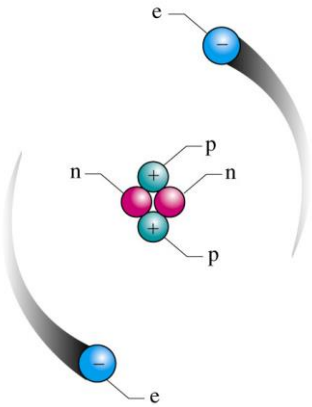

CHAPTER 2: Atoms and atomic theory

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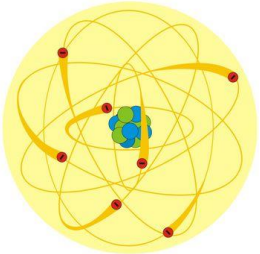
2-1 First Discoveries in Chemistry and Atomic Theory



- LAVOISIER
- PROUST
- DALTON
- THOMPSON
- MILLIKEN
- RUTHERFORD
- BOHR
- SCHRÖDİNGER

Antoine Lavoisier (1774) Law of Conservation of Mass

The sum of the masses of the products resulting from the reaction; is equal to the sum of the masses of the reacting substances.

Joseph Proust (1799) Law of Constant Proportions

All samples of a compound have the same composition. The components combine at a constant rate by mass.

3

Dalton's Atomic Theory

1. Each element is composed **indivisible particles** (called atoms). Atoms are neither created nor destroyed in chemical reactions.

2. All atoms of a given element are alike in mass (weight) and other properties but differ from all other elements

3. A chemical compound is formed by the combination of two or more elements in a simple numerical ratio.

For example, one atom A and one atom B (AB) or one atom A and two atoms B (AB_2).

Dalton's atomic theory also enabled us to understand «The Law of Multiple Proportions».

1766-1844

British scientist John Dalton is the scientist who put forward the first atomic theory.

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Consequences of Dalton's Atomic Theory

☆ In the formation of carbon monoxide (CO), 1.33 g of oxygen combines with 1.0 g of carbon.

☆ In the formation of carbon dioxide (CO_2), 2.66 g of oxygen combines with 1.0 g of carbon.

The second oxide is richer in oxygen and contains twice as much oxygen as the first. 2,66 g / 1,33 g = 2,00

CO and CO_2 1:1 and 1:2

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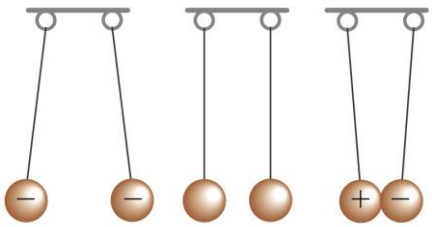
2-2 Electrons and Other Discoveries in Atomic Physics

Forces Between Electrically Charged Objects



(a) Objects carrying similar charges repel each other.

(b) Since objects do not carry any electrical charge, they do not exert force on each other.

(c) Objects carry opposite charges (one positive and the other negative) and attract each other.

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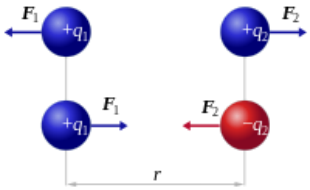
Coulomb's law (1785):

The magnitude of the attractive electrostatic force between two point charges is directly proportional to the product of the magnitudes of their charges and inversely proportional to the squared distance between them.



$$|F| = k_e \frac{|q_1||q_2|}{r^2}$$

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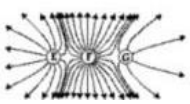
Coulomb's law

1. The direction of the electric field vector points outward for positive charges and inward for negative charges.
2. It creates an electric field around the charge.
3. The magnitude of the electric field is proportional to the charge.



Rank the objects according to which has the greatest magnitude of electric charge, beginning with the smallest charge. Also, **explain** how you determine the relative strength of the charge.

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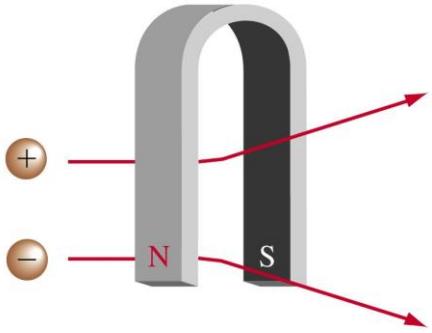
Effect of Magnetic Field on Charged Particles



• If charged particles are sent perpendicular to a magnetic field, they are deflected by the field. Negatively charged particles are deflected in one direction, positively charged particles are deflected in the opposite direction.

