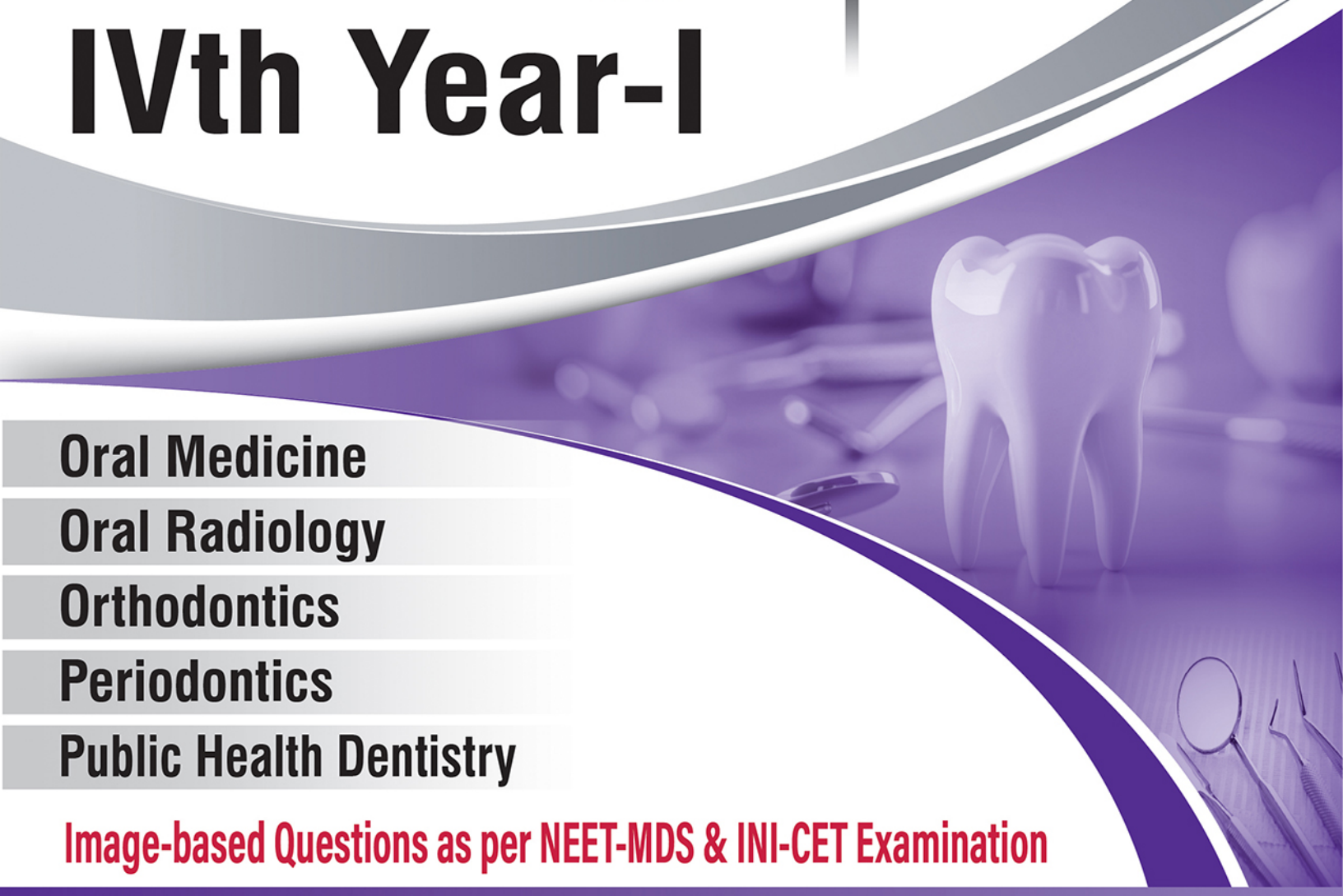
Thoroughly revised multiple choice questions and fill in the blanks according to the latest syllabus of DCI

Includes 2025 Papers

Mastering the BDS IVth Year-I

Last 20 Years Solved Questions



Oral Medicine
Oral Radiology
Orthodontics
Periodontics
Public Health Dentistry

Image-based Questions as per NEET-MDS & INI-CET Examination

Hemant Gupta

10th Edition

JAYPEE

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SECTION 2

Oral Radiology

ORAL RADIOLOGY

1. RADIATION PHYSICS

Q.1. Write short note on LASER.

(Feb/Mar 2005, 6 Marks) (Sep 2010, 5 Marks)

Ans. Light amplification by stimulated emission of radiation (LASER).

- It is a device which can operate in the infrared, visible and UV light of spectrum and which amplifies the electromagnetic waves by stimulated emission of radiation.
- When atoms or molecules absorb energy, then they can emit light spontaneously or they can be stimulated to do so by a light wave. If a body of atoms is raised to the excited state by pumping, then an incident light wave will stimulate photon emission and net amplification of the incident light beam results. The output is extremely powerful and mobilizes intense heat at close range as the atoms are stimulated to emit photons at an infinitely greater rate than would spontaneously.
- Laser light has four characteristics that distinguish it from the light produced from other sources, like the electric bulb and the sun. These are:
  - Laser light is highly directional and travels in a narrow beam, the sides of which stay almost parallel.
  - Laser produces coherent light, i.e., it has only one frequency.
  - Laser light is of a single color.
  - Laser light is very bright, powerful with very high intensity.

Types of Lasers

In dentistry, two types of lasers are used:

1. Soft Tissue Laser (800–990 nm), e.g., Argon soft tissue laser, CO_2 laser
2. Hard Tissue Laser (2500–3000 nm), e.g., Er: YAG Dental laser system, Erbium hard tissue laser.

Dental Applications

- Surgical excision of benign tumors and small soft tissue growths (e.g., Epulis).
- Frenectomy
- Nerve regeneration.
- Sleep apnea (LAUP: Laser Assisted Uvula Palatoplasty).
- Cavity detection.
- Viewing of tooth and gum tissue (optical coherence tomography).
- Treatment of cold sores—low intensity lasers used to reduce pain.
- Treatment of temporomandibular joint for reduction of pain and inflammation.
- Treatment of ulcerative lesions.
- Oral biopsies
- Treatment of gummy smile
- Treatment of tooth sensitivity
- Treatment of melanin-pigmented gingiva.
- Local anesthesia free cavity preparation.
- Hard tissue roughening or etching.
- Enameloplasty, excavation of pits and fissures for placement of sealants.
- Osseous crown lengthening.
- Cutting, shaving and contouring of oral osseous structures.
- Ostectomy
- Apicectomy
- For early detection of dysplastic cells (optical coherence tomography).

Advantages

- Causes less pain thereby reducing need for anesthesia.
- Minimizes bleeding and most surgical procedures done with lasers do not require sutures, because the high-energy light beam aids in clotting (coagulation) of exposed blood vessels thus inhibiting blood loss.
- Bacterial infections are minimized and wound heals faster. The high energy beam sterilizes the area worked on.
- Damage to surrounding tissue is minimized.
- Wounds heal faster.

2. PROPERTIES OF X-RAY

Q.1. Define X-rays, write the properties of X-ray in detail.

(Mar 2009, 8 Marks)

Or

Write short note on properties of X-ray.

(Oct 2017, 5 Marks) (Nov 2020, 5 Marks)

Or

Write short answer on properties of X-ray.

(Oct 2019, 3 Marks) (Jan 2021, 3 Marks) (Mar 2024, 3 Marks) (Sep 2024, 3 Marks)

Or

What are X-rays? Write a note about production of X-rays. *(Dec 2022, 10 Marks)*

Ans. X-rays are defined as weight less package of pure energy (Photon) that are without electrical charge and that travel in waves along a straight line with a specific frequency and speed.

Principle

Fundamental principle of X-ray production is, X-rays are produced by the sudden deceleration or stoppage of rapidly moving stream of electrons at a positively charged metal target in a high vacuum tube.

