

Introduction to Radiation

Introduction to Radiation – Study Notes

1. What Is Radiation?

Term	Definition
Radiation	The emission and propagation of energy in the form of particles or electromagnetic waves.
Ionizing radiation	Radiation with enough energy to remove tightly bound electrons from atoms, creating ions (e.g., X-rays, γ -rays, α -particles, β -particles, neutrons).
Non-ionizing radiation	Lower-energy radiation that does not ionize atoms (e.g., visible light, infrared, microwaves, radio waves, ultraviolet-A/B).

2. Types of Radiation

Category	Sub-type	Typical Sources	Typical Energy Range
Electromagnetic	X-rays, gamma-rays, UV, visible, IR, radio	X-ray tubes, radioactive decay, Sun, LEDs	10 eV – >10 MeV
	alpha-particles, beta-particles, neutrons, protons, heavy ions	Radioactive nuclei, nuclear reactors, cosmic rays	0.1 MeV – >100 MeV
Acoustic/Mechanical	Ultrasound	Medical imaging transducers	20 kHz – 1 GHz (energy expressed as pressure)

Only the first two groups are usually meant when discussing “radiation” in physics and health contexts.

3. Fundamental Concepts

Concept	Explanation	Units
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Energy (E)	Amount of work that can be done by the radiation.	electron-volt (eV), joule (J)
Frequency (f)	Number of wave cycles per second (for EM radiation).	Hertz (Hz)
Wavelength (λ)	Distance between successive peaks of a wave.	meters (m)
Speed of light (c)	Relationship: $c = f \cdot \lambda$ ($3.00 \times 10^8 \text{ m/s}$ in vacuum).	
Half-life ($t_{1/2}$)	Time for half of a radioactive sample to decay.	seconds, years, etc.
Activity (A)	Number of decays per unit time.	becquerel ($\text{Bq} = 1 \text{ decay/s}$)
Absorbed dose (D)	Energy deposited per unit mass.	gray ($\text{Gy} = 1 \text{ J/kg}$)
Equivalent dose (H)	Absorbed dose weighted by radiation type (quality factor Q).	sievert ($\text{Sv} = 1 \text{ J/kg}$)

4. Interaction Mechanisms

Radiation	Primary Interaction(s) with Matter
α-particles	Direct ionization; short range (a few μm in tissue).
β-particles	Ionization and bremsstrahlung; range up to a few mm in tissue.
γ-rays / X-rays	Photoelectric effect, Compton scattering, pair production (energy-dependent).
Neutrons	Elastic/inelastic scattering with nuclei, neutron capture, (n,γ) reactions.
UV-A/B	Electronic excitation, photochemical reactions (e.g., DNA damage).
Visible/IR	Electronic/vibrational excitation, thermal heating.

*The probability of each interaction is described by a **cross-section** (