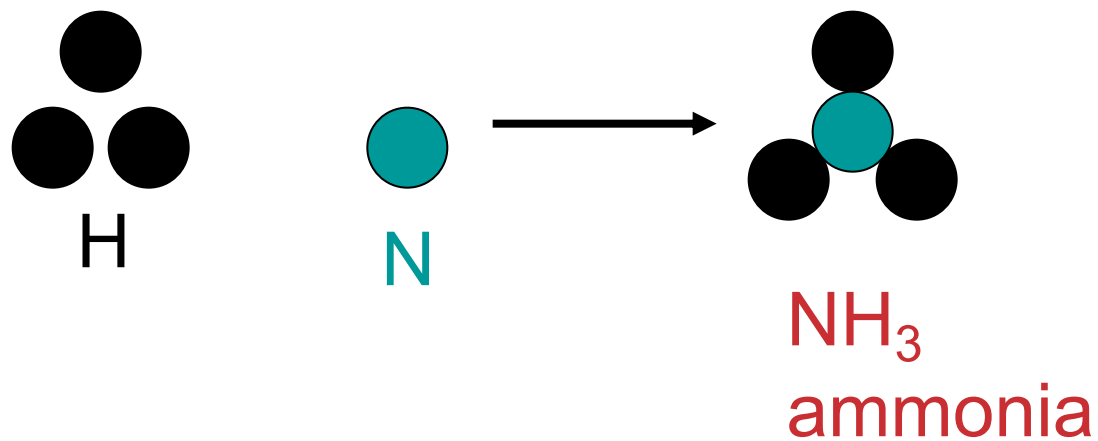


Red O's stay Os and aqua N's stay N's.



Dalton's Postulates

Compounds are formed when atoms of more than one element combine; a given compound always has the same relative number and kind of atoms.



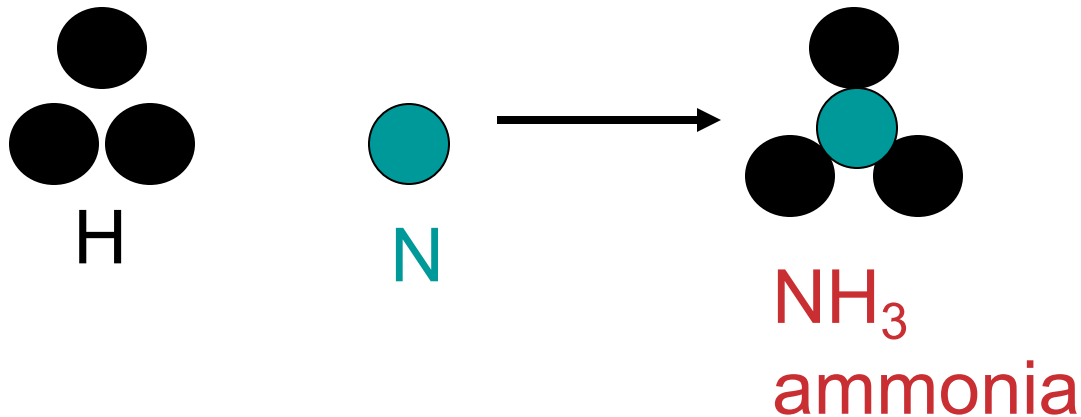
Chemistry happens when the balls rearrange



Law of Constant Composition

Joseph Proust (1754–1826)

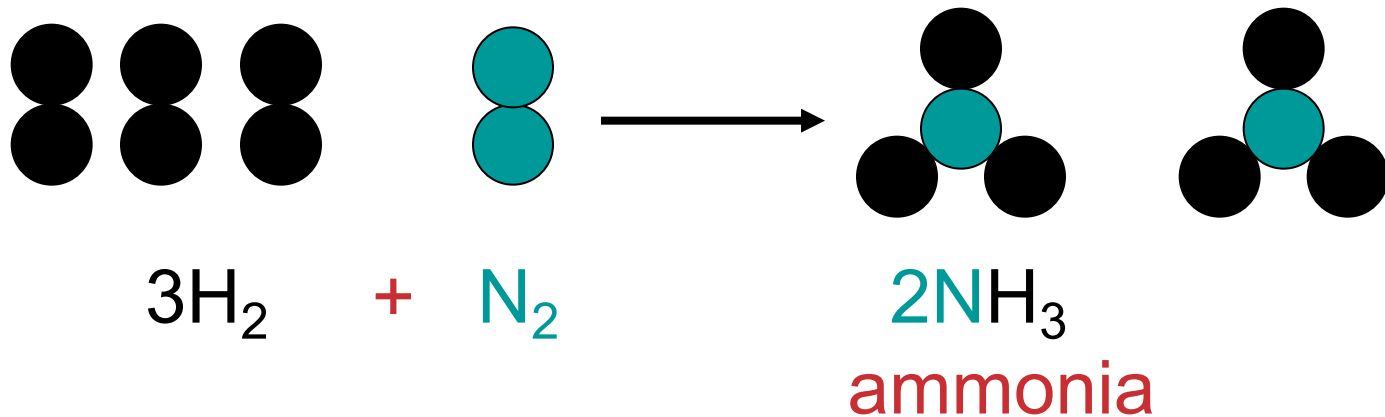
- Also known as the law of definite proportions.
- The elemental composition of a pure substance never varies.
- The relative amounts of each element in a compound doesn't vary.



ammonia always has 3 H and 1 N.

Law of Conservation of Mass

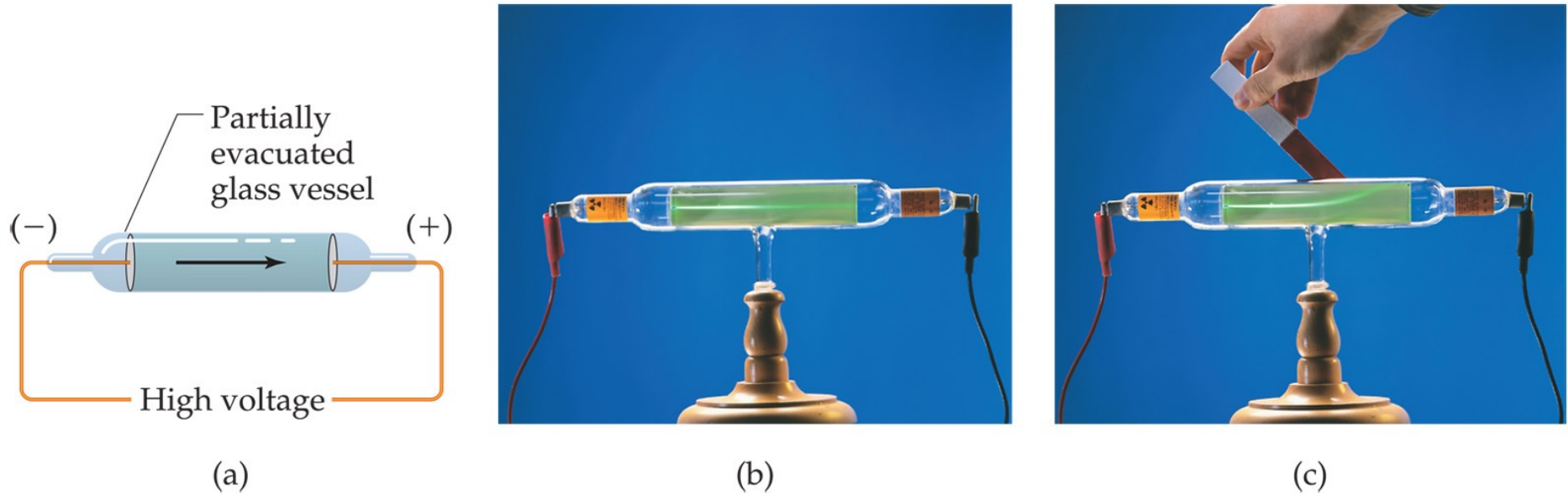
The total mass of substances present at the end of a chemical process is the same as the mass of substances present before the process took place.



The atoms on the left all appear on the right

The Electron

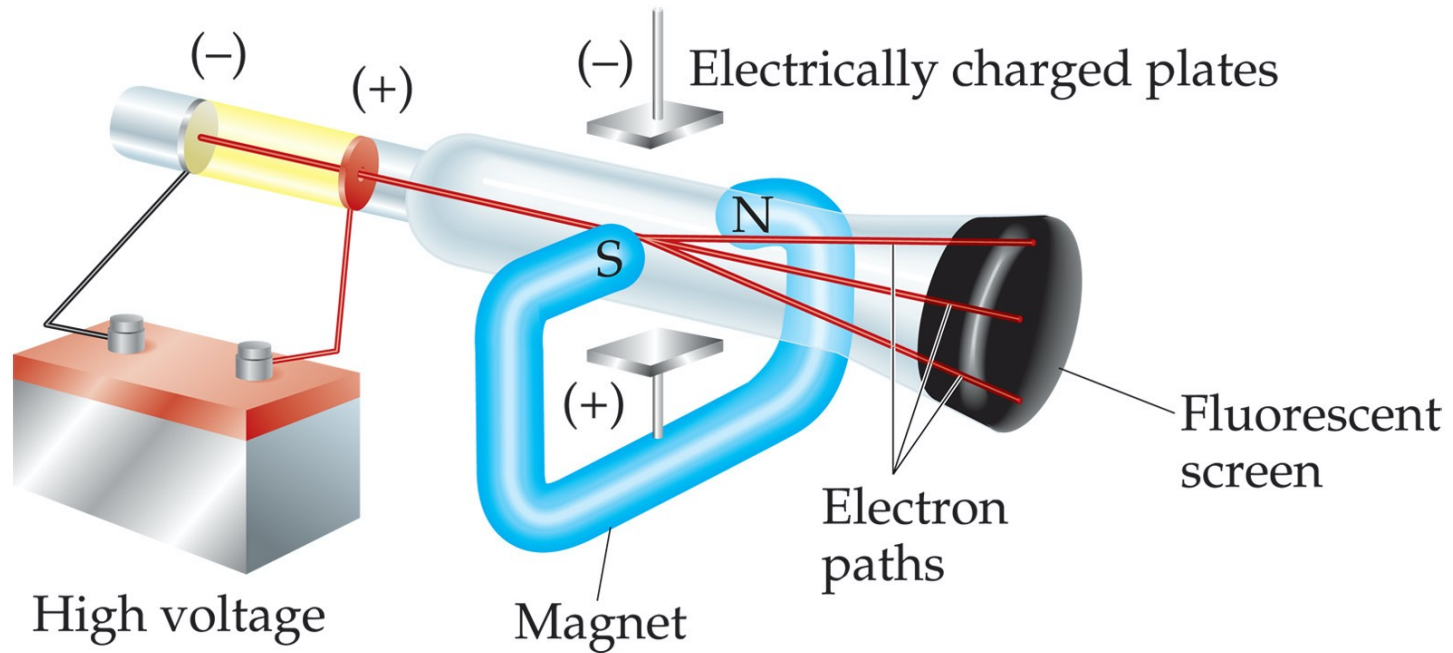
The first crack in the atomic theory



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- J. J. Thompson (1897).
- Streams of negatively charged particles were found to emanate from cathode tubes.
- Visualizing electric current.
- Maybe atoms weren't completely indivisible after all.

