**839.**

**Problem 54.49 (RHK)**

*An electron is emitted from a middle-mass nuclide* $(A = 150, \text{ say})$ *with a kinetic energy of* 1.00 MeV. (a) *We have to find its de Broglie wavelength*; (b) *calculate the radius of the emitting nucleus*; (c) *answer whether such an electron can be confined in a "box" of such dimensions*; *and* (d) *answer whether we can use these numbers to disprove the argument* (*long since abandoned*) *that electrons actually exist in nuclei*.

**Solution:**

(a)

An electron is emitted from a middle-mass nuclide $(A = 150, \text{ say})$ with a kinetic energy of 1.00 MeV. The momentum of the electron will be

$$p = \sqrt{2m_e E} = \sqrt{2 \times 0.51 \times 1.0} \text{ MeV } c^{-1}$$

$$= 1.01 \text{ MeV } c^{-1}.$$

The de Broglie wavelength of an electron of kinetic energy of 1 MeV will therefore be

$$\lambda = \frac{h}{p} = \frac{6.63\times10^{-34}\ \text{J s}}{1.01\ c^{-1}\ \text{MeV}} = \frac{6.63\times10^{-34}\times3\times10^{8}}{1.01\times1.6\times10^{-13}}\ \text{m}$$

$$= 1.23\times10^{-12}\ \text{m}.$$

(b)

The radius of nucleus of mass number $A = 150$ will be

$r = 1.2\times(150)^{1/3}\ \text{fm} = 6.37\times10^{-15}\ \text{m}$.

(c)

If an electron were confined in "box" of length $r = 6.37\times10^{-15}\ \text{m}$, its minimum energy will be

$$E = \frac{h^2}{8m_e r^2} = \frac{\left(6.63\times10^{-34}\right)^2}{8\times9.1\times10^{-31}\times\left(6.37\times10^{-15}\right)^2}\ \text{J}$$

$$= 1.49\times10^{-7}\ \text{J} = \frac{1.49\times10^{-7}}{1.6\times10^{-13}}\ \text{MeV}$$

$$= 0.93\times10^{6}\ \text{MeV}.$$

As the energy of the electron is 1.0 MeV it cannot be confined in a box of the size of the radius of the emitting nucleus.

(d)

Also, as the de Broglie wavelength of an electron of energy 1.0 MeV is about 193 times the radius of the nucleus, it cannot exist inside the nucleus.