# de Broglie

- de Broglie suggested that if light (and all types of EMR) could have particle properties, then, particles such as electrons and protons could have wave properties (again, supports the wave-particle duality)!
- He suggested that the wavelength of the objects is related to their momentum

momentum of object

$p = mv$

momentum of wave

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

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

$\therefore \lambda = \frac{h}{mv}$ * not on data sheet!*

known as de Broglie wavelength

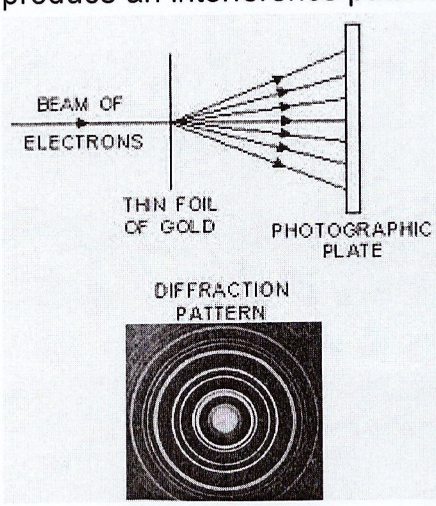
unit analysis

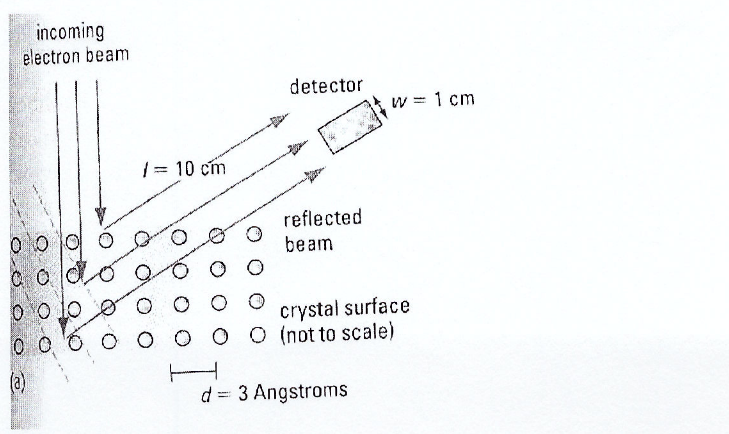
$\frac{J \cdot s}{kg \cdot m/s} \times \left( \frac{kg \cdot (m/s)^2}{J} \right)$

$= s(m/s) = m$ ✓

where p is momentum (kg.m/s or N·s)
m is mass of object (kg)
v is velocity of object (m/s)
λ is wavelength (m)
h is Planck's constant

- * The *wavelength of a particle* is often referred to as the *de Broglie wavelength*
- But how could you demonstrate that particles have wave properties and give support to de Broglie's idea?
  - * G.P. Thomson demonstrated that electrons could be diffracted (similar to Young's Double Slit Experiment) through a crystal or thin metal foil and produce an interference pattern (a property of waves)




interference pattern with constructive interference (ie. bright rings)

EXAMPLES:

1. An electron has a mass of $9.11 \times 10^{-31}$ kg. Calculate the de Broglie wavelength for an electron travelling at a speed of $2.15 \times 10^{6}$ m/s.

$m = 9.11 \times 10^{-31}$ kg

$\lambda_{e^-} = ?$

$v = 2.15 \times 10^{6}$ m/s

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

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

$$\lambda = \frac{6.63 \times 10^{-34}\ J \cdot s}{(9.11 \times 10^{-31}\ kg)(2.15 \times 10^{6}\ m/s)}$$

$\lambda = 3.38498 \ldots \times 10^{-10}$ m

$\boxed{\lambda = 3.38 \times 10^{-10}\ m}$

2. Calculate the wavelength of an electron that has kinetic energy of $3.10 \times 10^{-16}$ J.

de Broglie wavelength!

$E_k = 3.10 \times 10^{-16}$ J

$\lambda_{e^-} = ?$

* cannot use $E = \frac{hc}{\lambda}$ b/c an electron is not a photon!

$mv = \frac{h}{\lambda}$ ②

$E_k = \frac{1}{2}mv^2$ ①

① $E_k = \frac{1}{2}mv^2 \Rightarrow v = \sqrt{\frac{2E_k}{m}} = \sqrt{\frac{2(3.10 \times 10^{-16}\ J)}{9.11 \times 10^{-31}\ kg}} = 2.6087 \ldots \times 10^{7}$ m/s

② $mv = \frac{h}{\lambda} \Rightarrow \lambda = \frac{h}{mv} = \frac{6.63 \times 10^{-34}\ J \cdot s}{(9.11 \times 10^{-31}\ kg)(2.6087 \ldots \times 10^{7}\ m/s)}$

$\lambda = 2.7897 \ldots \times 10^{-11}$ m

$\boxed{\lambda = 2.79 \times 10^{-11}\ m}$

*****Now try pg. 296 #1, 2 (acceptable), 4-7(intermediate)*****