Matter Waves

- De Broglie stated that since EMR has momentum and acts like a wave, perhaps matter, which has momentum, also acts like a wave.
- • He used Compton's momentum of EMR formula, $p=h/\lambda$ and equated it to the formula for momentum of matter, $p=mv$

De Broglie wave equation

$$p = \frac{h}{\lambda} \quad \text{wave or photon momentum}$$

$$p = \frac{h}{\lambda} \quad p = mv \; mv = \frac{h}{\lambda} \qquad \therefore \lambda = \frac{h}{mv}$$

- De Broglie wavelength is more significant for small masses traveling at high speeds rather than large masses traveling at low speeds

Matter Waves

- This was not a popular idea. In fact, de Broglie's thesis was held up until Einstein reviewed his work and agreed with it.
- To prove the existence of such waves is very difficult because they are so small.

Solution

$$\lambda = \frac{h}{mv}$$

$$\lambda = \frac{6.63 \times 10^{-34}\, J \cdot s}{50 kg \cdot 16 m/s}$$

$$\lambda = 8.3 \times 10^{-37}\, m$$

This means what?

- This wavelength (8.3×10^{-37} m) is about a billion, trillion times smaller than a hydrogen atom!
- This wavelength is so small that it is completely unobservable.

Examples

- Calculate the wavelength of an electron moving at 1.0×10^6 m/s.

Solution

$$\lambda = \frac{h}{mv}$$

$$\lambda = \frac{6.63 \times 10^{-34}\ J \cdot s}{9.11 \times 10^{-31}\ kg \cdot 1.0 \times 10^{6}\ m/s}$$

$$\lambda = 7.3 \times 10^{-10}\ m$$

What does this mean?

- This wavelength (7.3 x 10-10 m) is in about the same wavelength of x-rays.
- This is observable.

Eg) Determine the De Broglie wavelength for an alpha particle traveling at 0.015c.

$$p = \frac{h}{\lambda} \quad p = mv \quad mv = \frac{h}{\lambda} \qquad \therefore \lambda = \frac{h}{mv}$$

$$\lambda = \frac{6.63 \times 10^{-34}\, Js}{6.65 \times 10^{-27}\, kg (0.015)(3.00 \times 10^{8}\, m/s)}$$

$$\lambda = 2.2 \times 10^{-14}\, m$$