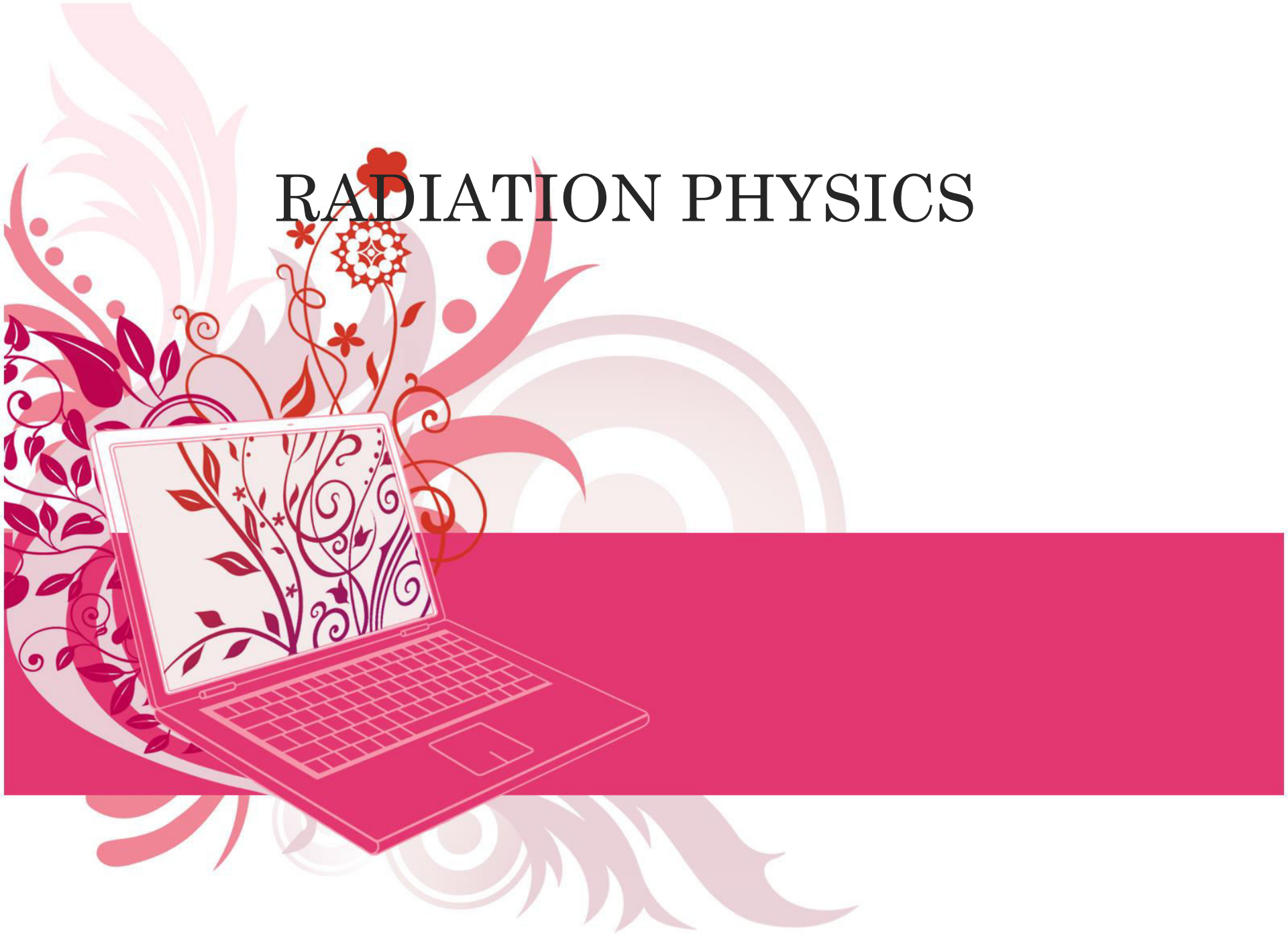

Good Morning

RADIATION PHYSICS

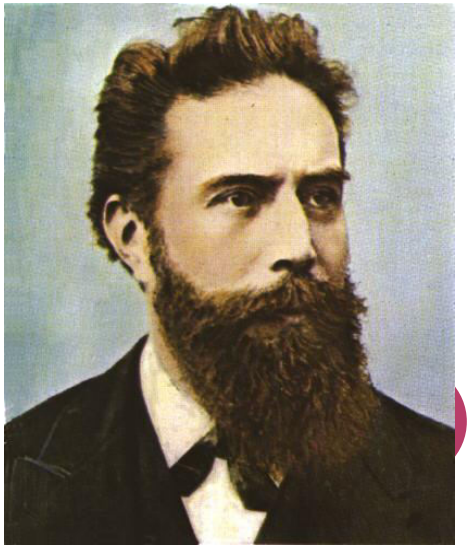


Contents

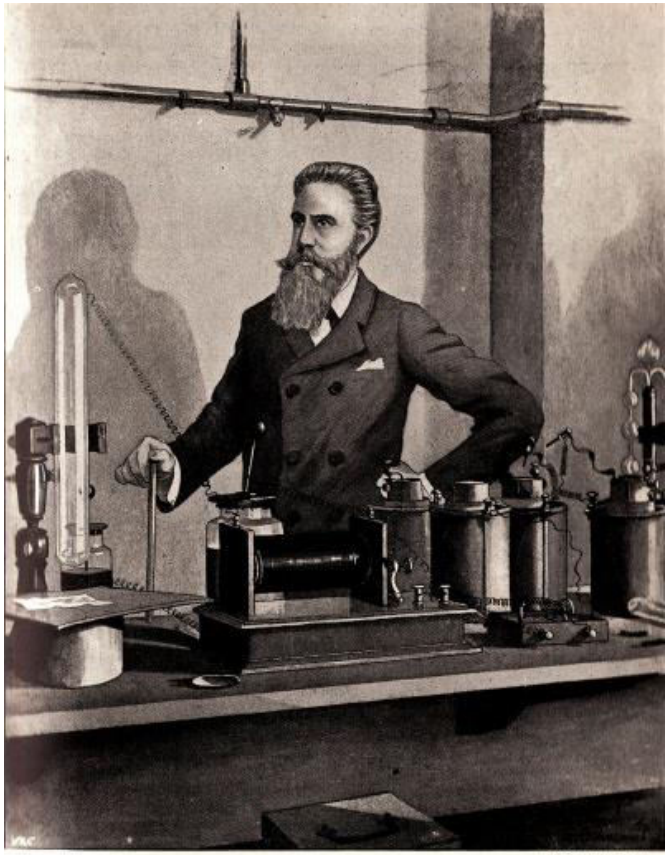
- Basics of physics
- History of radiology
- Radiation and types
- Concepts of electromagnetic radiation
- The x ray machine
- Production of x rays
- Factors controlling The x ray beam
- Types of x rays
- Interaction of x ray with matter

HISTROY OF RADIOLOGY

- Sir William Morgan(1785)
- Wilhem Hitroff (1870)
- Sir William Crookes(1880)
- Prof. Wilhem Conard Roentgen(1895)



Ref: TB of dental and maxillofacial radiology- freny



Professor Röntgen at work.

