Unit 2, Learning Target 1
Understand how the idea of the atom has changed over time.

# The History of the Atom

## The Greeks

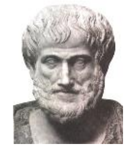
**DEMOCRITUS**

All things were made of **TINY** *invisible*, *indestructible* **PARTICLES**

(Greek "atomos" = indivisible)

**ARISTOTLE**

Proposed that the world IS **NOT** invisible **AND** that there were no "tiny particles"



## Pre-John Dalton

**JOSEPH PROUST**

Law of Definite Proportions

**ELEMENTS** form **COMPOUNDS** in fixed ratios.

NaCl = 1 Na + 1 Cl

$H_2O$ = 2 H + 1 O

**ANTOINE LAVOISIER**

Law of Conservation of Mass

Matter is neither created nor destroyed.


## Early Atomic Theory

**Dalton** developed:

**Law of Multiple Proportions**

Compounds in FIXED RATIOS

**-And-**

Reactant mass = Product Mass

**Examples**

A + B → AB
**1g 3g 4g**

A + 2B → $AB_2$
**1 2(3) 7**

2A + 3B → $A_2B_3$
**2(1) 3(3) 11**

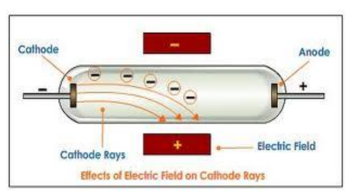
## Dalton's Early Atomic Theory

1. A matter is made of **ATOMS**.
2. (a) Atoms of the **same element are identical**.
   (b) Atoms of **different elements are different**.
3. Atoms can't be **subdivided**, created or destroyed
4. Atoms make compounds in **FIXED RATIOS**.
5. Atoms are **combined, separated or rearranged** to form **compounds**.

## Discovery of Electrons

**J.J. Thompson (1897)**

Concluded that the rays in the tube were composed of negatively charged particles – **"ELECTRONS"**



## YouTube Clip

Veritasium - Cathode Ray Tube EXPERIMENT

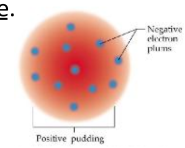
http://www.youtube.com/watch?v=2xKZRpAsWL8

http://www.youtube.com/watch?v=P18ejei5Uf4

## J.J. Thompson Reasoned…

1. Since atoms are neutral there must be a positively charged particle.

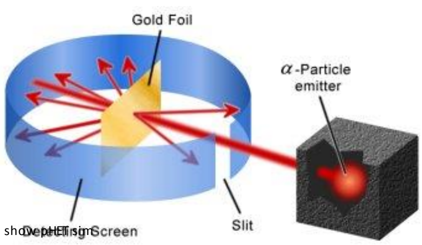
   "Plum Pudding Model"




2. Because the mass of an electron is so small there must be other particles in an atom.

## Discovery of Nucleus

**Ernest Rutherford (1918)**
***Gold Foil Experiment***

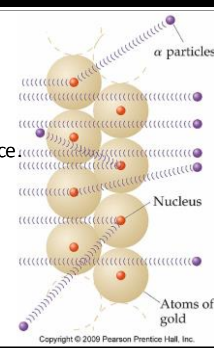



## Discovery of Nucleus

**Ernest Rutherford**
***Gold Foil Experiment***

1. The atoms is mostly empty space.
2. Positively charged particle.
3. Dense central region.

pHET sim
http://phet.colorado.edu/en/simulation/rutherford-scattering




## Discovery of Nucleus

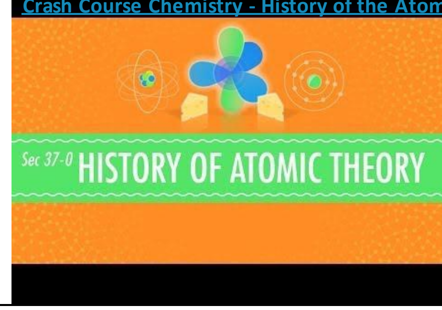
Composition of Nucleus

**Proton** Positive charge = negative charge.
Mass greater than the electron.

**Neutron** Electrically neutral.
Mass equivalent to the proton.
(Rutherford 1920, Chadwick 1932)

## Crash Course – History of the Atom

Crash Course Chemistry - History of the Atom



## Discovery of Nucleus

Composition of Nucleus

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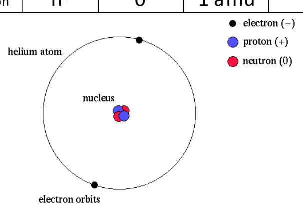
General Chemistry Unit 2 (Atomic Structure)

