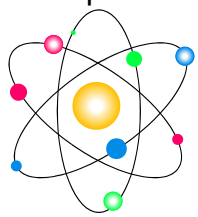
# Chapter 4

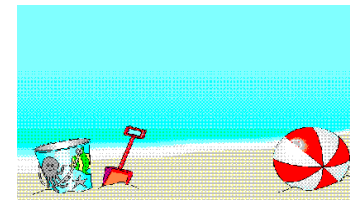


Atoms and their structure

## History of Atom

- Looked at beach
- Made of sand
- Cut sand - smaller sand

- **Smallest possible piece?**
- **Atom – Means indivisible**



## Another Greek

- Aristotle - Famous philosopher
- All substances are made of 4 elements
- Fire - Hot
- Air - light
- Earth - cool, heavy
- Water - wet
- Blend these in different proportions to get all substances

## Who's Next?

- Late 1700's - John Dalton- England
- Teacher- summarized results of his experiments and those of other's
- In Dalton's Atomic Theory
- Combined ideas of elements with that of atoms

## Dalton's Atomic Theory

| What Daltons Said | What changes have been made and what law was the restated. |
|---|---|
| All matter is made of tiny indivisible particles called atoms. | |
| Atoms of the same element have the same mass, size, properties. Atoms of different elements have different mass, size, properties. | Discovery of Isotopes forces a change that leaves out "mass". The mass of atoms of the same element can be different. |
| Atoms of different elements combine in whole number ratios to form compounds | Law of Definite Proportions. |
| No atoms can not created or destroyed. | Law of Conservation of Mass. The change is – Added the words under ordinary chemical means because of the discovery of nuclear reactions |
| In chemical reactions atoms are separated, rearranged or combined. | |

## Law of Definite Proportions (#3)

- Each compound has a specific ratio of elements
- It is a ratio by mass
- Water is always 8 grams of oxygen for each gram of hydrogen
- No matter where you find a molecule of water or how many of the molecules you find, each molecule has two atoms of hydrogen and one atom of oxygen.

## Law of Multiple Proportions

- if two elements form more that one compound, the ratio of the second element that combines with 1 gram of the first element in each is a simple whole number.
- Examples:
  - $H_2O$ and $H_2O_2$
  - $CO_2$ and CO
  - $CH_4$, $C_3H_6$, and $C_8H_{14}$
  - $C_6H_{11}O_6$ and $C_{12}H_{22}O_{12}$

This is because you can't add a part of an atom.

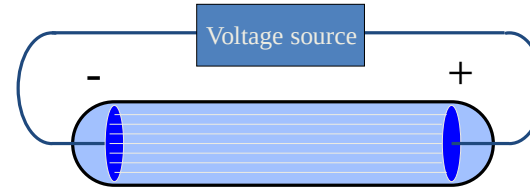
## What?

- Water is 8 grams of oxygen per gram of hydrogen.
- Hydrogen Peroxide is 16 grams of oxygen per gram of hydrogen.
- 16 to 8 is a 2 to 1 ratio
- True because you have to add a whole atom, you can't add a piece of an atom.

## Parts of Atoms

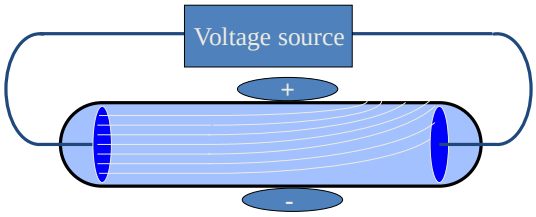
- J. J. Thomson - English physicist. 1897
- Made a piece of equipment called a cathode ray tube.
- It is a vacuum tube - all the air has been pumped out.

## Thomson's Experiment




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

## Thomson's Experiment




- By adding an electric field he found that the moving pieces were negative

Millikan used the cathode ray tube to determine the mass of electrons.

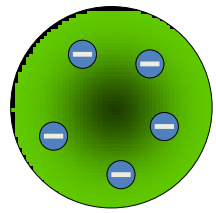
- He determined that the mass of the electron was about 2000 times less than the mass of a proton.

From his and Thompson's work scientists determined that:

- The atom had to have something positive to balance the negative electrons.
- The atom had to have something heavy since the electrons were so light.

## Thomsom'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



## Other pieces

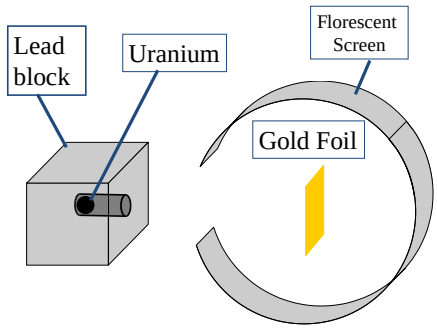
- Proton - positively charged pieces 1840 times heavier than the electron
- Neutron - no charge but the same mass as a proton.
- Where are the pieces?

