Unit-V th

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Radiopharmaceuticals

Radiopharmaceuticals are medicinal formulations containing radioisotope that are used in major clinical areas for diagnosis and therapy.

The facilities procedures for the production, use and storage of radiopharmaceuticals are subject to licensing by national and regional authorities.

They may be to the patient in several different ways.

• Radioactivity :-

Radioactivity is the phenomenon of the spontaneous disintegration of unstable atomic nuclei to atomic nuclei to form more energetically stable atomic nuclei.

Radioactive decay is a highly exoergic, statistically random, first-order process that occurs with a small amount of mass being converted to energy.

• Measurement of Radioactivity

→ In order to measure the radiations of alpha, beta and gamma particles, many techniques ~~pro~~ involving detection and counting of particles or photons have been available.

→ The gas ionisation devices include pulse ionisation chamber, proportional counter and Geiger - Muller counter, scintillation methods are especially employed for counting gamma radiations.

→ The method selected for the measurement of radioactivity depends upon the extend of energy dissipation & penetrability of radiation.

• For measuring radioactivity, three types of devices are available-

(1) Gas-filled tube counters e.g the Geiger Muller counter.

(2) Scintillation counters.

(3) Semi-conductor detectors.

→ The Geiger Muller counter :-

→ The particle detector developed by Geiger and Muller is a gas-filled counter.

→ This instrument is actually used for detecting and measuring ionizing radiation like alpha particles, beta particles, and gamma rays.

→ A Geiger-Muller counter can count individual particles at rates up to about 10,000 per second and is used widely in medicine and in prospecting for radio active ores.

• Construction of Geiger-Muller counter :-

(1) It consists of a hollow metal case enclosed in a thin glass tube. This hollow metal case acts as a cathode.

(2) Fine tungsten wire is stretched along the axis of the tube and is insulated by ebonite plugs. This wire acts as an anode.

(3) The tube is evacuated and then partially filled with a mixture of 90% argon at 10 cm pressure and 10% ethyl alcohol vapors at 1 cm pressure. stn.

(4) The fine tungsten wire is connected to positive terminal of a high tension battery through a resistance R and the negative terminal is connected to the metal tube.

(5) The direct current voltage is kept slightly less than that which will cause a discharge between the electrodes.

(6) At one end of the tube a thin window of mica is arranged to allow the entry of radiation into the tube.

- Principle of Geiger-Muller Counter :-

when an ionizing particle passes through the gas in an ionizing chamber, it produces a few ions. If the applied potential difference is strong enough, these ions will produce a secondary ion whose total effect will be proportional to the energy associated with the primary ionizing event.

→ The efficiency of the counter is defined as the ratio of the observed counts per second to the number of ionizing particles entering the counter per second. Counting efficiency is defined as the ability to count the GM counter.

Counting efficiency, $\eta = 1 - exp(SPI)$

where,

S = specific ionization at one atmosphere.

P = pressure in the atmosphere.

I = path length of the ionization particle in the counter.

- Advantage :-

→ They are relatively inexpensive.

→ They are durable and easily portable.

→ They can detect all types of radiation.

- Disadvantages :-

→ They can not differentiate which type of radiation is being detected.

→ They have a very low efficiency.

- Application of Geiger Muller counter :-

(1) To check possible leakage or exposure to x-rays in a medical facility.

(2) To check the radioactive contamination of clothing and shoes in your workplace.

(3) Radiation detection in the scrap metal processing business.

• Scintillation counter :-

→ Certain substances when exposed to radiation emit flashes of light through fluorescence.
The light output can be used as a measure of absorbed radiations in a scintillator detector.

→ The important properties of a good scintillator detector are- (i) high - scintillation efficiency.
(ii) The light produced should be proportional to the absorbed radiation.
(iii) The detector material should be transparent to the wavelength of its own emission.

Properties of α - radiation

(1) Velocity :- The α - rays are shot out from the radio-active material with large velocities ranging from 1.4×10^9 to 1.7×10^9 cm / second.
α - particles move with a velocity 10,000 miles / second.

(2) Ionising power :- They produce intense ionisation in the gas through which they pass. Their ionising power is 100 times greater than that of β - rays and 10,000 times greater than that of γ - rays.

(3) Penetration :- α - particles have shortest penetration power amongest three radioactive radiations.

(4) Fluorescence :-
α - rays emitted by a radioactive material produce fluorescence when an α - particle is emitted a fluorescent screen, a tiny flash of light, which is called 'scintillation'.

(5) The α - rays are scattered when they pass through thin sheets of mica, gold foil etc.

(6) Deflection:- The α-rays are deflected by electric and magnetic fields showing that they are charged particles.

(7) α-rays produce a heating effect:-
The evolution of heat is due to the stoppage of α, β and γ-rays by the radioactive substance.

(8) when exposed to α-rays the body suffers incurable burns.

Properties of β-radiation

(1) Velocity:- β-particles do not emerge out of a possitive nucleus with the same range and velocity. rather they have a wide band of velocity ranging from 1-99% of the velocity of light.

(2) Ionising Power:- β-rays produce ionisation in air, but the number of ions produced is hardly $\frac{1^{th}}{100}$ of those produced by α-rays.

(3) Penetration:- β-rays can penetrate through large thickness of matter, 1 cm- thickness of aluminium sheet.