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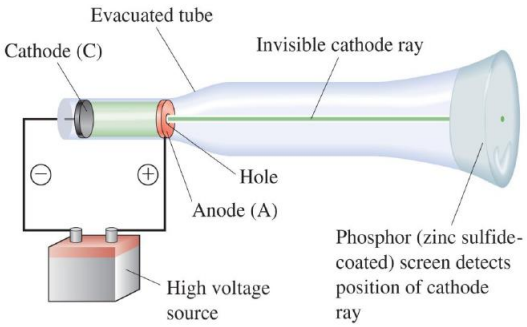
Discovery of Electrons

Cathode Ray Tube (CRT):

The first cathode ray tube was made by Michael Faraday (1791-1867) approximately 150 years ago.



Faraday discovered cathode rays emitted by the negative end (cathode) when he passed an electric current through a glass tube that was largely evacuated of air.

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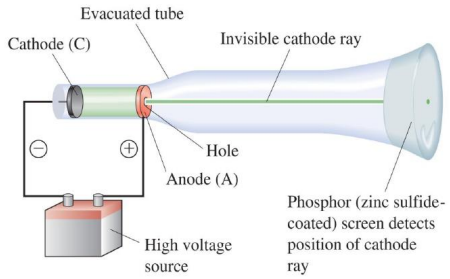
Cathode Ray Tube

•The high voltage source creates a negative charge on the left electrode (cathode). It creates a positive charge on the right electrode (anode).

•In reality, **cathode rays** are not visible to the naked eye, but they can be seen by the light they emit from a surface they hit.



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- Thomson proposed that cathode rays were negatively charged *elementary particles* found in all atoms.
- From now on, cathode rays were called **electrons**.
- The first person to use this term was **George Stoney** (1874).

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Charge of the Electron

☆ **Robert Millikan (1868-1940) determined the electron charge (e) by performing a series of 'oil drop' experiments between 1906 and 1914.**

☆ Millikan determined the electron charge. **The charge of the electron** is 1.6022x10^{-19} C.

☆ If this value is substituted in the mass/charge relation of the electron, the value for mass (m) is 9.1094 x 10^{-28} g.

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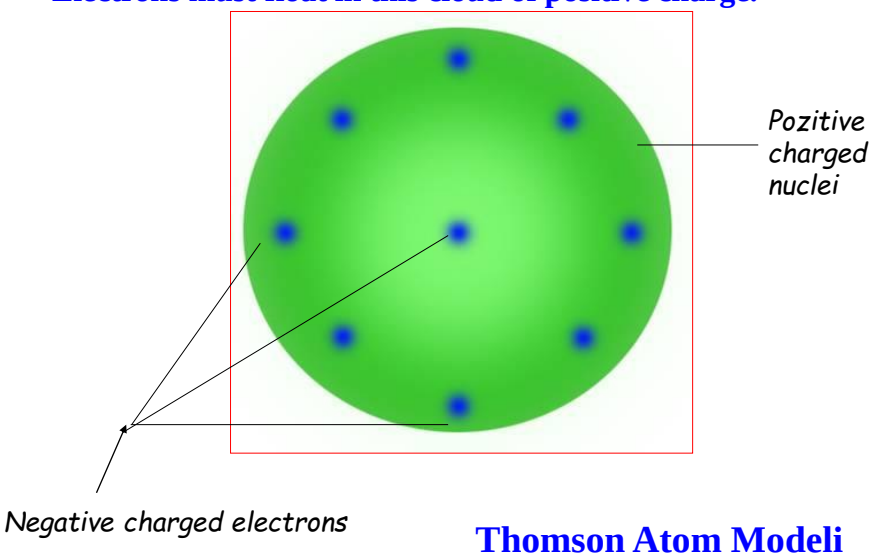
According to the J.J Thomson atomic model, a neutral atom should have positive charges that balance the negative charge, and these positive charges should be in the form of a cloud. Electrons must float in this cloud of positive charge.



