

State Examination Commission – Physics Higher Level, 2010

Question 9

What is thermionic emission? (6)

X-rays are produced when high-energy electrons collide with a target.

Draw a labelled diagram of an X-ray tube. (12)

What are X-rays and how do they differ from light rays?

Give two uses of X-rays. (18)

When electrons hit the target in an X-ray tube, only a small percentage of their energy is converted into X-rays. What happens to the rest of their energy and how does this influence the type of target used? (9)

A potential difference (voltage) of 40 kV is applied across an X-ray tube.

Calculate:

(i) the maximum energy of an electron as it hits the target

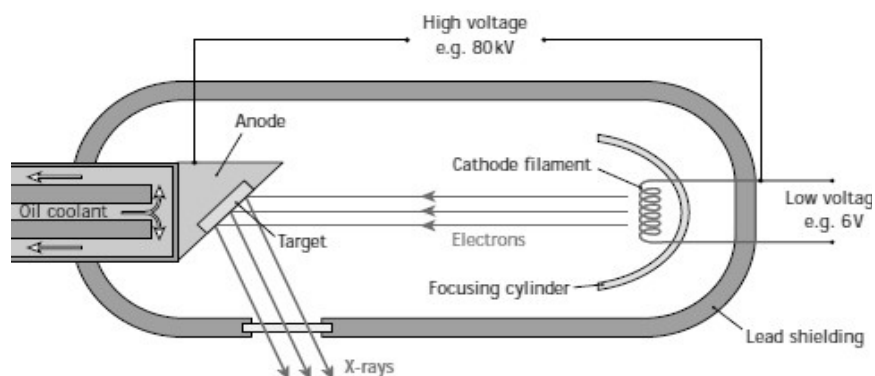
(ii) the frequency of the most energetic X-ray produced. (11)

(Plank constant = $6.6 \times 10^{-34} \text{ J s}$; charge on electron = $1.6 \times 10^{-19} \text{ C}$)

What is thermionic emission? (6)

The release of electrons from the surface of a hot metal

X-rays are produced when high-energy electrons collide with a target. Draw a labelled diagram of an X-ray tube. (12)



What are X-rays and how do they differ from light rays?

They are a form of electromagnetic radiation that have much higher frequencies (hence energies) than light rays. They are more penetrating and have a greater ionizing ability than light.

Give two uses of X-rays. (18)

Medical imaging and industrial quality control

When electrons hit the target in an X-ray tube, only a small percentage of their energy is converted into X-rays. What happens to the rest of their energy and how does this influence the type of target used? (9)

The rest of their energy is converted to heat, so the target metal used needs to have a very high melting point.

A potential difference (voltage) of 40 kV is applied across an X-ray tube. Calculate:

(i) the maximum energy of an electron as it hits the target

$$\frac{1}{2}mv_{max}^2 = eV = 1.6 \times 10^{-19} \times 40,000 = 6.4 \times 10^{-15} \text{ J}$$

(ii) the frequency of the most energetic X-ray produced. (11)

$$E = hf \Rightarrow f = \frac{E}{h} = \frac{6.4 \times 10^{-15}}{6.6 \times 10^{-34}} = 9.7 \times 10^{18} \text{ Hz}$$