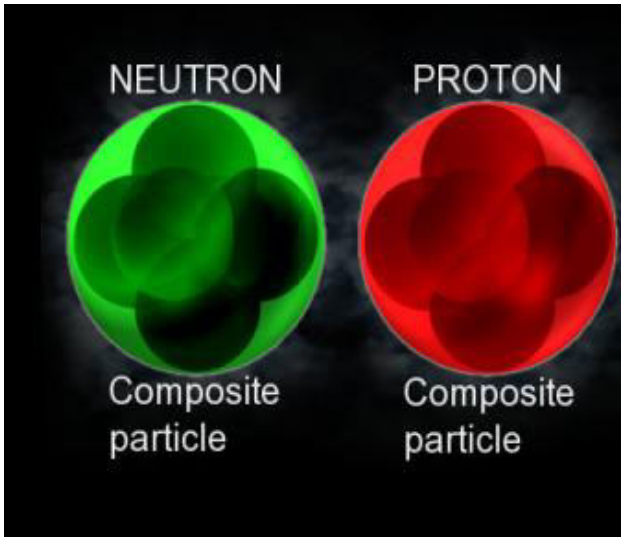
radiograph taken by roentgen

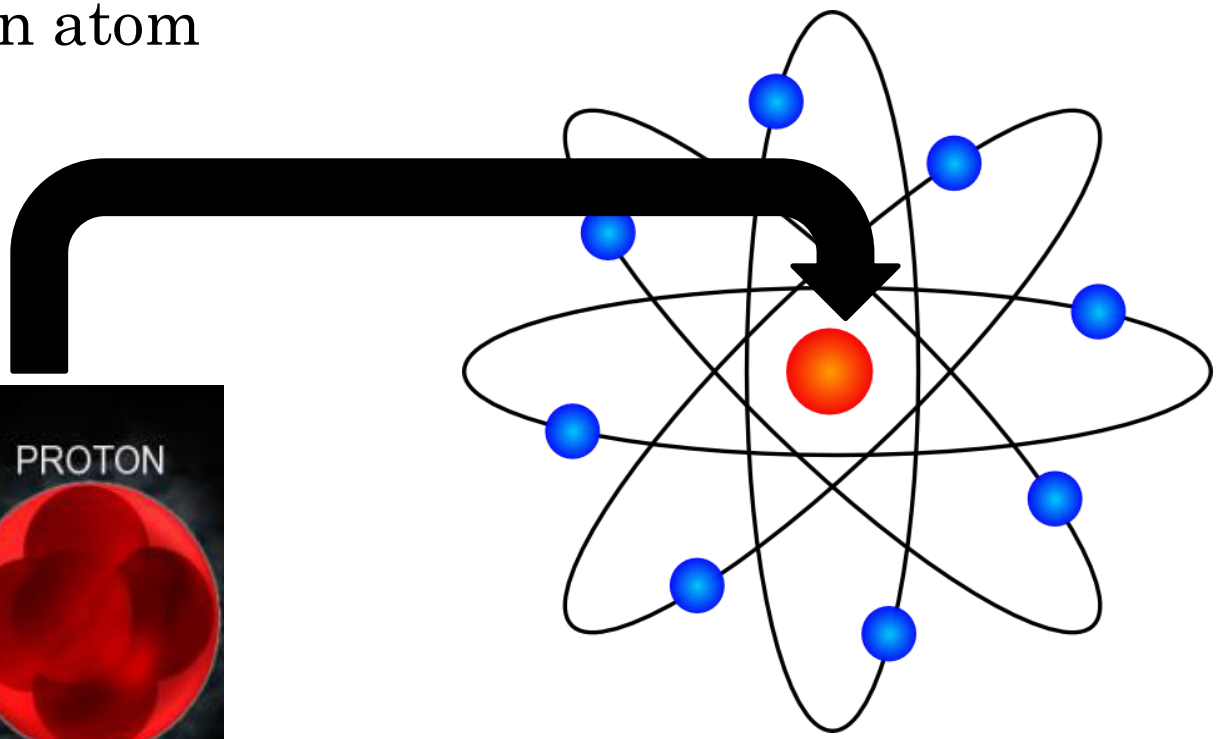
Dental radiology

- Dr.Otto walkhoff
- Dr Edmund Kells (1896)
- Franklin w. Mc cormarck(1910)
- Dr.Numatta (1933)
- Dr.Pateero (1946)

Basics of physics

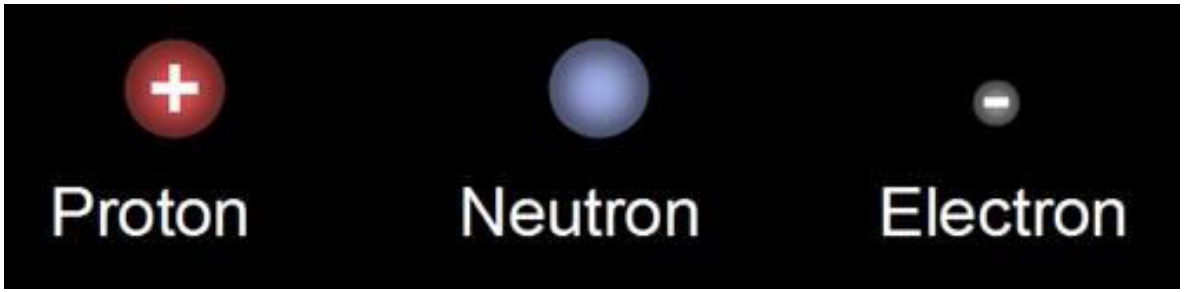
- Structure of an atom

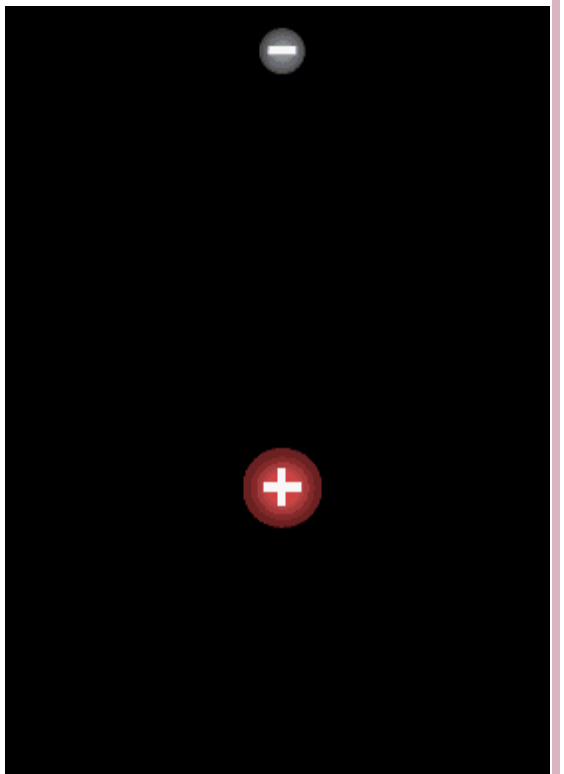




TB of dental radiology- Laura Jansen
Radiologic science for technologist- bushong

- Binding energy





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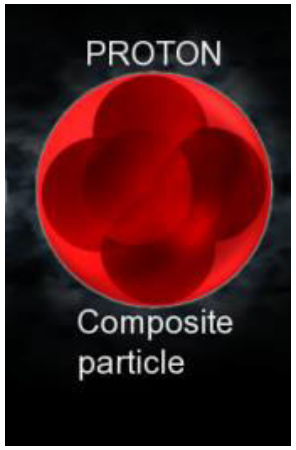
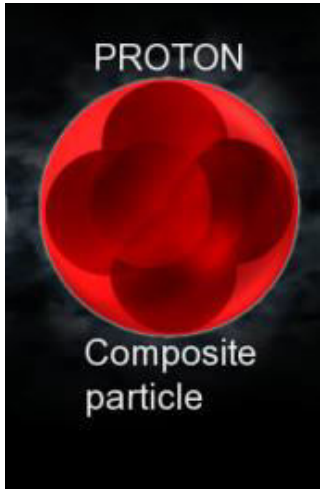
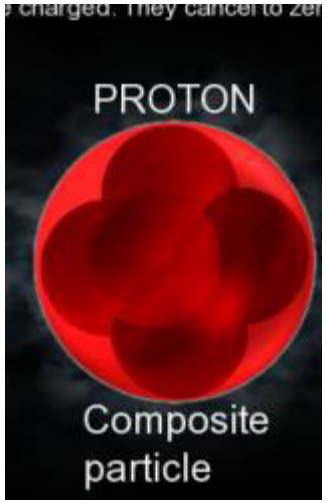


= atomic weight or mass no. (A)

or



= Atomic no. (Z)



