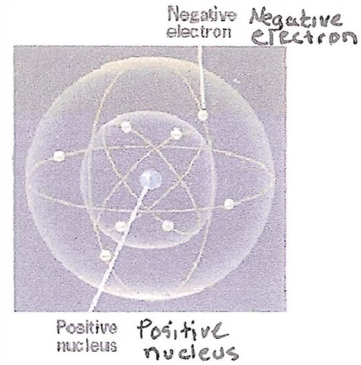
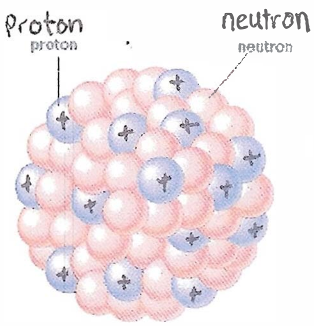
Module 3- Periodic Table and Atomic Models

1. ATOMIC NUMBER AND MASS NUMBER



Rutherford discovered that the atom consisted of a nucleus which contains protons and neutrons. The electrons orbit around the nucleus.

Protons and neutrons have roughly the same mass, and each is about 2000 times as massive as the electron. Therefore we can say that most of the mass of the atom is located in the nucleus.



Facts about atom:

- The number of protons is the same as the number of electrons.
- For any given element, all nuclei have the same number of protons, but the number of neutrons may vary.
- The charge on the electron is $-e$. The charge on the proton is $+e$.
- The charge on the neutron is zero.

Remember: The elementary unit of charge is $e = 1.602 \times 10^{-19}$ C.

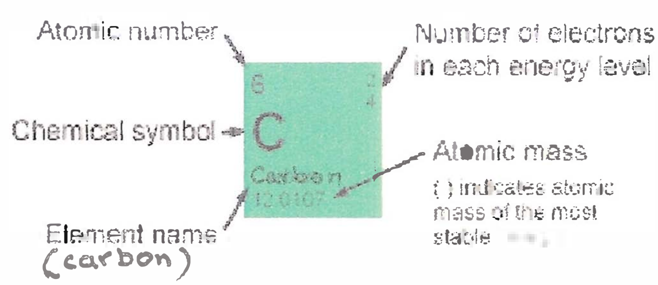
– Atomic **Number** is the number of protons in the nucleus, which is the same as the number of electrons in a neutral atom.

– Mass Number is the total number of neutrons and protons in the nucleus which is equal to the approximate mass of the atom to the nearest integer. (In fact the atomic mass is the sum of the masses of all the atom's components i.e., electrons, protons, and neutrons. As the electron's mass is too small, we may treat their contribution to the atomic mass as negligible.)

2. PERIODIC TABLE

The Periodic table is a listing of all known elements with their chemical symbols, atomic numbers, and atomic masses along with other information as shown in the table on page 3.

The way the table is organized in groups tells us a lot about these elements' structure and their properties. The on the right provides a key to read and understand the periodic table. Each horizontal row is called a **period** and each vertical column is called a **group**.



Periodic Table of the Elements

- Alkali metals
- Alkaline earth metals
- Transition metals
- Lanthanide series
- Actinide series
- Poor metals
- Nonmetals
- Noble gases
- C Solid
- Liquid
- Gas
- Tc Synthetic

