Modern Physics

- The unit in which atomic and nuclear masses are measured is called atomic mass unit (amu).

- One amu is defined as 1/12th of the mass of an atom of $_6C^{12}$ isotope.

  i.e., 1 amu = 1.66×10-27 kg

- Atomic masses can be measured using a mass spectrometer.

- The different types of atoms of the same element which exhibit similar chemical properties, but have different masses are called isotopes.
- Isotopes are the atoms of an elements whose nuclei have the same number of protons, but have different number of neutrons.
- Isobars are the nuclei with the same mass number (A), but with different atomic numbers.
- Isotones are the atoms of different elements with the same atomic weight, but with different atomic numbers.

Nucleus

- The nucleus has the positive charge possessed by the protons. For an element of atomic number Z, the total charge on an atomic electron is $(-Ze)$, while the charge of the nucleus is $(+Ze)$.

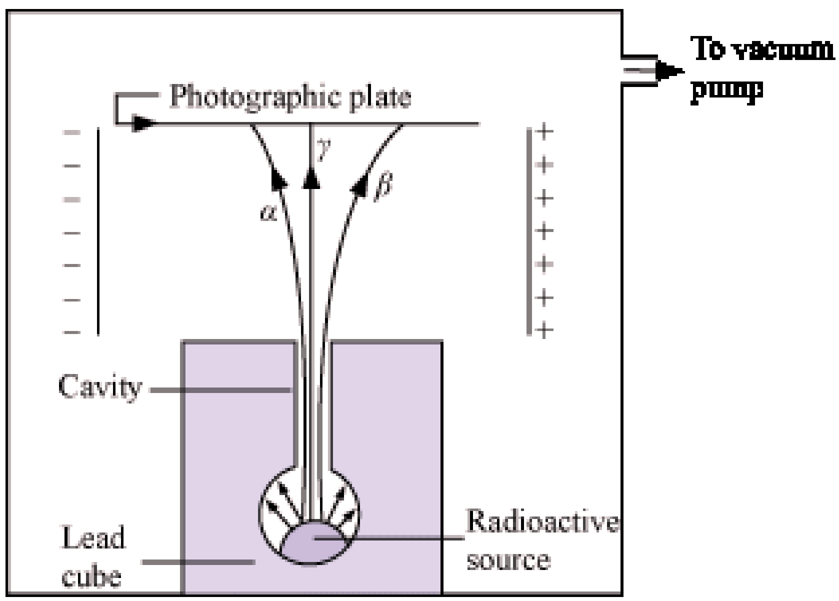
- The composition of a nucleus is described using the followings terms and symbols:

  Z = atomic number = number of protons

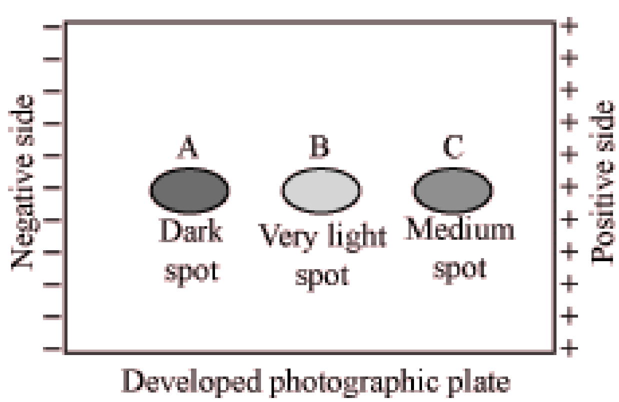
  N = neutron number = number of neutrons

  A = mass number = $Z + N$ = total number of protons and neutrons

- The elements that emit highly penetrating and high energy radiation beam are known as radioactive elements. Example, uranium, radium and thorium.
- **Becquerel rays:** Radiations given out by radioactive elements
- **Properties:**
    - Affect photographic plate
    - Ionise the gas
    - Penetrate through matter
    - Affected by electrostatic and magnetic fields
- During radioactivity, nucleons are ejected from the nucleus.
- **Alpha decay:** If nucleus ejects alpha particles
- **Beta decay:** If nucleus ejects beta particles
- **Experiment to demonstrate the properties of Bacquerel Rays**
    - The sample of radiactive element is placed in a small cavity.
    - A photographic plate is placed over the cavity.



- It was found that the photographic plate developed the following pattern.



- **Alpha particles**: The particles deflected towards the negative plate and having a dark spot.