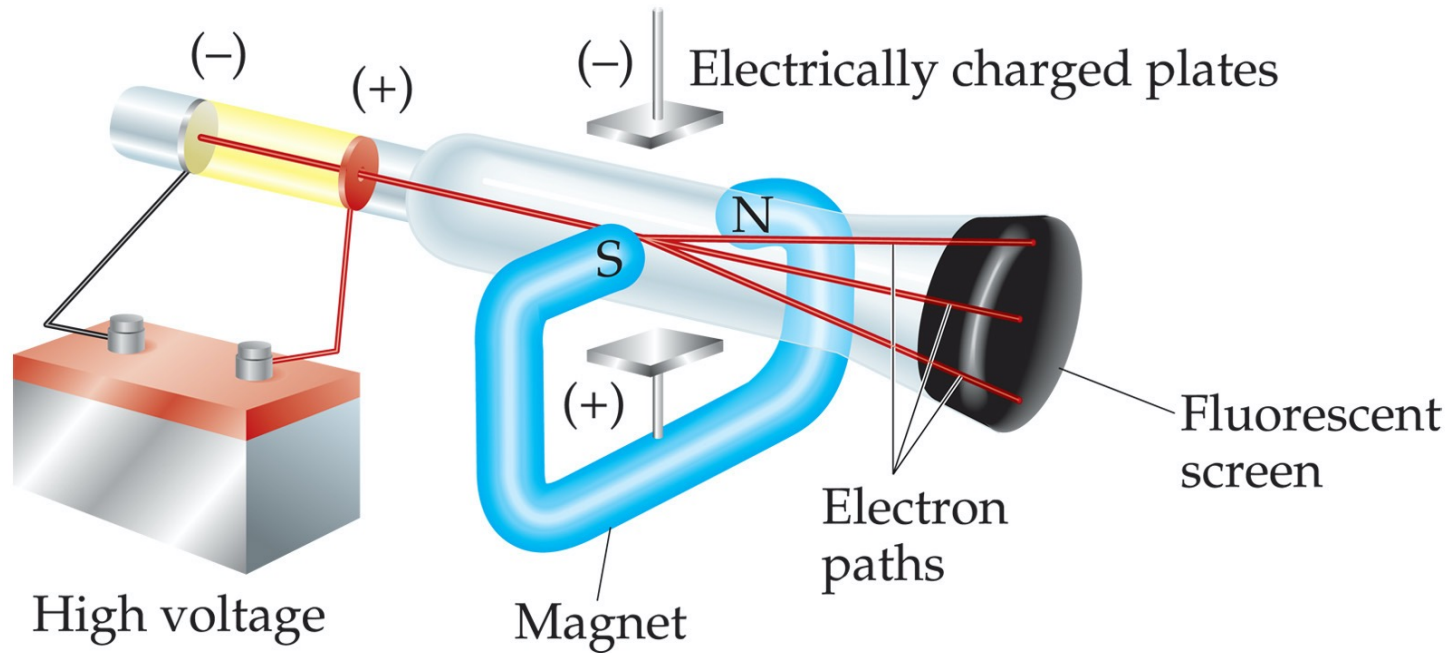
The Electron



Thompson measured the charge/mass ratio of the electron to be 1.76×10^8 coulombs/g.

How? by manipulating the magnetic and electric fields and observing the change in the beam position on a fluorescent screen.

The Electron



Thompson measured the charge/mass ratio of the electron to be 1.76×10^8 coulombs/g.

1 Coulomb = 1 Amp X 1sec. (charge transferred by 1 amp in 1 sec).

Example: Average bolt of lightning transfers **15 Coulombs!**

Conclusion. Electrons were either very highly charged, or very very light.

Millikan Oil Drop Experiment

Measured charge of electron
Univ. Chicago (1909).

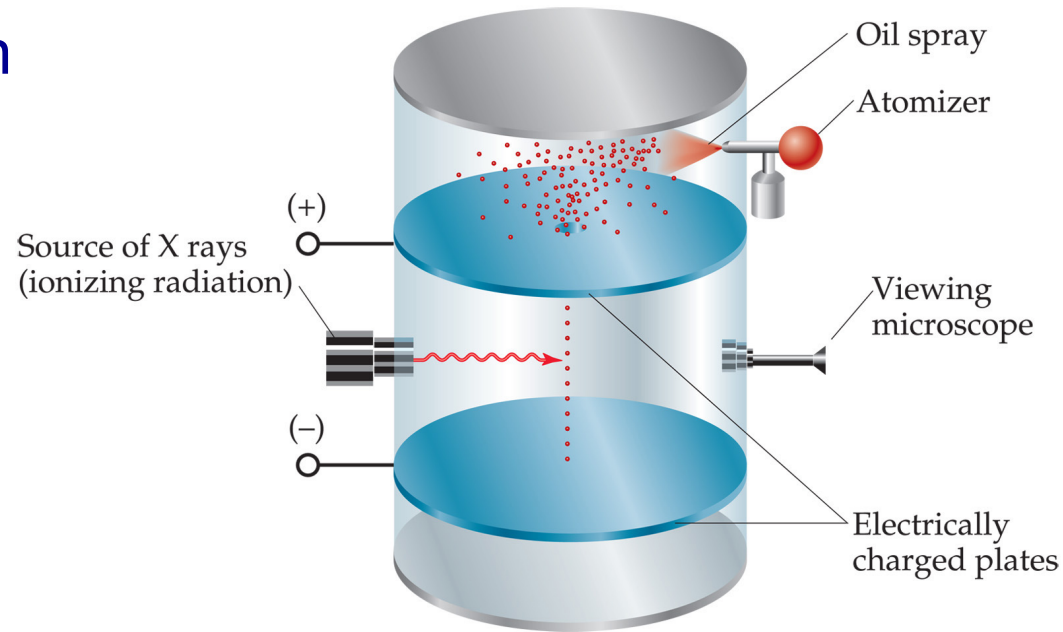
How?

Vary the electric field (E) until the drops float.

Vary the charge (q) on the drop with more X-rays

$$Eq = mg$$

You set E, measure mass of drop (m) & know g. Find q.



Major result: q couldn't be any number. It was a multiple of 1.6×10^{-19} Coulombs

Note: It's quantized.

Radioactivity:

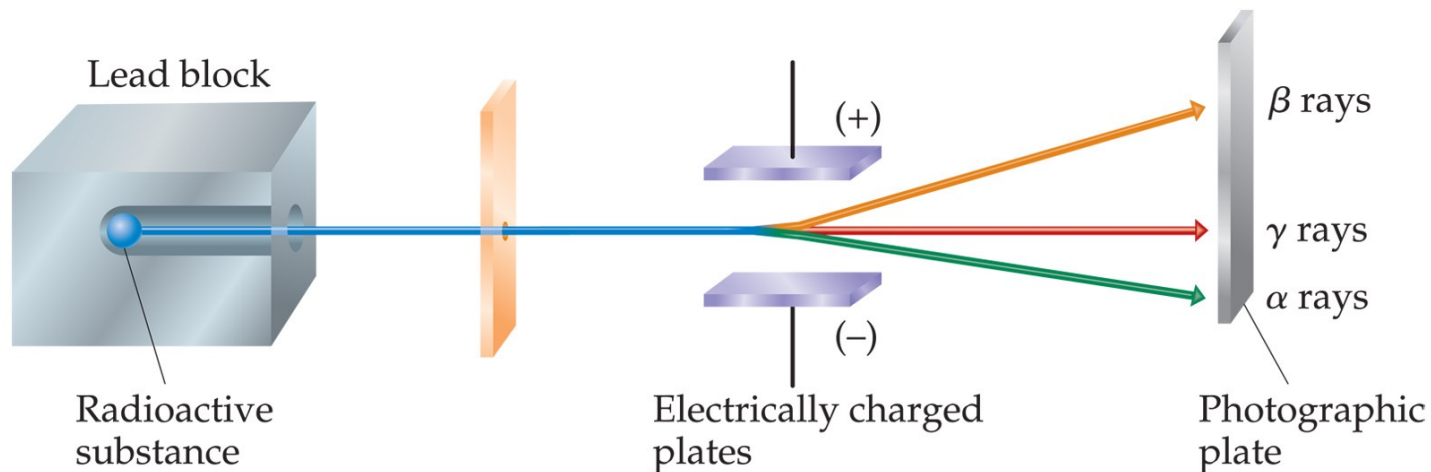
- The spontaneous emission of radiation by an atom.
- First observed by Henri Becquerel.
- (1903 Nobel Prize with Pierre and Marie Curie)
- Also studied by Marie and Pierre Curie.



