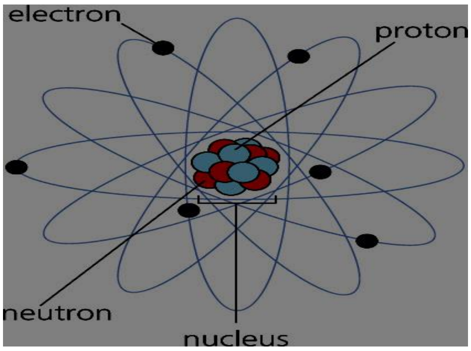
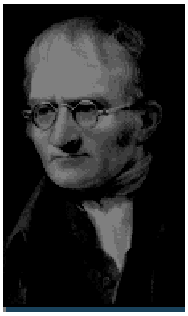
UNIT 4 ATOMS



An atom is the smallest particle of any element that still retains the characteristics of that element. However, atoms consist of even smaller particles.

1. DALTON'S ATOMIC THEORY.

Modelos atómicos



In 1800, Dalton proposed a modern atomic model based on experimentation. This theory can be summarized in:

a) All matter is made of atoms. Atoms are indivisible and indestructible.

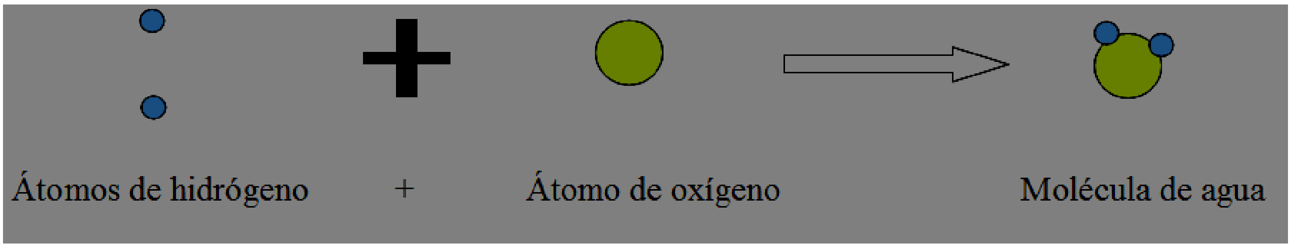
b) All atoms of a given element are identical in mass and properties.

c) Each element has different atoms.

d) Compounds are formed by a combination of two or more different kinds of atoms.

e) Atoms are rearranged in reactions.

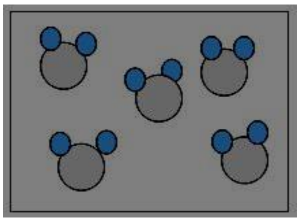
Ej:



This model could explain all the laws of chemistry and physics (with the exception of electricity, radioactivity and the emission of waves from atoms).

Remember

A **compound** :

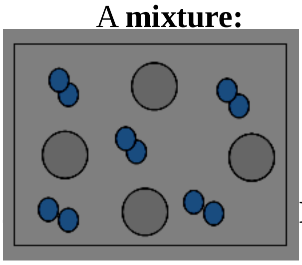


a) It is a **pure substance** composed of atoms bonded in the **same proportion.**

b) It **cannot** be separated by physical methods.

c) It keeps **chemical properties constant**.

A **mixture:**



a) It is composed of two or more pure substances in **any proportion**.

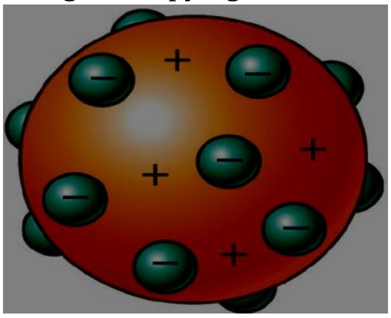
b) It **can** be separated by physical methods.

c) It **does not keep** chemical properties constant.

M .

Structure of atom

In 1897, 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 a sphere of positive charge, occupying the whole volume of the atom.



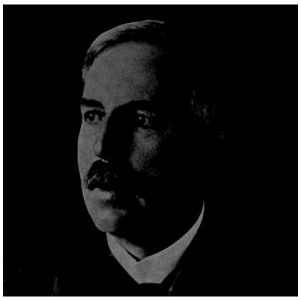
However, the Thomson model of the atom had to be abandoned, because new experiments showed that a least most of the positive charge (from protons) was concentrated in the center of the atom, not over the entire volume.

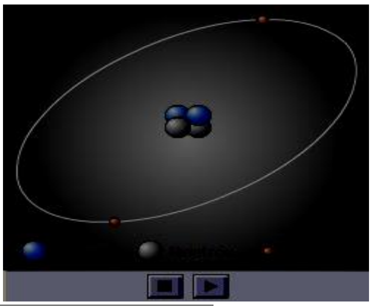
3. RUTHEFORD'S ATOM.

