AP Chemistry   Name ____________________________________
Ms. Ye   Date ________________________Block ______

The Evolution of the Atomic Model

Since atoms are too small to see even with a very powerful microscope, scientists rely upon indirect evidence and models to help them understand and predict the structure of an atom.

Democritus & Leucippus (~400 BC)

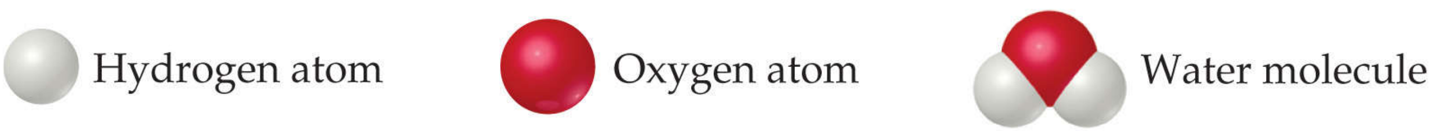
- Greek philosophers: first to propose that matter is made up of __________________________ __________________________________ particles called *atomos*, the Greek word for atoms

John Dalton (1803)

- Dalton theorized that the basic unit of matter is a tiny particle called an atom
- Dalton's theory of the atom can be summarized by the following postulates:

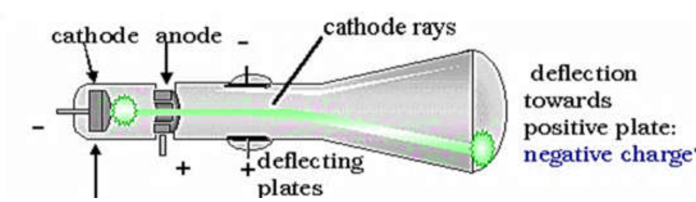
1. All ______________________ are composed of ____
2. All atoms of a given ____
3. Atoms of different elements are ____
4. ______________ are formed by the combination of _____________________________________

- **Billiard Ball Model:** An atom is represented by a ____________________________

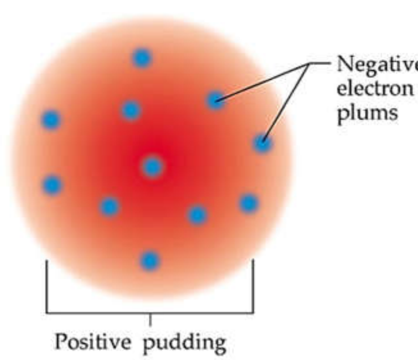


J.J. Thomson (1897)

- Used a ________________________________ to show one of the smaller units that make up an atom
- Because the cathode ray deflected towards the positively charged plate when an electric or magnetic field was applied, Thomson concluded ____ and the particles were ____

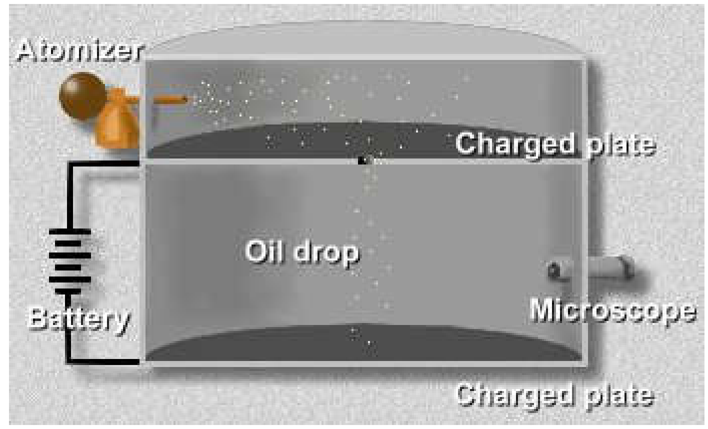


- Thomson discovered that the atom is made up of small, _____________________________________ which he called ____________________________
- Developed the ____



Robert Millikan (1909)

- Millikan's ______________________________ allowed him to determine the____________ ____

