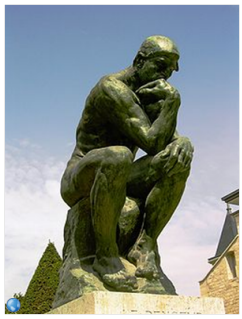
2.1 – 2.4 History of Chemistry, Fundamental Laws



Sep 21-6:56 AM

Greeks

No scientific method early on – only philosophy.
Explanations of events based on life experiences.

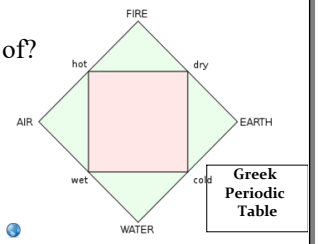
Sep 21-6:55 AM

Greeks

Elements were Earth, Air, Fire, and Water, which could be divided infinitely.

There was also a 5th element called "Aether".

What might these be made of?
1. A cow
2. Wood
3. Steam
4. A diamond?

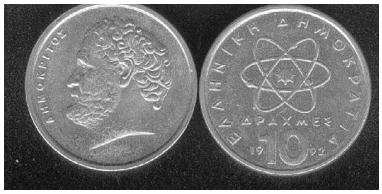


Greek Periodic Table

Sep 21-6:56 AM

Democritus (460 – 370 B.C.)

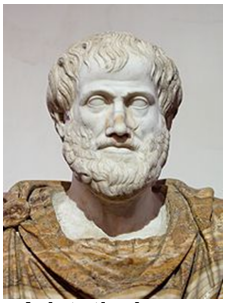
Matter not infinitely divisible – atom idea.
Atoms can't be created or destroyed.
Different sizes/shapes→ move through empty space.
His ideas were way ahead of his time, but he had only philosophy to defend them.



Sep 21-6:58 AM

Aristotle (Jones) (384 – 322 B.C.)

Stated that empty space can't exist.
Challenged atoms – believed in Earth, Air, Fire, Water model.
He asked "What holds atoms together?" to which there was no answer.
So influential was Aristotle that his denial of atom's existence went unchallenged for 2000 years.



Aristotle Jones

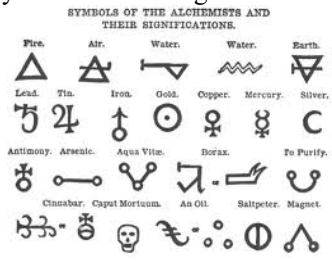
Sep 21-7:43 AM

Alchemists

Medieval chemists tried to turn base metals (Fe, Pb) to gold.

They also tried making an 'elixir of life' bestowing immortality upon the consumer.

Several symbols they used for their ingredients:



Oct 19-2:31 PM

Phosphorus Note

It's worth noting that the medieval alchemists did make some lasting contributions.
In addition to devising some methods of fabricating mineral acids (sulfuric, nitric, hydrochloric), some elements were discovered.
Anyone know how phosphorus (P (emphasis on P)) was discovered?
In 1669, in his quest to produce The Philosopher's Stone, Hennig Brand of Germany experimented with rotting urine, boiling it down until only a sludge remained. This sludge he distilled, and produced a white material that glowed in the dark and burned intensely.
It took 290 gallons of urine to produce 60 grams of P.
It was discovered that the urine didn't first have to rot.

Oct 19-2:31 PM

John Dalton (1766 – 1844)

An English chemist who revived the atomic concept in 1700's, by conducting Chemistry experiments which wound up supporting Democritus' ideas.

John Dalton

Sep 21-7:43 AM

Dalton's Theory:

1. Matter made of small particles called atoms.
Atoms of one element are:
2. - indivisible and indestructible,
3. - identical in size, mass, chemical properties,
4. - different from those of other elements.
5. Atoms combine in simple whole number ratios to form compounds.
6. During reaction, atoms in a compound are separated, combined, or rearranged.

Sep 21-7:43 AM

Significance

His theory explains the Law of Conservation of Mass atoms rearrange during reactions; are not created or destroyed.

Sep 21-7:45 AM

Law of Conservation of Mass

Matter is neither created nor destroyed during a chemical reaction– only transformed.
Mathematically,

Mass of Reactants = Mass of Products

Credit is given to Lavoisier for quantifying this.

Feb 27-12:39 PM

Antoine Lavoisier

(1743 – 1794) French chemist, a founder of modern chemistry.