Production of X-rays

- X-rays are produced in X-ray tube. When the X-ray machine is turned on, the electric current enter the control panel; via the plugged in cord and then to the tube head via extension wires in extension arms.
- The current is directed to the filament circuit through the step-down transformer, it reduces the 110–220 voltage to 3 to 5 volts.
- The filament circuit uses the 3 to 5 volts to heat the tungsten filament. The hot filament emits electron, this emission of electron from the cathode is known as thermionic emission. It forms the electron cloud around the cathode.
- When the exposure button is pushed the high voltage current is activated and the electron cloud is accelerated in X-ray tube from cathode to anode.

- Molybdenum cup of cathode directs the electron to the anode target in narrow beam.
- When the electron strikes the tungsten target, their kinetic energy is converted to X-ray energy. Less than 1% of the energy is converted to X-rays, the remaining 99% is lost as heat.
- The heat produced is carried away by copper stem and absorbed by the insulating oil in the tube head.
- The area where electron strike on tungsten (anode) is known as focus spot (Tungsten focus).
- Produced X-rays only exit from the X-ray tube via unleaded glass window portion of tube.
- X-rays travel through the unleaded glass window, the tube head seal, the aluminum discs, which filter the long wave X-rays from the beam.
- The size and shape of the X-ray beam is controlled by the lead collimator. X-ray beam then travels down the lead lines position indicating device and exit the tube head at the opening of position indicating device.
- X-rays produced in the X-ray tube vary in their energy and their wavelength, depending on how electrons interacted with tungsten atoms in anode. So kinetic energy of electrons is converted to X-ray photon either through Bremsstrahlung radiation or through characteristic radiation.

General (Bremsstrahlung Radiation or Breaking Radiation)

- The term refers to the sudden breaking of high speed electrons when they hit the tungsten target in the anode. 70% of the X-rays are produced in this manner.
- If the electron hits the nucleus of the tungsten atom all its kinetic energy is converted into "High Energy X-ray Photon".
- But most of the time, instead of hitting the nucleus, most electrons just miss the nucleus of the tungsten atom. When the electron comes close to the nucleus, it is attracted to the nucleus and slows down, consequently an X-ray photon is released. The electron that misses the nucleus continues to penetrate many such tungsten atoms producing many lower energy X-ray photons before it imparts all its kinetic energy.
- As a result general radiation consists of X-rays of many different energies and wavelengths. It is also known as continuous spectrum.

Characteristic Radiation

- It is produced when a high speed electron dislodges an inner shell electron from tungsten atom and leads to ionization of atom. Once the electron is dislodged remaining orbiting electrons are rearranged to fill the vacancy. This rearrangement causes loss of the energy which results in the X-ray photon, with the energy equal to the difference in two orbital energy states. So X-rays produced are known as characteristic radiation.
- This radiation accounts for very small part of X-rays which are produced in dental X-ray machine and occur at 70kVp and above.

Properties of X-rays

Properties of X-rays are of following types:

- Physical properties
- Chemical properties
- Biological properties
- Physiochemical properties

Physical Properties

- X-rays are electromagnetic radiation having a wavelength between 10A° and 0.01A°.
- In free space, they travel in straight line.
- They travel with the same speed as that of visible light, i.e., 1,86,000 miles/sec.
- They are invisible to eye and cannot be seen, heard or smelt.
- They cannot be reflected, refracted or deflected by magnet or electric field.
- They show the properties of interference, diffraction and polarization similar to visible tight.
- They can produce an electrical field at right angles to their path of propagation and a magnetic field at right angles to the electric field and propagation.
- They do not require a medium for propagation.
- Penetration of X-rays can penetrate liquids, solids and gases. The degree of penetration depends upon the quality of the X-ray beam and also on intensity and wavelength of X-ray beam.
- Absorption X-ray are absorbed by matter, the absorption depends on the atomic structures of the matter and the wavelength of X-ray.
- *Ionizing capability:* X-rays interact with materials they penetrate and causes ionization.
- *Fluorescence:* When X-rays fall upon certain materials, visible light is emitted called fluorescence.
- X-rays has the property of attenuation, absorption and scattering.
- Heating effect.

Chemical Properties

- X-ray induces color changes of several substances or their solution, e.g., methylene blue gets bleached.
- X-ray bring about chemical changes in solution because X-rays produce highly active radical "OH" in water, which reacts with the solutes.
- X-ray can cause destruction of the fermenting power of enzymes.

Biological Properties

- The "excitation" property of X-rays are used in treatment of malignant lesions.
- X-rays also have a germicidal or bactericidal effect (sterilization and preservation of food).
- *Somatic effect:* This ranges from simple sun burn to severe dermatitis or to change in blood supply to malignancy.
- *Genetic effect:* Effect due to radiation-induced mutation of genes and chromosomes.

Physiochemical Properties

- X-ray can produce an image on a photographic film.
- Photographic film when exposed to X-ray radiation and then developed will be found blackened. Irradiation affects the silver salt in emulsion, so after developing, the radiograph metallic silver releases and films appears to be black.

Q.2. Write in detail about interaction of X-rays with matter. *(Oct 2017, 10 Marks)*

Or

Write a note about interaction of X-rays with matter. Write about properties of X-rays. *(Dec 2022, 10 Marks)*

Ans. As X-rays strike the matter such as tissue of the patient, photons interact with atoms in the absorber and have three possible fates, i.e.,

1. Coherent scattering (8%)
2. Photoelectric effect (30%)
3. Compton scattering (62%)

Coherent Scattering

- It is also known as classical or elastic or Thompson scattering.
- Coherent scattering is the process by which radiation is deflected without losing energy.
- X-rays when pass close to an atom causes bound electrons to vibrate momentarily at a frequency which is equal to that of incident photon and the incident photon ceases to exist.
- The vibration causes electron to radiate energy in form of another X-ray photon of same frequency and energy as that in the incident beam. Usually, the second photon emitted is at an angle to the path of incidental X-ray.
- This interaction accounts for only 8% of total number of interactions in the dental examination.
- Coherent scattering is negligible in production of fog. This property is used to investigate internal molecular structure of materials by method of X-ray diffraction known as X-ray crystallography.

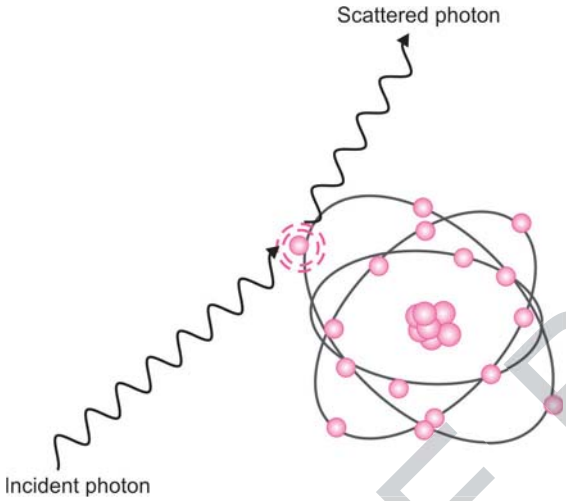

Fig. 1: Coherent scattering.

Photoelectric Effect

- It is the process of interaction of X-ray photon and the inner shell electron of atom.
- Inner shell electron is ejected which is now known as photoelectron. This will undergo further interactions.
- Energy of the photoelectron is equal to the energy of incident photon minus the ionization energy of inner shell electron.
- Vacancy present in the inner shell is filled by the outer shell electron leading to emission of characteristic radiation. Characteristic photons which are generated are of very low energy that they are absorbed inside the patient and do not fog the film.
- In this high energy, ejected photoelectrons behaves such as original high energy X-ray photon which undergo many similar interactions and ejecting other electrons as it pass through the tissues.
- So in the ejected high energy electrons which are responsible for majority of ionization interaction within the tissue and the possible resulting damage which is attributable to X-rays.
- Approximately 30% of photons which are absorbed from dental X-ray beam are absorbed by the photoelectric process.
- In diagnostic radiography, the characteristic radiation generated is of no significance as X-ray photons which are absorbed by the patients are of such a low energy that they are absorbed within the patient. So this is good for dentist as no scattered radiation is present but bad for the patient because of increased radiation absorption.

