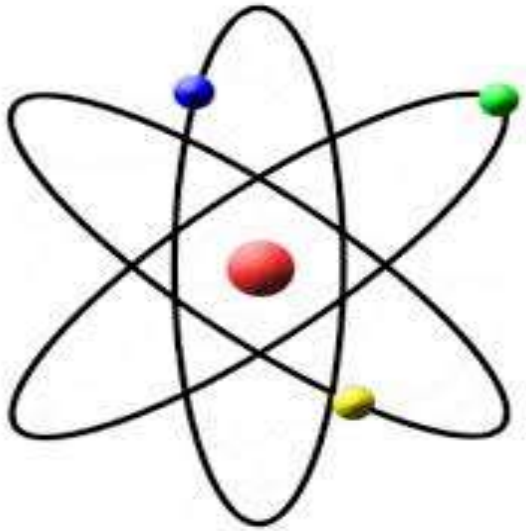
Atomic Structure



Dr.S.Abbas Manthiri,
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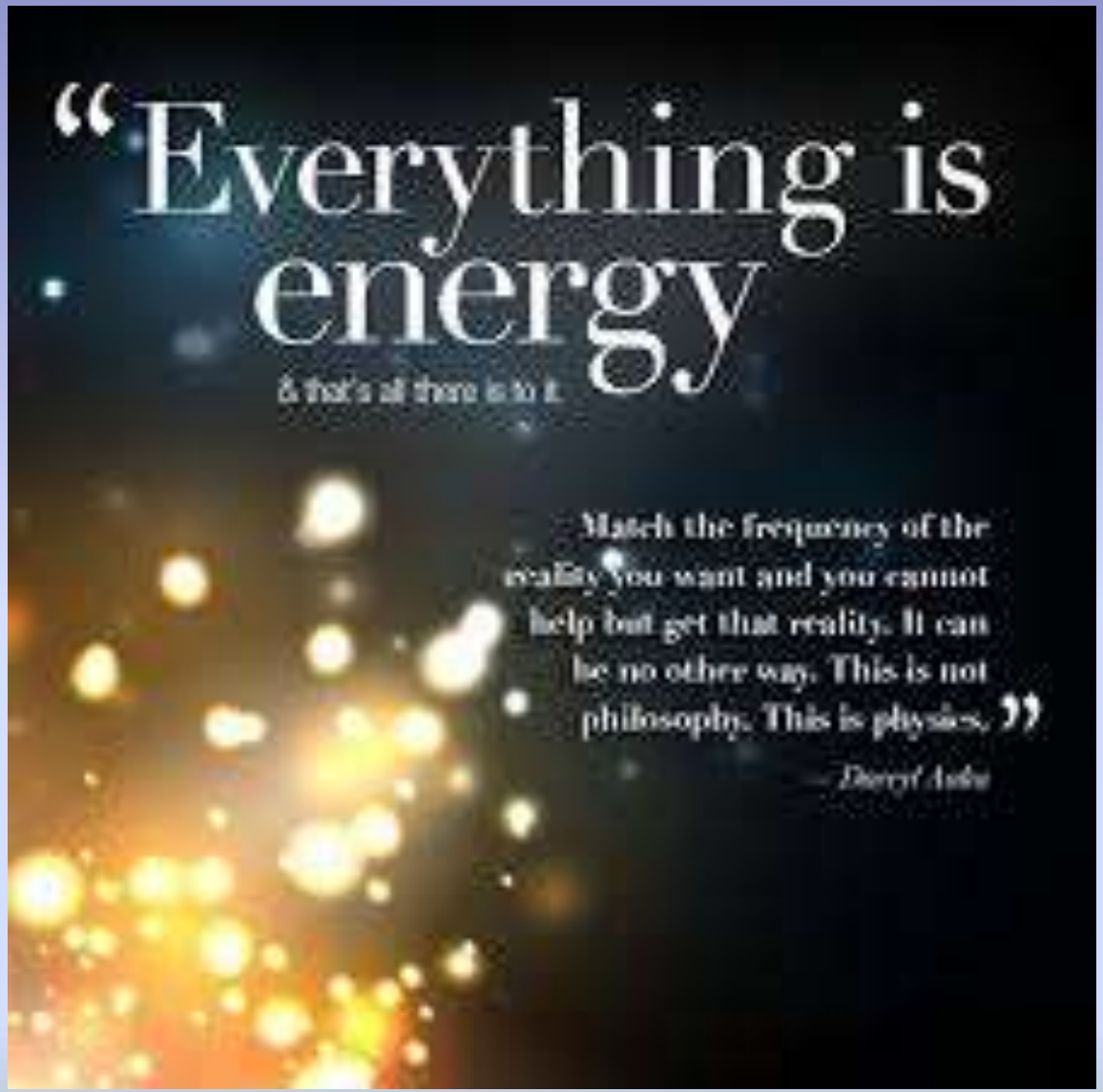

"Everything is energy
& that's all there is to it.
Match the frequency of the reality you want and you cannot help but get that reality. It can be no other way. This is not philosophy. This is physics."
— Darryl Anka

Syllabus:

Unit – I: Positive ray analysis

Production and properties of positive rays– Positive Rays Analysis - Thomson's Parabola method – Aston and Bainbridge Mass spectrographs – Critical Potentials: Franck and Hertz's experiment – Dempster's mass spectrograph

Unit –II: Photo Electricity

Photoelectric emission – laws – Lenard's method to determine e/m for photoelectrons - Richardson & Compton experiment -Einstein's Photoelectric equation and its verification by Millikan's experiment – Photoelectric cells and applications: Photomultiplier – exposure meter in photography – Sound reproduction in films – Automatic operation of street light.

Importance of Physics in our daily life

In our daily life, we hardly find a device in which laws of physics are not involved.

Examples

- Pulleys are used to lift heavy loads.
- **Electricity** is used to get light, heat and mechanical energy that drives fans and electric motors.

- Means of transportation such as cars and airplanes, domestic appliances such as air conditioners, refrigerators, vacuum cleaners, washing machines, and microwave oven, etc.

- The means of communication such as radio, TV, telephone, and computer are the result of applications of physics. These devices have made our lives much easier and faster and more comfortable than in the past.

