

Chapter 2

Atoms, Molecules, and Ions

History

- Greeks
- Democritus and Leucippus - atomos
- Aristotle- elements
- Alchemy
- 1660 - Robert Boyle- experimental definition of element.
- Lavoisier- Father of modern chemistry
- He wrote the book- used measurement

Laws

- Conservation of Mass
- Law of Definite Proportion- compounds have a constant composition by mass.
- They react in specific ratios by mass.
- Multiple Proportions- When two elements form more than one compound, the ratios of the masses of the second element that combine with one gram of the first can be reduced to small whole numbers.

What?!

- Water has 8 g of oxygen per g of hydrogen.
- Hydrogen peroxide has 16 g of oxygen per g of hydrogen.
- $16/8 = 2/1$
- Small whole number ratios

Example of Law Of Multiple Proportions

- Mercury has two oxides. One is 96.2 % mercury by mass, the other is 92.6 % mercury by mass.
- Show that these compounds follow the law of multiple proportion.
- Speculate on the formula of the two oxides.

Your Turn

- Nitrogen and oxygen form two compounds. Show that they follow the law of multiple proportions

	Amount N	Amount O
Compound A	1.206 g	2.755 g
Compound B	1.651g	4.714 g

Dalton's Atomic Theory

- 1. Elements are made up of atoms
- 2. Atoms of each element are identical. Atoms of different elements are different.
- 3. Compounds are formed when atoms combine. Each compound has a specific number and kinds of atom.
- 4. Chemical reactions are rearrangement of atoms. Atoms are not created or destroyed.

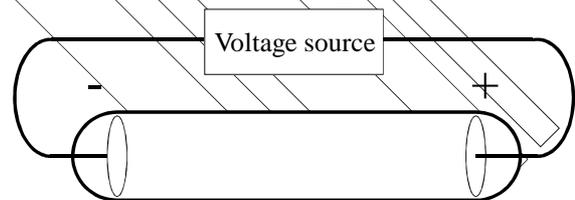
A Helpful Observation

- Gay-Lussac- under the same conditions of temperature and pressure, compounds always react in whole number ratios by volume.
- Avagadro- interpreted that to mean
- at the same temperature and pressure, equal volumes of gas contain the same number of particles
- (called Avagadro's hypothesis)

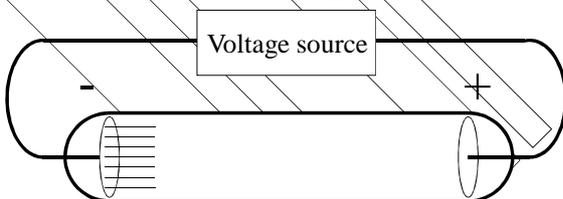
Experiments to determine what an atom was

- J. J. Thomson- used Cathode ray tubes

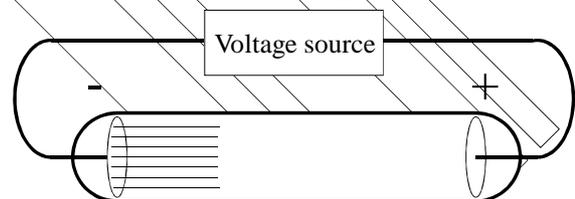
Thomson's Experiment



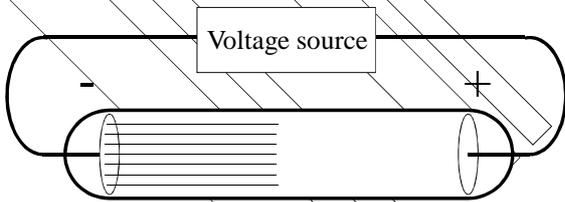
Thomson's Experiment



Thomson's Experiment

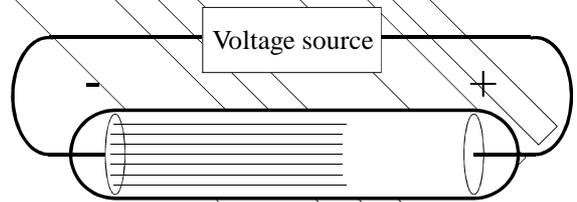


Thomson's Experiment



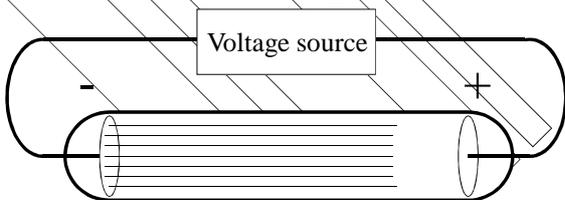
- Passing an electric current makes a beam appear to move from the negative to the positive end

Thomson's Experiment



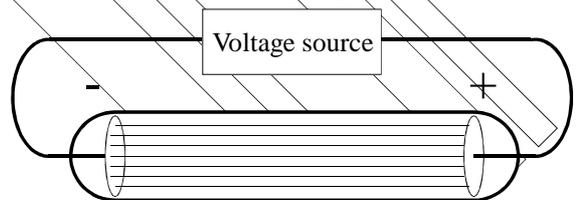
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Thomson's Experiment