Compton Scattering

- It is also known as inelastic scattering.
- Compton scattering is the interaction of photons with the free or loosely bound outer shell electrons, i.e., it is an absorption and scattering process predominating with higher energy photons.
- X-ray photon interacts with the outer shell electron of tissue atom and get ejected which is known as Compton recoil electron, with some energy of incoming photon this means there is some absorption.
- Ejected electron undergoes further ionizing interaction inside the tissues.
- Remainder of incoming photon energy is deflected or scattered from original path as scattered photon.
- Scattered photon then undergo further Compton interaction inside the tissues; photoelectric interaction inside the tissues and escape from the tissues.

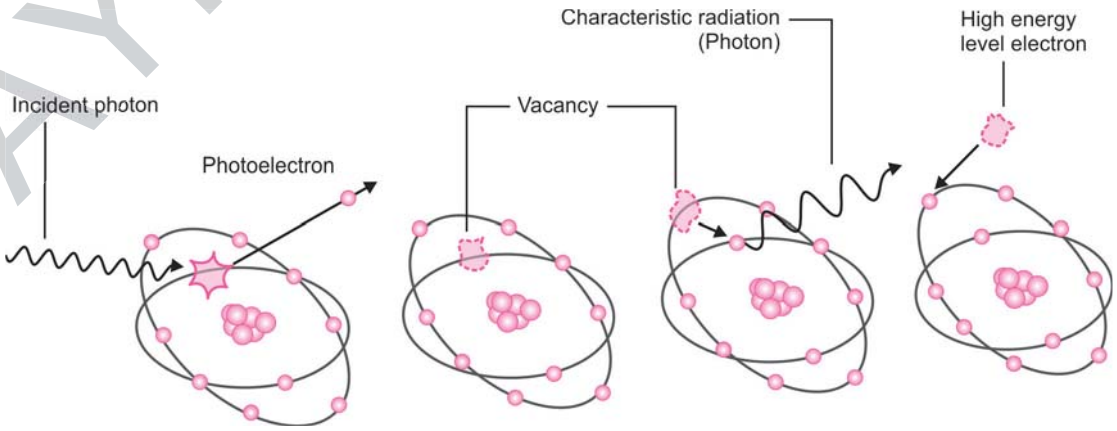

Fig. 2: Photoelectric effect.

- Photons which escaped from the tissues form scatter radiation in clinical era.
- Approximately, 62% of photons are absorbed from dental X-ray beam by this process.

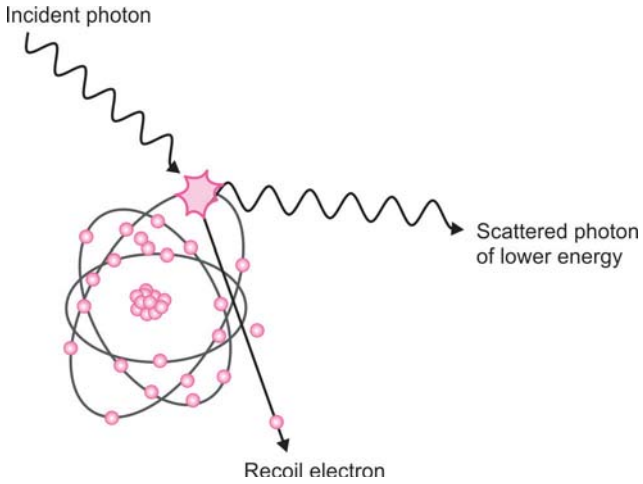

Fig. 3: Compton scattering.

- Importance of photoelectron and Compton absorption in diagnostic radiography relate to the difference in the way, photon are absorbed in various anatomic structures.
- The probability of both photoelectric and Compton interactions of photons with matter is more probable in hard tissues than in less mineralized soft tissues, there are more photons in the beam exiting the patient after traversing soft tissue, than through hard tissue. As a consequence, a radiograph readily distinguishes between many tissues including enamel, dentine, bone and soft tissue.

For properties of X-rays refer to Ans. 1 of same chapter.

Q.3. Describe diagnostic X-ray properties. *(Mar 2024, 5 Marks)*

Ans. Following are the diagnostic X-ray properties:

- X-rays travel in a straight line.
- *Penetration:* X-ray can penetrate liquid, solids and gases. The composition of substance determines whether the X-rays penetrate or are absorbed.
- *Absorption:* X-rays are absorbed by the matter, the absorption depends on atomic structure of matter and wavelength of the X-ray.
- *Ionizing capability:* X-rays interact with the materials they penetrate and causes ionization, dissociate silver ions in the film emulsions.
- *Fluorescence:* X-rays can cause substances to fluorescence or emit the light radiation in longer wavelengths. (e.g., visible light or UV light).
- *Effect on films:* X-ray can produce an image on a photographic film.
- *Effect on living tissues:* X-rays cause biological changes in the living cells.

3. PRODUCTION OF X-RAY

Q.1. Describe in detail components of X-ray tube and functions of each component. *(Sep 2012, 10 Marks)*

Or

Draw labeled diagram of X-ray tube. (Main X-ray generating system). *(Sep 2006, 5 Marks) (Mar 2008, 5 Marks)*

Or

Write short answer on components of an X-ray tube. *(July 2019, 3 Marks)*

Or

Draw neat diagram of X-ray tube head. Describe role of each component in detail. *(Mar 2020, 6 Marks)*

Or

Draw diagram of X-ray tube head. *(Oct 2021, 3 Marks)*

Or

Draw a neat and labeled diagram of X-ray tube head. Describe its components in detail. *(Sep 2024, 5 Marks)*

Ans. X-ray tube is the heart of the X-ray generating system. This consists of a glass vacuum tube from which all of the air has been removed. The X-ray tube used in dentistry measures approximately several inches long by one inch in diameter.

Parts of the X-ray Tube

- A leaded glass housing
- A negative cathode
- A positive anode.
- *A leaded glass housing:* It is a leaded glass vacuum tube that prevents X-rays from escaping in all directions (radiation leakage). One central area of the leaded glass tube has a "window" that permits the X-ray beam to exit the tube and directs the X-ray beam towards the aluminum disk, lead collimator and position indicating device. This is also used for earthing.
- A *negative cathode:* It is principally composed of two parts:
  i. Filament.
  ii. Focusing cup

  Filament
  - The filament is the source of electrons in the tube, it is made up of a coil of tungsten wire, approximately 0.2 cm in diameter, 1–2 mm wide, 0.1–0.2 mm thick and 7 to 15 mm in length. It is mounted on two strong stiff wires, that support it and carry the electric current.
  - These two mounted wires lead through the glass envelope to serve as a connection to the low and high voltage electrical source.
  - The filament is heated to incandescence through a range of temperatures by varying voltage (10 V), across the filament from a step-down transformer in a low voltage circuit.
  - The hot filament emits electrons that are separated from the outer orbits of tungsten atoms at a rate proportional to its temperature by a process called "Thermionic emission".
  - The electrons lost by the filament form a cloud or space charge around the filament.
  - A milliampere control provides for fine adjustment of voltage across the filament and in turn the flow of heating current through it.
  - The milliampere control, thereby controls the quantity of electrons the filament emits, which in turn controls tube current. Vaporization of the filament occurs over a period of time.
  - When the particles vaporize (turn into gaseous form) they solidify on the glass of the X-ray tube, which is called 'sunburning' or 'sun-tanning of the tube. This reduces the output of the X-ray tube, destruction of the vacuum and integrity of the tube, resulting in

