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# PHARMACEUTICAL INORGANIC CHEMISTRY

## UNIT 5

TOPIC :

- **Radiopharmaceuticals** : Radio activity, Measurement of radioactivity, Properties of  $\alpha$ ,  $\beta$ ,  $\gamma$  radiations, Half life, radio isotopes and study of radio isotopes- Sodium iodide I131, Storage conditions, precautions & pharmaceutical application of radioactive substances

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## RADIOPHARMACEUTICALS

### RADIOACTIVITY

- Radioactivity is the spontaneous emission of radiation from the nucleus of an unstable atom.
- It occurs due to an imbalance between the number of protons and neutrons, causing the nucleus to release energy in the form of particles or electromagnetic waves to become stable.

### RADIOACTIVE SUBSTANCES

- Radioactive substances contain unstable atomic nuclei that undergo spontaneous decay, emitting alpha ( $\alpha$ ), beta ( $\beta$ ), and gamma ( $\gamma$ ) radiations.

#### Examples

- Uranium-238
- Carbon-14
- Radium-226

### RADIOPHARMACEUTICALS

- Radiopharmaceuticals are radioactive compounds used for diagnosis or treatment of diseases.

They are designed to target specific organs, tissues, or cells in the body.

#### Examples

- **Iodine-131**: Treatment of thyroid cancer
- **Technetium-99m**: Diagnostic imaging
- **Phosphorus-32**: Treatment of leukemia

# Types of Radiations

## 1. Alpha ( $\alpha$ ) Rays

- Composition: Consist of 2 protons + 2 neutrons (like a helium nucleus).
- Charge: +2 positive charge.
- Mass: Heavy particles.
- Penetration Power: Very low penetration; can be stopped by paper or skin.
- Ionization Power: Very high; can ionize gases strongly.
- Effect on Nucleus:
  - Atomic Number decreases by 2.
  - Mass Number decreases by 4.
- Alpha particles are dangerous if inhaled or ingested but not harmful externally due to low penetration.

## 2. Beta ( $\beta$ ) Rays

- Composition:
  - $\beta^-$ : High-speed electrons (from neutron decay).
  - $\beta^+$ : High-speed positrons (from proton decay).
- Charge:
  - $\beta^- \rightarrow -1$  charge
  - $\beta^+ \rightarrow +1$  charge
- Mass: Very lightweight particles.
- Penetration Power: Moderate; can penetrate paper but stopped by aluminum sheet.
- Ionization Power: Moderate (less than  $\alpha$ -rays).
- Effect on Nucleus:
  - Atomic Number increases by 1 ( $\beta^-$ ).
  - No change in Mass Number.
- Beta particles can penetrate skin and are more hazardous externally than alpha particles.

### 3. Gamma ( $\gamma$ ) Rays

- Nature: High-energy electromagnetic radiation (photon).
- Charge & Mass: No charge and no mass.
- Penetration Power: Very high; can penetrate concrete and lead.
- Ionization Power: Very low (less than  $\alpha$  and  $\beta$ ).
- Effect on Nucleus:
  - No change in atomic or mass number.
  - Usually emitted along with  $\alpha$  or  $\beta$  emission to release excess energy.
- Gamma rays are highly dangerous and require lead shields or thick concrete for protection.

## RADIOISOTOPES

- Isotopes are atoms of the same element with same atomic number but different mass numbers (different neutrons).
- Radioisotopes are unstable isotopes that emit radiation to become stable.

### Examples

- Carbon-14 (used in carbon dating)
- Iodine-131 (thyroid treatment)
- Tritium ( $^3\text{H}$ ), Cobalt-60

## HALF-LIFE

- Half-life is the time required for a radioactive substance to decay to half of its original amount.
- Independent of temperature, pressure, or chemical state
- Used to determine dosage and safety of radiopharmaceuticals

### Example

Carbon-14 has a half-life of 5730 years

Start with 100g → after 5730 years → only 50g remains

## MEASUREMENT OF RADIOACTIVITY

### Instruments used

- Geiger-Müller (GM) Counter
- Scintillation Counter
- Ionization Chamber
- Dosimeters

## GEIGER-MÜLLER COUNTER (GM COUNTER)

### Purpose

- To detect and measure ionizing radiation ( $\alpha$ ,  $\beta$ ,  $\gamma$ )

