
RADIATION SAFETY

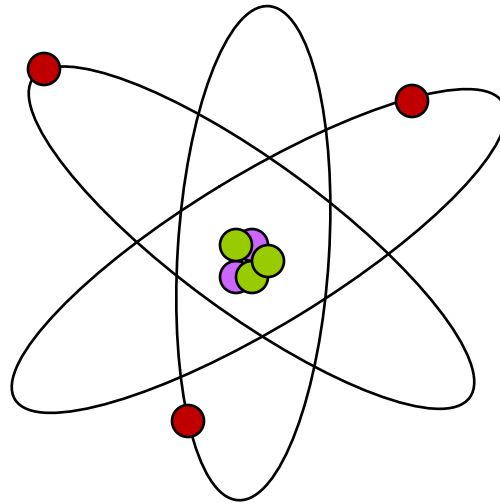
Introduction

- Radioactive isotopes occur naturally or can be generated artificially.
- They emit ionising radiation in the form of electromagnetic waves or energetic particles.
- Exposure to ionising radiation above permissible limits can result in serious biological damage.



Atoms - constituents

- All matter is made up of atoms.
- An atom consists of a nucleus in the center and electrons orbiting around it in defined shells.
- The nucleus of an atom consists of positively charged protons and neutral particles called neutrons.



Radioactive emission

- A radioactive nucleus is unstable due to an imbalance in the proton to neutron ratio.
- The unstable nucleus can become stable by ejecting particles and electromagnetic waves.
- If an atom loses an orbiting electron it becomes a positive ion as it will have more positive charges than negative charges. The electron that was removed becomes a negative ion.



Types of emissions

The electromagnetic wave/particles emitted by the radioactive isotopes are-

- Alpha
- Beta
- Gamma



Alpha radiation

- Alpha particle consist of two protons and two neutrons.
- Their range in air is about 10 cm. They will not penetrate through the dead layers of the skin.
- They can be stopped completely by a piece of paper or by clothing worn.



Alpha radiation

- Alpha source is not an external hazard to the body. But they are an internal hazard if it get inside the body through ingestion or via a wound, etc.
- Once inside the body they disintegrate, causing serious damage to the surrounding tissue within few microns depth.



Beta radiation

- Beta particles are electrons which are ejected from the nuclei of radioactive atoms by disintegration.
- They can penetrate into the human body from 0.2 to 1.3 cm and can travel few meters through air.
- If they are deposited on the skin for long periods of time they could cause severe burns.



Beta radiation

- Beta emitters are internal radiation hazards when taken inside the body.
- When the beta particle is slowed down or stopped, secondary X radiation known as bremsstrahlung may be produced.
- Beta particles can be stopped by the walls of a room or by a sheet of plastic about 1.3 cm thick.