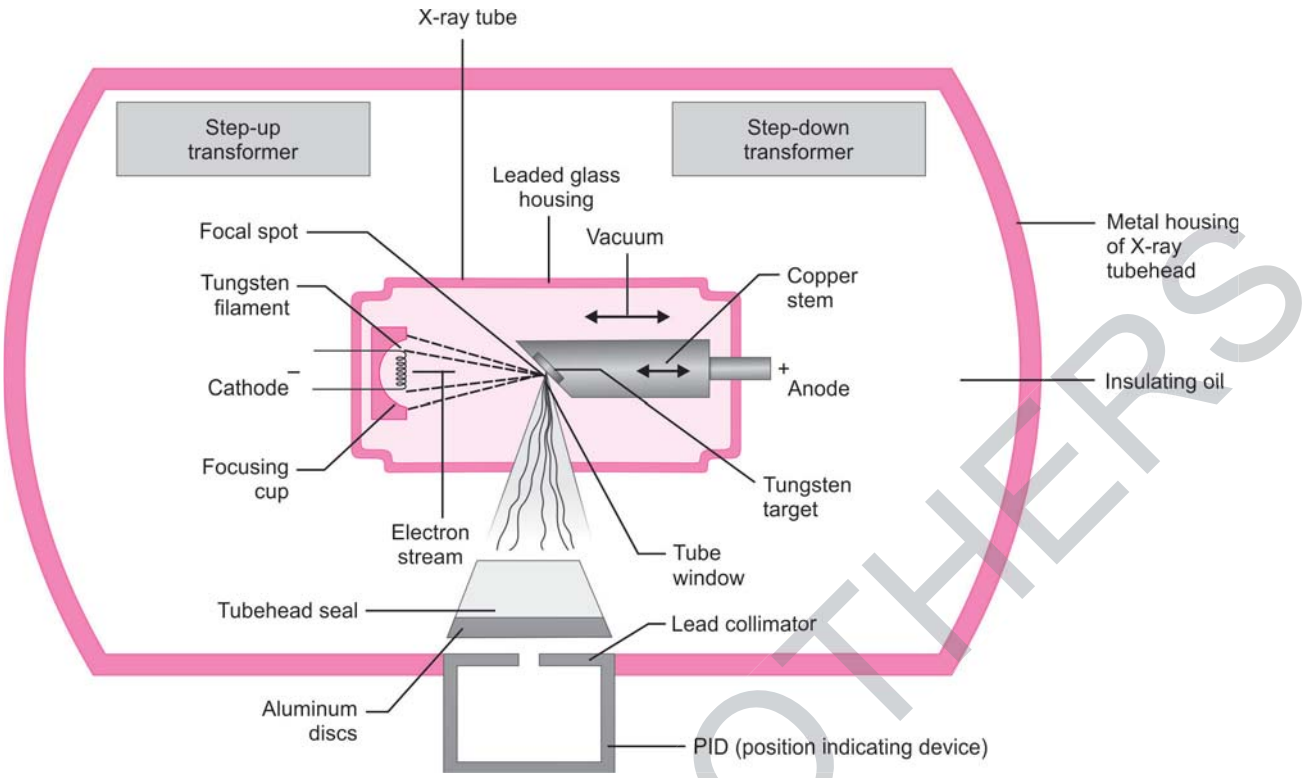

Fig. 4: X-ray tube.

'arcing' and ultimate tube failure. Thorium is added to the filament material to make the tube last longer.

Focusing Cup

- The focusing cup is a negatively charged concave reflector cup of molybdenum or nickel and houses the filament.
- The focusing cup electrostatically focuses the electrons emitted by the incandescent filament into a narrow beam, directed at a small rectangular area in the anode—the focal spot.
- The electrons are caused to move in this direction because of a strong electric field interposed between the cathode and the anode, by a high negative charge placed on the cathode which repels the electrons in the electron cloud towards the anode which has a high positive charge. This is achieved by applying a high voltage circuit between the anode and the cathode.
- To facilitate the movement of the electron cloud, the X-ray tube is evacuated as completely as possible to prelude collision of moving electrons with gas molecules, which could significantly reduce their speed. It also prevents oxidation or burn out of the filament.

♦ *A positive anode or the positive electrode*: It consists of a wafer thin tungsten plate (target) embedded in a solid copper stem. The purpose of the target is to convert the kinetic energy of the electrons generated from the filament into X-ray photons. The position of the anode is indicated externally as a depression, usually a red dot on the tube head by the manufacturer.

Q.2. Describe the parts of an X-ray tube and add a note on X-ray production. *(Nov 2010, 16 Marks)*

Or

Described parts of an X-ray tube along with a note on production of X-rays. *(Mar 2019, 10 Marks)*

Ans. *For parts of an X-ray tube refer to Ans. 1 of same chapter.*

Production of X-rays

- ♦ X-rays are produced in X-ray tube. When the X-ray machine is turned on, the electric current enter the control panel; via the plugged in cord and then to the tube head via extension wires in extension arms.
- ♦ The current is directed to the filament circuit through the step-down transformer, it reduces the 110 to 220 voltage to 3 to 5 volts.
- ♦ The filament circuit uses the 3 to 5 volts to heat the tungsten filament. The hot filament emits electron, this emission of electron from the cathode is known as thermionic emission. It forms the electron cloud around the cathode.
- ♦ When the exposure button is pushed the high voltage current is activated and the electron cloud is accelerated in X-ray tube from cathode to anode.
- ♦ Molybdenum cup of cathode directs the electron to the anode target in narrow beam.
- ♦ When the electron strikes the tungsten target, their kinetic energy is converted to X-ray energy. Less than 1% of the energy is converted to X-rays, the remaining 99% is lost as heat.
- ♦ The heat produced is carried away by copper stem and absorbed by the insulating oil in the tube head.
- ♦ The area where electron strike on tungsten (anode) is known as focus spot (Tungsten focus).
- ♦ Produced X-rays only exit from the X-ray tube via unleaded glass window portion of tube.
- ♦ X-rays travel through the unleaded glass window, the tube head seal, the aluminum discs, which filter the long wave X-rays from the beam.
- ♦ The size and shape of the X-ray beam is controlled by the lead collimator. X-ray beam then travels down the lead lines position indicating device and exit the tube head at the opening of position indicating device.

- X-rays produced in the X-ray tube vary in their energy and their wavelength, depending on how electrons interacted with tungsten atoms in anode. So kinetic energy of electrons is converted to X-ray photon either through Bremsstrahlung radiation or through characteristic radiation.

General (Bremsstrahlung Radiation or Breaking Radiation)

- The term refers to the sudden breaking of high speed electrons when they hit the tungsten target in the anode. About 70% of the X-rays are produced in this manner.
- If the electron hits the nucleus of the tungsten atom all its kinetic energy is converted into "High Energy X-ray Photon".
- But most of the time, instead of hitting the nucleus, most electrons just miss the nucleus of the tungsten atom. When the electron comes close to the nucleus, it is attracted to the nucleus and slows down, consequently an X-ray photon is released. The electron that misses the nucleus continues to penetrate many such tungsten atoms producing many lower energy X-ray photons, before it imparts all its kinetic energy.
- As a result general radiation consists of X-rays of many different energies and wavelengths. It is also known as continuous spectrum.

Characteristic Radiation

- It is produced when a high speed electron dislodges an inner shell electron from tungsten atom and leads to ionization of atom. Once the electron is dislodged remaining orbiting electrons are rearranged to fill the vacancy. This rearrangement causes loss of the energy which results in the X-ray photon, with the energy equal to the difference in two orbital energy states. So X-rays produced are known as characteristic radiation.
- This radiation accounts for very small part of X-rays which are produced in dental X-ray machine and occur at 70 kVp and above.

Q.3. Write short note on cathode in X-ray tube. *(Nov 2010, 3 Marks)*

Ans. Cathode present in X-ray tube consists of negative electrode, so it is known as negative cathode.

Negative Cathode Principally Composed of Two Parts

i. Filament.
ii. Focusing cup

For details of above mentioned parts refer to Ans. 2 of same chapter.

Q.4. Write short note on Bremsstrahlung radiation. *(Dec 2011, 3 Marks)*

Ans. It is also known as breaking radiation.