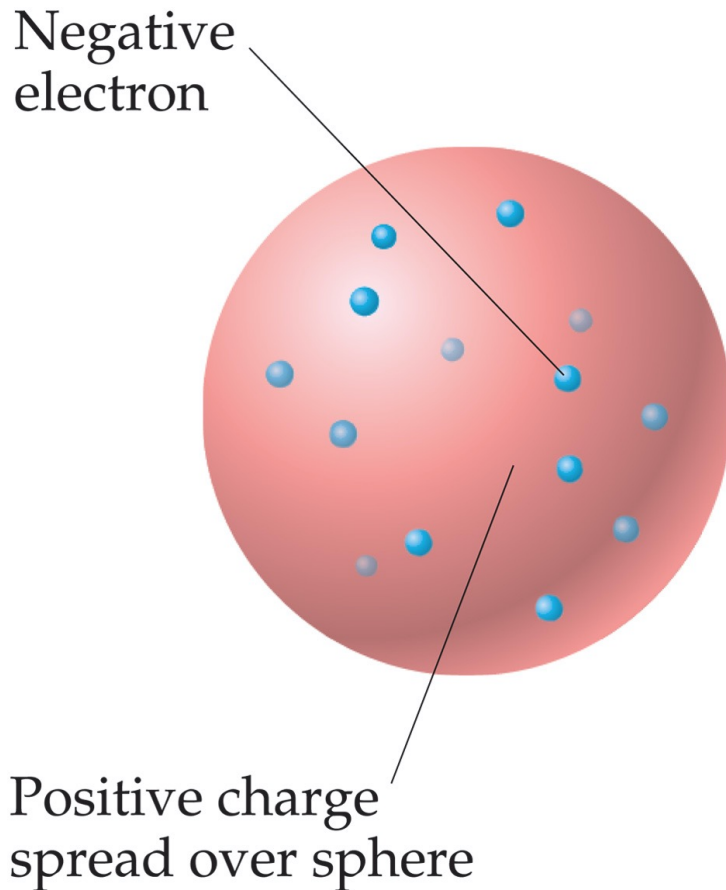
Stuff comes out of atoms, “subatomic particles”

Radioactivity

- Three types of radiation were discovered by Ernest Rutherford: (memorize the 3 types of radiation!)
 - α particles, attracted to negative electrode, so they have a positive charge, much more mass than negative stuff (turn out to be **He nuclei**)
 - β particles, attracted to positive electrode, so they have a negative charge, 1000s of times less massive (turn out to be **electrons** coming from nucleus).
 - γ rays, no charge, no mass, like light.



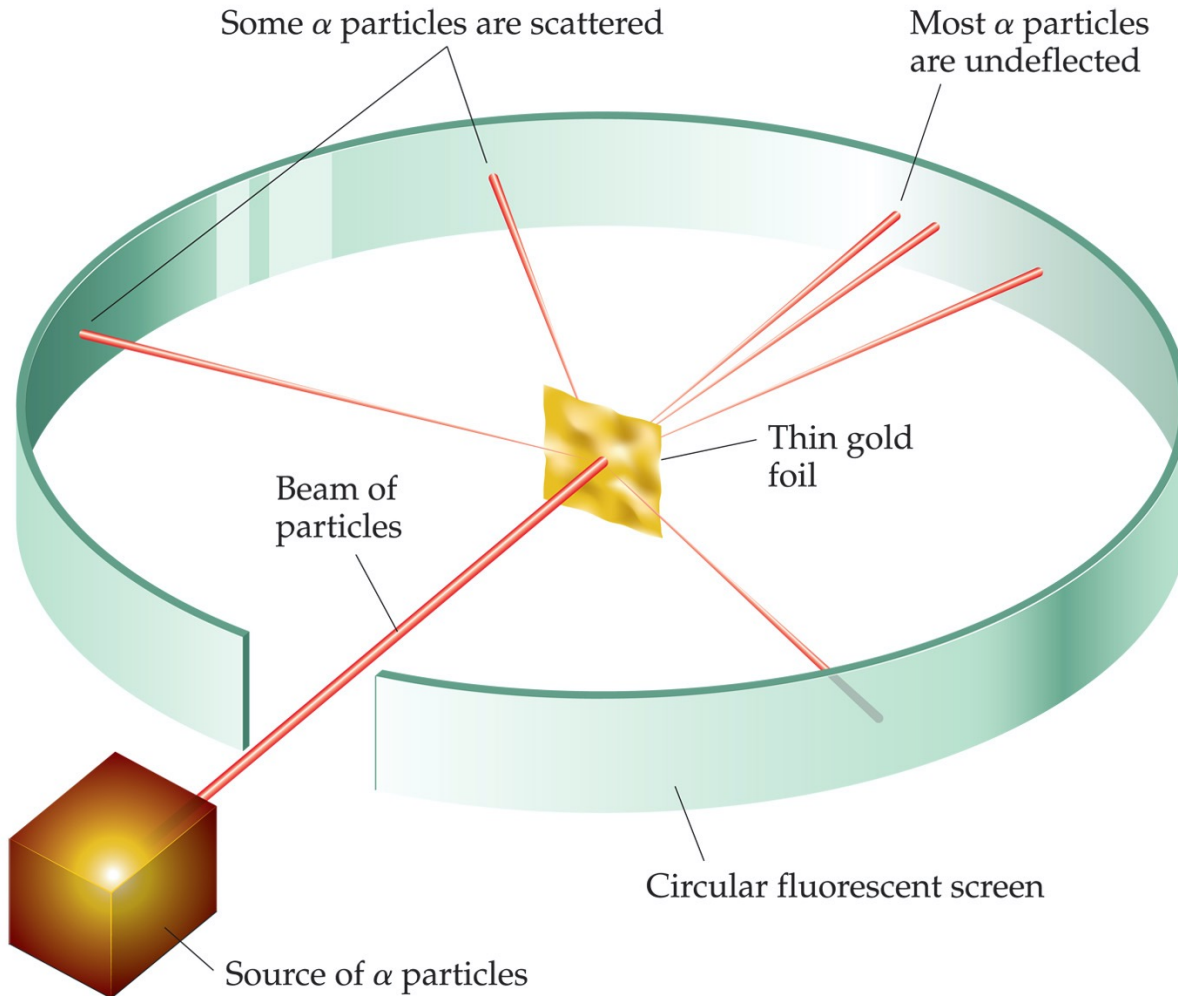
The Atom, circa 1900:



- No longer indivisible
- “Plum pudding” model, put forward by Thompson.
- Positive sphere of matter with negative electrons imbedded in it.
- most of the volume = positive stuff because most of the mass is positive
- Expectation: density more or less uniform throughout.

Discovery of the Nucleus

The Gold Foil Experiment

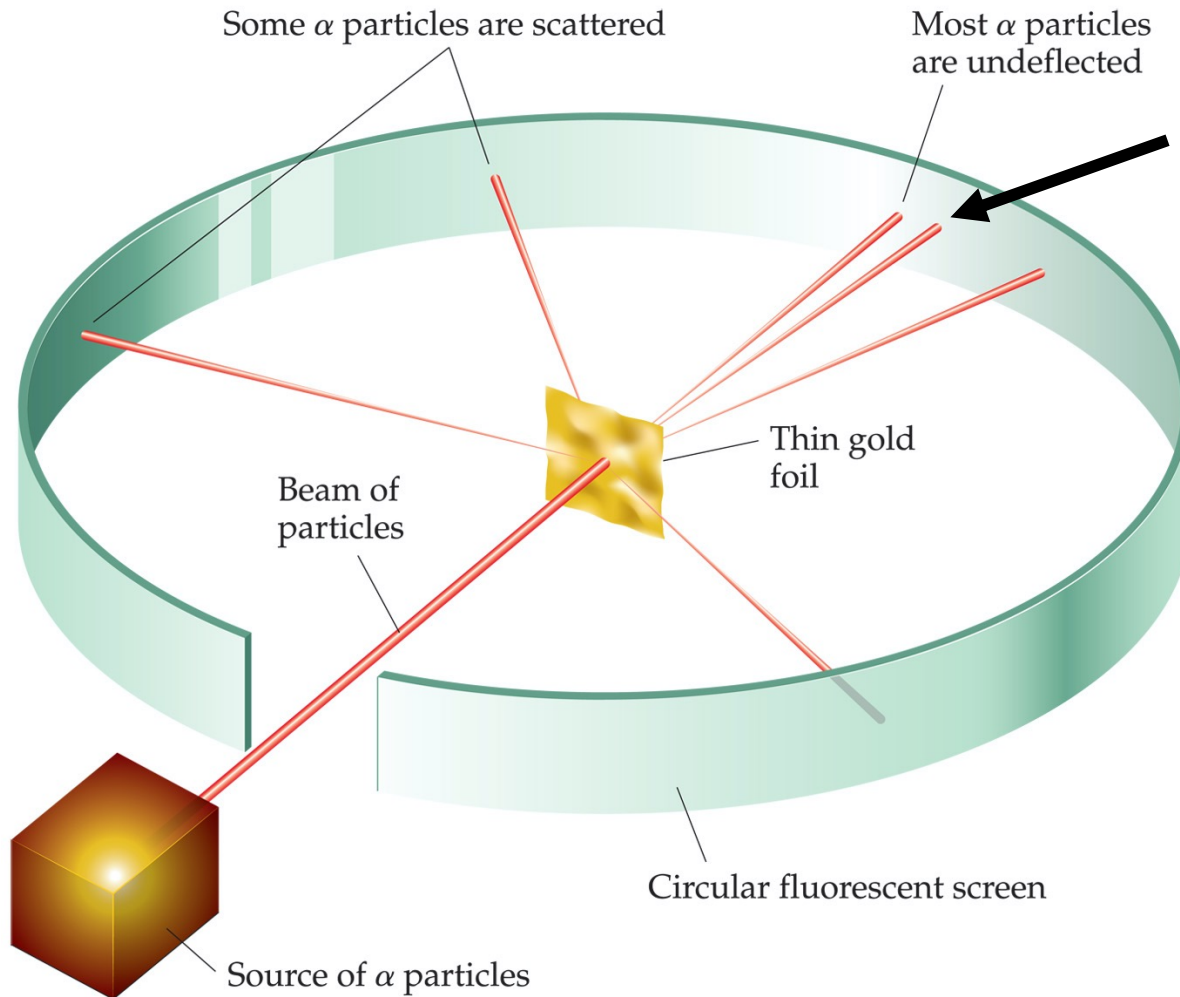


Rutherford and Marsden shot α particles at a thin sheet of gold foil and observed the scatter of the particles.

What do you expect to get from the plum pudding model?

Discovery of the Nucleus

The Gold Foil Experiment



Just this

What do you expect to get from the plum pudding model?