## Rutherford's experiment

- Ernest Rutherford  English physicist. (1910)
- Believed in the plum pudding model of the atom.
- Wanted to see how big they are
- Used radioactivity
- Alpha particles - positively charged pieces given off by uranium
- Shot them at gold foil which can be made a few atoms thick

## Rutherford's experiment

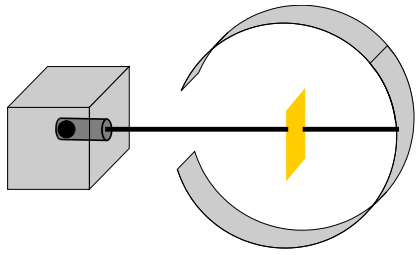
- When the alpha particles hit a florescent screen, it glows.
- Here's what it looked like



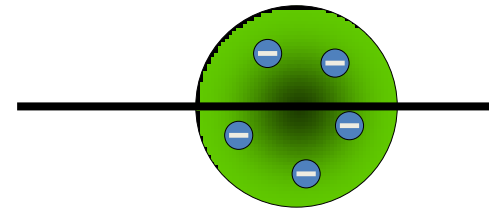

## He Expected

- The alpha particles to pass through without changing direction very much
- Because
- The positive charges were spread out evenly. Alone they were not enough to stop the alpha particles

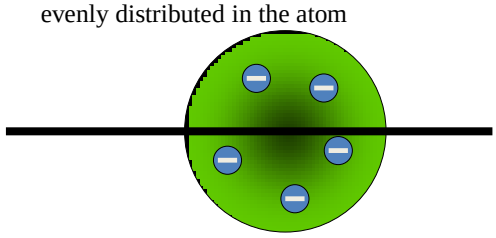
What he expected



Because



Because, he thought the mass was evenly distributed in the atom



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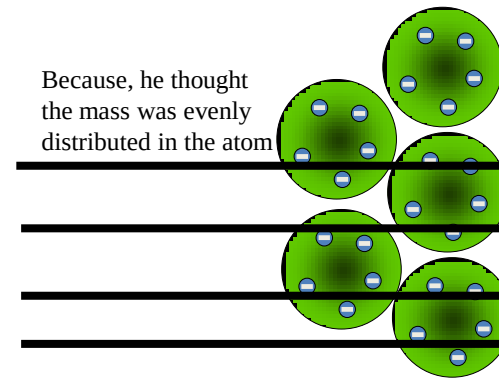
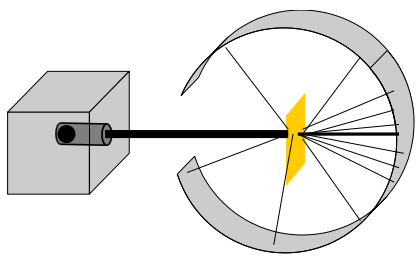
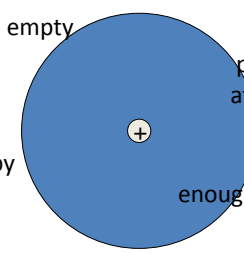


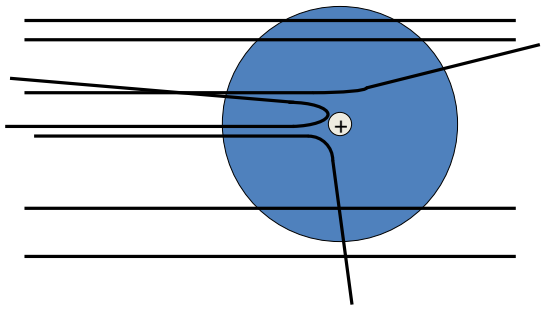
What he got



How he explained it

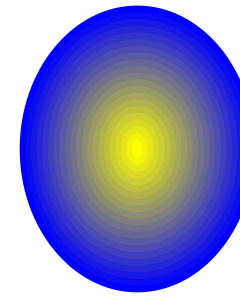
- Atom is mostly empty
- Small dense, positive piece at center
- Alpha particles are deflected by it if they get close enough





## Modern View

- The atom is mostly empty space
- Two regions
- Nucleus- protons and neutrons
- Electron cloud- region where you might find an electron



## Density and the Atom

- Since most of the particles went through, it was mostly empty.
- Because the pieces turned so much, the positive pieces were heavy.
- Small volume, big mass, big density
- This small dense positive area is the nucleus

## Subatomic particles

| Name | Symbol | Charge | Relative mass | Actual mass (g) |
|---|---|---|---|---|
| Electron | $e^-$ | -1 | 1/1840 | $9.11 \times 10^{-28}$ |
| Proton | $p^+$ | +1 | 1 | $1.67 \times 10^{-24}$ |
| Neutron | $n^0$ | 0 | 1 | $1.67 \times 10^{-24}$ |

## Structure of the Atom

- There are two regions
- The nucleus
- With protons and neutrons
- Positive charge
- Almost all the mass
- Electron cloud- Most of the volume of an atom
- The region where the electron can be found

## Size of an atom

- Atoms are small.
- Measured in picometers, $10^{-12}$ meters
- Hydrogen atom, 32 pm radius
- Nucleus tiny compared to atom
- IF the atom was the size of a stadium, the nucleus would be the size of a marble.
- Radius of the nucleus near $10^{-15}$m.
- Density near $10^{14}$ g/cm

## Counting the Pieces

- Atomic Number = number of protons
- # of protons determines kind of atom
- the same as the number of electrons in the neutral atom
- Mass Number = the number of protons + neutrons
- All the things with mass

## Isotopes

- Dalton was wrong.
- Atoms of the same element, same number of protons, same atomic number
- Can have different numbers of neutrons and different mass numbers
- called isotopes

## Symbols

- Contain the symbol of the element, the mass number and the atomic number

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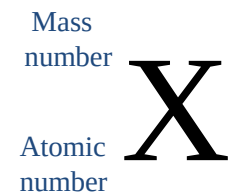


## Symbols

- Find the
  - number of protons
  - number of neutrons
  - number of electrons
  - Atomic number
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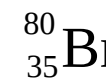

## Symbols

- if an element has an atomic number of 34 and a mass number of 78 what is the
  - –number of protons
  - –number of neutrons
  - –number of electrons
  - –Complete symbol

## Symbols

- if an element has 91 protons and 140 neutrons what is the
  - –Atomic number
  - –Mass number
  - –number of electrons
  - –Complete symbol

## Symbols

- if an element has 78 electrons and 117 neutrons what is the
  - –Atomic number
  - –Mass number
  - –number of protons
  - –Complete symbol

## Naming Isotopes

- Put the mass number after the name of the element
- carbon- 12
- carbon -14
- uranium-235

## Avagadro

- Avagadro Number is the amount of a substance that contains as many particles as there are atoms in exactly 12 g of carbon-12.
- Avagadro's number = $6.02 \times 10^{23}$ atoms (particles)
- One Mole of atoms = $6.02 \times 10^{23}$ atoms = gram atomic mass
- Gram atomic mass is the atomic mass in grams instead of amu's.

## Atomic Mass

- How heavy is an atom of oxygen?
- There are different kinds of oxygen atoms.
- More concerned with average atomic mass.
- Based on abundance of each element in nature.
- Don't use grams because the numbers would be too small

## Measuring Atomic Mass

- Unit is the Atomic Mass Unit (amu)
- One twelfth the mass of a carbon-12 atom.
- Each isotope has its own atomic mass we need the average from percent abundance.
- Amu is used to report the mass of a single atomic particle. Protons and neutrons are 1 amu each.

## Atomic Mass

- Calculate the atomic mass of copper if copper has two isotopes. 69.1% has a mass of 62.93 amu and the rest has a mass of 64.93 amu.

Average = % as decimal x mass +
% as decimal x mass +

.691 x 62.93 = 43.5

Rest = 100% - 69.1% = 30.9% SO +.309 x 64.93 = +20.1

63.6

## Atomic Mass

- Magnesium has three isotopes. 78.99% magnesium 24 with a mass of 23.9850 amu, 10.00% magnesium 25 with a mass of 24.9858 amu, and the rest magnesium 26 with a mass of 25.9826 amu. What is the atomic mass of magnesium?
- If not told otherwise, the mass of the isotope is the mass number in amu

ANSWER = 24.31

## Atomic Mass

- Is not a whole number because it is an average.
- are the decimal numbers on the periodic table.

## Shorten formulas

- The symbol for Atomic Number is "**Z**"
- Atomic # = # Protons = # Electrons
- Atomic mass = # P + # N
- Mass # = Atomic mass on Periodic Table Rounded Off to the nearest whole number.
- Amu = Atomic mass unit and is = to the mass of a proton.

Mass number

Atomic number

X

# The End