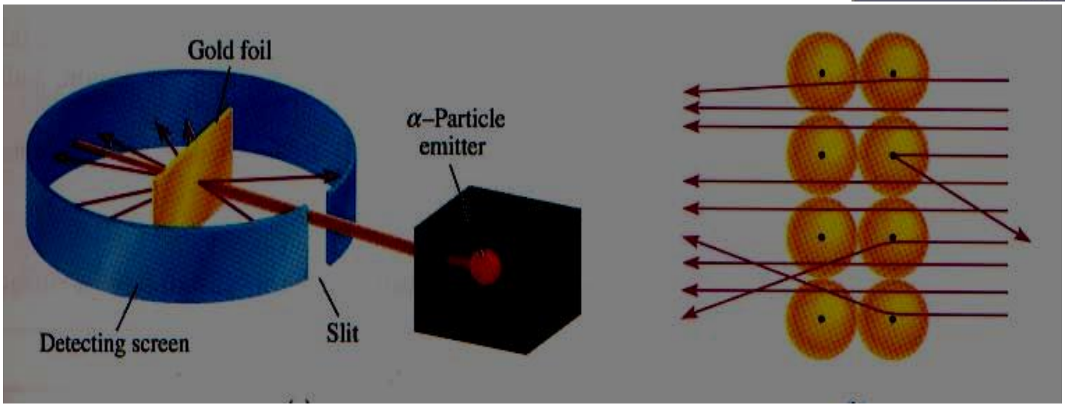
Structure of atom

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.

The picture below shows Rutheford's experiment.

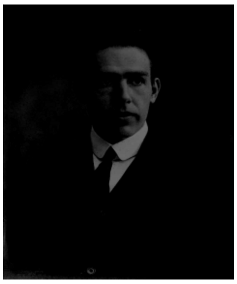






4. BOHR'S ATOM

Structure of atom



In 1915, Niels Bohr proposed his Model, it was a modification of the earlier Rutherford Model. The Bohr Model contains some errors, but it is important because **it describes most of accepted features of atomic theory without all of the high-level math of the modern version**. Bohr supposed.

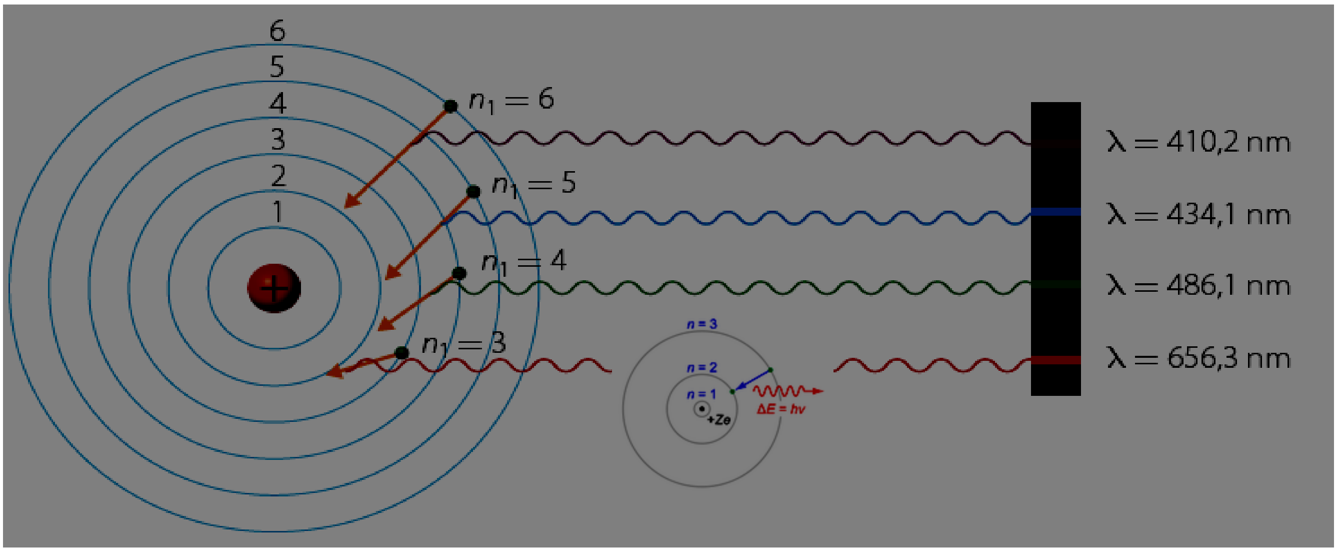
a) Electrons move in circular orbits / shells around the atomic nucleus.

b) Only **certain orbits are permitted**.

c) In these permitted orbits, the electrons would not radiate (would not create radio waves) .

d) Radiation is absorbed or emitted when an electron **moves** from **one orbit to another**. Light of certain colors (and wavelengths) would be created when the electron changed orbits.

These postulates were entirely arbitrary but could explain the most of the experiments.



5. PARTICLES OF THE ATOM

An atom is the smallest particle of any element that still retains the characteristics of that element. However, atoms consist of even smaller particles. Atoms consist of a central, dense nucleus that is surrounded by one or more lightweight negatively charged particles called **electrons**. The **nucleus** is made up of positively charged particles called **protons** and **neutrons** which are **neutral**. An atom is held together by forces of attraction between the electrons and the protons. The neutrons help to hold the protons together. Protons and neutrons are believed to be made up of even smaller particles called **quarks**. We will limit our discussions to protons, neutrons and electrons.

The properties of these particles can be summarized in the following table. These particles are tiny (minute) and it can be used another units.

Unidad de masa atómica (**u.m.a.= u**) (Atomic mass unit (amu)) $1\ u = 1{,}66.10^{-27}$ kg

Charge of electron (**e**): $1\ e = 1{,}6.10^{-19}$ C

	Proton (p)	Electron (e)	Neutron (n)
Mass	1 u	1/1840 u ≈ 0	1 u
Charge	+1 e	-1 e	0

- Atoms cannot be divided using chemicals. It is a basic chemical building of matter.

- Each **electron** has a negative electrical charge.

