Example 2

An x-ray tube operates at a potential difference of 33kV. Calculate the wavelength of x-rays produced.

Solution

By definition:

Potential = Work done per unit charge

$$V = \frac{W}{q}$$

therefore $W = q\,V$

$\text{Energy} = q\,V$

$\text{Energy} = e\,V$ in the case of an electron

$\text{Energy} = h\,f$ by Plank's equation

Therefore $h\,f = e\,V$

since $v = f\,\lambda$

then for electromagnetic waves $c = f\,\lambda$ where c is the velocity of light

therefore

$$f = \frac{c}{\lambda}$$

therefore

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

$$\lambda = \frac{h\,c}{e\,V}$$

$$= \frac{(6.6 \times 10^{-34})(3 \times 10^{8})}{(1.6 \times 10^{-19})(33 \times 10^{3})}$$

$$= \frac{3 \times 10^{-26}}{8 \times 10^{-16}}$$

$$\lambda = 0.375 \times 10^{-10}$$

$$\lambda = 37.5 \times 10^{-12}$$

$$\boldsymbol{\lambda = 37.5\ pm}$$