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Where Minds Pollinate

Class 12
Physics

Chapter 25

Exercise Solution

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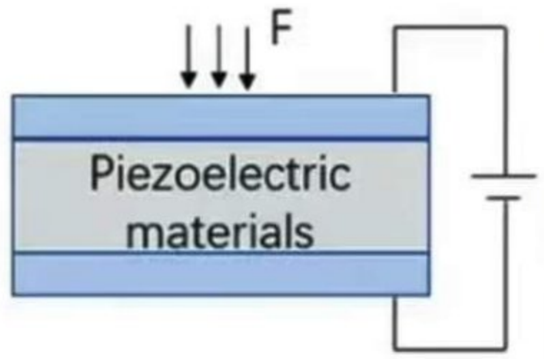
1) Differentiate between piezoelectric effect and inverse piezoelectric effect.

Answer: The **piezoelectric effect** is the production of electric charge on certain crystals when mechanical stress is applied. In this effect, mechanical energy is converted into electrical energy.



The **inverse piezoelectric effect** occurs when an applied electric field Causes mechanical deformation in a crystal. Here, electrical energy is converted Into mechanical energy.

Both effects are observed in crystals like quartz.

2) What is the distinction between a continuous X-ray and a characteristic X-ray?

Answer: Continuous X-rays are produced when fast electrons are suddenly decelerated on striking the target. They form a continuous range of wavelengths and are also called bremsstrahlung radiation.

Characteristic X-rays are produced when inner-shell electrons are ejected and outer-shell electrons fall to fill the vacancy.

Their wavelengths are fixed and depend on the target material.

Continuous X-rays depend on applied voltage, while characteristic X-rays depend on atomic structure.

3) What is the main purpose of X-rays?

Answer: The main purpose of X-rays is to observe internal structures of objects and the human body.

They are widely used in medical diagnosis to detect bone fractures and foreign objects.

X-rays are also used in industry to check cracks in metals.

In science, X-rays help in studying crystal structures.

They are useful because they can penetrate matter.

4) X-rays can emit electrons from metal surface and X-rays can be diffracted. Comment.

Answer: X-rays can eject electrons from a metal surface due to the **photoelectric effect**, which shows their **particle nature**.

X-rays can also undergo **diffraction** when they pass through crystals, which is a property of waves.

Diffraction of X-rays is explained by **Bragg's law**: $n\lambda = 2d \sin\theta$

Thus, X-rays show both **particle nature** and **wave nature**.

Hence, X-rays possess **dual nature**.

5) Why X-rays have different properties from light even though both originate from orbital transition of electrons in excited atoms?

Answer: X-rays originate from inner-shell electron transitions, while light comes from outer-shell transitions. Inner-shell transitions involve much higher energy changes. Due to higher energy, X-rays have shorter wavelength and higher frequency. This causes X-rays to be more penetrating than visible light. Therefore, their properties are different.

6) What is meant by breaking radiation?

Answer: Breaking radiation is produced when fast-moving electrons are suddenly slowed down on hitting the target. It is also called bremsstrahlung radiation.

The kinetic energy of electrons is converted into X-ray photons.

The minimum wavelength is given by:

$$\lambda_{min} = \frac{hc}{eV}$$

It forms a continuous spectrum.

7) What are K_β characteristic X-rays? Show with the help of diagram.

Answer: K_β characteristic X-rays are produced when an electron falls from the **M-shell to the K-shell**.

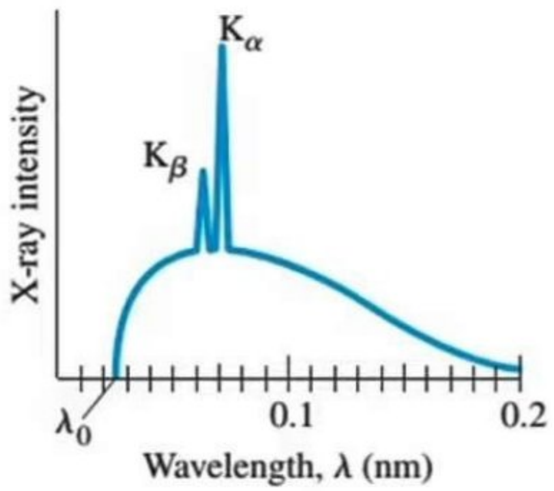
They have **higher energy and shorter wavelength** than K_α X-rays.