- Each **proton** has a positive electrical charge. The charge of a proton and a electron are equal in magnitude, yet opposite in sign.

- Each **neutron** is electrically neutral.

- Protons and neutrons are about the same size as each other are much larger than electrons.

- The mass of a proton is essentially the same as that of a neutron. The mass of a proton is 1840 times greater than the mass of an electron.

- The nucleus carries the positive electrical charge.

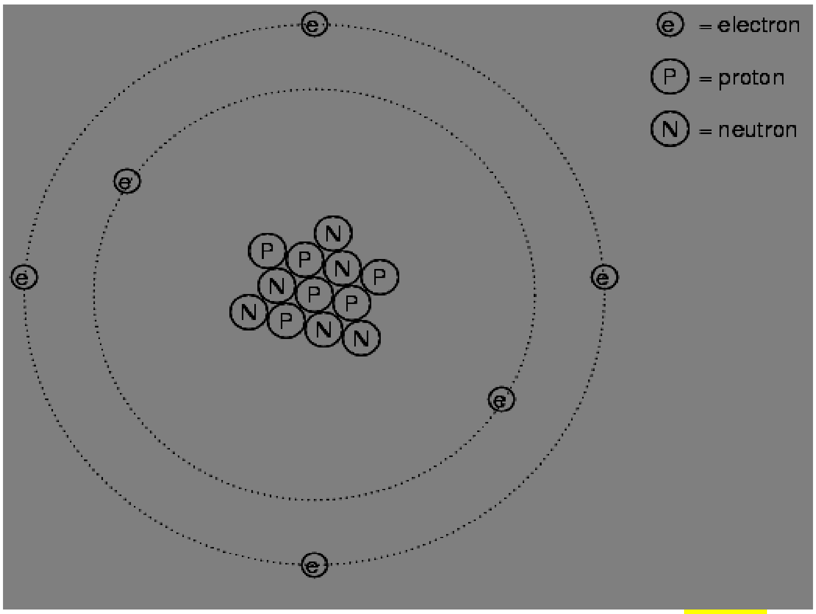
- Electron move around outside the nucleus.

- Almost of the **mass** of an atom is in its nucleus; almost all the **volume** of an atom is occupied by electrons.

- Electrons are in several energy levels (orbits). Each level contains **$2.n^2$** electrons

Nº OF ELECTRONS CONTAINED FOR EACH LEVEL (ORBIT).

Level (n)	TOTAL ELECTRONS ($2.n^2$)
1	2
2	8
3	18
4	32



6. ATOMIC MASSES.

Atoms

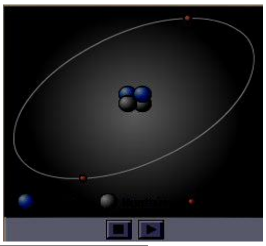
Nowadays, the atomic mass unit is the **amu**. (uma) . The amu is , aproximately, the mass of one atom of the lightest atom, the hidrogen atom. All other masses are **measured relative** to this standard.

For example, we do an experiment and find that oxygen has a mass that is 16 times that of hydrogen-1. Then the mass of one atom of oxygen-16 would be given by 1 * 16 = 16.

In this way, H is 12 times lighter than carbon-12 and its atomic mass is 1 amu. Or it is 16 times heavier that of hydrogen, it has a mass of 16 amu.

7. ATOMIC NUMBER. ATOMIC MASS NUMBER. ISOTOPES. IONS.

Building atoms



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

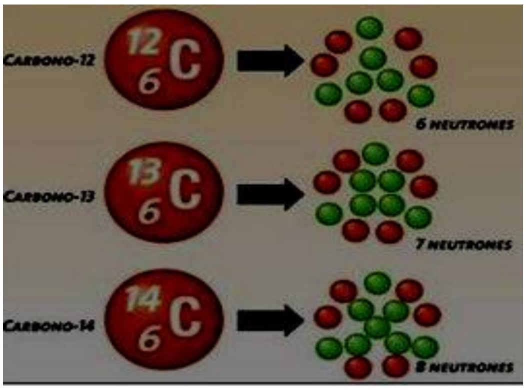
b) Atomic mass number (Número másico (A): It is the sum of the number of protons and neutrons of an atomic nucleus. It signifies/indicates the atomic mass of the atom. $A = p + n$

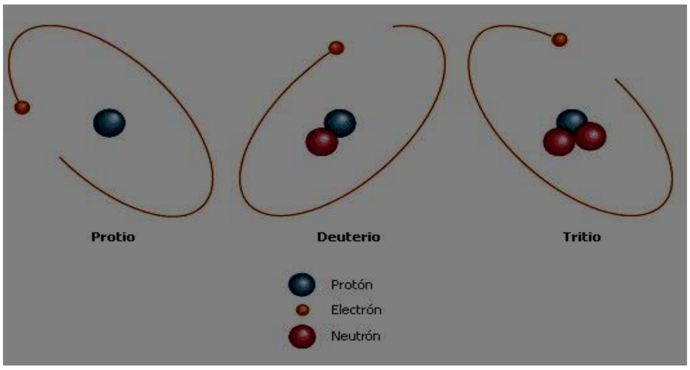
Example: ${}^{37}_{17}Cl$ has a mass number of 37. Its nucleus contains 17 protons and 20 neutrons.

