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PAPER = radiation science and technology

Q NO 1 =

ANS 1=

BREMSSTRAHLUNG RADIATION

[**X-rays**](https://radiopaedia.org/articles/x-rays-1?lang=gb)**are produced by high-energy electrons bombarding a target, especially targets that have a high proton number (Z). When bombarding electrons penetrate into the target, some electrons travel close to the nucleus due to the attraction of its positive charge and are subsequently influenced by its electric field. The course of these electrons would be deflected, and a portion or all of their kinetic energy would be lost. The principle of the conservation of energy states that in producing the X-ray photon, the electron has lost some of its kinetic energy (KE):**

1. **final KE of electron = initial KE of electron - energy of X-ray photon**

**The 'lost' energy is emitted as X-ray photons, specifically bremsstrahlungradiation (bremsstrahlung is German for 'braking radiation'). Bremsstrahlung can have any energy ranging from zero to the maximum KE of the bombarding electrons (i.e., 0 to Emax), depending on how much the electrons are influenced by the electric field, therefore forming a continuous spectrum. The 'peak' of the spectrum typically occurs at approximately one-third of Emax so for a bremsstrahlung spectra with an Emax value of say 120 keV, the peak of the spectrum would be at approximately 40 keV.**

**The intensity of bremsstrahlung radiation is proportional to the square of the atomic number of the target (Z), the number of unit charges of the bombarding particle (z) and inversely with the mass of the bombarding particle (m): Z² z / m. It follows that light particles such as electrons and positrons bombarding targets of high atomic number are more efficient producers of bremsstrahlung radiation than heavier particles such as alpha particles or neutrons (which can also cause X-rays to be produced through bremsstrahlung,**

2=CHARACTERISTICS RADIATION

When a fast-moving electron collides with a K-shell electron, the electron in the K-shell is ejected (provided the energy of the incident electron is greater than the binding energy of K-shell elect

ron) leaving behind a 'hole'. An outer shell electron fills this hole (from the L-shell, M-shell, etc. ) with an emission of a single x-ray photon, called**characteristic radiation**, with an energy level equivalent to the energy level difference between the outer and inner shell electron involved in the transition.

As opposed to the continuous spectrum of [bremsstrahlung radiation](https://radiopaedia.org/articles/bremsstrahlung?lang=gb), characteristic radiation is represented by a line spectrum. As each element has a specific arrangement of electrons at discrete energy level, then it can be appreciated that the radiation produced from such interactions is 'characteristic' of the element involved.

For example, in a tungsten target electron transitions from the L-shell to the K-shell produce x-rays photons of 57.98 and 59.32 keV. The two energy levels are as a result of the Pauli exclusion principle which states that no two particles of half-integer spin (such as electrons) in an atom can occupy exactly the same energy state at the same time; therefore the K-shell represents two different energy states, the L-shell eight states and so on.

When an electron falls (cascades) from the L-shell to the K-shell, the x-ray emitted is called a K-alpha x-ray. Similarly, when an electron falls from the M-shell to the K-shell, the x-ray emitted is called a K-beta x-ray 1. However, it is possible to have M-L transitions and so on but their likelihood is so low they can be safely ignored.

Each element differs in nuclear binding energies, and characteristic radiation depends on the binding energy of particular element.

In [mammography](https://radiopaedia.org/articles/mammography?lang=gb) x-ray tubes which typically use a [molybdenum](https://radiopaedia.org/articles/molybdenum?lang=gb) target, more than 80% of radiation is characteristic radiation. However, characteristic radiation never exists in isolation and the line spectra is usually superimposed on the continuous spectra of bremsstrahlung radiation.

Q NO 3=

**ANS 3 =**

**Contrast is the difference in density or difference in the degree of grayness between areas of the radiographic image. The radiographic contrast depends on the following three factors:**

1. **Subject Contrast: it refers to the difference in the intensity transmitted through the different parts of an object. For example, in an intraoral radiograph, enamel will attenuate x-rays more than dentin. Subject contrast is affected by the following factors:**
   * ***Thickness difference:* if the x-ray beam is attenuated by 2 different thicknesses of the same material, the thicker part will attenuate more x-rays than the thinner part.**
   * ***Density difference:* this is also known as the mass per unit volume. It is the most important factor contributing to subject contrast. A higher density material will attenuate more x-rays than a lower density material.**
   * ***Atomic number difference:* A higher atomic number material will attenuate more x-rays than a lower atomic number material.**
   * ***Radiation quality or kVp:* it has a great effect on subject contrast. A lower kVp will make the x-ray beam less penetrating. This will result in a greater difference in attenuation between the different parts of the subject, leading to higher contrast. A higher kVp will make the x-ray beam more penetrating. This will result in less difference in attenuation between the different parts of the subject, leading to lower contrast**
2. **Receptor Contrast: it refers to the ability of a receptor to show adequately the information that the photons transmitted through the subject. In conventional radiography, the contrast depends on the size of the grains, the development time, the concentration and temperature of the developing solution, and overall film density. As conventional film use has been reduced, we will not discuss the details of these factors.  
     
