# MSE228 Engineering Quantum Mechanics

## Quiz 2 Duration: 30 minutes Open Book Quiz

1. A particle of charge q and mass m is accelerated from rest through a small potential difference V. (a) Find its de Broglie wavelength, assuming that the particle is nonrelativistic. (b) Calculate λ if the particle is an electron and V=50 V.

charge q
mass m
from rest
V

(a) $KE = PE$

$\frac{1}{2}mv^2 = qV$

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

$\rightarrow \frac{m^2v^2}{2m} = qV$

$\frac{p^2}{2m} = qV$

$\rightarrow \lambda = \frac{h}{\sqrt{2mqV}}$ //

b) particle: $e^-$ & $V = 50V$

$$\lambda = \frac{6.63\times10^{-34} J\cdot s}{\sqrt{2(9.1\times10^{-31}kg)(1.6\times10^{-19}C)(50V)}}$$

$= 1.7\times10^{-10} m = 17\ nm$

2. Compute the de Broglie wavelength of the following: (a) A 1000-kg automobile traveling at 100 m/s. (b) A 10-g bullet traveling at 500 m/s. (c) A smoke particle of mass 10−9 g moving at 1 cm/s. (d) An electron with a kinetic energy of 1 eV. (e) An electron with a kinetic energy of 100 MeV.

de Broglie wavelength, $\lambda = h/p = h/mv$

i) $m = 1000\ kg$, $v = 100\ m/s \rightsquigarrow \lambda = 6.63\times10^{-34} J\cdot s/(1000\ kg)(100\ m/s) = 6.63\times10^{-39} m$

ii) $m = 10\times10^{-3} kg$, $v = 500\ m/s \rightsquigarrow \lambda = 1.33\times10^{-34} m$

iii) $m = 10\times10^{-12} kg$, $v = 1\times10^{-2} m/s \rightsquigarrow \lambda = 6.63\times10^{-20} m$

iv) $m = 9.1\times10^{-31} kg$, $v = \sqrt{\frac{2*KE}{m}} \Rightarrow \lambda = \frac{h}{mv} = \frac{6.63\times10^{-34} J\cdot s}{9.1\times10^{-31} kg\sqrt{\frac{2\ 9.1\times10^{-31} * 1eV \times 1.6\times10^{-19} J/eV}{9.1\times10^{-31} kg}}}$

$KE = 1\ eV << 0.511\ MeV$

$= \frac{6.63\times10^{-34} J\cdot s}{5.4\times10^{-25} kg\ m/s} = 1.2\ nm$

v) $m = 9.1\times10^{-31} kg$

$KE = 100\ MeV >> 0.511\ MeV$

relativistic consideration

$E = KE + E_0 = KE \quad (KE >> m_e c^2)$

$E = pc = KE$

$\rightsquigarrow \lambda = \frac{hc}{pc} = \frac{hc}{KE} = \frac{(6.63\times10^{-34} J\cdot s)(3\times10^8 m/s)}{100\times10^6 eV\ (1.6\times10^{-19} J/eV)} = 12.4\ fm$