EXAMPLE 11.4

$$= \frac{6.63\times10^{-34}\ \text{J s}}{4.50\times\ \text{kg m/s}}$$

$$\lambda' = 1.47\times10^{-34}\ \text{m}$$

The de Broglie wavelength of electron is comparable with X-ray wavelengths. However, for the ball it is about 10^{-19} times the size of the proton, quite beyond experimental measurement.

EXAMPLE 11.5

Example 11.5 An electron, an α-particle, and a proton have the same kinetic energy. Which of these particles has the shortest de Broglie wavelength?

Solution

For a particle, de Broglie wavelength, $\lambda = h/p$

Kinetic energy, $K = p^2/2m$

Then, $\lambda = h/\sqrt{2mK}$

For the same kinetic energy *K*, the de Broglie wavelength associated with the particle is inversely proportional to the square root of their masses. A proton $\left({}^1_1\text{H}\right)$ is 1836 times massive than an electron and an α-particle $\left({}^4_2\text{He}\right)$ four times that of a proton.

Hence, α – particle has the shortest de Broglie wavelength.

PROBABILITY INTERPRETATION TO MATTER WAVES

It is worth pausing here to reflect on just what a matter wave associated with a particle, say, an electron, means. Actually, a truly satisfactory physical understanding of the dual nature of matter and radiation has not emerged so far. The great founders of quantum mechanics (Niels Bohr, Albert Einstein, and many others) struggled with this and related concepts for long. Still the deep physical interpretation of quantum mechanics continues to be an area of active research. Despite this, the concept of matter wave has been mathematically introduced in modern quantum mechanics with great success. An important milestone in this connection was when Max Born (1882-1970) suggested a probability interpretation to the matter wave amplitude. According to this, the intensity (square of the amplitude) of the matter wave at a point determines the probability density of the particle at that point. Probability density means probability per unit volume. Thus, if *A* is the amplitude of the wave at a point, $|A|^2\ \Delta V$ is the probability of the particle being found in a small volume ΔV around that point. Thus, if the intensity of matter wave is large in a certain region, there is a greater probability of the particle being found there than where the intensity is small.

EXAMPLE 11.6

Example 11.6 A particle is moving three times as fast as an electron. The ratio of the de Broglie wavelength of the particle to that of the electron is 1.813×10^{-4}. Calculate the particle's mass and identify the particle.

Solution

de Broglie wavelength of a moving particle, having mass *m* and velocity *v*: