بسم الله الرحمن الرحيم

King Saud University
College of Science
Physics & Astronomy Dept.

Phys 145 (General Physics)

Chapter 10: Ionizing Radiation

Week n° 14

This presentation has been prepared by: Pr. Nabil BEN NESSIB

Chapter 10: Ionizing Radiation

- **We will learn in this chapter 10:**
- Interaction of Radiation with Matter
- Radiation Units

Interaction of radiation with matter

- There are four major categories of radiation of interest to us.
- In order of increasing range in matter, there are:

1. Positive ions, such alpha particles.
2. Electrons and positrons
3. Photons (gamma and X rays)
4. Neutrons

Energy loss rate

- An ion traveling through a medium collides repeatedly with atomic electrons and gradually loses energy.
- In a given medium, the energy ΔK lost per unit distance by an ion with charge q and velocity v is proportional to the square of q/v.

$$\Delta K \propto -\frac{q^2}{v^2} \quad \text{or} \quad \Delta K = -C_o \frac{q^2}{v^2}$$

- This energy is also proportional to the density of atomic electrons in the medium (different C_o for different medium).
- The minus sign indicates that the ion is losing kinetic energy.
- Using that the kinetic energy of the ion is: $K = \frac{mv^2}{2}$
- We find: $\Delta K = -C_o \frac{mq^2}{2K}$

Video 01 of week 14: Ionizing radiation

Radiation unit

Four types of radiation measurements are used in various applications:

1. Source activity
2. Exposure
3. Absorbed dose
4. Biologically equivalent dose

Radiation unit

Source activity

The **activity** is related to the **half-life** by:

$$A = \lambda N = \frac{0.693}{T} N$$

The SI **source activity unit** is the **becquerel** (Bq), which is: 1 disintegration per second.

1 Bq = 1 desintegration/s

We can use the curie (Ci) also:

1 Ci = 3.70 x 10^{10} disintegrations/s

Radiation unit

Exposure

Four types of radiation measurements are used in various applications:

Exposure is defined as the amount of ionization produced in a unit mass of dry air at standard temperature and pressure (STP: 1 atmosphere and 0 Celsius).

The unit of **exposure** is the **roentgen** (R):

2.58×10^{-4} **1R = 2.58x10^{-4} C/kg**

Exposure is defined only for X rays and gamma rays with energies up to 3 MeV and not for other types of radiation. Thus 1 R of X rays will produce 2.58x10^{-4} of positive ions in a kilogram of air at STP, and an equal amount of negative ions.

$$1 \text{ R} = 2.58 \times 10^{-4} \text{ coulomb per kilogram}$$

Radiation unit

Absorbed dose

The absorbed dose is the energy imparted by ionizing radiation to a unit mass of absorbing tissue.

The SI unit for **adsorbed dose** is the **gray** (Gy), which is defined as 1 joule per kilogram.

1 Gy = 1 J/kg

Another unit is the rad, which is defined as 0.01 joule per kilogram. Thus:

1 Gy = 100 rad

Absorbed dose is used with all kinds of ionizing radiation.

Radiation unit

Biologically equivalent dose

The effects of radiation on biological systems depends on the type of radiation and its energy.

Each radiation has a **quality factor** (QF) associated with it. This factor is defined **by comparing its effect** to those of a standard kind of radiation, which is usually taken to be **200-keV X rays**.

For example, fast neutrons have a quality factor equal to 10 for causing cataracts. This means that the dose of 200-keV X rays needed to produce cataracts is 10 times the dose required for neutrons.

The QF varies with animal species and the biological effect under consideration.

Radiation unit

Biologically equivalent dose

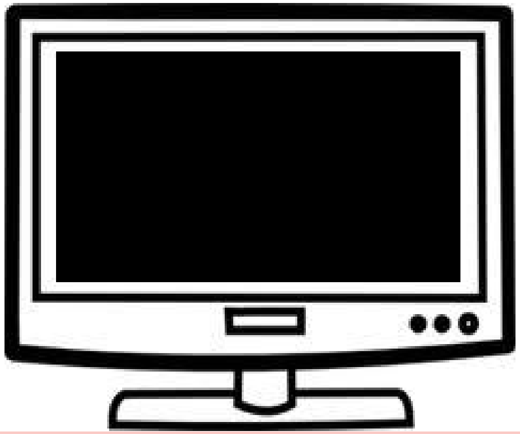
The units used in discussion of biological effects are:

In SI system the sievert (Sv) and the rem.

The **biologically equivalent dose** in **sieverts** units (SI) is given by the **product** of the **physical absorbed dose in grays** times the **QF**.

The **biologically equivalent dose** in **rems** is given by the **product** of the **physical absorbed dose in rads** times the **QF**.

Video 01 of week 14: Radiation unit



Summary of week 14

The energy loss rate formula is: $\Delta K \propto -\dfrac{mq^2}{2K}$

We have the conversion formula:

1 Gy = 1 J/kg = 100 rad

Radiation damage is measured using dosimetry.

Effect of absorbed dose depends on type of radiation.

Quiz for week 14