- **Properties:**

- It is similar to doubly ionised helium atom and has the speed of the order of 10^7 ms^{-1}.
- Alpha particles have large kinetic energy and momentum.
- It strongly ionises the gas through which it passes.
- It rapidly dissipates its energy as it moves through a medium and therefore its penetrating power is quite small.
- As alpha particles are positively charged, so they are deflected by electric and magnetic fields.
- Alpha particles cause fluorescence on striking a fluorescent material.
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- **Beta particles**: The particles deflected towards the positive plate and having a lighter spot.

- **Properties:**

- These particles have speed of the order of 10^8 ms^{-1}. Different beta particles emitted from same radioactive substance have different speed.
- The rest mass of the beta particle is equal to the mass of an electron and charge on it is equal to the charge on an electron.
- These particles ionise the gas through which they pass. Also, their ionising power is equal to 1/100 times that of the alpha particles.
- Their penetrating power is more than the alpha particles.
- As these particles are negatively charged, so they are deflected by electric and magnetic fields.
- Beta particles cause fluorescence on striking a fluorescent material.
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- **Gama particles**: The particles which were not deflected towards the any plate and having a very light spot.

- **Properties:**

- The speed of these particles is of the order of speed of light 3×10^8 ms^{-1}.

- Their ionising power is very low and it is 1/1000 times that of the alpha particle.
- Penetration power is very high for these particles.
- As these particles have no charge on them, so they do not get deflected by electric and magnetic fields.
- Gamma particles cause fluorescence on striking a fluorescent material.
- Gamma radiations are very useful in the treatment of cancer.

Radioactivity as Emission of Alpha, Beta and Gamma

When radiations are given out by radioactive substances and are subjected to a magnetic field or an electric field in the direction perpendicular to their path, they separate out into three distinct constituents i.e. alpha, beta and gamma.

Fields	Alpha (α)	Beta (β)	Gamma (γ)
Magnetic Field (Inward direction)	Turn to left	Turn to right	Go straight
Electric Field (from right (+) to left (-)	Turn toward the negative plate	Turns towards the positive plate	Go straight

Uses of Radioactivity or Radio isotopes

- Medical use: In treating leukaemia, cancer or detecting the suspected brain tumour and blood clot before they become dangerous.
- Scientific use: In agriculture science to study the growth of plants by using particular chemical manure or to study the rate of decay of carbon in the remains of dead plants to study its age.
- Industrial use: As a fuel in nuclear reactors to generate power or for controlling the thickness of paper, plastic and metal sheets during their manufacturing.

Sources of Harmful Radiation

- Radioactive leak out from nuclear plants
- Nuclear waste
- Cosmic radiation and X-rays

Harmful effects of radiation: The radiations interact with the living tissue within 10^{-14} s and cause biological damage. The biological damage can be of three types:

- Short term recoverable effects, like diarrhoea, sore throat, loss of hair, nausea etc.
- Long term irrecoverable effects like leukaemia and cancer
- Genetic effects

- Einstein's mass-energy relation and is given as $\Delta E = \Delta M c^2$
- **Nuclear Fission**: A reaction in which a heavy nucleus breaks into two small nuclei with the liberation of energy is known as nuclear fission.
    - Example: ${}_{0}^{1}n + {}_{92}^{235}U \rightarrow {}_{92}^{236}U \rightarrow {}_{56}^{144}Ba + {}_{36}^{89}Kr + 3{}_{0}^{1}n$
- A continuous nuclear fission reaction is called a **chain reaction**.
- When the fission neutrons are built up to a level and the number of fission producing neutrons is kept constant, then it is known as **controlled chain reaction**.
- **Nuclear reactors** work on the principle of controlled chain reaction.
- **Critical Size**: The minimum size of fissionable material required to sustain a nuclear fission chain reaction.
- **Nuclear** F**usion:** A reaction in which two light nuclei combine to form a heavy nulei with the liberation of energy is known as nuclear fusion.
    - Example: ${}_{1}^{2}H + {}_{1}^{2}H \rightarrow {}_{1}^{3}H + \text{Energy}$
- The energy produced per unit mass in nuclear fusion is higher that that of nuclear fission.

Radiation Hazards

- Radiations are dangerous to both human health and the environment
- Gamma radiations and X rays are highly penetrative and cause serious to the DNA and may lead to cancer, genetic defects and birth defects.
- UV rays cause skin burns, premature cataract and skin cancer