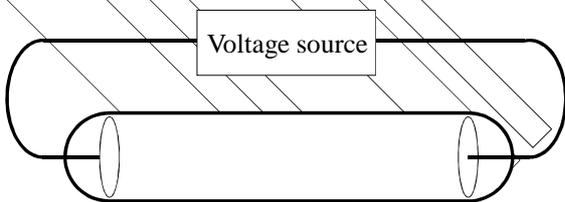
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Thomson's Experiment



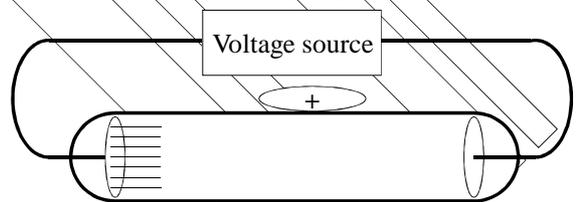
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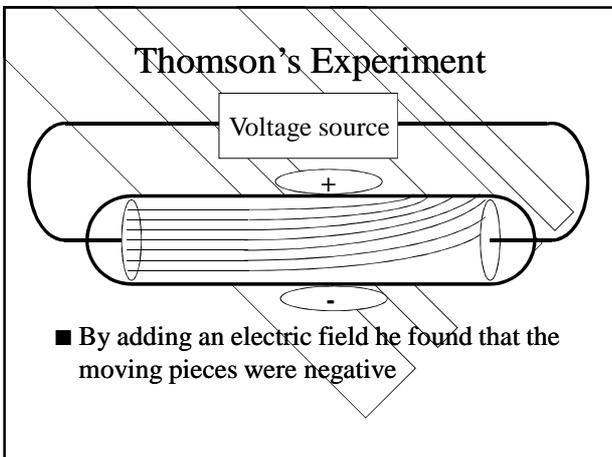
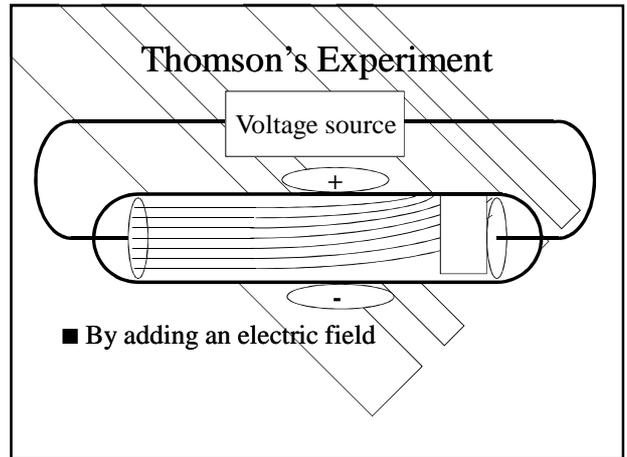
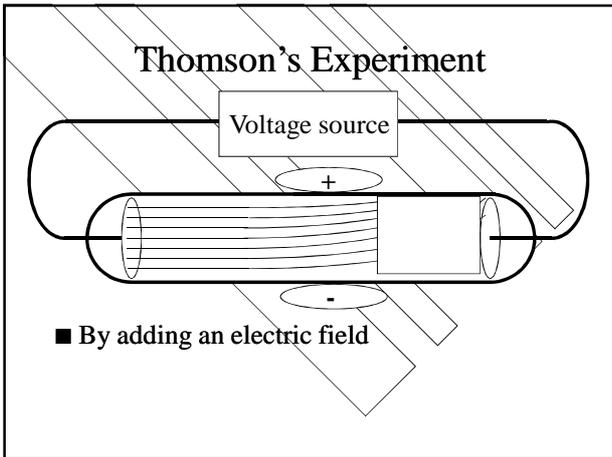
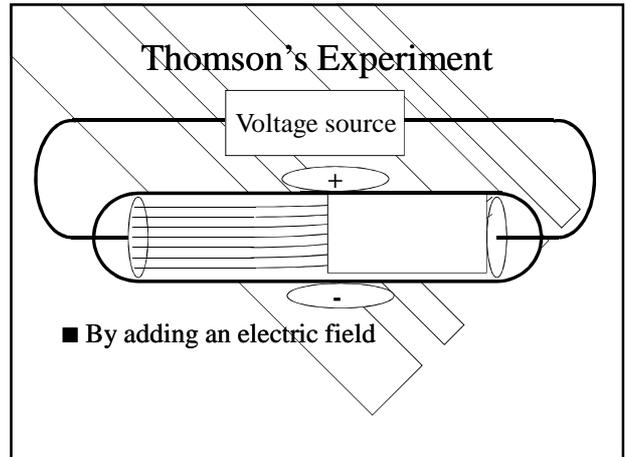
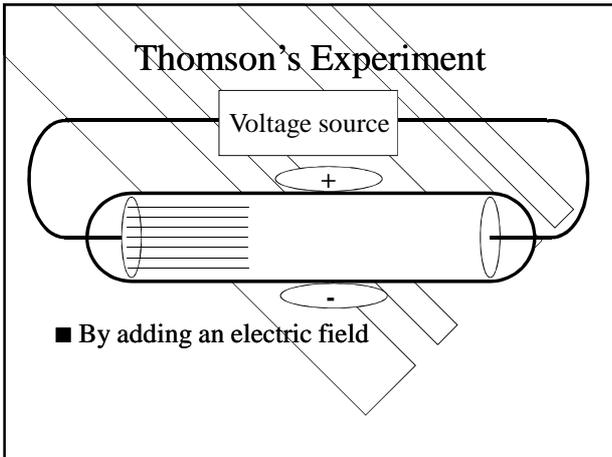


- By adding an electric field

Thomson's Experiment

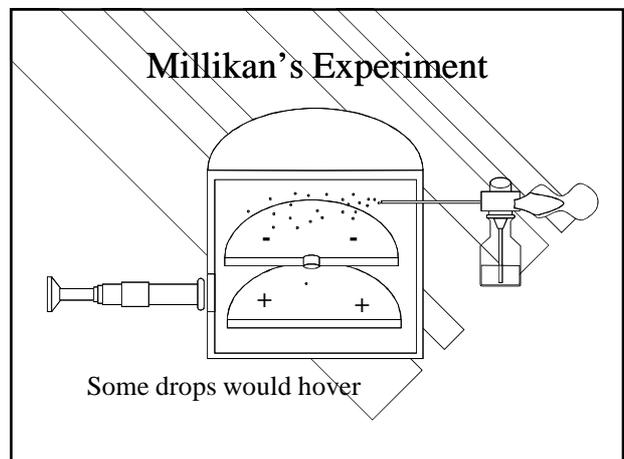
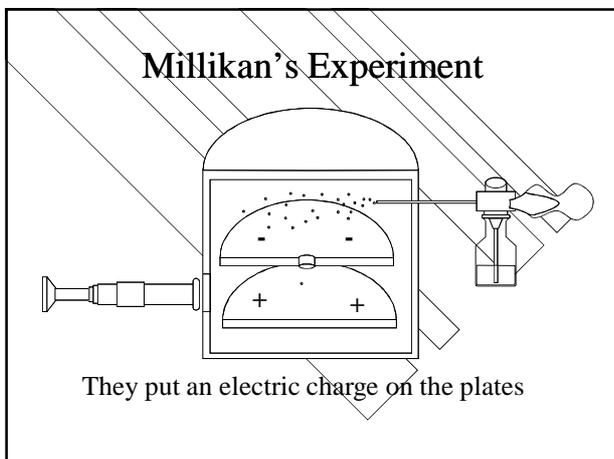
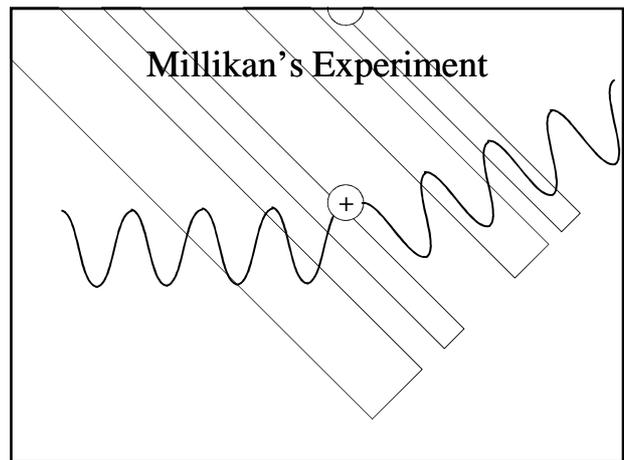
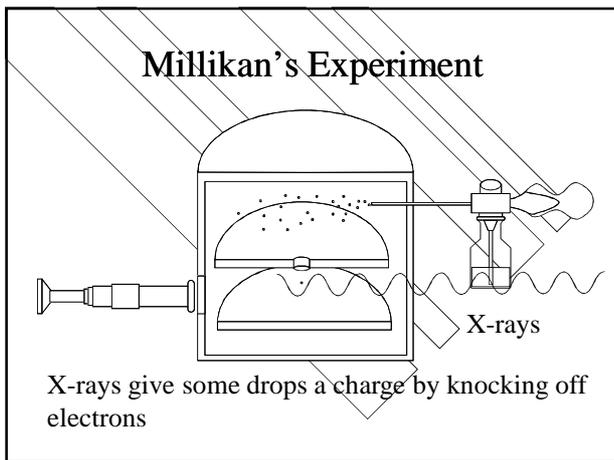
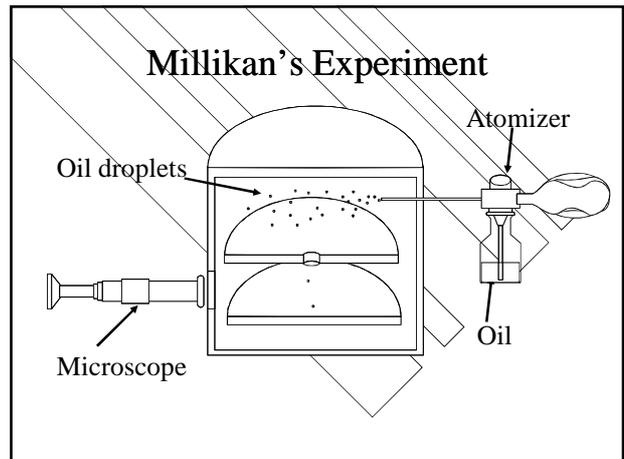
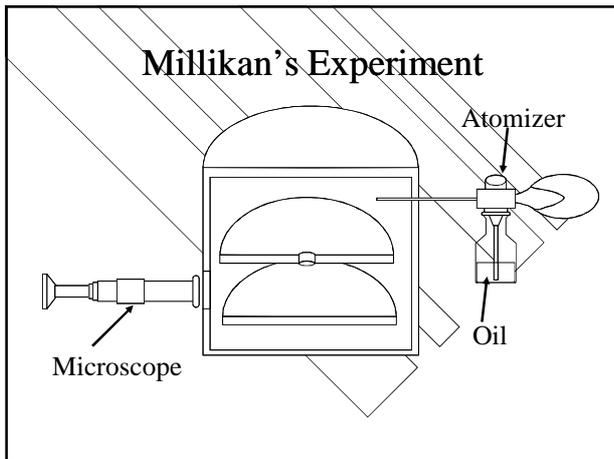


- By adding an electric field

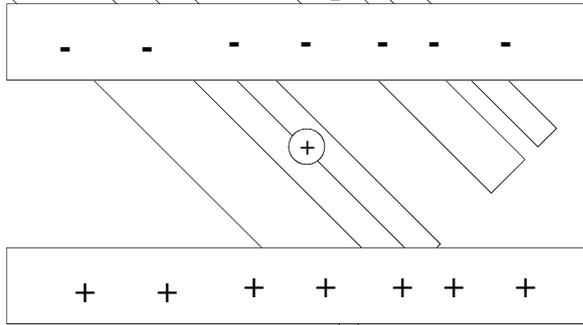


Thomson's Model

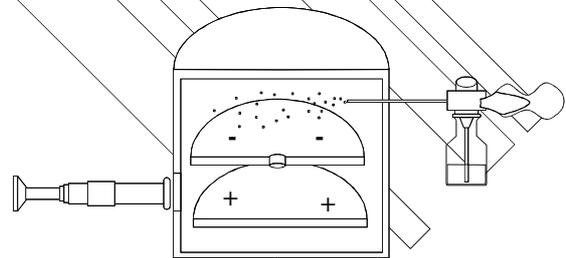
- Found the electron
- Couldn't find positive (for a while)
- Said the atom was like plum pudding
- A bunch of positive stuff, with the electrons able to be removed



Millikan's Experiment

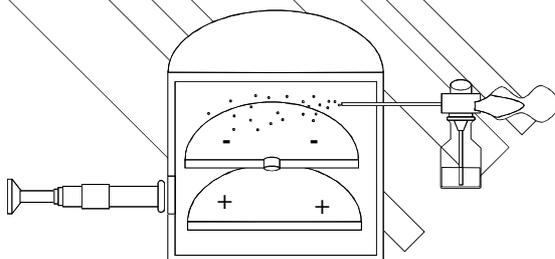


Millikan's Experiment



Measure the drop and find volume from $\frac{4}{3}\pi r^3$
 Find mass from $M = D \times V$

Millikan's Experiment



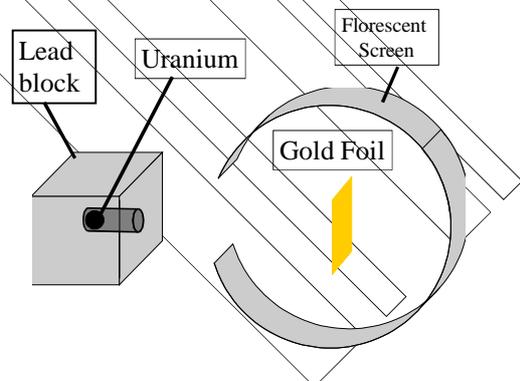
From the mass of the drop and the charge on the plates, he calculated the charge on an electron

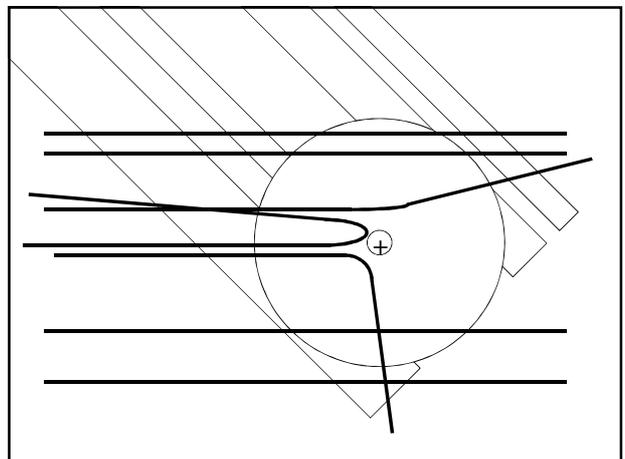
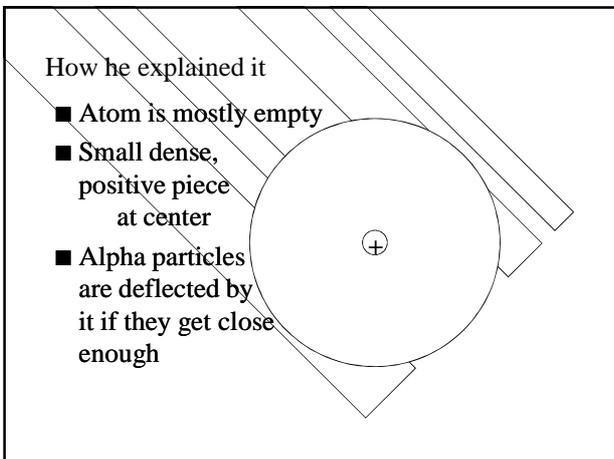
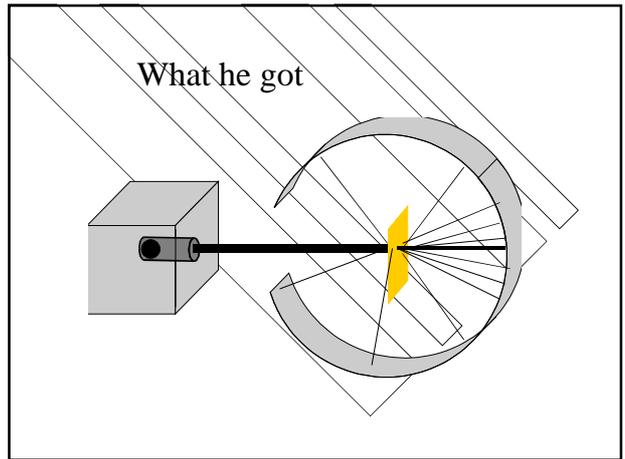
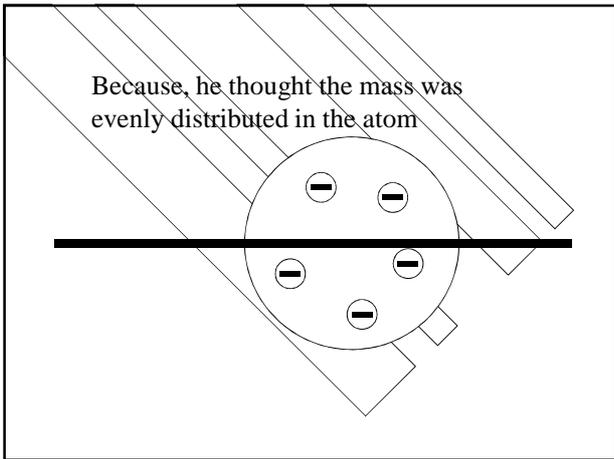
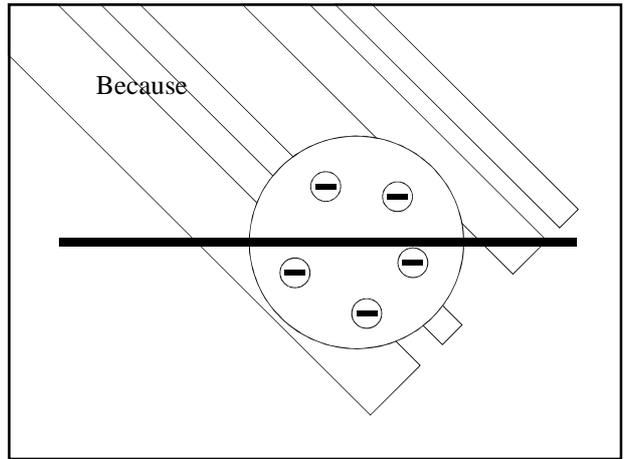
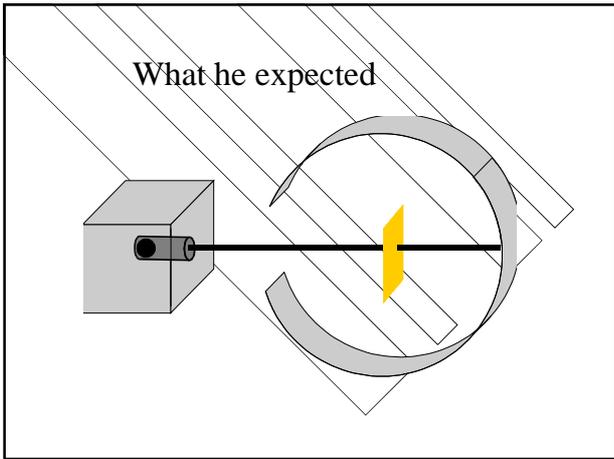
Radioactivity

- Discovered by accident
- Bequerel
- Three types
 - alpha- helium nucleus (+2 charge, large mass)
 - beta- high speed electron
 - gamma- high energy light

Rutherford's Experiment

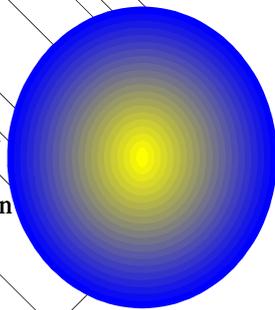
- Used uranium to produce alpha particles
- Aimed alpha particles at gold foil by drilling hole in lead block
- Since the mass is evenly distributed in gold atoms alpha particles should go straight through.
- Used gold foil because it could be made atoms thin





Modern View

- The atom is mostly empty space
- Two regions
- Nucleus- protons and neutrons
- Electron cloud- region where you have a chance of finding an electron



Sub-atomic Particles

- Z - atomic number = number of protons determines type of atom
- A - mass number = number of protons + neutrons
- Number of protons = number of electrons if neutral

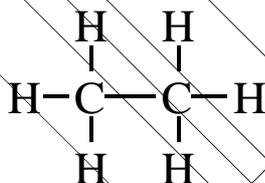
Symbols



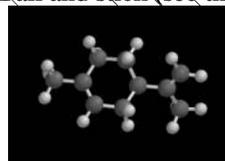
Chemical Bonds

- The forces that hold atoms together
- Covalent bonding - sharing electrons
- makes molecules
- Chemical formula- the number and type of atoms in a molecule
- C_2H_6 - 2 carbon atoms, 6 hydrogen atoms,
- Structural formula shows the connections, but not necessarily the shape.

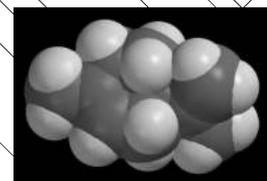
■ Structural Formula



- There are also other model that attempt to show three dimensional shape
- Ball and stick (see the models in room)



- Space Filling



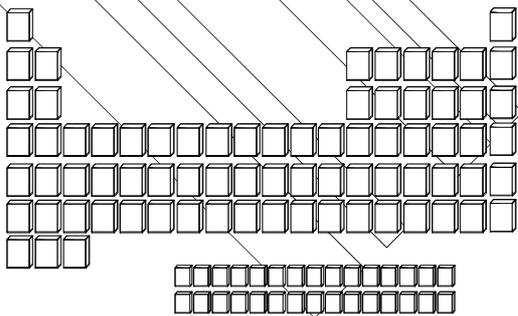
Ions

- Atoms or groups of atoms with a charge
- Cations- positive ions - get by losing electrons(s)
- Anions- negative ions - get by gaining electron(s)
- Ionic bonding- held together by the opposite charges
- Ionic solids are called salts

Polyatomic Ions

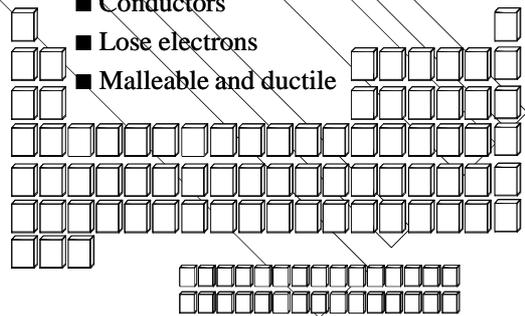
- Groups of atoms that have a charge
- Yes, you have to memorize them.
- List on page 65

Periodic Table



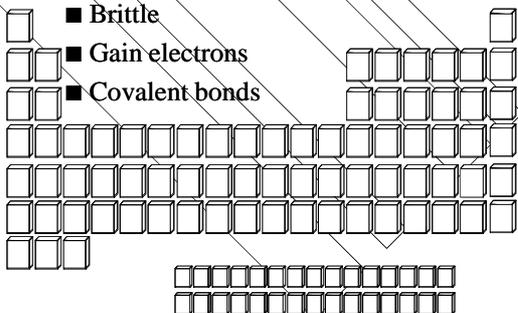
Metals

- Conductors
- Lose electrons
- Malleable and ductile

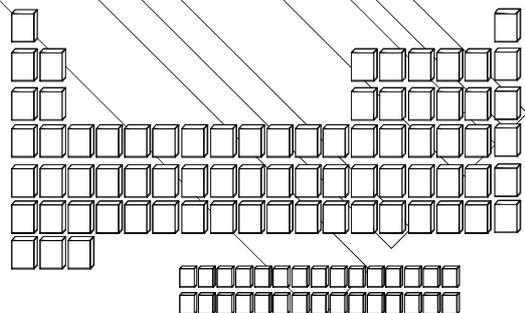


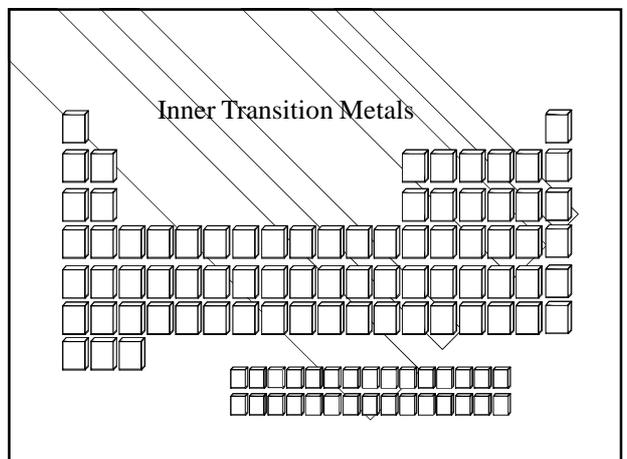
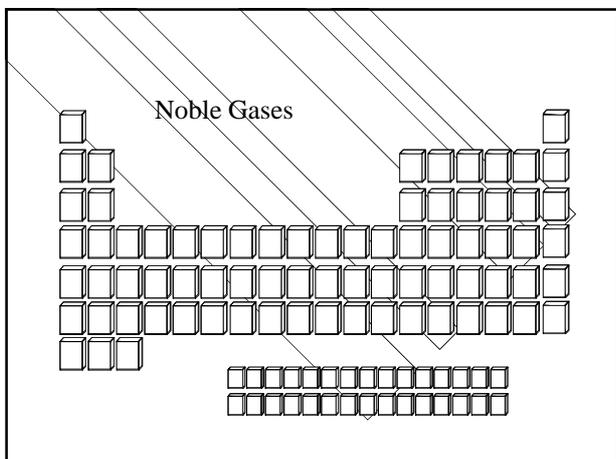
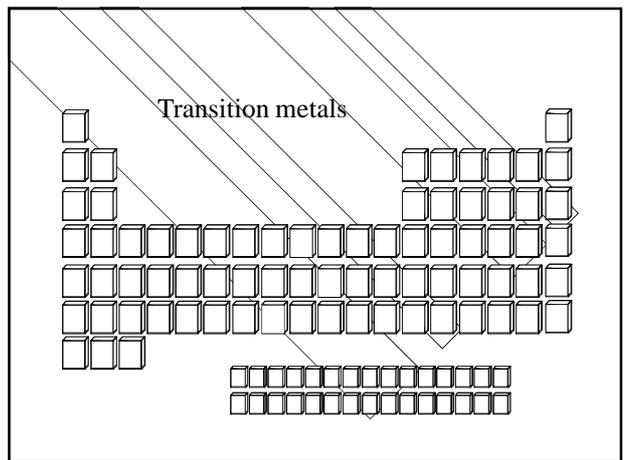
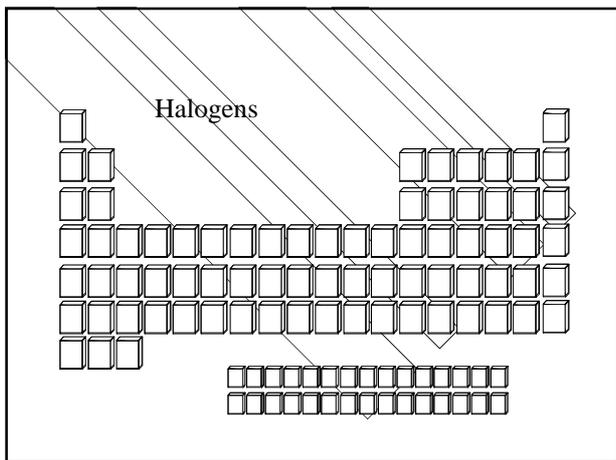
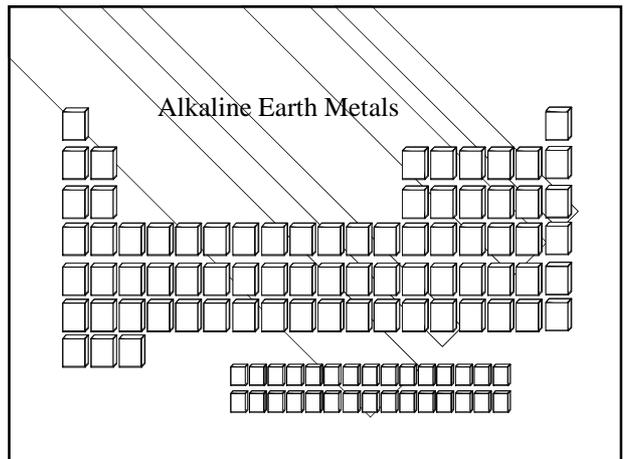
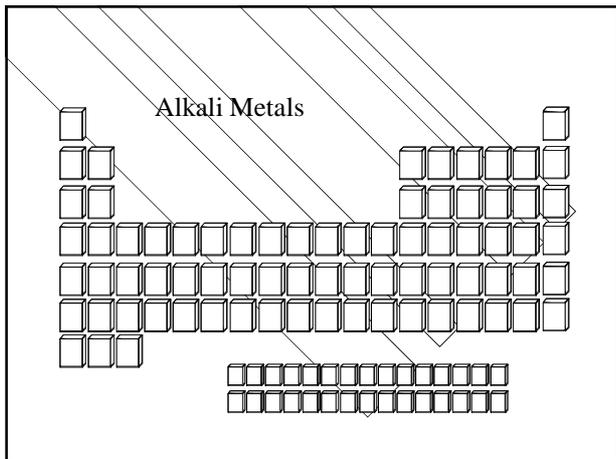
Nonmetals

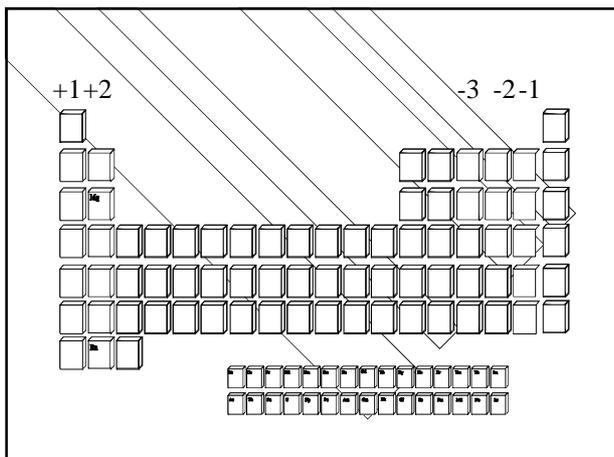
- Brittle
- Gain electrons
- Covalent bonds



Semi-metals or Metalloids







Naming compounds

- Two types
- Ionic - metal and non metal or polyatomics
- Covalent- we will just learn the rules for 2 non-metals

Ionic compounds

- If the cation is monoatomic- Name the metal (cation) just write the name.
- If the cation is polyatomic- name it
- If the anion is monoatomic- name it but change the ending to -ide
- If the anion is poly atomic- just name it
- practice

Covalent compounds

- Two words, with prefixes
- Prefixes tell you how many.
- mono, di, tri, tetra, penta, hexa, septa, nona, deca
- First element whole name with the appropriate prefix, except mono
- Second element, -ide ending with appropriate prefix
- Practice

More Naming

Ionic compounds

- If the cation is monoatomic- Name the metal (cation) just write the name.
- If the cation is polyatomic- name it
- If the anion is monoatomic- name it but change the ending to -ide
- If the anion is poly atomic- just name it
- practice

Ionic Compounds

- Have to know what ions they form
- off table, polyatomic, or figure it out
- CaS
- K₂S
- AlPO₄
- K₂SO₄
- FeS
- CoI₃

Ionic Compounds

- Fe₂(C₂O₄)
- MgO
- MnO
- KMnO₄
- NH₄NO₃
- Hg₂Cl₂
- Cr₂O₃

Ionic Compounds

- KClO₄
- NaClO₃
- YBrO₂
- Cr(ClO)₆

Naming Covalent Compounds

- Two words, with prefixes
- Prefixes tell you how many.
- mono, di, tri, tetra, penta, hexa, septa, nona, deca
- First element whole name with the appropriate prefix, except mono
- Second element, -ide ending with appropriate prefix
- Practice

Naming Covalent Compounds

- CO₂
- CO
- CCl₄
- N₂O₄
- XeF₆
- N₄O₄
- P₂O₁₀

Writing Formulas

- Two sets of rules, ionic and covalent
- To decide which to use, decide what the first word is.
- If is a metal or polyatomic use ionic.
- If it is a non-metal use covalent

Ionic Formulas

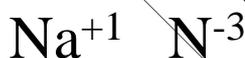
- Charges must add up to zero
- get charges from table, name of metal ion, or memorized from the list
- use parenthesis to indicate multiple polyatomics

Ionic Formulas

- Sodium nitride
- sodium- Na is always +1
- nitride - ide tells you it comes from the table
- nitride is N^{-3}

Ionic Formulas

- Sodium nitride
- sodium- Na is always +1
- nitride - ide tells you it comes from the table
- nitride is N^{-3}
- doesn't add up to zero



Ionic Formulas

- Sodium nitride
- sodium- Na is always +1
- nitride - ide tells you it comes from the table
- nitride is N^{-3}
- doesn't add up to zero
- Need 3 Na



Ionic Compounds

- Sodium sulfite
- calcium iodide
- Lead (II) oxide
- Lead (IV) oxide
- Mercury (I) sulfide
- Barium chromate
- Aluminum hydrogen sulfate
- Cerium (IV) nitrite

Covalent compounds

- The name tells you how to write the formula
- duh
- Sulfur dioxide
- diflourine monoxide
- nitrogen trichloride
- diphosphorus pentoxide

More Names and formulas

Acids

- Substances that produce H^+ ions when dissolved in water
- All acids begin with H
- Two types of acids
- Oxyacids
- non oxyacids

Naming acids

- If the formula has oxygen in it
- write the name of the anion, but change
 - ate to -ic acid
 - ite to -ous acid
- Watch out for sulfuric and sulfurous
- H_2CrO_4
- $HMnO_4$
- HNO_2

Naming acids

- If the acid doesn't have oxygen
- add the prefix hydro-
- change the suffix -ide to -ic acid
- HCl
- H_2S
- HCN

Formulas for acids

- Backwards from names
- If it has hydro- in the name it has no oxygen
- anion ends in -ide
- No hydro, anion ends in -ate or -ite
- Write anion and add enough H to balance the charges.

Formulas for acids

- hydrofluoric acid
- dichromic acid
- carbonic acid
- hydrophosphoric acid
- hypofluorous acid
- perchloric acid
- phosphorous acid

Hydrates

- Some salts trap water crystals when they form crystals
- these are hydrates.
- Both the name and the formula needs to indicate how many water molecules are trapped
- In the name we add the word hydrate with a prefix that tells us how many water molecules

Hydrates

- In the formula you put a dot and then write the number of molecules.
- Calcium chloride dihydrate = $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$
- Chromium (III) nitrate hexahydrate = $\text{Cr}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$