RADIATION DOSIMETRY

Q**uantifying the energy** deposited in a medium by directly or indirectly ionising radiation and **Defines the relationship** between radiation and the effect it causes when deposited in a medium.

Exposure: charge liberated by ionisation per unit mass o**f AIR.** (quantifies ability of X rays to ionise air). Only secondary electrons calculated in this, and calculated the Energy that needs to be absorbed by a material to release a set amount of charge)

Kerma: Energy liberated per unit mass in medium. (Energy transferred to medium)

Exposure can be calculated by measuring charge. Kerma cannot be directly calculated.

KERMA air = Exposure x W/e

W/e = constant. Energy transfer to air required to release unit charge in air. Energy required to produce an ion pair in air== 33.7J/C

Absorbed dose: Dose absorbed in unit mass of medium.
Depends on mass energy absorption coefficients, i.e. u/p (linear attention coefficient divided by density)

Kerma and Absorbed dose at a point are usually different due to particle range (particle travels before depositing its energy)

Where CPE exists (charged particle equilibrium)
KERMA = AD

CONDITIONS FOR CPE

atomic composition and density of medium is homogenous
Negligible attenuation of photon irradiation within volume
No inhomogeneous electric or magnetic fields (only really true if photon E < 300kV)
Exposure can be measured with a FREE AIR CHAMBER:

Dose from exposure calculation breaks down at energy of photons >1MeV

For High energy photons measurements:
Need cavity theory (bragg gray cavity theory)
This essentially assumed that in a thimble chamber, the graphite is very dense air. And hence a massive free air chamber is condensed into the graphite wall. This assume that the volume of air inside the chamber is the central volume or CPE exists across that region. This mean electrons produced in graphite and entering air are equal to electrons produced in air and leaving the cavity. As it is quite small there is negligible attenuation within the volume and the composition is as homogenous as possible. IF all charge in the chamber is measured, that gives an accurate description of exposure and hence dose.
many assumptions

Dosimetry (what can you use as a surrogate measure?):
Ionisation: air chambers
Temp changes: Calorimeters
Excitations: TLD (DIODES)
Chemical detectors/Colours: (optical density) Radiographic films with AgBr crystals. chemical change due to radiation. On developing film crystals reduced to metallic silver which causes blackening. Optical density related to dose… OR Radiochromic films. GafChromic: Radiation causes polymerisation of radiation sensitive monomer. Seen as a coloured dye.

GAS FILLED DETECTORS
can detect different levels of ionisation depending on voltage applied across electrodes.
AS voltage increases different regions are identified:
Ionisation Region; detect primary ionisation
Proportional Region: Detect secondary ionisations (and proportional counters can be used depending on types and E or radiation)
Geiger Region: Insensitive. Avalanche of secondary ionisation. Can detect if ionisation present on not. Not good for quantifying.

FREE AIR CHAMBER
A large air chamber
Radiation enters through a narrow beam and a window at one end.
Measurement of charge, are thereby radiation in a small central region across which CPE is maintained.
Beam intensity must be constant across measuring central region
Distance from collimator to central volume and electrode to central volume must both be more than particle range to ensure CPE

Essentially 2 electrodes separated by air gap

OTHER AIR CHAMBERS:
Thimble chamber or parallel plate chamber
Thimble chamber cannot be used less than 9.5MeV

Correction factors

Temp and pressure (std temp 20degree C and pressure 1.013Bar)
Ion pair recombination (approx 1%)
Polarity effect (worse with electron beams, charge measures differs depending on polarity of collecting electrode)

Temp and pressure correction factor: (273.15 + T / 293.15) x (1013.25/P)
As temp inc, or pressure decreases = air is less dense and hence dosimetry reading decreases and correction factor will be >1

(0 celcius in kelvin in 273.15)

Ion pair recombination - not all ion pair produced are measured as some recombine

DIODES:

Silicon is an insulator in pure form
More Sensitive , W/e = 3.5 J/C or W = eV, energy req to produce an ion pair is less and Si is 1800x more dense than air
impurities lead to n or p type semiconductors. (n = excess negative free electrons, p = positive holes)
joining them together creates a depletion region where no charge, no holes, small PD across this. Radiation creates charge in this region and this can be measured. **Gives a direct read out**
Correction for SSD, temp, field size, wedge, **DIRECTION**

Thermoluminisence diodes: crystalline structures with impurities which emit light when heated.
Radiation - frees electrons which are trapped in impurity caused higher energy levels —— when heated, trapped electrons released — emit light —> light relates to dose
Very sensitive, poor accuracy
Can be re-used, but reading taken only once per event.No direct read out

Scintillation counters. radiation— generates light — photo multiplier tube changes light to electric current.
Use in radiation protection.

In vivo dosimetry (on surface of patient)
TLD
Diodes

Practical reference dosimetry usually uses TLDs or small thimble chambers
(to calibrate linacs)
Measured in water