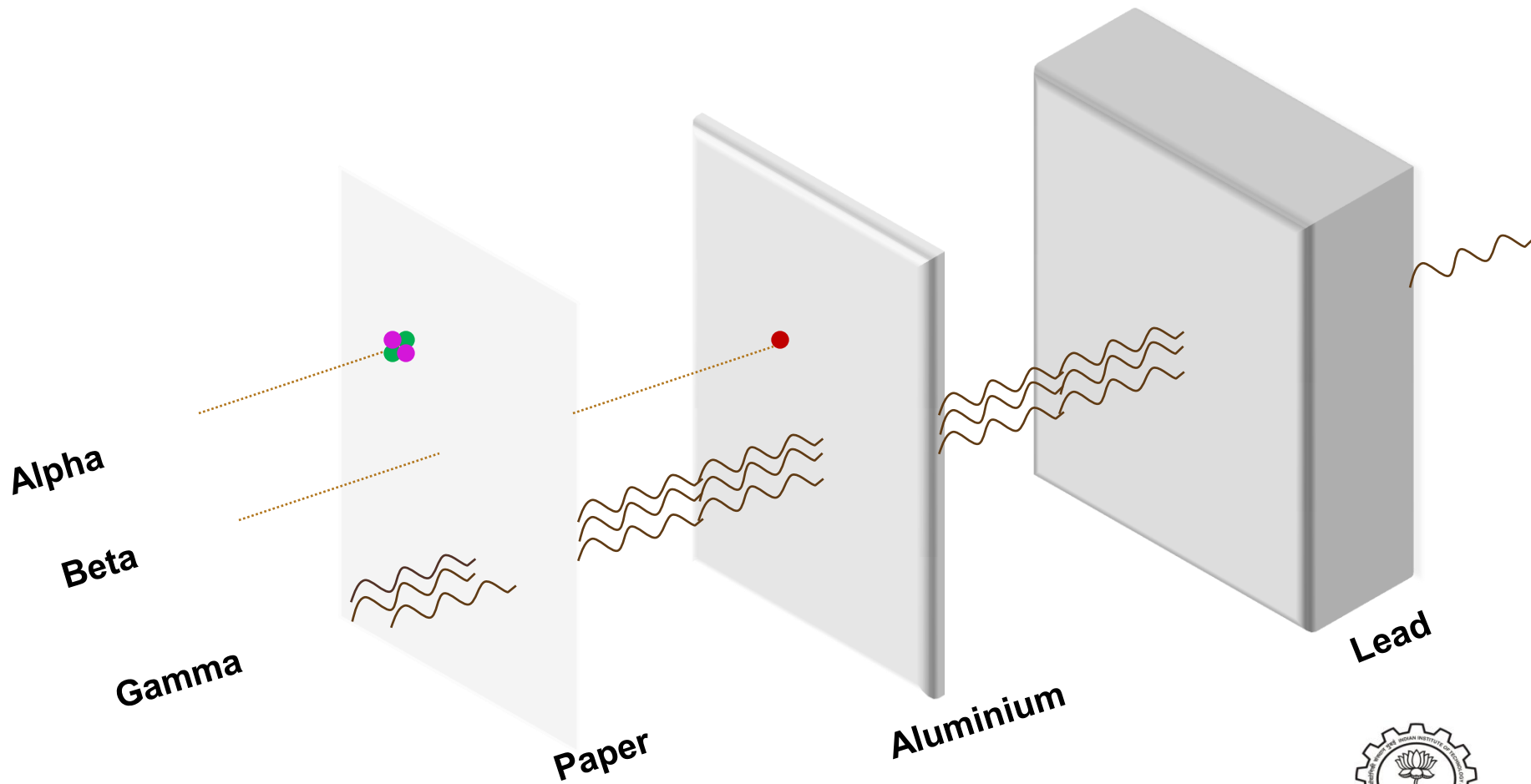


Gamma radiation

- Gamma rays are electromagnetic radiation of short wavelength that are deep penetrating.
- Due to the deep penetration, they present an external exposure hazard.
- They can travel many meters in air.



Penetration power of radiation



Biological effects of radiation

- As radioactive photons/particles pass through living cells, they cause rupture of bonds in the molecules resulting in molecular changes that injure the affected cells.
- This destroys the capacity of reproduction in some cells or causes mutation, in which the cells resulting from division are different from parent cell.
- A very weak exposure over several years, can be as potentially injurious as a large single exposure.



Biological effects of radiation

- An important characteristic of injuries arising from penetrating radiation is the latent period that intervenes between the exposure and the visible signs of its effects.
- The time between the exposure and the first signs of radiation damage is called the “latent period”. The larger the dose, the shorter the latent period.



Basic safety factors

For external radiation exposure hazards, the basic protection measures are associated with

- Time
- Distance
- Shielding



Time

- The simplest method for protection from ionizing radiation is to spend as little time as possible in the vicinity of radiation source.
- This is applicable even when other protection methods are adopted.
- Reducing the exposure time by one half reduces the dose received by one half.



Distance

- Doubling the distance between the person and the source helps to reduce the exposure to a quarter of its original value.
- Maintaining a safe distance is important when working near inadequately shielded sources of radiation.



Shielding

- The more mass that is placed between a source and a person, the less radiation the person will receive.
- Transparent plates of thick plastic or aluminium is used for shielding beta particles.
- Gamma rays can be attenuated by using lead shields or concrete.



Monitoring Instruments

Film badges

- The film badge is worn on the outer clothing of the user.
- It consists of a photographic film. Radiation interacts with the silver atoms in a photographic film, resulting in the darkening of the film.
- The darkened film is then compared to a control film that was not exposed to radiation to determine the amount of radiation exposure.



Monitoring Instruments

Thermo luminescence detectors (TLD)

- TLDs are worn by the person as badges or as finger rings, which consists mostly of lithium fluoride chips.



Monitoring Instruments

Thermo luminescence detectors (TLD)

- The absorbed radiation displaces electrons from their ground state. The electrons are trapped in a meta stable state and light is emitted when electrons return to the ground state.
- The amount of light released is related to the absorbed radiation dose.



