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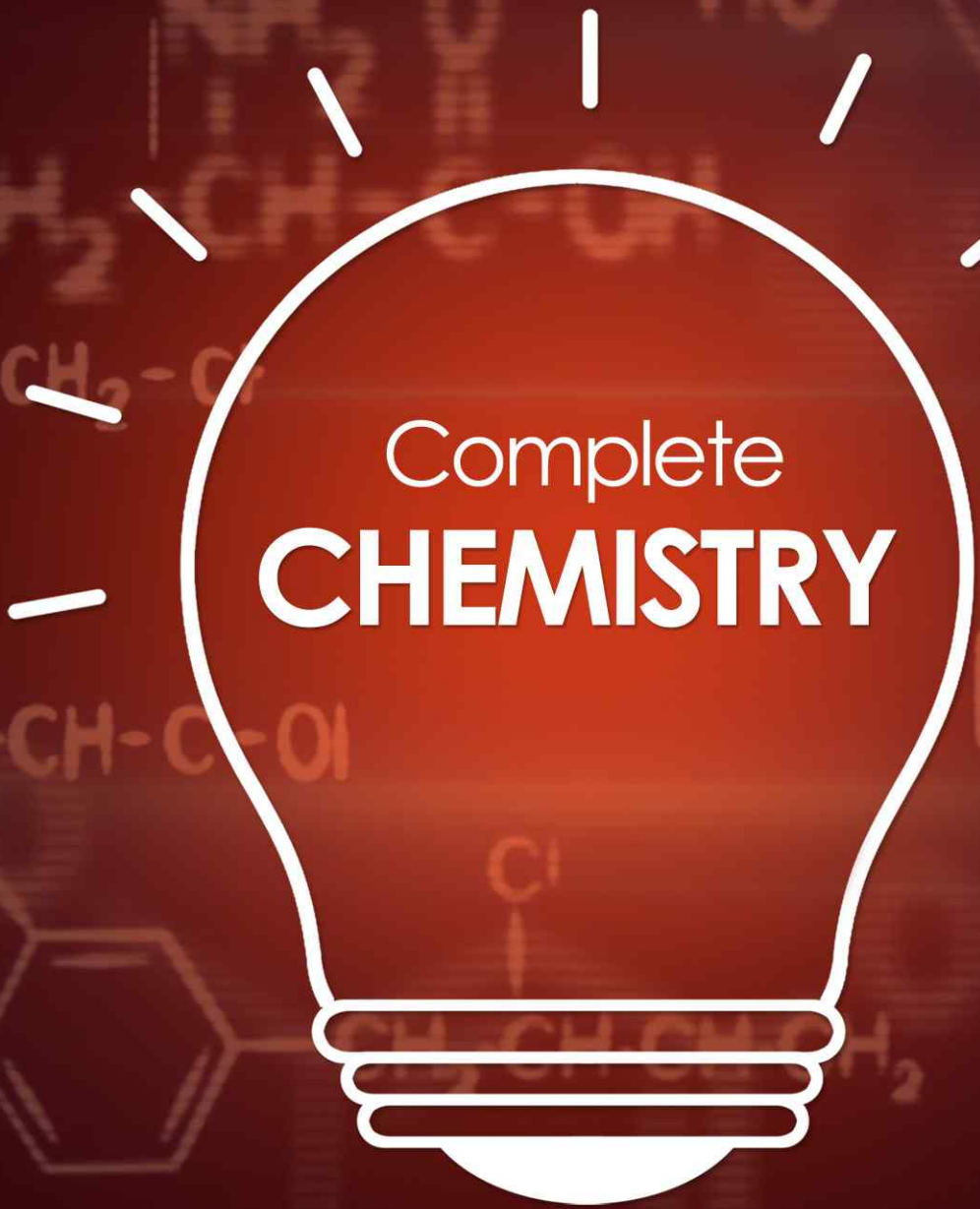

Complete CHEMISTRY

IIT-JEE · NEET · CBSE eBOOKS

CLASS 11&12th

CLASS 11th

Nuclear Chemistry

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01. Radioactivity

Radioactivity is a process in which nuclei of certain elements undergo spontaneous disintegration without excitation by any external means.
All those substances which have the tendency to emit these radiations are termed radioactive materials. Radioactivity is a nuclear phenomenon.

