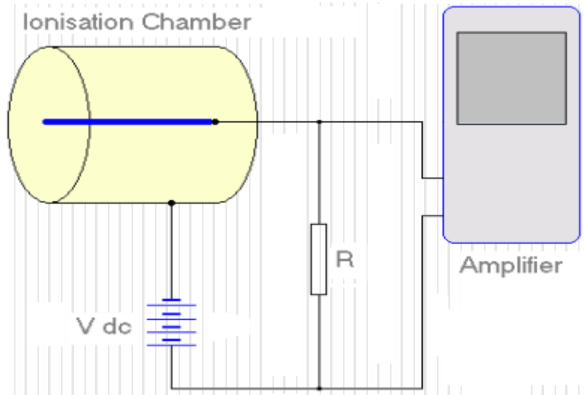
Session 4

IMAGING PHYSICS MADE EASY

RADIATION DOSIMETRY

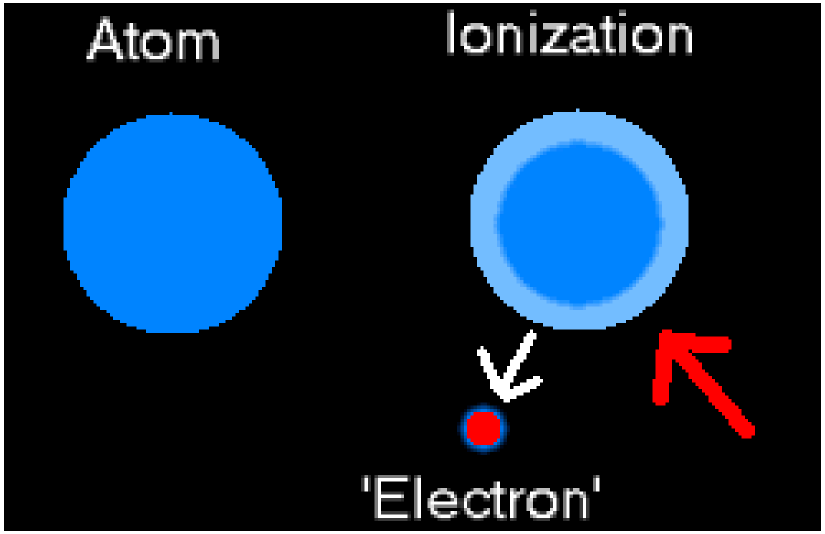


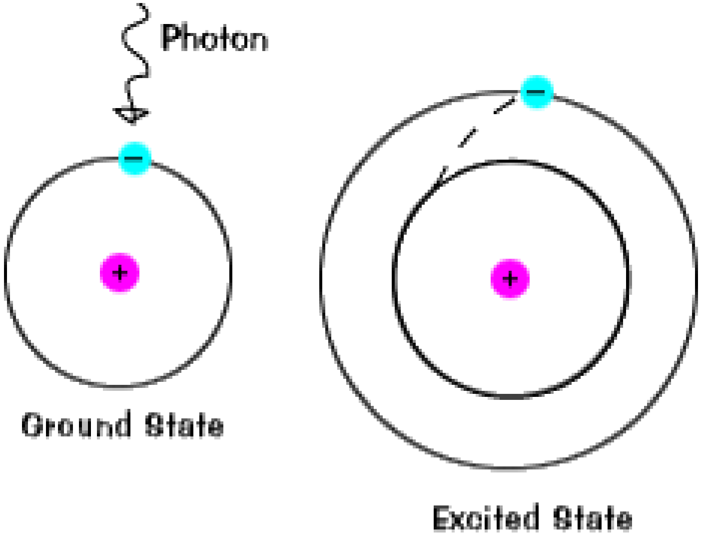
By

Dr. Ahmad Mokhtar Abodahab

Absorbed dose

- Effects of ionizing radiations → correlated with the energy deposited as **ionization** and **excitation** of atoms of the material.





- **Absorbed dose:** energy deposited per unit mass of the material (in **joules / Kg**).

SI unit of Absorbed Dose

Gray (Gy)

- **1(Gy) =** J / kg
- **Absorbed dose rate →** is measured in grays / second,
- with the usual **multiples** and **sub-multiples**.
- **Absorbed dose :** is used to define the **quantity of radiation** delivered at a specified point in radiation field.
- It is valuable when considering tissue and biological effects.

SI unit = International System Units

(الجول Joule)
الوحدة الرياضية/الفيزيائية لقياس الطاقة

- **Before 1980,**

➔ **Rad** was the international unit of absorbed dose.

It is used in some old textbooks.

