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Problem 50.7 (RHK)

The existence of atomic nucleus was discovered in 1911 *by Ernest Rutherford, who properly interpreted some experiments in which a beam of alpha particles was scattered from a foil of atoms such as gold*. (a) *If the alpha particles had a kinetic energy of* 7.5 MeV, *we have to find their de Broglie wavelength*. (b) *We have to answer whether wave nature of the incident alpha particles should have been taken into account in interpreting these experiments. The distance of closet approach of alpha particles to the nucleus in these experiments was* 30 fm.

Solution:

Mass of an alpha particle,

$m_{^4He} = 4.00 \text{ u} = 4.00 \times 1.661 \times 10^{-27} \text{ kg}.$

Kinetic energy of the alpha particles,

$KE = 7.5 \text{ MeV} = 7.5 \times 1.6 \times 10^{-13} \text{ J}$.

Therefore, the de Broglie wavelength of the alpha particles will be

$$\lambda = \frac{h}{p} = \frac{6.63\times10^{-34}}{\sqrt{2\times4\times1.661\times10^{-27}\times7.5\times1.6\times10^{-13}}}\ \text{m}$$
$$= 5.25\times10^{-15}\ \text{m} = 5.25\ \text{fm}.$$

(b)

As the de Broglie wavelength of alpha particles was 5.25 fm and the distance of the closest approach to the nucleus was about 30 fm, quantum effects such as barrier penetration were not significant and therefore the wave nature of alpha particles in analysing the scattering experiments was not crucial.