Thomson Atom Modeli

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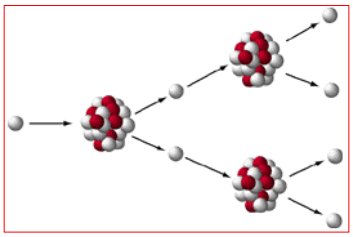

RADIOACTIVITY

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X-rays and Radioactivity

- **Radioactivity:** It is the phenomenon in which an unstable atomic nucleus gives off small matter particles and electromagnetic radiation.

- In 1895, while Wilhelm Roentgen (1845-1923) was working with cathode rays, he noticed that some substances outside the cathode ray tube were glowing or emitting fluorescent light.
- Since the nature of this light was unknown, Roentgen called it **X-ray.**

- Ernest Rutherford discovered two of the rays emitted by radioactive substances, **alpha (α) ray and beta (β) ray.**

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Rutherford Atomic Model

Rutherford explained the results of this experiment in 1911.

Rutherford atomic model has the following features:

1. Most of the mass of an atom and all of its positive charge is concentrated in a very small region called the nucleus. Most of the atom is an empty piece of space.
2. The size of the positive charge varies from atom to atom and is approximately half the atomic weight of the element.
3. Outside the nucleus there are a number of electrons equal to the nuclear charge. The atom itself is neutral in electrical charge.

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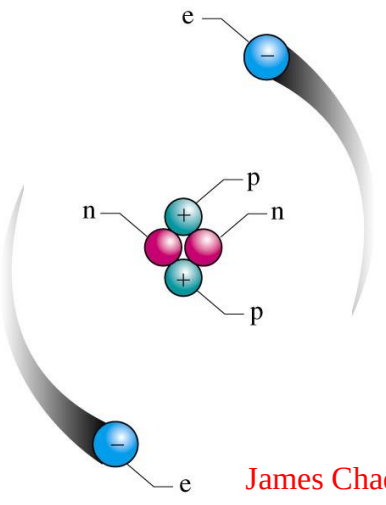
Atomic Nucleus - Discovery of Protons and Neutrons

Rutherford discovered protons (1919)



Here the electrons are drawn much closer to the nucleus than they actually are.

In reality;

If the atom is a room with dimensions of 5m x 5m x 5m, the nucleus is only as much as the space occupied by this written sentence.

James Chadwick discovered neutrons (1932)

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2.3-STRUCTURE OF THE ATOM

Matter is made of atoms.

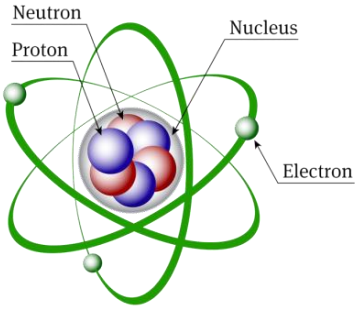
The smallest part of a substance that cannot be broken down by chemical means is called an atom.

The atom consists of 3 fundamental particles:

Proton: It is located in the nucleus of the atom and has a positive (+) charge.

Neutron: It is found in the nucleus of the atom and has no charge.

Electron: They orbit around the nucleus and have a negative (-) charge.



An atom whose number of electrons is equal to the number of protons is called a neutral atom, and an object whose atoms are neutral is called an uncharged object.
However, being called uncharged means that the (+) and (-) charges are equal. This means there is no excess load on it.

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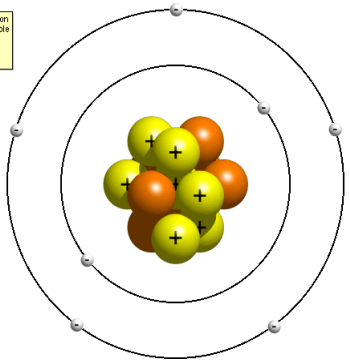
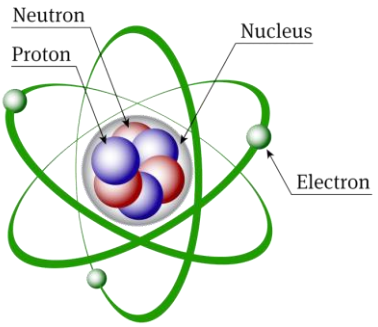
STRUCTURE OF THE ATOM



Positively charged object: When a neutral object loses electrons, an excess of (+) charge occurs. Objects with such (+) excess charge are called positively (+) charged objects.