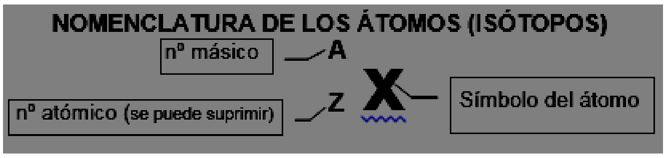
c) Isotopes: Atoms with the same number of protons, but differing numbers of neutrons. They are different forms of a single element.

Examples: Carbon-12 and carbon-14 are both isotopes of carbon, one with 6 neutrons and one with 8 neutrons (both with 6 protons).

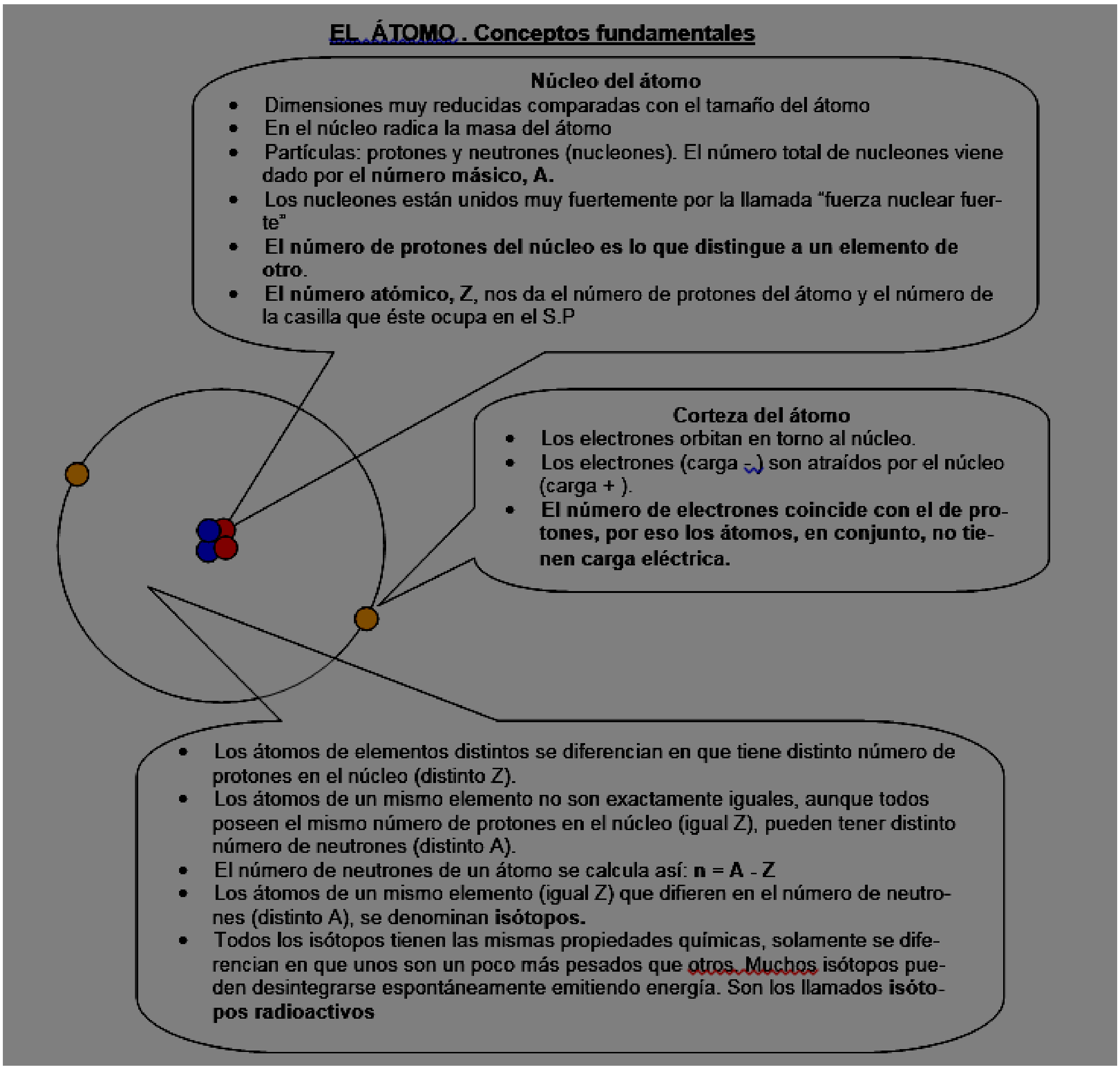
Carbon's isotopes **Hydrogen's isotopes**





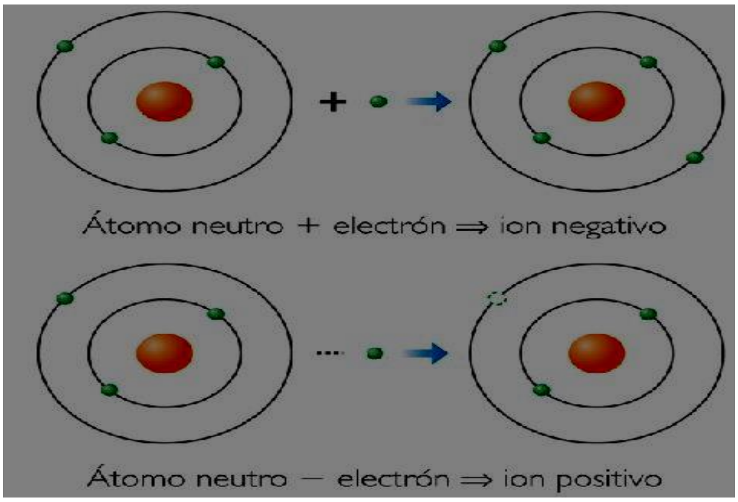


Example: $^{34}_{16}S^{2-}$ - It has got 16 **protons** and for this reason, it is sulfur (azufre)
- It has 34 – 16 = 18 **neutrons**. Its mass is 18 amus (umas)
- It has got charge of – 2 that indicates that there are 16 + 2 = 18 **electrons.**



d) Ion: An atom or molecule 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.



