The Material World

Chapter 1

Atoms and the Elements

What is a model?

"Picture" of what we can't see

Aristotle's "Continuous" Model

- "Magic" knife – cut forever → smaller and smaller pieces created
- No **gaps** in matter
- All things are made of earth, water, air & fire
- Matter **does not** contain atoms

Democritus' "Discontinuous" Model

- **Gaps** inside matter (unused space)
- Matter made of particles called atoms
- Atoms are indivisible
- All atoms have the same size
- Different substances exist because they have different gap sizes.

Dalton's Model (1808)

1. Matter made of particles called atoms
2. Atoms are indivisible
3. Atoms have **no internal structure**
4. Atoms of same element are identical (same mass and size)
5. Atoms of different elements are different.

6. During a chemical reaction, atoms combine to form new products called compounds

7. Atoms are not created nor destroyed, merely rearranged.

Conservation of Mass
"Atoms Do Not Disappear"

- **Atoms**: can be represented by shapes
- Different atoms have different colours or different sized shapes
- **Molecules**: represented by shapes of different colours or sizes "stuck" together

Conservation of Mass

"Mass Does Not Disappear"

Iron + sulfur → iron sulfide

56 g 32 g 88 g

carbon + oxygen gas → carbon dioxide

12 g _____ g 44 g

copper oxide + carbon → carbon dioxide + copper

159 g 12 g 44 g ____ g

Example 1:

iron. + sulfur → iron sulfide

Fe + S → FeS

 = Fe (iron)

 = S (sulfur)

Touching means bonded

Example 2:

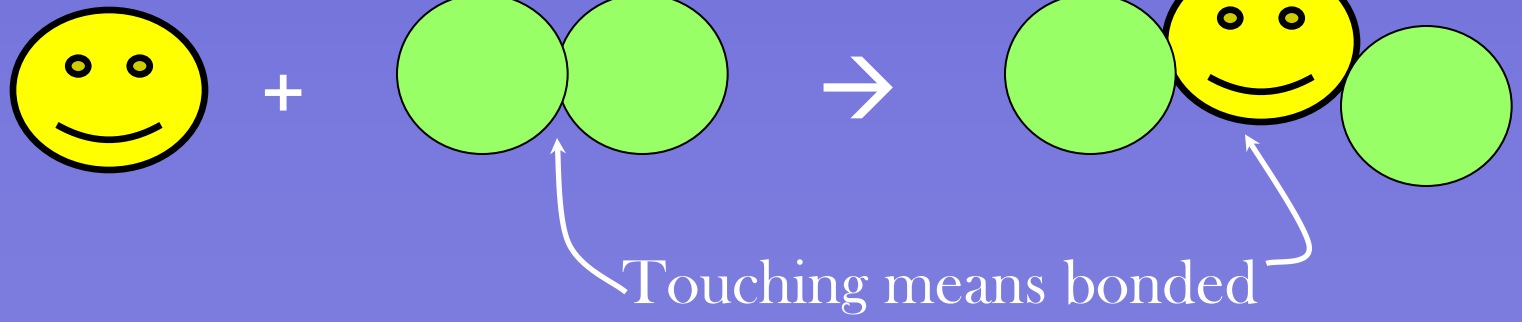
carbon + oxygen gas → carbon dioxide

$C + O_2 \rightarrow CO_2$ products are:

reactants are:

= carbon (C)

= oxygen (O)



Example 3:

copper oxide + carbon → carbon dioxide + copper

$2CuO + C \rightarrow CO_2 + 2Cu$

products are:

reactants are:

Atoms ...

- smallest particles that exists and that participate in chemical reactions
- have mass → atomic mass
- represented by symbols:

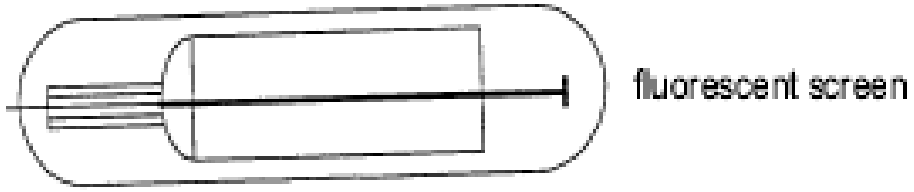
  - i.e. Hydrogen atom H
  - Oxygen atom O

CATHODE RAY TUBE VS. LASER
(Demonstration)

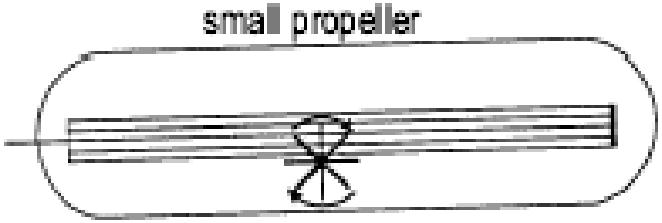
Property	Cathode Ray	Laser Beam
Trajectory of beam		
Effect of a magnet		
Effect on a propeller		
Effect of an electrostatic field surrounding beam		

Which diagram indicates that electrons have mass?

