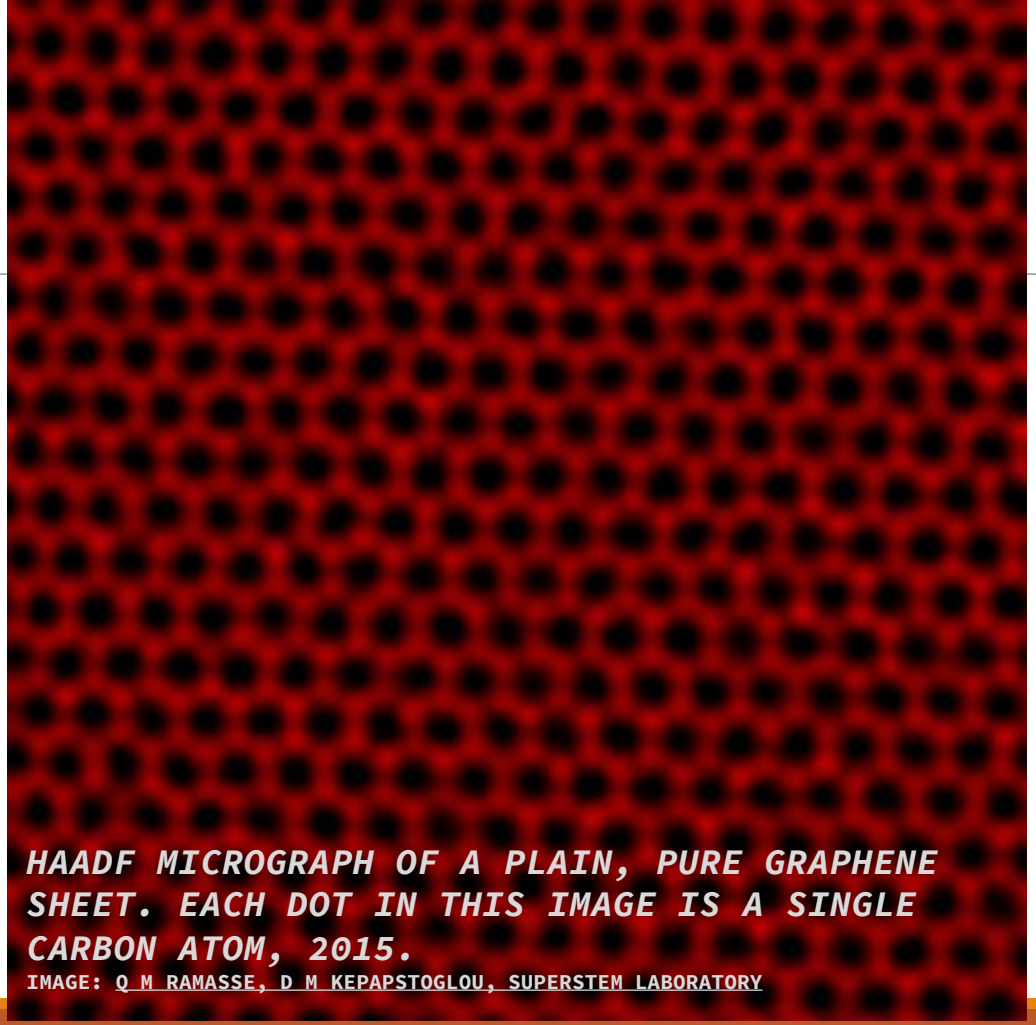


HAADF MICROGRAPH OF A PLAIN, PURE GRAPHENE SHEET. EACH DOT IN THIS IMAGE IS A SINGLE CARBON ATOM, 2015.

IMAGE: Q M RAMASSE, D M KEPAPSTOGLOU, SUPERSTEM LABORATORY

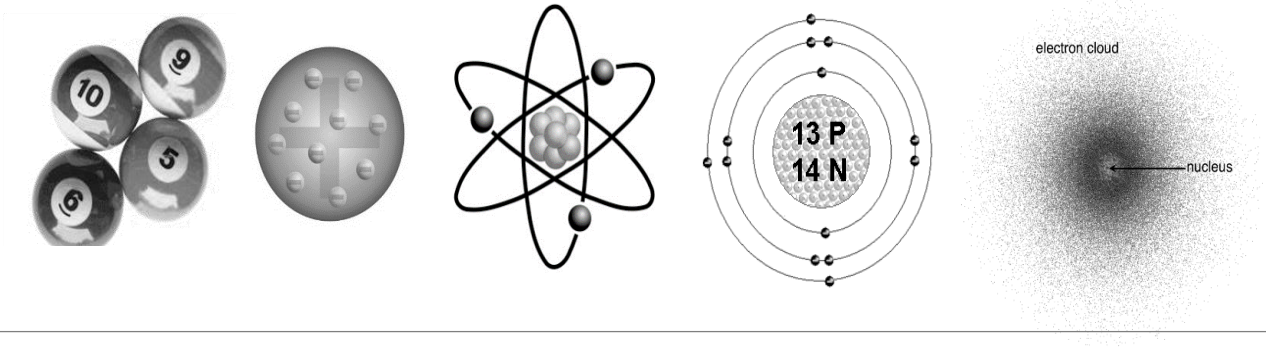
*"**Knowing** without **seeing** is at the heart of chemistry"*