- The term refers to the sudden breaking of high speed electrons when they hit the tungsten target in the anode. About 70% of the X-rays are produced in this manner.
- If the electron hits the nucleus of the tungsten atom all its kinetic energy is converted into "High Energy X-ray Photon".
- But most of the time, instead of hitting the nucleus, most electrons just miss the nucleus of the tungsten atom. When the electron comes close to the nucleus, it is attracted to the nucleus and slows down, consequently an X-ray photon is released. The electron that misses the nucleus continues to penetrate many such tungsten atoms producing many lower energy X-ray photons before it imparts all its kinetic energy.
- As a result general radiation consists of X-rays of many different energies and wavelengths. It is also known as continuous spectrum.

Q.5. Write short note on white radiation. *(Mar 2010, 6 Marks)*

Ans. A form of radiation that results from the rapid deceleration of high-speed electrons striking target, as occurs when the electron beam of a tungsten cathode strikes the tungsten or molybdenum target of the anode in an X-ray tube. Most of the X-rays emitted from a diagnostic or therapeutic X-ray unit represent white radiation. Also called Bremsstrahlung radiation.

- The term refers to the sudden breaking of high speed electrons when they hit the tungsten target in the anode. About 70% of the X-rays are produced in this manner.
- If the electron hits the nucleus of the tungsten atom all its kinetic energy is converted into "High Energy X-ray Photon".
- But most of the time, instead of hitting the nucleus, most electrons just miss the nucleus of the tungsten atom. When the electron comes close to the nucleus, it is attracted to the nucleus and slows down, consequently an X-ray photon is released. The electron that misses the nucleus continues to penetrate many such tungsten atoms producing many lower energy X-ray photons before it imparts all its kinetic energy.
- As a result general radiation consists of X-rays of many different energies and wavelengths. It is also known as continuous spectrum.

Q.6. Write short note on line focus principle. *(Mar 2012, 6 Marks)*

Or

What is line focus principle? *(May 2017, 3 Marks)*

Or

Write short answer on line focus principle. *(May 2020, 3 Marks)*

Ans. The focal spot is the area on the target onto which the focusing cup directs the electrons from the filament.

- As the focal spot becomes smaller, heat generated per unit target area becomes greater. Thus in order to derive benefit from a small focal spot and yet to effectively distribute the bombarding electrons over a greater surface of a large target, the target is placed at an angle to the electron beam.
- In practice, the target is inclined at an angle of 20° to the central ray of electrons. This causes the effective focal spot to be 1 mm × 1 mm, in contrast to 1 mm × 3 mm of the actual focal spot size. This results in a smaller source of X-rays and sharper image with a larger actual focal spot for effective heat dissipation. This is known as "Line focus principle".

Q.7. Describe the working of X-ray machine and write in detail about production of X-ray. *(Mar 2005, 16 Marks)*

Ans. Working of X-ray machine and production of X-rays

- When the X-ray machine is turned on, the electric current enter the control panel; via the plugged in cord and then to the tube head via extension wires in extension arms.
- The current is directed to the filament circuit through the step down transformer, it reduces the 110 to 220 voltage to 3 to 5 volts.
- The filament circuit uses the 3 to 5 volts to heat the tungsten filament. The hot filament emits electron, this emission of electron from the cathode is known as thermionic emission. It forms the electron cloud around the cathode.
- When the exposure button is pushed the high voltage current is activated and the electron cloud is accelerated in X-ray tube from cathode to anode.

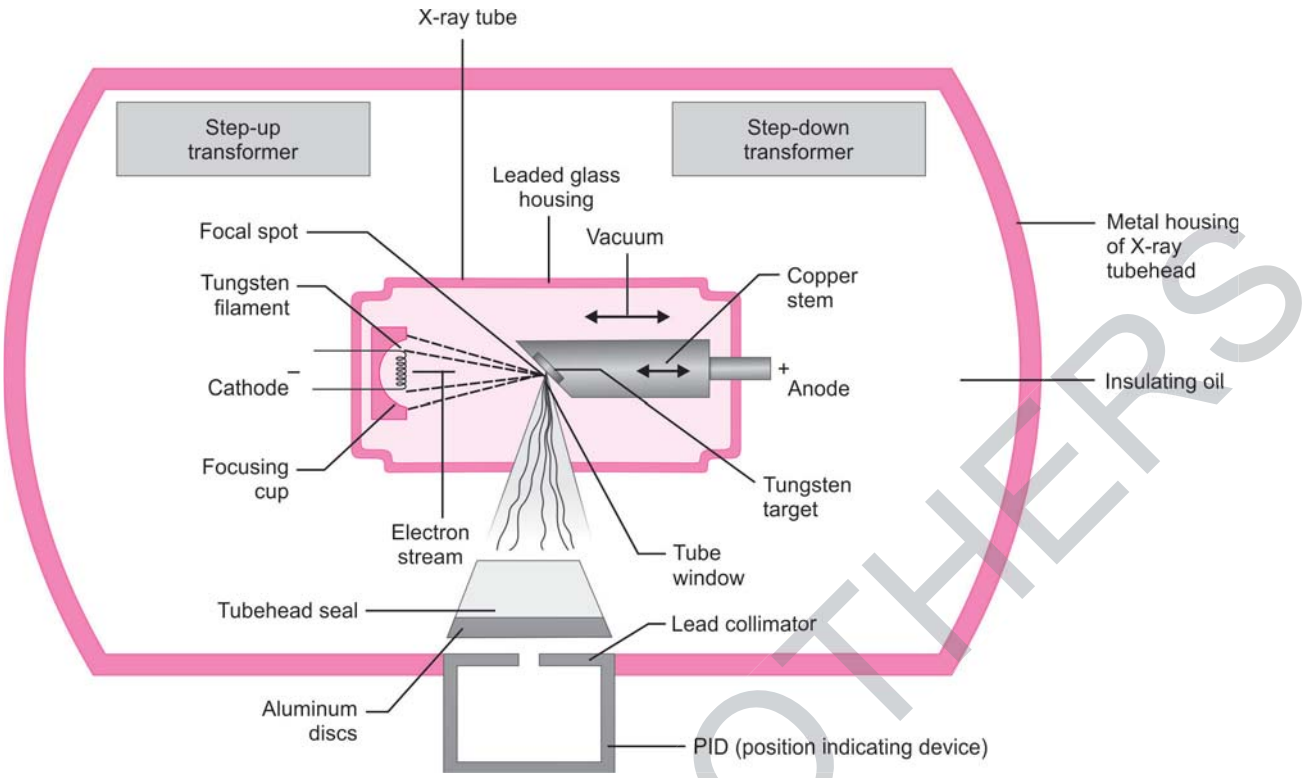

Fig. 5: Circuit diagram of X-ray tube.

- Molybdenum cup of cathode directs the electron to the anode target in narrow beam.
- When the electron strikes the tungsten target, their kinetic energy is converted to X-ray energy. Less than 1% of the energy is converted to X-rays, the remaining 99% is lost as heat.
- The heat produced is carried away by copper stem and absorbed by the insulating oil in the tube head.
- The area where electron strike on tungsten (anode) is known as focus spot (Tungsten focus).
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- The size and shape of the X-ray beam is controlled by the lead collimator. X-ray beam then travels down the lead lines position indicating device and exit the tube head at the opening of position indicating device.

Production of X-rays

For production of X-ray refer to Ans. 2 of same chapter.

Q.8. Define radiation. Explain with the help of diagram the construction of X-ray tube and production of X-rays. *(Feb 2014, 10 Marks)*

Or

Discuss in detail about production of X-ray. Draw a well-labeled circuit diagram of X-ray tube. *(Feb 2014, 8 Marks)*

Or

Draw a labeled diagram for X-ray tube and discuss production of X-rays. *(Oct 2016, 10 Marks)*

Or

Draw a neat and labeled diagram of X-ray tube. Describe production of X-rays in detail. *(Sep 2022, 5 Marks)*

Ans. Radiation is defined as the emission and propagation of energy through space or a substances in form of waves or particles.