Used analytical balances to study reactions.

Mercuric oxide decomposes into mercury and oxygen. Doing this in an enclosed container, he determined the mass of reactants equaled the mass of products.

5. Guess how he died?

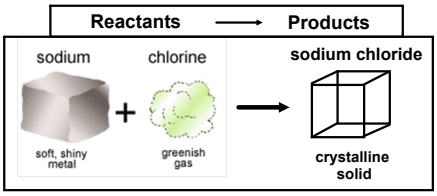
He was executed during the French Revolution.

Feb 27-12:39 PM

Conservation of Mass Example

6. If 28.5 grams of sodium chloride (NaCl)form by reacting 11.2 grams of sodium metal with chlorine gas, how many grams of chlorine reacted with the sodium?

Mass Reactants = Mass Products
11.2 g Na + ???? g Cl = 28.5 g NaCl
So: 28.5 g NaCl – 11.2 g Na = 17.3 g Cl



Feb 27-12:39 PM

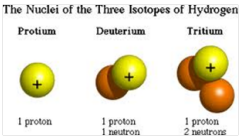
Drawbacks

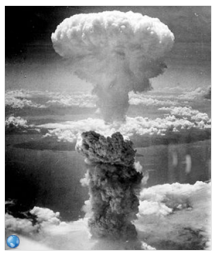
Humanity has learned that Dalton's theory is not totally accurate.

7. Which of John Dalton's points are inaccurate, and how are they?

A. Atoms are divisible.

B. Different elementalisotopes have different masses.



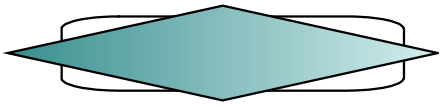


Sep 21-7:45 AM

Law of Definite Proportions

A compound is composed of the same elements in the same proportions by mass regardless of the sample size.

% mass: ratio of an element's mass to the total mass of a compound.



Feb 27-12:51 PM

Percent Mass Example

8. A 78.0 g sample of unknown compound contains 12.4 g H. What is the percent by mass of hydrogen?

$$\%\,mass = \frac{Mass\ of\ Element}{Mass\ of\ Compound} \bullet 100\%$$

$$\%\,mass = \frac{12.4\,g}{78.0\,g} \bullet 100\% = 15.9\%$$

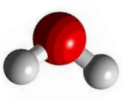
Feb 27-12:51 PM

Law of Multiple Proportions

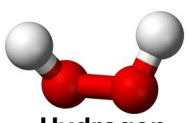
Different compounds form when the same elements combine in different ratios of small whole numbers.

Example: Water (H_2O) and Hydrogen Peroxide (H_2O_2).

Comparing the two compounds, the ratio of hydrogen to oxygen in water is 2:1.
In hydrogen peroxide, the ratio is 2:2 (or 1:1).



Water
H_2O



Hydrogen Peroxide
H_2O_2

Feb 27-12:51 PM

9. Law of Multiple Proportions Example

The following data were collected for several compounds of nitrogen and oxygen. The numbers are how many grams of nitrogen reacted with one gram of oxygen:
Compound A: 1.750 g
Compound B: 0.8750 g
Compound C: 0.4375 g

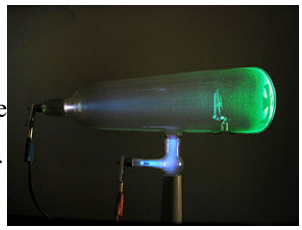
Show how these data support the law of multiple proportions.

Feb 27-12:51 PM

Electrons - First Observed 1869

Originally called "Cathode Rays", because they were observed to come streaming off a cathode (negative electrode) of a vacuum tube.
Old television sets have these tubes. Demo.

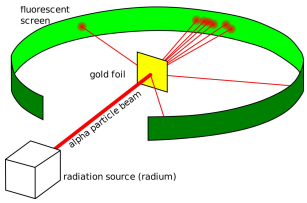
They are negatively charged particles which are deflected by magnetic and electric fields.
Mass = 9.1 E -28 grams.



J. J. Thompson identified the electron as the particle in cathode rays in 1867, as well as the presence of its negative charge.

Sep 23-7:12 AM

Brace yourselves for amazing machines!