Branches of Physics list

In the practical field, the common branches of physics are:

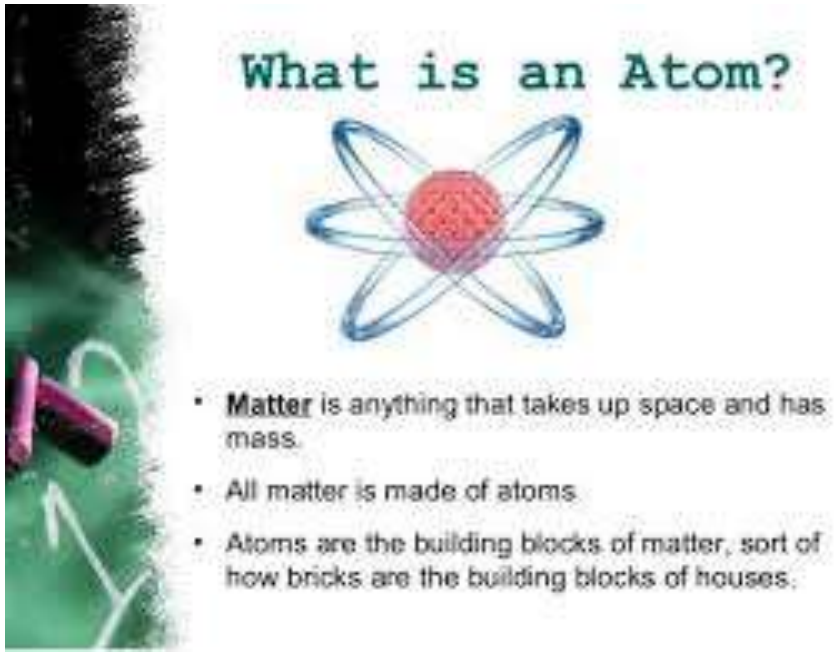
- **Mechanics**
- Classical physics
- Modern physics
- Thermodynamics

- Electricity
- Magnetism
- Geo physics
- Plasma physics
- Optics
- Sound and oscillation
- Electronics

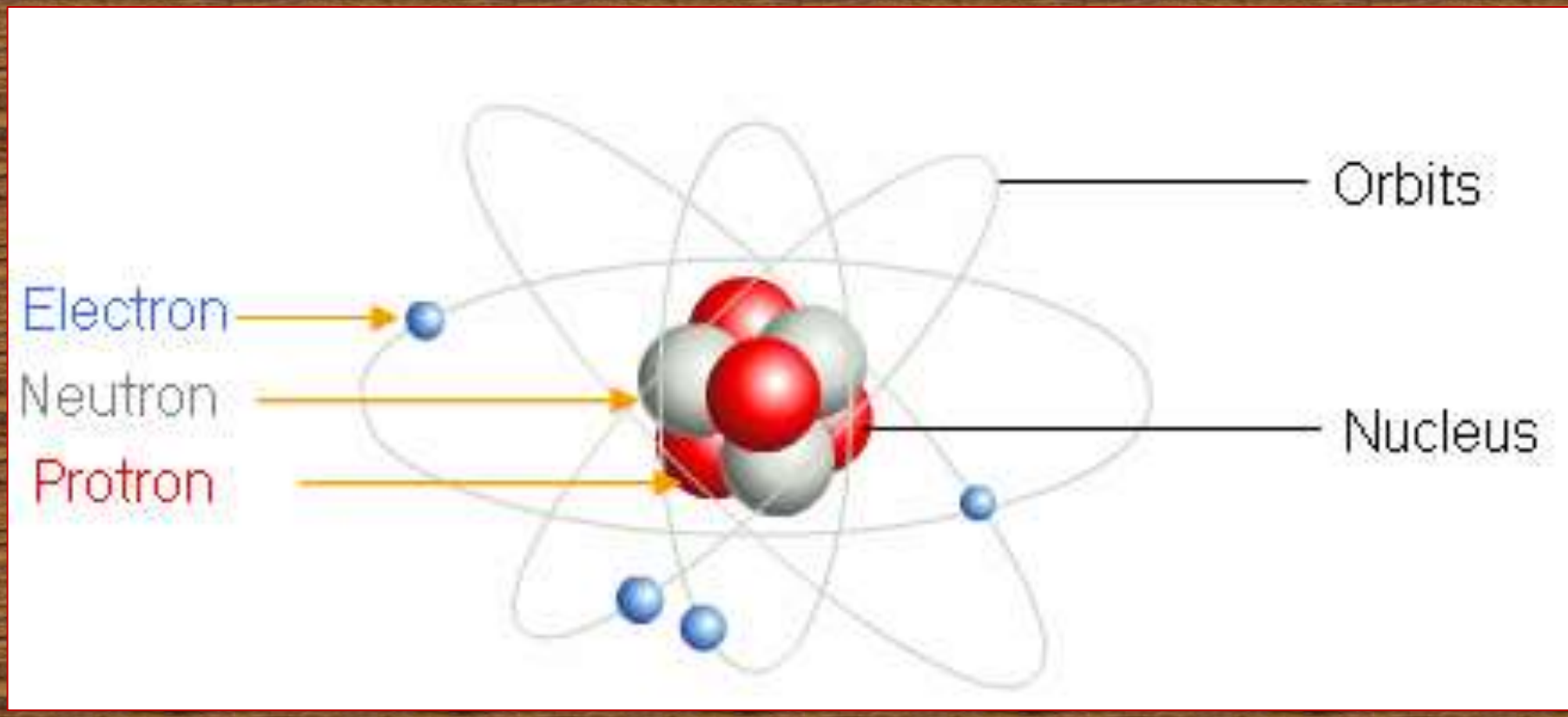
- Chemical physics
- Engineering physics
- Solid state physics
- Quantum physics
- Nuclear physics
- Particle physics
- Bio physics
- Astrophysics
- Condensed matter Physics

Atomic Physics

It is the study of the structure and properties of atoms.

