

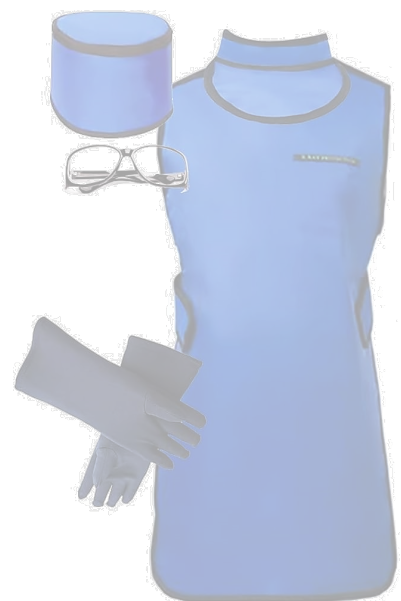
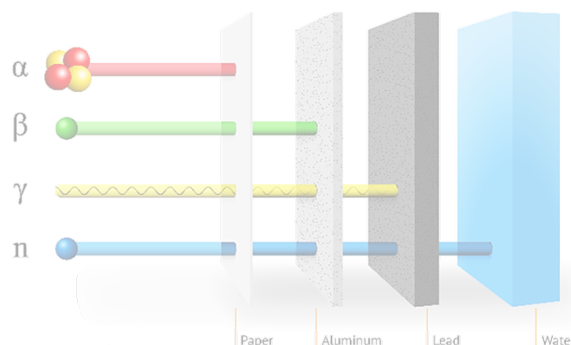
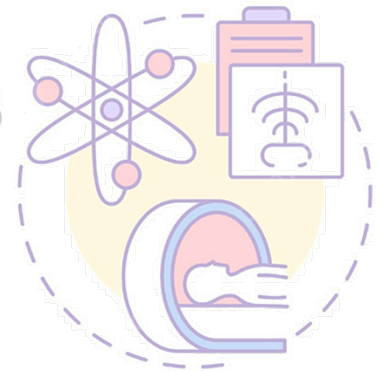
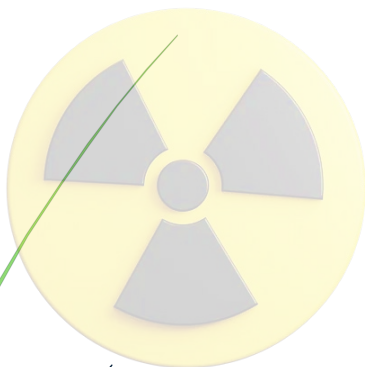
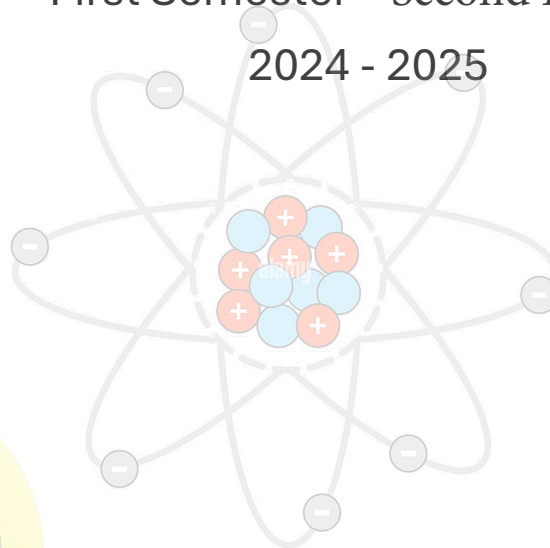


Radiation Protection

The Second Stage

First Semester – Second Lecture

2024 - 2025



Asses. Prof.: Mahmoud Abdelhafez Kenawy

Introduction to the Radiation

OUTLINES:

- Atomic Theory.
- Structure of Atom.

N_A	Avogadro's number	$=6.022 \times 10^{23}$	Atom/mol	$=6.022 \times 10^{23}$	mol^{-1}
C	Speed of light in vacuum	$=3 \times 10^8$	m/s	$=300,000$	kilometers / second
e	Electron charge	$=1.6 \times 10^{19}$	Ampere. Second	$=1.6 \times 10^{-19}$	coulomb
m_e	Electron rest mass	$=0.511$	Mev/c ²	$=9.109 \times 10^{-31}$	kilograms
m_p	Proton rest mass	$=938.2$	Mev/c ²	$=1.67262 \times 10^{-27}$	kilograms
m_n	Neutron rest mass	$=939.3$	Mev/c ²	$=1.67262 \times 10^{-27}$	kilograms
u	Atomic mass unit	$=931.5$	Mev/c ²	$=931.5$	Mev/c ²

