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Radiopharmaceuticals

Que: Define Radioactive substance. Define radioactivity. Explain types of rays.

Definition: The substances that have property to emit the radioactive rays are known as **radioactive substances**. This property of radioactive substance to emit radioactive rays is known as **radioactivity**.

•This radioactive rays affect photographic plate.

Types of radioactive rays:

Radioactive rays are of three types:

1. Alpha rays
2. Beta rays
3. Gamma rays.

1. Alpha rays:

- Least penetrating power.
- Most ionization power.

- Positive charge (two)
- Similar to helium nuclei and mass of 4 amu.
- Emitted by certain heavy metals. Ex. Radium
- When radioactive elements emit alpha particle from the nucleus, the resulting nucleus will be having two positive charge less than the original nucleus. So resulting atom have atomic number two less than the initial. The mass number will 4 less than the initial.
- Ex. Radioactive decay of radium gives radon nucleus that gives alpha particles.

$$^{226}_{88}\mathrm{Ra} \longrightarrow {}^{222}_{86}\mathrm{Rn} + {}^{4}_{2}\mathrm{He}$$

- Due to least penetrating power, alpha rays can not penetrate the tissue so alpha rays emitting element have no any biological applications.

2. Beta rays:

These are of two types:

i). Electrically positive (also known as positrons)

ii). Electrically negative (also known as negatrons)

- Greater penetrating power than alpha rays but less than the gamma rays.
- Less ionization power than alpha rays but more ionization power than gamma rays..
- Negligible mass 1/1836 of hydrogen ion.
- Emission of beta particle does not change in atomic mass but change in atomic number that will be one higher than the original.

$$^{14}_{6}C \longrightarrow {}^{14}_{7}N + ß^{-}$$

- Negatrons have biological application but positron are unstable and they are not having any biological applications.

3. Gamma rays:

- More penetrating power than alpha and beta rays.
- Have same character like X-rays in very short electromagnetic waves.
- Not affected by magnetic force.
- Have speed of light.
- Have neither mass nor charge.
- Produced by disintegration of radioactive substance along with beta radiation.
- Uncharged so poor ionization power.
- Due to high penetration power, they have biological applications.

- So, penetration power: Gamma > Beta > Alpha
- Ionization power: Alpha > Beta > Gamma.

Que: Define radioactivity. Write a short note on measurement of radioactivity

Definition: The substances that have property to emit the radioactive rays are known as **radioactive substances**. This property of radioactive substance to emit radioactive rays is known as **radioactivity**.

•This radioactive rays affect photographic plate.

Measurement of radioactivity:

Radioactivity can be measured by;

1). Ionization chambers

2). Proportional counters

3). Geiger-Muller counters and

4). Scintillation counters.

1). Ionization chambers:

It consists of chambers filled with gas and fitted with two electrodes that kept at different electrical potentials and a measuring device to indicate the flow of current.

Radiation will brings about ionization of gas molecules or ions that cause emission of electrons that shows changes in electric current.

2). Proportional counters

These are modified ionization chambers in that applied ionization potential of primary electrons cause production of more free electrons that carried to anode. So the current through electric circuit gets amplified. This voltage range at which amplification occurs is known as proportional region and the counter working in this region is known as proportional counters.

3). Geiger-Muller counters

These are the most popular radiation detectors. They do not require use of amplifier and can detect alpha, beta and gamma radiations.

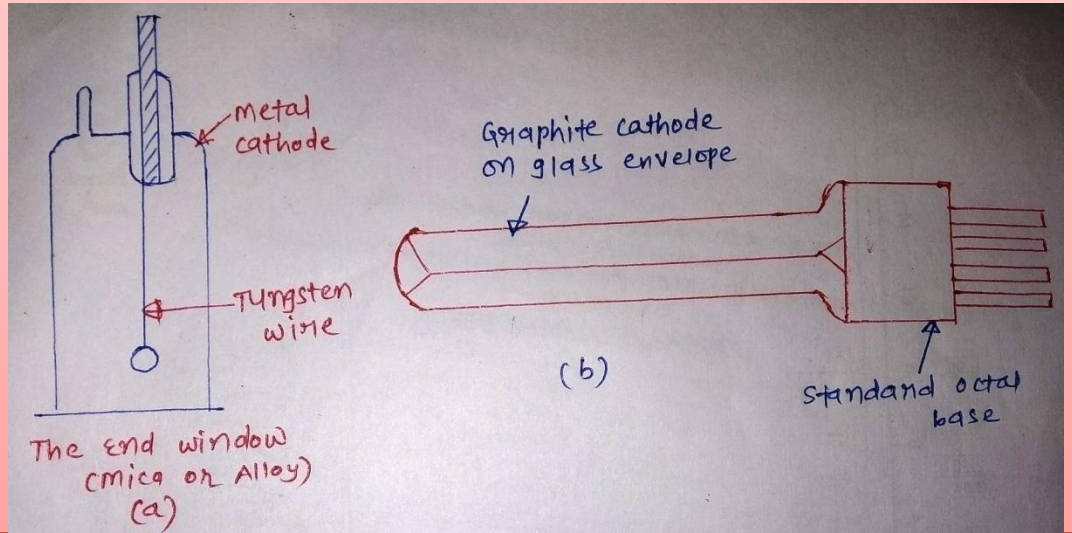
Construction:

It contains cylindrical cathode of 1-2 cm in diameter along with a anode made up of

wire. The space is filled with a special gas mixture that readily ionised with quenching vapour.

For counting radioactive solid source, end window type Geiger-Muller counter can be used. In that the window is made up of an aluminium alloy (7 mg/cm^2), mica or thin glass bubble (15 mg/cm^2). (A)

To count medium and high energy beta particles and gamma particles thin glass walled counters can be used. These have 1 cm diameter and 20-40 mg/cm^2 thickness. Inside wall is coated with graphite to form cathode. (B)



To count radioactive liquids, 10 cm^3 capacity GM counter can be used.
Another type of G-M counter are connected by a plug and a socket and have a capacity of 5 cm^3.
For counting of radioactive gases, another type G-M counter is used. In that lead or copper cathode have been used.

Operation:
Geiger-Muller counter consists of a Geiger-Muller tube, the sensing element that detects radiation and processing electronics.
G-M tube is filled with an inert gas like helium, neon or argon at low pressure on which high voltage is applied.
When a particle or photon makes the gas to conduct ionization, G-M tube conducts electrical charge.
Applications:
To detect alpha and beta rays.
To detect radioactive rocks and minerals.

4. Scintillation counter

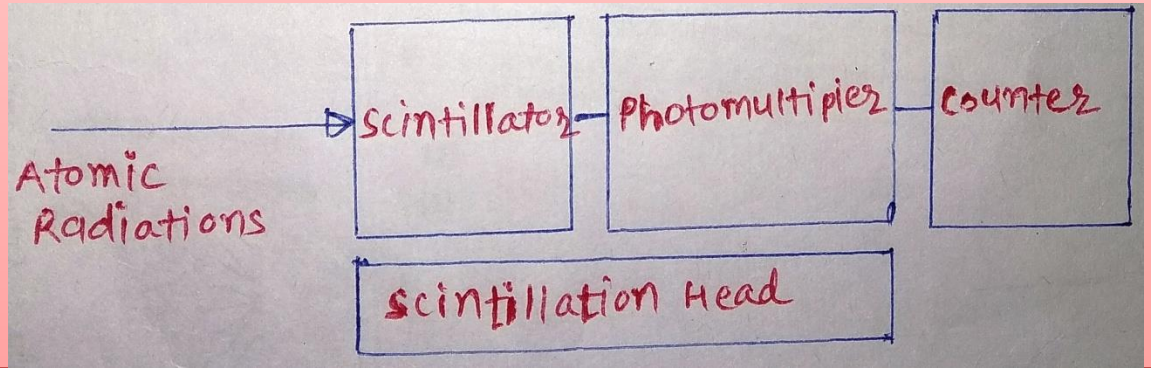
It is an instrument used to detect and measure ionizing radiation by using exciting effect of incident radiation on scintillation material and detect resultant light pulses.

Construction:

It consists of scintillator that generates photon and photomultiplier tube.

Principle:

When an ionizing particle passes into the scintillator, atoms are ionizes. Photon from the scintillation will strike on cathode an emits an electron that produce voltage. This voltage is amplified and recorded by an electronic counter.



Applications:

Used to measure radiation in medical imaging, radiometric assay, nuclear security, nuclear plant safety.

They have been designed for border security.

Que: Define half life. Give precautions while handling and storage of radioactive materials.

Half life: It is the time that required by radioactive substance to emit the radioactive rays half of the initial.

$$\lambda_{½} = 0.693/K$$

As radioactive substances emit harmful radiations, certain precautions have to be taken while working with detectors, experiments radio-assays, manufacturing or handling of radioactive substances.

Following precautions have to be taken while handling and storage of radioactive substance.

1). Person should not touch radioactive emitter with hand but handled by forceps or suitable instruments.

2). Smoking, eating and drinking should not be done in the laboratories where radioactive materials are handled.