# Parts of the Atom

## Atomic Particles

| | Symbol | Electrical Charge | Mass Number | Location |
|---|---|---|---|---|
| electron | $e^-$ | -1 | 0 amu | Outside Orbit |
| proton | $p^+$ | +1 | 1 amu | Nucleus |
| neutron | $n^o$ | 0 | 1 amu | Nucleus |




## Counting $p^+$ $n^0$ $e^-$

**Z** = Atomic Number
# Protons

**X** = Atomic Symbol

**A** = Mass Number
# Protons and Neutrons

Z
**X**
NAME
A

## Element Notation

Hyphen Notation

"Symbol" – **Mass Number**

Na – **23**

11
**Na**
Sodium
23

$p^+$ 11 $n^0$ 12 $e^-$ 11

Nuclear Notation

**Mass Number** "Symbol"

$^{23}$Na

11
**Na**
Sodium
23

$p^+$ 11 $n^0$ 12 $e^-$ 11

## Counting $p^+$ $n^0$ $e^-$

Sodium:

$p^+$ = 11

$n^0$ = **12** (23-11)

$e^-$ = 11

11
**Na**
Sodium
23

## Isotopes and Atomic Number

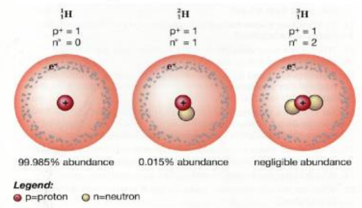
**Isotope** "SAME" → → → **Same #$p^+$ but different #$n^0$.**

**SAME** element

-BUT-

**DIFFERENT** mass

### Isotopes of HYDROGEN




## Isotope Notation

| Hyphen Notation | Nuclear Notation |
|---|---|
| Symbol – **Atomic Mass** | **Atomic Mass** Symbol |
| U – **235** | $^{235}U$ = Atomic Number 92 |
| $p^+$ 92 $n^0$ 143 $e^-$ 92 | $p^+$ 92 $n^0$ 143 $e^-$ 92 |
| U – **238** | $^{238}U$ = Atomic Number 92 |
| $p^+$ 92 $n^0$ 146 $e^-$ 92 | $p^+$ 92 $n^0$ 146 $e^-$ 92 |

## $p^+$ $n^0$ $e^-$ Homework

| Element Name | Element Symbol | Mass Number | Atomic Number | Protons | Neutrons | Electrons |
|---|---|---|---|---|---|---|
| Ex. Boron | B | 11 | 5 | 5 | 6 | 5 |
| 1. Sodium | Na | 24 | 11 | 11 | 13 | 11 |
| 2. Gallium | Ga | 68 | 31 | 31 | 37 | 31 |
| 3. Yttrium | Y | 89 | 39 | 39 | 50 | 39 |

| | | | | |
|---|---|---|---|---|
| 12. Magnesium (Mg) | Mg – 24 | 12 | 12 | 12 |
| | Mg – 25 | 12 | 13 | 12 |
| | Mg – 26 | 12 | 14 | 12 |

## Beanium (Bn) Exploration

## Beanium (Bn) Exploration

## Beanium (Bn) Exploration

Count them, mass them, record the data!

| Bn Group | Number of Atoms | Total Mass of Isotope |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| Total Number of Atoms (Group 1+2+3) | | |

## YouTube Clip

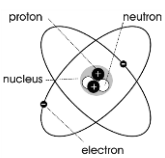
[WKRP in Cincinatti – Explain the Atom](http://www.youtube.com/watch?v=hhbqIJZ8wCM)
http://www.youtube.com/watch?v=hhbqIJZ8wCM

