Chapter 31

Nuclear Energy; Effects and Uses of Radiation

Lecture 1

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31-4] Passage of radiation through; biological damage

↳through matter

Nuclear radiation includes:

$^4_2He^{++}$ ← $\alpha, \beta^+, \beta^-, p, n, \pi, \gamma, \ldots$

X-rays are also a type of radiation but NOT nuclear radiation as x-rays don't originate from the nucleus. X-rays are emitted from transitions of electrons between atomic energy levels.

Nuclear radiation and X-rays are called ionizing radiation. Why?

ion → Na^+, e^- ← free e^-

When radiation passes through matter it ionizes the atoms (produce free e^- and positive ions).

When radiation passes through matter it can cause considerable damage.

Metals and structural materials become brittle and become weakened due to passage of radiation.

Biological Damage

Damage of biological cells is primarily due to the ionization that is caused by the radiation.

- Free electrons and positive ions can interfer with the normal operations of the cell like, for example, important chemical reactions.
- Knocking electrons off atoms and molecules (ionization) can break molecules and may also change their structure which eventually interfers with the normal functions of the cell.

- Radiation may also damage the DNA. Each alteration to the DNA can affect a gene and alter the molecule it codes for.

31-5] Measurement of Radiation - Dosimetry

Controlled amount of radiation can be used for diagnosis and also for treatment of cancer. Radiation is used to kill malignant (cancerous) cells.

Therefore, it is important to quantify the amount or dose of radiation. This is known as dosimetry.

The strength of a radioactive source is specified by stating its activity at a given time. Remeber

$$A = A_0 e^{-\lambda t} \qquad t_{1/2} = \frac{\ln 2}{\lambda}$$

Therefore, activity decreases with time. Therefore, we must state the time when we specify the activity particularly when the radioactive source has a short half-life.

SI unit of activity is the Becquerel (Bq)

1 Bq = 1 decay/s.

Another more commonly used unit is the Curie (Ci)

1 Ci = 3.7×10^{10} Bq (decays/s).

1 Ci is the activity of exactly one gram of radium.

Note that activity gives the number of decays per second. But it gives NO information regarding the effect of radiation on biological tissues.

Exposure

Measured in units of Roentgen (R).

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NOTE: The definition of exposure has limited

① radiation type to X-rays and γ-radiation.

② matter where energy is deposited to air. [nothing about biological tissues or the effect of radiation on biological tissues].