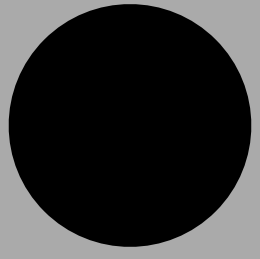
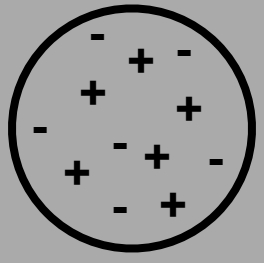
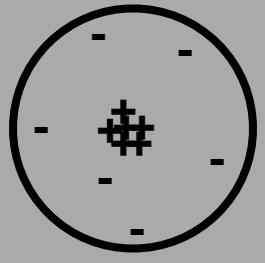
The History of the Development of the Human Understanding of the Atom.



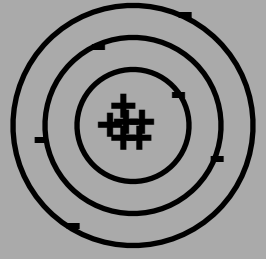
Dalton



Thomson



Rutherford

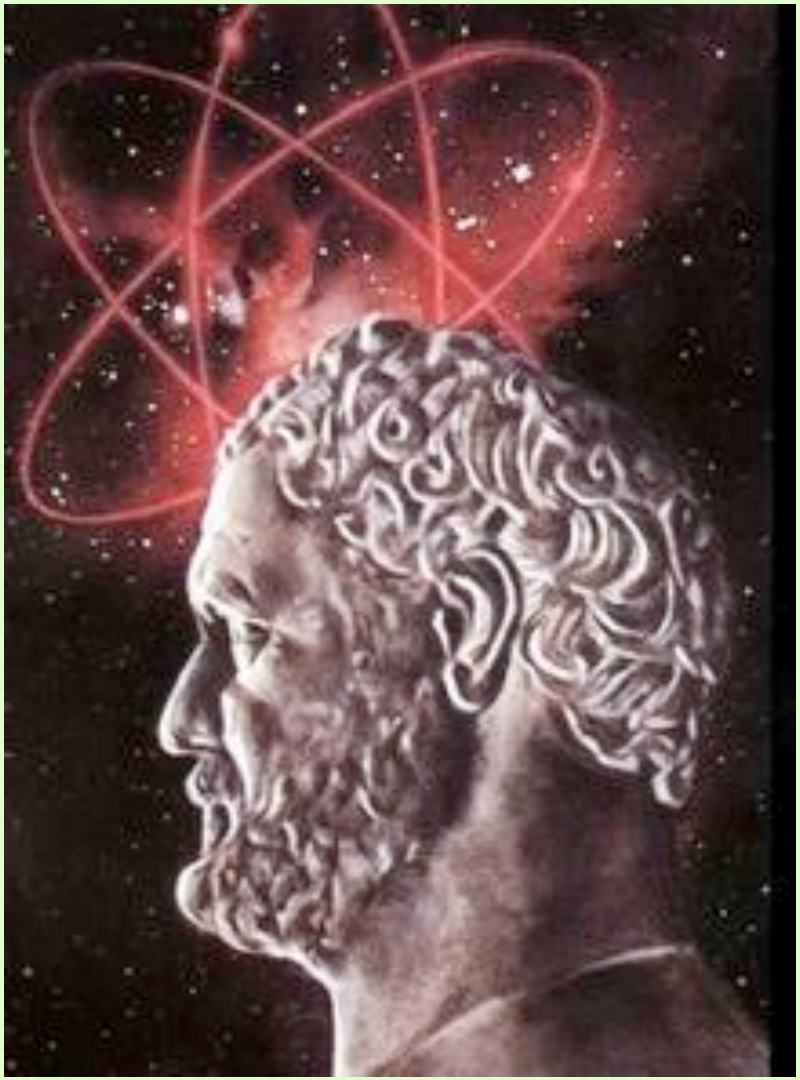


Bohr

In chap 11

Democritus 460-370 BC

- Democritus was a Greek *Philosopher.*
- He *believed* that matter was made of tiny discrete particles that he called "atomos" *(atoms)*.



background information 2

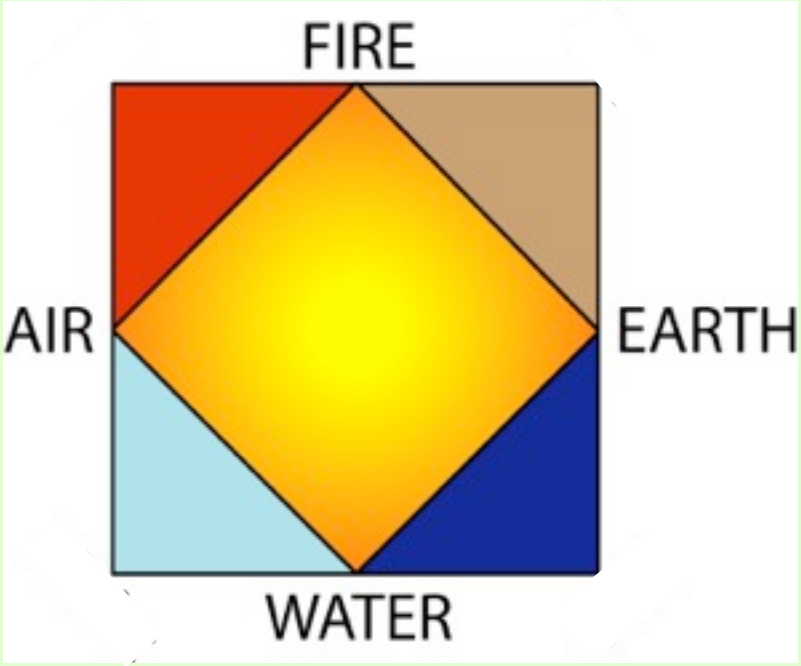
Did it make sense?