New / Original

	1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 —	9 VIIIB	10 —	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1	1 H Hydrogen 1.00794																	2 He Helium 4.002602
2	3 Li Lithium 6.941	4 Be Beryllium 9.012182											5 B Boron 10.811	6 C Carbon 12.0107	7 N Nitrogen 14.00674	8 O Oxygen 15.9994	9 F Fluorine 18.9984032	10 Ne Neon 20.1797
3	11 Na Sodium 22.989770	12 Mg Magnesium 24.3050											13 Al Aluminum 26.981538	14 Si Silicon 28.0855	15 P Phosphorus 30.973761	16 S Sulfur 32.066	17 Cl Chlorine 35.453	18 Ar Argon 39.948
4	19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.955910	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938049	26 Fe Iron 55.8457	27 Co Cobalt 58.933200	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.409	31 Ga Gallium 69.723	32 Ge Germanium 72.64	33 As Arsenic 74.92160	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.798
5	37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.90585	40 Zr Zirconium 91.224	41 Nb Niobium 92.90638	42 Mo Molybdenum 95.94	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.90550	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	52 Te Tellurium 127.60	53 I Iodine 126.90447	54 Xe Xenon 131.293
6	55 Cs Cesium 132.90545	56 Ba Barium 137.327	57 to 71	72 Hf Hafnium 178.49	73 Ta Tantalum 180.9479	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.078	79 Au Gold 196.96655	80 Hg Mercury 200.59	81 Tl Thallium 204.3833	82 Pb Lead 207.2	83 Bi Bismuth 208.98038	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
7	87 Fr Francium (223)	88 Ra Radium (226)	89 to 103	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (266)	107 Bh Bohrium (264)	108 Hs Hassium (269)	109 Mt Meitnerium (268)	110 Ds Darmstadtium (271)	111 Rg Roentgenium (272)	112 Uub Ununbium (285)	113 Uut Ununtrium (284)	114 Uuq Ununquadium (289)	115 Uup Ununpentium (288)	116 Uuh Ununhexium (292)	117 Uus Ununseptium	118 Uuo Ununoctium

Atomic masses in parentheses are those of the most stable or common isotope.

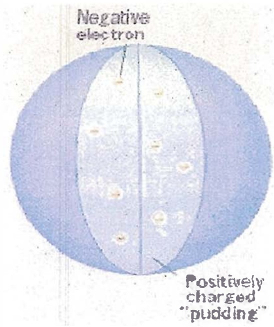
57 La Lanthanum 138.9055	58 Ce Cerium 140.116	59 Pr Praseodymium 140.90765	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92534	66 Dy Dysprosium 162.500	67 Ho Holmium 164.93032	68 Er Erbium 167.259	69 Tm Thulium 168.93421	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.967
89 Ac Actinium (227)	90 Th Thorium 232.0381	91 Pa Protactinium 231.03588	92 U Uranium 238.02891	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)

Note: The subgroup numbers 1-18 were adopted in 1984 by the International Union of Pure and Applied Chemistry. The names of elements 112-118 are the Latin equivalents of those numbers.

1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Uub		114 Uuq		116 Uuh		118 Uuo

57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb
89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No

3. THE STRUCTURE OF THE ATOM



Earlier model

The atom was once thought to be a solid ball of positive material with pudding-like consistency with electrons placed as shown in the figure. The atom was supposed to be of a uniform density.

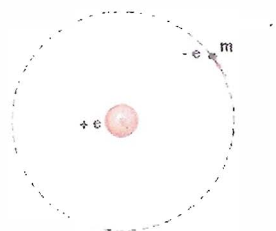
This was an incorrect model of the atom.

Rutherford Model

Ernest Rutherford was the first to show that the atom does not have a uniform density, and that most of its mass is located at its center.

Based on his alpha-particle scattering experiment on gold, Rutherford concluded that the atom consisted of a hard central core where most of the mass of the atom is present.

Ernest Rutherford won 1908 Nobel Prize for studies in radioactivity.

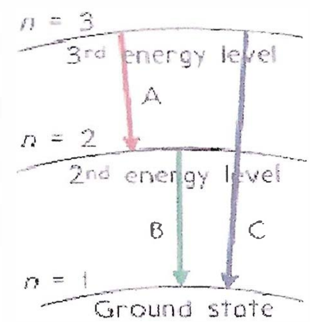


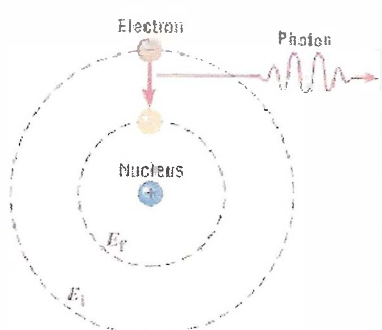
Bohr's model

Neils Bohr, a Danish physicist, treated the hydrogen atom as if it were an electron of charge -e orbiting in a circular path about a proton of charge +e.

Energy levels in hydrogen

Bohr also suggested that the electrons may reside in various energy levels of the atom. Three such levels are shown in the figure. In this figure "n" is the **principle quantum number** which is always an integer. n = 1 is the ground state, n = 2 is the 2nd energy level, n = 3 is the 3rd energy level, and so on. The electron can undergo a transition from a lower to higher or from a higher to lower energy level.