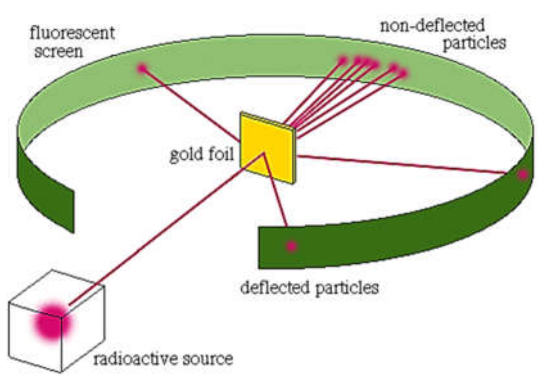


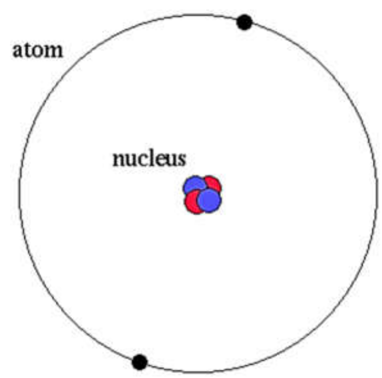
Experiment:

- **Determining the mass**: Using a microscope, allowed drops to fall and measured their terminal velocity to calculate the mass of each oil drop.
- **Determining the charge**: Millikan applied a charge to the falling drops of oil and applied an electric voltage in the chamber. If the voltage applied was just right, the drop would hang suspended in mid-air.
  - When a drop is suspended, the force of gravity acting on the drop is exactly equal to the electric force applied and Millikan was able to solve for the charge on the oil drop.
  - Repeated experiments showed that the charge on a drop was always a multiple of -1.6×10^{-19} C, the charge on a single electron.
  - This number was the one Millikan was looking for, and it also showed that the value was quantized; the smallest unit of charge was this amount, and it was the charge on a single electron.

Ernest Rutherford (1911)

- Conducted the ____
  - Directed ________________________________, which are positively charged particles much smaller than an atom, at a ____
  - Results: Most of the alpha particles ____________________________________ and a few were slightly deflected
  - Some of the alpha particles were ________________________and ________________________





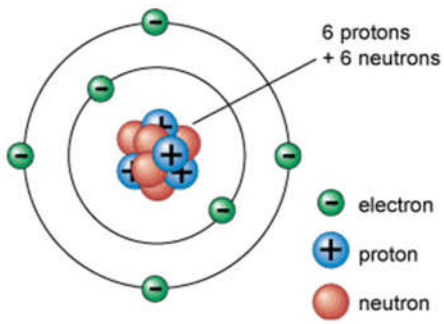
- Rutherford concluded atoms have a _________________________ called the __________________, while the remainder of the atom is essentially ________________________________
- Positively charged particles known as the ___________________________ are found in the nucleus ***provided no information about electrons other than the fact that they were located outside the nucleus

James Chadwick

- First to prove the existence of the ________________________
- Provided explanation as to why the positively charged protons in the nucleus stayed intact and did not repel each other.

Neils Bohr (1913)

- **Bohr Model of the Atom**
  - The nucleus contained the ____
  - The ___________________________orbited around the nucleus (like planets orbiting the sun)



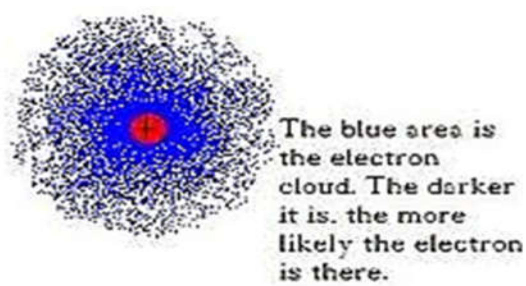
- Electrons are shown in concentric circles or shells around the nucleus
  - The first shell can hold ___________________
  - The second shell can hold _________________
  - The third shell can hold ___________________
  - Electrons in the outermost shell are called the ________________________

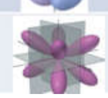
Wave or Quantum-Mechanical Model a.k.a. Electron-Cloud Model (modern, present-day model)

- Developed after the famous discovery that energy can be viewed as both ____________________
- Like planetary model, atom is pictured as having _______________________________________

