DEPTH OF BIOLOGY

UNIT V **07 Hours**

- **Radiopharmaceuticals**: Radio activity, Measurement of radioactivity, Properties of α, β, γ radiations, Half life, radio isotopes and study of radio isotopes - Sodium iodide I^{131}, Storage conditions, precautions & pharmaceutical application of radioactive substances.

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RADIOPHARMACEUTICALS

- Radio activity
- Measurement of radioactivity
- Properties of alpha, beta, gamma radiations
- Half life, radio isotopes
- Study of radio isotopes – Sodium iodide I131
- Storage conditions, precautions & pharmaceutical application of radioactive substances

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RADIOPHARMACEUTICALS

By

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Preview

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RADIOPHARMACEUTICALS

- Radiopharmaceuticals are the **radioactive substances** or radioactive drugs for **diagnostic or therapeutic** use.

OR

- Radiopharmaceuticals are medicinal formulations containing radioisotopes which are safe for administration in humans for diagnosis or for therapy

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Define

Radiopharmaceuticals

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RADIOPHARMACEUTICALS

- *Radioactive*
- *Radioisotopes*

RADIOPHARMACEUTICALS

- *Radioactivity :-* The process by which certain elements emit particular forms of radiation
- *Radioactive :-* Any element that emits any of these forms of radiation

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Define

Radioactivity

Radioactive

Units Of Radioactivity

- Unit of Radioactivity is Curie
- Symbol as Ci or C
- It refer to activity of 1 gram of Radioactive material and is equal to 3.7 X 1010 disintegration per second (dps)
- 1 Curie = 3.7 X 1010 dps

Units Of Radioactivity

- BUT nowadays unit of curie is replaced by Rutherford (Rd).
- The Becquerel (Bq) is the SI derived unit of radioactivity
- One becquerel is defined as the activity of a quantity of radioactive material in which one nucleus decays per second

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- The gray (Gy) is defined as the absorbed dose of radiation per unit mass of tissue. One gray is the absorption of one joule of radiation energy per kilogram of matter. The amount of radiation your cells absorb is measured in gray.
- The Sievert (Sv) is a measure of the health effects of low levels of ionizing radiation on the human body.

Units Of Radioactivity

- Roentgen : It is a unit of measurement for the exposure of X-rays and Gamma rays.
- RAD (Radiation Absorbed Dose) : It is a unit of absorbed radiation dose.
- Pharmaceutical dosage forms are described in terms of RAD units.
- RBE (Relative Biological Effectiveness) : Since the effect of given radiation on biological effectiveness depends upon the type of radiation, a unit known as Relative Biological Effectiveness expresses the relative effects of radiations (alpha, beta and gamma) on the biological system.

Radioactive Rays

Radioactive Rays

- All substances are made of atoms.
- These have electrons (e) around the outside, and a nucleus in the middle.
- The nucleus consists of protons (p) and neutrons (n), and is extremely small.
- In some types of atom, the nucleus in unstable, and will decay into a more stable atom.

Radioactive Rays

This radioactive decay is completely spontaneous.

When an unstable nucleus decays, there are three ways that it can do so.

It may give out:-

- ❑ An alpha particle
- ❑ Beta particle
- ❑ Gamma ray

Properties Of Alpha Beta Gamma

Alpha Particles

- The alpha particles are the heaviest as they are produced when the heaviest element decay
- They are not waves but high energy particles which are from unstable nuclei
- These are similar to Helium atom and contain two protons and two neutrons
- These particles are large and heavy in nature, so cannot penetrate but easily get absorbed.

Alpha Particles

- Due to less penetration of alpha particles, elements which emit them do not find any use in biological application as they cannot penetrate tissues.
- They get deflected in electric and magnetic field.
- They produce fluorescence
- They ionize the gas through which they pass and can penetrate through matter

Beta Particles

1. They are much lighter energy particles and have less ionizing power than alpha particles.
2. Beta particles are 8000times smaller than the alpha particles
3. The emission of beta particles from element does not alter the atomic mass and is converted to element with next higher atomic number
4. Beta particles have negligible masses

Beta Particles

5. They get deflected in electric and magnetic field.
6. They ionize the gas through which they pass and can penetrate through matter.
7. Their penetrating power is 100 times more than that of alpha particles.
8. They produce fluorescence

Gamma Particles

- They are having completely different character. They do not have any charge or mass on them. It travels with the same velocity of light
- Gamma rays are like X-rays, have shorter wavelength than the visible light.
- Penetrating power of gamma rays was found to be more than alpha and beta rays.
- When gamma rays are emitted from a radioactive element, no change or loss of atomic mass or number takes place, only there is lowering of nuclear energy.

Gamma Particles

- They produce fluorescence in some materials
- They produce heat on the surface on which they fall
- They can produce nuclear reaction

Radioactive Decay Law

- When a radioactive material undergoes alpha, beta or gamma- decay, the number of nuclei undergoing the decay, per unit time, is proportional to the total number of nuclei in the sample material

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Isotopes

ISOTOPES

- *Isotopes are atoms with the same atomic number but different mass numbers.*

Radioisotopes

- Radioactive nuclide, radioisotope, radionuclide
- Species of the same chemical element with different masses whose nuclei are unstable and dispel excess energy by spontaneously emitting radiation in the form of alpha, beta and gamma rays.

Radioactive Decay Law

How do radioisotopes occur ?

Naturally- as in radium – 226, Carbon-12

Artificially – altering the atoms by using a nuclear reactor or a cyclotron

Radioactive Decay Law

i. Most of the isotopes which occur naturally are stable.

ii. A few naturally occurring isotopes and all of the man-made isotopes are unstable

iii. Unstable isotopes can become stable by releasing different types of particles

iv. This process is called radioactive decay and the elements which undergo this process are called radioactive isotopes/ radioisotopes / radionuclides.

Characteristics of an isotope

- Should release high energy photon
- Should decay without particle emission
- Should be readily available
- Should have specific activity
- Should have compound ability

Application of radioisotopes

a) Scientific research

b) Analytical

c) Diagnostic

d) Therapeutic

Half - Life

- Half life of radio isotope is the time period required for radionuclide to decay to one half the amount originally present
- Abbreviated t1/2

- Gamma is decay constant, a characteristic of a given isotope decaying in unit time

Measurement of Radioactivity

- The measurement of nuclear radiation and detection is an important aspect in the identification of type of radiation (alpha, beta, gamma) and to assay the radionuclide emitting the radiation, suitable detectors are required
- The radiations are identified on the basis of their properties

Classification

A) Based on measuring discharge current due to ionization current

e.g. Geiger- Muller counter, proportional counter

B) Based on visualization of track of ions

e.g. bubble chamber, Cloud chamber

C) Based on light emission

e.g. Scintillation counter

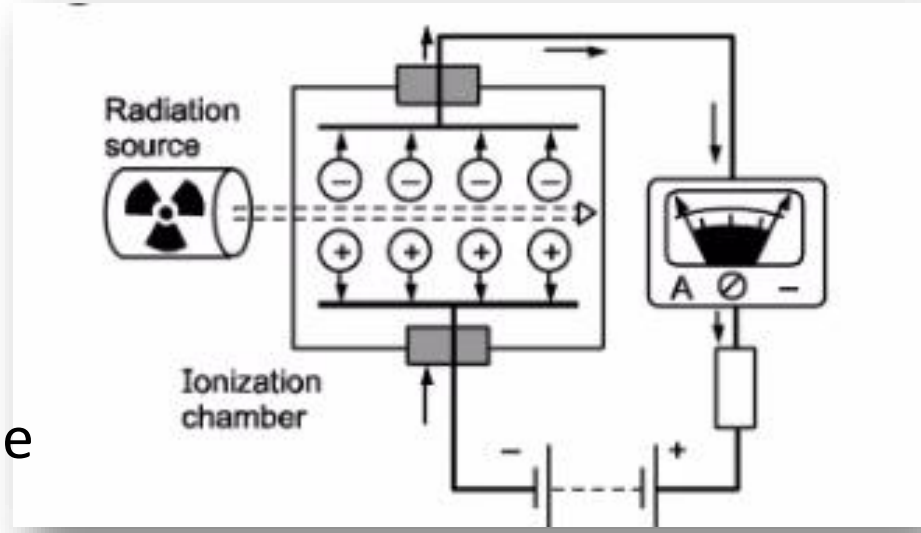
Principle

- All the detectors are based on the principle that the radiation deposits its energy through the formation of charge carriers, either directly or indirectly in the detector which results in the flow of current or a voltage pulse.
- The ions created in the detector can be collected by applying the electric field within the detector and the current flowing through the detector can be measured using an electrometer

1. Gas Filled Detectors

Ionization Chamber:-

- It is the simplest gas filled detector which is based on the collection of all the changes created by direct ionization of the gas molecules through the application of electric field
- It consists of chamber filled with gas like Argon, Helium or Air etc.
- Ionization chamber is fitted with two electrodes kept at different electric potential and a measuring device to indicated the flow of current.
- Radiations bring about ionization of gas molecules or ions which cause emission of electrons which in turn reveals the changes in electric current.



2. Proportional Counters

- It is the modified form of ionization chamber in which an applied potential causes ionization of primary electron which further leads to bursting/ production of more free electrons, which get carried to anode and current pulse through electric circuit gets amplified.
- The voltage range over which ionization occurs is called proportional region and counters working in this region is called proportional counter.

3. Geiger-Muller Counter

- GM counter was developed by Geiger and Muller in Germany in the year 1928. It is the oldest radiation detector due to its low cost, simplicity and in case of operation; it is the best detector among all.
- It does not require use of any high gain amplifier and can detect alpha, beta, gamma radiations easily.

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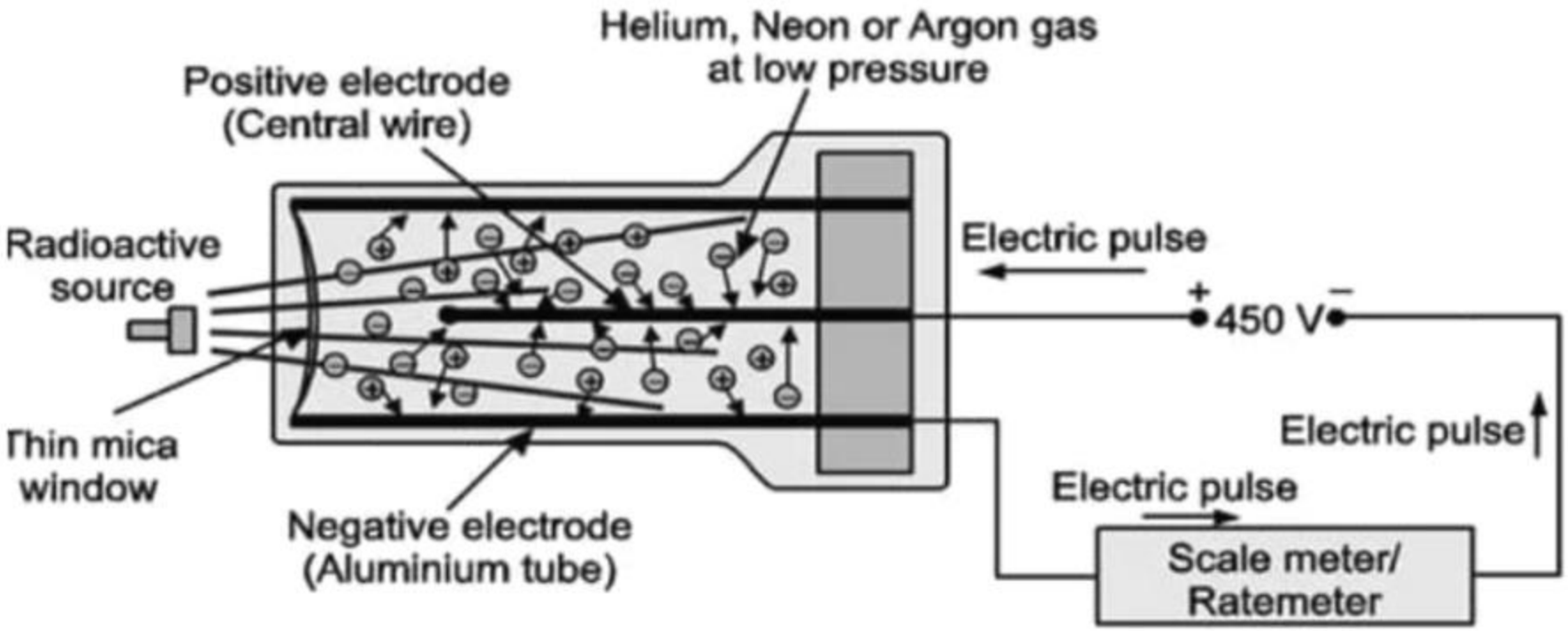
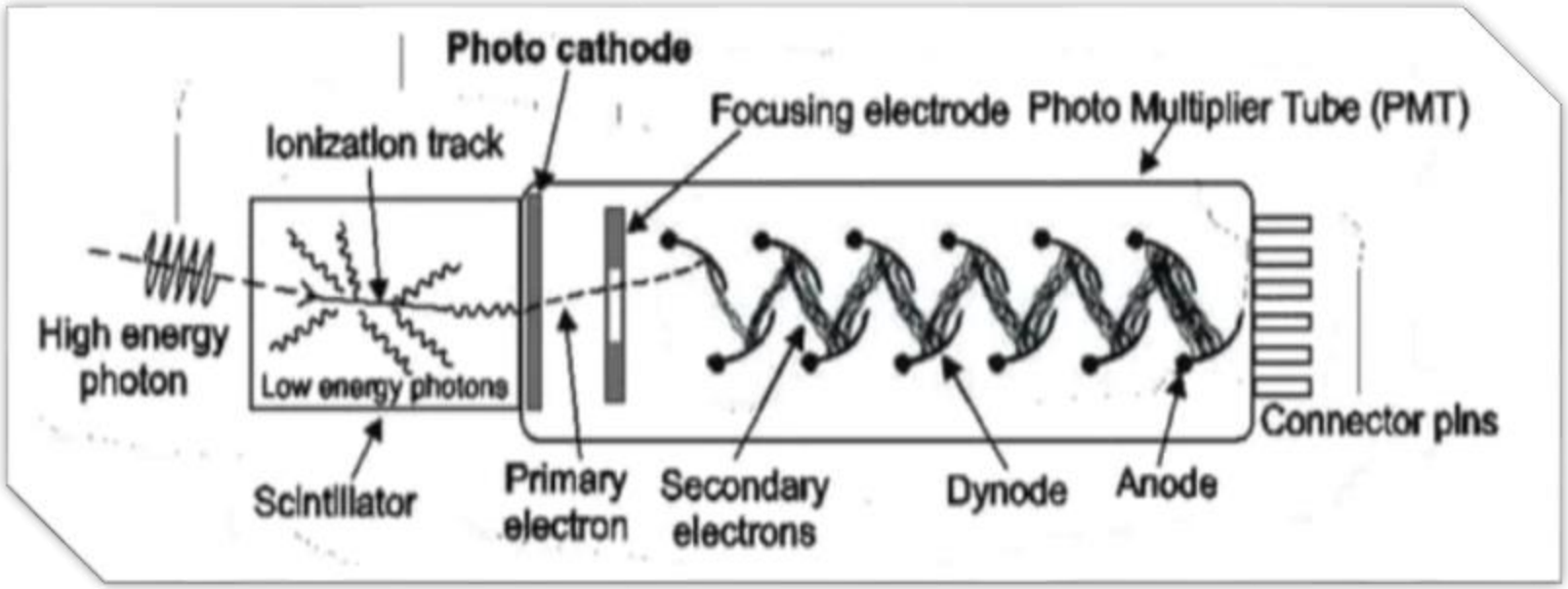