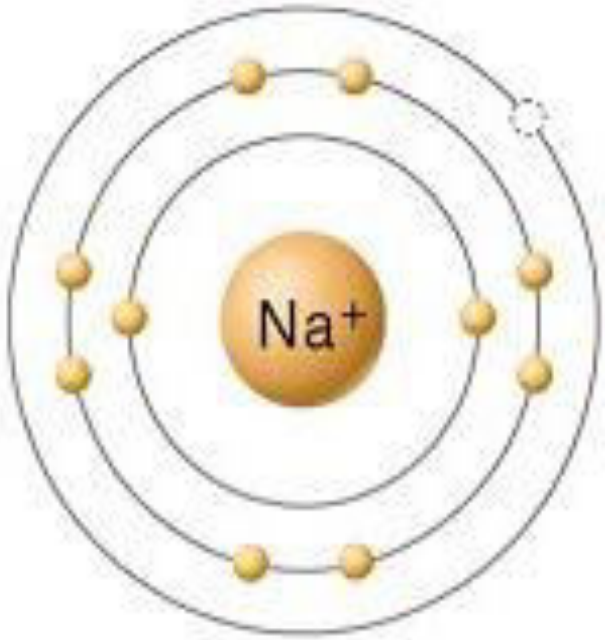
=

→ Stable atom

↓

≠ → Unstable atom

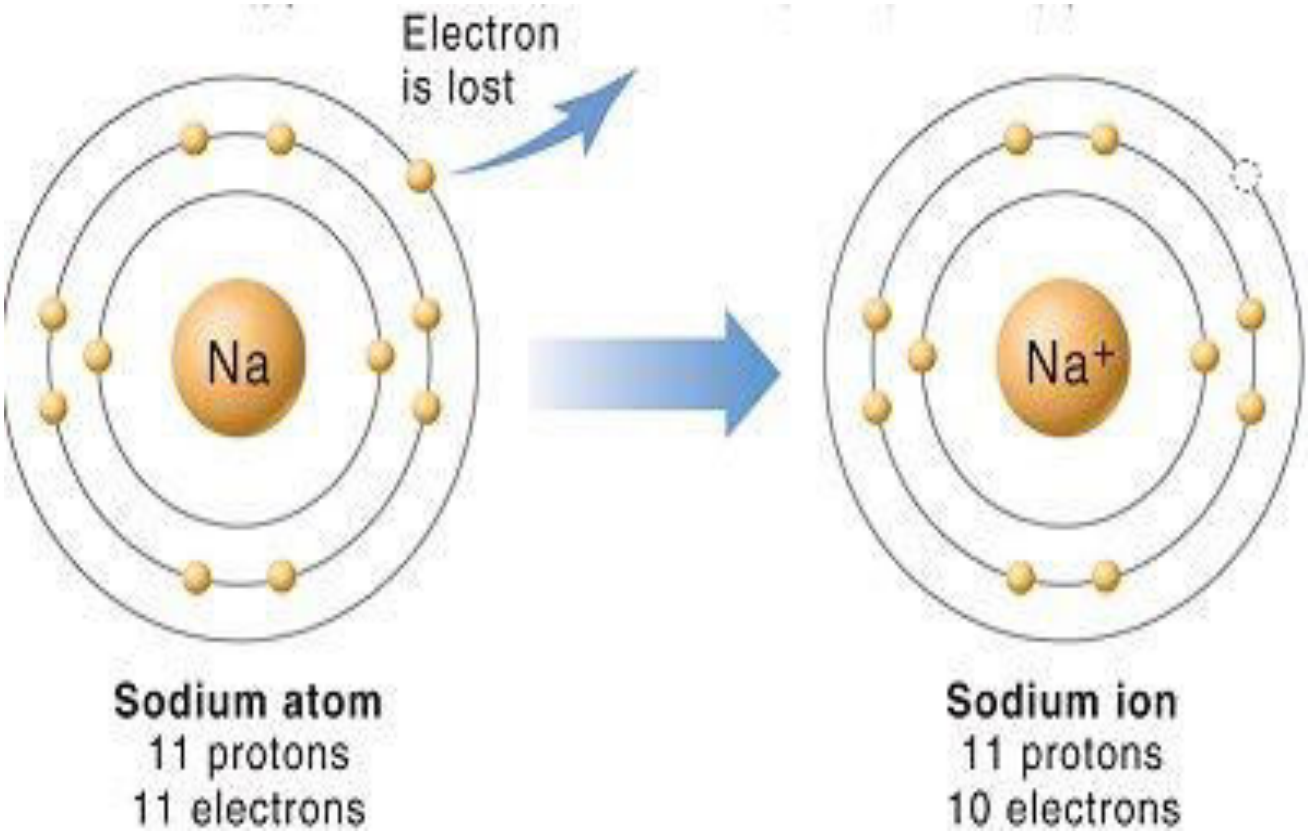
- What is an ion?



Sodium ion
11 protons
10 electrons

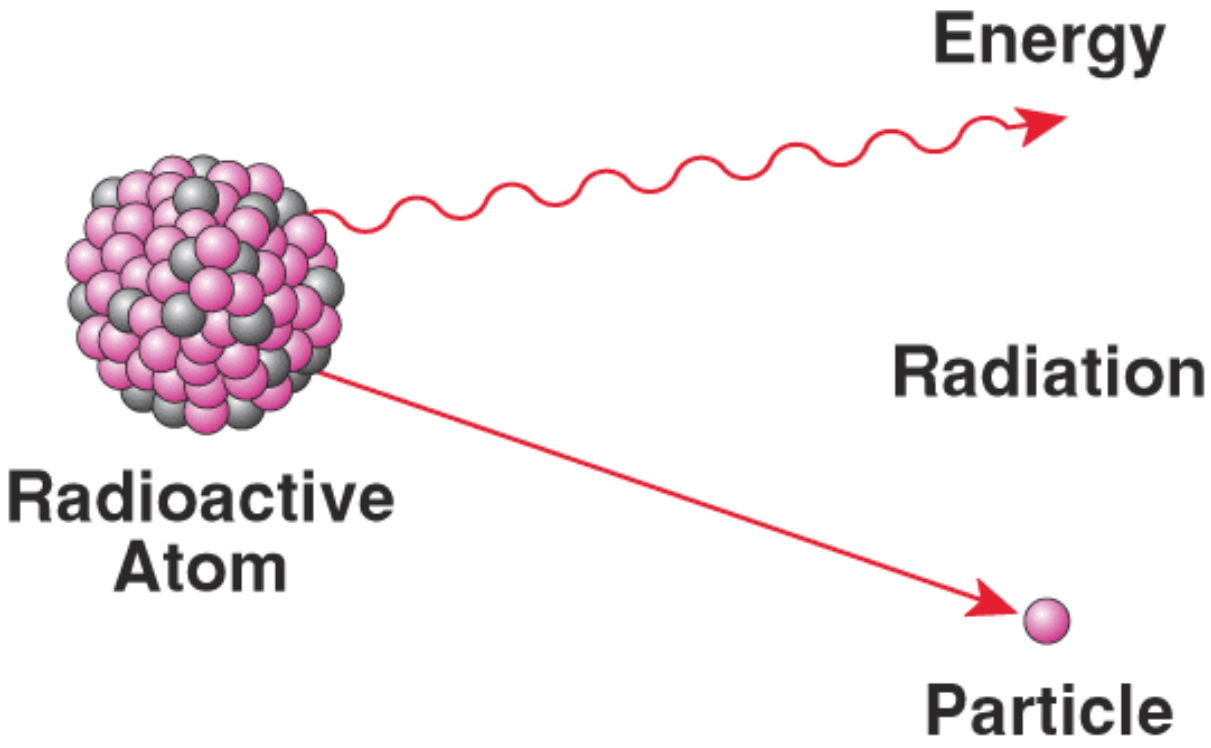
Ref; Oral radiology- White & Paroah
TB of oral radiology- Ghom

What is ionisation? & ionisation energy

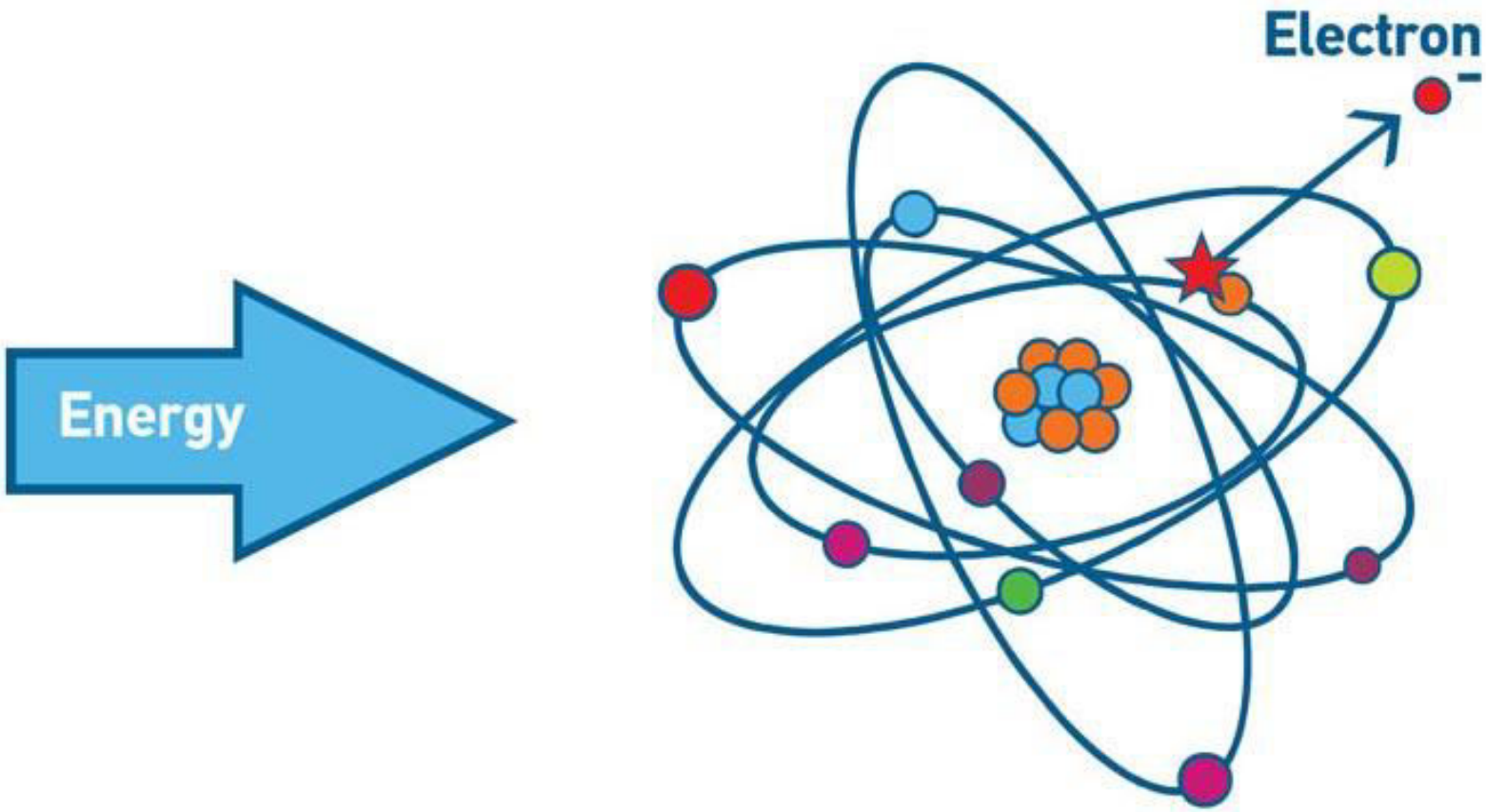


Methods- heating,collision, radiation

- What is radiation?
- What is radioactivity?



