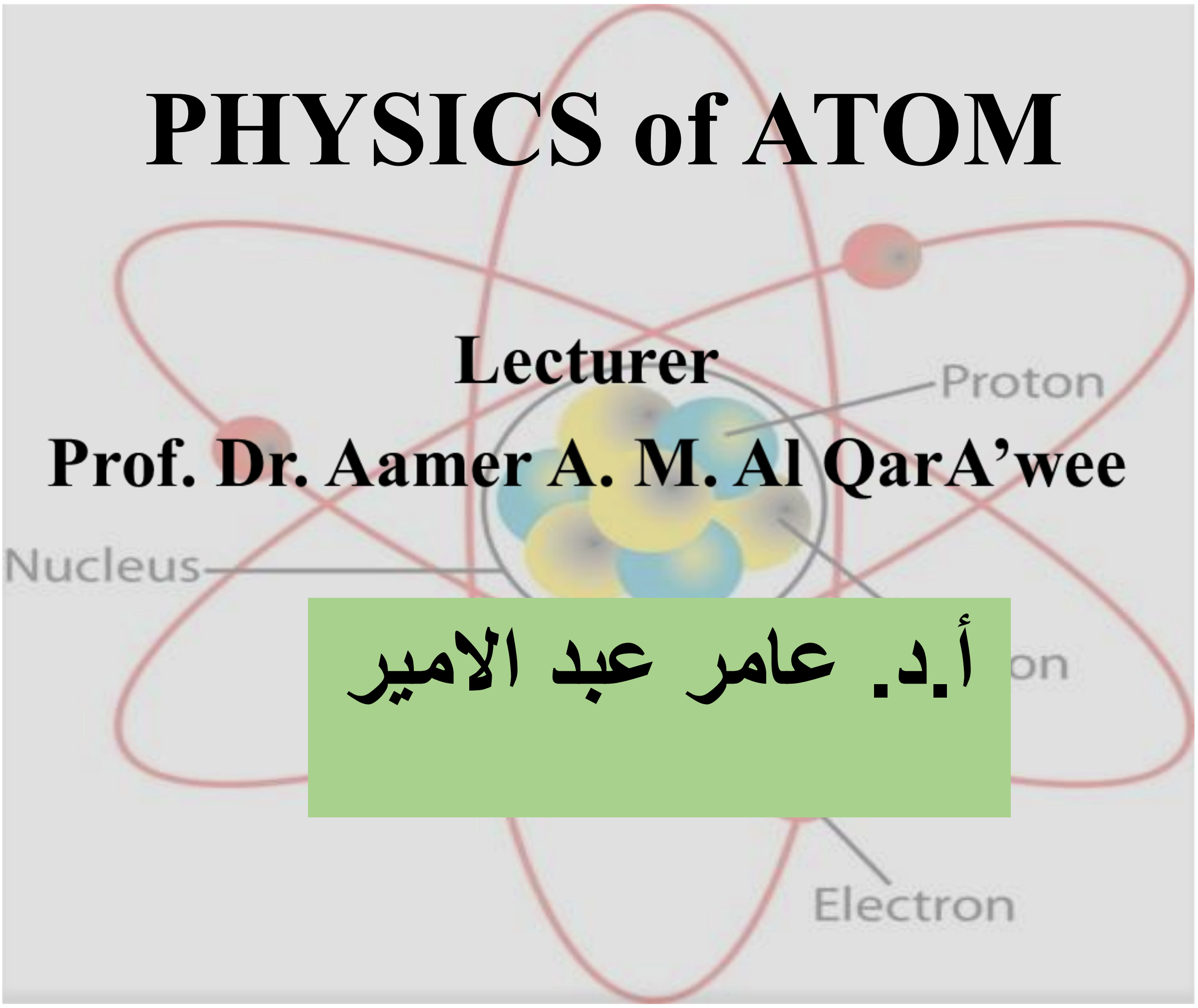
Al-Mustaqbal University
College of Health and
Medical Techniques
Radiological Techniques
Department