- Since no one could see atoms, Democritus' ideas were hard for people to believe.
- It seemed much more intuitive to think that matter was continuous.
- A young charming Aristotle who was far more popular, rich, outspoken, handsome challenged Democritus' ideas and it was Aristotles ideas that endured for many years.

background information

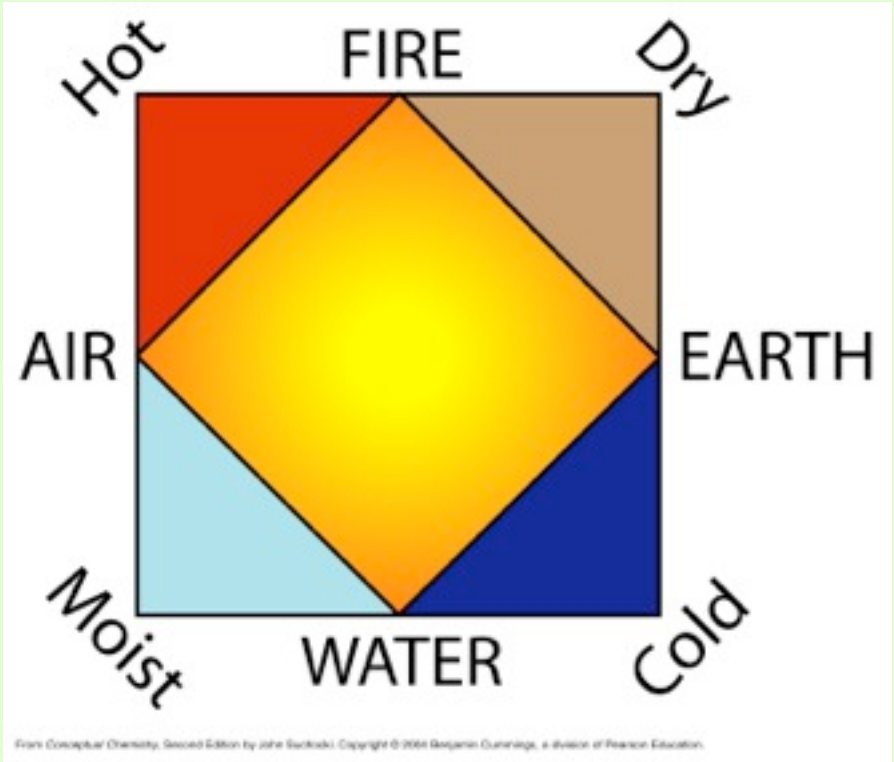
Aristotle 384-322 BC

- Aristotle was a Greek *Philosopher*.
- He was 14 years old when Democritus died.
- Aristotle believed that matter was made of 4 basic elements.
- Aristotle disagreed with Democritus and believed matter was continuous
  - ✓ "hyle" not "atomos"
- Aristotle's ideas endured for 2000 years.



Alchemy for 2000 years

- Aristotle believed that any substance could be *transmuted* (transformed) into any other substance simply by changing the relative proportions of the 4 basic qualities:
  - ✓hot
  - ✓dry
  - ✓cold
  - ✓moist



background information

Alchemy for 2000 years

- The idea of *transmutation* laid the foundation for *alchemy*
- Alchemists were searching for the evolution from ignorance to enlightenment. They were searching for the
  - ✓ elixir of life
  - ✓ philosopher's stone
  - ✓ the aqua vitae
  - ✓ the panacea
- This lead to the search for the ability transmute matter.
- In spite of their unsuccessful search, to change lead into gold, they did a lot of good experimentation that laid the foundation for modern science.

The Importance of the Printing Press

- Just as the internet has changed the accessibility of information since it became available to the public in the early ’90’s,
- The invention of the printing press in the 1400’s finally allowed information to be easily recorded and ideas could be more easily exchanged.
- Evidence against Aristotle’s model of matter began to accumulate.