Ionising radiation



Types of ionizing radiation

- Particulate radiation
- Electromagnetic radiation

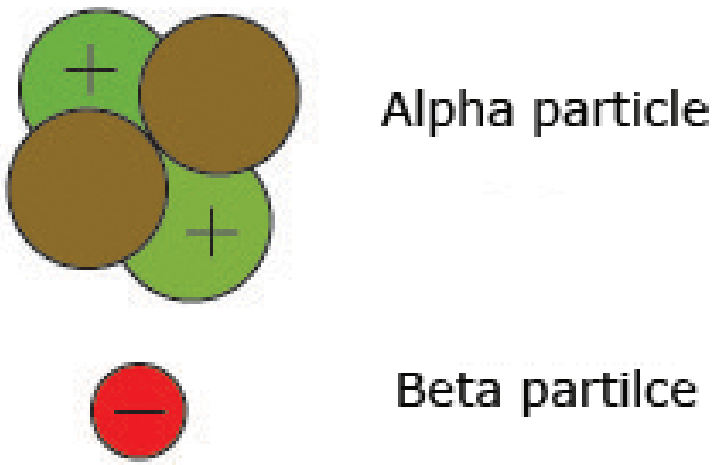
Ref: oral radiology- White & Paroah
radiologic science-Bushong

Particulate radiation

- Subatomic particles
- Travel in straight line
- Transmit kinetic energy

Types of particulate radiation

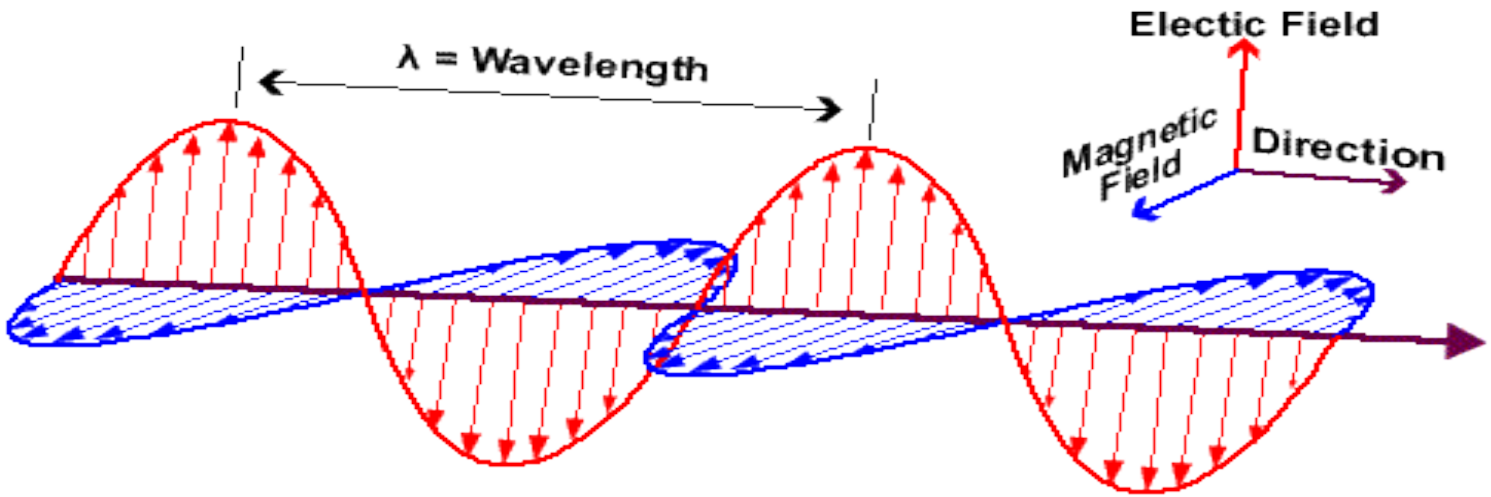
- Alpha particles
- Beta particles
- Cathode rays
- Protons
- Neutrons



Ref: TB of dental radiology- Freny
Radiologic science- Bushong

Electromagnetic radiation

- Wave like energy
- Energy is propogated accompanied by electric and magnetic fields
- Donot have mass nor weight nor charge



Ref: Oral radiology- Ghom
TB of dental radiology- Freny

- They travel at the speed of light
- They transfer energy in quanta
- Properties of attentuation, absorption and scattering
- In free space they obey inverse square law
- Have measurable temperatures and energy (vary)
- Are invisible to eye (except visible light)

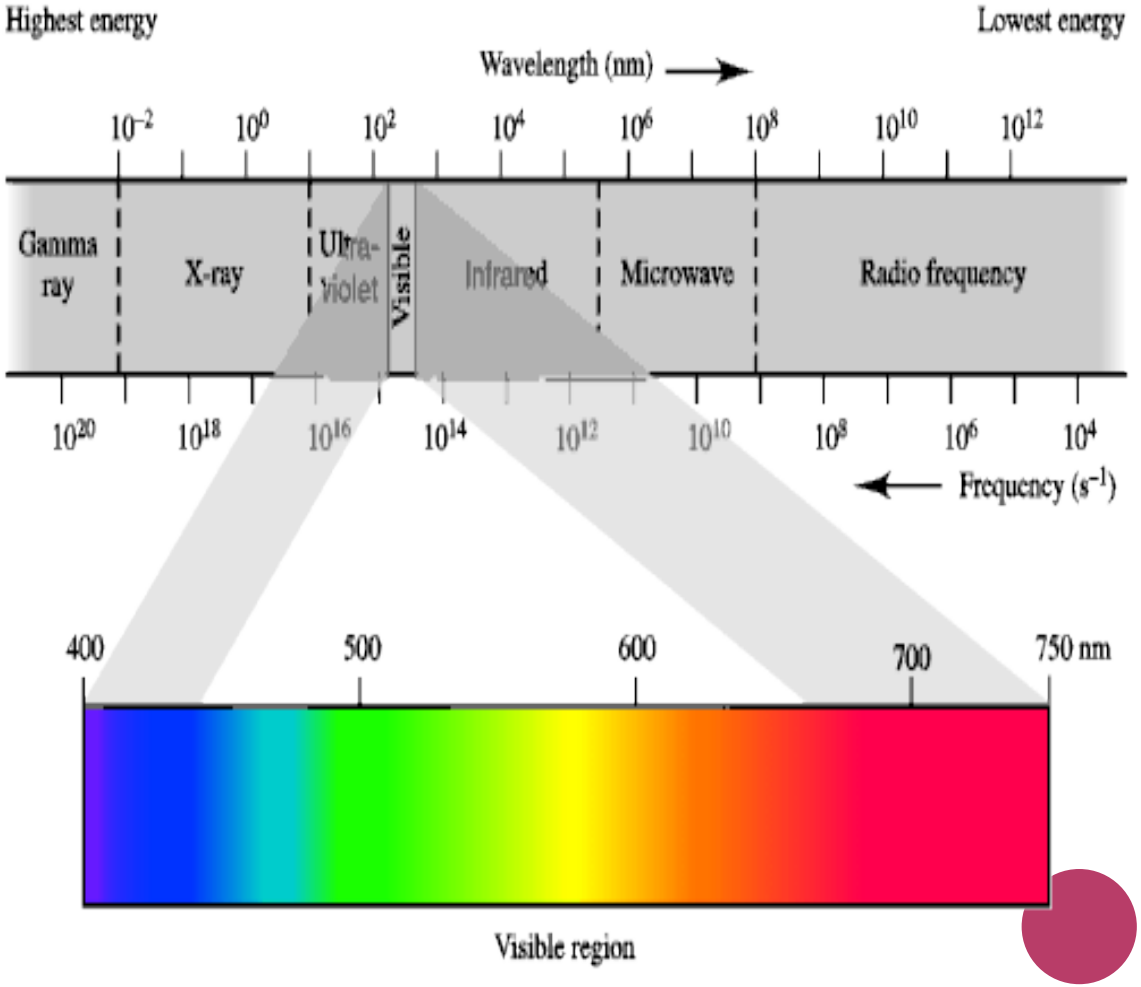
E.M.RADIATION CONTD…

- Classification of electromagnetic radiation
  - based on production
    - artificial
    - natural
  - based on energy levels
    - ionising
    - non- ionising

E.M RADIATION CONTD…

- Electromagnetic spectrum

- Two concepts
  - particle concept
  - wave concept



- Wave concept: - Hugens- deals with reflection, refraction, diffraction, interference, and polarization

Wave- dist in transfer of energy from one point to other

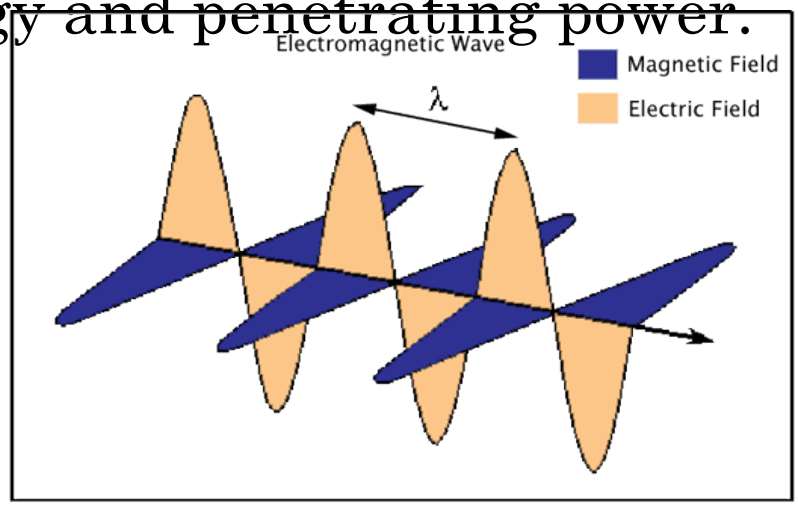
VELOCITY: (c) unit- meter / sec

-speed of the wave

-equal to light

wavelength: (λ) unit- nanometer

- distance between the crest of one wave and the other
- determines the energy and penetrating power.