If it's uniform you expect all the deflections to be more or less the same.

The Nuclear Atom *(it ain't plum pudding)*

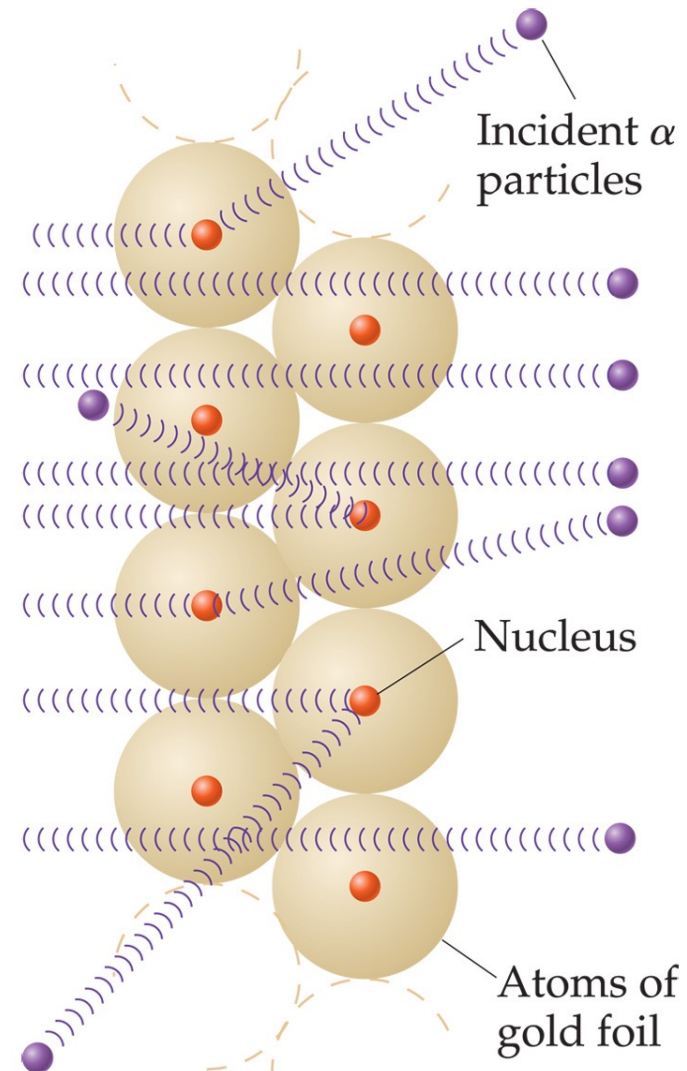
**Virtually all the particles
went straight through**

Most of the atom
essentially empty

**A few particles
deflected, some straight
back.**

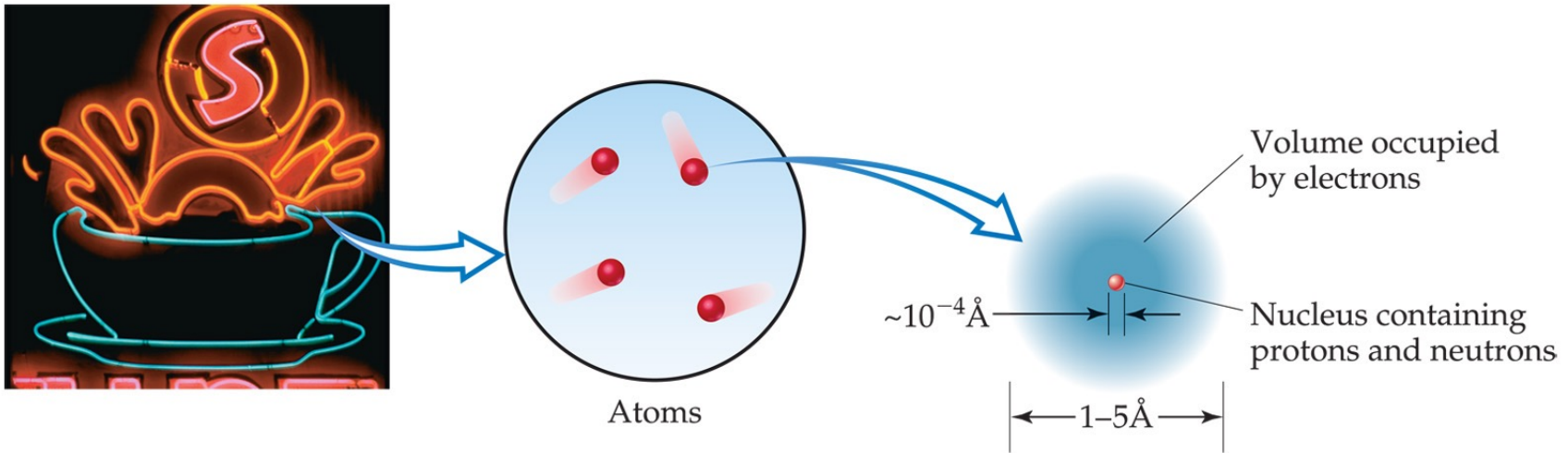
A very small part of
the atom is very
dense, impenetrable.
The mass must be
concentrated.

The size of nucleus will be
proportional to the # of
highly scattered particles.



The Nuclear Atom

- Rutherford and Marsden postulated a very small, dense nucleus with the negative electrons around the outside of the atom.
- Most of the volume of the atom is empty space.



If the nucleus were 1 inch
The atom would be 833 feet in diameter.

Other Subatomic Particles

- Protons were discovered by Rutherford in 1919.
 - Have the positive charge in the atom.
- Neutrons were discovered by James Chadwick in 1932.
 - Have mass like proton, but no charge.
Why was it harder to discover them?

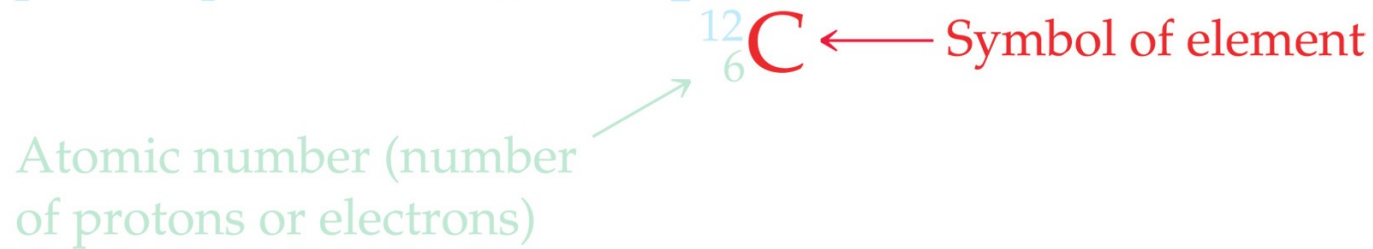
Subatomic Particles

- Protons and electrons are the only particles that have a charge.
- Protons and neutrons have similar mass.
- The mass of an electron is so small we will often ignore it.

Particle	Charge	Mass (amu)
Proton	Positive (1+)	1.0073
Neutron	None (neutral)	1.0087
Electron	Negative (1-)	5.486×10^{-4}

Symbols of Elements: depicting the subatomic particles

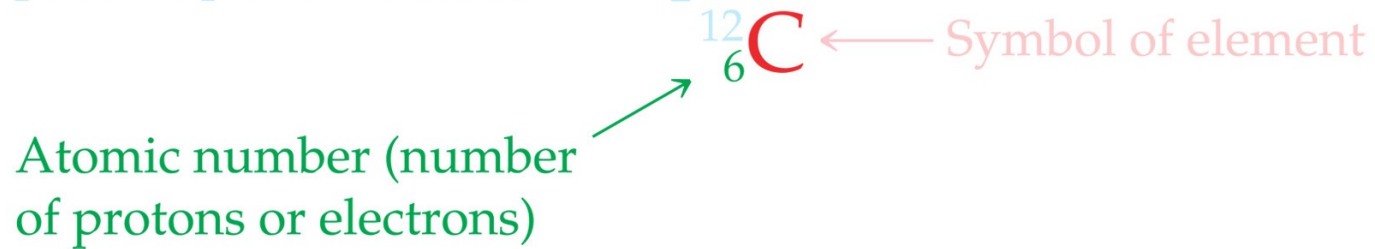
Mass number (number of
protons plus neutrons)



Elements are symbolized by one or two letters.

Atomic Number

Mass number (number of
protons plus neutrons)

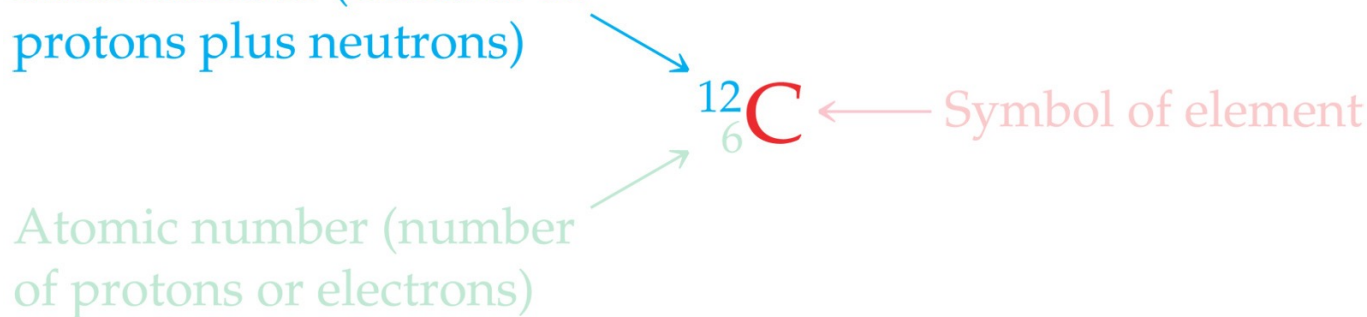


All atoms of the same element have the same
number of protons:

The atomic number (Z)

Atomic Mass

Mass number (number of protons plus neutrons)