Robert Boyle 1627-1691

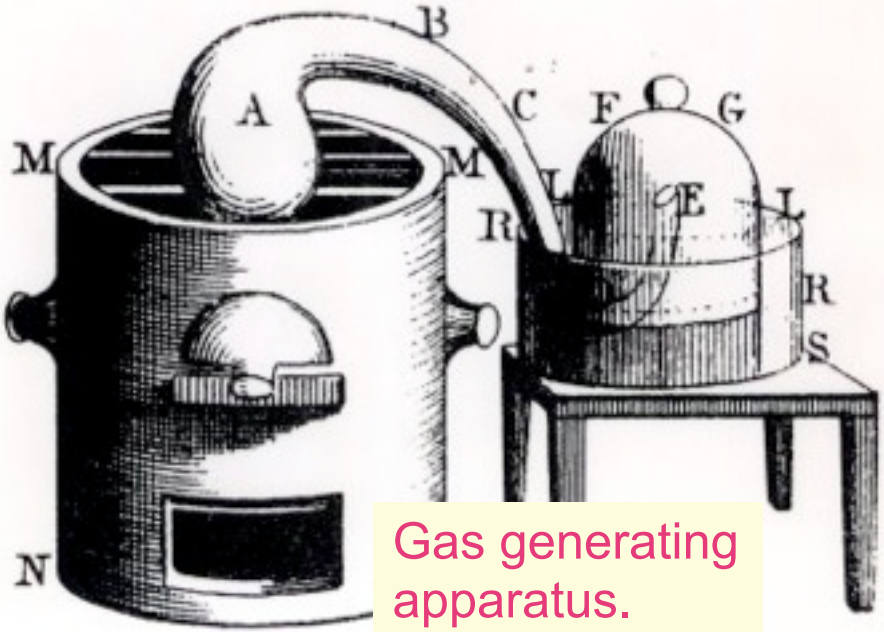
- Sometimes referred to as the Father of Modern Chemistry
- He was one of the first to publish all the experimental details of his work, *including experiments that did not work.*
- Boyle revived Democritus' ideas by proposing that a substance was *not* element if it were made of two or more components.
- Although, his work primarily studied the inverse relationship between the pressure and volume of gases.
  - ✓ As volume gets smaller, pressure gets greater.
  - ✓ We'll get to this in chap 13

background information

8

Marie-Anne and Antoine Lavoisier 1743-1794

- Sometimes referred to as the mother and father of modern chemistry?
- They studied various types of reactions involving *oxygen* - respiration, burning, rusting.
- Beheaded in 1794 during the French revolution for his involvement as a part-time tax collector for the king.

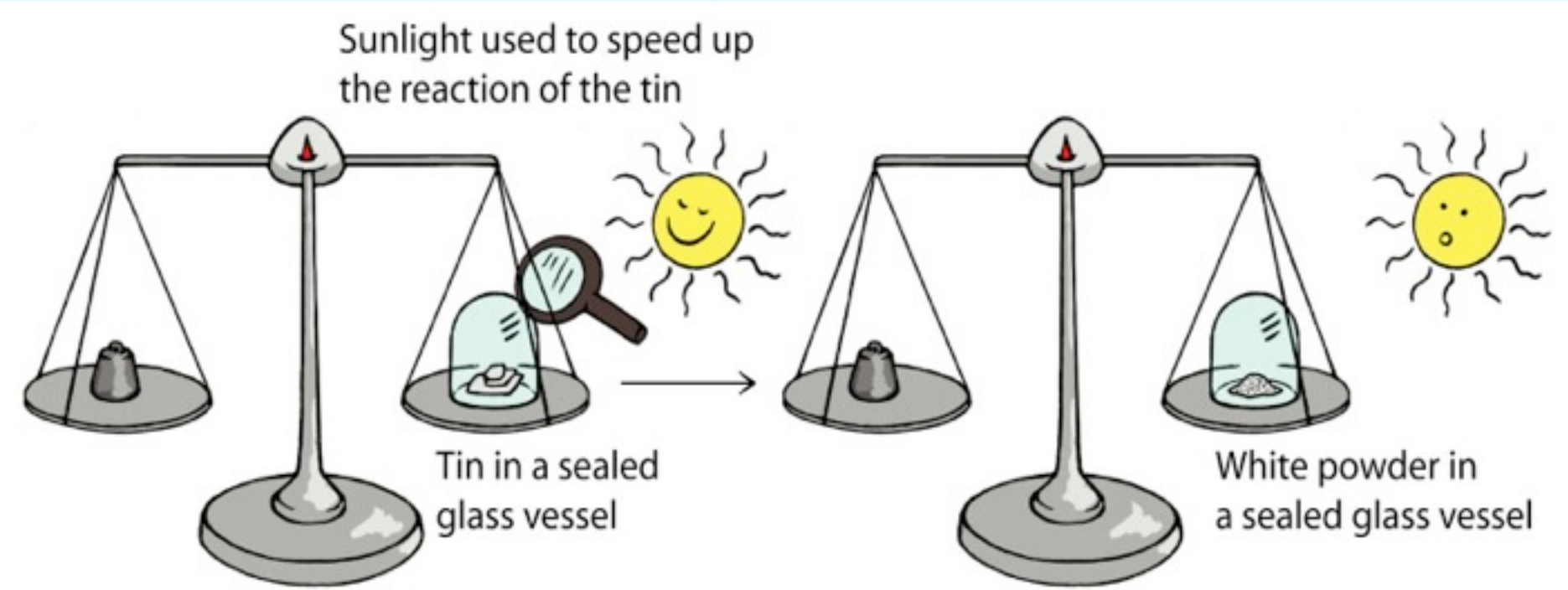


Gas generating apparatus.

background information

Lavoisier - Law of Conservation of Mass

- Explain how the experiment in this picture demonstrates the Law of Conservation of Mass.
- We attempted to verify the Law in LAD 3.1 - The Law of Conservation of Mass



10

Antoine Lavoisier

The many ways you could state:

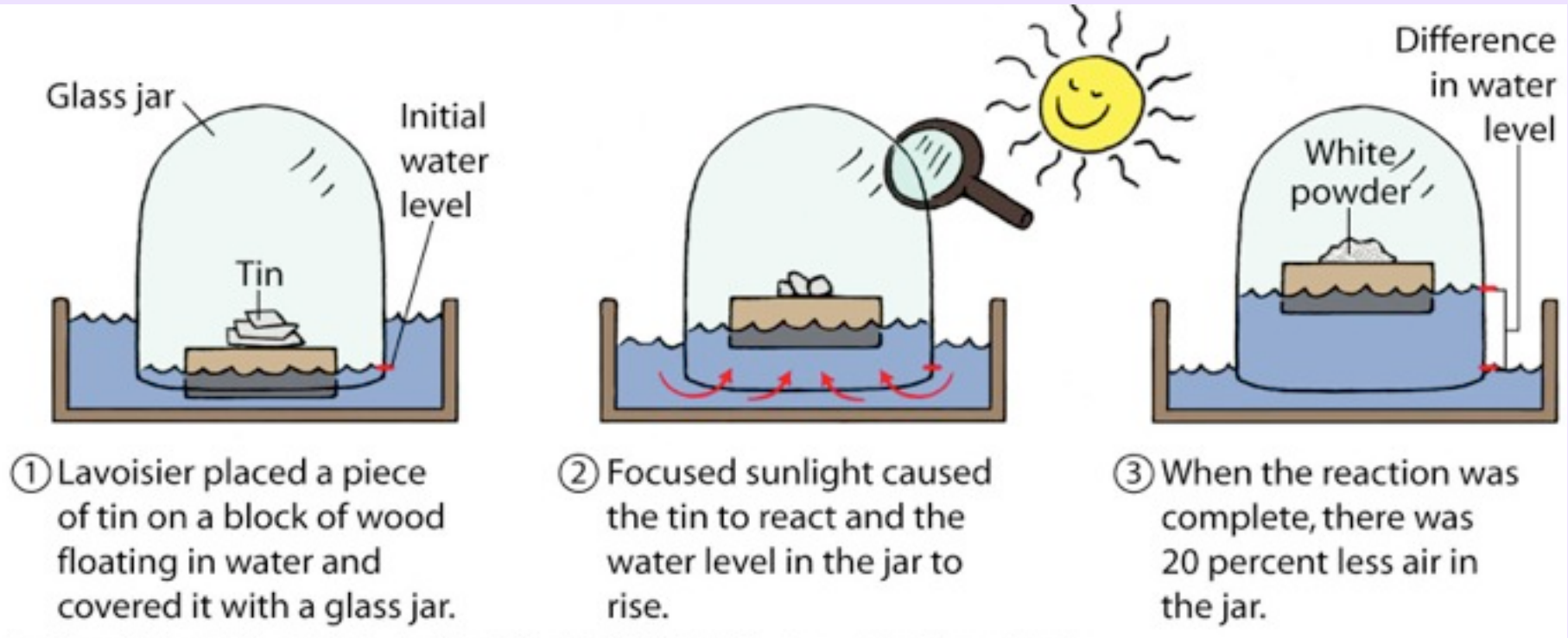
The Law of Conservation of Mass

- There is no detectable change in the total mass of materials when they react chemically to form new materials.
- The mass of the products will equal the mass of the reactants in a chemical reaction.
- The mass of what you start with is what you'll finish with in a chemical reaction.
- During a chemical reaction, matter is neither created nor destroyed.

11

Lavoisier - Reacting Component of Air

- Lavoisier's experiment below convinced him that air contained more than one element.
- Lavoisier used the experiment below to determine the amount of the "reacting component" in the air.
- He named this reacting component oxygen.
- The experiment below is the same as LAD 3.2 - % O_2 in Air



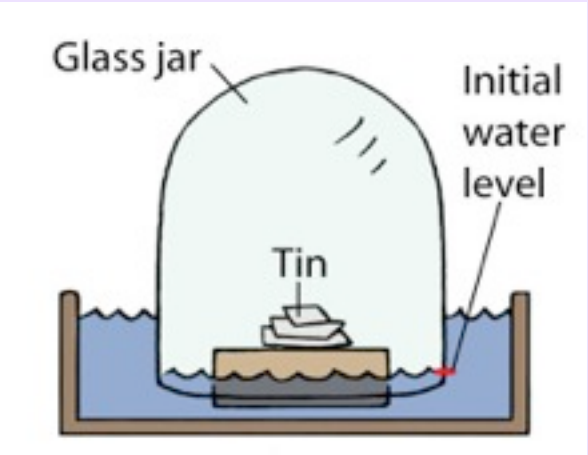
① Lavoisier placed a piece of tin on a block of wood floating in water and covered it with a glass jar.

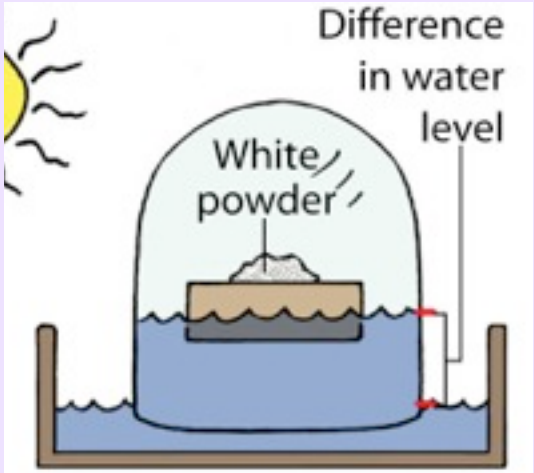
② Focused sunlight caused the tin to react and the water level in the jar to rise.