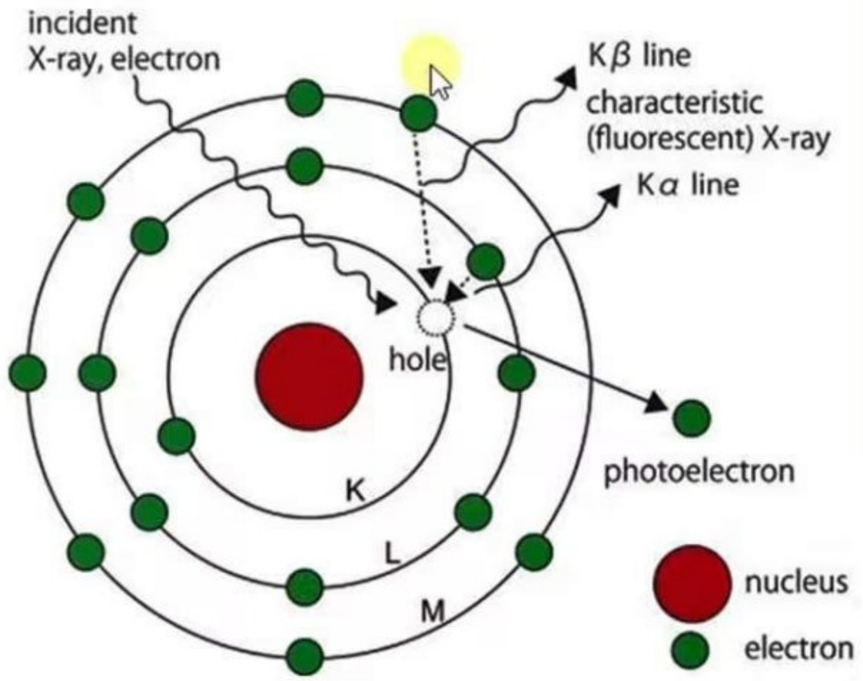
These X-rays are characteristic of the target element.

Their frequency depends on atomic number.

Transition:

$M \rightarrow K \rightarrow$ **K_β X-rays**





What will be the minimum wavelength of X-rays produced, if the electrons were slowed down by the target. The potential difference across the x-ray tube is 4000 V.

Given Data

Potential difference,

V = 4000 V

Planck's constant,

$h = 6.63 \times 10^{-34}$ J·s

Speed of light,

$c = 3.0 \times 10^{8}$ m/s

Charge of electron,

$e = 1.6 \times 10^{-19}$ C

To Find

Minimum wavelength, λ_{min} = ?

Solution

$$eV = \frac{hc}{\lambda_{min}}$$

$$\lambda_{min} = \frac{hc}{eV}$$

$$\lambda_{min} = \frac{(6.63 \times 10^{-34})(3.0 \times 10^{8})}{(1.6 \times 10^{-19})(4000)}$$

$$\lambda_{min} = 3.1 \times 10^{-10}\ \text{m}$$

$$\lambda_{min} = 0.31\ \text{nm}$$

1) If potential difference of **3000 V** is applied across an X-ray tube. What will be the minimum wavelength of X-rays produced, if the electrons were slowed down by the target.

Given Data

$V = 3000\ V$

$h = 6.63 \times 10^{-34}\ J{\cdot}s$

$c = 3.0 \times 10^{8}\ m/s$

$e = 1.6 \times 10^{-19}\ C$

To Find

$\lambda_{min} = ?$

Formula

$$\lambda_{min} = \frac{hc}{eV}$$

Solution

$$\lambda_{min} = \frac{(6.63 \times 10^{-34})(3.0 \times 10^{8})}{(1.6 \times 10^{-19})(3000)}$$

$$\lambda_{min} = 4.14 \times 10^{-10}\ \mathrm{m}$$

$$\lambda_{min} = 0.414\ \mathrm{nm}$$

2) Find the voltage across the X-ray tube through which an electron must be accelerated in order to generate the continuous X-ray of exactly **0.1 nm**.

Given Data

$\lambda = 0.1\ \text{nm} = 0.1 \times 10^{-9}\ \text{m}$

$h = 6.63 \times 10^{-34}\ \text{J·s}$

$c = 3.0 \times 10^{8}\ \text{m/s}$

$e = 1.6 \times 10^{-19}\ \text{C}$

To Find

V = ?

Formula

$$eV = \frac{hc}{\lambda}$$

Solution

$$V = \frac{hc}{e\lambda}$$

$$V = \frac{(6.63 \times 10^{-34})(3.0 \times 10^{8})}{(1.6 \times 10^{-19})(0.1 \times 10^{-9})}$$

$$V = 1.24 \times 10^{4}\ \text{V}$$

$$V = 12,400\ \text{V}$$