ROALD HOFFMAN

POLISH-AMERICAN THEORETICAL CHEMIST WHO WON THE 1981 NOBEL PRIZE IN CHEMISTRY

TOPIC 2

THE ATOMIC MODEL



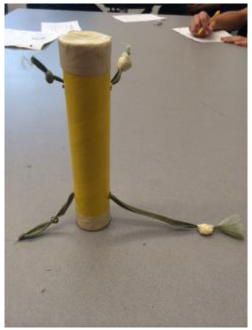
In this lesson you will

- ❑ *outline the role of indirect evidence in the development of the atomic model.*
- ❑ *use Bohr's model to represent atoms of any element.*

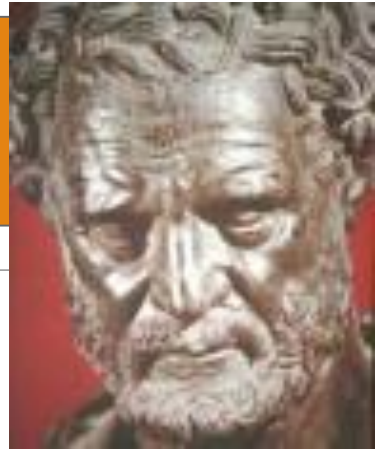
Indirect Evidence

Indirect evidence is evidence that relies on an inference to connect it to a conclusion of fact.

Example: a fingerprint at the scene of a crime (in criminal law this is usually called circumstantial evidence)



Democritus



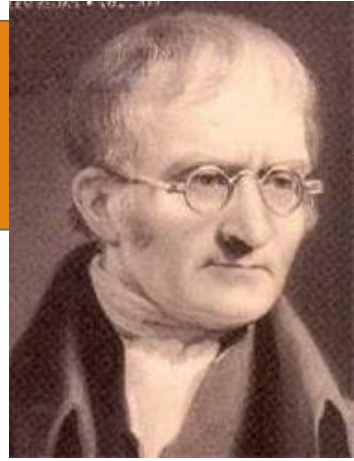
Democritus
c. 400 BCE

- Greek philosopher
- **Model**: He hypothesized that matter was made of tiny indivisible particles called **atomos.**

  Eg. Atomos of water, sand, wood

- **Evidence**: Democritus observed that you could keep cutting a material in half without changing what it was.

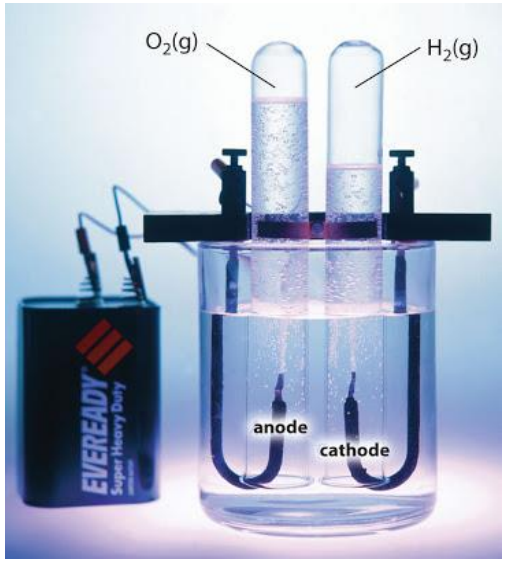
John Dalton



John Dalton
(1766 – 1844)

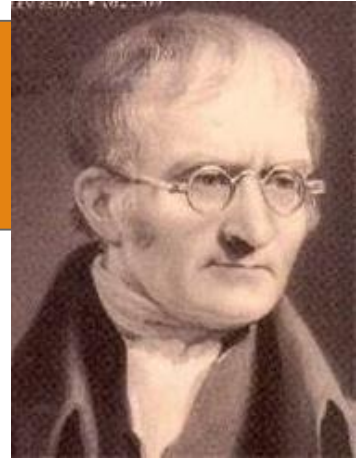
- **Experiment**: 2000 years after Democritus, Dalton used electricity to split water into hydrogen and oxygen in a process called electrolysis.

- **Evidence:** He observed that the splitting of water gives a 2:1 ratio of hydrogen to oxygen. Exactly. Always.



https://youtu.be/HQ9Fhd7P_HA

John Dalton

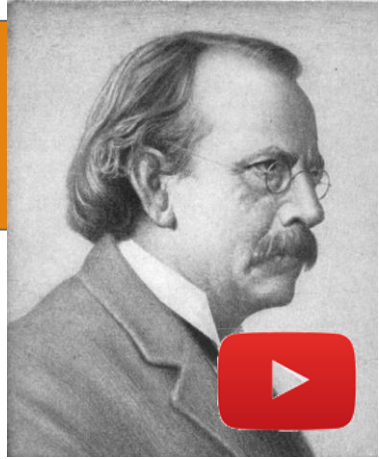


John Dalton
(1766 – 1844)

The "Billiard Ball" model

- Atoms of the same element are identical.
- Atoms combine in fixed ratios to form compounds during a chemical reaction

J.J. Thomson



J.J. Thomson
(1856 – 1940)

- **Experiment**: Thomson shot beams of particles through a glass vacuum tube (called a **cathode ray tube**) connected by metal electrodes to a voltage source.
- **Evidence:** some particles were deflected (curved away) from the straight line of the beam.