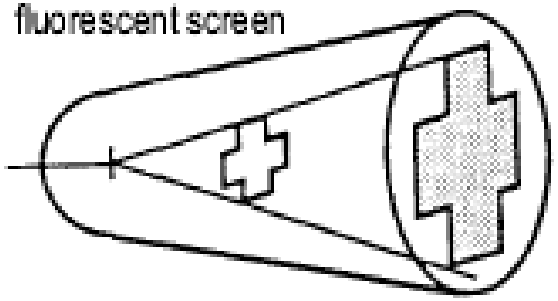
a) The cathode rays travel in a straight line.



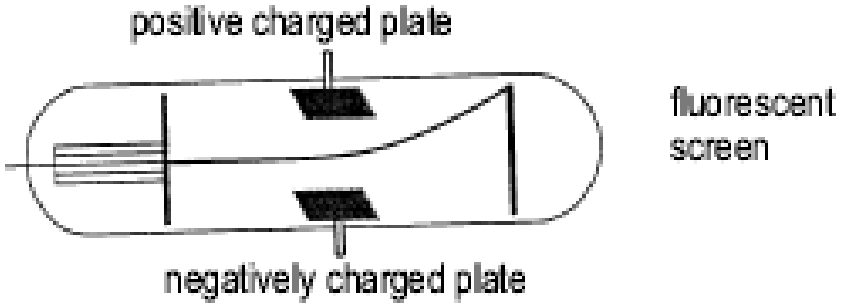
b) The cathode rays drive a small propeller located in their path.



c) The cathode rays cause the shadow of the object in their path to be projected on the fluorescent screen.

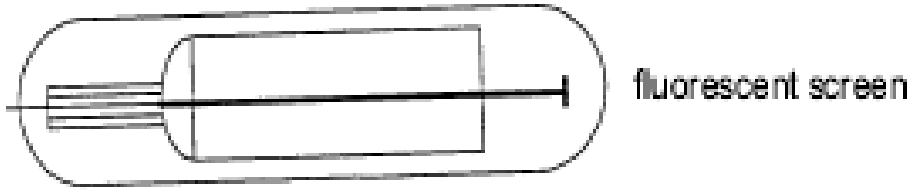


d) The cathode rays are deflected towards the positively charged plate.



Which diagram indicates that the cathode ray is negative?

a) The cathode rays travel in a straight line.



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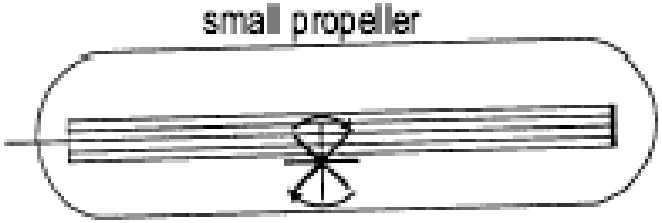

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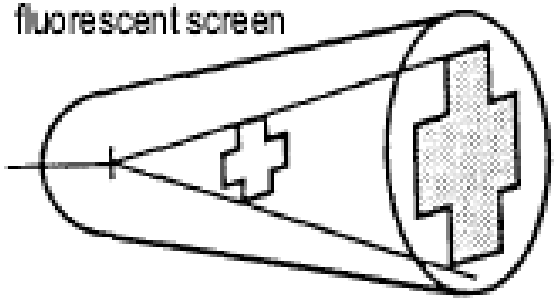

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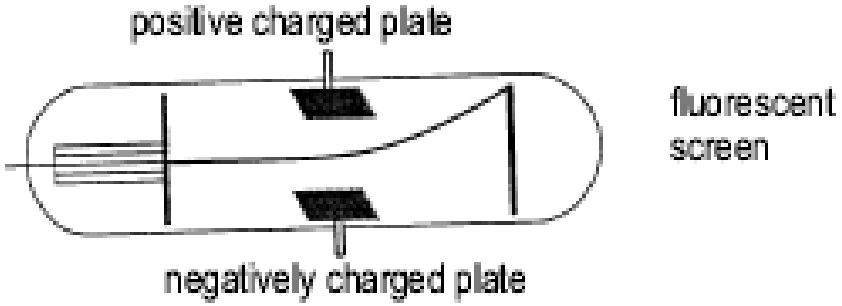


Cathode Ray Tube
(Conclusions)

1. A cathode ray is not a light beam. (different characteristics)
2. A cathode ray contains particles that have mass.
3. The particles have a negative charge.