Unit 2, Learning Target 4
Relate mass to the number of atoms or moles in a substance

## Average Atomic Mass

## Atomic Mass

### Parts of the Atom




| Particles | Mass (g) | Mass (amu) |
|---|---|---|
| Proton | *1.673 X 10 $^{-24}$* 0.00000000000000000000 0000 167 3 g | **1 amu** |
| Neutron | *1.675 X 10 $^{-24}$* 0.00000000000000000000 0000 167 5 g | **1 amu** |
| Electron | *9.110 X 10 $^{-28}$* 0.00000000000000000000 0000 000 0911 g | **0 amu** |

**1 atom Mg** = 4.02 x $10^{-23}$g = 0.0000000000000000000000402 g

## Mass Number vs. Atomic Mass

**MASS NUMBER**

Total number of
PROTONS and NEUTRONS
in the nucleus of an isotope

Example:

| | | |
|---|---|---|
| Mg-24 | 12 $p^+$ | **12 $n^0$** |
| Mg-25 | 12 $p^+$ | **13 $n^0$** |
| Mg-26 | 12 $p^+$ | **14 $n^0$** |

**ATOMIC MASS**

Weighted average
of all the
ISOTOPE MASS NUMBERS

Example:

| | |
|---|---|
| Mg-24 | 78.99% |
| Mg-25 | 10.00% |
| Mg-26 | 11.01% |

**= 24.31 amu**

## Atomic Mass 1

Calculate the average atomic mass of copper if…

**69.17%** of Copper has a mass of **62.94** amu.

**30.83%** of Copper has a mass of **64.93** amu.

| 29 |
|---|
| **Cu** |
| Copper |
| 63.546 |

## Atomic Mass

Calculate the average atomic mass of copper if…

(1) Change all percents back to **decimals** (Relative Abundance) $\left(\frac{\%}{100}\right)$

(2) **Multiply** each decimal by AMU mass.

(3) **Add** the isotopes together.

*Double check* with the Periodic Table.

## Atomic Mass 1

Calculate the average atomic mass of copper if...

**69.17%** of Copper has a mass of **62.94** AMU

**30.83%** of Copper has a mass of **64.93** AMU.

| 29 |
|---|
| **Cu** |
| Copper |
| 63.546 |

69.17% = (0.6917)
30.83% = (0.3083)

## Atomic Mass 2

Calculate the average atomic mass of magnesium

Magnesium-24 is **78.99% abundant**
Magnesium-25 is **10.00% abundant**
Magnesium-26 is **11.01% abundant**

| 12 |
|---|
| **Mg** |
| Magnesium |
| 24.31 |

## Atomic Mass 3

Calculate the average atomic mass of Iodine if...

**$^{127}$I = 80%, $^{126}$I = 17%** and **$^{128}$I = 3%**

| 53 |
|---|
| **I** |
| Iodine |
| 126.90447 |

## Gen Chem Thursday Oct 02

# Think/Pair/Share

**THINK**: Individual Work (~20 minutes)

**PAIR**: Choose a Partner (~15 minutes)

**SHARE**: Class Discussion (Remaining Time)


Unit 2, Learning Target 4
Relate mass to the number of atoms or moles in a substance

## The MOLE!

## Consider the following...


**A Dozen** Donuts or **A Dozen** Smart Cars.

Q1: Which would have **more** numbers?

Q2: Which would have **more** mass?

## Relative Measurement

Measurements to GROUP ITEMS.

| | |
|---|---|
| **12** eggs | = One **Dozen** |
| **13** donuts | = One **Baker's Dozen** |
| **144** pencils | = One **Gross** |

Chemists use a relative measurement called **THE MOLE** to determine the number of atoms in a sample.

