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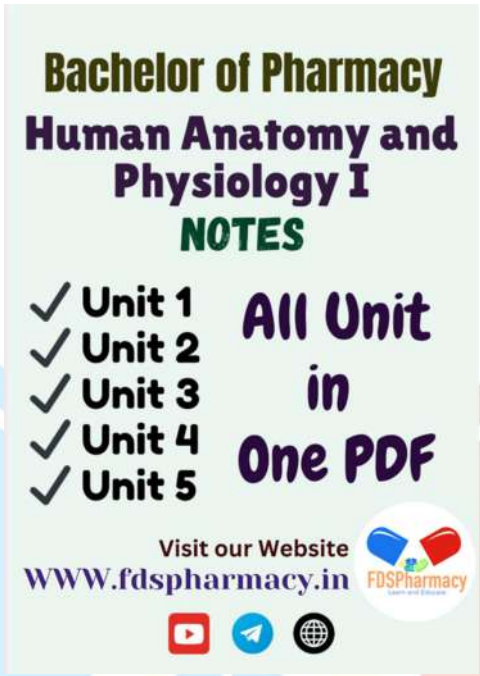
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PHARMACEUTICAL INORGANIC CHEMISTRY

UNIT 5

TOPIC :

- **Radiopharmaceuticals :** Radio activity, Measurement of radioactivity, Properties of α, β, γ radiations, Half life, radio isotopes and study of radio isotopes- Sodium iodide I131, Storage conditions, precautions & pharmaceutical application of radioactive substances

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 (α), beta (β), and gamma (γ) 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 (α) 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 (β) Rays

- Composition:
  - β^-: High-speed electrons (from neutron decay).
  - β^+: 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 α-rays).
- Effect on Nucleus:
  - Atomic Number increases by 1 (β^-).
  - No change in Mass Number.
- Beta particles can penetrate skin and are more hazardous externally than alpha particles.

3. Gamma (γ) 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 α and β).
- Effect on Nucleus:
  - No change in atomic or mass number.
  - Usually emitted along with α or β 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 (^3H), 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 (α, β, γ)

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
Name	Sodium Iodide I-131
Chemical Formula	NaI (with radioactive isotope Iodine-131)
Isotope Used	Iodine-131 (I^{131})
Atomic Number of Iodine	53
Mass Number of I-131	131
Half-Life	~8 days
Type of Radiation	Emits **β (beta)** and **γ (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.