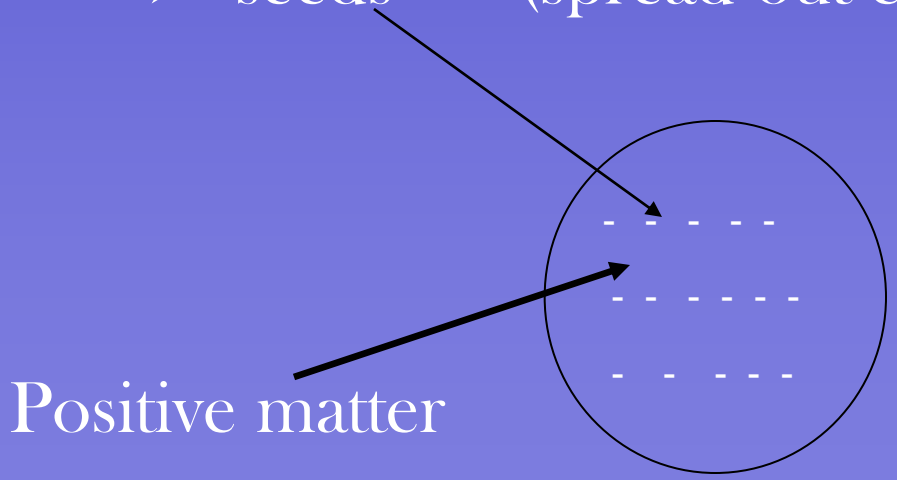
Cathode rays are beams of **negatively** charged particles called **electrons**. The beam moves from the negative cathode to the positive anode.

Thomson's Model (1897)

Using the cathode ray tube, J.J. Thomson discovered electrons.

Belief:

- Atom a solid sphere
- "pulp" +
- "seeds" - (spread out evenly in the pulp)



Like a watermelon

or a plum pudding

Electrical Charge

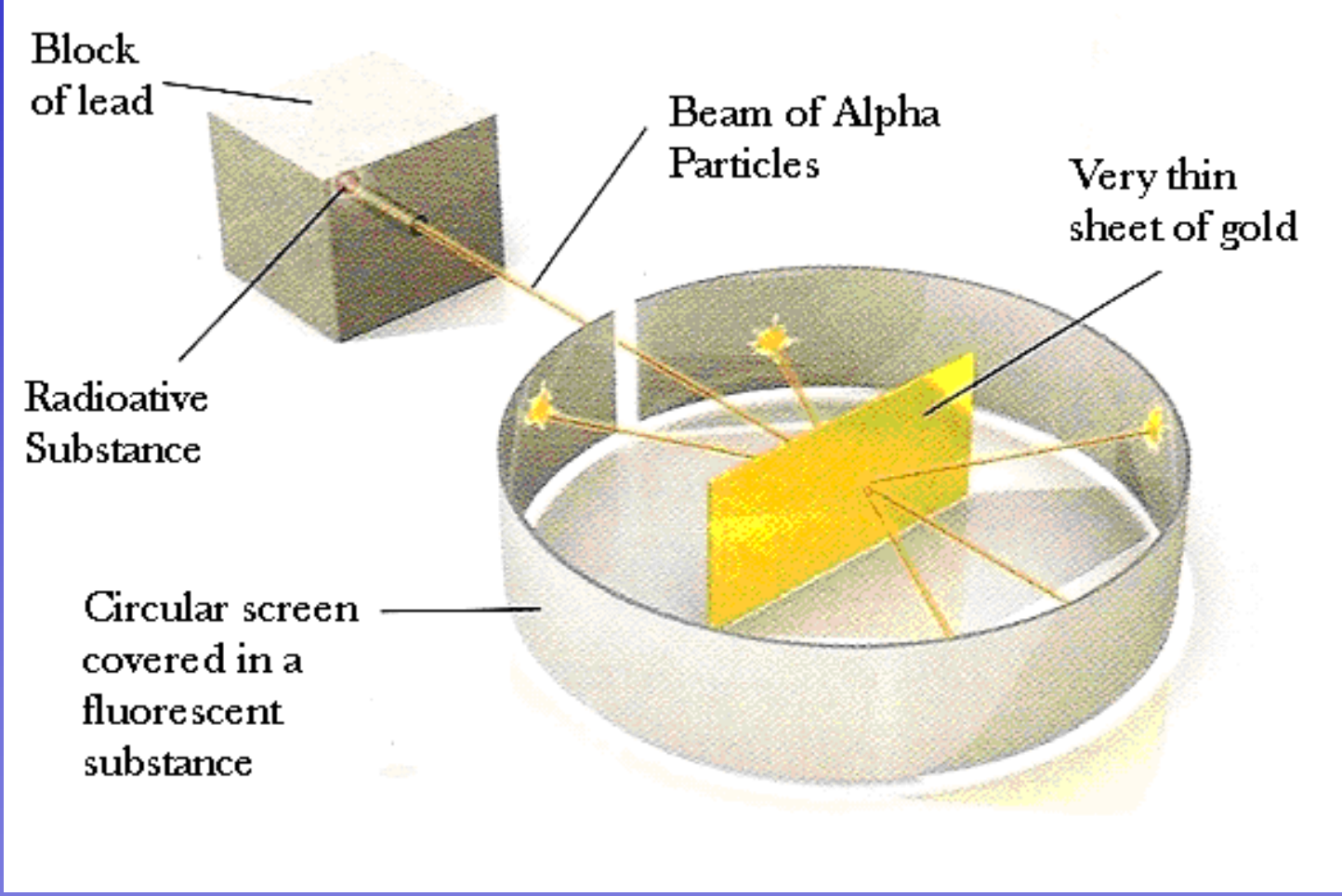
- Matter has a property called **charge**
- Charge come in two "flavors"
  1. Positive (+)
  2. Negative (-)
- What determines the charge of matter?
  - Small negative particles called **electrons**
  - **Electrons** "jump" from one object to another when they touch or are rubbed together
  - surplus of electrons _____ charge
  - deficit of electrons _____ charge
  - right amount of electrons _____
- Scientists *disproved* _____ model when they discovered the existence of electrons.

