DEPARTAMENT OF PHYSICS AND CHEMISTRY

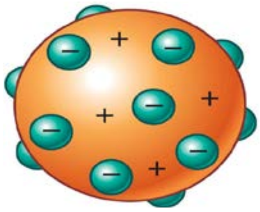
Group:	2º ESO	Date:	
Content:	Unit 4 – Structure of matter 3: Atomic models; 4: Atomic and mass number. Isotopes and Ions		
Subject:	Physics and Chemistry		
Student:			

3. ATOMIC MODELS

DALTON´S BILLIARD BALL MODEL (1803)

In 1803, Dalton proposed his atomic theory. This theory lead to a model that represented the atom as a solid ball of matter that is indivisible with no parts. It shows that atoms of the same elements have the same masses (same sized billiard balls), and atoms of different elements have different masses (different sized billiard balls).
It became obsolete because of the discovery of electrons.

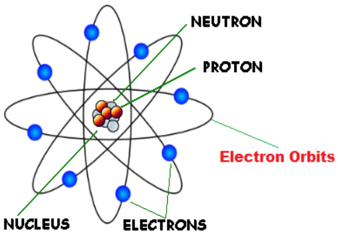
THOMSON´S PLUM PUDDING MODEL (1897)



In 1897, Sir Joseph John Thomson showed by an experiment that there were small charged particles inside of atoms; today we call these particles **electrons.** Thomson´s model indicates that an atom is composed of electrons surrounded by a soup of positive charge to balance the electron´s negative charges, like negatively "plums" surrounding by positively charged "pudding". This model was known as the "plum cake" or "plum pudding" atomic model.

However, the Thomson model of the atom had to be abandoned, because new experiments showed that a least most of the positive charge (from protons) was concentrated in the center of the atom, not over the entire volume.

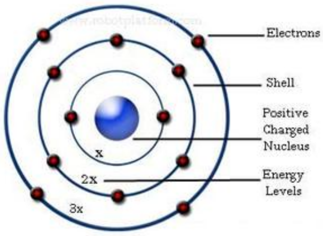
RUTHERFORD´S PLANETARY MODEL (1911)



Based on the Geiger–Marsden "Gold Foil" experiment, in 1911 Rutheford put forward the hypotheses that the positive charge of the atom was concentrated in a very small volume called nucleus. In this model, the electrons were scattered around the volume of the atom outside the nucleus. Rutherford postulated that the atom looked like a planetary model with the nucleus would be the central star and the electrons would be the planets orbiting around it.

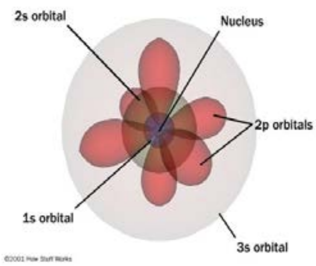
According to this model, the electrons would have to be accelerating as they orbit the nucleus due to the net centripetal force acting on them. This should cause them to emit electromagnetic radiation, and they should then lose energy, causing them to collide into the nucleus and implode the atom. However, since this does not occur, this model failed as well.

BOHR MODEL (1913)



Niels Bohr (1885-1962) discovered that the electrons move themselves in stables orbits, forming a cortex outside the nucleus. This model represents the electrons orbiting the nucleus of an atom in circular orbits. These electrons had specific orbits and distinct orbital levels. Electrons that gained energy would jump to higher energy levels and become "excited", and as they jumped back down to the ground state, they would emit that energy. However, this model worked well for only the simple Hydrogen atom.

ELECTRON CLOUD MODEL/QUANTUM MECHANICS MODEL (1925)



This is the model of the atom that is accepted today as being the most accurate one. This model is similar to Bohr's model, except that in this model, the electrons aren't limited to fixed orbits -- they surround the nucleus in a cloud formation. It states that it is impossible to know both the position and the momentum of electrons, and relies on the concept of probability to predict where electrons might be at a given time.

4. ATOMIC AND MASS NUMBER

Each type of atom represents a chemical element. This means that there must be a part of the atom that it is responsible of the distinction between one element and another. The element copper (Cu) has 29 protons, nickel (Ni) has 28 protons and zinc (Zn) has 30 protons. Each one has different properties. What conclusions can you draw? The number of protons inside the nucleus of an atom characterize this atom and differentiate it from another.

Atomic number (Z): It is the number of protons in an element. It serves to identify elements. It determines the element.

$$Z = p^+$$

It is represented by a number situated as a subscript on the left of the element symbol. For example: ${}_{8}O$, ${}_{17}Cl$, ${}_{26}Fe$

When an atom is electrically neutral, the number of electrons is the same of the number of protons.

As the electrons have a very small mass, the mass of the atom is almost exclusively the mass of the protons and electrons and it allows us to define the mass number:

Mass number (A): It is the sum of the number of protons and neutrons of an atomic nucleus. It signifies/indicates the atomic mass of the atom. $A = p^+ + n^o$

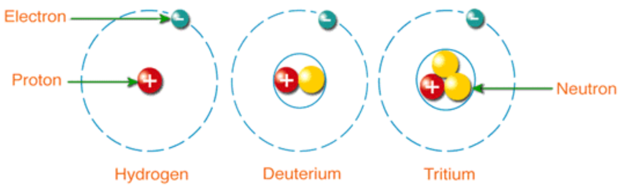
It is represented by a number situated as a superscript on the left of the element symbol. For example: ${}^{16}O$, ${}^{35}Cl$, ${}^{56}Fe$

4.1 ISOTOPES

Some of the particles that make the atom can alter its number without changing the type of the element.
Isotopes: They are atoms with the same number of protons, but differ numbers of neutrons. They are different forms of a single element.

For example, there are atoms of carbon (Z=6) with mass numbers 12, 13 and 14 because they contain 6, 7 and 8 neutrons respectively. They are isotopes with each other.

Elements in nature are a mixture of isotopes. The majority of chemical elements have more than one isotope. Only 21 elements have only one natural isotope. Isotopes of an elemet are named by its name or symbol with its mass number: iron-57, uranium-238 or helium-3.



Hydrogen has three isotopes with specific name: **protium** (without neutrons), **deuterium** (with 1 neutron) and **tritium** (with 2 neutrons)

Besides natural isotopes, there are **artificial isotopes** which are made on the laboratory. Many isotopes are unstable and they disintegrate easily emitting particles in a process called **radioactivity.**

4.2 IONS

You have already seen what happens to an element when we change its number of neutrons but, what happens when we change the electrons?
Ion: It is an atom which has gained or lost one or more of its electrons, giving it a net positive or negative electrical charge. There are two types:

- Cations: number of electrons < number of protons . The charge is positive.
- Anions: number of electrons > number of protons. The charge is negative.

So when fluoride (Z=9) gains one electron, it continues being fluoride because it has 9 protons but it will have 10 electrons making its net charge be -1. We say that we have a fluoride ion (or fluorine) and we represent it as F^-. If a sodium (Z=11) loses one electron, it becomes a sodium ion and its net charge will be +1. It is represented as Na^+.