Construction of X-ray Tube

- *X-ray tube:* It is the main X-ray generating system. It consists of three parts, i.e., lead glass housing, negative cathode and positive anode.
  - Lead glass housing is a glass vacuum tube which prevents X-rays in escaping all the directions.
  - Negative cathode consists of filament and focusing cup. Filament is basically a coiled wire of tungsten and produces electron on heating. Focusing cup is a holder formed by molybdenum and it houses the filament. Focusing cup focus electrons in a narrow beam and direct beam across the tube towards tungsten target of anode. Cathode supply the electrons which are necessary in generation of X-rays.
  - Positive anode converts electrons into X-ray photons. Anodes are of two types, i.e., stationary and rotating anode.
- *Circuits*: In X-ray machine, two types of circuits are used, i.e., filament circuit or high voltage circuit.
  - Filament circuit is of low voltage, i.e., 3 to 5 volts. It regulates flow of electric current to filament of X-ray tube.
  - High voltage circuit uses 65,000 to 1,00,000 volts which provide high voltage required to accelerate electrons for generation of X-rays in X-ray tube.

- *Transformers*: It either increases or decrease voltage in an electrical circuit. Transformers are of three types i.e.
  1. Step-down transformer: It decreases the voltage from incoming 110 to 220 line voltage to 3 to 4 volt as required for the filament circuit.
  2. Step-up transformer: It increases the voltage from incoming 110 to 220 line voltage to 65,000 to 1,00,000 volts as required by high voltage circuit.
  3. *Auto transformer*: It serves as a voltage compensator, which correct minor fluctuation in current.
- *Timer*: It completes the circuit with high voltage transformer and controls the time for which high voltage is applied to the tube.
- *Tube rating*: It is the maximum safe interval the tube is energized at given range of voltage (kVp) and the tube current (mA) values.
- *Duty cycle*: It refers to how frequently successive exposures can be made.

For production of X-ray refer to Ans. 2 of same chapter.

Q.9. Write short note on angle of truncation.

(Jan 2013, 6 Marks)

Ans.

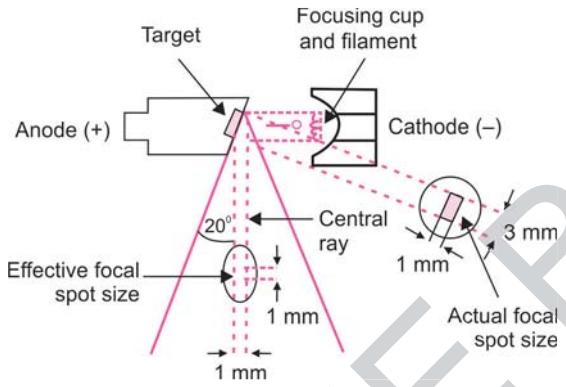

Fig. 6: 20° angle represents the angle of truncation.

In the practice, inclination of target is at 20° to central ray of electrons. This leads to effective focal spot to be 1 mm × 1 mm in contrast to 1 mm × 3 mm of actual focal spot size. This results in formation of small source of X-rays and sharp image with large actual focal spot for the effective heat dissipation. The 20° angle is known as angle of truncation.

Q.10. Draw a neat labeled diagram and explain construction and working of dental X-ray machine.

(Mar 2017, 16 Marks)

Or

Draw well labelled diagram and discuss in detail about X-ray machine. *(Nov 2020, 10 Marks)*

Or

Discuss in detail about the components of X-ray machine with a neat labeled diagram. Write about Bremsstrahlung radiation. *(Feb 2025, 5 Marks)*

Ans.

Construction of Dental X-ray Machine

Dental X-ray machine is made up of three parts or components:

1. Control panel
2. Extension arm
3. Tube head

Control Panel

It contains

- An on and off switch and an indicator light.
- An exposure button and indicator light.
- Control devices (time, kilovoltage, milliamperage, selectors).

The control panel is plugged into an electrical outlet.

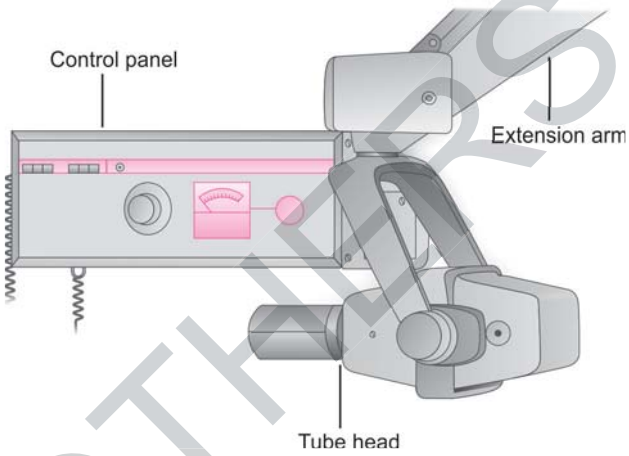

Fig. 7: Diagram of dental X-ray machine.

Extension Arm

- It extends from control panel to tube head.
- It houses the electrical wires.
- The extension arm also allows the movement and positioning of tube head.

Tube Head

For diagram refer to Ans. 7 of same chapter.

- It is an important part of X-ray machine.
- It contains heavy metal housing that contains X-ray tube that produce X-rays.
- Following are the components of tube head:
  - *Metal housing*: This is a metal body of tube head that surrounds the X-ray tube and transformer.
  - *Insulating oil*: That surrounds the X-ray tube and transformer inside the tube head, it prevents over heating during X-ray production.
  - *Tube head seal*: Aluminum or leaded glass of the tube head, it act as filter to the X-ray beam and seal the oil in tube head. Permit the exit of X-rays.
  - *Aluminum disk*: Sheets of 0.5 mm thick aluminum is placed in the path of X-ray beam. They act as filter of X-ray beam. In dental X-ray tube head, there are two types of filtration:
    a. *Inherent filtration*: When the primary beam passes through the glass window of the X-ray tube, the insulating oil and the tube head seal. It is approximately equivalent to 0.5 to 1 mm of aluminum.
    b. *Added filtration*: Placement of aluminum disks in the path of the X-ray beam between the collimator and the tube head seal in dental X-ray tube head.
  - *Lead collimator*: It is a lead plate with controlled hole. It is used to restrict the size and shape of the X-ray beam. It is placed directly over the opening of the metal housing where X-ray exit. They are of two types, i.e., fixed (dentistry) and adjustable.
    Lead collimator reduces the patient's exposure.

- *Position indicating device (PID)*: It is also called "Open ended lead cylinder" or "Cone". It extends from opening of metal housing of tube head. It appears as an extension of tube head and it aims and shape X-ray beam. They are of following type, i.e., conical, Rectangular and round. Both rectangular and round PID are available in two lengths, i.e., Short (5 inches) and Long (16 inches). Long PID is preferred because less divergence of X-ray beam occurs. Rectangular type is most effective in reducing patient's exposure.
- *X-ray tube*: It is the main X-ray generating system. It consists of three parts, i.e., lead glass housing, negative cathode and positive anode.
  - Lead glass housing is a glass vacuum tube which prevents X-rays in escaping all the directions.
  - Negative cathode consists of filament and focusing cup. Filament is basically a coiled wire of tungsten and produces electron on heating. Focusing cup is a holder formed by molybdenum and it houses the filament. Focusing cup focus electrons in a narrow beam and direct beam across the tube towards tungsten target of anode. Cathode supply the electrons which are necessary in generation of X-rays.
  - Positive anode converts electrons into X-ray photons.
- Circuits: In X-ray machine two types of circuits are used, i.e., filament circuit or high voltage circuit.
  - Filament circuit is of low voltage, i.e., 3 to 5 volts. It regulates flow of electric current to filament of X-ray tube.
  - High voltage circuit uses 65,000 to 1,00,000 volts which provide high voltage required to accelerate electrons for generation of X-rays in X-ray tube.
- *Transformers*: It either increases or decrease voltage in an electrical circuit.
- *Timer*: It completes the circuit with high voltage transformer and controls the time for which high voltage is applied to the tube.
- *Tube rating*: It is the maximum safe interval the tube is energized at given range of voltage (kVp) and the tube current (mA) values.
- *Duty cycle*: It refers to how frequently successive exposures can be made.