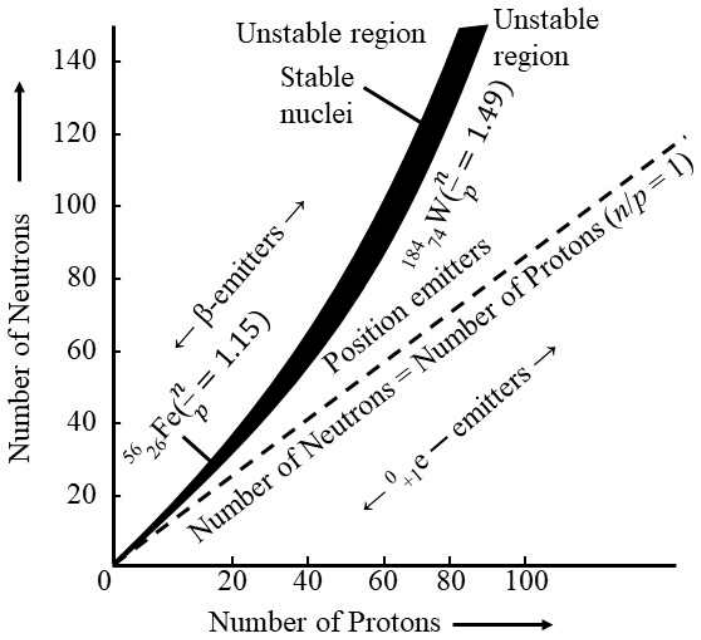
02. Analysis of Radioactive Radiations

Property	α-rays	β-rays	γ-rays
(i) Nature	These consist of small positively charged particles which are merely nuclei of helium atoms, each consisting of 2 protons and 2 neutrons. These are represented as $^{4}_{2}He$.	These consist of negatively charged particles which have the same e/m value as the cathode rays. β-rays are merely electrons. The β-rays are represented as $^{0}_{-1}\beta$ or $^{0}_{-1}e$.	γ-rays are similar to X-rays. These are neutral in nature. They have very small wavelengths of the order of 10^{-10} to 10^{-13} m.
(ii) Velocity	The α-rays are ejected with high velocities ranging from 1.4×10^{9} to 1.7×10^{9} to cm/sec. The velocity of α-rays depends upon the kind of nucleus from which they are emitted.	The β-rays are much faster than α-rays. They have generally different velocities sometimes approaching the velocity of light.	They travel with the velocity of light.
(iii) Penetrating power	α-particles have small penetrating power due to relatively larger size. They are stopped by a piece of aluminium foil of 0.1 mm thickness.	β-rays are more penetrating than α-particles. This is due to small size and high velocity. These are stopped by a 1 cm thick sheet of aluminium.	Due to high velocity and non-material character, γ-rays are 10^{10} times more penetrating than α-rays.

(iv) Ionising power	α-particles produce intense ionisation in gases, Ionising power is 100 times greater than β-rays and 10,000 times greater than γ-rays. This is due to high kinetic energy.	Due to low value of kinetic energy ionising power is less than α-particles but 100 times greater than γ-rays.	γ-rays produce minimum ionisation or no ionisation.

03. Cause of Radioactivity

The stable nuclei lie within the shaded area which is called the **region** or **zone of stability**. All the nuclei falling outside this zone are invariably radioactive and unstable in nature. **Nuclei that fall above the stability zone have an excess of neutrons while those lying below have more protons**. Both of these cause instability. These nuclei attain stability by making adjustment in the *n*/ *p* ratio.



Nuclide	$\frac{n}{p}$ Ratio	Nature of Emission
$^{35}_{16}S$	$\frac{19}{16}=1.2$	β–emission $^{35}_{16}S \longrightarrow {}^{35}_{17}Cl + {}^{0}_{-1}e$
$^{17}_{9}F$	$\frac{8}{9}\left(\frac{n}{p}<1\right)$	Positron emission $^{17}_{9}F \longrightarrow {}^{17}_{8}O + {}^{0}_{+1}e$
$^{105}_{47}Ag$	$\frac{n}{p}=\frac{58}{47}=1.23$	Lies below stability belt, it has a heavy nucleus and it decays by K-electron capture. $^{105}_{47}Ag + {}^{0}_{-1}e \longrightarrow {}^{105}_{46}Pd + h\nu$
$^{238}_{92}U$	$\frac{n}{p}=\frac{146}{92}=1.59$	It is a neutron rich species. It undergoes decay by α-emission. $^{238}_{92}U \longrightarrow {}^{234}_{90}Th + {}^{4}_{2}He$

04. Theory of Radioactive Disintegration

(i) The atomic nuclei of the radioactive elements are unstable and liable to disintegrate any moment.

(ii) The disintegrate is spontaneous, *i.e.*, constantly breaking. The rate of breaking is not affected by external factors like temperature, pressure, chemical combination, etc.

(iii) During disintegration, atoms of new elements called daughter elements having different physical and chemical properties than the parent element come into existence.

(iv) During disintegration, either alpha or beta particles are emitted from the nucleus.

(a) **α-particle emission :** When an α-particle [$^{4}_{2}He$] is emitted from the nucleus of an atom of the parent element, the nucleus of the new element, called daughter element, possesses atomic mass or atomic mass number less by four units and nuclear charge or atomic number less by 2 units because α-particle has mass of 4 units and nuclear charge of two units.

The daughter element after α-emission is called an isodiaphere of parent element.

	Parent element $\xrightarrow{-\alpha}$	**Daughter element**
Atomic mass	W	W – 4
Atomic number	Z	Z – 2

(b) **β-particle emission :** β-particle is merely an electron which has negligible mass. Whenever a beta particle is emitted from the nucleus of a radioactive atom, the nucleus of the new element formed possess the same atomic mass but nuclear charge or atomic number is increased by 1 unit over the parent element. Beta particle emission is due to the result of decay of neutron into proton and electron.

$$^{1}_{0}n \longrightarrow {}^{1}_{1}p + {}^{0}_{-1}e$$

The electron produced escapes as a beta particle leaving proton in the nucleus.