CHAPTER NINE

RADIOACTIVITY, X - RAY AND NUCLEAR REACTIONS:

Radioactivity: This refers to the disintegration of the nuclei of an atom, to emit radiation and heat so as to become stable. Three types of radiations are emitted during radioactivity, and these are:

- (I) Alpha particles or rays, i.e. \ltimes particles or rays.
- (II) Beta particles or rays, i.e. β rays or particles.
- (III) Gamma rays i.e. γ rays.

Causes of radioactivity:

- Radioactivity occurs when the nucleus of an atom becomes unstable.

- An unstable nucleus is the type, in which the number of neutrons is the same or almost the same as that of the protons.

- If the number of protons is divided by the number of neutrons, we get what is referred to as the proton to neutron ratio

- A nucleus is stable when its proton to neutron ratio, is either equal to or almost equal to 1.

- But if this ratio is far from 1 or not close to 1, then the nucleus become unstable.

- In order to obtain stability, the unstable nucleus disintegration or undergoes radioactivity.

- An example of an unstable nucleus is that of radium, which has a proton to neutron ratio of 0.6.

- When a radioactive atom emits radiation, it is said to have decay or undergone decay and after this decay, a new atom is usually formed.

Types of radioactivity: There are two types and these are:

- (I) Natural radioactivity.
- (II) Artificial radioactivity.

Natural radioactivity: This refers to the spontaneous or self-occurring disintegration of an unstable nucleus of an atom, with the emission of radiation and heat.

Artificial radioactivity: This occurs when a stable nucleus is bombarded with atomic particles so as to make is become unstable, and cause it to disintegrate emitting radiation and heat.

Radioactive Emissions: There are three types of radioactive emissions, and these are:

- (a) Alpha particles.
- (b) Beta particles.
- (c) Gamma rays.

Characteristics or properties of Alpha particles:

- (1) They are helium atoms which have lost their two orbital electrons.
- (2) They have a charge of +2.
- (3) Among the three types of emission, they have the least power of penetration and as such can be stopped by a thin foil of aluminum.
- (4) They have the highest power of ionization as well as the slowest speed.

Characteristics or properties of Beta particles:

- (1) They are electrons of high energy, and each carry a charger of -1.
- (2) Their power of penetration is greater than that of alpha particles.
- (3) They are strongly deflected by magnetic and electric fields.
- (4) Their ionization power is moderate.
- (5) They have varying speeds.

Characteristics or properties of gamma rays:

- (1) They are neutral or have no charge.
- (2) They are electromagnetic waves.
- (3) They are not affected by both magnetic and electric fields.
- (4) They have the lowest ionization power.

(5) Their penetration power is the greatest.

The effect of magnetic field:

(1) Since γ – rays are neutral, they are undeviated.

(2) Because \ltimes - particles are positively charged and β – particles are negatively charged, they are deflected in opposite directions.

Comparism of the three radiations:

	×	β	γ
Nature	Helium – nucleus	Fast moving electrons	Electro-magnetic waves
Charge	Positive	Negative	Neutral
Mass	Heaviest	Heavy	No mass
Speed/ velocity	Slow	Fast	Very fast
Ionization	High	Small	Nil
Penetration	Least	Great	Greatest
Effect in electric field	Attracted towards the negative plate	Attracted towards the positive plate	Not attracted by either plate.
Effect in magnetic field	Deflected in the positive direction	Deflected in the negative direction	Un-deflected

Similarities between Alpha and Beta Particles:

- (1) Both are charged particles.
- (2) Both are deflected by magnetic and electric fields.
- (3) Both can ionize gases when they pass through them.

Radio-isotopes or radioactive isotopes (ionizing radiations

A radio-isotope is an unstable nuclide, which undergoes radioactive decay spontaneously.

Uses of radio-isotopes:

- (1) Used to sterilize materials.
- (2) Used to determine the ages of ancient materials, i.e. in radiocarbon dating.
- (3) Used in agriculture and industries.
- (4) Used in medicine for the treatment of diseases such as cancer.

Hazards or dangers of radio-isotopes (ionizing radiation):

- (I) They can destroy the cells of the body and cause cancer.
- (II) They cause radiation sickness and radiation burns.
- (III) They can cause sterility.
- (IV) They can destroy vegetation and animal life.

The half-life: Due to the emission of alpha, beta and gamma rays, a radioactive substance or isotope continuously decreases in mass, leading to the formation of a new substance or isotope. The time taken by the atoms of a radioactive substance, to decay to half of its initial value is known as its half-life.

Thermionic emission: This refers to the process whereby electrons are emitted from the surface of a metal, when it is heated. When a metal is heated, the heat causes the release of electrons from the surface of the metal.

<u>X- rays</u>: These are a type of electro-magnetic waves, which are produced when fast moving electrons are brought to a halt in a target material and give up their kinetic energy.

Production of X – rays:



<u>The X – ray tube:</u>

- This is the apparatus used to produced x – rays.

- It consists of a cathode which is heated by electrical means.

- The tube also consists of the anode or the target, which is made up of a material of high melting point, such as tungsten.

- A high voltage electric field is connected between the anode and the cathode.

-The heating of the cathode by the electrical means, causes it to produce electrons by means of thermionic emission.

- These electrons are accelerated or made to move very fast towards the anode, by the high voltage electric field.

- X – rays are produced when these fast moving electrons hit the anode and are brought to a stop or a halt.

Properties of x-rays:

- They are electromagnetic waves and as such can travel in vacuum.
- They travel in straight line, and have the same speed as that of light.
- They can penetrate matter.
- They can cause the ionization of gases.
- They are not deflected or affected by electric and magnetic fields.
- They can be reflected and refracted as in the case of light.

Application of X – ray, (i.e. their uses or importance):

(1) Medicine:

- They are used in medicine for diagnosis purposes.

(2) <u>Radiotherapy:</u>

- X- rays are used to destroy diseased cells.

(3) Industrial usage:

- X – rays are used to detect flaws or cracks in metal casting.

(4) <u>X – ray crystallography:</u>

- X – rays can be used to detect the structures of crystals.

Types of X – rays produced: There are two types of x –rays and these are:

- (I) Soft x rays.
- (II) Hard x rays.

<u>Soft X – rays:</u>

- These are produced at low voltages.
- They have low energy and long wavelength.
- They have less penetrating power and as such, cannot pass through dense metals.

Hard X – rays:

- They are produced at high voltages.

- They have high energy and short wavelengths.- They have great penetrating power, and as such can penetrate dense metals such as lead.

Dangers or hazards of x-rays:

- X-rays cause cancer and skin burns.
- X-rays cause damage to cells and tissues.
- X-rays produce genetic changes which appear in later generations.
- X-rays can cause graying and baldness.

N/B: These given facts prove that even though x-ray is quite good, it can be very dangerous if not properly used. For this reason, certain precautions measures must be taken, when x-ray is being used

Precautions taken:

- Since X rays are dangerous to man, then the amount that a person is exposed to must be controlled.
- Precautions taken include the following:
- (1) Surrounding x ray machines with lead shields, to absorb any stray radiation.
- (2) Workers who are likely to be exposed to radiation, such as these working with atomic radiation centres and hospital x – ray units, wear x – ray meter to measure the amount of x –ray they have been exposed to.
- (3) Protective clothing may also be worn by such workers.
- (4) Remote control can be used to operate x ray machines, or handle items which emit x rays.

<u>**N/B:**</u> - The target (anode) of an x - ray tube, is always made of metal of high melting point.

- This is due to the fact that the fast moving electrons bombardment, generate heat in it causing the anode's temperature to rise.

Nuclear/ atomic energy:

- This is heat energy which is had from the decay of the nucleus of a radioactive atom.

- Atomic energy can be produced in two ways and these are:

- (I) Nuclear fusion or fusion.
- (II) Nuclear fission or fission.

- According to a scientific law, energy can be converted into mass, and mass can also be converted into energy.

- During fission or fusion, there is always a loss in mass, since the mass of the reactants (reacting items) is always greater than the mass of the products formed.

- It is this loss in mass which is converted into energy which is released in the form of heat radiation, commonly referred to as atomic or nuclear energy.