- A force exists between two charged objects
  1. Charges the same – **repulsion**
     - positive – positive
     - negative – negative
  2. Charges different – **attraction**
     - positive – negative

- When electrons "JUMP" from one object to another we have .....

Static Electricity

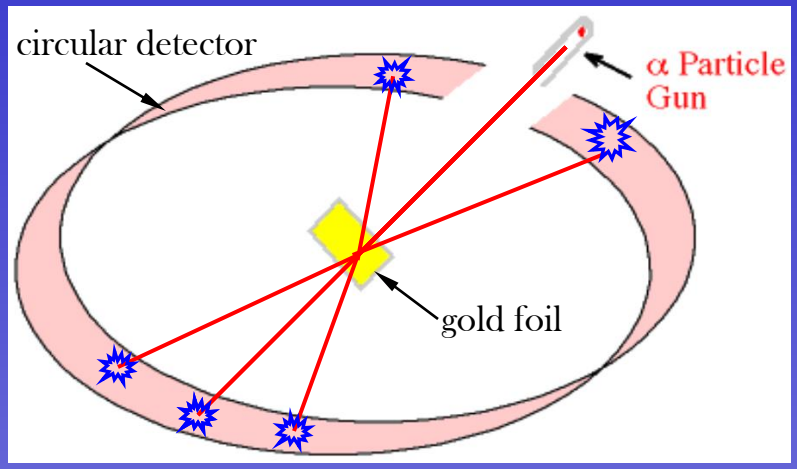
Rutherford's Scattering Experiment



Rutherford's Scattering Experiment

Rutherford fired a beam of alpha particles at a piece of thin gold foil.

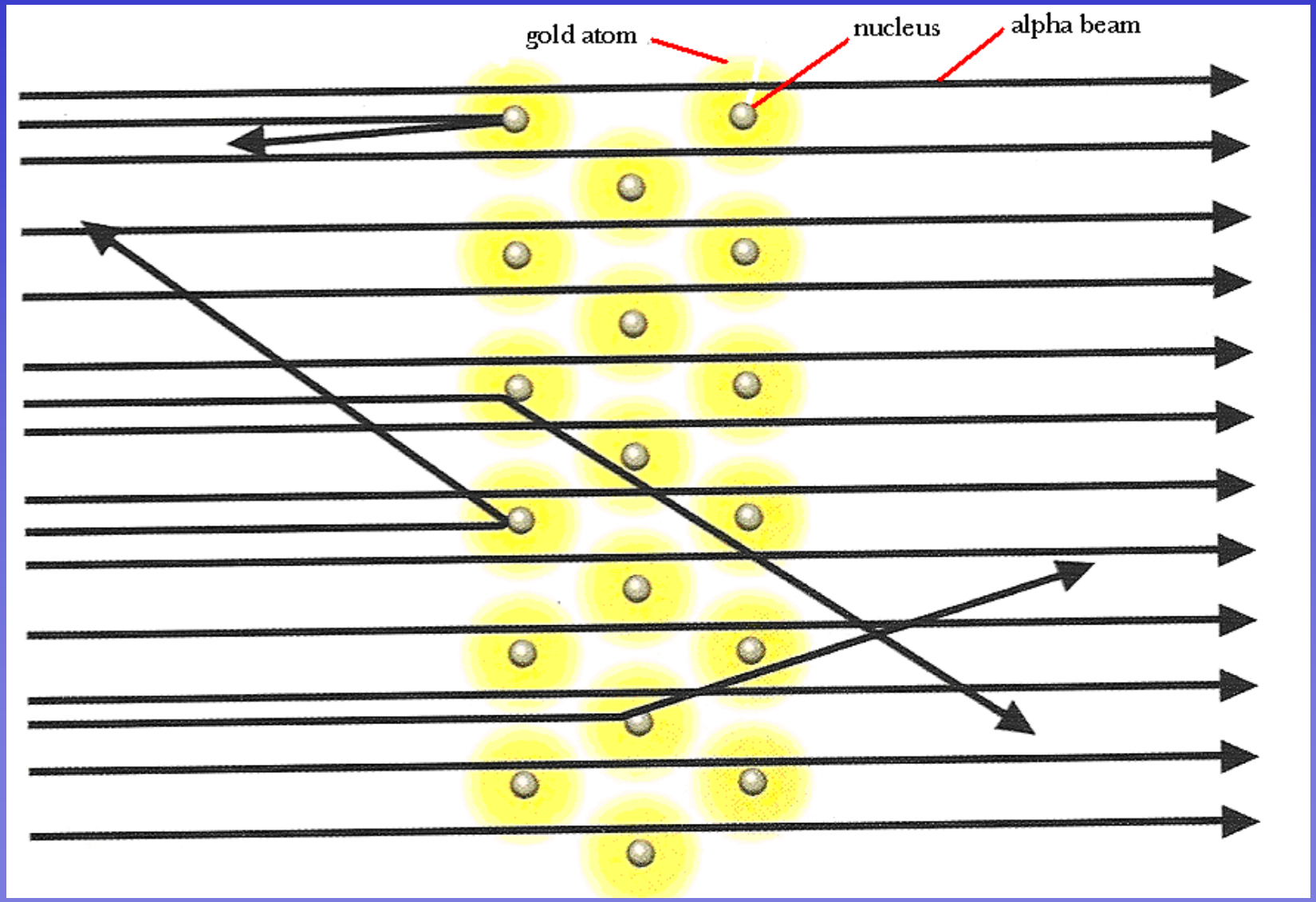
Alpha particles (α) are **dense** and have a **positive** charge (+).