Ref: radiologic science-Bushong

- Frequency: (v) unit- hertz

  - no of waves that pass a point in a given time

- Amplitude: (a)

  - maximum displacement of wave at rest point

Velocity = frequency x wavelength

$c = v\lambda$

$v = hc/\lambda$

h- constant (6.6256×10^{-34})

- Particle concept: (quantum theory)

  Max Planck – 1901

  explains diffraction, interference

  bundles of energy called photons

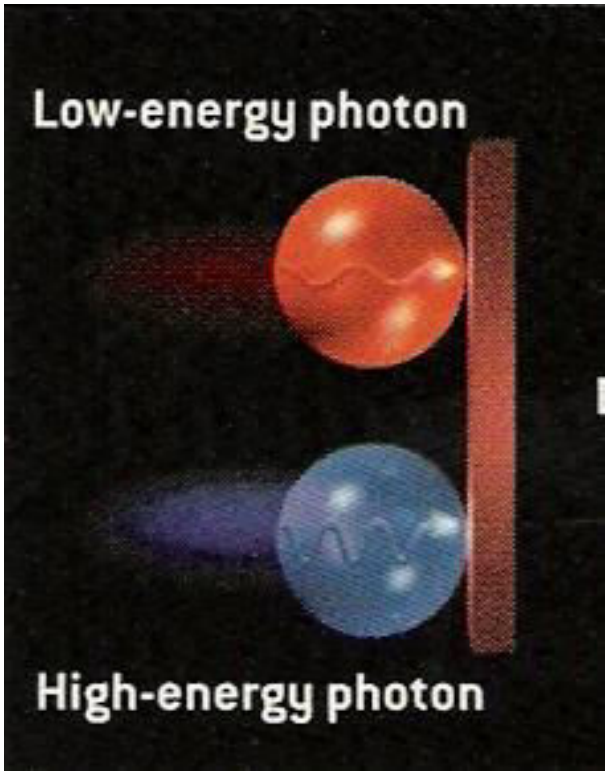
  unit of energy photon is E

  $E = hv$

  $E = hc/\lambda$ ($v = c/\lambda$)

C is the velocity constant

Therefore $E = 1/\lambda$



Ref: radiologic science- Bushong

X RAY

- What are x rays?

high energy ionising E.M radiation with no charge With a specfic frequency and wavelength

- Properties of x rays

  - show properties of wave and particle
  - energy level of 25 to 125 kev
  - has electric and magnetic fields
  - travel in a straight line with the velocity of light
  - they carry no mass or charge
  - wavelength ranges from 0.1 to 0.5 A˚
  - frequency ranges from
  - ionise the matter through which they penetrate

Ref ; TB of oral radiology- Ghom

- can cause biological damage to tissues
- affect photographic plates
- Fluorescence and phosphorescence
- Diverge from a point
- Attenuation and scattering
- No medium is required for propogation
- Obeys inverse square law
- Charecteristic radiation
- Not deviated by electric and magnetic feilds

Dental x ray machine

- Parts

  control panel

  extension arm

  tube head

Ref: TB of oral radiology- Freny
TB of oral radiology -Ghom

- Control panel

on off switch

exposure button

control devices(kvp,ma)

- Extension arm

- Tube head- components include
- 1. x ray tube

2 .metal housing- body of the tube

contains x ray tube and transformers

3.insulating oil- surrounds the x ray tube

4.tube head seal- aluminium or leaded glass

outlet for the x ray beam

seals the oil

5. filters- removal of unwanted radiation

inherent filteration- glass wall, oil, aperture window

added filtration-additional materials placed along path

Ref: radiologic science- Bushong

requirements for a filter material:

- should discriminate the lower energy photons
- the material should have absorption edge greater than the energy of the photons
- thickness of the material should be high

Materials used for filtration: based on the kvp used

30 -120 kvp- aluminum

100 -250 kvp- copper with backing

200- 600 kvp- tin with backing

600 kvp- 2mv- lead with backing

above 2mv- none

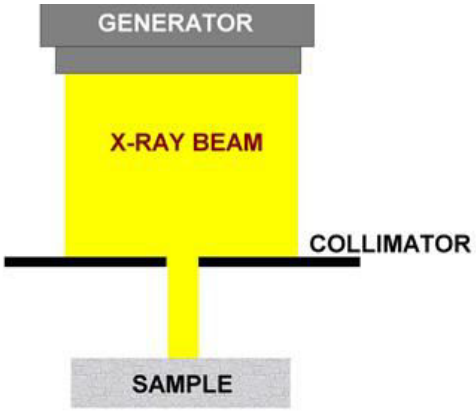
1.5 mm of aluminum for upto 70 kvp

2.5 mm of aluminum for all higher voltages

Ref: TB of oral radiology- Freny
TB of oral radiology- ghom

Collimator:

lead plate with hole
restrict the size
shape of the beam



types – based on fixity

1. fixed
2. adjustable

- based on shape

1. diaphragm
2. tubular
3. rectangular
4. slit

- Position indicating device
  extension of tube head
  aims the beam
  shapes the beam

Types: based on shape

1. conical
2. rectangular
3. round

based on lengths

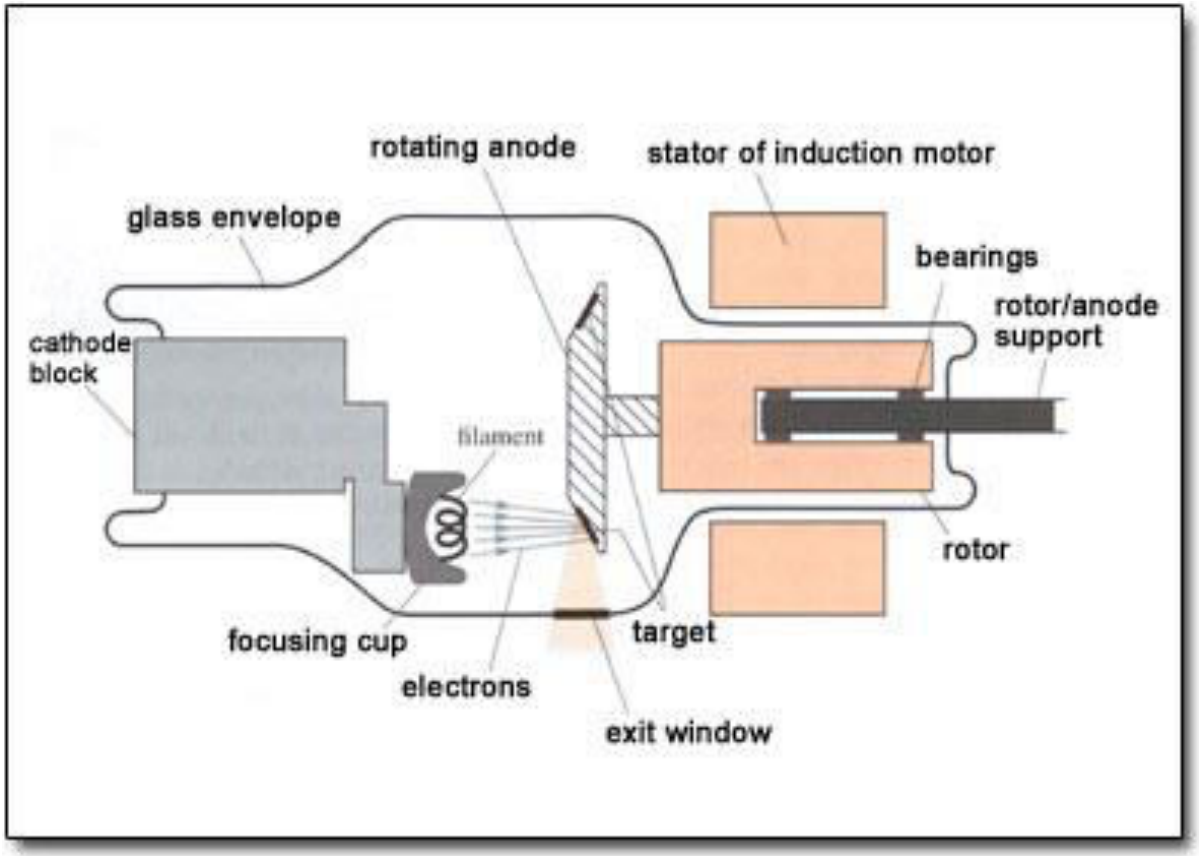
1. short (8 inch)
2. medium (12 inch)
3. long (16 inch)