③ When the reaction was complete, there was 20 percent less air in the jar.

12

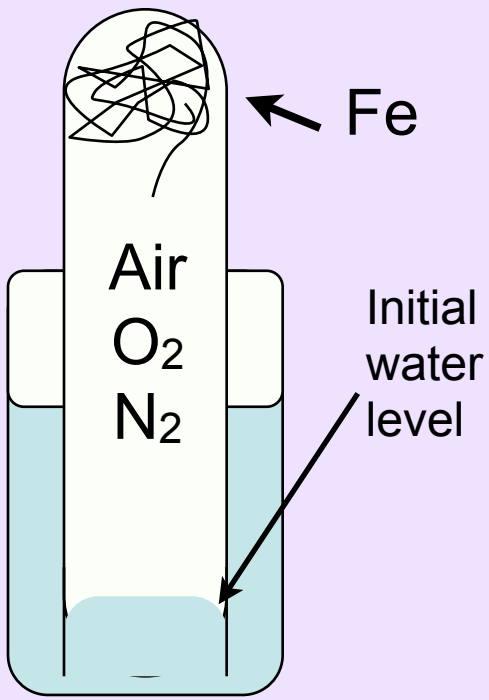
LAD 3.2 - % of O_2 in Air

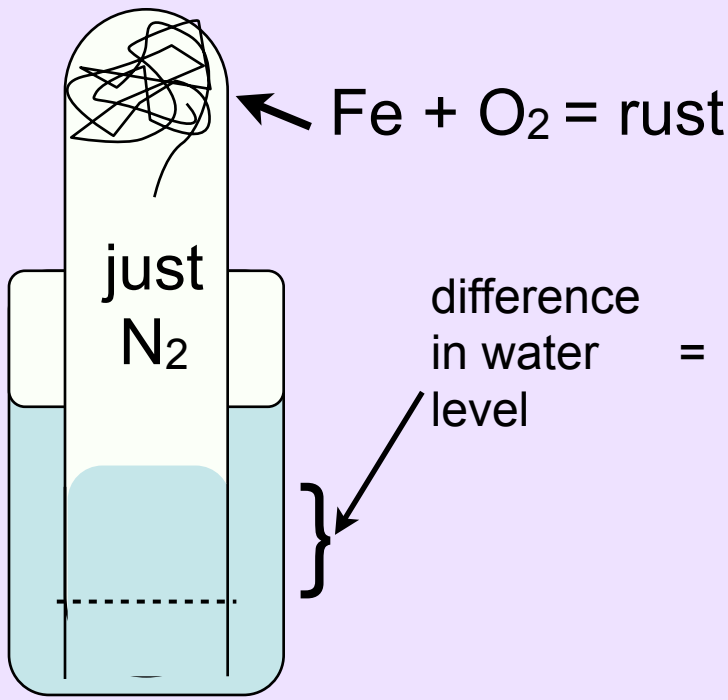




- Compare Lavoisier's experiemnt with our LAD 3.2

= oxygen reacted with tin





13

Joseph Proust (1754-1826)

- By 1790 Proust recognized that elements in compounds combine in *definite ratios by mass*.
  - ✓Law of Constant Composition
- We will attempt to verify this in LAD 3.4A

14

Joseph Gay-Lussac (1778-1850)

- Gay-Lussac was a balloonist.
- Because of his hobby, he was very interested in gases.
  - He determined that the gasses combine in *definite ratios by volume*.

Do LAD 3.4B

15

Proust & Gay-Lussac
The Law of Constant Composition

- Elements combine in definite mass ratios to form compounds.
- A given chemical compound always contains the same proportion by mass of its constituent elements.
- The relative amount of each element in a particular compound is always the same, regardless of preparation or source.

16

John Dalton (1766-1844)

- Dalton used the work of Lavoisier, Proust, and Gay-Lussac to revive Democritus' idea that matter was made of atoms.
- He based much of his theory on two laws
  - ✓ The law of Conservation of Mass
  - ✓ The Law of Constant Composition

17

John Dalton (1766-1844)

- He developed a system of symbols for each known element.
- His symbols were round to model the tiny round atoms he was theorizing about
- Today we have changed to the lettering system.
  - ✓ H
  - ✓ Ar
  - ✓ W
  - ✓ Mg

background information

18

Dalton's Atomic Theory published 1808
a comparison with Modern Atomic Theory

1. Each element made of *indivisible*, minute particles called atoms.
   - (He didn't know about protons, neutrons or electrons.)
2. All atoms of a given element are *identical*.
   - (Not exactly, after all we now know about isotopes of the same element have different mass.)
3. Atoms of different elements are *different* mass.
   - (Isotopes of different elements may have the same mass.)
4. Atoms chemically combine in definite ratios to form compounds.
5. Atoms can be neither created nor destroyed in *chemical* reactions.
   - (They can be created and destroyed in a *nuclear* reaction, but not in a *chemical* reaction.)