Results:

- Most α went through the foil undeflected
- Some α were slightly deflected from a straight line path
- A few α bounded back towards the α particle gun

Rutherford's Scattering Experiment

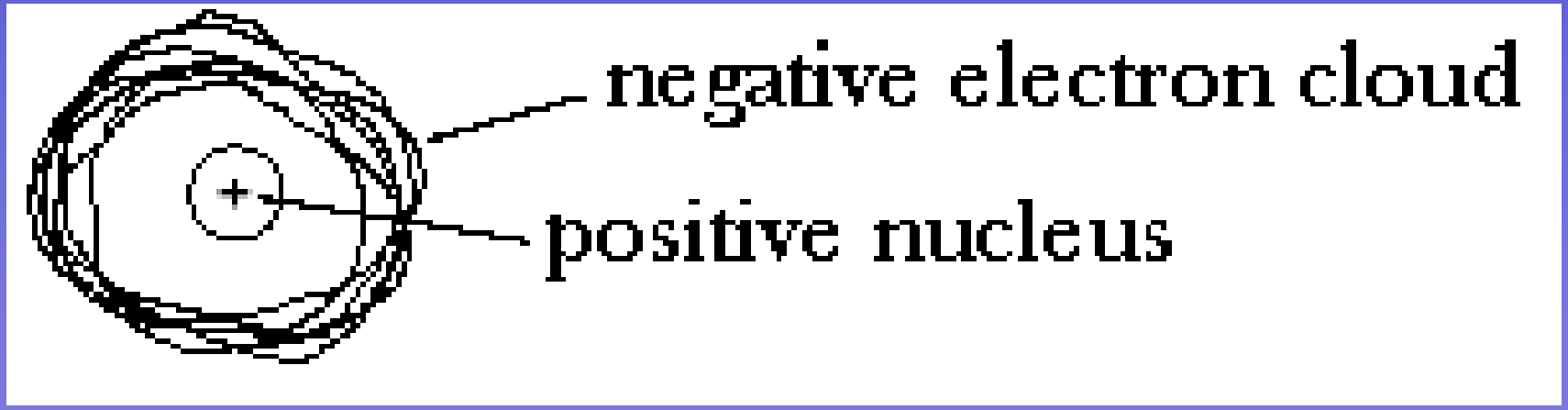


Rutherford's Scattering Experiment

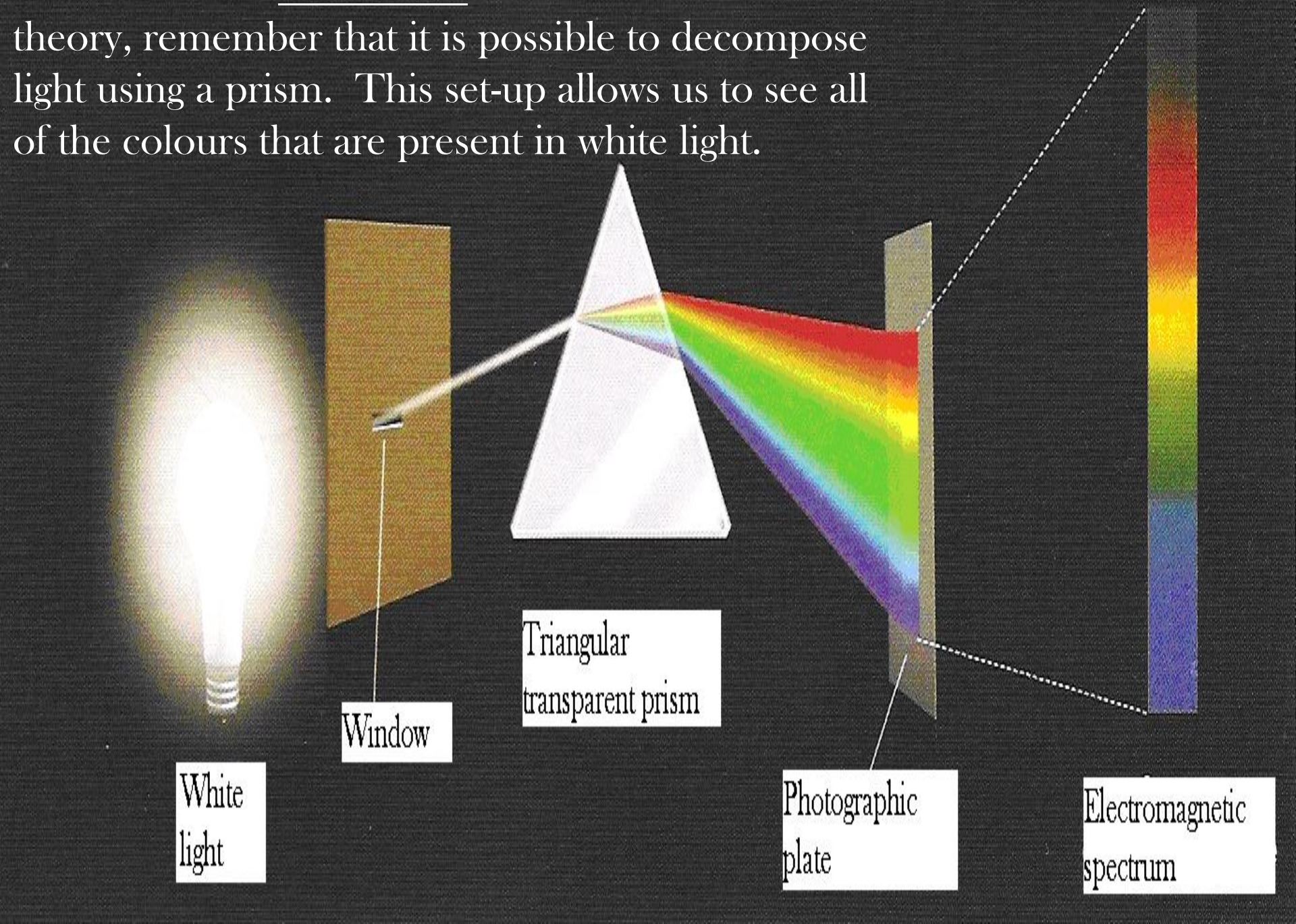
Observations	Conclusions
Most of the alpha particles passed straight through without any deflection	Most of the atom is made up of empty space