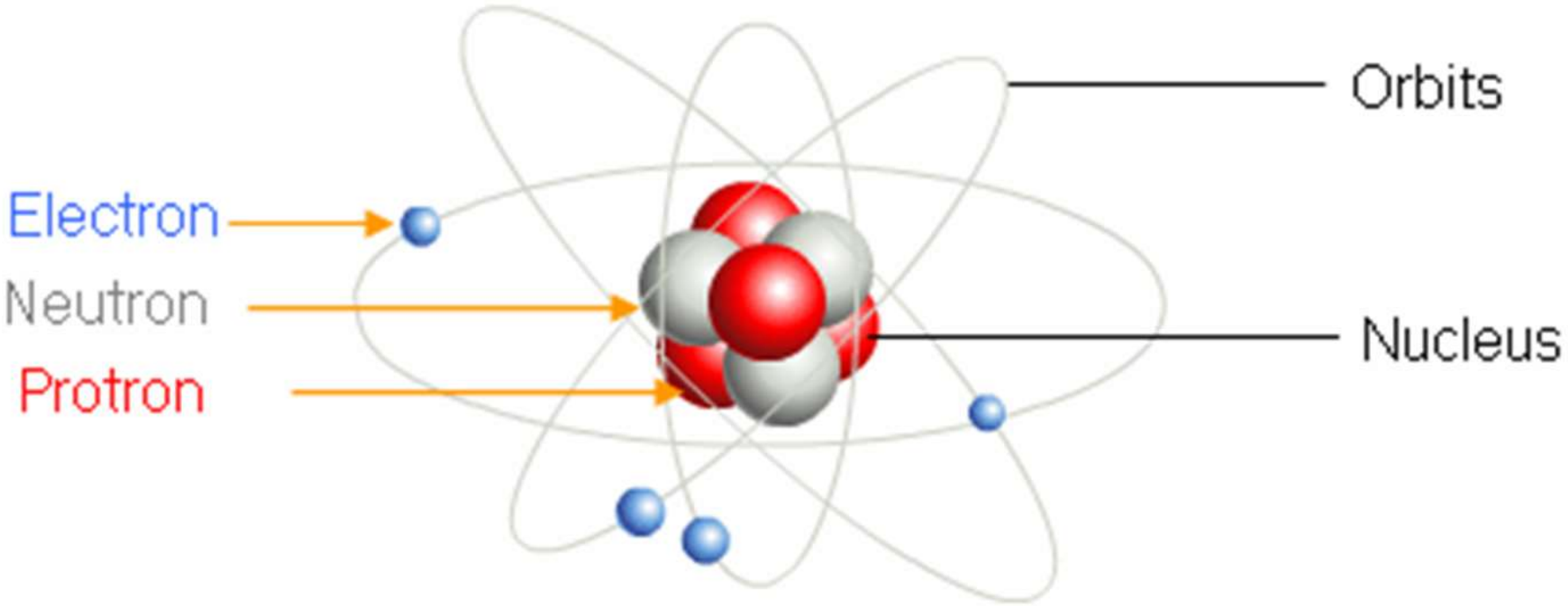


Structure of an atom



Properties of Subatomic Particles

- Protons, neutrons and electrons are subatomic particles



Protons

- positively charged subatomic particles found in the nucleus of an atom
- Has the mass of about 1840 times that of an electron
- Charge = +1
- Varies for each element

Electrons

- negatively charged subatomic particle found in space outside the nucleus
- Charge = -1
- Discovered by Thomson in 1897

Neutrons

- neutral subatomic particle that is found in the nucleus
- Charge = 0
- Discovered by James Chadwick in 1932
- Nearly the same mass of a proton

Protons and Neutrons

- Atoms have no net electric charge
- Electric charges are carried by particles of matter
- Electric charges always exist in whole-number multiples of a single basic unit (no fractions of charges)
  - When a given number of positively charged particles are combined with a given number of negatively charged particles the result is an electrically neutral particle

Atomic Number

- = equals the number of protons in an atom of a particular element
- Atoms of a specific element ALWAYS has same # of protons
- If the atom is neutral, atomic # is also equal to the number of electrons

Mass Number

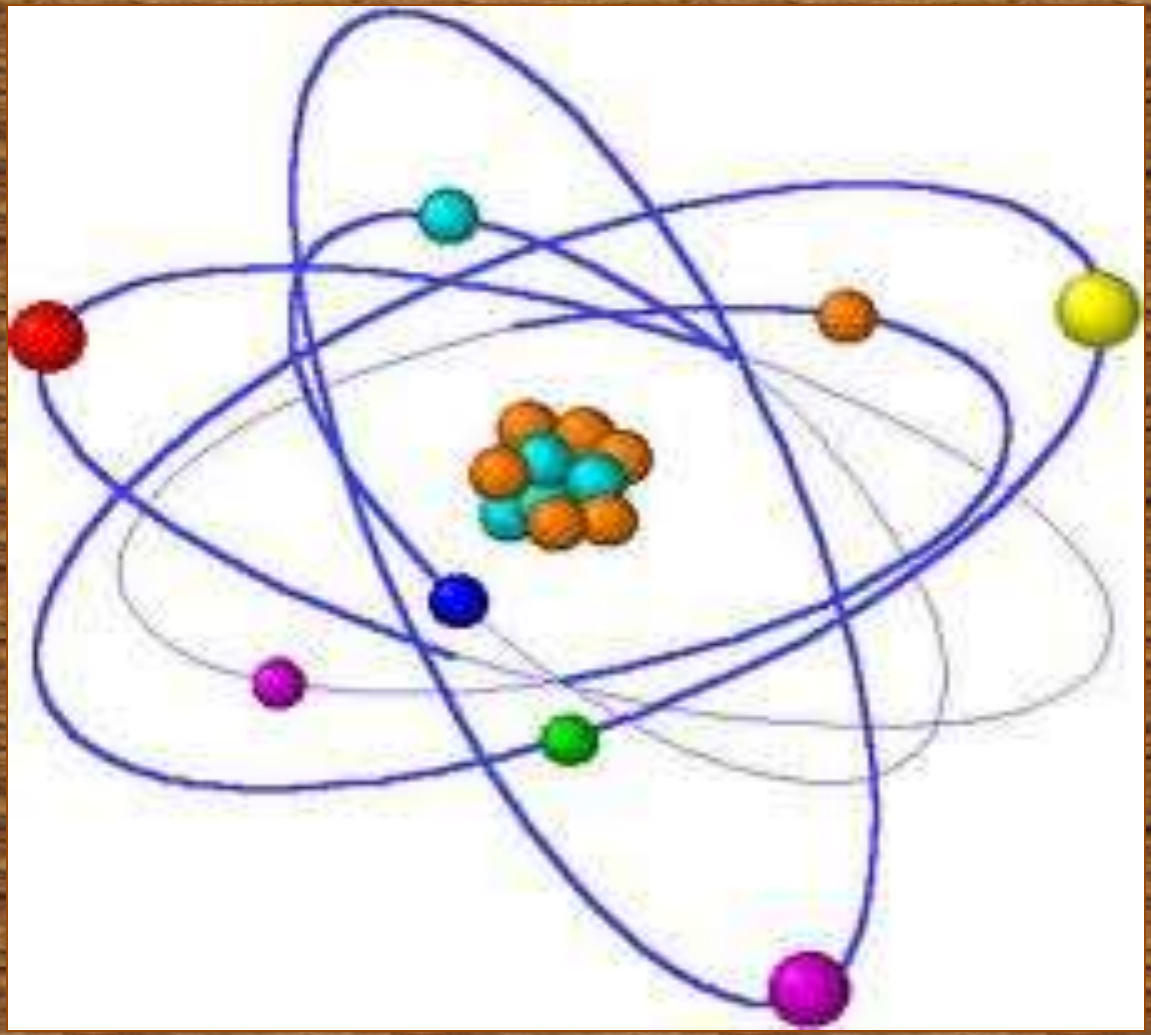
- Sum of protons and neutrons in nucleus of that atom
- Most of the mass of an atom is in the nucleus
- Atomic mass is an average because of isotopes
- Number of neutrons = mass number – atomic number