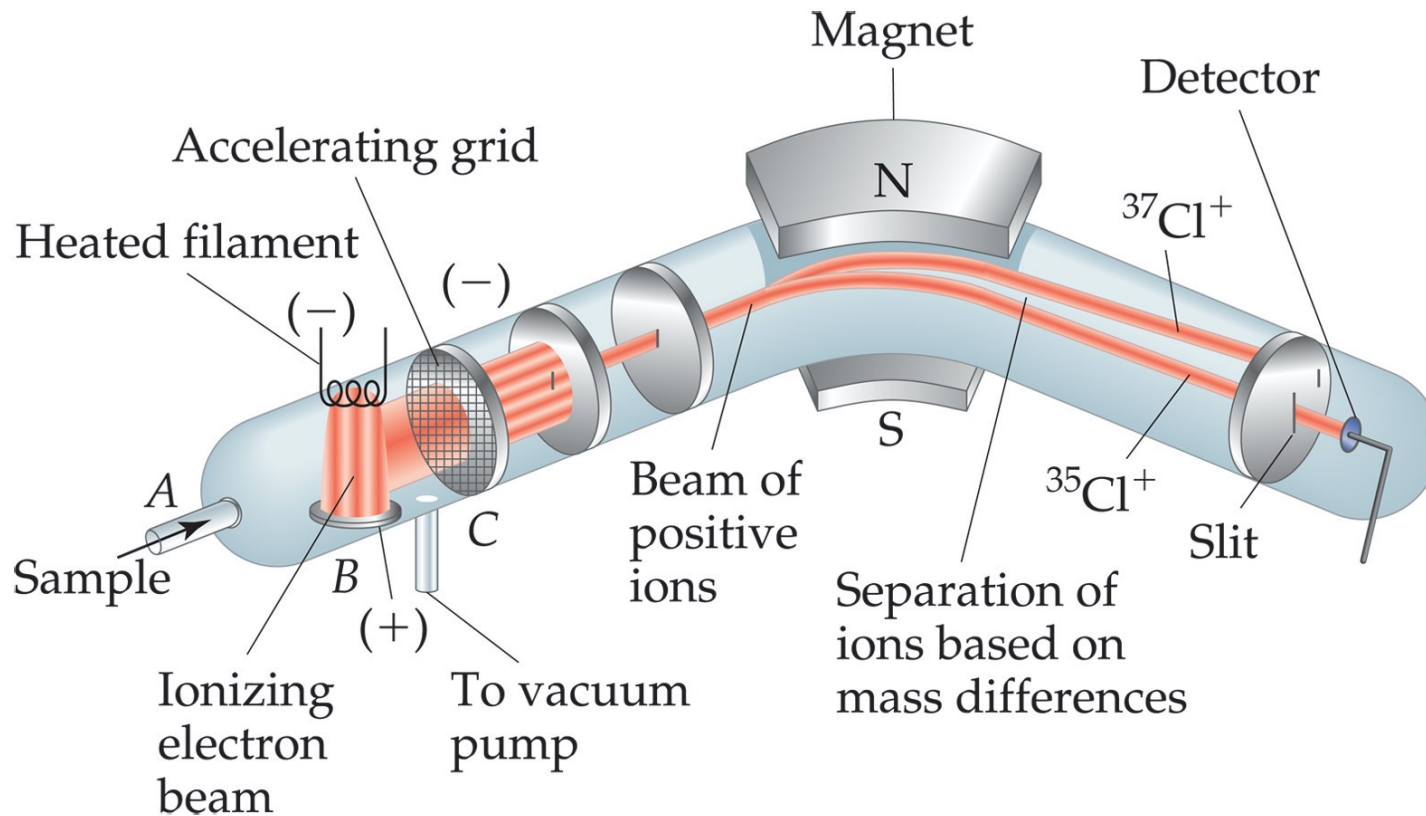
The mass of an atom in atomic mass units (amu) is approximately the total number of protons and neutrons in the atom.

Isotopes:

- Elements are defined by the number of protons.
- Isotopes are atoms of the same element with different masses.
- Isotopes have different numbers of neutrons.

	$^{11}_6\text{C}$	$^{12}_6\text{C}$	$^{13}_6\text{C}$	$^{14}_6\text{C}$
# Neutrons	5	6	7	8

Atomic Mass



Atomic and molecular masses can be measured with great accuracy with a **mass spectrometer**. Heavier ion turns less in the magnetic field (more momentum, because of higher mass (mv)) (magnetic moments of ions similar). Aston, 1919.

Average Mass

- Because in the real world all the elements exist as mixtures of isotopes.
- And we measure many many atoms at a time

“Natural abundance”

- Average mass is calculated from the isotopes of an element weighted by their relative abundances.

Average Mass

- Because in the real world all the elements exist as mixtures of isotopes.
- And we measure many many atoms at a time

“Natural abundance”

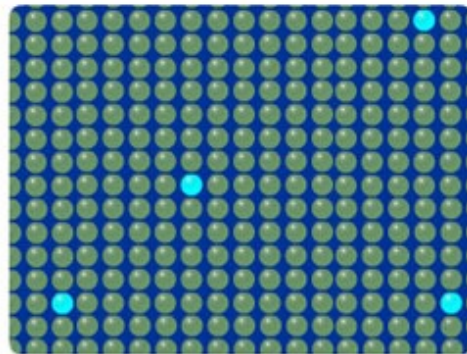
- Average mass is calculated from the isotopes of an element weighted by their relative abundances.



Isotopic Abundance of carbon atoms

There exists two stable carbon isotopes in the natural world; ^{12}C and ^{13}C . The abundance ratio of ^{13}C is about 1% of ^{12}C .

	^{12}C	^{13}C
Mass Number	12	13
Relative Abundance (%)	100	1.08



^{12}C atom



^{13}C atom

Average mass, example

Isotope	abundance	Atomic mass
^{24}Mg	78.99%	23.98504 amu
^{25}Mg	10.00%	24.98584 amu
^{26}Mg	11.01%	25.98259 amu

Given the above data, what is the average molecular mass of magnesium (Mg)?

$$.7899(23.98504) + 0.1000(24.98584) + 0.1101(25.98259) = 18.95 + 2.499 + 2.861 = 24.31$$

Periodic Table:

1A 1	2A 2											3A 13	4A 14	5A 15	6A 16	7A 17	8A 18
1 H												5 B	6 C	7 N	8 O	9 F	10 Ne
2 Li	4 Be																
3 Na	12 Mg	3B 3	4B 4	5B 5	6B 6	7B 7	8B 8 9 10			1B 11	2B 12	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6 Cs	56 Ba	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7 Fr	88 Ra	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110	111	112	113	114	115	116		

Metals	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb
Metalloids	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No
Nonmetals														

- A systematic catalog of elements.
- Elements are arranged in order of atomic number. (original atomic mass)
- But why like this?

Periodicity

Atomic number	1	2	3	4	...	9	10	11	12	...	17	18	19	20	...
Symbol	H	He	Li	Be	...	F	Ne	Na	Mg	...	Cl	Ar	K	Ca	...
		Nonreactive gas	Soft, reactive metal			Nonreactive gas	Soft, reactive metal				Nonreactive gas	Soft, reactive metal			

When one looks at the chemical properties of elements, one notices a repeating pattern of reactivities.

Periodic Table

1A 1	1 H	2A 2											3A 13	4A 14	5A 15	6A 16	7A 17	8A 18	
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne	
3	11 Na	12 Mg	3B 3	4B 4	5B 5	6B 6	7B 7	8B 8 9 10			1B 11	2B 12	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar	
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr	
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe	
6	55 Cs	56 Ba		71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra		103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110	111	112	113	114	115	116		

Metals

Metalloids

Nonmetals

57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb
89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No

- The rows on the periodic chart are periods.

Periodic Table

1A 1	1 H	2A 2											3A 13	4A 14	5A 15	6A 16	7A 17	8A 18	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne	
3	11 Na	12 Mg	3B 3	4B 4	5B 5	6B 6	7B 7	8B 8 9 10			1B 11	2B 12	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar	
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr	
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Metalloids	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No
Nonmetals														

- Columns are groups.
- Elements in the same group have similar chemical properties.
- Derived *empirically*, no theory to explain it.

Groups

Group	Name	Elements
1A	Alkali metals	Li, Na, K, Rb, Cs, Fr
2A	Alkaline earth metals	Be, Mg, Ca, Sr, Ba, Ra
6A	Chalcogens	O, S, Se, Te, Po
7A	Halogens	F, Cl, Br, I, At
8A	Noble gases (or rare gases)	He, Ne, Ar, Kr, Xe, Rn

These five groups are known by their names.
You gotta know these.

Periodic Table

	1A 1																	8A 18	
1	1 H	2A 2											3A 13	4A 14	5A 15	6A 16	7A 17	2 He	
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne	
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	Nonmetals														

Nonmetals are on the upper right-hand corner of the periodic table (with the exception of H).

Periodic Table


	1A 1																	8A 18	
1	1 H	2A 2											3A 13	4A 14	5A 15	6A 16	7A 17	2 He	
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Nonmetals														

Metalloids border the stair-step line (with the exception of Al and Po, which are both metals).

Periodic Table

	1A 1																											8A 18
1	1 H	2A 2																										2 He
2	3 Li	4 Be																										10 Ne
3	11 Na	12 Mg	3B 3	4B 4	5B 5	6B 6	7B 7	8B 8 9 10			1B 11	2B 12	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar										18 Ar
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5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe										54 Xe
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	Nonmetals														

Metals are on the left side of the chart.

Elements of life

1A																	8A
H																	He
2A																	
Li	Be											3A	4A	5A	6A	7A	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
		3B	4B	5B	6B	7B	8B			1B	2B						
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn

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- Elements required for living organisms.
- Red, most abundant
- blue, next most abundant
- Green, trace amounts.

Chemical Formulas



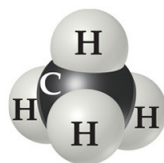
Water, H₂O



Carbon dioxide, CO₂



Carbon monoxide, CO



Methane, CH₄



Hydrogen peroxide, H₂O₂



Oxygen, O₂

The subscript to the right of the element



tells the number of atoms of that element in the compound.