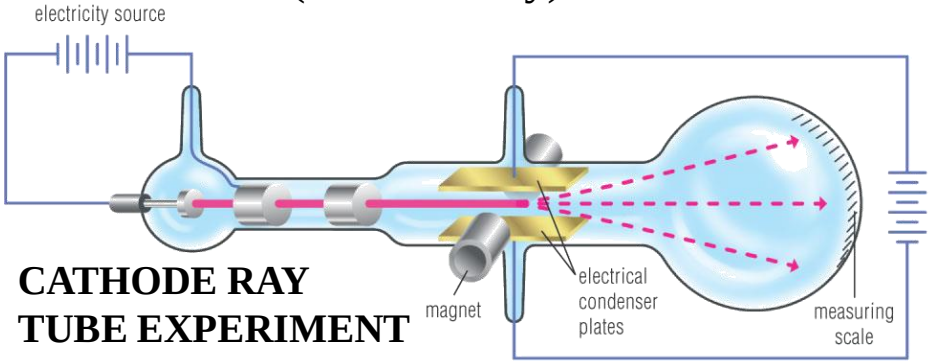
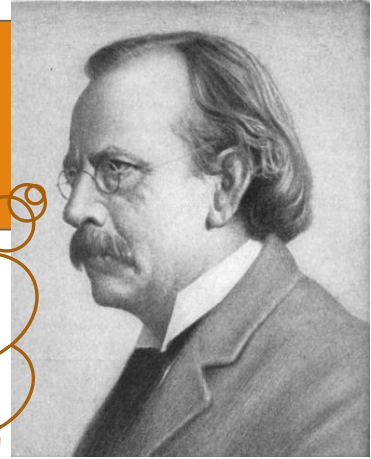


FIGURE A1.15 J. J. Thomson used this apparatus to produce beams of particles.

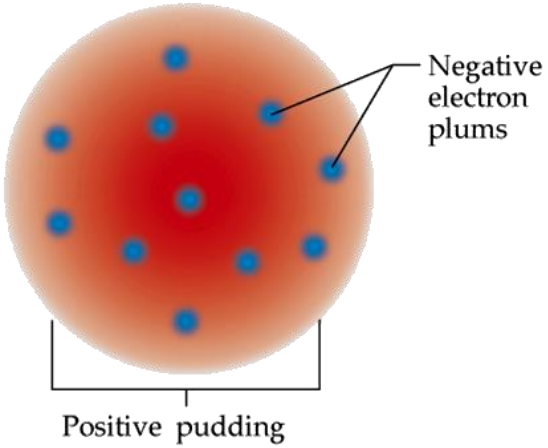
https://youtu.be/O9Goyscbazk

J.J. Thomson



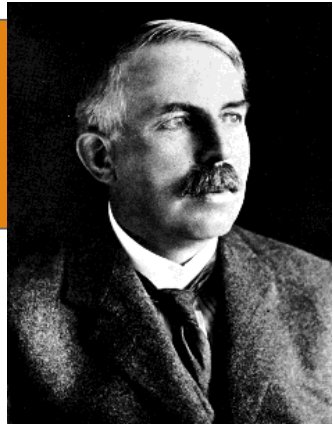
J.J. Thomson
(1856 – 1940)

The "Plum Pudding" model



- **Model**: Atoms are mostly empty space made of positively charged "fluid" and many tiny negative charges embedded in it (he called these electrons).

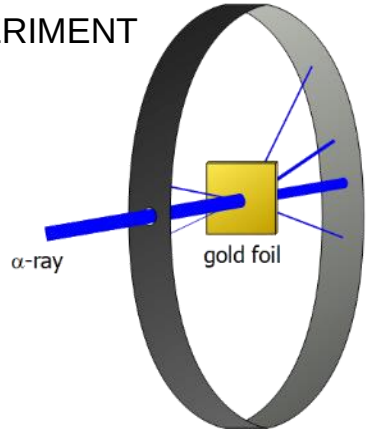
Ernest Rutherford

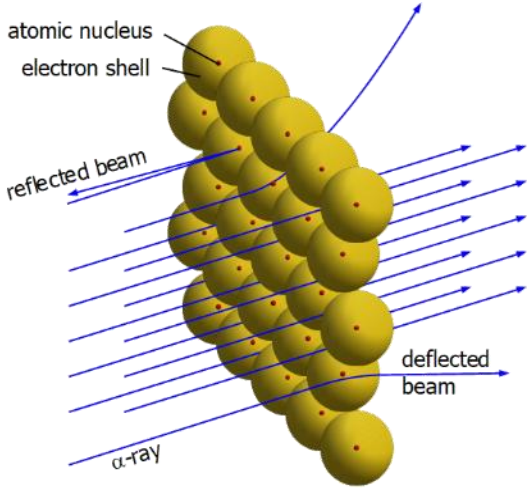


Ernest Rutherford
(1871 – 1937)

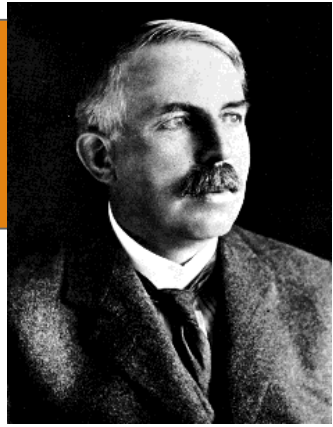
- Using Thomson's idea that atoms were mostly empty space, Rutherford predicted that a beam of extremely tiny particles, would pass right through a sheet of very thin gold foil.