- X RAY TUBE: consists of the following

  a leaded glass housing

  a negative cathode

  a positive anode



Ref: radiologic science- Bushong

- A leaded glass housing:
  vacuum tube
  prevent x rays from escaping
  window- outlet

- Negative cathode
  filament- coil of tungsten wire
  0.2 cm in diameter, 1 cm in length
  mounted through strong stiff wires
  filament is heated through a low voltage circuit
  ma provides fine adjustment of the voltage
  focusing cup- negatively charged molybdenum cup
  focuses the emitted electrons

the electrons produced by heating the filament forms a electron cloud, the are directed by the focusing cup towards the anode by applying a voltage difference between the anode and cathode

- A positive anode: tungsten target embedded in a copper stem converts kinetic energy of electrons to x ray

- tungsten properties:
  - high melting point
  - high atomic no.
  - low vapor pressure
  - low specific heat
- methods of heat dissipation:
  - conduction
  - convection
  - radiation

- Types of anode

  stationary

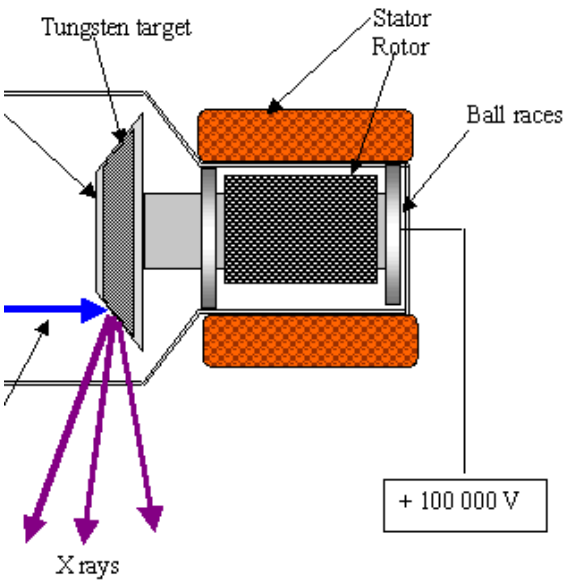
  rotating

Rotating anode:

electrons strike successive areas- wide target

target is in the form of a beveled disk that rotates

easy dissipation of heat



- Parts of the rotating anode:

  stator- equally spaced electromagnets

  rotor- bars of copper and soft iron made into a mass

Working: current through the stator- electromagnetic field

induced E.M field rotates on the axis of the stator

magnetic field interaction with the rotor

rotor rotates in synchrony with the stator

Ref; Radiologic science-Bushong

- Focal spot: area into which electrons are directed

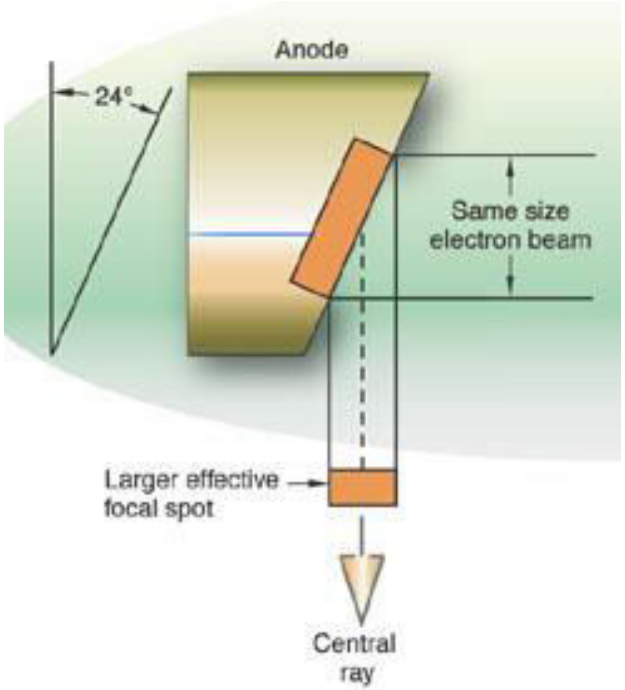
larger focal spot- good heat dissipation

smaller spot – sharp image

angulation of the target

line focus principle

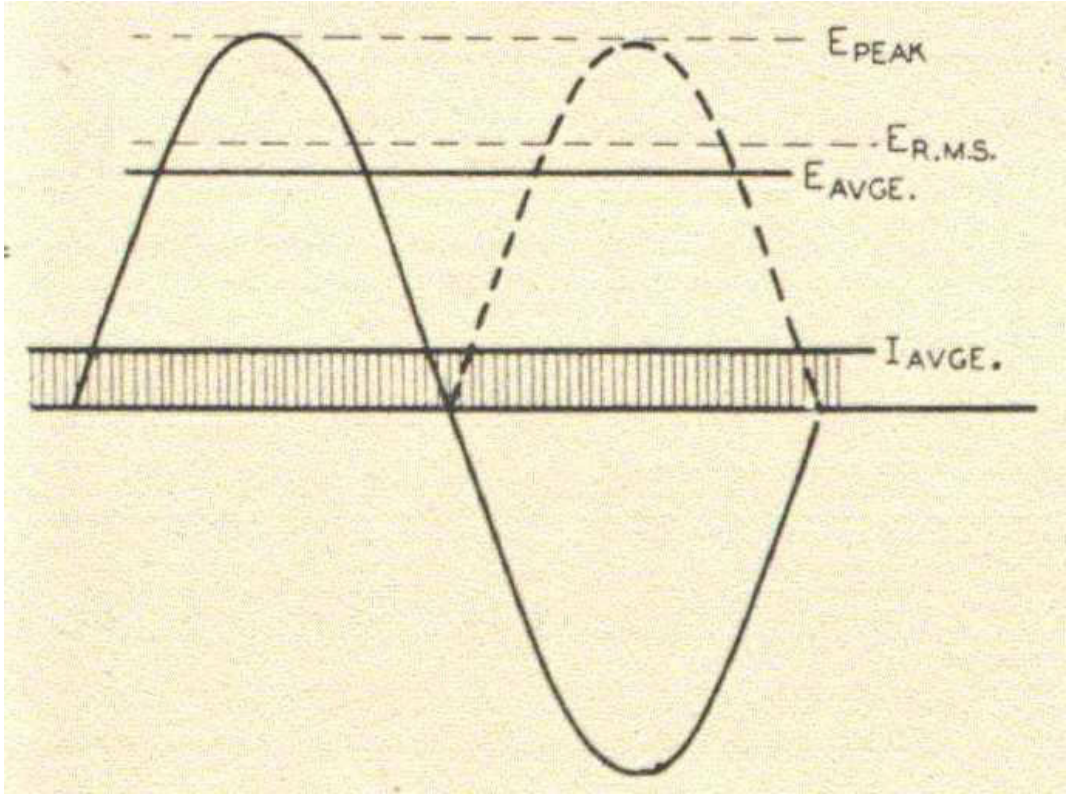
inclined at an angle of 20˚- angle of truncation



REF; Oral radiology- freny
radiologic science- Bushong

- Electricity and the x ray machine

  what is alternate current and direct current?



- What is rectification?
- What is voltage and ma?

Ref: TB of oral radiology- Freny
radiologic science-Bushong

- Types of circuit in a x ray machine

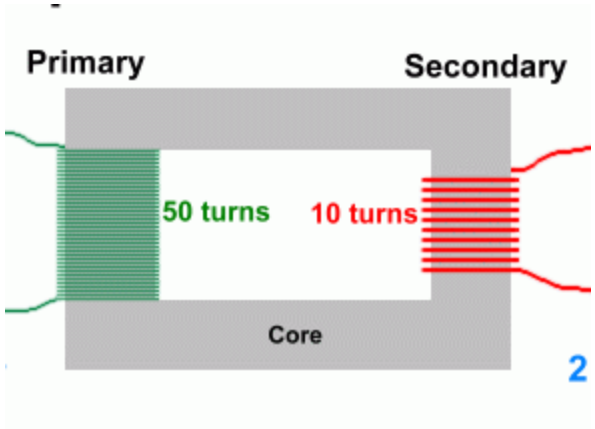
  low voltage circuit- 3-5 volts

  current to the filament

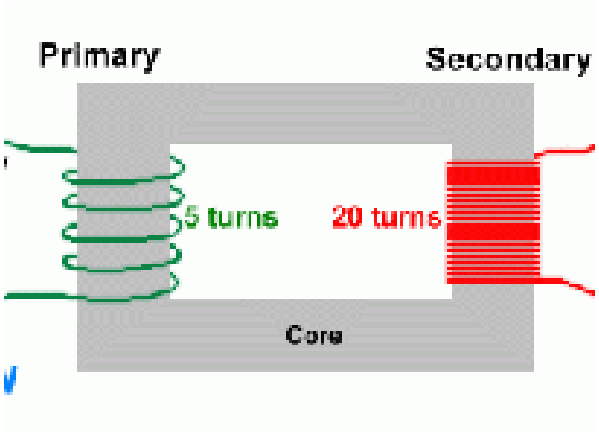
  controlled by ma setting

- Transformers

  step down transformer-



- high voltage circuit- 65,000 – 1,00,000 volts
  required for electron acceleration
  controlled by kvp setting
- Step up transformer