A few alpha particles were diverted from their path or had a rebound	The atom has a small and dense nucleus that is positive in charge. Positively charged nucleus is called PROTON.

Rutherford's Atom

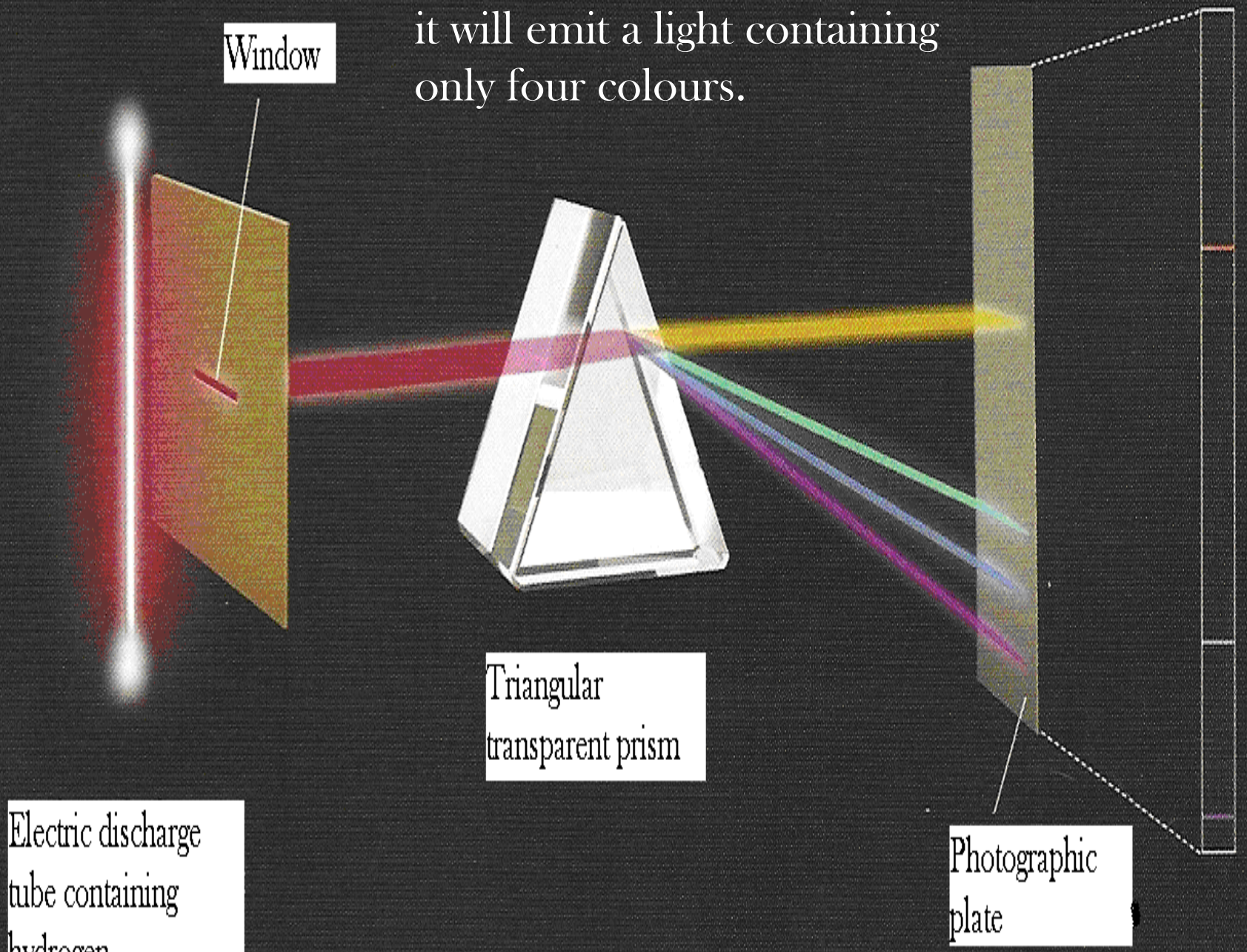
- The proton is a positive particle that is part of an atom.
- Protons are located in the center or nucleus of the atom.
- Negative particles, electrons, circle around the nucleus.