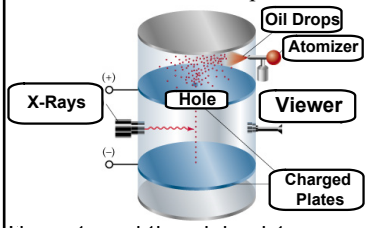
Oil Drop Experiment

Gold Foil Experiment

Sep 26-11:03 AM

Robert Millikan's Oil Drop Experiment - 1909

Millikan determined the mass to charge ratio of electrons.
10. Label Millikan's setup.



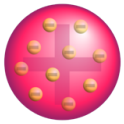
1. Oil droplets are sprayed into the upper chamber.
2. Some pass through a hole, entering an electric field between two plates.
3. X-Rays charge the droplets, so they hover between the plates (like charges repel, opposites attract).
4. A calibrated microscope allows one to see the size of the droplets, and determine mass.

The motion of the oil droplets depends on their charge and size.
Millikan's calculated charge is only 0.6% different than today's value!!
Charge is 1.60 E -19 Coulombs (C).

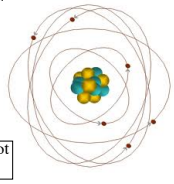
Aug 15-1:12 PM

Two Warring Atomic Models

"Plum Pudding" Model - J. J. Thompson posited that the negative electrons in atoms must be balanced by positive charge equal in magnitude. His model: Spherical atoms have electrons distributed uniformly in a cloud of positive charge.



Plum Pudding Model **Vs.** Nuclear Model



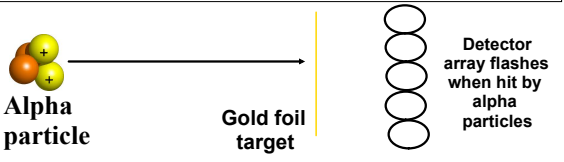
Nucleus not to scale.

Nuclear Model: Atoms have tiny, dense central nucleus which electrons orbit.

Sep 23-7:16 AM

Rutherford's Gold Foil Experiment - 1911

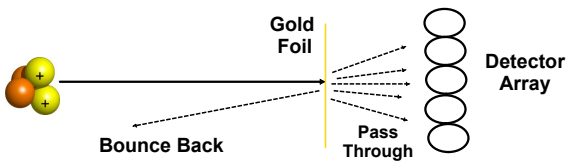
Alpha particles were fired at a thin gold foil target.
The particles cause a detector array to emit a light flash when they hit it.



Sep 23-7:18 AM

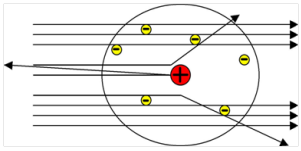
Rutherford's Gold Foil Experiment - 1911

Most particles went through the foil with no difficulty, but some bounced straight back.



Sep 23-7:21 AM

What Happened to the Particles

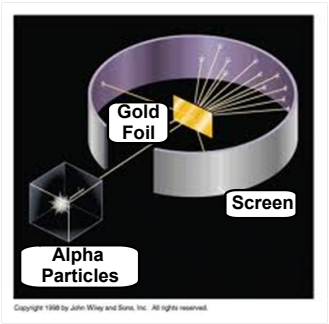


Most particles passed through with little deflection, but those that bounced back suggested a dense, tiny nucleus – NOT a uniform cloud of positive charge.

Sep 23-7:27 AM

Rutherford's Gold Foil Experiment - 1911

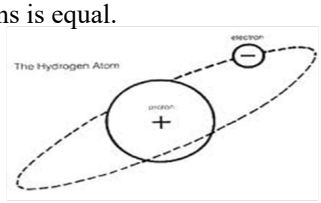
11. Draw and label Rutherford's apparatus.



Sep 23-7:18 AM

Proton - Discovered 1917

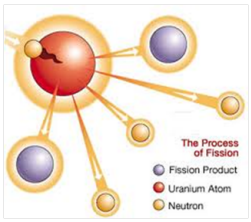
Positively charged particle in nucleus.
Mass = 1.67 E-24 grams.
Henry Mosley discovered that each element has a unique number of protons - this is the Atomic Number from the Periodic Table.
In an electrically neutral atom, the number of protons and electrons is equal.



Sep 23-7:08 AM

Neutron - Discovered 1932

Neutrally charged particle in nucleus.
Mass = 1.68 E -24 grams.



Neutrons can cause nuclear fission.

Sep 23-7:30 AM

Homework

Read 2.5 - 2.8

2.1 - 2.4 Problems in your Booklet
Due: Next Class.

Sep 21-7:50 AM