Molecular Compounds



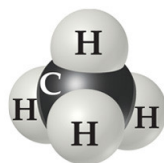
Water, H_2O



Carbon dioxide, CO_2



Carbon monoxide, CO



Methane, CH_4



Hydrogen peroxide, H_2O_2



Oxygen, O_2

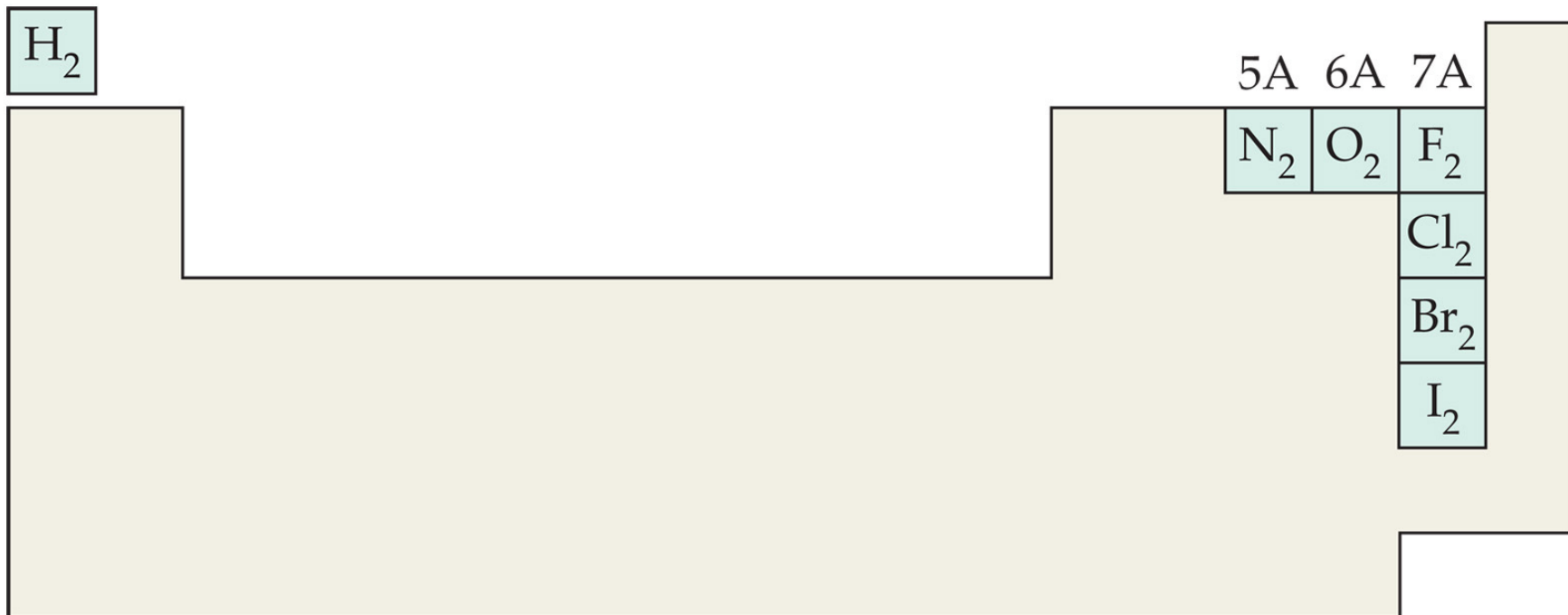
Molecular compounds
are composed of
molecules

almost always contain only
nonmetals.

What is a molecule?

compound held together
by **covalent** bonds.

Diatomic Molecules



These seven elements occur naturally as molecules containing two atoms.

You should know these guys.

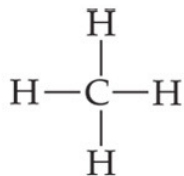
Types of Formulas

- Empirical formulas give the lowest whole-number ratio of atoms of each element in a compound.
- Molecular formulas give the exact number of atoms of each element in a compound.

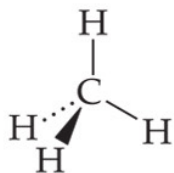
Example: ethane:

Empirical formula: CH_3

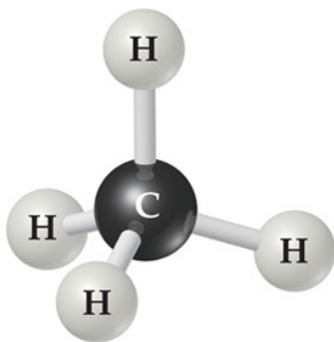
Molecular formula: C_2H_6



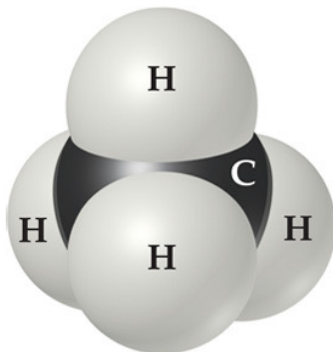
Structural formula



Perspective drawing



Ball-and-stick model



Space-filling model

Types of Formulas

- Structural formulas show the order in which atoms are bonded.
- Perspective drawings also show the three-dimensional array of atoms in a compound.

Ions

When an atom gains or loses *electrons*

1A	2A											3A	4A	5A	6A	7A	8A
H ⁺																H ⁻	N O B L E G A S E S
Li ⁺														N ³⁻	O ²⁻	F ⁻	
Na ⁺	Mg ²⁺											Al ³⁺			S ²⁻	Cl ⁻	
K ⁺	Ca ²⁺														Se ²⁻	Br ⁻	
Rb ⁺	Sr ²⁺														Te ²⁻	I ⁻	
Cs ⁺	Ba ²⁺																

- When atoms lose or gain electrons, they become ions. Often they lose or gain electrons to have the same number of electrons as the nearest noble gas.
 - Cations are positive and are formed by elements on the left side of the periodic chart (**metals**).
 - Anions are negative and are formed by elements on the right side of the periodic chart (**nonmetals**).

Mono-atomic ions

1A	2A											3A	4A	5A	6A	7A	8A
H ⁺														N ³⁻	O ²⁻	H ⁻	N O B L E G A S E S
Li ⁺															S ²⁻	F ⁻	
Na ⁺	Mg ²⁺	Transition metals										Al ³⁺			Se ²⁻	Cl ⁻	
K ⁺	Ca ²⁺														Te ²⁻	Br ⁻	
Rb ⁺	Sr ²⁺														I ⁻		
Cs ⁺	Ba ²⁺																

metals

nonmetals

- Metals usually become cations (+)
- Nonmetals usually become anions (-)

Ionic compounds

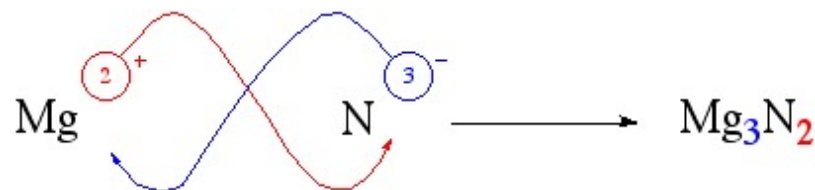
- A metal will give up electrons to a nonmetal forming a cation (+) (the metal), and an anion (-) (the nonmetal).



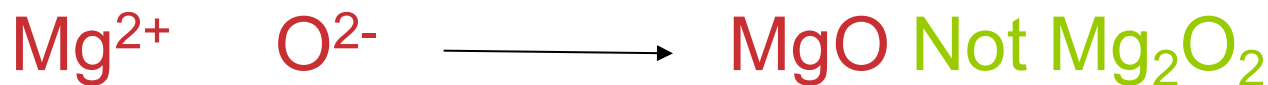
Note, everybody gains or loses electrons to be like the nearest noble gas.

Compounds are always electrically neutral!!

Writing Formulas



- Because compounds are electrically neutral, one can determine the formula of a compound this way:
 - The charge on the cation becomes the subscript on the anion.
 - The charge on the anion becomes the subscript on the cation.
 - If these subscripts are not in the lowest whole-number ratio, divide them by the greatest common factor.



Common Cations

Charge	Formula	Name	Formula	Name
1+	*H ⁺	Hydrogen ion	*NH ₄ ⁺	Ammonium ion
	*Li ⁺	Lithium ion	*Cu ⁺	Copper(I) or cuprous ion
	*Na ⁺	Sodium ion		
	*K ⁺	Potassium ion		
	*Cs ⁺	Cesium ion		
	*Ag ⁺	Silver ion		
2+	*Mg ²⁺	Magnesium ion	Co ²⁺	Cobalt(II) or cobaltous ion
	*Ca ²⁺	Calcium ion	*Cu ²⁺	Copper(II) or cupric ion
	*Sr ²⁺	Strontium ion	*Fe ²⁺	Iron(II) or ferrous ion
	*Ba ²⁺	Barium ion	Mn ²⁺	Manganese(II) or manganous ion
	*Zn ²⁺	Zinc ion	Hg ₂ ²⁺	Mercury(I) or mercurous ion
	*Cd ²⁺	Cadmium ion	Hg ²⁺	Mercury(II) or mercuric ion
			*Ni ²⁺	Nickel(II) or nickelous ion
			*Pb ²⁺	Lead(II) or plumbous ion
			Sn ²⁺	Tin(II) or stannous ion
3+	*Al ³⁺	Aluminum ion	*Cr ³⁺	Chromium(III) or chromic ion
			*Fe ³⁺	Iron(III) or ferric ion

*The most common ions are in boldface.

***You should know these.**

Common Anions

Charge	Formula	Name
1−	H [−]	Hydride ion
	F[−]	Fluoride ion
	Cl[−]	Chloride ion
	Br[−]	Bromide ion
	I[−]	Iodide ion
	CN [−]	Cyanide ion
	OH[−]	Hydroxide ion
2−	O^{2−}	Oxide ion
	O ₂ ^{2−}	Peroxide ion
	S^{2−}	Sulfide ion
3−	N ^{3−}	Nitride ion

*The most common ions are in boldface.