Monitoring Instruments

Pocket Dosimeter

- It consists of electrostatically charged quartz fiber and ionisation chamber. When chamber is exposed to radiation, the air atoms in the chamber become ionised.
- This allows the static electricity charge to leak from the quartz fiber in direct relationship to the amount of radiation present.
- The advantage is that it allows the individual to determine his/her radiation dose while working with radioactive isotopes.



Monitoring Instruments

Ionisation Chamber

- It consists of an ionisation chamber with a positive and negative electrode.
- When exposed to a beam of radiation, a current will flow in the circuit because the electrons that are knocked out of the air atoms by the radiation will be attracted by the positive electrode.
- The flow of current will be in proportion to the radiation received.



Monitoring Instruments

Geiger- Mueller Counters

- Capable of detecting very small amounts of radiation.
- It uses an ionization chamber but it is filled with a special gas and has a greater voltage supplied between its electrodes.



Radiation Units

Becquerel (Bq)

- The strength of a radioactive source is measured in units of Becquerel (Bq).
- It is equivalent to one disintegration per second. This unit provides a measure of the rate of radioactive disintegration.
- There are 3.7×10^{10} Bq per curie of radioactivity.



Radiation Units

Absorbed dose

- The amount of energy absorbed per unit weight of the organ or tissue is called the absorbed dose. It is expressed in units of Gray (Gy).
- One Gy is equal to one Joule of absorbed energy per kilogram of matter.
- Rad is the older unit and $1 \text{ Gy} = 100 \text{ rads}$



Radiation Units

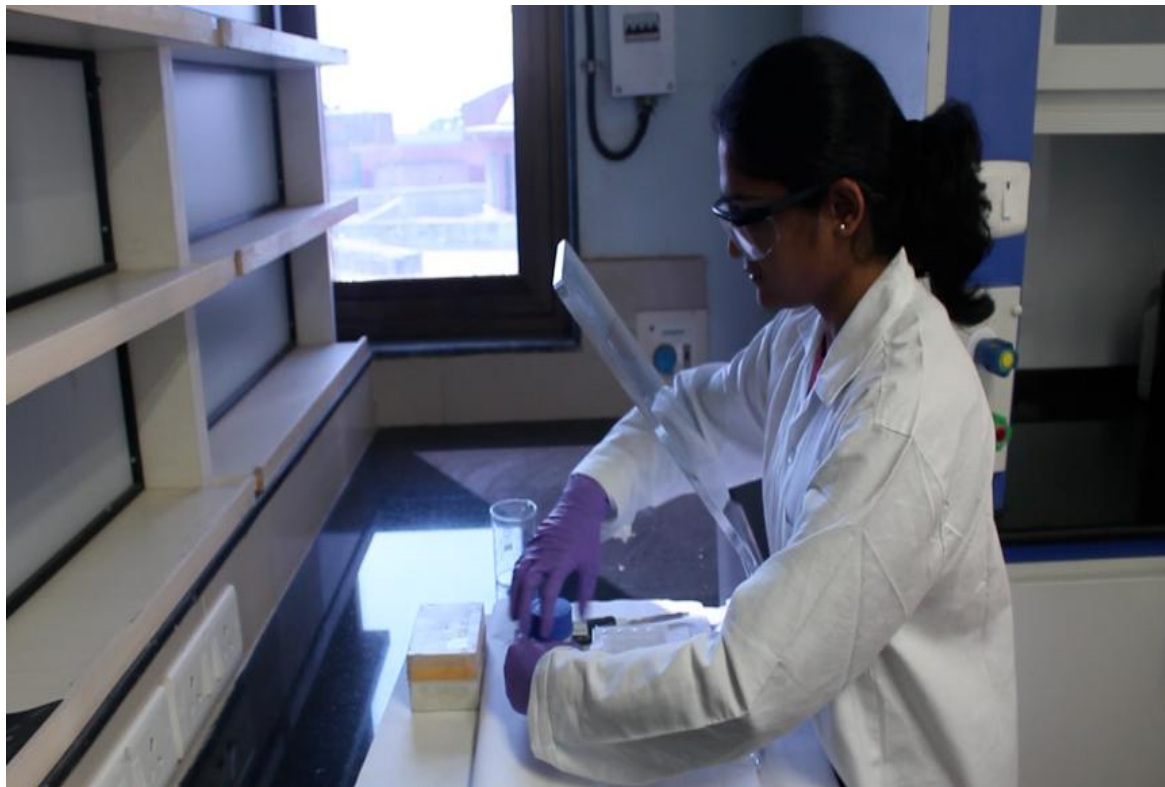
Equivalent dose

- The equivalent dose in Sv is equal to "absorbed dose" multiplied by a "radiation weighting factor".
- Rem is the older unit of equivalent dose.
- $1 \text{ Sv} = 100 \text{ rem}$



Safety Precautions

- Lab coats, shoes and safety glasses must be worn in the laboratory.