Negatively charged object: When a neutral object gains electrons, an excess of (-) charge occurs. Objects with such (-) excess charge are called negatively (-) charged objects.



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The properties of 3 Basic particles

Particle	Mass		Electricle Charge	
	SI(**kg**)	**(amu)**	**SI(Coulomb)**	**Atom**
Electron	9,109 x 10^{-31}	0,00054858	–1,602 x 10^{-19}	–1
Proton	1,673 x 10^{-27}	1,0073	+1,602 x 10^{-19}	+1
Neutron	1,675 x 10^{-27}	1,0087	0	0

- The atomic mass unit (amu) is exactly 1\12 of the mass of carbon-12.
- 1 amu = 1.66054 x 10^{-24} kg

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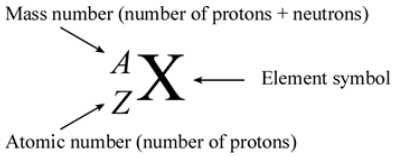
2.4- Elements

- Each element has a name and symbol;



A= Mass number **Z = Atomic number**

neutron number = A-Z

Charge of ion= Number of proton- Number of electron

- Same atomic number (Z), different mass number (A) Atoms that have ions are called **isotopes.**

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2-5 Atomic Mass

- The **atomic mass (weight)** of an element is the average of the weighted atomic masses of the isotopes according to their occurrence in nature.

- The **weighted atomic mass** is calculated according to the following general equation;

Atomic mass of the element= (fractional abundance of isotope 1) x (atomic mass of isotope 1) + (fractional abundance of isotope 2) x (atomic mass of isotope 2) + ...

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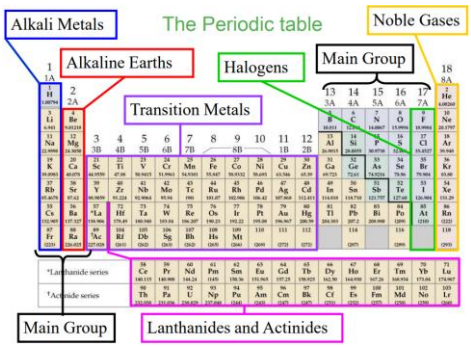
The Periodic Table:

- We can distinguish one element from all others by its particular set of observable physical properties.
- Periodic Table is the classification system, in which we can;
  * read atomic masses,
  * read the ions formed by main group elements,
  * read the electron configuration.
  * learn trends in physical and chemical properties.



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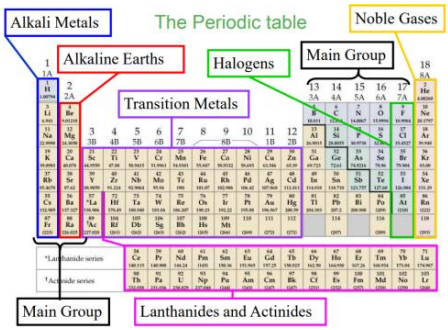

✓ In the periodic table, elements are listed according to increasing atomic number starting at the upper left and arranged in a series of horizontal rows,called periods.
✓ This arrangement places similar elements in *vertical* **groups, or families** The elements can also be subdivided into broad categories.
✓ One categorization is that of **metals, nonmetals, metalloids, and noble gases.**
✓ **Another is that of maingroup elements and transition elements (transition metals). Included among the transition elements are the** two subcategories **lanthanides and actinides.**

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2-7 Mole Concept and Avogadro's Number

- The amount of an uncountable amount of a single type of substance is expressed in units of **moles** in the SI unit system.

- The number of particles contained in one mole of particles such as atoms and molecules is called Avogadro's number (NA).

- $N_A = 6{,}02214199 \times 10^{23}\ mol^{-1}$

- The mass of one mole of atoms is called molar mass, M_A

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2.8- Concept of Mole in Calculations

- Potassium-40 is one of the few isotopes of elements with small atomic numbers that are naturally radioactive, and its abundance among K isotopes in nature is 0.012%.

- How many ^{40}K atoms will you ingest when you drink 225 mL of milk containing 1.65 mg/mL potassium?

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