PHYSICS of ATOM

Lecturer

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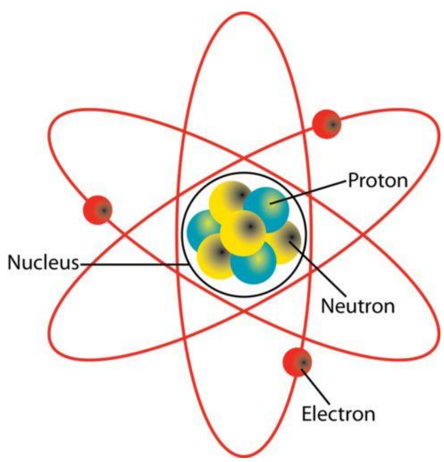
Chapter One
Atomic and Nuclear Structure

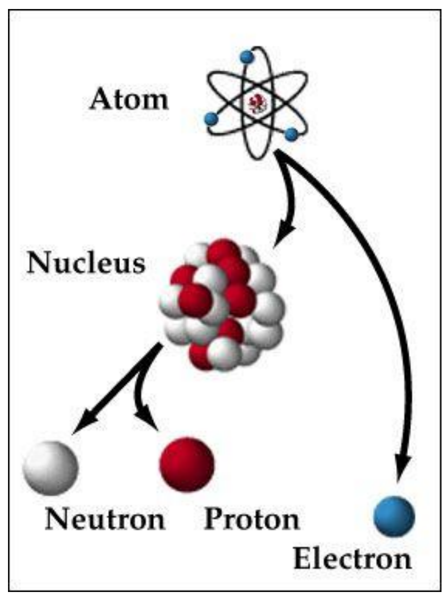
Introduction: The atomic structure refers to the structure of an atom comprising a nucleus (center) in which the protons (positively charged) and neutrons (neutral) are present. The negatively charged particles called electrons revolve around the center of the nucleus.

Atomic structure: atom consists of a central nucleus, which contains protons and neutrons, and electrons that orbit the nucleus. Here's a breakdown of the components:

A-Nucleus: The central part of an atom, composed of protons and neutrons. The nucleus contains most of the mass of an atom.

B- Electrons: particles that orbit the nucleus in electron shells or energy levels. Electrons are much smaller in mass compared to protons and neutrons.





Atoms are the basic building blocks of matter. They consist of three main subatomic particles fundamental Particles:

1- Proton: Z = proton number (atomic number)

Charge: Protons carry a positive electric charge, which is equal in magnitude but opposite in sign to the negative charge of electrons. This positive charge plays a crucial role in the structure and behavior of atoms. The elementary charge of a proton is approximately 1.602×10^{-19} coulombs.

Mass: The mass of a proton is approximately 1 atomic mass unit (amu). The exact mass is approximately 1.6726219 × 10 $^{(-27)}$ kilograms. This mass is roughly 1836 times the mass of an electron, making protons much more massive than electrons. m_p=1.00727 u

Location: Protons are found in the nucleus of an atom. The nucleus is the central part of the atom, and it contains protons and neutrons. Electrons orbit the nucleus in electron shells.

Understanding the properties and behavior of protons is essential in the study of atomic and nuclear physics. Protons, along with neutrons and electrons, contribute to the overall structure and properties of matter. The study of protons has practical applications in various fields, including medicine (such as proton therapy in cancer treatment) and fundamental research in particle physics.

2- Neutron: Neutrons are subatomic particles with several characteristic features:

N = neutron number

Charge: Neutrons are electrically neutral, meaning they carry no electric charge. The elementary charge of a neutron is zero.

Mass: Neutrons have a mass of approximately 1.675×10^{-27} kilograms. This mass is similar to that of protons, making both protons and neutrons much more massive than electrons.

m_n=1.008665u

Location: Neutrons are found in the nucleus of an atom, along with protons. The nucleus is the central, dense core of the atom.

A = nucleon number (atomic mass number) $A=Z+N$

3- Electron: Electrons are subatomic particles with several characteristic features:

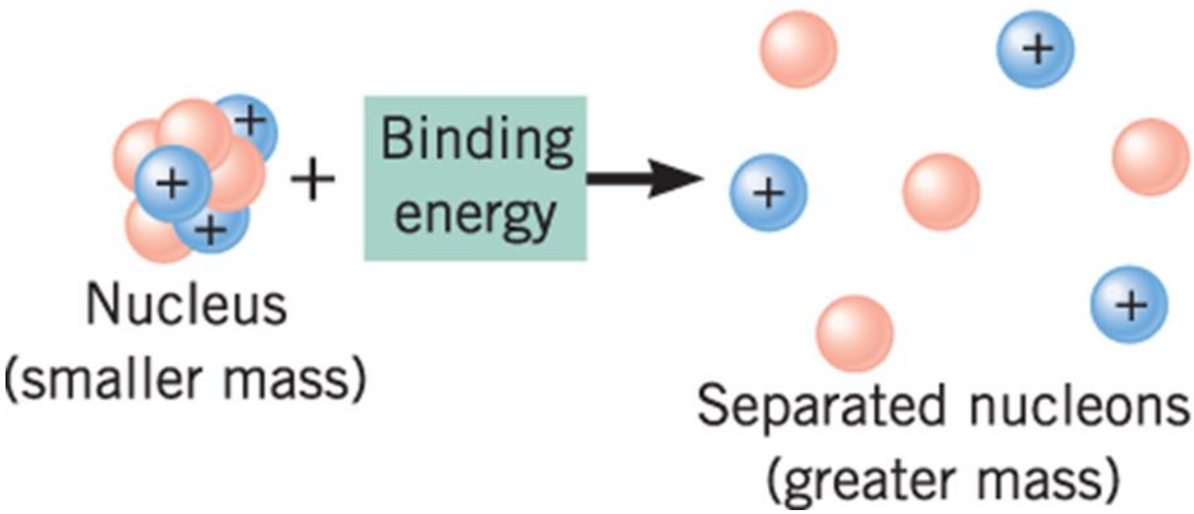
Charge: Electrons carry a negative electric charge. The elementary charge of an electron is approximately -1.602×10^{-19} coulombs. The negative charge of electrons is equal in magnitude but opposite in sign to the positive charge of protons.

Mass: Electrons have a very small mass compared to protons and neutrons. The mass of an electron is approximately 9.109×10^{-31} kilograms, making it about 1/1836th the mass of a proton. m_e=0.000548u

Location: Electrons are located outside the nucleus, in electron shells or energy levels.

Nuclear Binding energy

Nuclear binding energy is the energy required to disassemble a nucleus into its individual protons and neutrons. It is also the energy released during the formation of a nucleus from its individual protons and neutrons.



Mass Defect: is the total mass of the nucleons (the individual proton and neutron) is always greater than the mass of nucleus.

The mass defect refers to the difference in mass between a nucleus and the sum of its individual nucleons (protons and neutrons). This difference in mass is converted into energy during the formation of the nucleus. Einstein's mass-energy equivalence formula, $E=mc^2$, states that energy (E) is equal to mass (m) times the speed of light (c) squared. The mass defect (Δm) is related to the released energy (ΔE) through Einstein's formula. The relationship can be expressed as follows: $\Delta E=\Delta mc^2$

$$\text{Mass defect formula: } \Delta M = \left(Zm_p + Nm_n - {}^{A}_{Z}M_n\right)$$

Nuclear Binding Energy: Nuclear binding energy is the energy required to split a nucleus of an atom into its component parts: protons and neutrons, or, collectively, the nucleons. The binding energy of nuclei is always a positive number, since all nuclei require net energy to separate them into individual protons and neutrons.

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$$BE = \Delta M C^2$$

$$1u = 1.66054 \times 10^{-27} Kg = 931.5 MeV$$

An important measure of how tightly a nucleus is bound together is the binding energy per nucleon.

$$Binding\ enerper\ nucleon = \frac{BE}{A}$$

Example (1): Calculate the mass defect and the binding energy of the deuteron ${}_1^2H$. The mass of the deuteron is m_D=2.013553212745u.

1) Find mass defect

$$\Delta M = \left(Zm_p + Nm_n - {}_Z^AM_n\right)$$

$$\Delta M = (1 \times 1.00727647u + 1 \times 1.008\ 664\ 915\ 95\ u - 2.013553212745u)$$

2.01594138u

$$\Delta M = 0.00238926u$$

2) binding energy $BE = \Delta M C^2$

$$BE = 0.00238926u \times c^2 \times \left(931.5 \frac{MeV}{u}\right) = 2.22559569\text{MeV}$$

This is the amount of energy that would be needed to pull the deuteron apart into a proton an a neutron

binding energy per nucleon $= \frac{BE}{A} = \frac{2.22559569 MeV}{2} = 1.11279784\ MeV$