GOLD FOIL EXPERIMENT





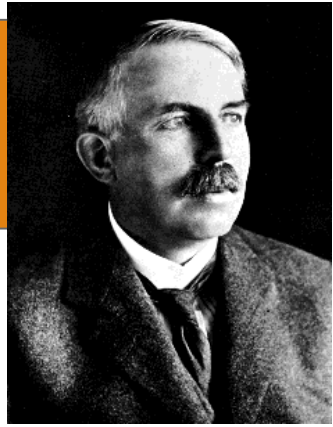
Ernest Rutherford



Ernest Rutherford
(1871 – 1937)

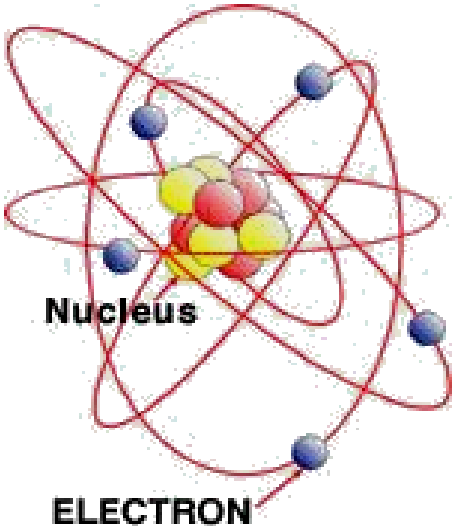
- **Evidence**: Rutherford was surprised when **some particles bounced back**. Rutherford compared this observation to firing a cannonball at tissue paper and finding that the cannonballs bounced back!

Ernest Rutherford



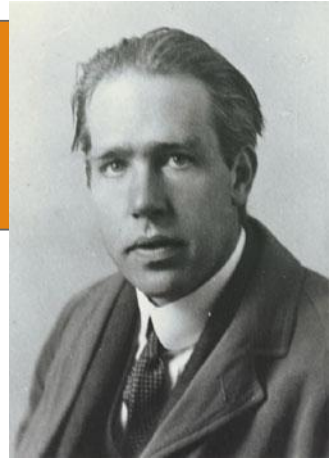
Ernest Rutherford
(1871 – 1937)

The "Planetary" model



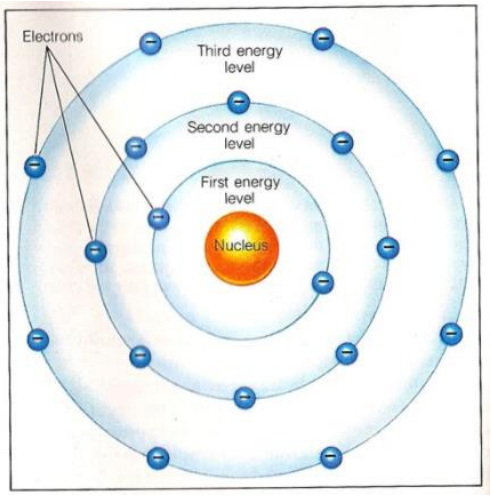
- **Model**: Every atom has a dense positively charged core which he called the **nucleus**. The electrons orbit the nucleus like planets around the sun

Niels Bohr



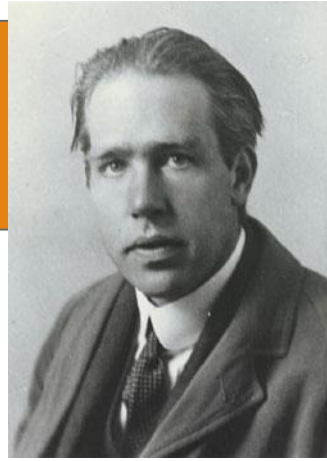
Niels Bohr
(1885 – 1962)

The "Energy Level" model



- **Model**: Building on Rutherford's observations, Bohr hypothesized that electrons are arranged around the nucleus in very specific **energy levels**.

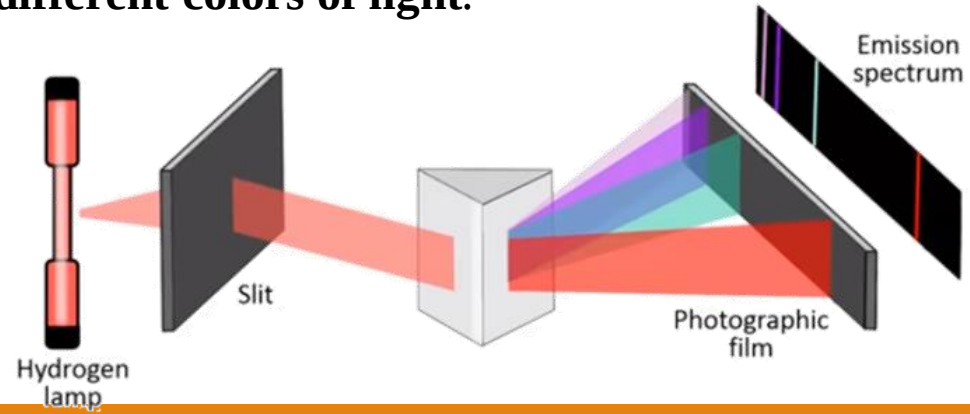
Niels Bohr



Niels Bohr
(1885 – 1962)

- **Experiment**: To test his energy level hypothesis, **Bohr looked at the light released by hydrogen atoms** when they are made to glow in a tube.