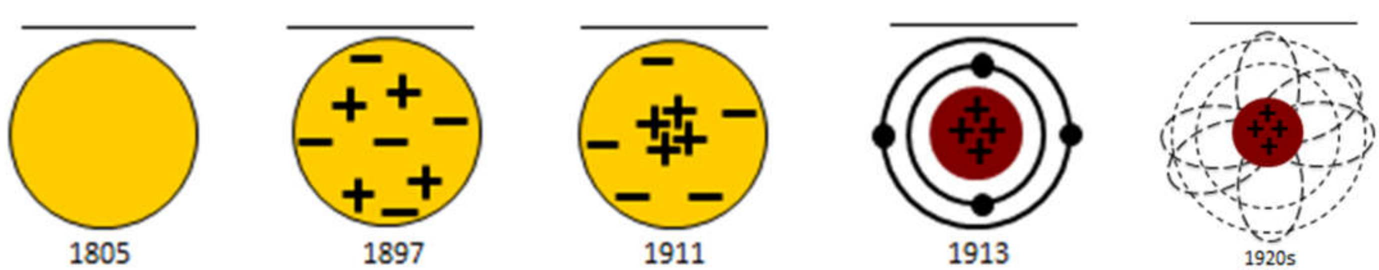
  The difference in this model is how the electrons are pictured.

  Electrons have distinct __________________ and move in areas called ______________________
- An **<u>orbital</u>** is a region ____



Value of *l*	Orbital (subshell)	Orbital Shape	Name*
0	*s*		*sharp*
1	*p*		*principal*
2	*d*		*diffuse*
3	*f*		*fine*

Summary:



Atomic Structure:

1. What is important about the atomic number?

2. How do you figure out the number of…
   a. Protons in an atom?

   b. Electrons in an atom?

   c. Neutrons in an atom?

3. What are **isotopes**?

   Isotopes are different forms of the ____________________ that have a __________________

   Isotopes of the same element have the _____________________ but ___________________

4. What are **ions**?

   Ions are atoms that have a ____

   In an ion, the ____

5. What is **standard nuclear notation**?

$$ {}^{A}_{Z}X^{+/-n} $$

6. What is the *one thing* that determines the ***identity*** of an atom?

7. If the number of protons remains the same, but the number of neutrons change, what property of the element changes? Is this an ion or an isotope?

8. If the number of protons remain the same, but the number of electrons change, what property of the element changes? Is this an ion or an isotope?

Atomic Structure Practice

9. Complete the following table: assume these are all **neutral atoms**

Element	Nuclear Notation	Mass Number	Atomic Number	# Protons	# Neutrons	# Electrons
Sodium – 23	$^{23}_{11}Na$					
Aluminum - 27						
				28	30	
	$^{184}_{74}W$					
					51	40

10. Indicate the number of protons, neutrons and electrons for the following **ions**:

Element	Nuclear Notation	Mass Number	Atomic Number	# Protons	# Neutrons	# Electrons
Sodium (+1)	$^{23}_{11}Na^{+}$					
Sulfur (-2)		32				
	$^{80}_{35}Br^{-}$					
		25	12			10

Average Atomic Mass: the average atomic mass listed on the periodic table is a weighted average of the masses of all naturally occurring isotopes for a particular element.

Calculating Average Atomic Mass

Ex: The element carbon occurs in nature as two isotopes. Calculate the average atomic mass for Carbon.

Isotope	Mass (amu)	% abundance
C-12	12	98.89%
C-13	13	1.11%

Step 1: Multiply the mass of each separate isotope by its percent abundance in DECIMAL FORM (move the decimal place of the percent abundance 2 places to the left)

$$\text{Carbon} - 12: \quad 12 \times \frac{98.89}{100} = \mathbf{11.8668}$$

$$\text{Carbon} - 13: \quad 13 \times \frac{1.11}{100} = \mathbf{0.1443}$$

these are weighted masses

Step 2: Add up the weighted masses from step 1.

$$\begin{array}{r} 11.8668 \\ +\ 0.1443 \\ \hline \boxed{\mathbf{12.011}} \end{array}$$

this is your average atomic mass

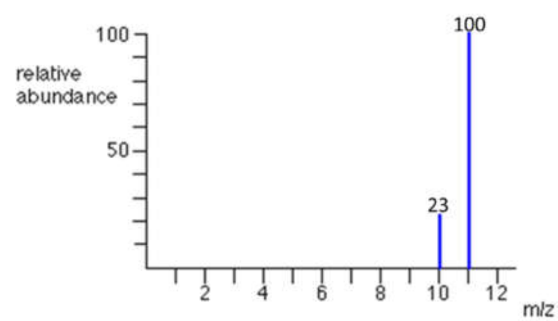
Practice:

1. An unknown element has the following atomic masses for three isotopes. Determine the average atomic mass and identify the element (write in standard nuclear notation).

