RADIATION PHYSICS

OUTLINE –

Radiation physics is a branch of physics that deals with the behaviour and interaction of electromagnetic and particulate radiations with matter.

INTRODUCTION

➢ Radiation is a process in which the energetic particles or energy or waves travel through a medium or space.

➢ Two types:

1. Ionizing radiations

2. Non ionizing radiations

➢ Geiger counters are usually required to detect its presence.

➢ In some cases, it may lead to secondary emission of visible light upon interaction with matter, as in radioluminescence Ionizing radiation

➢ Illustration of the relative abilities of three different types of ionizing radiation to penetrate solid matter. Alpha particles (α) are stopped by a sheet of paper while beta particles (β) are stopped by an aluminium plate. Gamma radiation (γ) is dampened when it penetrates matter.

Types of radiation

➢ Particulate radiation :e.g.:- α rays, β rays, protons, electrons, neutrons

➢Electro magnetic radiation :e.g.:- with electric and magnetic fields perpendicular each

other and to the line of propagation.

Uses of radiation

➢ In medicine

Radiation and radioactive substances are used for diagnosis, treatment, and research.

Eg:X-rays

➢ In communication

All modern communication systems use forms of electromagnetic radiation

➢ In science

Radiocarbon dating.

Environmental scientists use radioactive atoms known as tracer atoms to identify the pathways taken by pollutants through the environment.

Properties of x-rays

➢ Electromagnetic radiations with wavelength 0.1 – 0.5 A◦ and energy 25 – 125 keV.

➢ Able to penetrate materials which reflects visible light.

➢ Unaffected by electric and magnetic fields.

➢ Produce phosphorescence and fluorescence.

Discovery

➢ Wilhelm Rontgen discovered and named X rays.

➢ Henri Becquerel found that uranium salts caused fogging of an unexposed photographic plate.

➢ Marie Curie discovered radioactivity of Radium and Polonium.

➢ Alpha particles, beta particles and gamma ray radiation were discovered by Ernest Rutherford.

➢ R. Eberle in is known as the father of veterinary radiology, who described the uses of X rays in veterinary practices

FIRST MEDICAL X-RAY BY WILHELM RÖNTGEN OF HIS WIFE

ANNA BERTHA LUDWIG'S HAND – 1896

X-ray interactions

➢ Coherent scattering.

➢ Photoelectric effect.

➢ Compton effect.

➢ Pair production.

➢ Photodisintegration.

Photoelectric effect

➢ When X ray photon interacts with inner shell electron.

➢ Photoelectron is emitted.

➢ X ray ceases to exist.

➢ Characteristic radiation.

➢ High kVp reduces patient dose.

Compton effect

➢ When X ray interacts with an outer shell electron.

➢ Produces scattered radiation.

➢ Major radiation hazard in diagnostic radiology.

Production of x-rays

➢ X ray tube: vacuum tube, converts electrical energy to X rays.

➢ Evolved from Crooke's tube.

➢ Used in radiography, CAT scanners, X ray crystallography etc.

X-ray tube

.➢ Cathode : tungston filament.(MP- 3370◦c, Z- 74)

➢ Focusing cup : nickel or molybdenum

➢Anode :tungston – rhenium alloy embedded in a block of copper.

➢ Two types:

1. stationary

2. rotatory

➢ Focal spot : The area in the target which is bombarded by the electrons from the cathode during exposure.

➢ Target angle : The degree of bevelling in the tungsten strip of rotatory anode is called target angle.

➢ Heel effect : The radiation intensity on cathode side is higher than that of anode side, and the difference is as high as 40%.

➢ Thicker parts are positioned towards cathode.

Electron target interactions

➢ Collisional interaction : produce heat

➢ Radiative interaction : produce 2 types of radiations

➢ Characteristic radiations-happens when low E electron interacting with inner shell electron of target atom (homogenous X-rays).

➢Bremsstrahlung/general/white radiation-happens when E of incidental electron is high(heterogenous X-rays).

Crooke's x-ray tube

Invented by British physicist William Crookes. The cathode is on the right, the anode is in the centre with attached heat sink at left. The electrode at the 10 o'clock position is the anticathode. The device at top is a 'softener' used to regulate the gas pressure.

Coolidge tube

Coolidge X-ray tube, from around 1917. The heated cathode is on the left, and the anode is right. The X-rays are emitted downwards.

Coolidge tube

Rotatory anode

Factors affecting quantity

➢ Tube current (mA).

➢ Tube potential (kVp).

➢ Focal film distance (FFD).

➢ Filtration

Factors affecting quality

➢ Tube potential: when kVp increases, quality of X rays increases.

➢ Filtration: removes soft X rays, thereby increasing quality.

Microfocus x-ray tube

➢ Some x-ray examinations (e.g.: non-destructive testing and 3-D microtomography) need very high resolution images and do therefore require x-ray tubes that can generate very small focal spot sizes, typically below 50 µm in diameter. These tubes are called microfocus x-ray tubes.

➢ There are two basic types of microfocus x-ray tubes: solid-anode tubes and metal-jet anode tubes.