## Avogadro creates THE MOLE.

Lorenzo Romano Amedeo Carlo **Avogadro**

*Equal volumes of two different gases would have the same number of particles.*

Scientists dedicated the measurement by calling it **Avogadro's Number**

## Avogadro's Number

Chemists later discovered that when the **ATOMIC MASS** (in AMU) was set equal in **GRAMS**, every element and compound has

602,200,000,000,000,000,000,000

**atoms or molecules.**

**Avogadro's Number**

**$6.022 \times 10^{23}$** particles = 1 mole.

## The Mole

| | |
|---|---|
| **1 mole** carbon (C) | = **$6.022 \times 10^{23}$** atoms |
| **1 mole** water ($H_2O$) | = **$6.022 \times 10^{23}$** molecules |
| **1 mole** elephants | = **$6.022 \times 10^{23}$** elephants |
| **1 mole** donuts | = **$6.022 \times 10^{23}$** donuts |
| **1 mole** dollars | = **$\$6.022 \times 10^{23}$** |
| **1 mole** sand | = **$6.022 \times 10^{23}$** grains of sand (enough to cover Los Angeles 800 meters deep) |

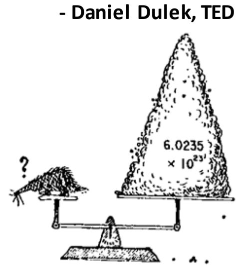
## Intro to THE MOLE videos

**Stoichiometry (Start through 8:15)**
**- Crash Course Chemistry**

https://www.youtube.com/watch?v=UL1jmJaUkaQ


## Intro to THE MOLE videos

**How big is a mole? (Not the animal, the other one.)**
**- Daniel Dulek, TED Ed YouTube**




http://www.youtube.com/watch?v=TEl4jeETVmg

## The Measured Mole

**1 mole = $6.022 \times 10^{23}$ of ANYTHING**

| Apple | Brick | Truck |
|---|---|---|
|  |  |  |
| 1 mole Apples | 1 mole Bricks | 1 mole Trucks |
| $6.022 \times 10^{23}$ | $6.022 \times 10^{23}$ | $6.022 \times 10^{23}$ |
| Grams | Grams | Grams |

## The Measured Mole

**1 mole = $6.022 \times 10^{23}$ of ANYTHING**

| Helium | Oxygen | Iron |
|---|---|---|
| 2 He Helium 4.00 | 8 O Oxygen 16.00 | 26 Fe Iron 55.85 |
| 1 mole Helium | 1 mole Oxygen | 1 mole Iron |
| $6.022 \times 10^{23}$ | $6.022 \times 10^{23}$ | $6.022 \times 10^{23}$ |
| 4.00 g | 16.00 g | 55.85 g |

## Avogadro's Number

**Lithium** (Atomic Number 3)

6.941 amu = mass of one ATOM (atomic mass)

6.941 grams = mass of one MOLE (molar mass)

-or- = $6.022 \times 10^{23}$ atoms Li

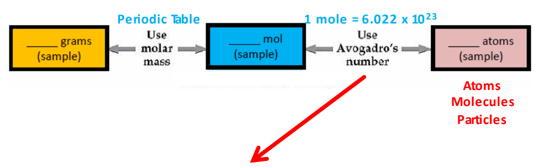
**Aluminum** (Atomic Number 13)

26.98 amu = mass of one ATOM (atomic mass)

26.98 grams = mass of one MOLE (molar mass)

-or- = $6.022 \times 10^{23}$ atoms Al

## Relate MASS to ATOMS




*Avogadro's Number in a Scientific Calculator:*

6.022 [EE] 23 = $6.022 \times 10^{23}$

## Relate MASS to ATOMS

1. How many moles are in **$1.50 \times 10^{12}$ atoms lead (Pb)**?
2. How many grams are in of **2.25 mol iron (Fe)**?
3. How many grams are in **$7.85 \times 10^{27}$ atoms zinc (Zn)**?

## Relate MASS to ATOMS

1. How many moles are in **$1.50 \times 10^{12}$ atoms lead (Pb)**?

   **$2.49 \times 10^{-12}$ moles Pb**

2. How many grams are in of **2.25 mol iron (Fe)**?

   **165.66 grams Fe**

3. How many grams are in **$7.85 \times 10^{27}$ atoms zinc (Zn)**?

   **852,654.43 grams Zn**

## Gen Chem Thursday Oct 09

# Think/Pair/Share

**THINK**: Individual Work (~20 minutes)

**PAIR**: 3 Different Pairs (~15 minutes)

**SHARE**: Class Discussion (Remaining Time)