Isotopes

- Atoms of the same element that have different #s of neutrons and different mass numbers
- Element will always have same atomic number , but can have different mass number
- Most isotopes of same element do not act/look different
- Ex: Oxygen – 16, Oxygen -17, and Oxygen – 18 all can react with Hydrogen to make water or Iron to make rust

Studying Atoms ⬇

The Modern Model



Ancient Greek Models of Atoms

Democritus

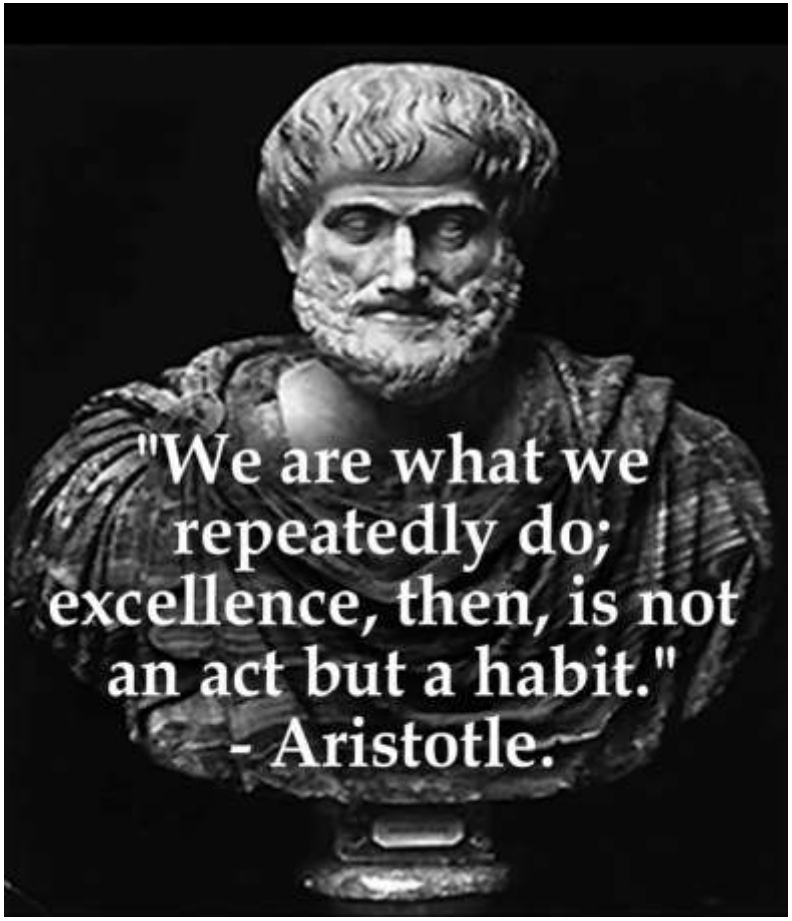
- Said : All matter consists of small particles that can't be divided = atoms
  - **from the latin word *Atomos* = indivisible**
- Said there were 3 different types of atoms
  - Liquid = smooth and round
  - Solid = rough and prickly
  - Gas

Aristotle

- Thought all substances built from earth = fire, air, earth, water

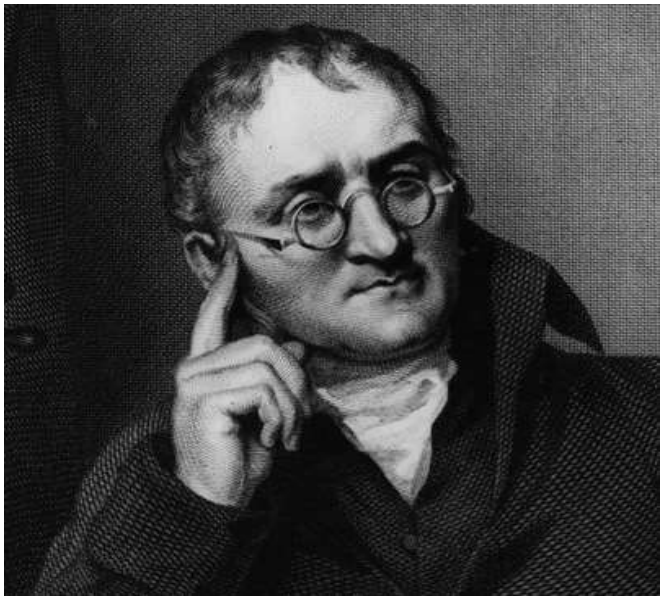
Democritus

Aristotle



Dalton's Atomic Theory

John Dalton – *England*



- Studied gases and pressure

  Evidence for Atoms

- Measured mass of elements that combined to form compounds, showing compounds have a fixed composition

Dalton's Atomic Theory

- Dalton proposed the theory that all matter is made up of individual particles called atoms, which cannot be divided
- The main points of his theory are:
  - All elements made of atoms
  - Atoms of same element = same mass, different element = different mass
  - Compounds = more than 1 element
  - In a particular compound, atoms combine in same way always

DALTON'S ATOMIC THEORY

This theory was proposed around 1808 by John Dalton, and was a major step towards our understanding of atoms.

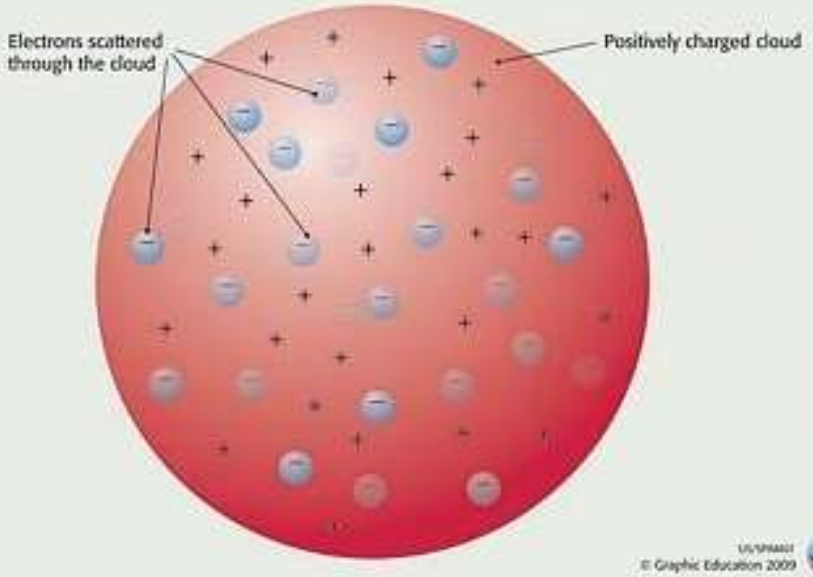
Dalton's main ideas were:

1. *All matter is made up of tiny indivisible particles called atoms.*
2. *All the atoms of a given element are identical.*
3. *Atoms of different elements differ from one another.*
4. *Atoms from different elements combine in simple whole number ratios to form compounds.*
5. *Atoms retain their identity during chemical reactions.*

Dalton's idea of indivisible atoms was destroyed with the discovery of electrons and protons in the late nineteenth century.