3). Protective clothing or shielding have to be used.
4). Radioactive materials should be stored in suitable labeled containers, shielded by lead bricks and preferably in a remote corner.
5). Area at which radioactive materials have been stored should be monitored and tested regularly.
6). Disposal of radioactive materials should be carried out with great care.
7). The area at which radioactive materials have been stored should not frequently visited by people.
8). Shielding should be required. To protect from gamma radiations, lead shielding should be required.
9). Working area should not contaminated with radioactive substance.
10). For handling of liquid radioactive substance, tray with absorbent tissue paper must be used to absorb any spillage.
11). Rubber gloves must be used.
12). Pipettes never be operated by mouth.
13). Even the waste radioactive material has to be stored till the activity becomes low.

Que: Define radioactive substance. Define radioactivity. Give applications of radioactive substances.

Radioactive substance: The substances that have property to emit the radioactive rays are known as **radioactive substances**. This property of radioactive substance to emit radioactive rays is known as **radioactivity**.

•Radioactive substances can be used in medicine in four different ways:

1). In therapeutics

2). In diagnosis

3). Research

4). Sterilization.

1). Radioisotopes in therapeutics

•Use of radioisotope in therapy depend mainly on their ability to ionize atoms.

•Radioisotopes may be used internally or externally.

•If radioisotopes are used externally or used as implants in sealed capsules in a tissue then dose can be stopped by removal of the sources. Whereas, if they are given internally as unsealed source dose can not be stopped by removal of source.

•Gold (^{198}Au) can be used in the treatment of abdominal and pleural effusions associated with malignant tumors.
•Gold (^{198}Au) can also used in the treatment of carcinoma of uterus and urinary bladder.
•Sodium phosphate (^{32}P) used in the therapy of polycythemia vera to decrease the rate of formation of erythrocytes leukemia.
•Isotopes of cobalt Co-57, Co-58 and Co-60 cyanocobalamine (vitamin B_{12}) can be used in the diagnosis of pernicious anemia.
•Sodium iodide (^{131}I) can be used in the treatment of thyroid disorders.

2). Radioisotopes in diagnosis

•Labelled cyanocobalamin can be used to measure glomerular filtration rate.
•Ferric citrate (^{59}Fe) injections can be used for diagnosis of haematological disorders.
•Colloidal gold (^{198}Au) injection used for diagnosis of blood circulation in liver.
•Sodium iodide (^{131}I) injection can be used to diagnose functioning of thyroid gland.
•Iodinated (^{131}I) human serum albumin injection finds use to investigate cardiovascular functions.

•Sodium iodohippurate I-131 injection can be used for diagnostic study of renal functions.
•Sodium rose bengal I-131 injection can be used as a diagnostic agent to test liver functions.

3). Research

•With the use of radioactive isotopes, excellent biological and medicinal studies have been carried out.
•Many biochemical processes can be studied by use of such radioactive isotopes.
•$_{6}C^{14}$ and $_{1}H^{3}$ are most commonly used radio-nucleides for this purpose.

4). Sterilization

•As radiation does not destroy pharmaceutical products so Strong radiation source can be useful for sterilizing pharmaceuticals in final packed containers.
•Also useful for sterilization of surgical instruments in hospitals.
•Thermolabile substances such as vitamins, hormones, antibiotics can be safely sterilized by radioactive substances.

•$_{27}Ce^{60}$ or cesium-137 can be used for sterilizing surgical instruments and pharmaceuticals.

•Some other applications of radio pharmaceuticals:

1). Calcium (Ca-44 and Ca-45): To study bone structure and in the treatment of carcinoma of bone.

2). Radioactive C-14: Important in medical and pharmaceutical research. Ex: Silicone fluids, EDTA.

3). Strontium-90: Used for treatment of superficial carcinoma.

4). Cobalt-60: For sterilization of surgical materials and dressings.

5). Calcium-47: For calcium absorption studies.

6). Cyanocobalamin (Co-57): For diagnosis of pernicious anaemia.

7). Cyanocobalamin (Co-57) capsules USP: For diagnosis of pernicious anaemia.

8). Cyanocobalamin (Co-57) solution USP: For cyanocobalamin absorption tests.

9). Cyanocobalamin (Co-60) capsules USP: It is a product of nuclear reactor.

10). Cyanocobalamin (Co-60) solution USP: To study absorption and deposition of

vitamin B_{12} in normal persons.

11). Gold solution (Au-198): It is neoplastic suppressant.

12). Hydrogen (H-2 and H-3): To determine total body water.

13). Iron (Fe-59): For research studies about utilization and absorption of iron salts.

14). Nitrogen (N-13 and N-15): For investigation of amino acids and protein metabolism and also in studies of nitrogen fixation by plants.

15). Oxygen (O-17 and O-18): For studies in organic reactions and photosynthesis.

16). Sodium (Na-22 and Na-24): For estimation of extracellular fluid, blood circular rate, cellular permeability, excretion and distribution of water.

17). Sodium chromate solution (Cr-51): To study red cell volume and survival time.

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