- rectifier
- Auto transformer- voltage compensator
- Timer- included in the high voltage
  controls the timing high voltage is applied
- tube rating & duty cycle- operating limits, gap b/w exposure

Production of x ray

- Electric current enters the control panel
- Activation of the low voltage circuit/ step down transformer
- Heating of the filament
- Thermionic emission- electron cloud
- Activation of the high voltage circuit/step up transformer
- electron cloud strikes the target area of the anode
- Heat-99%- 1% x ray
- X ray exit thro the PID

Intensity of the x ray

- Quantity and quality are described together- intensity

$$\text{intensity} = \frac{(\text{no.of photons}) \times (\text{energy of each photon})}{(\text{area}) \times (\text{exposure rate})}$$

Factors altering the intensity:

kilovoltage (kvp): voltage- measurement of electric force that drives an electron from one pole to the other

unit- volts

1000 volts = 1 kilovolt (kv)

kilovoltage peak (kvp) - maximum or the peak voltage

Ref: TB of oral radiology- ghom

Kvp regulates the penetrating power or energy of each x ray photon

↑kvp- ↑ in the speed of the electrons

↑ in the production of shorter wavelength of photons

↑ in the energy of the photons

↑ in the intensity of the beam

kilovoltage peak rule

Milliampere-

ampere – unit of measure used to describe the no. of electrons flowing thro a conductor

ampere of a dental unit is small- milliampere

1 milliampere = 1/1000 of an ampere

↑ma- ↑in the no electrons

↑ in the no of x rays produced

↑ in the intensity of the beam

- Exposure time-

  interval of time during which xrays are produced

  determines the no. of electrons striking the anode

  ↑ in exposure time-↑ in no of photons produced

  ↑ in the intensity of the beam

- Distance –

  several distances should be considered they are

  1. target- surface distance(source & patient skin)
  2. target object distance(source & tooth)
  3. target flim distance(source& flim)

Distance between the source and the flim ↑ - ↓ in intensity

6 inch PID – more intense beam than 8 inch PID

Inverse square law-

" the intensity of radiation is inversley proportional to the square of the distance from the source of radiatioon"

$$\frac{\text{original intensity}}{\text{new intensity}} = \frac{\text{new distance}^2}{\text{original distance}^2}$$

Filtration: aluminum filters – remove longer wavelength

remove lesser energy photons

↓ intensity of the x ray beam

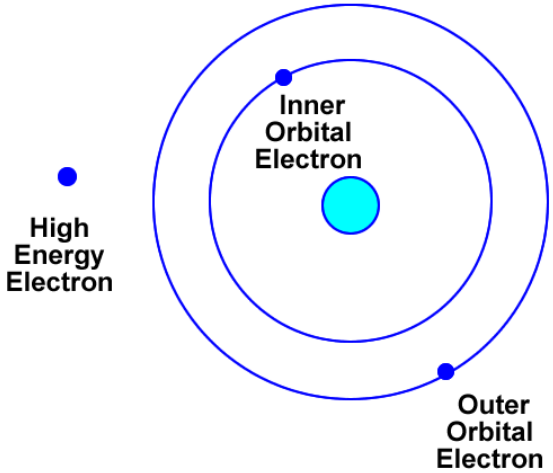
Half value layer- thickness of a specified material such as aluminum in the path of an x ray beam reduces the intensity of the beam to one half

Anode material- choice of the material

Types of x rays:

- Based on the interaction of the electron with tungsten atom

Charecteristic radiation



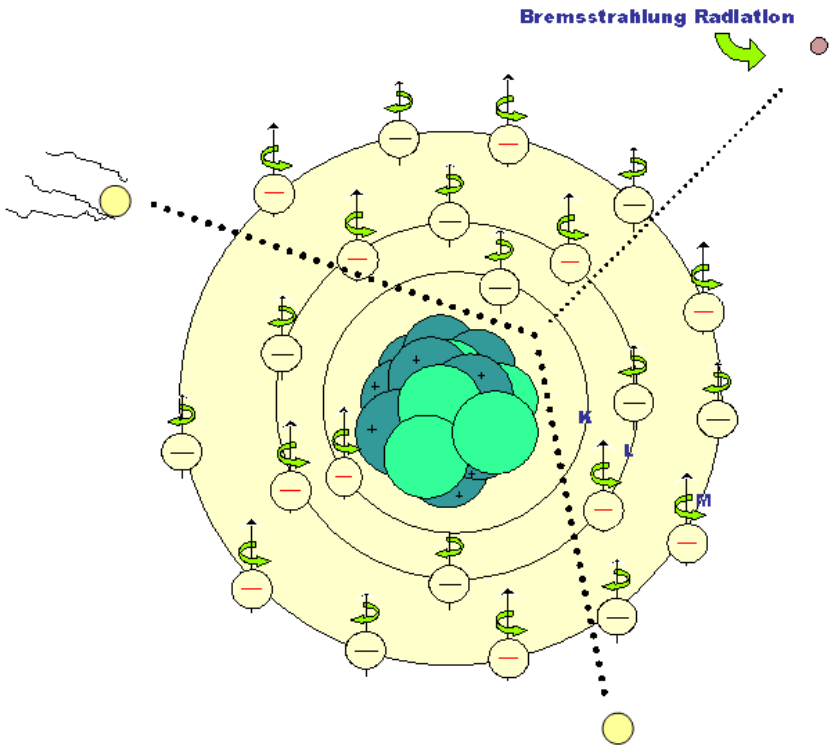
Occurs only at 70 kvp and above

Very minimal amount

Ref: radiologic science- Bushong

- Bremstrahlung radiation

70% of the total x rays



- Homogenous radiation- similar wavelength & energy

  Heterogenous radiation- diff. wavelengths and energy
- based on wavelength

super soft or grenz x rays- 1-2 A°

Soft x rays- 1- 0.5 A°

medium x rays- 0.5 – 0.1 A°

hard x rays – 0.1 A°

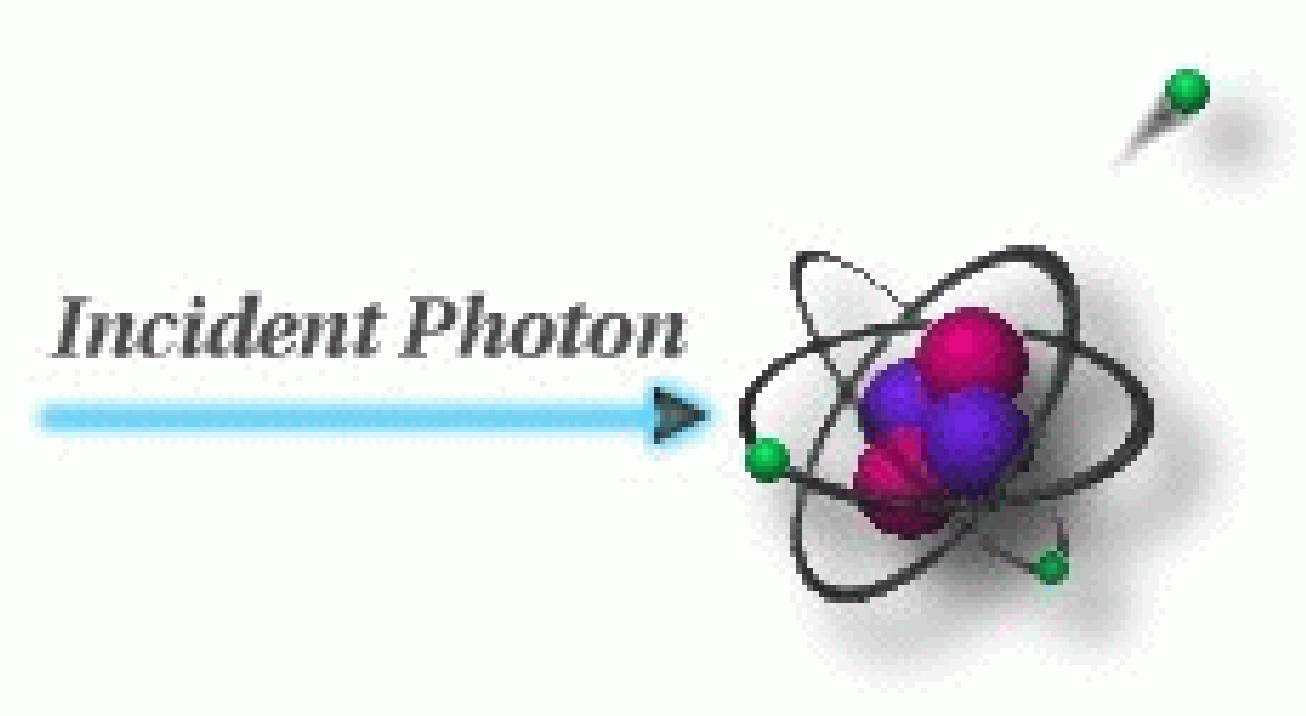
gamma rays or high powered x rays- 0.001 A°