- **1 Gy = 100 Rad** i.e. 1 **rad** = 1 cGy or 10 mGy
-

kerma

__k__inetic __e__nergy __r__eleased to __ma__ss unit.

- **kerma**, it applies to X- rays , gamma rays & neutrons.
- **Exposure :** was old term to described absorbed dose.
- It was measured by the unit **Rontgen = 10mGy**

Summary – Radiation Quantities & Units

Quantity	Equation	Medium	Type of Radiation	SI unit	Classical unit	Relation
Activity	$A = dN/dt$	Any medium	Any radiation	Bq (dps)	Ci	$1\ Ci = 3.7 \times 10^{10}\ Bq$
Absorbed dose	$D = dE/dm$	Any medium	Any radiation	Gy (J/kg)	Rad 1Rad=100 ergs/g	1 Gy=100 Rad
Equivalent dose	$H = D \times W_R$	Living tissue	Radiation dependent	Sv	rem	1 Sv = 100 rem
Effective Dose	$E = H \times W_T$	Whole body		Sv	rem	1 Sv = 100 rem
Collective effective dose	$S = E_i N_i$			man-Sv	man-rem	
Exposure	$X = dQ/dm$	Air	X, γ	C/kg	Roentgen, R	$1\ R = 2.58 \times 10^{-4}$ C/kg

Measurement of X- and gamma ray dose

- It is extremely difficult to measure absorbed dose in solids or liquids directly.
- **In theory**, this can be done by measuring temperature rise,
- **In practice**, temperature change for high absorbed dose of 1 Gy → a temperature rise not Significant → it is impractical.

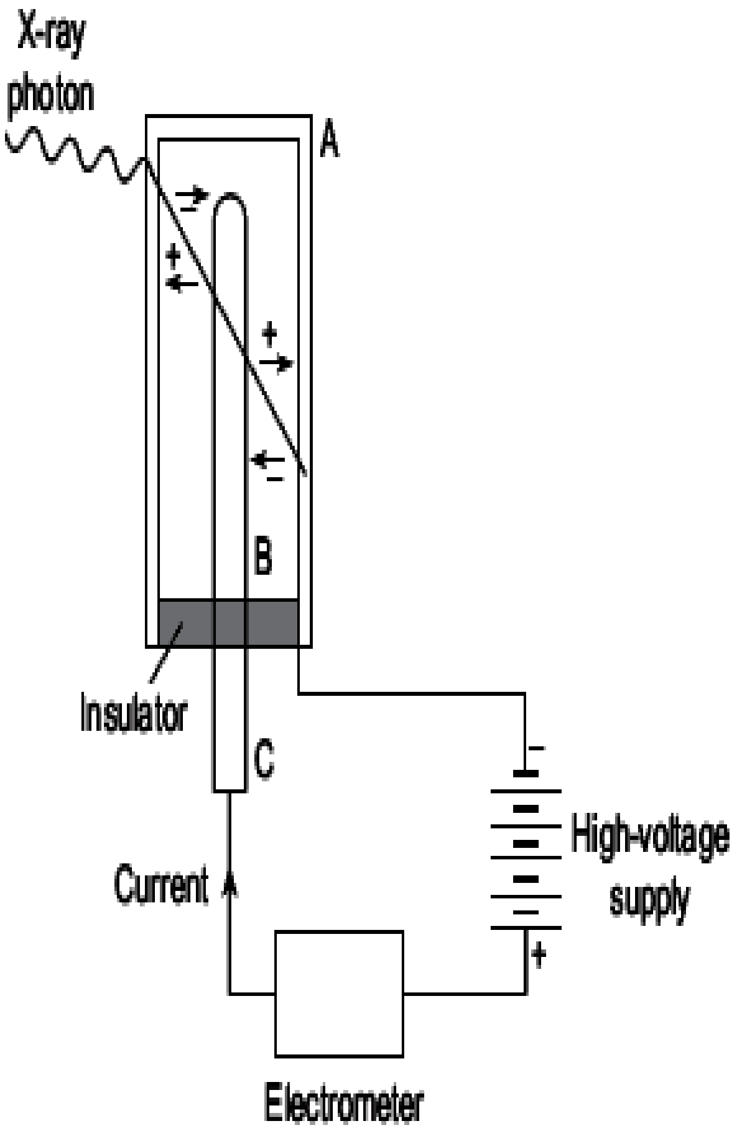
TOOLS OF DOSIMETER

1- Ionization chamber

- **Air kerma**

= measuring the amount of ionization produced by the photon beam in air.

- **Chamber** consists of:
  - Plastic outer wall (A)
  - Air-filled cavity (B),
  - Insulator separating it from
  - thin central electrode (C).



- **wall material** : (***air-equivalent material***) matches air of its effective atomic number.

- **Wall thickness** : sufficiently thick → electrons produced outside the chamber will not penetrate the wall & deposit ionization in the cavity;

  ✓ (**0.2 mm** is sufficient for photoelectrons from 140 keV X-rays)

  ⌧If the wall is **Too thick**, → **Attenuate** the radiation being measured.

Its use In practice, need to apply ***several corrections***,

- **Chamber Shape** : commonest →cylindrical (as illustrated here)

or consist of parallel electrodes.

- **Chamber volume**: for diagnostic radiology → **10–30 cm**^{3}

  for the measurement of scatter radiation →**150 cm**^{3} or bigger.

Why air in ionization chamber ?

