NUCLEAR CHEMISTRY (RADIOACTIVITY)

Nuclear chemistry deals with the study of process and reactions involving the protons and neutrons in the nuclei of atoms during nuclear processes, atoms of one elements may be converted into atoms of other elements by any of the following nuclear reactions. Radioactive decay, nuclear disintegration, atomic fission and atomic fusion.

Nuclear reactions differ from the common chemical reactions which involved the valence electrons in the atoms. Again the heat liberated during any nuclear reaction is many thousands times greater than that of the most exothermic chemical reaction

Radioactivity is the spontaneous decay or disintegration of the nucleus of an atom with the emission of the radiations and a large quantity of heat.

Radioactivity is due to energy changes occurring within the nucleus of the atom. Any substance capable of undergoing radioactivity is said to be radioactive e.g Uranium, Radium, Radon and Carbon-14

TYPES OF RADIOACTIVITY

There are two classes of naturally occurring isotopes of elements; stable and unstable isotopes

1. Atoms of stable isotopes consist of nuclei with approximately equal numbers of protons or neutrons. For instance the two isotopes of chlorine have proton to neutron rations of 17:18 and 17:20

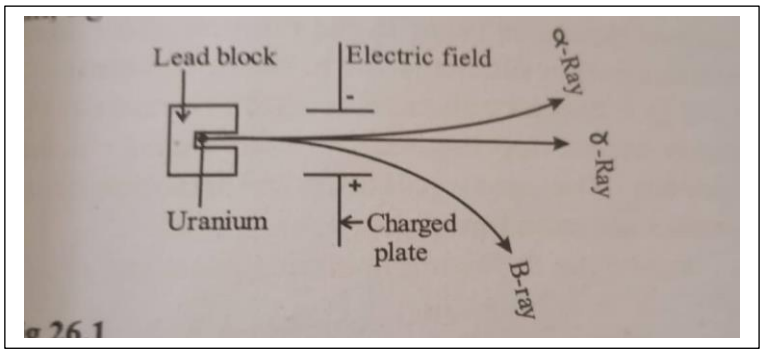
2. Atoms of unstable isotopes consist of nuclei with much more neutrons than protons. For instance Uranium – 238 with atomic number 92 has a nucleus of 92 protons and 146 neutrons. The nuclei of atoms of elements with atomic numbers greater than 83 are unstable.

An unstable isotope tends to become stable by emitting nuclear particles and radiations. Hence an unstable isotope is radioactive

TYPES OF RADIATIONS

Ernest Rutherford (1904) a physicist, studied the nature of radiations emitted during radioactivity by subjecting the radiations from a small piece of Uranium salt to a strong electromagnetic field. Three types of radiations were identified: alpha rays, beta rays and gamma rays

He discovered that the alpha and beta rays were deflected in opposite direction by the magnetic field, while the gamma rays were not deflected at all.



PROPERTIES OF RADIOACTIVE RADIATIONS

1. Alpha Rays

a. Alpha Rays consists of positively charged particles, hence they are deflected towards the negative pole of electromagnetic field

b. They are massive hence only slightly deflected

c. They are the longest wavelength, hence the least energetic. move with a velocity of about one tenth that of light and have the least penetrating power, a sheet of paper a thin aluminium foil can stop them

d. Being massive they cause ionization on collision with particles on their path they cause substances such as zinc blend ZnS to glow brightly (fluorescence). An alpha particle has a mass unit of 4 and is regarded as the nucleus of an atom of helium. Its nuclear symbol is represented as $^{4}_{2}He$ or $^{4}_{2}\gamma$

2. Beta Rays

a. Beta rays consist of negative charged particles, hence they are deflected towards the positive pole of the electromagnetic field

b. They are less massive than the alpha particles; hence more deflected towards the positive pole

c. They have a shorter wavelength than the alpha particles hence more energetic, faster and have higher penetrating power than the alpha particle. They will pass through a sheet of paper or an aluminium foil, a 5mm thick foil of aluminium can only stop them.

d. They have less ionizing effect than the alpha particle. A beta particle is called an electron. It has neither proton nor neutron its nuclear symbol is $^{0}_{-1}B$ or $^{0}_{-1}e$

3. Gamma rays

a. They are electromagnetic radiations that have no mass or charge i.e they are neutral, hence they are not deflected at all by the magnetic field.

b. They have the shortest wavelength, hence the most energetic. They move at the velocity of light and have the highest penetrating power. They can only be stopped by 15cm thick steel or lead block.

c. Gamma rays have the least ionizing power

RELATIVE ENERGY OF RADIATION

When compared with X-rays , the order of increasing energy of the radioactive radiations is

X-rays < ɣ -Rays < B- Rays < Gamma rays

Increasing energy ⟶

Detection of radioactive radiations

Radioactive radiations are not only harmful, they are dangerous-being invisible. The following devices or instruments can be used to detect the radiations

1. Geigher-muller Crunters

2. Wilson diffusion Cloud Chamber

3. Scintillation Counter

4. Photographic Plate

5. Fluorescent screen coated with zinc sulphide ZnS

Nuclear symbols of radiations particles

The table below shows the nuclear symbols of various radiation particles. Note that the mass number A is written as Superscript while the atomic number Z is written as subscript

	PARTICLE	SYMBOL

1.	Alpha Particle; helium nucleus	$^{4}_{2}\alpha$ or $^{4}_{2}H$
2.	Beta Particle, an electron	$^{0}_{-1}B$ or $^{0}_{-1}e$
3.	Proton, hydrogen nucleus	$^{1}_{1}P$ or $^{1}_{1}H$
4.	Neutron, neutral	$^{1}_{0}n$
5.	Positron, positive electron	$^{0}_{1}e$

Nuclear symbols of nuclear particles

NUCLEAR REACTIONS

Nuclear reactions occurs in the nucleus of the atom of a radioactive element, due to energy changes. A nuclear reaction can be represented by a balanced nuclear equation. The atoms of different isotopes of an element are called nuclides

Consider the following nuclear equations

1. $^{a}_{b}X + {}^{c}_{d}Y \longrightarrow {}^{e}_{f}Z$ ----------1

2. $^{g}_{h}M + {}^{i}_{j}Q \longrightarrow {}^{K}_{J}R + {}^{M}_{-N}T$ ---------- 2

A nuclear equation is balanced if

a. The sum of the mass numbers of the nuclides on the left is equal to those on the right

i.e In equation 1 $a + c = e$

In equation 2 $g + l = k+m$

b. The sum of the atomic numbers of the nuclides on the left is equal to those on the right i.e

In equation 1 $b + d = f$

In equation 2 $h + j = I - n$

TYPES OF NUCLEAR REACTIONS

There are four types of nuclear reactions

1. Radioactive decay – nuclear disintegration

2. Nuclear (atomic fission – nuclear atomic) fusion. Nuclear fission and nuclear fusion are the two nuclear reactions that provides the so called nuclear energy.