Scintillation Detector

- When high energy radiation or photons is incident on certain substance, a flash of light is emitted by the phenomenon called fluorescence or phosphorescence



OTHERS……

1.Semiconductor Detector:

2.Solid State Detectors:

Handling and Storage of Radioactive Material

1. Great care must be taken in handling and storage of radioactive material so as to protect the people from its harmful effects.
2. The radioactive materials are stored in remote areas such that it should be away from exposure to human beings.
3. Alpha and Beta-emitters are stored in thick glass such that shielding effect is provided, which gamma-emitters are stored in lead containers.
4. The area of radioactive material should be tested for intensity of radioactivity.
5. Exposure to radioactive radiation can cause blood cancer to persons

Certain precautions must be taken:

1) Radioactive material should never be touched with hands but handled by means of forceps.
2) Food contaminated with radioactive material can cause serious damage to internal organs, so avoid and food intake, drinking and smoking within the lab.
3) Sufficient protective clothing or shielding must be used while handling the material.
4) Radioacitve material should be kept in labelled containers and must be shield
5) Area of storage must be under proper supervision
6) Disposal of radioactive material is done with great care.

Labelling

- Every radiopharmaceutical preparation must comply with the labelling requirements established under Good Manufacturing Practice.
- The label on the primary container should include: Document
- A statement that the product is radioactive or the international symbol for radioactivity
- The name of the radiopharmaceutical preparation;
- Where appropriate, that the preparation is for diagnostic or for therapeutic use;
- The route of administration;

Labelling

- The total radioactivity present at a stated date and, where necessary, time; for solutions, a statement of the radioactivity in a suitable volume may be given instead;
- The expiry date and, where necessary, time;
- The batch (lot) number assigned by the manufacturer;
- For solutions, the volume.

Sodium Iodine (I^{131})

Synonym: Radioactive iodine

Out of all radioactive isotopes of iodine, I^{131} is most commonly used.

It is used as an aqueous solution of sodium iodide having sodium thiosulphate in addition as a reducing agent

Method of Preparation:

Most I-131 is prepared in nuclear reactor by neutron-irradiation of a natural Tellurium target

Standards:

It should not contain less than 90% and not more than 110% of labelled amount of Iodine-131 as iodide at the time indicating in the labelling.

Sodium Iodine (I^{131})

Properties:

1. It forms a colorless solution.
2. I^{131} half-life of 8.4 days and emits beta and gamma radiations.
3. Its solution is having pH range of 7 to 10.
4. Hyperthyroidism Treatment by I^{131}:
5. Iodide inhibits the release of thyroid hormone and forms the basis for its use in hyperthyroidism. All the isotopes of iodine are rapidly taken up by thyroid follicles. Radioactive iodine i.e. I131 is available as Na I^{131} solution and is administered orally.

Sodium Iodine (I^{131})

Uses :

1. Radioactive iodine is mainly used for the diagnosis of disorders of thyroid function.
2. It is also used in the treatment of hyperthyroidism.
3. Radioactive iodine is also used in the treatment of Grave's disease
4. It is also used in radiotherapy of thyroid cancer.

Sodium Iodine (I^{131})

Packaging and Storage Condition:

1. The solution has to be prepared in single dose or multiple dose containers that have been previously treated to prevent absorption.
2. So as to avoid absorption of radionuclides on the wall of the container including laboratory vessels, it has been recommended that containers used to handle sodium iodide.
3. I-131 solution, should be first of all rinsed with a solution having approximately o.8% of sodium bisulphate and 0.25% of sodium iodide and then water until the last rinsing has been neutral to litmus.

Application of Radioisotopes

a) Scientific Research

b) Analytical

c) Diagnostic

d) Therapeutic

1. Radioisotopes in Diagnosis

1. Chromium in the form of sodium chromate attaches strongly to the hemoglobin of red blood cells. This makes radioactive chromium-151 an excellent isotope for determining the flow of blood through the heart.
2. Ferric citrate (59Fe) injection finds the use in hematological disorders.
3. Colloidal gold (198Au) has been used in studying the blood circulation in Liver.
4. Sodium iodide (131I) injection is used to study the functioning of Thyroid gland.

2. Radioisotopes in Therapy

1. Iodine-131 is used to treat the thyroid for cancers and abnormal conditions such as hyperthyroidism,
2. Phosphorus-32 is used to control the excess of RBC production in bone marrow.
3. Boron-10 is used in the treatment of tumor. Boron-10 gets concentrated in tumor and on irradiation with neutrons, it produces high energy alpha-particle which kills the cancer.
4. Lead-212 can be attached to monoclonal antibodies for cancer treatment.

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3) In Research :

- Excellent biological and medicinal study can be carried out with radioactive isotopes as tracers. Generally Carbon-14 are most commonly used.

4) Sterilization:

- Thermolabile substances like vitamins, hormones, antibiotics can be safely sterilized by strong radiation sources.

Eg:- Cobalt-60 may be used for sterilizing surgical instrument.

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Sr. No.	Radio-isotope	Applications/Uses
1.	Calcium-44, 45 (Ca-44, 45)	Study of bone structure and bone cancer
2.	Carbon-14(C-14)	Emit beta-radiations, used in medical and pharmaceutical research
3.	Strontium-90(Sr-90)	Pure beta-emitter, used in radiotherapy of superficial carcinoma.
4.	Cobalt-60 (Co-57)	Gamma-emitter, radiotherapy, sterilization of heat labile substances, study of vitamin B12
5.	Cobalt-57(Co-57)	Used in diagnosis of pernicious anemia