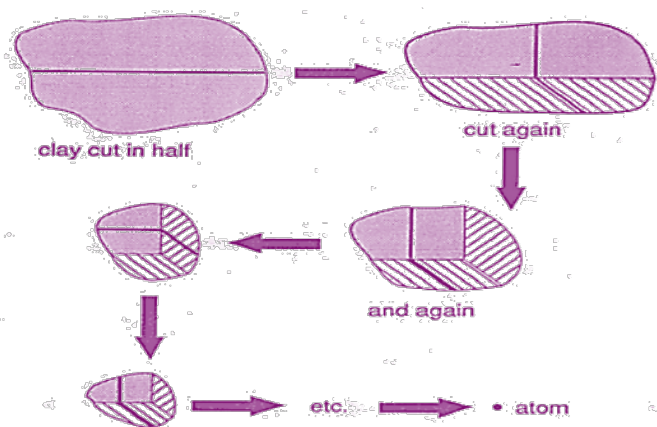
PROTON VERSUS POSITRON

Proton is a subatomic particle with a positive electrical charge of +1	Positron is the antiparticle or the antimatter counterpart of the electron
Mass is 1.6726×10^{-24} g	Mass is 9.1094×10^{-28} g
Atomic mass is 1.0073 amu	Atomic mass is 0.00054858 amu
Responsible for the atomic number of a chemical element	Antiparticles of electrons
Do not undergo annihilation	Undergo annihilation

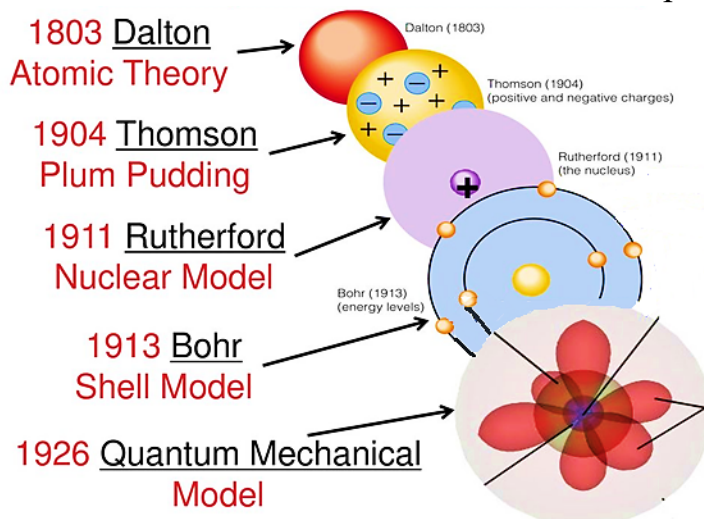
Atomic Theory

The idea of an atom first originated with the Greeks. The thinking was that if one were to cut an object with a knife, one would get pieces that are smaller than the original. Keep this process up and one gets smaller and smaller pieces. It seemed logical that if one continued this process long enough one would reach a point.

Where one has a piece that cannot be cut further. They called these pieces “Atoms” which means indivisible.



- Later in the early 19th century **John Dalton** gave this idea a shot in the arm by proposing that matter is composed of atoms and that these atoms are the basic units of chemical reactions.
- In 1904, **Thompson** develops the idea that an atom was made up of electrons scattered unevenly within an elastic sphere surrounded by a soup of positive charge to balance the electron's charge. It is called the plum pudding model.
- The British physicist **Rutherford** postulated, in 1911, that the positive charge in an atom was concentrated in a central massive point called the nucleus and that the negative electrons were situated at some remote points.



Structure of Atom

Atom is the basic building block of all matter.

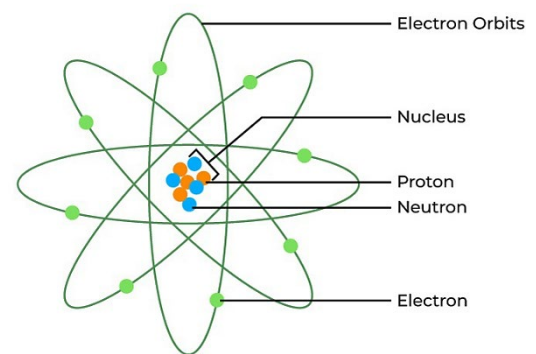
A simple theory of the atom tells us that it consists of Two Components: a Nucleus surrounded by an Electron cloud.

The situation can be considered as being similar in some respects to planets orbiting the sun.

The nucleus discovered by Rutherford is made of one or more protons and a number of neutrons. Only the most common variety of hydrogen has no neutrons. Protons and neutrons are called nucleons.

- The protons have a positive electric charge.
- The electrons have a negative electric charge.
- The neutrons have no electric charge.

The atomic structure of an element refers to the constitution of its nucleus (including protons and neutrons) and the arrangement of the electrons around it (in the orbital).



- Protons:

- ✓ Protons are positively charged subatomic particles.
- ✓ The charge of a proton is ($1e$), which corresponds to approximately $+1.602 \times 10^{-19}$ coulomb.
- ✓ The mass of a proton is approximately 1.672×10^{-27} Kilograms.
- ✓ Protons are over 1800 times heavier than electrons.
- ✓ The total number of protons in the atoms of an element is always equal to the atomic number of the element.