Ref: TB of dental imaging – Langman& Langlais
Oral radiology-Freny

Interaction of x ray with matter

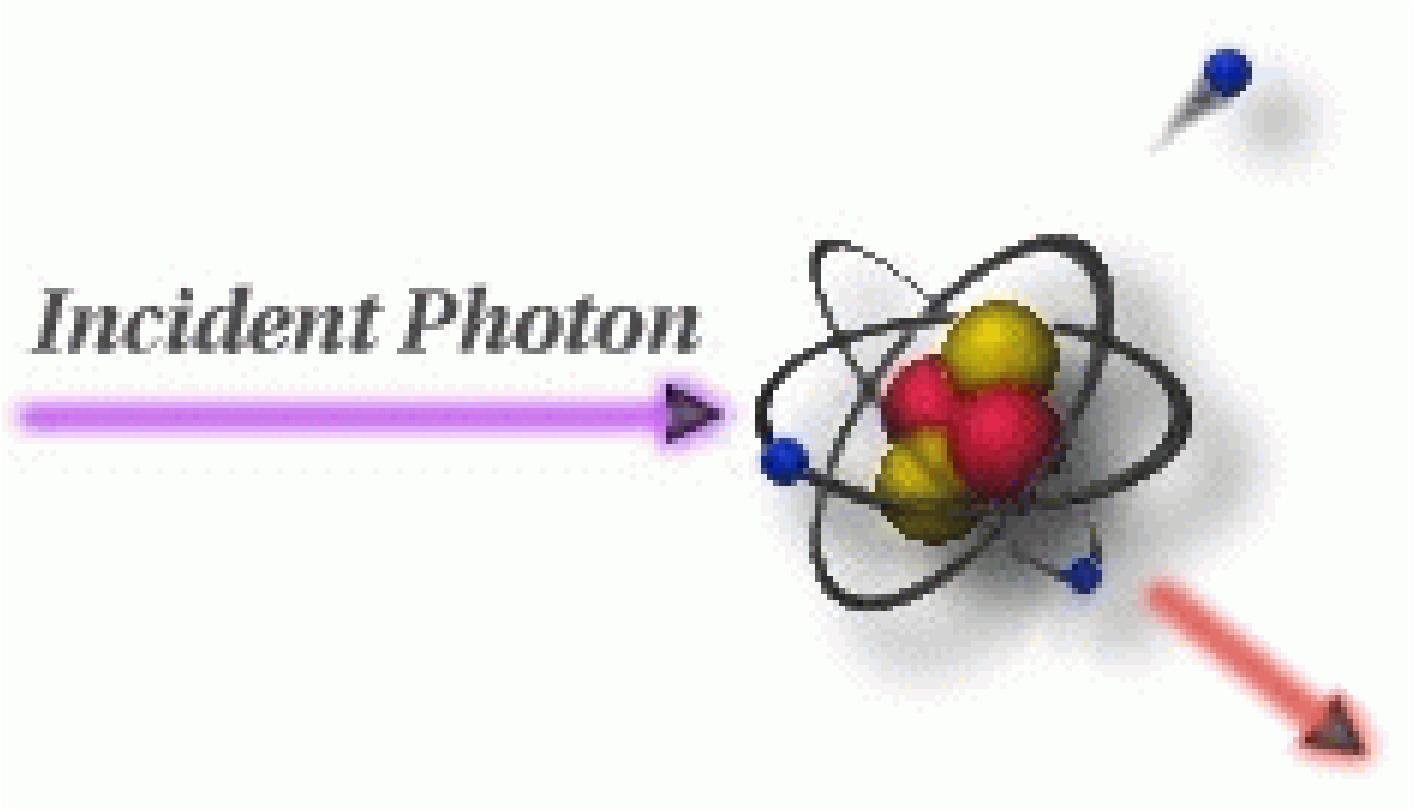
- Pass through without interaction
- Completely absorbed by the patient
- Can be scattered

photoelectric effect- 30%

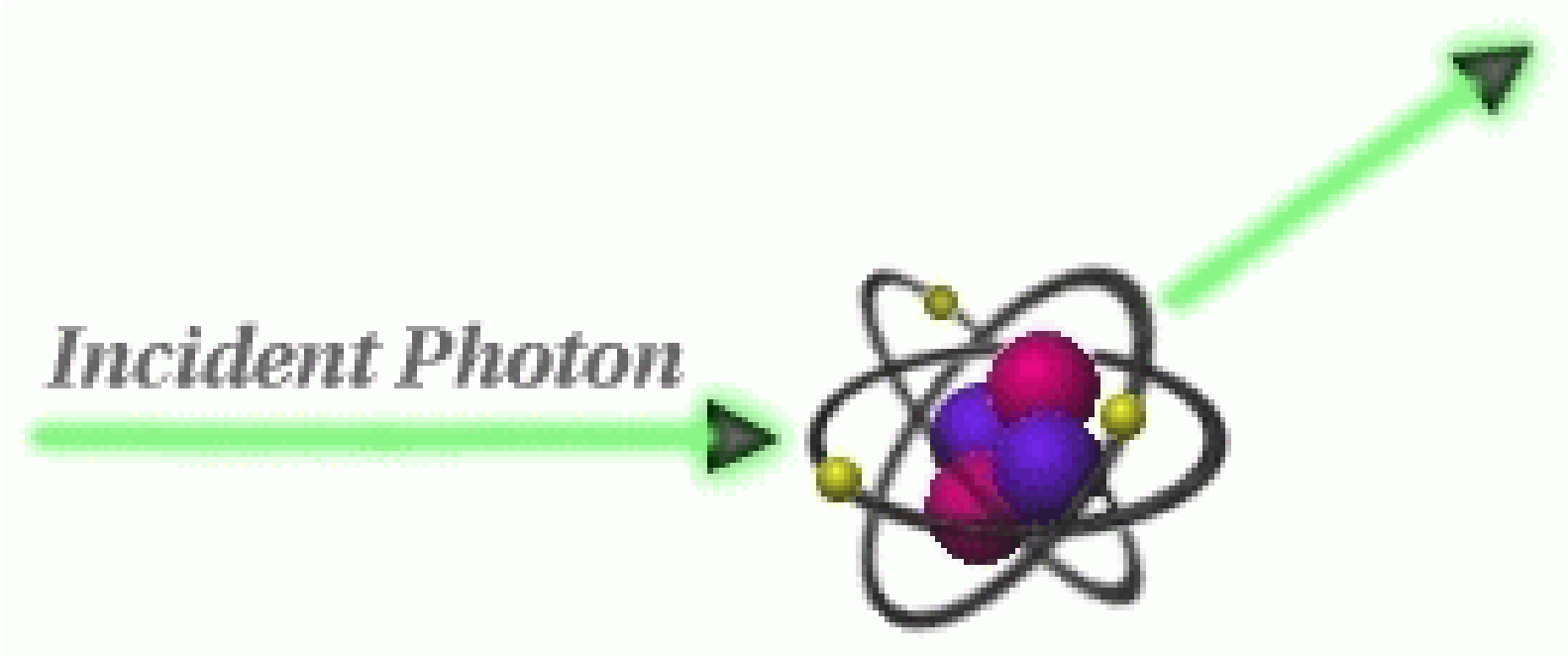


Ref: radiologic science- Bushong

- Compton scatter- 62%



- Coherent scatter (elastic scatter)- 8%



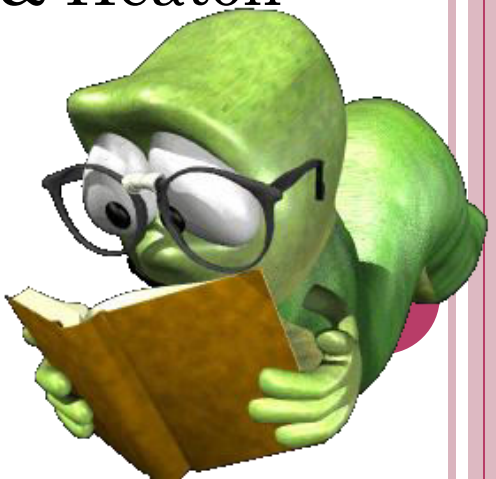
Dosimetry: Quantity of radiation exposure

- Dose
- Exposure
- Equivalent dose
- Effective dose
- Radioactivity

CONCLUSION

REFERENCES

- Txt book of oral radiology- Anil Govind Roa Ghom
- Txt book of dental imaging- Langman& Langlais
- Txt book of oral radiology- White & Paroah
- Txt book of dental radiology- Eric Whaites
- Txt book of dental radiology- Freny Kajrodhker
- Radiologic science for technicians- Stewart Bushong
- Radiation physics for technicians- Dendy& Heaton




THANK
YOU