19

Ben Franklin (1706-1790)

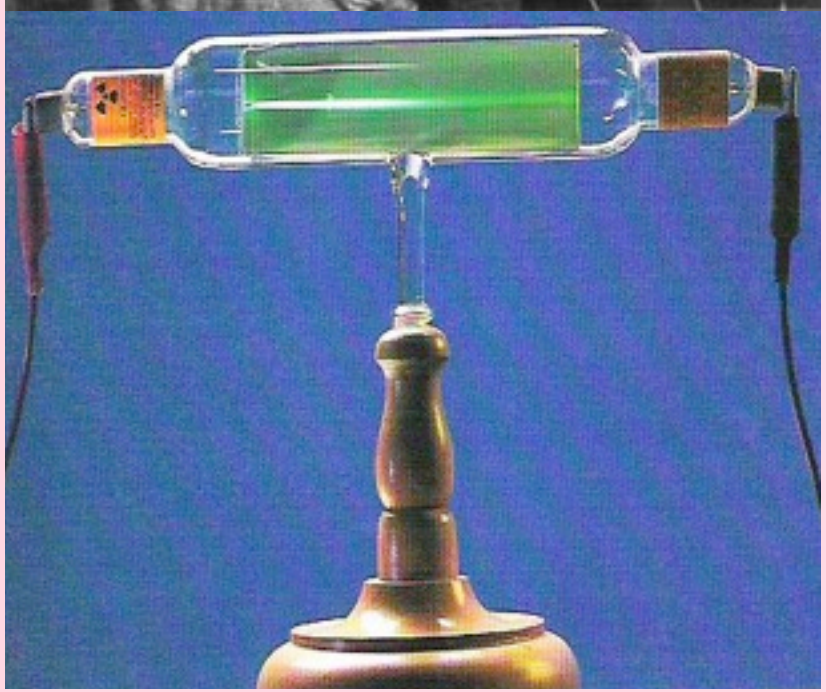
- Before Dalton's Atomic Theory, scientists were studying about the electrical nature of matter.
- Franklin realized that lightening is the flow of electrical energy.
- He "invented" the terms positive and negative for opposite electrostatic charges.

background information

20

J.J. Thomson (1856-1940)

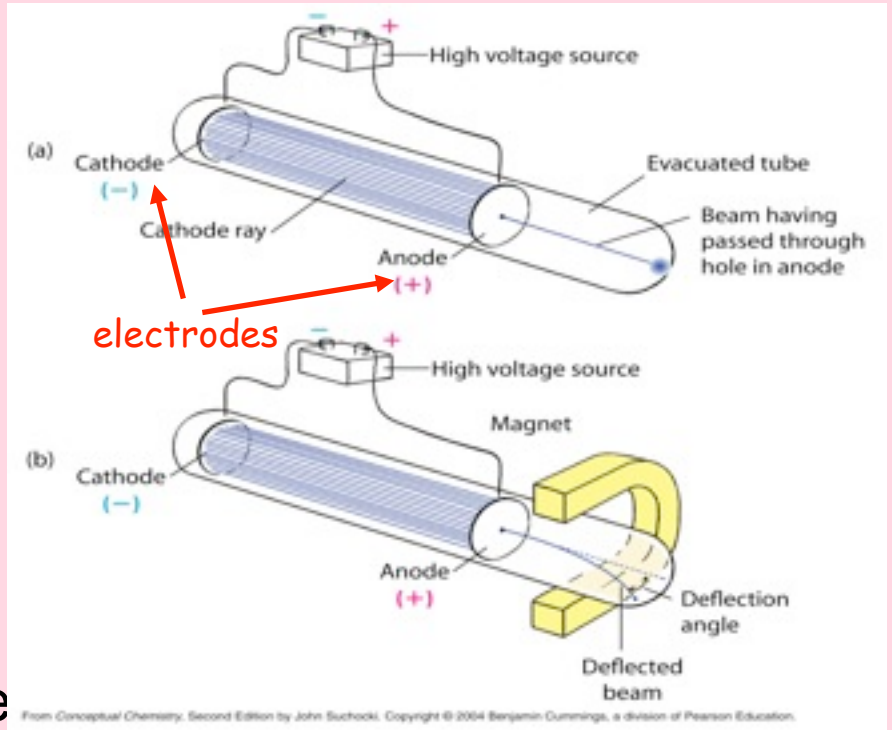
- Electricity (which we now know is nothing more than moving electrons) was applied to cathode ray tubes.
- The beam of electrons itself can not be seen. The green beam is caused by the electrons' effect on the phosphorescent screen or the small amount of gas in the cathode ray tube.