- Neutrons:

- ✓ The mass of a neutron is almost the same as that of a proton, i.e., 1.674×10^{-27} kg.
- ✓ Neutrons are electrically neutral particles and carry no charge.

- ✓ Different isotopes of an element have the same number of protons but vary in the number of neutrons present in their respective nuclei.
- Electrons:
 - ✓ The charge of an electron is $-1e$, which approximates to -1.602×10^{-19} coulomb.
 - ✓ The mass of an electron is approximately 9.1×10^{-31} kg.
 - ✓ Due to the relatively negligible mass of electrons, they are ignored when calculating the mass of an atom.

Definition:

Atomic mass unit: Masses of atoms and atomic particles are conveniently given in terms of atomic mass unit (AMU), an AMU is defined as $1/12$ of the mass of a $^{12}_6\text{C}$ atom, which equal to 1.674×10^{-27} kg.

Name	Symbol	Absolute charge/C	Relative charge	Mass/kg	Mass/u	Approx. mass/u
Electron	e	-1.6022×10^{-19}	-1	9.10939×10^{-31}	0.00054	0
Proton	p	$+1.6022 \times 10^{-19}$	+1	1.67262×10^{-27}	1.00727	1
Neutron	n	0	0	1.67493×10^{-27}	1.00867	1

Atomic Number (Z) and Mass Number (A)

The atomic number of an element is determined by the number of protons in it, and it is used to differentiate one element from another.

The mass number of an element is determined by the number of protons and neutrons combined.

Mass number
Number of protons and neutrons in atom

Atomic symbol
Abbreviation used to represent atom in chemical formulas

Atomic number
Number of protons in atom

Problem 1:

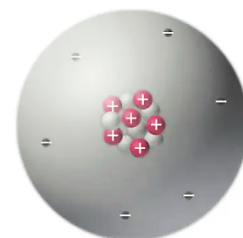
Calculate the number of protons, neutrons, and electrons in $^{40}_{91}\text{Zr}$.

Solution:

In this case: $Z=40$; $A=91$; number of protons = number of electrons = 40 in a neutral atom.

Number of neutrons = $91 - 40 = 51$.

$^{12}_6\text{C}$
6 protons
6 neutrons
6 electrons

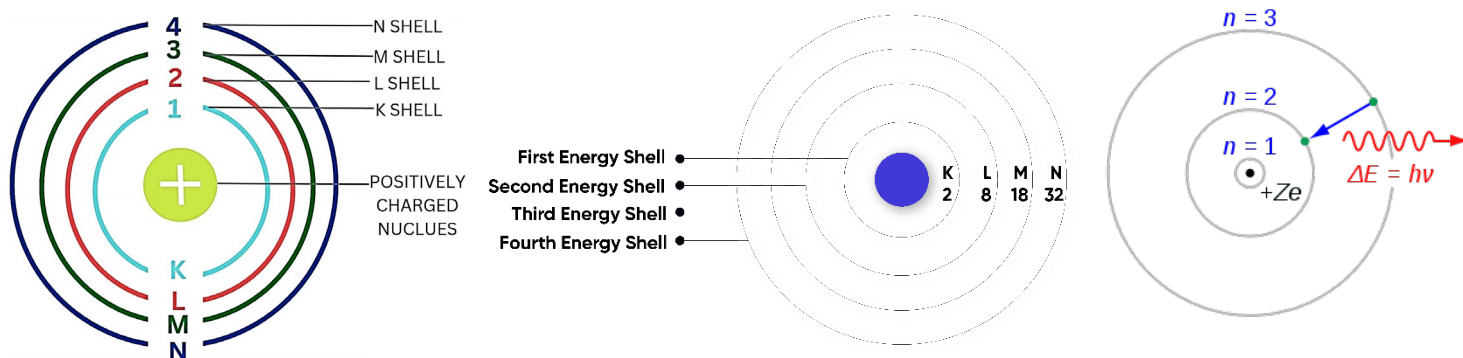


Bohr's Atomic Theory (Bohr's model):

Bohr's model consists of a small nucleus (positively charged) surrounded by negative electrons moving around the nucleus in orbits. Bohr found that an electron located away from the nucleus has more energy, and the electron which is closer to nucleus has less energy.

Postulates of Bohr's Model of an Atom

- The atom looks like a vacuum and its mass concentrated in the nucleus.
- In an atom, electrons (negatively charged) revolve around the positively charged nucleus in a definite circular path called orbits or shells.
- Each orbit or shell has a fixed energy and these circular orbits are known as orbital shells.
- The energy levels are represented by an integer ($n=1, 2, 3\dots$) known as the quantum number. This range of quantum numbers starts from nucleus side with $n=1$ having the lowest energy level. The orbits $n=1, 2, 3, 4\dots$ are assigned as K, L, M, N.... shells and when an electron attains the lowest energy level, it is said to be in the ground state.
- The electrons in an atom move from a lower energy level to a higher energy level by gaining the required energy and an electron moves from a higher energy level to lower energy level by losing energy.



Atomic gram – atom: is the number of grams of atomic compound that contains exactly one Avogadro's number of atoms.