Isotope	Atomic Mass (amu)	Natural Abundance (%)
1	27.9769271	92.2297
2	28.9764949	4.6832
3	29.9737707	3.0872

2. An unknown element exists in nature as two isotopes: Isotope 1 has a mass of 150.9196 amu in a 47.81% abundance and Isotope 2 has a mass of 152.9209 amu in 52.19%. What is the identity and average atomic mass of the unknown element?

3. The following is the mass spectrum for the stable isotopes of Boron. Determine the average atomic mass of Boron from the information provided. (note: you need to calculate the percent abundance first)



4. Chlorine has two naturally occurring isotopes, Cl-35 (mass 34.9689 amu) and Cl-37 (mass 36.9659 amu). If chlorine has an average atomic mass of 35.4527, what is the percent abundance of each isotope?

Atomic Structure Review HW

1. The gold foil experiment led to the conclusion that each atom in the foil was composed mostly of empty space because most alpha particles directed at the foil
a. Remained trapped in the foil
b. Were deflected by the nuclei in the gold atoms
c. Were deflected by the electrons in the gold atoms
d. Passed through the foil

2. J.J. Thomson's cathode ray tube experiment led to the discovery of
a. The positively charged subatomic particle called the electron
b. The positively charged subatomic particle called the proton
c. The positively charged subatomic particle called the electron
d. The negatively charged subatomic particle called the electron

3. The modern model of the atom states
a. Electrons are found in areas of high probability called orbitals
b. Electrons travel around the nucleus in circular paths called orbits
c. Electrons are found in areas of high probability called orbits
d. Electrons travel around the nucleus in random paths called orbitals

4. Every chlorine atom has
a. 7 electrons
b. 17 neutrons
c. A mass number of 35
d. An atomic number of 17

5. A particle of matter contains 6 protons, 7 neutrons, and 6 electrons. This must be a
a. Neutral carbon atom
b. Neutral nitrogen atom
c. Positively charged carbon ion
d. Positively charged nitrogen ion

6. What is the total number of neutrons in an atom of O-18?
a. 18 b. 16 c. 10 d. 8

7. Which ion contains the same total number of electrons as Cl^{1-}?
a. S^{2-} b. Br^{1-} c. Mg^{2+} d. Na^{1+}

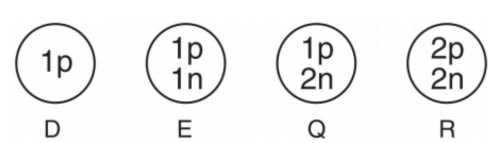
8. A Ca^{2+} ion differs from a Ca atom in that the Ca^{2+} ion has
a. More protons c. more electrons
b. Fewer protons d. fewer electrons

9. Compared to an atom of phosphorus-31, an atom of sulfur-32 contains
a. One less neutron
b. One less proton
c. One more neutron
d. One more proton

10. Which pair of atoms are isotopes of element X?
A. ${}^{226}_{90}X$ and ${}^{226}_{91}X$ B. ${}^{226}_{91}X$ and ${}^{227}_{91}X$
C. ${}^{227}_{91}X$ and ${}^{227}_{90}X$ D. ${}^{226}_{90}X$ and ${}^{227}_{91}X$

11. A sample of element X contains 90 percent ${}^{25}X$ atoms, 5 percent ${}^{27}X$ atoms, and 5 percent ${}^{28}X$ atoms. The average isotopic mass is closest to
a. 22 b. 25 c. 27 d. 28

12. Each diagram represents the nucleus



of a different atom. Circle the diagrams which represent nuclei of the same element.

13. Element X has two isotopes. If 72.0% of the has an isotopic mass of 84.9 atomic mass units, and 28.0% of the element has an isotopic mass of 87.0 atomic mass units, the average atomic mass of element X is

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