e) Atomic mass of an element. Its is a weighted average of all elements' isotopes based on their natural abundance. It is calculated by multiplying each istope's mass by its abundance. If the abundance is a percent, divide your answer by 100

$$Atomicmass = \frac{m_1 * \%_1 + m_2 * \%_2 + \ldots\ldots}{100}$$

For this reason, atomic mass are often decimal numbers.

Example: The element boron (boro) consists of two isotopes, ^{10}B and ^{11}B. Their masses, based on the carbon scale, are 10,01 and 11,01 , respectively. The abundance of ^{10}B is 20 %. What is the abundance of ^{11}B.

Solution: Since boron only has two isotopes, the abundance of one must be 100,0 - abundance of the other. Abundance of ^{11}B = 100,0 – abundance of ^{10}B .

Abundance of ^{11}B = 100,0 – 20,0 = 80,0 %

Example: The element boron (boro) consists of two isotopes, ^{10}B and ^{11}B. Their masses, based on the carbon scale, are 10,01 and 11,01 , respectively. The abundance of ^{10}B is 20 % and the abundance of ^{11}B is 80,0%. What is the atomic mass of boron?

Solution: Apply the following equation to the problem:

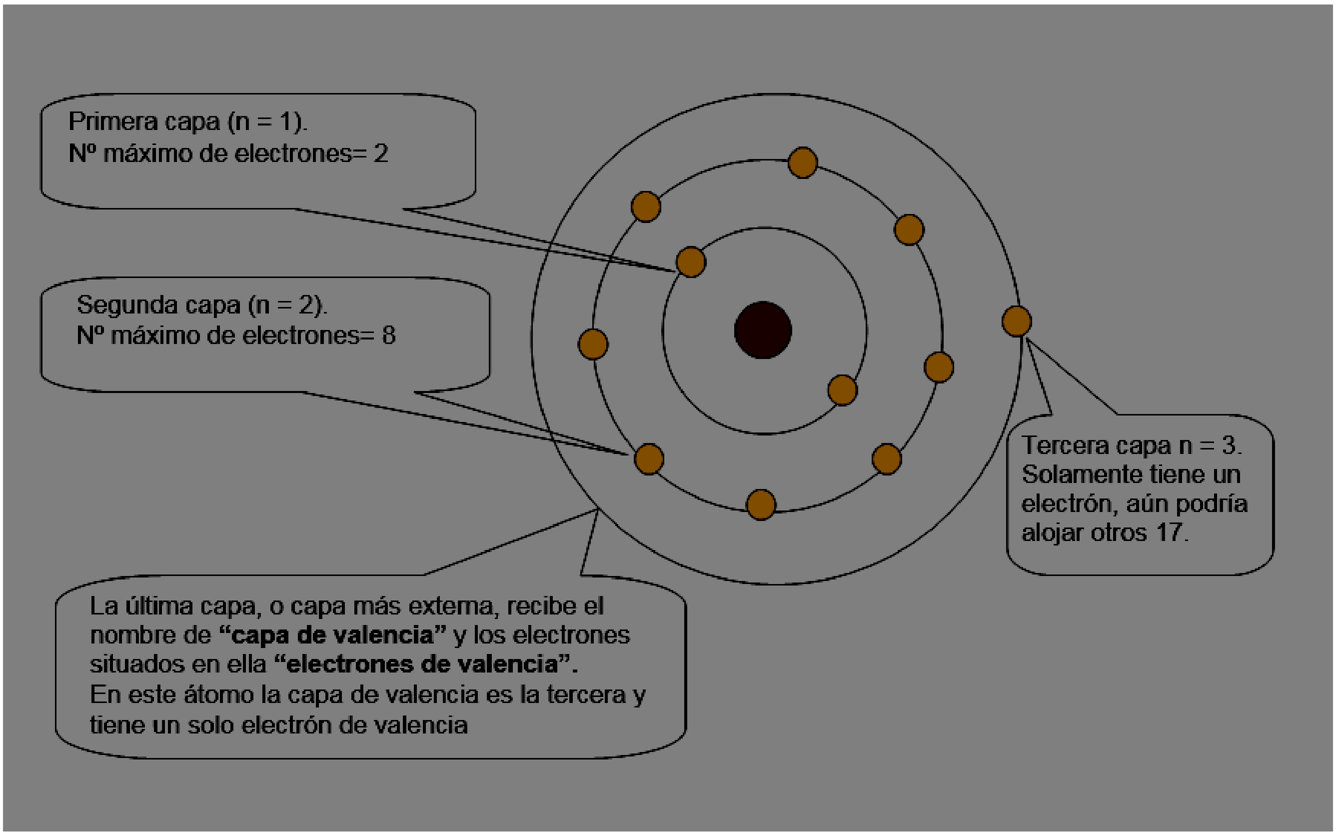
$$Atomicmass = \frac{10{,}01*20+11{,}01*80}{100} = 10{,}81u$$ **Solution: Atomic mass of B = 10,81 u**

Note that this is the value listed in the Periodic Table for the atomic mass of boron. Although the atomic number of boron is 10, its atomic mass is nearer to 11 than to 10, reflecting the fact that the heavier isotope is more abundant than the lighter isotope.