- **When electrons fall from higher energy levels to lower energy levels, they release different colors of light.**



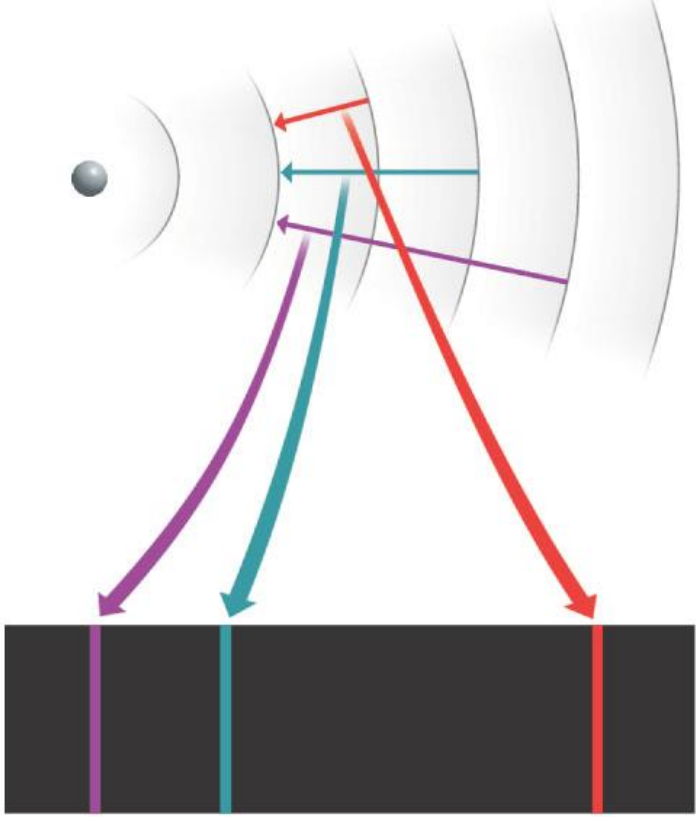
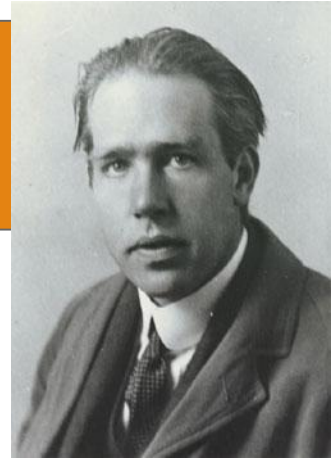


FIGURE A1.21 Electron energy levels and the hydrogen emission spectrum. When an electron falls from the third energy level to the second energy level, red light is emitted. When it falls from the fourth energy level to the second energy level, blue-green light is emitted. Similarly, a fall from the fifth to the second energy level emits violet light.

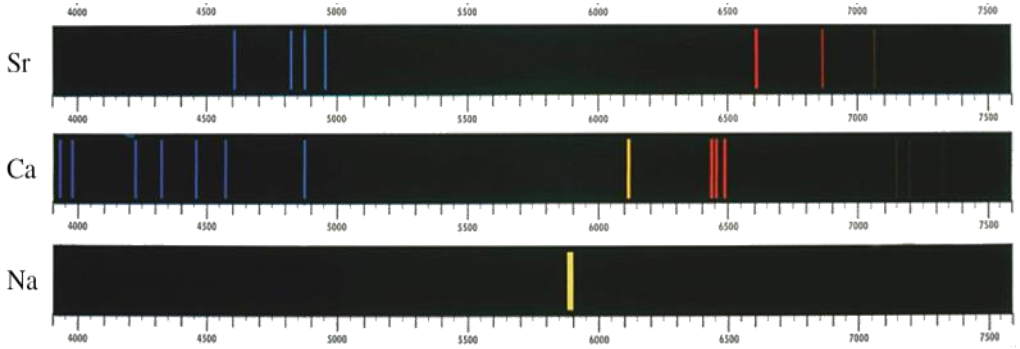
This observation supported Bohr's hypothesis that electrons exist in different energy levels around the nucleus of the atom.

Niels Bohr

- Different elements emit their own unique emission spectrum. This observation also supports Bohr's model because each atom has a different number of electrons.