Working of Dental X-ray Machine

- When the X-ray machine is turned on, the electric current enter the control panel; via the plugged in cord and then to the tube head via extension wires in extension arms.
- The current is directed to the filament circuit through the step down transformer, it reduces the 110 to 220 voltage to 3 to 5 volts.
- The filament circuit uses the 3 to 5 volts to heat the tungsten filament. The hot filament emits electron, this emission of electron from the cathode is known as thermionic emission. It forms the electron cloud around the cathode.
- When the exposure button is pushed the high voltage current is activated and the electron cloud is accelerated in X-ray tube from cathode to anode.
- Molybdenum cup of cathode directs the electron to the anode target in narrow beam.
- When the electron strikes the tungsten target, their kinetic energy is converted to X-ray energy. Less than 1% of the energy is converted to X-rays, the remaining 99% is lost as heat.
- The heat produced is carried away by copper stem and absorbed by the insulating oil in the tube head.
- The area where electron strike on tungsten (anode) is known as focus spot (Tungsten focus).
- Produced X-rays only exit from the X-ray tube via unleaded glass window portion of tube.
- X-rays travel through the unleaded glass window, the tube head seal, the aluminum discs, which filter the long wave X-rays from the beam.
- The size and shape of the X-ray beam is controlled by the lead collimator. X-ray beam then travels down the lead lines position indicating device and exit the tube head at the opening of position indicating device.

For Bremsstrahlung radiation in detail refer to Ans. 2 of same chapter.

Q.11. Write short note on collimation and filtration. *(Sep 2006, 5 Marks)*

Or

Write short note on filtration and collimation. *(Mar 2013, 3 Marks) (Oct 2015, 6 Marks)*

Or

Write short note on filtration. *(Sep 2008, 3 Marks)*

Or

Write short answer on collimation. *(May 2018, 3 Marks)*

Or

Give functions and types of collimation. *(May 2017, 3 Marks)*

Or

Write short answer on collimation and filtration. *(Sep 2022, 3 Marks)*

Or

Enumerate types of collimators used in dental radiology and write its function. *(Nov 2019, 3 Marks)*

Or

Write short answer on filtration and collimation. *(Feb 2025, 3 Marks)*

Ans.

Filtration

An X-ray beam has photons of different energies but only the photon with sufficient energy are able to penetrate the anatomic structures and useful in diagnostic radiography. Those photons with low penetrating power (long wavelength) contribute only to patient exposure and not to information on film. Thus for patient safety these photons with low power should be removed. This procedure of increasing the quality of radiation by removal of low power photon is known as "filtration".

It is done by placing an aluminum filter in path of beam.

Type of Filtration

1. Inherent filtration.
2. Added filtration
3. Total filtration

Inherent Filtration

Filtration provided by materials of X-ray tube head, e.g., glass, insulating oil and the tube head seal. It is equivalent to 0.5 to 1.5 mm of aluminum.

Added Filtration

As the name suggests additional, an additional aluminum disk is placed between the tube head seal and collimator in the path of primary beam. It is 0.5 mm thick.

Total Filtration

- Total filtration is the sum of inherent filtration and added filtration.
- At or below 70 kVp requires minimum total filtration of 1.5 mm of aluminum thickness.
- Above 70 kVp require a minimum total filtration of 2.5 mm of aluminum thickness.
- Contrast and quality of films get increase with the use of filter.

Fig. 8: Filter.

Collimation

Collimation is the process of restriction of the size of X-ray beam and thus the volume of irradiated tissue of patient from which the scattered photons originate.

- It allow only useful beam to emerge (useful beam is defined as that part of the primary radiation which is allowed to emerge through collimating device).

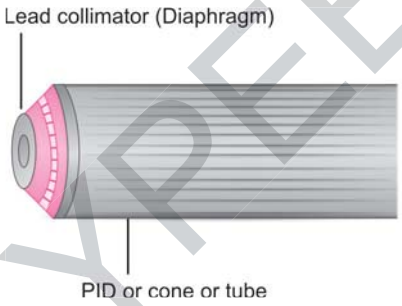

Fig. 9: Collimator.

- When an X-ray beam falls on tissue 90% of it is absorbed by tissue and 10% result in scattered beam and travels in all direction.
- The scattered radiation does not contribute to information but only adds to film fog and degrades the image.
- The collimation decreases the risk of radiation, minimizes scattered radiation and decreases the fog with sharper image and better contrast.
- In intraoral machines, there are fixed collimators and in extraoral machines, they are adjustable.

Uses/Functions of Collimation

- It reduces the volume of irradiated tissues and decreases the radiation exposure to patient.
- It reduces the size of X-ray beam and amount of scattered photons.
- It reduces the film fog and enhances the quality of image.

Types of Collimators

Following are the type of collimators:

Diaphragm Collimator

- It consists of a thick plate of radiopaque material with opening in it.
- Collimator should lie over the port in X-ray head by which X-ray beam emerges.
- Aperture should be of different size and shape depending on requirement.

Tubular Collimator

- It is a tube which is manufactured by radiopaque material.
- Combination of diaphragm type and tubular type is used.
- The combination helps in reducing the penumbra at periphery of image.
- Longer the tube small is penumbra.

Rectangular Collimator

- They limit the size and they are larger than size of an X-ray film.
- It can be incorporated in a film-holding device.

Slit Collimator

- It is used in OPG machines.
- In CT machines, collimators are of two types:
  1. *Source collimator:* It lies in front of X-ray tube and reduces the beam of radiation to form maximum required fan beam and determines the emitted dose.
  2. *Detector collimator:* It is positioned directly in front of detector and is used to shield detector against scattered radiation and prevent the artifacts.

Q.12. Write short note on collimator.

(Mar 2015, 5 Marks)

Ans. Radiation beam emitted by X-ray tube is shaped using special diaphragm known as collimator. Collimation is the method by which one can control size and shape of the X-ray beam.

- Collimator decreases the risk of radiation, minimizes scattered radiation and decreases the fog with sharp image and better contrast.
- Collimators used in intraoral machines are fixed while in extra-oral machines collimators used are adjustable.

Types of Collimators

Following are the type of collimators:

Diaphragm Collimator

- It consists of a thick plate of radiopaque material with opening in it.
- Collimator should lie over the port in X-ray head by which X-ray beam emerges.
- Aperture should be of different size and shape depending on requirement.

Tubular Collimator

- It is a tube which is manufactured by radiopaque material.
- Combination of diaphragm type and tubular type is used.
- The combination helps in reducing the penumbra at periphery of image.
- Longer the tube small is penumbra.

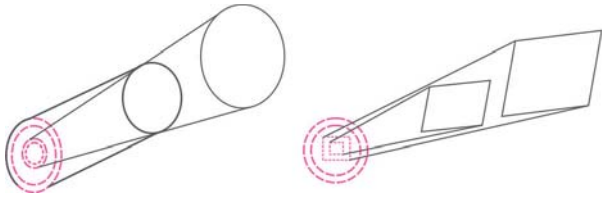

Fig. 10: Tubular and rectangular collimator.

Rectangular Collimator

- They limit the size and they are larger than size of an X-ray film.
- It can be incorporated in a film-holding device.

Slit Collimator

It is used in OPG machines.

In CT machines, collimators are of two types, i.e.:

a. *Source collimator:* It lies in front of X-ray tube and reduces the beam of radiation to form maximum required fan beam and determines the emitted dose.
b. *Detector collimator:* It is positioned directly in front of detector and is used to shield detector against scattered radiation and prevents the artifacts.

Q.13. Describe X-ray tube in detail and factor controlling production of X-ray beam.