(4) Deflection:- β-rays are deflected by electric and magnetic fields. Their direction of deflection shows that they are negatively charged particles.

(5) Fluorescence:- β-rays produce fluorescence in barium platinocyanide, calcium tungstate etc.

(6) They are readily scattered when passing through matter because of their extremely small mass.

(7) They affect photographic plates more strongly than α-particles.

Properties of γ-radiation

(1) Velocity :- γ-rays possess the same velocity as that of light i.e 3×10^{10} cm/second.

(2) Ionisation Power :- They ionise the gas through which they pass, although the ionisation produced by them is comparatively small.
Consequently, their penetrating power is very high as compared to that of β-rays.
e.g → They can pass easily through 30 cms, thickness of iron.

(3) Deflection :- They are diffracted by crystals in the same way as X-ray.

(4) Fluorescence :- They are capable of producing fluorescence and affecting photographic plates more intensely than β-rays.

Half-life period

The term half-life is defined as the time it takes for one-half of the atoms of a radioactive material to disintegrate. Half life for various radioisotopes can range from a few microseconds to billions of years.

$$\text{Half life } t_{1/2} = 0.693/\lambda$$

where λ is disintegration constant in a unit of sec^{-1}

• Significance :-
The half-life of a nucleotide will decide utility in medicine. If the half-life is short will be inconvenient for setting satisfactory experiment. Too long half-life is an absolute property of nuclide and is unaffected by the chemical and biological condition.

Radio active isotope

The radioactive isotope, also called radioisotope, radionuclide or radioactive nuclide any of several species of the same chemical element with different masses whose nuclei are unstable and dissipate excess energy by spontaneously emitting radiation in the form of alpha, beta and gamma rays.

• Radioactive isotopes applications

(1) In medicine, for example, cobalt-60 is extensively employed as a radiation source to arrest the development of cancer.

(2) Iodine-131 has proved effective in treating hyperthyroidism.

(3) Another medically important radioactive isotope is carbon-14, which is used in a breath test to detect the ulcer-causing bacteria Helicobacter pylori.

Sodium Iodine-131

• Sodium Iodide I-131 is a radiopharmaceutical containing the beta- and gamma-emitting radioisotope I-131. After absorption, the iodide is distributed through the extracellular fluid of the body and accumulates in the thyroid gland, thereby allowing the imaging of the thyroid.

• **Description:-** sodium iodide I-131 is a radiopharmaceutical.

• **Molecular weight:-** 153.895896 g/mol.

• **Molecular formula:-** INa.

• **Mechanism of action:-**

Sodium iodide I 131 is taken by mouth, readily absorbed into the body and is trapped within the thyroid gland. The trapped sodium I 131 irradiates the thyroid gland. The trapped sodium iodide I 131 irradiates the thyroid gland thereby damaging it. As a result, the activity of the thyroid gland (that is, the production and release of thyroid hormone) is reduced.

- **Shelf-life :-** 2-6 weeks
- **Storage :-** Do not store above 25°C.
- **Uses :-**

(1) Treatment of thyrotoxicosis.
(2) Treatment of thyroid cancer.

Storage of Radioactive substances

→ Radiopharmaceuticals should be kept in well-closed containers.

→ The storage conditions should be such that the maximum radiation dose rate to which persons may be exposed is reduced to an acceptable level.

→ Care should be taken to comply with national regulations for protection against ionizing radiation.

→ Radiopharmaceutical preparation that are intended for parenteral use should be kept in a glass vial, ampoule or syringe that is sufficiently transparent to permit the visual inspection of the contents.

→ Glass containers may darken under the effect of radiation.

Safety precautions in handling radioactive substances :-

(1) Read and follow the advice and instructions marked on radioactive sources.

(2) Place radioactive solids in lead and unbreakable containers.

(3) Gloves must be worn at any time while handling radioactive materials.

(4) wash hands and forearms throughly after handling radioactive materials.

Applications of Radioisotopes

Radioisotopes find use in medicines in four different ways-

(i) Radiations source in therapy.
(ii) Radioactive tracers for diagnostic purposes.
(iii) Research
(iv) sterilisation.

(1) Radioisotopes in therapeutics :-

→ The therapeutics used radioisotopes have been found to depend mainly on their ability to ionize atoms.

→ The energy measurement involved in radiation and resulting in ionization may be expressed in million of electron volts called MeV.

e.g :- ^{198}Au finds use in the treatment of carcinoma of uterus and urinary bladder.

→ sodium iodide (^{131}I) preparation finds use in the treatment of thyroid dissorders etc.

(2) Radioisotope in Diagnosis :-

Labelled cyanocobalamin finds use for measuring the glomerular rate.

e.g → colloidal gold (^{198}Au) injection - (Diagnostic use in the study of blood circulation in the liver).

sodium iodohippurate I-131 injection - study of renal functions.

(3) Research:-

Excellent biological & medicinal studies have been carried out with radio-active isotopes as tracers. Modern knowledge of many biochemical processes have been the cause of such elaborate studies.

e.g → $^{16}_{6}C$ and $^{3}_{1}H$ are most commonly used radio-nuclides for this purpose.

(4) Sterilization:-

Excellent use is being made of the radiation constantly available from some strong radiation source for sterilising pharmaceuticals in their final packed containers and surgical instruments in hospitals.

e.g → $^{50}_{27}Co$ or cesium-137 may be used for sterilising surgical instrument.