- **Air is the standard material for dosimetry because**:

●it has an effective atomic number (7.6) close to that of tissue (7.4),

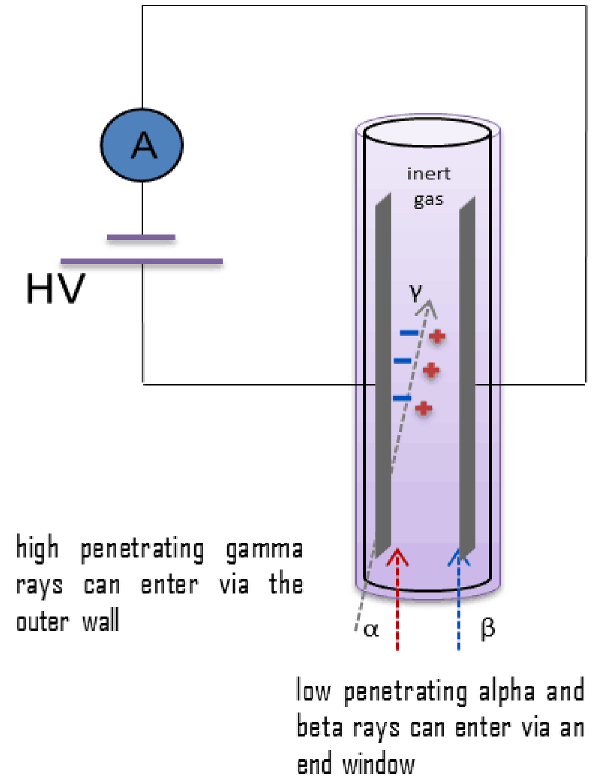
→ factor used to convert absorbed dose in air to absorbed dose in tissue can be made **easily** and **accurately**

●it is applicable for measurement over a wide range of X- and gamma ray energies

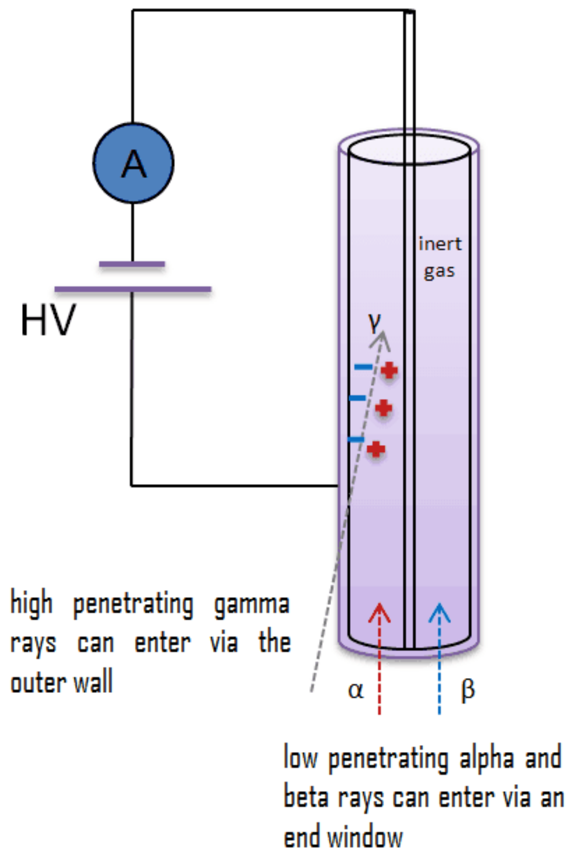
●large and small doses are easily and accurately measured

Ionization chamber made by Pierre Curie, c 1895-1900

Ionization Chamber



Detector of Ionizing Radiation basic scheme



Other dosimeters

- **Lithium fluoride thermo-luminescence dosimeters**

used for both personal and patient dosimetry

- **Photographic effect** in silver bromide, used in film badge
- **Photoconductivity** in silicon diodes to be used in

direct reading electronic personal dosimeters and

dosimeters used for quality assurance.

Radiation quantity and quality

Intensity = the **amount** or **quantity** of radiation

approximately

- proportional to the square of the kV
- proportional to the mA
- inversely proportional to the square of the distance F from a point source.

- these quantities are:
- ●decreased as the filtration is increased
- ●greater for a constant potential than a pulsating potential
- ●greater for high rather than low atomic number targets.

Quality

The penetrating power of an X-ray beam.

LUMINESCENCE

The process in which a material absorbs energy from an external source and re-emits that energy in the form of visible light.

- The external energy source may be : chemical, biological and physical sources,
- in radiology we are concerned only with radiation sources for which the term **photoluminescencemay** be used.
- Luminescence can be divided into **two types**:
- **fluorescence,** which is (more or less) the emission of light directly following energy input
- **phosphorescence**, which describes delayed light emission referred to as afterglow.

Fluorescence

- Is the function of intensifying screen of X ray cassette
- It convert X ray to light directly
- X film is more sensitive for light more than X ray
- Thus it reducing dose of x ray & improving image

Sources & Further reading

- https://petervis.com/electronics%20guides/polonium%20detector/ionisation%20chamber.html
- https://en.wikipedia.org/wiki/Ionization_chamber
- https://www.radiation-dosimetry.org/what-is-ionization-chamber-ion-chamber-definition/


THANK YOU
A.M. Abodahab
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