Energy transitions in atoms

When an atom absorbs some energy the electron can jump to a higher energy level. But the electron cannot stay in this energetic state for a long time and it will fall back to its original energy level after emitting light. This light consists of discrete particles called ***"photons"***. For such transitions we can say that:

(i) *Energy of photon = Energy lost by electron*

(ii) The energy of the emitted photon is equal to the difference in energy between the two levels involved in the transition.

4. RADIOACTIVITY

Radioactivity is a process by which certain elements (with unstable nuclei, e.g., U_{238}, C_{14}, etc.) emit particular forms of radiation and decay into another element.

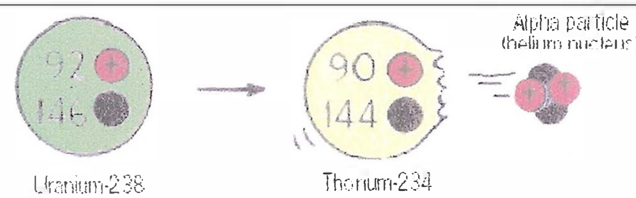
There are three major forms of radiations known as ***alpha***, (α) ***beta*** (β), **and** ***gamma*** (γ) radiation.

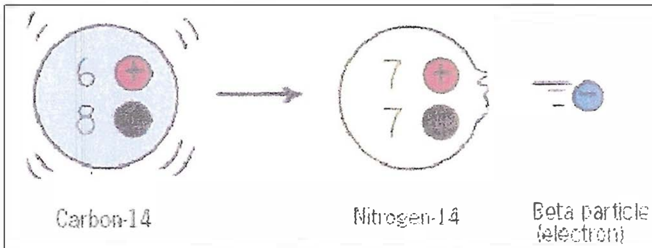
The first particle/radiation discovered in such a decaying process of an unstable nucleus was called an alpha particle because alpha is the first letter of the Greek alphabet.

An element that emits any of these forms of radiation is called a **radioactive element**.

Alpha emission

U_{238} emits an alpha-particle and decays into Th_{234} element as shown. Alpha particle consists of two protons and two neutrons, which is the same as a helium nucleus.



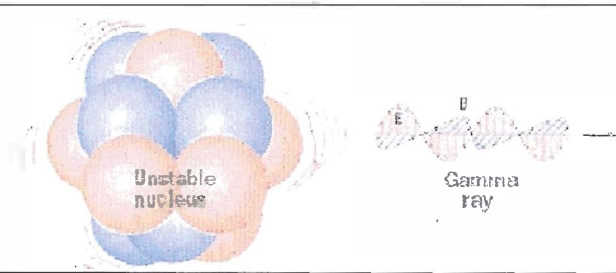


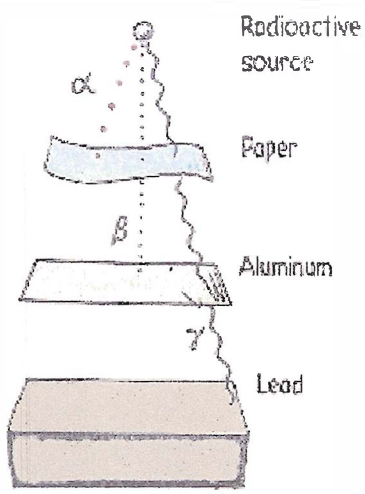
Beta emission

C_{14} emits a beta-particle and decays into N_{14} element as shown. The beta particle is just an electron.

Gamma emission

Nuclei with excess energy emit gamma-rays which have extremely short-wavelength (very high energy $E = h\upsilon$) electromagnetic waves or photons.





Blocking radiation

Alpha particles are 8,000 times as heavy as beta particles.

Paper or clothing can easily block alpha particles, while beta particles require a few sheets of aluminum foil.

Gamma radiations are extremely dangerous, a thousand times more dangerous than x-rays. They can easily penetrate most of the material except materials that are extremely dense such as lead (Pb). Thick lead slabs are normally used to block gamma radiations in hospitals, nuclear plants etc. to minimize their harmful effects.