Polyatomic anions

I_3^-	triiodide	HPO_4^{2-}	hydrogen phosphate
O_2^-	Superoxide	H_2PO_4^-	dihydrogen phosphate
OH^-	hydroxide	PO_4^{3-}	Phosphate
CN^-	cyanide	PO_3^{3-}	Phosphite
SCN^-	thiocyanate	ClO^-	hypochlorite
NO_3^-	nitrate	ClO_2^-	chlorite
NO_2^-	nitrite	ClO_3^-	chlorate
SO_3^{2-}	sulfite	ClO_4^-	perchlorate
HSO_3^-	bisulfite	MnO_4^-	Permanganate
SO_4^{2-}	sulfate	CrO_4^{2-}	Chromate
HSO_4^-	bisulfate	$\text{Cr}_2\text{O}_7^{2-}$	Dichromate
HCO_3^-	bicarbonate		
CO_3^{2-}	carbonate		
CH_3CO_2^-	Acetate		

You must memorize
ALL of these!

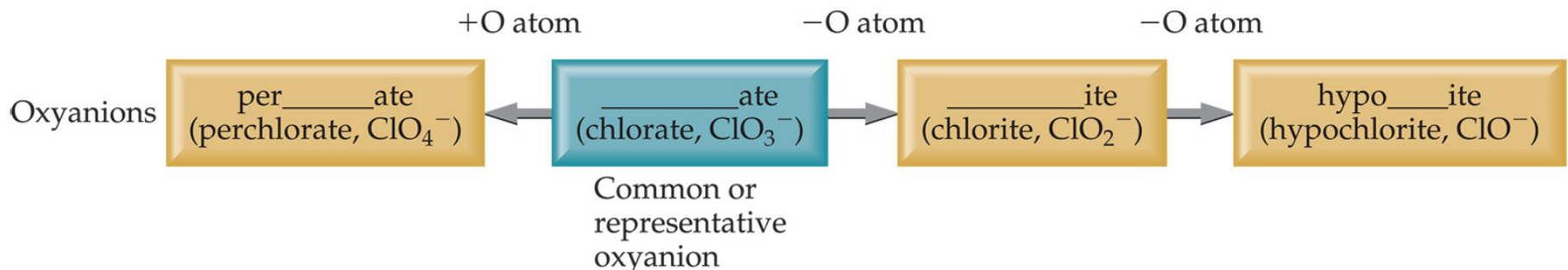
Patterns in Oxyanion Nomenclature

- When there are only two oxyanions involving the same element:
 - The one with fewer oxygens ends in *-ite*
 - NO_2^- : nitrite; SO_3^{2-} : sulfite
 - The one with more oxygens ends in *-ate*
 - NO_3^- : nitrate; SO_4^{2-} : sulfate

Patterns in Oxyanion Nomenclature

When there are more than two:

- The one with the fewest oxygens has the prefix *hypo-* and ends in *-ite*
 - ClO^- : hypochlorite
- The one with the second fewest oxygens ends in *-ite*
 - ClO_2^- : chlorite
- The one with the second most oxygens ends in *-ate*
 - ClO_3^- : chlorate
- The one with the most oxygens has the prefix *per-* and ends in *-ate*
 - ClO_4^- : perchlorate



Inorganic Nomenclature

- name of **cation** goes **first**.
- If anion is element, change ending to *-ide*;
- If anion is polyatomic ion, simply write the name of the polyatomic ion.
- If the cation can have more than one possible charge, write the charge as a Roman numeral in parentheses. (Fe(II), Fe(III)) (When is this true? Anytime I haven't told you to memorize the ion.

Examples

naming inorganic compounds

- Write the name of the cation.
- If the anion is an element, change its ending to *-ide*; if the anion is a polyatomic ion, simply write the name of the polyatomic ion.
- If the cation can have more than one possible charge, write the charge as a Roman numeral in parentheses.



sodium chloride



ammonium nitrate



Iron(II) sulfate



potassium cyanide



Rubidium hydroxide



lithium acetate



sodium chlorate



sodium perchlorate



potassium chromate



Sodium hydride

Examples

naming inorganic compounds

- Write the name of the cation.
- If the anion is an element, change its ending to *-ide*; if the anion is a polyatomic ion, simply write the name of the polyatomic ion.
- If the cation can have more than one possible charge, write the charge as a Roman numeral in parentheses.

potassium permanganate



Calcium carbonate



Calcium bicarbonate



ammonium dichromate



potassium phosphate



Lithium oxide



sodium peroxide



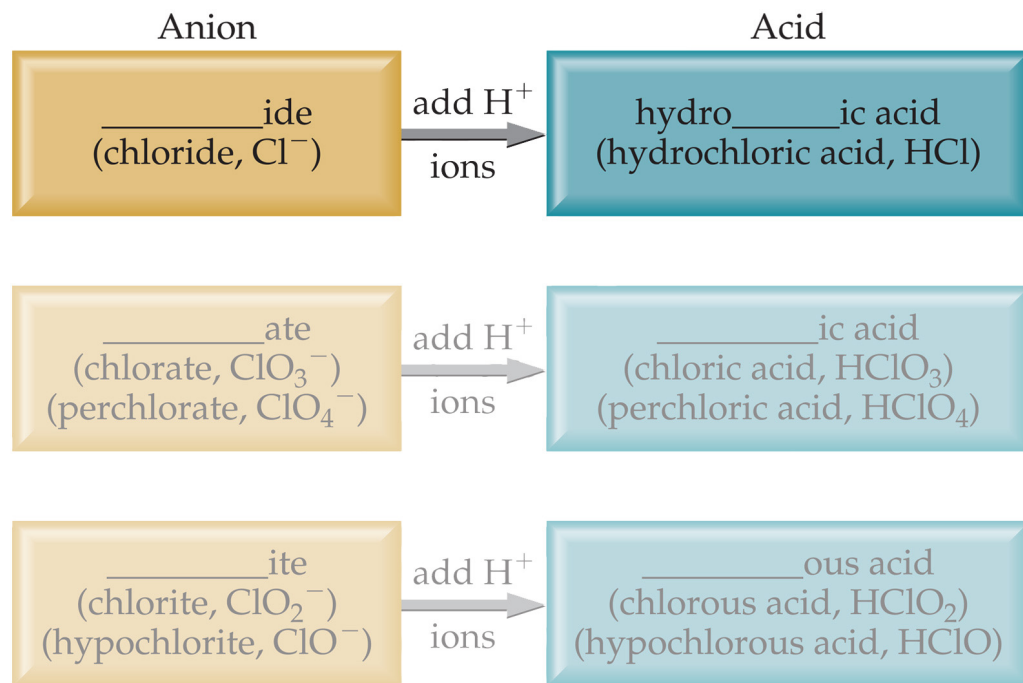
Calcium sulfide



Hydrogen

- H can be cation or anion
- H^- hydride
- H^+ (the cation of an ionic compound) **makes an acid**, naming different.
- Any compound that has H^+ as the cation is an acid.

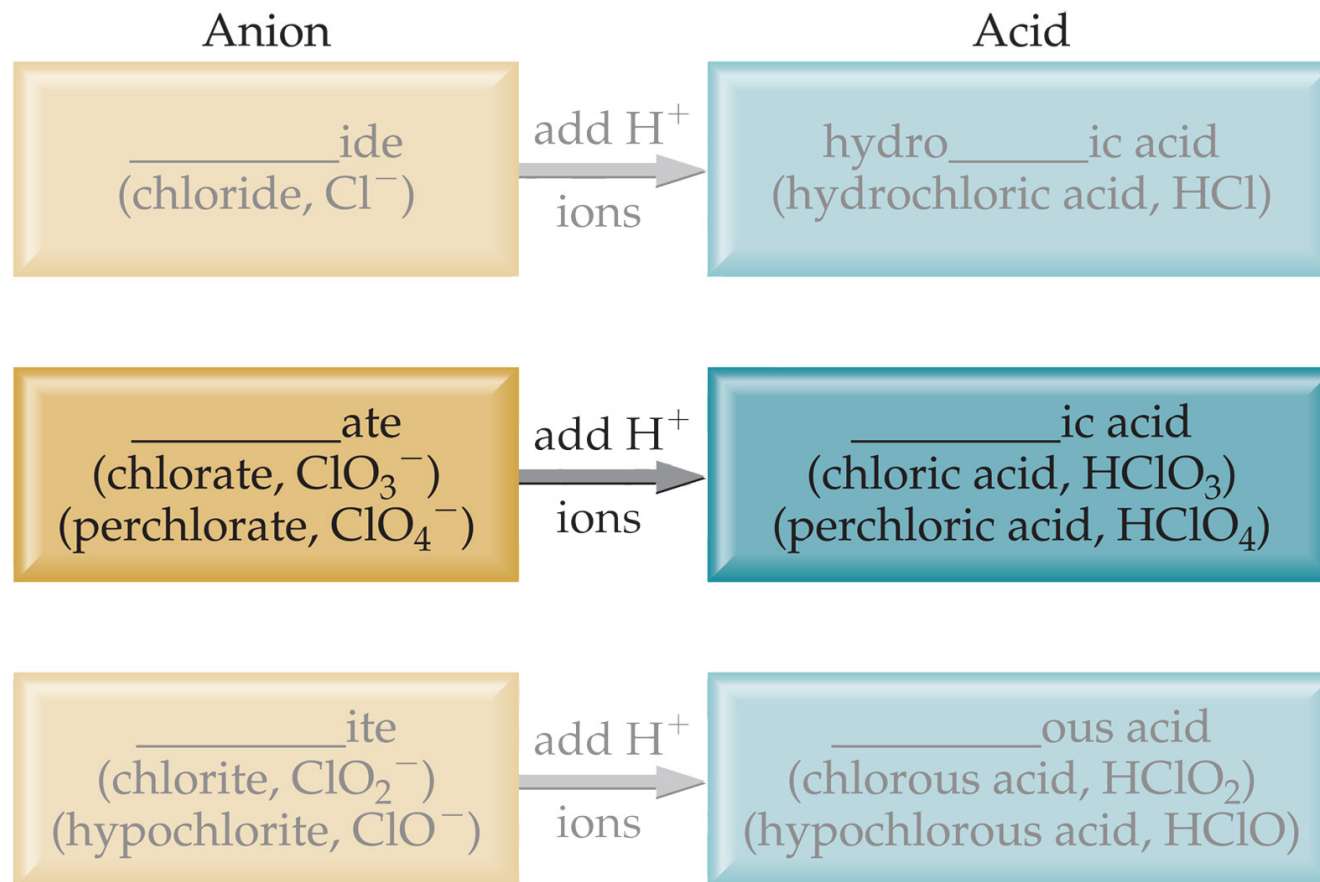
Acid Nomenclature



- If the anion in the acid ends in *-ide*, change the ending to *-ic acid* and add the prefix *hydro-* :