Safety Precautions

- Materials/equipment which are not required must not be brought into the laboratory or stored inside.
- An inventory of radioactive sources used in the laboratory must be maintained and updated.
- Food items must not be stored or consumed inside the laboratory.



Safety Precautions

- Radiation symbols must be displayed wherever active sources are being manipulated or stored.



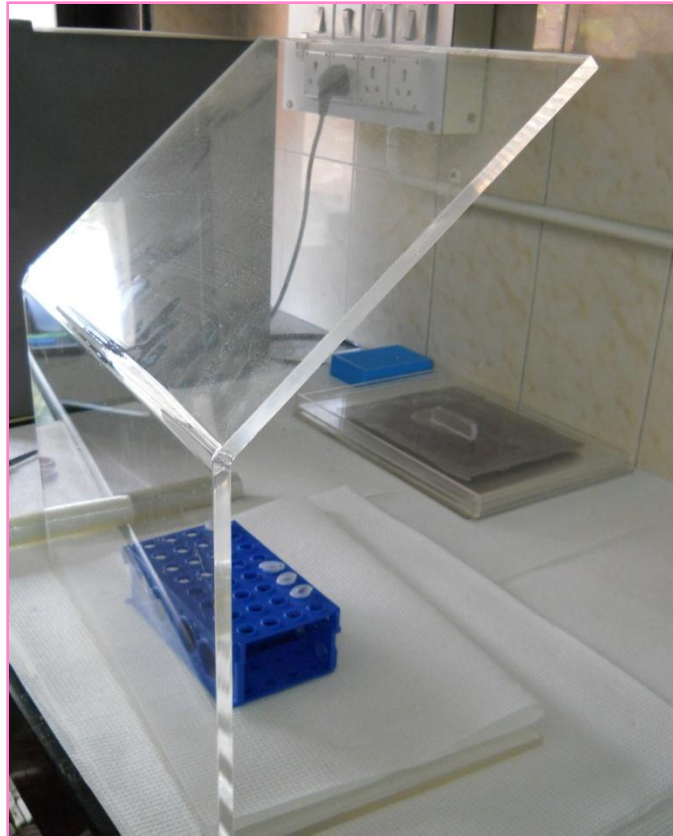
Safety Precautions

- Gloves, clothing, apparatus and benches must be monitored after work with radioactive materials.



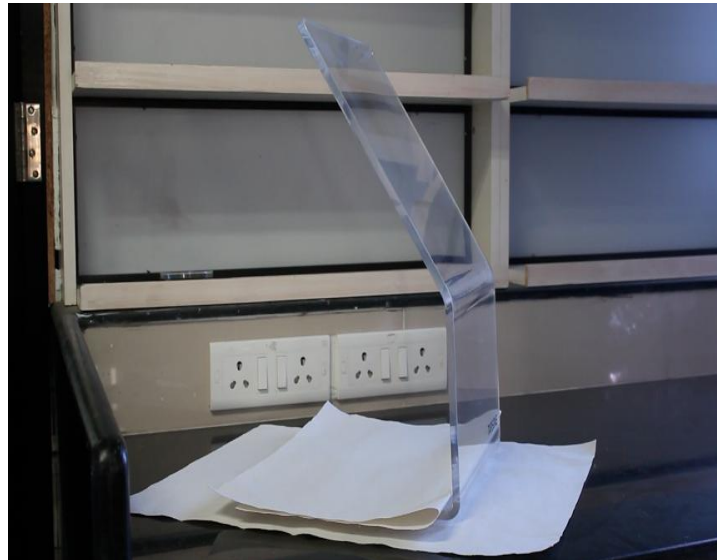
Safety Precautions

- Always use appropriate shielding when working with radioactive materials



Safety Precautions

- Use remote handling devices such as forceps, tongs wherever possible.
- Never pipette solutions by mouth.
- Work surface must be covered with smooth, non absorbent materials.



THANK YOU
