TENDER HEART HIGH SCHOOL, SECTOR-33'B, CHD. Date; 28.10.24

CLASS- X

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CHAPTER-12

SUBJECT- PHYSICS

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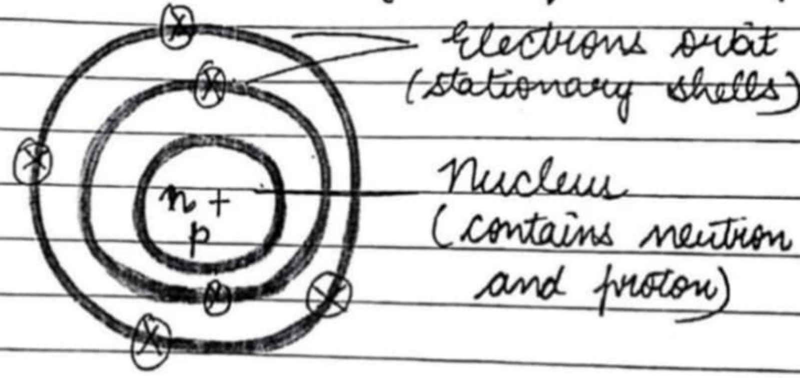
Good Morning Students!

This lesson is of class-IX, for the subject of 'Physics', Topic - 'Atomic Structure and Radioactivity' which is covered in chapter -12 'Radioactivity' starting on Page Number- 283 of your textbook, titled - 'Concise Physics by Selina Publications' and is being submitted to you on October 9, 2023

Students, you all have done the structure of atom and Nucleus in the subject of chemistry also.



Students, the electrons while moving in orbits do not radiate out energy and therefore these orbits are called stationary orbits.

The maximum number of electrons in a shell can be $2n^2$, where n is the number of that shell.

For shell K, $n = 1$, number of electrons $= 2 \times 1^2 = 2$

For shell M, $n = 2$, number of electrons $= 2 \times 2^2 = 8$

For shell N, $n = 3$, number of electrons $= 2 \times 3^2 = 18$

Students, mass of proton and mass of neutron are nearly same i.e. 1.67×10^{-27} Kg while mass of an electron is 9.1×10^{-31} Kg (which is negligible as compared to that of a proton or a neutron). Thus, total mass of an atom can be considered as same as that of nucleus.

Atomic Number- Atomic Number of an atom is equal to the number of protons in its nucleus (which is also same as number of electrons in a neutral atom) It is denoted by Z.

Mass Number(A)-The mass number of an atom is equal to total number of nucleons (i.e. sum of number of protons and number of neutrons) in its nucleus.

ISOTOPES - The atoms of same element, having same Z, but different mass number A, are called isotopes.

For example - $^{238}_{92}U$ and $^{235}_{92}U$

so, number of electrons (or protons) = 92

number of neutrons in $^{238}_{92}U$ = $238-92=146$

while, number of neutrons in $^{235}_{92}U$ = $235-92=143$

ISOBARS - The atoms of different elements which have the same mass number A, but different atomic number Z, are called isobars.

For example - $^{23}_{11}Na$ and $^{23}_{12}Mg$

	$^{23}_{11}Na$	$^{23}_{12}Mg$
Number of electrons	11	12
Number of protons	11	12
Number of neutrons	12	11

Both $^{23}_{11}Na$ and $^{23}_{12}Mg$ have same number of nucleons (i.e. equal to mass number = 23)

ISOTONES - The atoms having different number of protons but same number of neutrons i.e. different Z and A but same (A-Z), are called isotones.

RADIOACTIVITY

Henry Becquerel discovered the phenomenon of radioactivity in 1896.

Radioactivity is a nuclear phenomenon. It is the process of spontaneous emission of α or β and γ radiations from the nucleus of atoms during their decay.

The substances which disintegrates (or decay) by the spontaneous (on their own) emission of radiations, are called the radioactive substances.

For example - Uranium, Radium, Polonium, Thorium, Actinium etc.

Students, the isotopes of nearly all elements of atomic number higher than 82 are radioactive because in their nucleus, the number of neutrons is much more than the number of protons.

These are called the NATURAL RADIOACTIVE SUBSTANCES

NOTE - 1.) Since radioactivity is a natural phenomenon, thus any physical change (such as change in pressure and temperature) or chemical change (such as freezing, action of strong electric and magnetic fields, chemical treatment, oxidation etc.) does not change the nature of radiation emitted by the substance and its rate of decay.

(2) Radioactive decay is a random phenomenon i.e. there is no law by which the disintegration of an individual nucleus can be known (or predicted)

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CHANGES WITHIN THE NUCLEUS IN ALPHA, BETA AND GAMMA EMISSION.