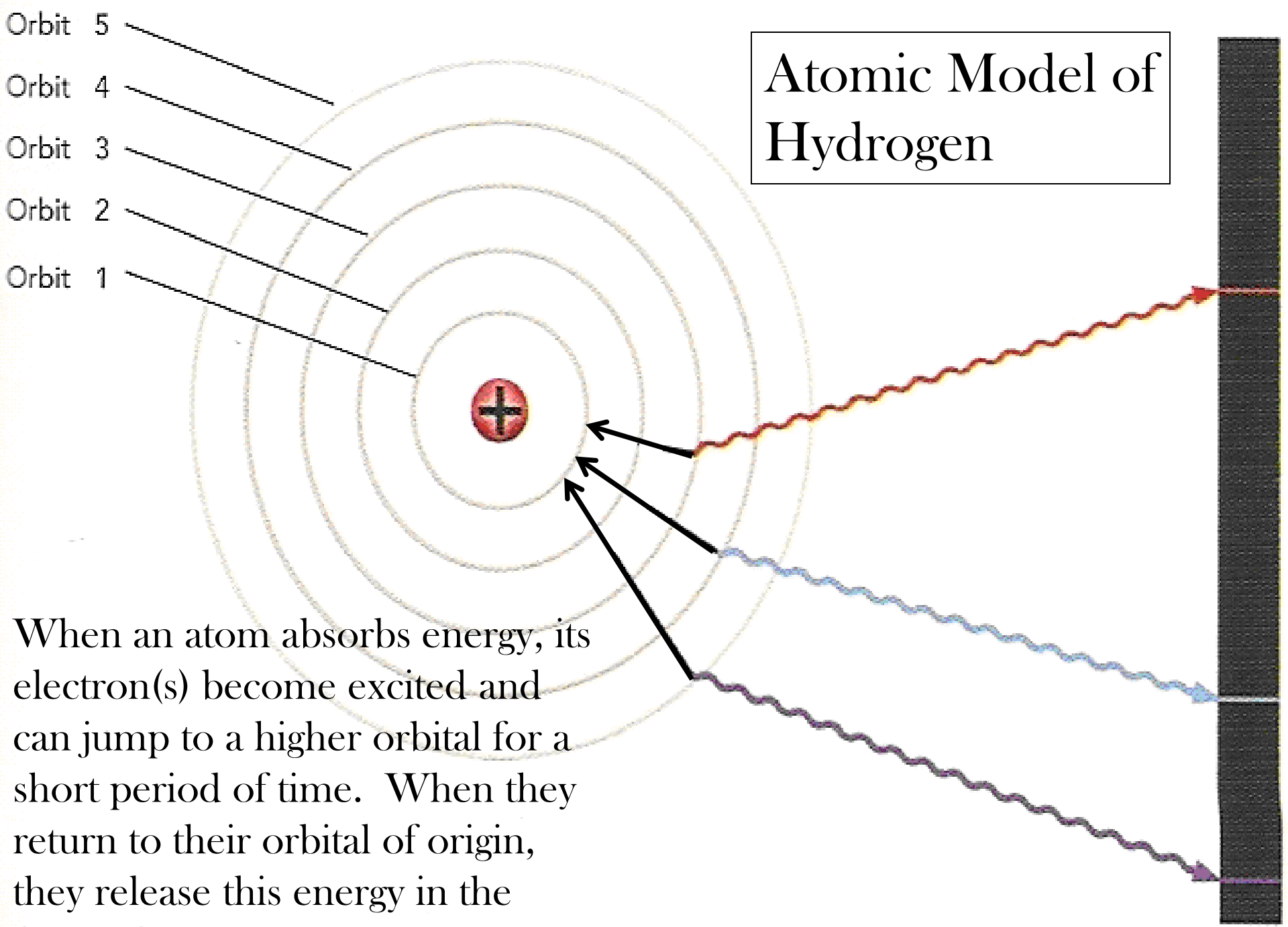
To understand **Neils Bohr**'s contribution to atomic theory, remember that it is possible to decompose light using a prism. This set-up allows us to see all of the colours that are present in white light.



