

Chapter 7

Short answer question

This question is about a chest x-ray where a photographic film receives photons which have travelled through flesh and bone from a source.

- (a) Explain why, although photons strike a particular place on the film 'randomly', a clear picture is built up.

Some areas of the photographic film have a high probability of photon arrival and a picture eventually emerges with enough photons.

- (b) Accelerated electrons colliding with a target produce the x-ray photons. Show that to produce an x-ray, quantum energy of 10^{-15} J electrons must be accelerated through a potential difference of about 6 kV.

Energy = eV

$$\setminus 1 \times 10^{-15} = 1.6 \times 10^{-19} \times V$$

$$\setminus V = 6250 \text{ V} \approx 6 \text{ kV}$$

- (c) Suppose that on average 10 x-ray photons fall on each grain of the photographic film and the grains are about $1 \mu\text{m}$ across.

1. Estimate the area of a film, which covers the chest of a patient.

$$\text{Area} \approx 0.2 \text{ m} \times 0.3 \text{ m} = 0.06 \text{ m}^2$$

2. Use your estimate to estimate the total x-ray energy falling on the film.

$$\text{Number of grains} = 0.06 \div (1 \times 10^{-6}) = 6 \times 10^{10}$$

$$\text{Energy} = (10 \times 6 \times 10^{10}) \times 10^{-15} = 6 \times 10^{-4} \text{ J}$$

- (d) When all possible photon paths are summed, the amplitude for paths travelling through flesh is four times the size of the amplitude for paths travelling through bone.

Calculate the ratio: $\frac{\text{Probability of arrival through flesh}}{\text{Probability of arrival through bone}}$

Since probability \propto (amplitude)²

The ratio is $4^2:1$ or $16:1$