THOMSON'S PLUM PUDDING MODEL

Developed during the late 1890s, Thomson's model could be viewed as a spherical ball of positive charge with negatively charged electrons scattered throughout, similar to raisins scattered through a plum pudding.



Thomson's Model of the Atom

- Electric current = flow of charged particles

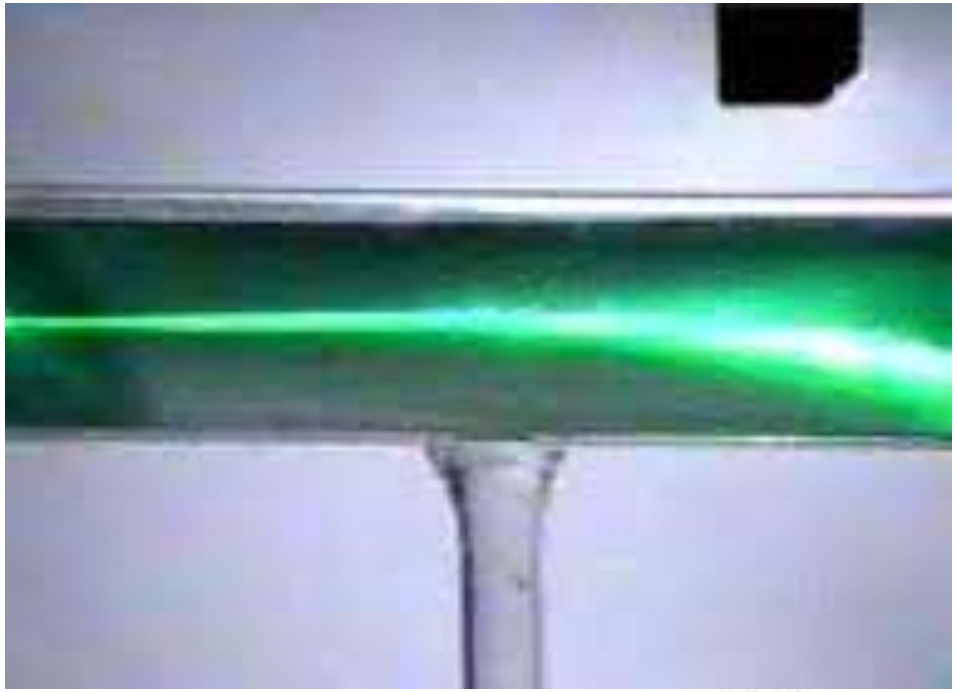
  Joseph John Thomson – used electric current to learn about atoms
- Used device to prove info:
  - Sealed glass tube (air removed)
  - Metal disk at each end
  - Wires connect disks to source of current
  - Current turned on = 1 disk negative, other disk positive
    - Produces glowing beam = cathode ray

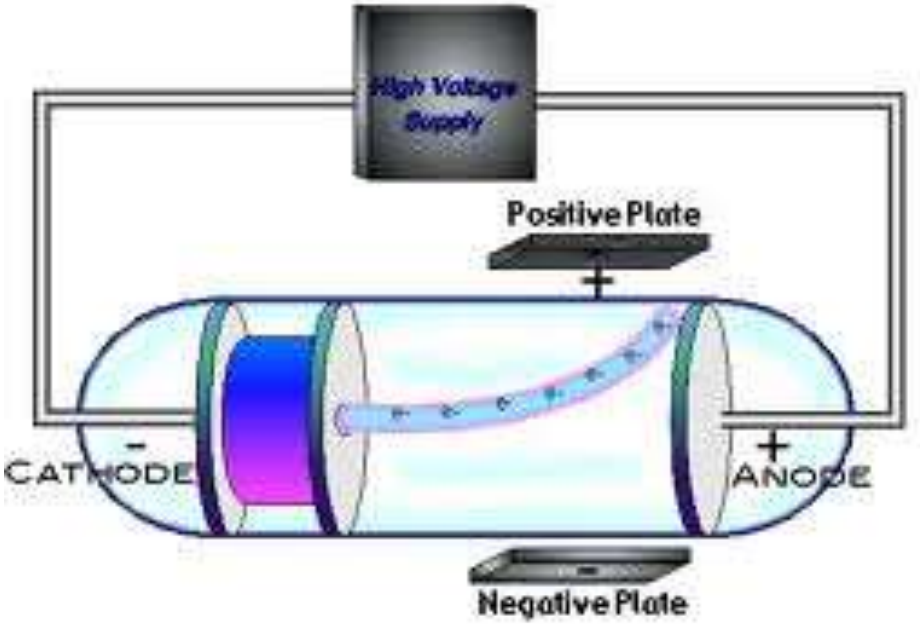
J J Thomson and Cathode Ray

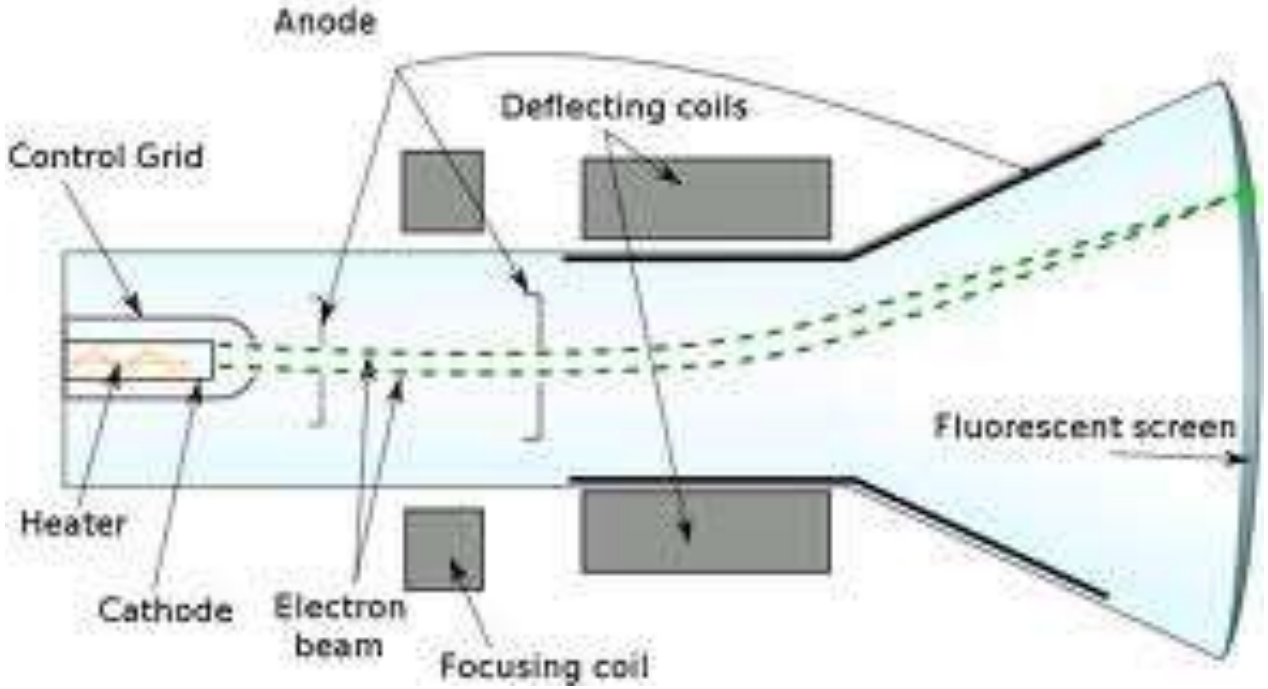
- Cathode Ray video
- Short Cathode Ray Video