EL ÁTOMO . Estructura de la corteza

- Los electrones del átomo se distribuyen en órbitas o capas alrededor del núcleo.
- Las distintas órbitas se identifican por un número entero, **n**, llamado **número cuántico principal**. Así para la primera capa (la más próxima al núcleo n = 1; para la segunda n = 2; para la tercera n = 3...
- El número de capas u órbitas que posee un elemento viene dado por el número del periodo en que está situado en la tabla periódica
- Para distribuir los electrones en las capas se deben tener en cuenta unas reglas obtenidas de la experimentación:
    1. Las capas se van llenando por orden: primero se llena la de n = 1, a continuación n= 2, después n = 3 ...
    2. No se puede empezar a llenar un nivel superior si aún no está lleno el inferior.
    3. El número máximo de electrones que se puede alojar en cada capa es:

n	nº máx electrones
1	2
2	8
3	18
4	32



EL ÁTOMO . Configuración electrónica

- Los electrones se distribuyen en las capas ocupando los distintos niveles que en ellas existen

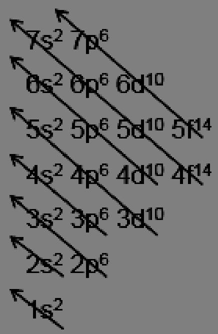
CAPA	NIVELES
1	s
2	s, p
3	s, p, d
4	s, p, d, f
5	s, p, d, f
6	s, p, d, f
7	s, p, d, f

- Cada nivel puede alojar un número màximo de electrones

NIVELES	Nº Max
s	2
p	6
d	10
f	14

- Los niveles se van llenando por orden y hasta que un nivel no está totalmente lleno no se pasa a llenar el siguiente

- El orden de llenado de los niveles se obtiene a partir del diagrama de Möeller:



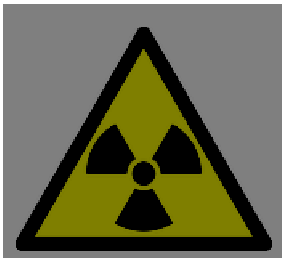
Para obtener la configuración electrónica de un átomo:

1. **Considera el número de electrones que debes distribuir**. Recuerda que el número de electrones en un átomo neutro viene dado por el número atómico Z.
2. **Vete colocando los electrones por orden** en los niveles de cada capa. Cuando un nivel se complete, pasa al siguiente (ayúdate del diagrama de Möeller)
3. Cuando hayas colocado todos los electrones habrás terminado.

Ejemplos

Li	**Z = 3**	$1s^2 2s^1$
N	**Z = 7**	$1s^2 2s^2 p^3$
Mg	**Z = 12**	$1s^2 2s^2 p^6 3s^2$
Si	**Z = 14**	$1s^2 2s^2 p^6 3s^2 p^2$
S	**Z = 16**	$1s^2 2s^2 p^6 3s^2 p^4$
Ar	**Z = 18**	$1s^2 2s^2 p^6 3s^2 p^6$
Ti	**Z = 22**	$1s^2 2s^2 p^6 3s^2 p^6 4s^2 3d^2$
Au	**Z = 79**	$1s^2 2s^2 p^6 3s^2 p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 4f^{14} 5d^9$
U	**Z = 92**	$1s^2 2s^2 p^6 3s^2 p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 4f^{14} 5d^{10} 6p^6 7s^2 4f^4$

8. RADIOACTIVITY.



Unstable atomic nuclei will spontaneously decompose to form nuclei with higher stability. The decomposition process is called **radioactivity**.

The **energy** and **particles** which are released during the decomposition process are called **radiation**.

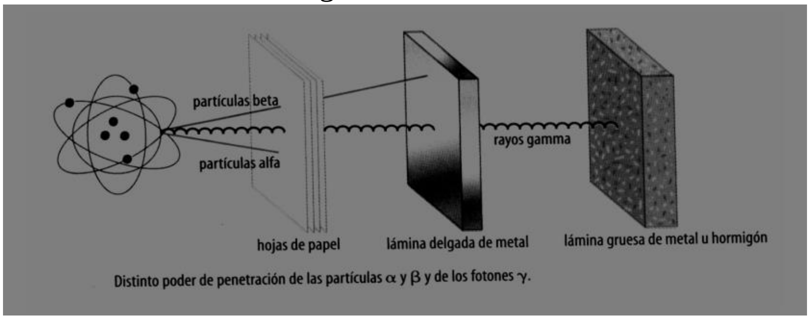
Radioactivity releases a great amount of energy because part of **nuclear mass** become energy ($E = m c^2$).

There are three types of radiations: α, β and γ.

a) Alpha Radiation. (α). It consists of a stream of positively charged particles, called alpha particles, which have an atomic mass of 4 and a charge of +2 (a helium nucleus).

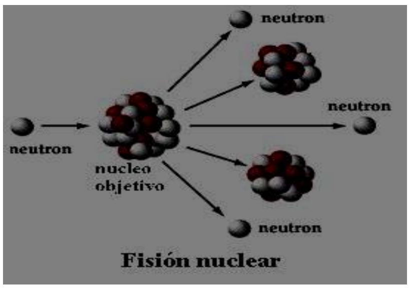
b) Beta Radiation. β. It is a stream of electrons (from nucleus), called beta particles. When a beta particle is ejected, a neutron in the nucleus is converted to a proton, so the mass number of the nucleus is unchanged, but the atomic number increases by one unit.