(Mar 2017, 10 Marks)

Ans. *For X-ray tube in detail refer to Ans. 1 of same chapter.*

Factors Controlling Production of X-ray Beam

Following are the factors which control production of X-ray beam:

- Tube current
- Tube voltage
- Exposure time
- Filtration
- Collimation
- Inverse square law
- Quality of X-ray beam
- Quantity of X-ray beam
- Half value layer

Tube Current

- Tube current (mA) determines the number of X-ray photons generated.
- Increase in the mA increases the generation of more electrons at cathode which strike the target to produce more X-ray photons.
- So the quantity of radiation produced by the X-ray tube is directly proportional to the tube current and the time, tube is operated.
- Linear relationship exist between mA and tube output.

Tube Voltage

- Tube voltage is the measurement of electrical force which causes electrons to move from negative cathode to positive anode.
- Energy of electrons is controlled by the tube voltage. As there is an increase in (kVp), energy of each electron striking the target increases which leads to increase in number of X-ray photons generated.
- Increase in kVp increases number of photons generated; increase mean energy of photons and increases maximum energy of photons.

Exposure Time

- When the exposure time is doubled and kVp as well as mA should be kept constant the number of X-ray photons generated become doubled.
- As changes in exposure time is made this influences the quantity of X-rays produced.

Filtration

- In filtration X-ray photons of less penetrating power are removed by placing a filter in path of primary beam, this allows only X-ray photons of sufficient energy to pass through.
- Usage of filters increases the contrast and quality of film while the density gets affected, so when there is an increase in filtration, increase in the exposure time is needed.

Collimation

- Collimator shape or restrict the size of an X-ray beam which strikes the tissue of a patient.
- Collimation leads to decrease in the size of X-ray beam and the amount of scattered photons.
- Volume of irradiated tissues is decreased by the collimation so there is decrease in exposure of radiation to the patient.
- Collimation reduces the film fog and enhances the quality of image.

Inverse Square Law

- The law states that the intensity of an X-ray beam at a given point is inversely proportional to the square of the distance from the source of radiation.
- Decrease in intensity of X-ray is because of divergent nature of X-rays.

Quality of X-ray Beam

- Quality of X-ray beam is its mean energy or penetrating ability.
- Quality of an X-ray beam is governed by its kVp. As there is increase in kVp, X-ray photons of high energy and better penetrating power are produced.

Quantity of X-ray Beam

- It refers to the number of X-ray photons produced.
- Quantity depends on the product of mA and exposure time in seconds.
- As there is increase in mA, more number of electrons are released in cathode and they strike the target to produce more number of X-ray photons.

Half Value Layer

- It refers to the thickness of specified material which is required to reduce the intensity of an X-ray beam by one half.
- Half value layer designates the penetrating power of X-ray beam.

Q.14. Why tungsten metal used as target material in X-ray tube? *(Nov 2017, 3 Marks)*

Ans. Tungsten is usually selected as the target material because it represents an effective compromise between the features of an ideal target material, which are as follows:

i. **High atomic number:** This is needed for more efficient production of X-rays. High atomic number usually indicates the high charge over the nucleus (more protons) and high binding of energy of the orbital electrons. This high charge on nucleus leads to the greater deceleration of bombarding electrons which usually approach the nucleus and of

incoming electrons which collide with inner shell of electrons which produce higher energy radiation. In brief, high atomic number gives rise to increased inter action between electrons and atoms, and so increasing X-ray photons.

ii. **High melting point:** It is around 3422°C, so that even if the temperature rises the target will not melt.
iii. **Low vapor pressure:** At high temperatures, the target does not evaporate.
iv. **High specific heat (conduction of heat):** This facilitate dissipation of heat, but tungsten is the poor conductor of heat.
v. **High thermal conductivity:** Tungsten target is embedded in a copper block which is a good thermal conductor, it dissipates heat and helps prevent risk of target melting.

4. RADIATION BIOLOGY

Q.1. Discuss in detail radiation effects on oral cavity. *(Mar 2015, 10 Marks) (July 2019, 6 Marks)*

Or

Describe harmful effect of radiation on oral mucosa, taste buds, salivary glands, teeth and jaw bones. *(Mar 2011, 16 Marks)*

Or

Write in detail about radiation hazards in dentistry. *(Mar 2015, 8 Marks) (Dec 2015, 8 Marks)*

Or

Describe in detail about the effect of radiation on mucosa, salivary gland and bone. *(Oct 2017, 15 Marks)*

Or

Write short answer on effect of radiation on salivary glands. *(Feb 2019, 3 Marks) (Nov 2022, 3 Marks)*

Ans. Study of the effects of ionizing radiation on the living system is called as radiation biology.

Harmful Effect of Radiation in Oral Cavity/Oral Mucosa

The oral cavity is irradiated during the course of healing of radiosensitive oral malignant tumors, e.g., squamous cell carcinoma.

Oral Mucosa

- Oral mucous membrane contains the basal layer of differentiating inter mitotic cells which are highly radiosensitive at the end of second week of therapy, the mucous membrane begins to show areas of redness and inflammation, this state is called as "mucositis".
- As the therapy continues the mucous membrane breaks down with the formation of white or yellow pseudomembrane.
- At the end of therapy, the mucositis is severe, painful leading to difficulty in talking, eating and swallowing.
- After termination of therapy, the healing may be complete after about 2 months, but the mucous membrane tends to become thin, atrophic and relatively avascular. Secondary infection by *Candida albicans* is very common complication.
- Patient is usually to oral ulcerations and unable to tolerate dentures.

Effects on Taste Buds

- Taste buds are sensitive to radiation even therapeutic dose of radiation causes degeneration of taste buds.
- Loss of taste sensation occurs during 2nd and 3rd week of therapy.
- Loss of taste sensation can be partial or complete.
- Posterior two-third of the tongue when irradiated affects the bitter and acid flavors.
- Anterior one-thirds of the tongue when irradiated affects sweet and salty flavors.

Effects on Salivary Glands

- Parenchymal component of the gland is sensitive to radiation.
- Glands demonstrate progressive fibrosis, adiposis, loss of fine vasculature.
- There is marked decrease in salivary flow.
- The composition of saliva is affected.
- There is increased concentration of sodium, chloride, calcium, magnesium ions and proteins.
- Saliva losses its lubricating properties.
- Mouth becomes dry and tender due to xerostomia.
- pH of saliva is decreased which may initiate decalcification of enamel.

Effects on Teeth

Adult teeth are resistant to the effects of radiation.

Radiation Caries

- Involve mainly cementum and dentin at cervical lesion.
- Dark pigmentation of crown.
- Superficial lesion affect buccal, incisal, palatal and occlusal surfaces.

During Development

- *Before calcification:* There is complete destruction of tooth bud which results in partial anodontia.
- *Once calcification starts:* Hypoplastic changes seen.
- *During root development:* Retardation or loss of root development.

After Eruption

Radiation caries: It is a form of rampant caries; it is secondary to the change in saliva.

Effects on Bone

- Marrow is replaced by bone marrow and fibrous connective tissue.
- Endosteum becomes atrophic.
- Bone becomes hypovascular hypocellular and hypomineralized.
- The complication following irradiation, i.e., "osteoradionecrosis".
- Necrosis of bone may result in nonhealing ulcer which may occur after tooth extraction.
- Lack of osteoblastic and osteoclastic activity in endosteum.
- Mandible affects more than maxilla.

Q.2. Write long answer on biological effects of radiation. *(Jan 2021, 6 Marks)*

Or

Write short answer on biological effects. *(Jan 2021, 6 Marks)*

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Hemant Gupta MDS (Oral and Maxillofacial Pathology, Microbiology and Forensic Odontology) has two decades of experience of authorship. He is the CEO of Shivom Multispeciality Dental Clinic, Indore, Madhya Pradesh, India. He is a general practitioner and also a consultant as oral cancer diagnostician at various clinics and hospitals. He is an eminent as well as dedicated clinician, practitioner, instructor, and consultant. He has also specialized in pathology technique such as immunohistochemistry. He has published research papers in various indexed journals of national repute. He has experience of coaching of dental students at personal level, which helps them to build up the basics in dentistry, and also to clear the various university examinations. His pioneer work in "forensic odontology is on ameloglyphics".

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