Q1: Radionuclides in medicine and biology:

Nuclear medicine is a field of medicine that uses a trace amount of radioactive substances called radioisotopes for the diagnosis and treatment of many health conditions such as certain types of cancer, and neurological and heart diseases. In nuclear medicine, radionuclides are used to provide diagnostic information about the body. The scans performed in nuclear medicine are carried out by a radiographer. This specialty of nuclear medicine is sometimes referred to as Endo radiology because the radiation emitted from inside the body is detected rather than being applied externally, as with an X-ray procedure Systemic radioisotope therapy (also known as radionuclide therapy) can be used to address a range of health conditions, such as cancer, blood disorders, or those affecting the thyroid gland. It involves small amounts of radioactive material, such as lutetium-177 or yttrium-90, taken into the body through a body cavity, intravenously, orally or other routes of administration that then target different body parts or organs for treatment. A patient with a thyroid condition may be treated with radioactive iodine, sodium-iodide-131, therapy. This involves the patient swallowing a small amount of sodium-iodide-131, which is then absorbed into the bloodstream through the gastrointestinal tract and later concentrates in the thyroid gland, which absorbs iodine-131 thousands of times more than the rest of the body. Once in the thyroid gland, iodine-131 begins to destroy highly-active cancer cells in the gland, thus removing those cells causing the health condition better.

Based on their applications, the important radionuclides are explained below:

1. **Technetium-99m** (^{99m}Tc) Technetium-99m is the most commonly used diagnostic radionuclide in nuclear medicine due to its short half-life (about 6 hours) and gamma-ray emission suitable for imaging. It is used in bone scans, cardiac imaging, brain scans, renal studies, and liver–spleen imaging.

2. **Iodine Isotopes** (^{131}I and ^{123}I) Iodine-131 emits both beta and gamma radiation and is widely used for the diagnosis and treatment of thyroid disorders, especially hyperthyroidism and thyroid cancer. Iodine-123 is mainly used for diagnostic imaging of the thyroid because of its lower radiation dose.

3. **Fluorine-18** (^{18}F) Fluorine-18 is a positron-emitting radionuclide used in PET imaging. The compound ^{18}F-FDG (fluorodeoxyglucose) is commonly used to detect cancer, evaluate brain metabolism, and assess heart function.

4. **Cobalt-60** (^{60}Co) Cobalt-60 is a strong gamma-ray emitter used in radiotherapy for cancer treatment. It is also used in sterilization of medical equipment and in biological research for radiation effect studies.

5. **Phosphorus-32** (^{32}P) Phosphorus-32 is a beta-emitting radionuclide used in the treatment of blood disorders such as polycythemia vera and leukemia. In biology, it is widely used as a tracer to study DNA, RNA, and phosphate metabolism.

6. **Strontium-89** (^{89}Sr) Strontium-89 is used for palliative treatment of bone pain in patients with bone metastases, as it mimics calcium and selectively accumulates in bones.

7. **Gallium-67** (^{67}Ga) Gallium-67 is used in nuclear medicine imaging to detect infections, inflammations, and certain types of tumors, especially lymphomas.

8. **Thallium-201** (^{201}Tl) Thallium-201 is used mainly in myocardial perfusion imaging to evaluate blood flow to the heart muscle and diagnose coronary artery disease.

9. **Lutetium-177** (^{177}Lu) Lutetium-177 is a therapeutic radionuclide used in targeted radionuclide therapy, especially for neuroendocrine tumors and prostate cancer. It emits both beta and gamma radiation.

10. **Carbon-14** (^{14}C) Carbon-14 is used in biological research as a tracer to study metabolic pathways, photosynthesis, and biochemical reactions. It is also used in radiocarbon dating.

Q2: LD50 Q3: Causes of Radiation Death Radiation death occurs when a person is exposed to a very high dose of ionizing radiation within a short period of time. Such exposure severely damages vital tissues and organs, leading to failure of essential body systems. The main causes of radiation death are explained below:

1. **Damage** to the Hematopoietic System High radiation doses destroy bone marrow cells, which are responsible for producing red blood cells, white blood cells, and platelets. This leads to severe anemia, infections due to low immunity, and uncontrolled bleeding, which can be fatal.

2. **Gastrointestinal** (GI) Tract Damage Radiation damages the rapidly dividing cells lining the gastrointestinal tract. This results in severe nausea, vomiting, diarrhea, dehydration, electrolyte imbalance, and intestinal bleeding. Loss of nutrient absorption and infections can lead to death.

3. **Central Nervous System** (CNS) Failure Very high radiation doses can cause damage to the brain and spinal cord. Symptoms include confusion, convulsions, loss of consciousness, coma, and respiratory failure, leading to rapid death.

4. **Extensive Cell Death** and Tissue Necrosis Ionizing radiation causes direct DNA damage and indirect damage through free radical formation. Massive cell death in vital organs such as the liver, lungs, heart, and kidneys lead to organ failure.

5. **Severe Infections** (Sepsis) Radiation suppresses the immune system by destroying white blood cells. This makes the body highly vulnerable to bacterial, viral, and fungal infections, which can progress to sepsis and death.

6. Hemorrhage Radiation-induced destruction of platelets and blood vessel damage results in internal and external bleeding. Uncontrolled hemorrhage is a major cause of radiation-related death.

7. Electrolyte Imbalance and Dehydration Persistent vomiting and diarrhea due to radiation injury lead to severe dehydration and imbalance of electrolytes, causing cardiac arrhythmias and circulatory collapse.

8. Combined Injury Radiation exposure along with burns, trauma, or chemical injuries significantly increases mortality. The combined effects overwhelm the body’s repair mechanisms