Evidence of Subatomic Particles

- Concluded particles in beam were negative because they were attracted to the positive end of a magnetic plate
- Hypothesized there was more than one particle in atom
- Thompson's experiments provided 1st evidence to suggest atoms are made of smaller particles




High Voltage Supply
Positive Plate
+
CATHODE
-
+
ANODE
Negative Plate


Anode
Deflecting coils
Control Grid
Fluorescent screen
Heater
Cathode
Electron beam
Focusing coil

Thomson's Model

- atoms are neutral so there must be a positive (+) to cancel a negative (-)

Plum Pudding Model

- The plum pudding model = an atomic model showing electrons "stuck" in a lump of positive charge, similar to raisins stuck in dough
  - Short lived model
- Think of chocolate chip ice cream
  - Positive mass was the vanilla ice cream
  - Chocolate chips are the negative particles

Rutherford's Atomic Theory

- Ernest Rutherford
  (1871 – 1937)

Rutherford's Hypothesis

- Discovered Uranium emits fast-moving particles w/ positive charge = alpha particles
- Student – Ernest Marsden = Rutherford asked to find out what happens when they pass through thin sheet of gold
- Said the mass of the gold would be too small to change the path of the alpha particle so most particles should travel straight through

Rutherford's Gold-Foil Experiment

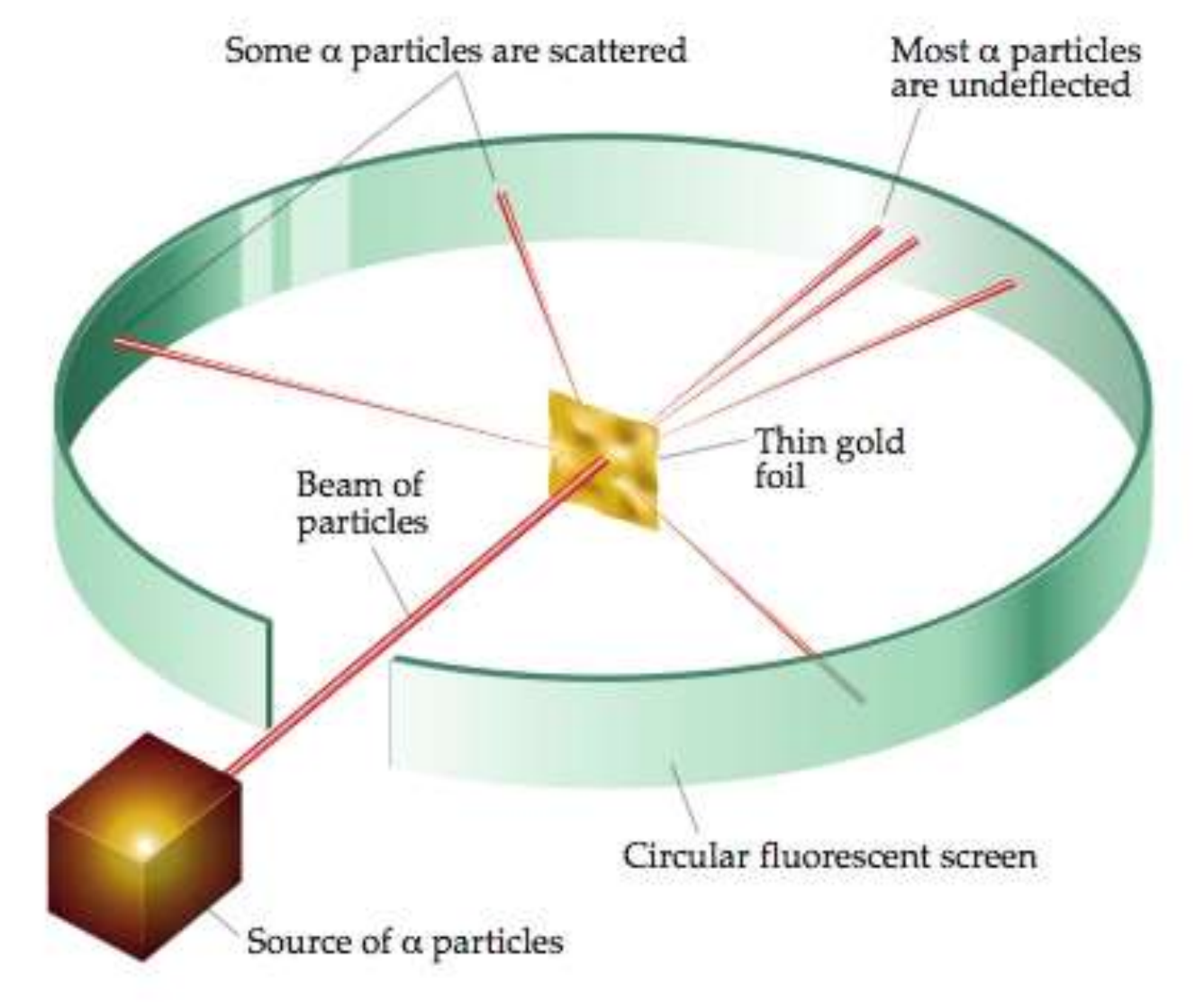
- Used relatively massive alpha particles, which are helium atoms that have lost their two electrons, directed in a narrow beam at a thin sheet of gold foil
- Some of the particles passed through the foil without deflection, while others bounce off the foil at very large angles

The Gold Foil Experiment

- During the experiment more particles were deflected than expected some acted as though they had been struck and bounce directly back

- gold foil explained
- Gold Foil Video

Rutherford's Gold Foil Experiment



Discovery of the Nucleus

- The deflected positive alpha particles must have come close to a charged object but, some still passed through
- Drew the conclusion that the positive charge part is not evenly spread throughout the atom, it is all concentrated at the center in the nucleus
  - Nucleus = dense, positively charged mass located at the center of the atom

Eventually people noticed something.