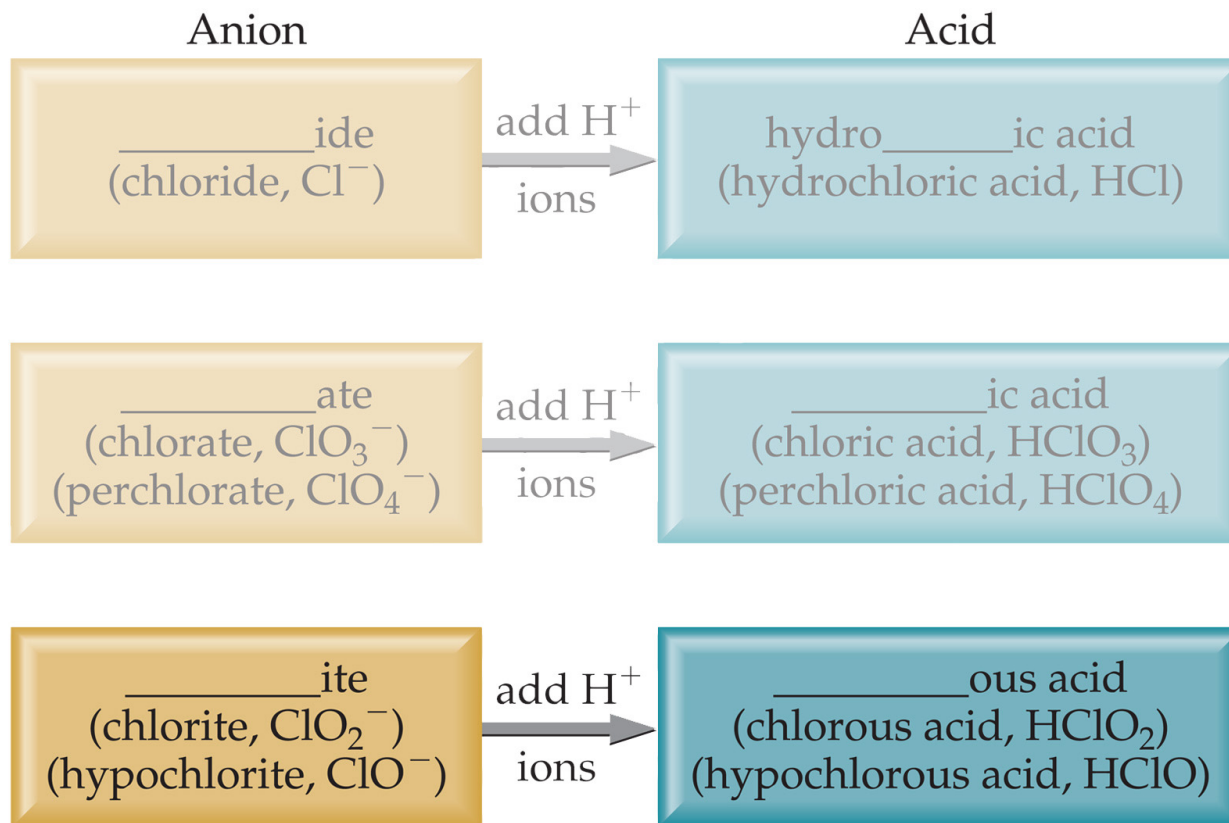
- HCl : hydrochloric acid
- HBr : hydrobromic acid
- HI : hydroiodic acid

Acid Nomenclature



- If the anion in the acid ends in *-ate*, change the ending to *-ic acid*:
 - HClO_3 : chloric acid
 - HClO_4 : perchloric acid

Acid Nomenclature



- If the anion in the acid ends in *-ite*, change the ending to *-ous acid*:
 - HClO : hypochlorous acid
 - HClO_2 : chlorous acid

Naming Binary Compounds (2 nonmetals)

<i>Prefix</i>	<i>Meaning</i>
<i>Mono-</i>	1
<i>Di-</i>	2
<i>Tri-</i>	3
<i>Tetra-</i>	4
<i>Penta-</i>	5
<i>Hexa-</i>	6
<i>Hepta-</i>	7
<i>Octa-</i>	8
<i>Nona-</i>	9
<i>Deca-</i>	10

- less electronegative atom (element closest to the lower lefthand corner of periodic table).
- A prefix is used to denote the number of atoms of each element in the compound (*mono-* is not used on the first element listed, however.)

Nomenclature of Binary Compounds (two nonmetals)

<i>Prefix</i>	<i>Meaning</i>
<i>Mono-</i>	1
<i>Di-</i>	2
<i>Tri-</i>	3
<i>Tetra-</i>	4
<i>Penta-</i>	5
<i>Hexa-</i>	6
<i>Hepta-</i>	7
<i>Octa-</i>	8
<i>Nona-</i>	9
<i>Deca-</i>	10

- The ending on the more electronegative element is changed to *-ide*.
 - CO_2 : carbon dioxide
 - CCl_4 : carbon tetrachloride

Nomenclature of Binary Compounds

<i>Prefix</i>	<i>Meaning</i>
<i>Mono-</i>	1
<i>Di-</i>	2
<i>Tri-</i>	3
<i>Tetra-</i>	4
<i>Penta-</i>	5
<i>Hexa-</i>	6
<i>Hepta-</i>	7
<i>Octa-</i>	8
<i>Nona-</i>	9
<i>Deca-</i>	10

If the prefix ends with *a* or *o* and the name of the element begins with a vowel, the two successive vowels are often merged into one:

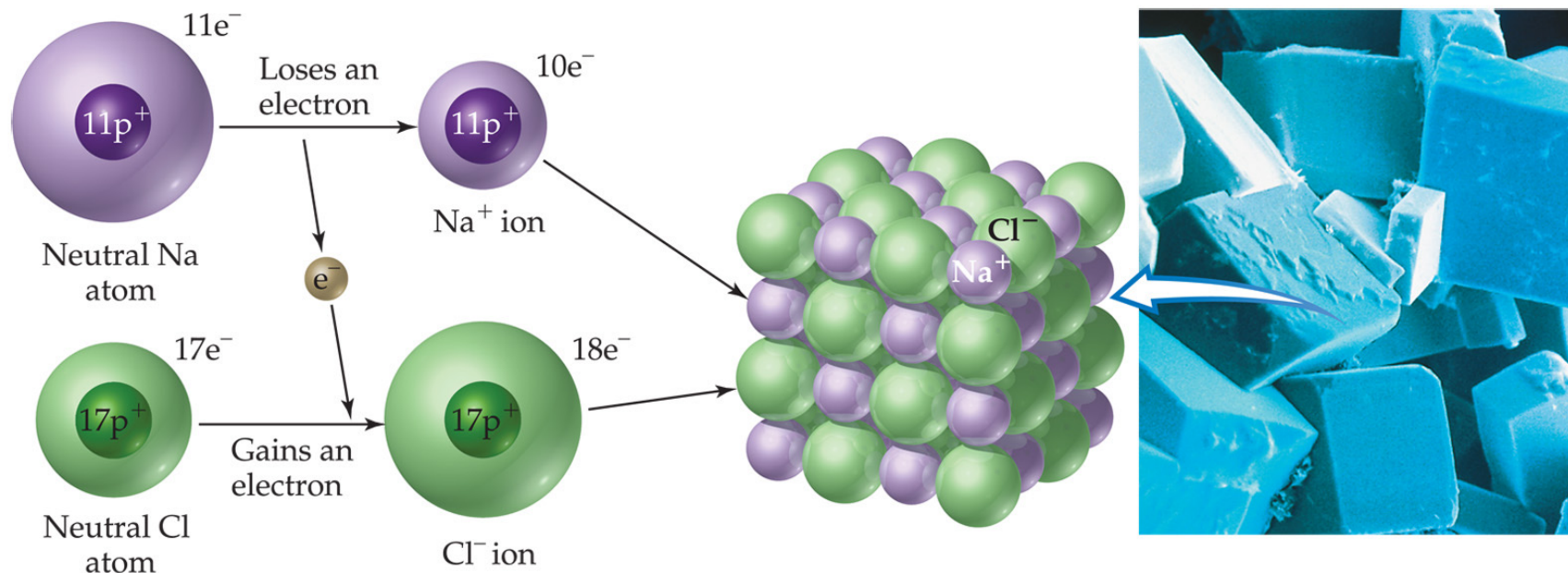
N_2O_5 : dinitrogen pentoxide
not: dinitrogen pentaoxide

Nomenclature of binary compounds

- carbon dioxide
- carbon tetrafluoride
- nitrogen triiodide
- oxygen difluoride
- phosphorous pentachloride
- hydrogen sulfide
- tetraphosphorous decoxide
- CO_2
- CF_4
- NI_3
- OF_2
- PCl_5
- H_2S
- P_4O_{10}

Ionic Bonds

Ionic compounds (such as NaCl) are generally formed between metals and nonmetals.

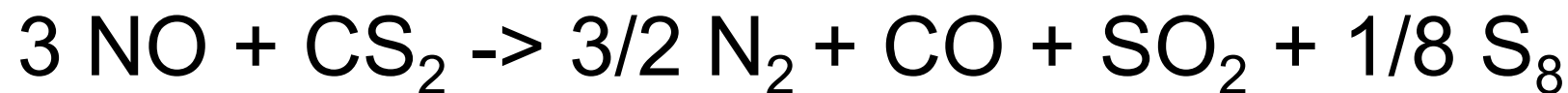


Jewelry problem

- This is just like a natural abundance problem

- $\frac{m_{Tot}}{D_{Au}} X_{Au} + \frac{m_{Tot}}{D_{Ag}} (1 - X_{Au}) = V_{Tot}$
- $\frac{9.75g}{19.3g/cm^3} X_{Au} + \frac{9.75g}{10.5g/cm^3} (1 - X_{Au}) = 0.665 cm^3$
- $.505X_{Au} + 0.929cm^3 - 0.929X_{Au} = 0.665$
- $-.424 =$
- $X_{Au} = 0.623$

Barking Dog



Barking Dog