1.) **ALPHA (α) EMISSION** - Since radioactive substances are not stable and if an unstable nucleus contains much more neutrons than the number of protons, it may emit a particle containing two protons and two neutrons tightly bound together (known as α particle). α-particle is a doubly ionised Helium atom i.e. ${}^{4}_{2}He^{++}$ or simple He^{2+} (2 protons, 2 neutrons, 0 electrons)

If X nucleus of a radioactive element of mass number A and atomic number Z emits an α-particle, the daughter nucleus Y of a new element is formed which has mass number (A-4) and atomic number (Z-2). i.e.

$$\underset{\text{Parent nucleus}}{{}^{A}_{Z}X} \longrightarrow \underset{\text{Daughter nucleus}}{{}^{A-4}_{Z-2}Y} + {}^{4}_{2}He$$

The resulting daughter nucleus has 2 protons and 2 neutrons less than the original parent nucleus.

(Students, the mass number and atomic number remains conserved in any nuclear reaction)

Example :

$${}^{238}_{92}U \longrightarrow \underbrace{{}^{234}_{90}Th + {}^{4}_{2}He}_{\text{(Total Z = 92 and A = 238)}}$$

2) **BETA (β) EMISSION** - When an unstable nucleus contains neutrons more than the protons, a neutron may change into a proton by emitting an electron (for charge conservation)

neutron $\longrightarrow$ proton + electron

$$^{1}_{0}n \longrightarrow ^{1}_{1}p + ^{0}_{-1}e \hookrightarrow \text{(Beta Particle)}$$

EXAMPLE : $^{14}_{6}C \longrightarrow ^{14}_{7}N + ^{0}_{-1}e$

The daughter product is an isobar (same mass number, but different atomic number) of the parent atom.

$$\underset{\text{(Parent Nucleus)}}{^{A}_{Z}P} \longrightarrow \underset{\text{(Daughter Nucleus)}}{^{A}_{Z+1}Q} + ^{0}_{-1}e$$

GAMMA EMISSION

When a nuclei is in excited state (i.e. if it has more energy), then this extra energy is released in form of electromagnetic radiation known as γ- radiation (or γ- ray photon).

Students, γ ray takes no mass and no electric charge from the nucleus i.e. no neutrons or protons are lost, hence the nucleus does not decay into a different nucleus, i.e. There is no change in the mass number A and atomic number Z of the nucleus in γ- emission

$$^{A}_{Z}X^{*} \longrightarrow ^{A}_{Z}X + \gamma \longrightarrow (\gamma\text{-ray})$$

$\hookrightarrow$ (stable nuclei)

$*$ $\rightarrow$ means excited state of nucleus.

Students, γ rays are energy only and thus we don't write it as γ- particle.

Note: In a single radioactive decay, α and β particles are never emitted simultaneously. There will be either an α- emission or a β- emission, which may be accompanied by γ- emission.

Basic Properties of Alpha, Beta And Gamma Radiations

Property	α-particle	β-particle	γ-radiation
1. Nature	Stream of positively charged particles i.e., helium nucleus.	Stream of negatively charged particles, *i.e.*, energetic electrons.	Highly energetic electromagnetic radiations.
2. Speed	Nearly 10^7 m s^{-1}	About 90% of the speed of light or 2.7×10^8 m s^{-1}	3×10^8 m s^{-1} (in vacuum)
3. Rest mass	Four times the mass of proton *i.e.*, 6.68×10^{-27} kg	Equal to the mass of electron *i.e.*, 9.1×10^{-31} kg	No mass (rest mass is zero)
4. Charge	Positive charge (two times that of a proton) $= +3.2 \times 10^{-19}$ C (or $+2e$)	Negative charge $= -1.6 \times 10^{-19}$ C (or $-e$)	No charge
5. Specific charge (q/m)	4.79×10^7 C kg^{-1}	1.76×10^{11} C kg^{-1}	—
6. Wavelength	—	—	10^{-4} nm or 10^{-13} m
7. Effect of electric and magnetic fields	Less deflected but opposite to that of beta particle.	More deflected than alpha particles, but in a direction opposite to those of α-particles	Unaffected
8. Ionising power	Maximum (10,000 times of γ)	Less than alpha particle (100 times of γ)	Minimum
9. Penetrating power range in air	Small 3 to 8 cm in air	Large up to a few metres in air	Very large up to a few hundred metres in air
10. Stopping substance	Thin paper, human skin	About 1 mm thick lead or about 5 mm thick aluminium	About 30 cm thick lead sheet or few metre thick concrete
11. Biological damage	Less damage	More damage	Immense damage

γ-radiations are most energetic and they have a smaller rate of collisions with the atoms of the medium through which they pass. Thus, they have minimum ionising power, but maximum penetrating power.

In terms of Ionising power (increasing order is):

$\gamma < \beta < \alpha$

In terms of Penetration Power (increasing order is):

$\alpha < \beta < \gamma$

Thus, γ-radiations can cause immense biological damage.