### Construction

- A sealed tube filled with inert gas (argon or neon)
- Anode (central wire) and Cathode (outer metal tube)

### Working

- Ionizing radiation enters the tube
- It ionizes gas molecules, creating ion pairs
- Electrons move towards the anode
- A pulse of current is generated and recorded

## Advantages

- ✓ Portable
- ✓ Detects low levels of radiation
- ✓ Provides real-time data

## STORAGE & HANDLING OF RADIOACTIVITY

### A. Handling Precautions

- Wear gloves, lab coat, goggles
- Work quickly to limit exposure time
- Use tongs/forceps instead of bare hands
- Use lead shields/containers
- Label materials with radioactive symbols
- Use fume hood for volatile substances

### B. Storage Precautions

- Store in lead-lined boxes
- Keep different isotopes separated
- Store at controlled temperature
- Lock storage rooms (authorized personnel only)
- Regularly check for leaks using Geiger counter
- Maintain records for receipt, usage, disposal

### C. Transport Precautions

- Use shielded and labeled containers
- Follow government safety regulations
- Minimize transport time and avoid unnecessary stops

## Pharmaceutical Applications of Radioactive Substances

### ➤ Diagnosis (Medical Imaging)

- Used to scan and detect diseases.
- Common techniques: PET, SPECT, Scintigraphy.
- Isotopes used:
  - Technetium-99m → bone, heart, kidney scan.
  - Iodine-123 → thyroid scan.
  - Thallium-201 → heart imaging.

### ➤ Therapy (Treatment of Diseases)

- Used in the treatment of cancers and thyroid problems.
- Isotopes used:
  - Iodine-131 → thyroid cancer & hyperthyroidism.
  - Phosphorus-32 → blood cancer (leukemia).
  - Strontium-89 → bone cancer pain.
  - Lutetium-177 → tumor therapy.

### ➤ Sterilization

- Used to sterilize surgical instruments, syringes, etc.
- Isotope used: Cobalt-60 (gamma rays).

### ➤ Research

- Used to study drug metabolism and biochemical processes.
- Isotopes used: Carbon-14, Tritium (Hydrogen-3).

### ➤ Radioimmunoassay (RIA)

- Detects hormones, drugs, and proteins in blood.
- Very sensitive lab test.

### ➤ Pain Relief in Cancer

- Used to relieve bone pain caused by cancer.

- Isotopes: Samarium-153, Strontium-89.
- **Radiotherapy (Cancer Treatment)**
  - External radiation (Cobalt-60) or internal (Iridium-192).
  - Destroys cancer cells.

### Radioisotope: Sodium Iodide I-131

Feature	Details
<b>Name</b>	Sodium Iodide I-131
<b>Chemical Formula</b>	NaI (with radioactive isotope Iodine-131)
<b>Isotope Used</b>	Iodine-131 ( $I^{131}$ )
<b>Atomic Number of Iodine</b>	53
<b>Mass Number of I-131</b>	131
<b>Half-Life</b>	~8 days
<b>Type of Radiation</b>	Emits $\beta$ (beta) and $\gamma$ (gamma) rays

#### Production

- Iodine-131 is produced by nuclear fission of Uranium-235 or by neutron irradiation of Tellurium-130 in a nuclear reactor.

#### Mechanism of Action

- Iodine has natural affinity for the thyroid gland.
- When Sodium Iodide I-131 is administered:
  - It gets absorbed and concentrated in the thyroid.
  - Beta radiation destroys overactive or cancerous thyroid tissue.
  - Gamma radiation helps in imaging and diagnosis.

## Pharmaceutical Applications

### 1. Diagnostic Use:

- Thyroid Function Test – to evaluate hyperthyroidism or hypothyroidism.
- Thyroid Scanning – imaging of thyroid using gamma rays.

### 2. Therapeutic Use:

- Treatment of Hyperthyroidism (e.g., Graves' disease)
- Treatment of Thyroid Cancer – ablation of thyroid remnants after surgery.

## Safety & Precautions

- Patient should be isolated for a short period after administration to prevent radiation exposure to others.
- Avoid close contact with pregnant women or children.
- Urine and saliva may contain radioactive material – handled with care.

## Advantages

- ✓ Targets only thyroid tissue – less systemic effect.
- ✓ Effective, non-surgical treatment for thyroid disorders.
- ✓ Both diagnostic and therapeutic use.