- 3 things that can happen when an atom absorbs energy

  - Increase kinetic energy
  - Phase change
  - Temporarily absorb energy and then emit as light

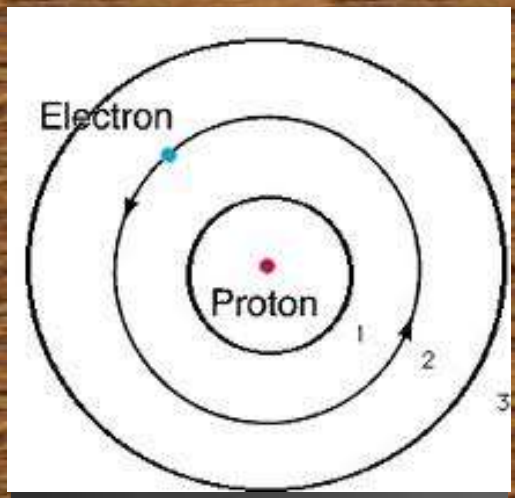
The Development of Atomic Models

Rutherford's atomic model could not explain the chemical properties of elements.

- Proposed a model which placed electrons orbiting the nucleus like the planets of a solar system
- Needed a model that better describes the behavior of electrons within atoms

The Bohr Model

- Niels Bohr – (1885 – 1962) was a Danish physicist who worked with Rutherford. Bohr focused on electrons
- thought Rutherford's model needed improvement
- Bohr proposed that an electron is found only in specific circular paths, or orbits around the nucleus.



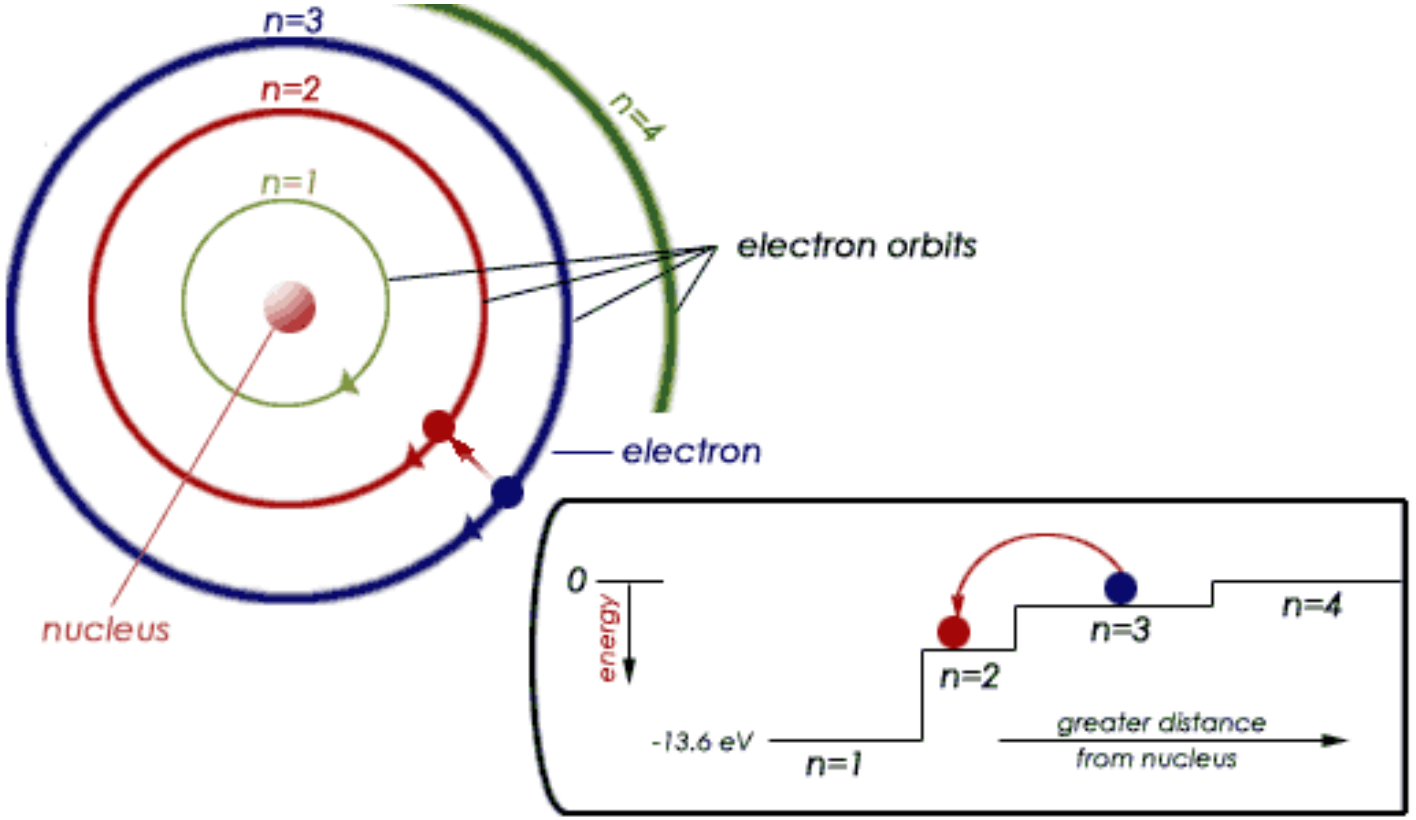
Energy Levels

Energy levels = fixed energies an electron can have

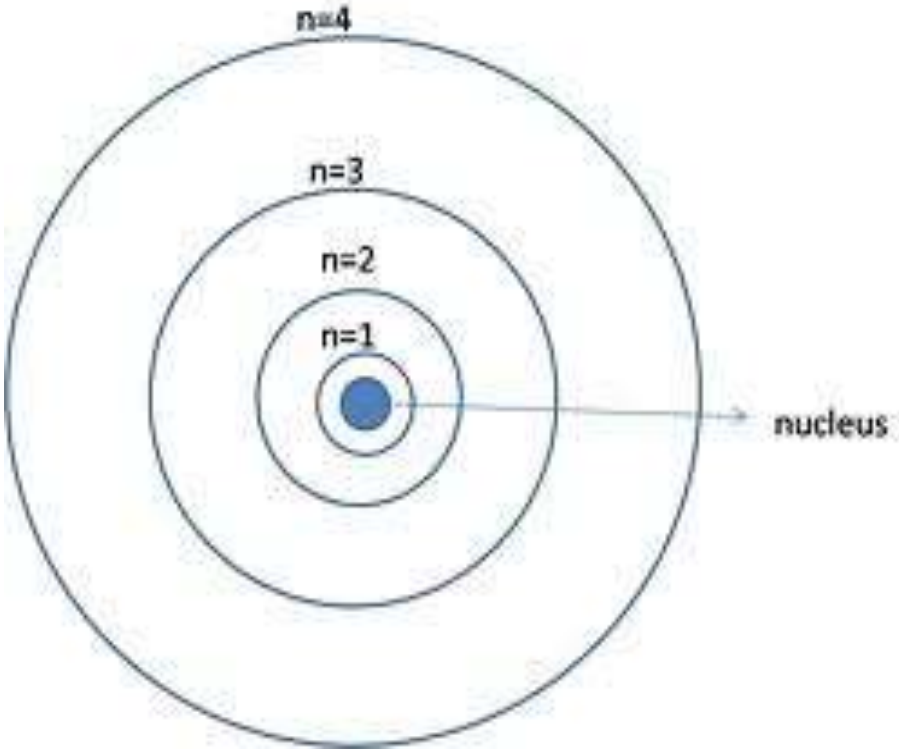
- Each orbit would have a fixed energy and stay at an energy level
- Lower energies are near the bottom and as the levels increased, so did the energy level
- Electrons move with constant speed in fixed orbits around the nucleus like planets around a sun