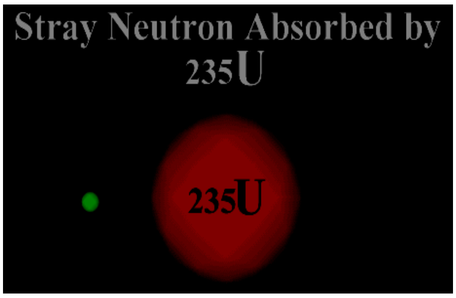
c) Gamma Radiation. γ. It is high-energy photons. This emission results from an energy change within the atomic nucleus. This radiation changes neither the atomic number nor the atomic mass.

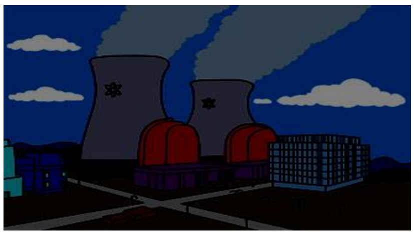


A huge amount of energy can be obtained by transforming small amounts of matter into energy. ($E = m c^2$). There are two methods :

8.1. NUCLEAR FISSION. A heavy nucleus (uranium, plutonium, etc...) splits into several smaller fragments. These fragments, or fission products, are about equal to half the original mass. Two or three neutrons are also emitted. This fact can made possible a chain reaction with an unprecedented energy yield.



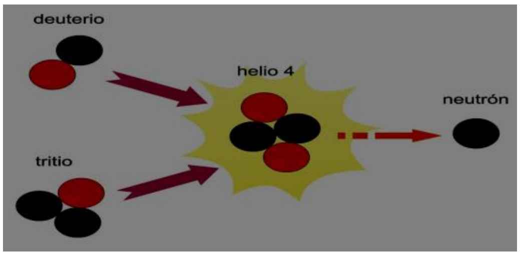


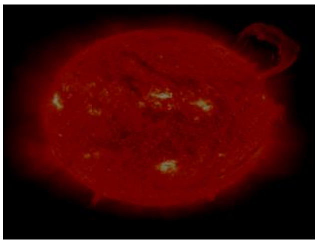


Advantages: The fission process has a high energy efficiency, 1 Kg of uranium produces as much energy as 2000 tons of oil.

Disadvantages: It presents risk of radioactive contamination and it exists difficulty to eliminate waste (thousand years).

8.2. NUCLEAR FUSSION. It joins two light elements (usually hydrogen), forming a more massive element (helium), releasing a tremendous amount of energy in the process. It has been used as a bomb (H bomb). Nowadays, its peaceful use is being researched.





Advantages: A lot more energy than fission can be obtained. There are large reserves of energy (hydrogen from ocean water) and it almost does not produce waste or polluting substances.

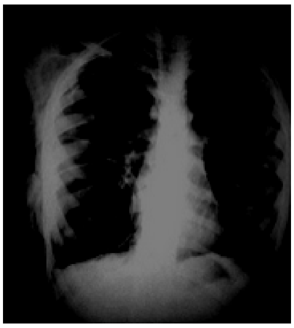
Disadvantages: It is necessary a extremely high temperature (about million of degrees) to start the nuclear reaction (lasers are used to reach this temperatures). Magnetic fields are used to keep this matter in a determine space. All these process are being researched.

8.3. APPLICTIONS OF RADIACTIVITY AND RADIOISOTOPES. LINK

Radioactive isotopes (radioisotopes) are not always harmful, they find numerous uses in different areas such as medicine, chemistry, biology, archaeology, agriculture, industry and engineering.

8.1. Determination of age of minerals and rocks and archaeological objects. Many minerals contain radioactive isotopes. The age of any of these minerals can be determined by counting the isotopes in the mineral and using the known decay rate to calculate the time required in that process. Example: Radiocarbon dating (prueba del carbono 14) **LINK Carbono 14**

8.2. Medicine. Sterilization of surgical equipment, cancer treatment and study of organs, forensic investigations



8.3. Industry. X-rays to examine steel plates, welding and construction.

8.4. Scientific research and experiments. Study reaction mechanisms and chemical manufacturing.

8.5. Energy source.

8.6. Others. Auxiliary generator for satellites, precision clocks, sterilization of agricultural pests.

ACTIVITIES

Ejercicios

1º Halla la Masa atómica del C, sabiendo que tiene 2 isótopos estables, el C-12 y el C-13, y que la abundancia isotópica de este último es del 1,1%.

Sol.: 12,01 u

2º Sabiendo que la Masa atómica del N es de 14,0067 u, y que existen dos isótopos estables, N-14 y N-15, halla la abundancia isotópica de cada uno de ellos.

Sol.: 99,6 y 0,4%

3º Indicate how many protons, neutrons and electrons have the following items. Also indicate, the electric charge. Some of them are isotopes?

$^{1}_{1}H$; $^{17}_{8}O$, $^{60}_{28}Ni$; $^{26}_{13}Al^{3+}$; $^{16}_{8}O$; $^{29}_{14}Si$; $^{35}_{17}Cl^{-}$; $^{2}_{1}H$

4º Haz la configuración electrónica de los átomos anteriores.

5º Explica la diferencia entre los tres tipos de radiaciones radiactivas.