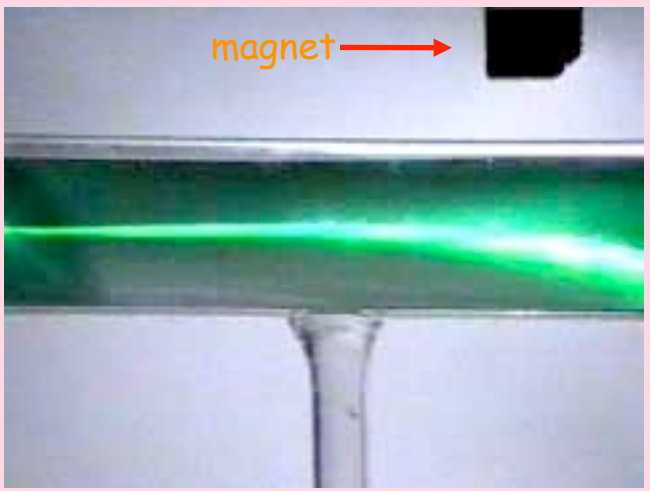


21

“Discovery of the Electron“ (and Proton)

- The cathode ray tube caused electrons to travel from an electrode (the cathode) at one end to an electrode (the anode) at the other end.
- The beam of electrons can be bent by a magnetic force - repelled by the negative end of a magnet. The beam behaved the same regardless of which gas was in tube or which metal was at the cathode.
- Thomson named these negatively charged particles, electrons.
- Scientists knew that matter was neutral, they quickly “discovered” the proton as well.

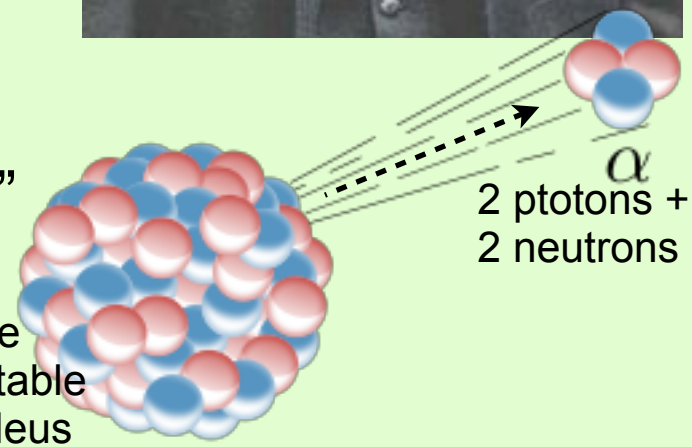




22

Ernest Rutherford (1871-1937)

- The father of nuclear physics
- Won a Nobel prize in 1908 for his investigations into the disintegration of the elements, and the chemistry of radioactive substances
- Of particular interest to us, he isolated and identified the alpha and beta particles. Charged particles that "spew" out of radioactive substances.
- Alpha particles are really just a helium nucleus emitted from the overly large nucleus of some radioactive element.
- These alpha particles can be "pointed" at something else and used as a nanoscopic probe.

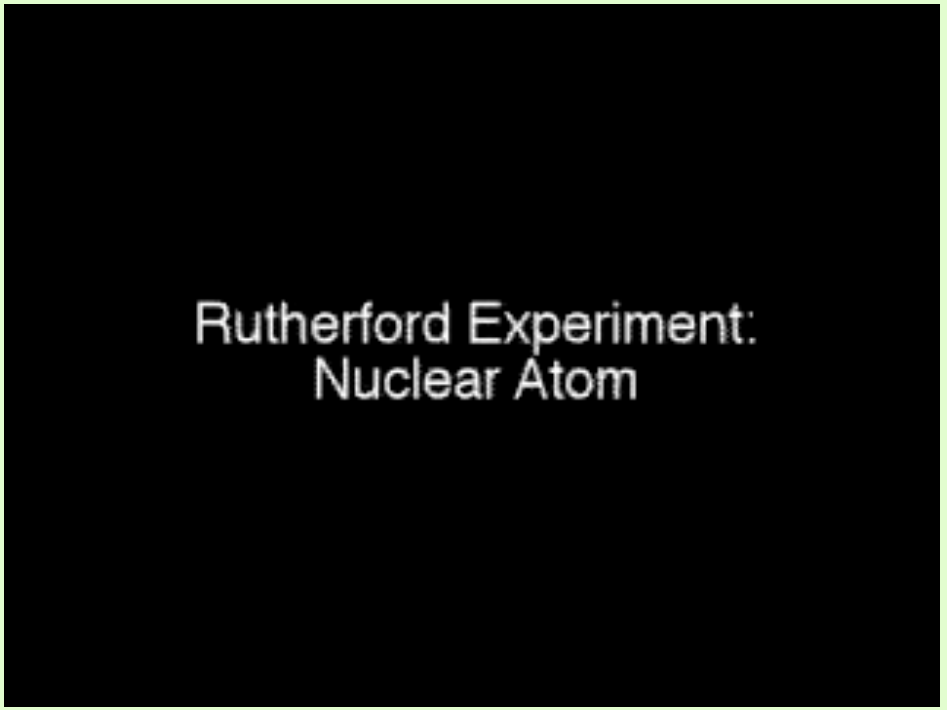


background information

23

Ernest Rutherford (1871-1937)

- Rutherford sent fast-moving, heavy, positively-charged alpha particles at very thin gold foil.
- The scientists expected they would blast through.
- Click Movie ➪