When hydrogen is heated, it will emit a light containing only four colours.



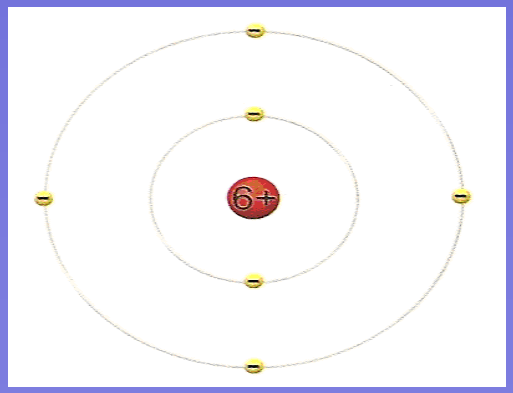
Atomic Model of Hydrogen



When an atom absorbs energy, its electron(s) become excited and can jump to a higher orbital for a short period of time. When they return to their orbital of origin, they release this energy in the form of light.

Bohr's Modifications to the Atomic Model

- Electrons move around the nucleus in orbits (like planets move around the sun)
- Each orbit has an energy level
- When electrons receive energy they can move to orbits further away from the nucleus
- When electrons move back to their "home" orbit they release the energy in the form of light



Bohr-Rutherford model of carbon

6 protons

6 electrons

Energy/Orbital/Shell	Capacity (for the purposes of this course)
1	2 electrons
2	8 electrons
3	8 electrons
4	2 electrons

Calculation of the # of Atomic Particles

protons = atomic number (from periodic table)

electrons (neutral atom) = atomic number

Lab: Locate metals, nonmetals and metalloids in the periodic table

(Science Quest – Experiment 5.2)

Purpose: To group elements according to their properties.

Hypothesis: The following substances are metals _____.

The following substances are nonmetals _____.

The following substances will act both like metals and nonmetals

(these are called metalloids) _____.

Observations:

Element	State of Matter	Reactivity with an acid	Thermal Conductivity	Metallic Luster	Electrical Conductivity	Malleability
Carbon (C)						
Iron (Fe)						
Nickel (Ni)						
Magnesium (Mg)						
Silicon (Si)						
Sulphur (S)						
Zinc (Zn)						

Properties of Metals

- Shiny (metallic luster)
- Good conductors of heat
- Good conductors of electricity
- Malleable
- Ductile
- React with acids to produce ...
- Solids at room temperature except for ...
- Located to the left of the "Step" on the periodic table

Properties of Nonmetals

- Lustreless (no shine)
- Poor conductors of heat
- Poor conductors of electricity
- Non-malleable
- Non-ductile
- Can be solids, liquids or gases at room temperature
- Located to the right of the "Step" on the periodic table

Properties of Metalloids

- Have properties of both metals and nonmetals
- Located around the "Step" on the periodic table
- B, C, Si, Ge, As, Se, Sb, Te, Bi, Po

Properties of Alkali Metals

(blue highlight column and write name)

- Soft
- Light
- Melt at low temperatures
- Never found as free elements in nature – always combine with other elements
  - i.e. NaCl – sodium chloride (table salt)
- Excellent conductors
- Highly reactive with air and water (stored in oil)
- Never handle with bare hands

Uses of Alkali Metals

sodium chloride	= table salt	= NaCl
sodium bicarbonate	= baking soda	= $NaHCO_3$
sodium nitrate	= fertilizer	= $NaN0_3$
potassium nitrate	= fertilizer	= KNO_3
lithium	= drugs to treat depression	
rubidium	= detect brain tumors	

Properties of Alkaline Earth Metals

(green highlight column and write name)

- Harder then alkali metals
- Higher melting points than alkali metals
- Excellent conductors
- Highly reactive but less than alkali metals

Uses of Alkaline Earth Metals

calcium & magnesium	→	present in many compounds found in water, soil and living organisms
magnesium	→	fireworks
calcium salts	→	melt ice on roads
barium sulphate	→	medical diagnosis of digestive problems

Properties of Halogens

(purple highlight column and write name)

- coloured substances
- never found as free elements in nature – always combine with other elements
  - i.e. NaCl – sodium chloride (table salt)
- form salts when combined with alkali metals
- form strong acids when combined with hydrogen (HCl)
- toxic and corrosive

Uses of Halogens

- halogen lamps (incandescent lamp with a halogen added to increase the intensity)
- iodine – thyroid gland
- fluorine – frosting glass and dulling ceramic surfacies
- chlorine and bromine – disinfectants, swimming pools
- iodine – antiseptic solutions

Properties of Inert/Noble Gases

(yellow highlight column and write name)

- colourless
- cmit characteristic colours in vacuum tubes
- almost completely unreactive

Uses of Inert/Noble Gases

- “Neon” lights
- Helium – weather balloons – party balloons
- Argon – light bulbs and electronic flashbulbs