   In digital imaging, contrast depends on the bit-depth of the receptor. Bit-depth refers to the number of possible grey values that can be stored in an image. The higher the bit-depth, the more gray values it can store. The simplest image, a 1-bit image, can only show two colors, black and white. That is because 1-bit can only store one of two values, 0 (white) and 1 (black). An 8-bit image can store 256 possible gray values, while a 12-bit image can display 4096 gray values.**
3. **Factors that Affect Radiographic Contrast:Scatter radiation will decrease the contrast of the radiograph; however, collimation can counterbalance this effect.**

**Q no 5=**

**ANS 5 =**

**Compton scattering, discovered by**[**Arthur Holly Compton**](https://en.m.wikipedia.org/wiki/Arthur_Compton)**, is the scattering of a**[**photon**](https://en.m.wikipedia.org/wiki/Photon)**by a**[**charged**](https://en.m.wikipedia.org/wiki/Electric_charge)**particle, usually an**[**electron**](https://en.m.wikipedia.org/wiki/Electron)**. If it results in a decrease in**[**energy**](https://en.m.wikipedia.org/wiki/Energy)**(increase in**[**wavelength**](https://en.m.wikipedia.org/wiki/Wavelength)**) of the photon (which may be an**[**X-ray**](https://en.m.wikipedia.org/wiki/X-ray)**or**[**gamma ray**](https://en.m.wikipedia.org/wiki/Gamma_ray)[**photon**](https://en.m.wikipedia.org/wiki/Photon)**), it is called theCompton effect. Part of the energy of the photon is transferred to the recoiling electron.Inverse Compton scattering occurs when a charged particle transfers part of its energy to a photon.**

**PHOTOELECTRIC EFFECT**

**Photoelectric effect**, phenomenon in which electrically charged particles are released from or within a material when it absorbs [electromagnetic radiation](https://www.britannica.com/science/electromagnetic-radiation). The effect is often defined as the ejection of [electrons](https://www.britannica.com/science/electron) from a [metal](https://www.britannica.com/science/metal-chemistry)[plate](https://www.britannica.com/technology/anode) when [light](https://www.britannica.com/science/light) falls on it. In a broader definition, the [radiant](https://www.britannica.com/technology/radiation-measurement)energy may be [infrared](https://www.britannica.com/science/infrared-radiation), visible, or[ultraviolet](https://www.britannica.com/science/ultraviolet-radiation) light, [X-rays](https://www.britannica.com/science/X-ray), or [gamma rays](https://www.britannica.com/science/gamma-ray); the material may be a solid, liquid, or gas; and the released particles may be [ions](https://www.britannica.com/science/ion-physics) (electrically charged atoms or molecules) as well as electrons. The phenomenon was fundamentally significant in the development of modern [physics](https://www.britannica.com/science/physics-science) because of the puzzling questions it raised about the nature of light—particle versus wavelike behaviour—that were finally resolved by [Albert Einstein](https://www.britannica.com/biography/Albert-Einstein)in 1905. The effect remains important for research in areas from [materials science](https://www.britannica.com/technology/materials-science) to[astrophysics](https://www.britannica.com/science/astrophysics), as well as forming the basis for a variety of useful devices.

**Q NO 4=**

**ANS 4=**

**APERTURE DIAPHRAGM**

In [optics](https://en.m.wikipedia.org/wiki/Optics), a diaphragm is a thin opaque structure with an opening ([aperture](https://en.m.wikipedia.org/wiki/Aperture)) at its center. The role of the diaphragm is to stopthe passage of light, except for the light passing through the aperture. Thus it is also called a stop (an [aperture stop](https://en.m.wikipedia.org/wiki/Aperture_stop), if it limits the brightness of light reaching the focal plane, or a field stop or flare stop for other uses of diaphragms in lenses). The diaphragm is placed in the light path of a [lens](https://en.m.wikipedia.org/wiki/Lens_(optics)) or [objective](https://en.m.wikipedia.org/wiki/Photographic_lens), and the size of the aperture regulates the amount of light that passes through the lens. The centre of the diaphragm's aperture coincides with the [optical axis](https://en.m.wikipedia.org/wiki/Optical_axis) of the lens system

IMAGE CONTRAST

image. Contrast is the difference in brightness between objects or regions. For example, a white rabbit running across a snowy field has poor contrast, while a black dog against the same white background has good contrast.

**COLLIMATION FILTRATION**

A collimator is a device which narrows a beam of particles or waves. To narrow can mean either to cause the directions of motion to become more aligned in a specific direction (i.e., make [collimated light](https://en.m.wikipedia.org/wiki/Collimated_light) or [parallel](https://en.m.wikipedia.org/wiki/Parallel_(geometry)) rays), or to cause the spatial [cross section](https://en.m.wikipedia.org/wiki/Cross_section_(geometry)) of the beam to become smaller (beam limiting device).

**Q NO 2=**

**ANS 2=**

**Current (mAs) =** An increase in quantity ; no change in quality.

2=**Voltage (kVp)=** An increase in quantity and quality.

3=**Added filtration =**A decrease in quantity and an increase in quality.

4=**target atomic number (Z)=**An increase in quantity and quality.

5=**Voltage ripple =**An decrease in quantity and quality.