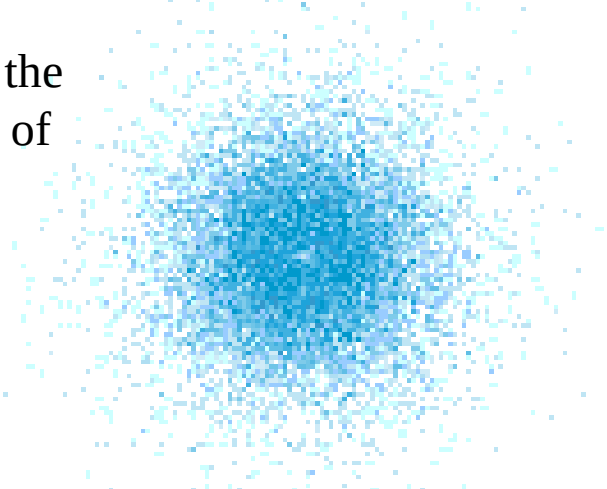
Niels Bohr
(1885 – 1962)



https://youtu.be/apuWi_Fbtys (stop at 2:50)

The Electron Cloud Model of the Atom

The modern model of the atom describes the positions of electrons in an atom in terms of mathematical probabilities.



The "electron cloud" model

An electron can potentially be found at any distance from the nucleus but tends to exist more frequently in certain regions around the nucleus than others, depending on its energy level.

This model is more complex and not easy to work with in a practical sense; it is beyond the scope of this course.

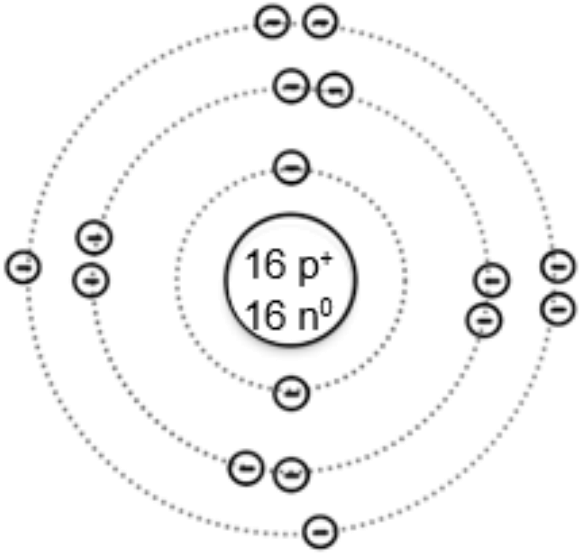

Kahoot!

Bohr Diagrams

- A maximum number of electrons can exist in each level:

  2 _____ electrons in the 1st energy level
  8 _____ electrons in the 2nd energy level
  8 _____ electrons in the 3rd energy level

- Electrons prefer to be arranged in pairs, but each of the four "corners" must be filled before they can buddy up.



Who am I?