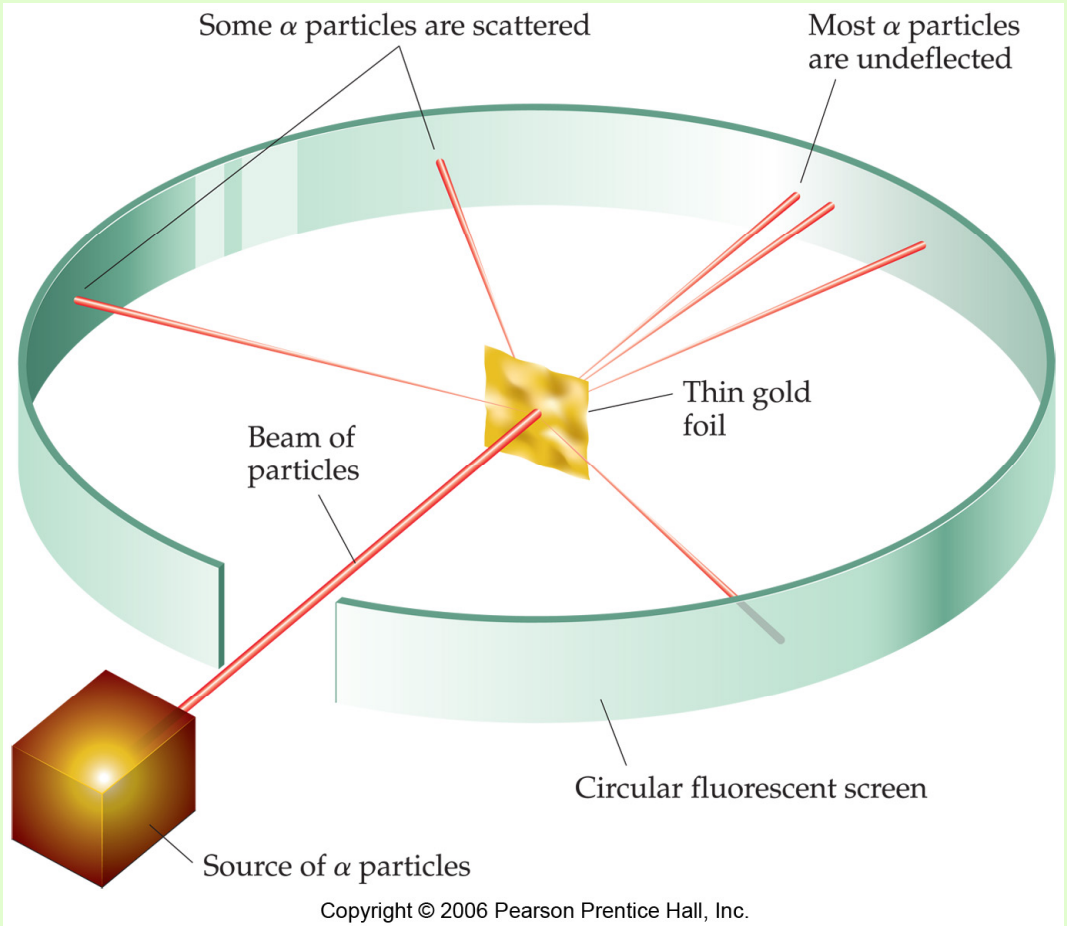


Check out this online animated model of Rutherford's experiment

24

Ernest Rutherford (1871-1937)

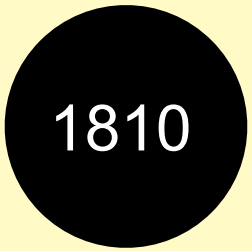
- They were amazed that some were deflected.
- Rutherford suggested that the deflected particles hit a very small dense positively charged mass - the nucleus.



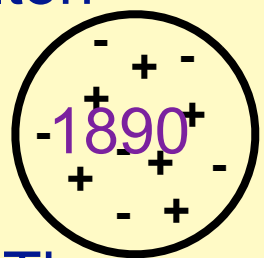
25

How the View of the Atom was Revised

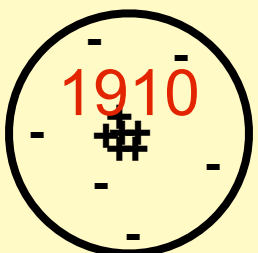
- Dalton thought that atoms were solid indivisible particles.
- Thomson revised the view to the "chocolate chip cookie" model.
- Rutherford revised the view to include the very small dense nucleus with electrons outside the nucleus, perhaps in rings.
- Bohr provided experimental evidence to support the energy levels associated with the rings.



Dalton



Thomson



Rutherford

Bohr

In chap 11

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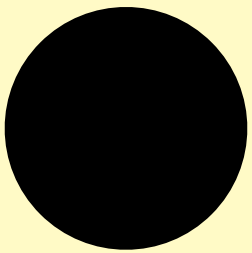
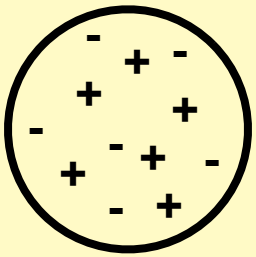
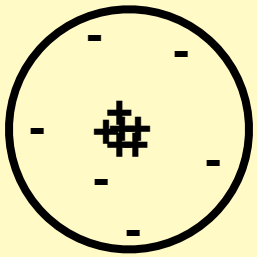
The end



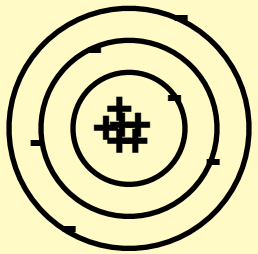
Dalton



Thomson



Rutherford



Bohr

In chap 11