Bohr's Model of the Atom

- An electron must gain or lose energy to change orbitals, but the orbitals are not evenly spaced
  - The size of the jump between energy levels determines the amount of energy gained or lost



- Evidence for Energy Levels
  - Scientists can measure the amount of energy when electrons absorb or release energy as they shift energy levels.
- This is the reason different elements will give off different colors of light



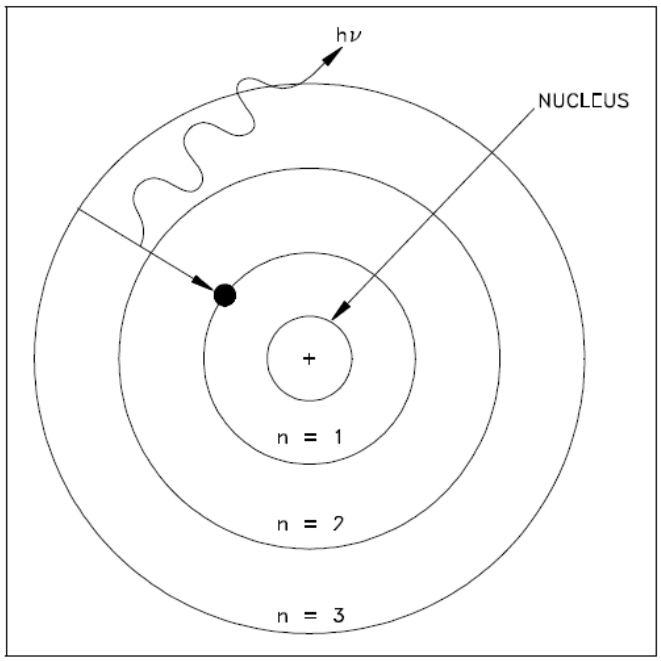
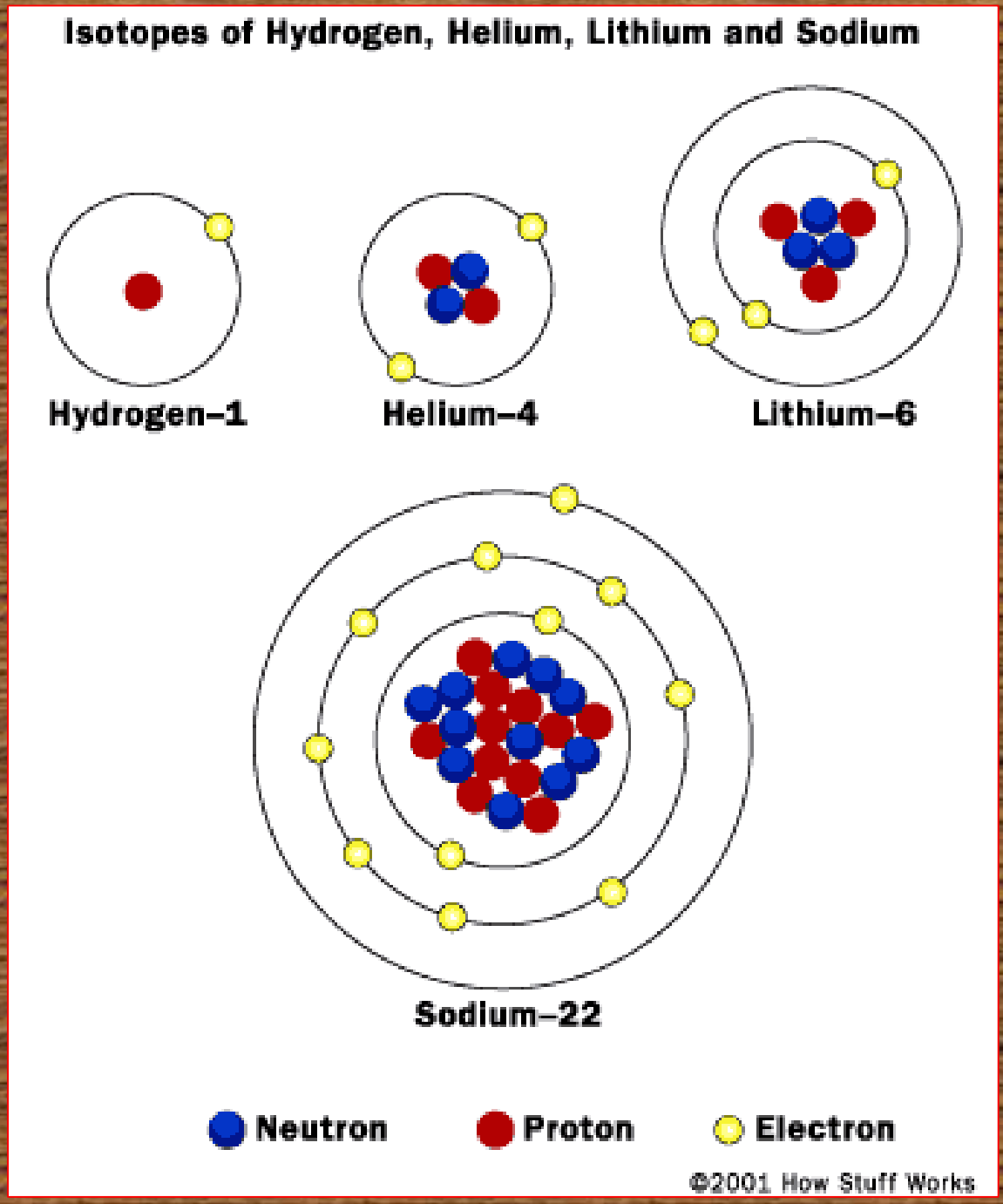


Figure 1 Bohr's Model of the Hydrogen Atom

Bohr Model



Thank You Students