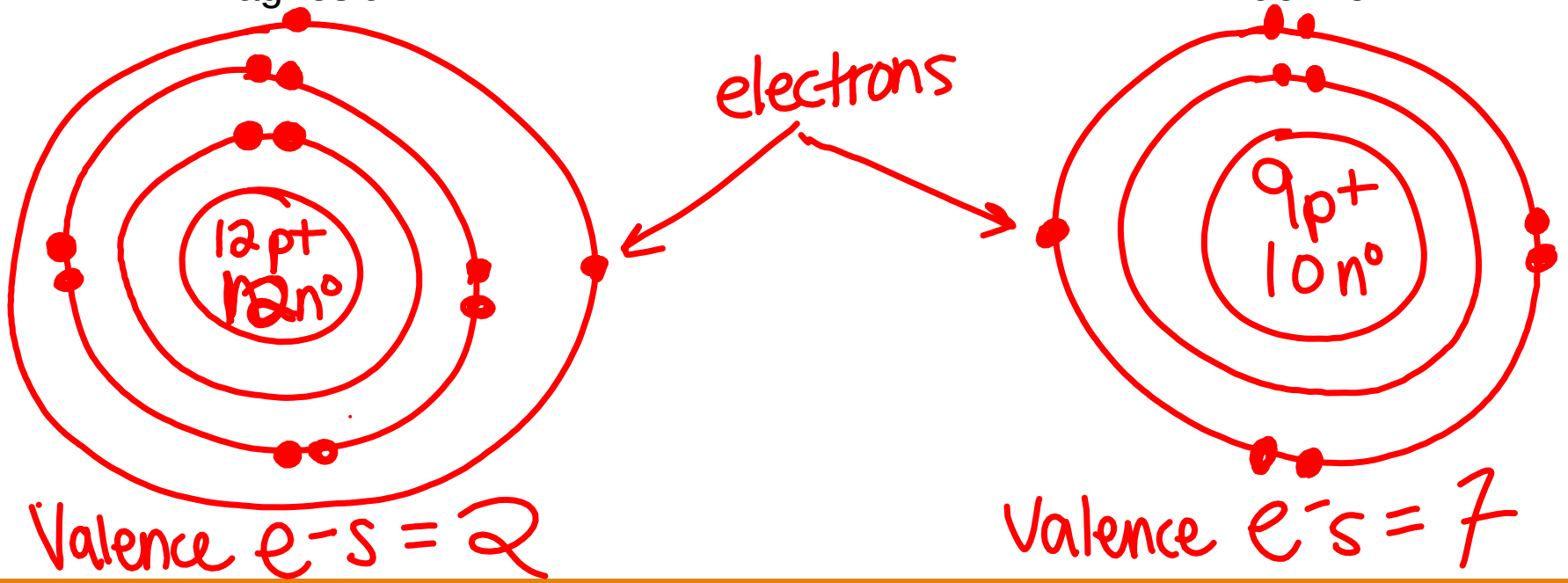
EXAMPLES

$n^o = 24 - 12 = 12 n^o$

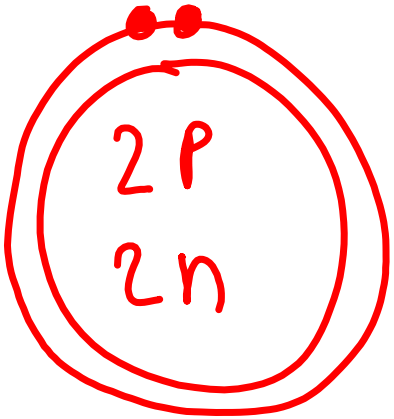
$n^o = 19 - 9 = 10$

Magnesium

Fluorine



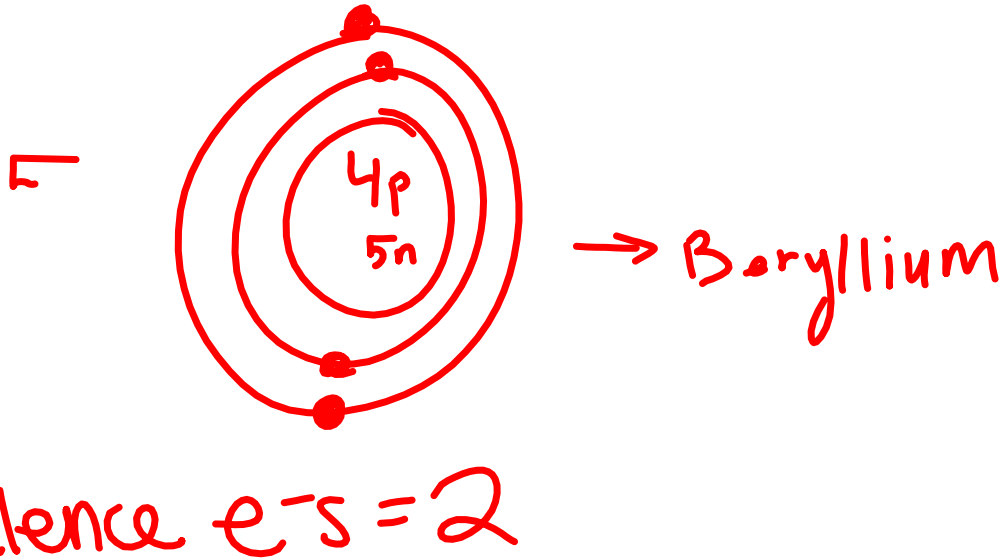
Bohr Diagrams - Helium



Helium

Valence e⁻s = 2

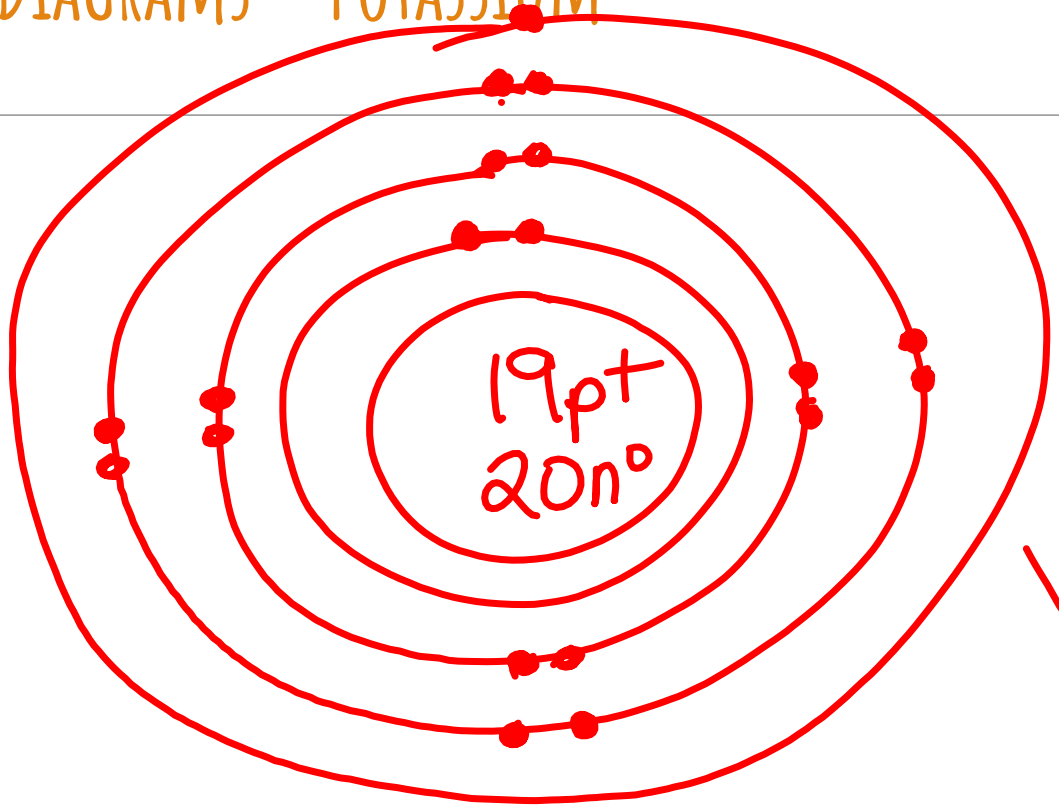
Bohr Diagrams - Beryllium



Bohr Diagrams - Fluorine

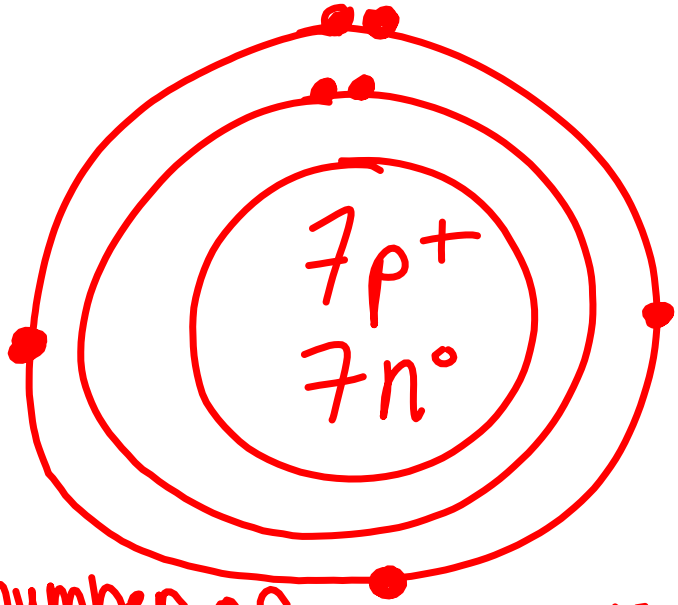
Valence e-s = 7

Bohr Diagrams - Potassium



valence e⁻s = 1

Bohr Diagrams - Nitrogen

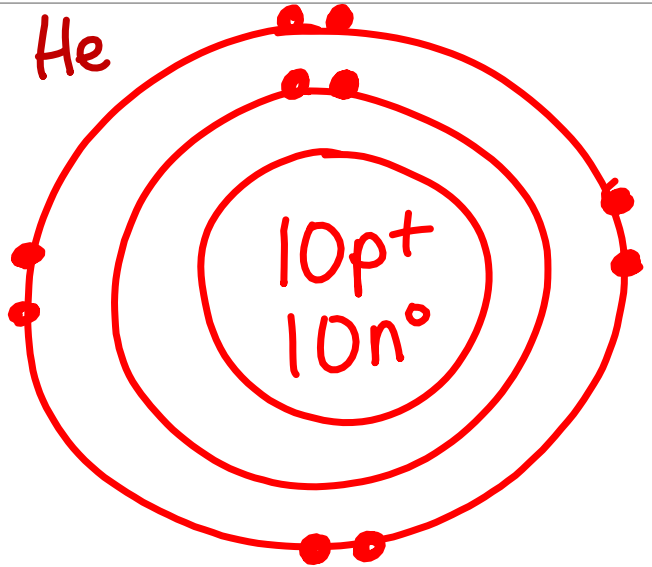


Valence e⁻s = 5