6º ¿Cuál es la principal diferencia entre la fisión y la fusión nuclear?

LINKS

1) http://www.ndt-ed.org/EducationResources/HighSchool/Electricity/atommodels.htm
2) http://www.regentsprep.org/regents/physics/phys05/catomodel/default.htm
3) http://www.commonsensescience.org/atom_models.html
4) http://chemistry.about.com/od/chemistryforkids/Chemistry_for_Kids.htm
5) http://www.chem4kids.com/files/atom_intro.html
6) http://www.iun.edu/~cpanhd/C101webnotes/index.html
7) http://www.kentchemistry.com/links/Nuclear/radioisotopes.htm
8) http://chemistry.tutorvista.com/nuclear-chemistry/application-of-radioactivity.html
9) http://library.thinkquest.org/17940/texts/fission/fission.html

FisQuiWeb

1,008 **1** **H** Hidrógeno																	4,002 **2** **He** Helio
6,941 **3** **Li** Litio	9,012 **4** **Be** Berilio											10,811 **5** **B** Boro	12,010 **6** **C** Carbono	14,007 **7** **N** Nitrógeno	15,999 **8** **O** Oxígeno	18,998 **9** **F** Flúor	20,180 **10** **Ne** Neón
22,989 **11** **Na** Sodio	24,305 **12** **Mg** Magnesio											26,981 **13** **Al** Aluminio	28,086 **14** **Si** Silicio	30,974 **15** **P** Fósforo	32,065 **16** **S** Azufre	35,453 **17** **Cl** Cloro	39,948 **18** **Ar** Argón
30,098 **19** **K** Potasio	40,078 **20** **Ca** Calcio	44,955 **21** **Sc** Escandio	47,867 **22** **Ti** Titanio	50,942 **23** **V** Vanadio	51,996 **24** **Cr** Cromo	54,938 **25** **Mn** Manganeso	55,845 **26** **Fe** Hierro	58,933 **27** **Co** Cobalto	58,693 **28** **Ni** Níquel	63,546 **29** **Cu** Cobre	65,409 **30** **Zn** Zinc	69,723 **31** **Ga** Galio	72,64 **32** **Ge** Germanio	74,921 **33** **As** Arsénico	78,96 **34** **Se** Selenio	79,904 **35** **Br** Bromo	83,798 **36** **Kr** Kriptón
85,468 **37** **Rb** Rubidio	87,62 **38** **Sr** Estroncio	88,905 **39** **Y** Itrio	91,224 **40** **Zr** Zirconio	92,906 **41** **Nb** Niobio	95,94 **42** **Mo** Molibdeno	(98) **43** **Tc** Tecnecio	101,07 **44** **Ru** Rutenio	102,91 **45** **Rh** Rodio	106,42 **46** **Pd** Paladio	107,87 **47** **Ag** Plata	112,41 **48** **Cd** Cadmio	114,82 **49** **In** Indio	118,71 **50** **Sn** Estaño	121,76 **51** **Sb** Antimonio	127,60 **52** **Te** Teluro	126,90 **53** **I** Yodo	131,29 **54** **Xe** Xenón
132,91 **55** **Cs** Cesio	137,33 **56** **Ba** Bario	138,91 **57** **La** Lantano	178,49 **72** **Hf** Hafmio	180,95 **73** **Ta** Tántalo	183,84 **74** **W** Wolframio	186,21 **75** **Re** Renio	190,23 **76** **Os** Osmio	192,22 **77** **Ir** Iridio	195,08 **78** **Pt** Platino	196,97 **79** **Au** Oro	200,59 **80** **Hg** Mercurio	204,38 **81** **Tl** Talio	207,2 **82** **Pb** Plomo	208,98 **83** **Bi** Bismuto	(209) **84** **Po** Polonio	(210) **85** **At** Astato	(222) **86** **Rn** Radón
(223) **87** **Fr** Francio	(226) **88** **Ra** Radio	(227) **89** **Ac** Actinio	(261) **104** **Rf** Rutherfodio	(262) **105** **Db** Dubnio	(266) **106** **Sg** Seaborgio	(264) **107** **Bh** Bohrio	(227) **108** **Hs** Hassio	(268) **109** **Mt** Meitnerio	(271) **110** **Ds** Darmstadtio	(272) **111** **Rg** Roentgenio	(285) **112** **Cn** Copernicio	**113**	**114** **Fl** Flerovio	**115**	**116** **Lv** Livermo-rio	**117**	**118**

140,12 **58** **Ce** Cerio	140,91 **59** **Pr** Praseodimio	144,24 **60** **Nd** Neodimio	(145) **61** **Pm** Prometio	150,36 **62** **Sm** Samario	151,96 **63** **Eu** Europio	157,25 **64** **Gd** Gadolinio	158,93 **65** **Tb** Terbio	162,50 **66** **Dy** Disprosio	164,93 **57** **Ho** Holmio	167,26 **68** **Er** Erbio	168,93 **69** **Tm** Tulio	173,04 **70** **Yb** Yterbio	174,97 **71** **Lu** Lutecio

232,04 **90** **Th**	231,04 **91** **Pa**	238,03 **92** **U**	(237) **93** **Np**	(244) **94** **Pu**	(243) **95** **Am**	(247) **96** **Cm**	(247) **97** **Bk**	(251) **98** **Cf**	(252) **99** **Es**	(257) **100** **Fm**	(258) **101** **Md**	(259) **102** **No**	(262) **103** **Lr**