Remember: the number of electrons is the same as the number of protons... for now.

Bohr Diagrams - Neon

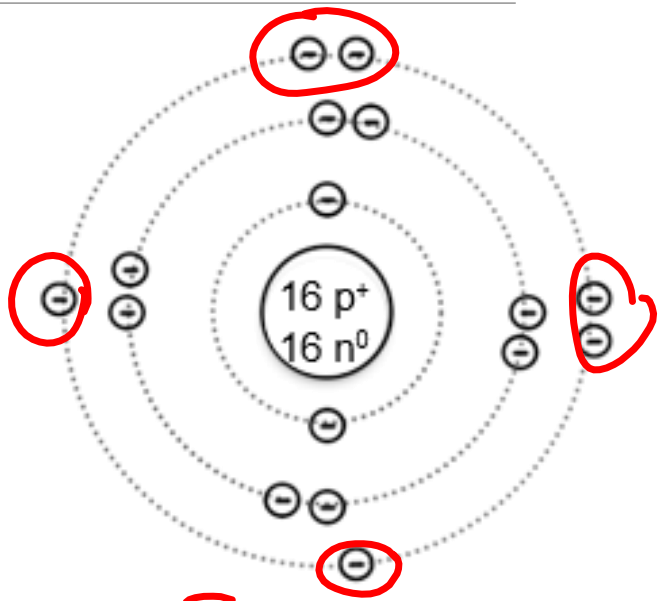
How are Ne & He different from the rest?



Valence e-s = 8

Valence Electrons

- The electrons located in the outermost orbital, or electron shell, are called valence electrons.
- Valence electrons are important because they take part in chemical reactions.
  - Example: Sulfur has 6 valence electrons



➢ *Return to each of the examples above and indicate the number of valence electrons in each atom.*