1. Find the de brogile wavelength of
1. An electron accelerated through a P.D of 182 volts.
2. 1 Kg object moving with a speed of 1 m/s.

— Given

$V = 182V$ $h = 6.63 \times 10^{-34} J.s$ $m = 1 Kg$ $v = 1 m/s$.

1. Formula

$$\lambda = \frac{12.27 A^{\circ}}{\sqrt{V}}$$

$$= \frac{12.27}{\sqrt{182}}$$

$$\lambda = \cancel{6.63 \times}\ 0.91 A^{\circ}$$

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

$$= \frac{6.63 \times 10^{-34}}{1 \times 1}$$

$$\lambda = 6.63 \times 10^{-34} A^{\circ}$$

2. If electron has existed inside nucleus, then de brogi wavelength would be roughly of order of nuclear d, lo How much momentum corresponds to this wavelength. Express much energy corresponds to this wavelength. Expres energy in MeV and explain how this result prov

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that the electron cannot resist inside the nucleus. The maximum binding energy is 8.8 MeV per nuclear particle

— Given

$h = 6.63 \times 10^{-34}$ Js $\lambda = 10^{-14}$ m

Formula

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

Solution

$$p = \frac{\lambda}{p} = \frac{6.63 \times 10^{-34}}{10^{-14}}$$

$$p = 6.63 \times 10^{-20} \text{ kg m/s}$$

The corresponding energy is,

$$E = \frac{p^2}{2m} = \frac{(6.63 \times 10^{-20})^2}{2 \times 9.1 \times 10^{-31}}$$

$$E = 2.415 \times 10^{-9} \text{ J}$$

As $1 \text{MeV} = 1.6 \times 10^{-13}$ J

$$E = \frac{2.415 \times 10^{-9}}{1.6 \times 10^{-13}} \text{ MeV}$$

$$E = 15093.75 \text{ MeV}$$

This energy of the electron is much larger than the 8.8 MeV energy required to keep the electron inside the nucleus. Hence, the electron cannot exist inside the nucleus.

3. An electron initially at rest is accelerated through a P.D of 3000V. Calculate for the electron wave.

1. Momentum
2. the de brogile wavelength.

— Given

$V = 3000V$

1. momentum 2. de brogile wavelength

1. Formula

$$\lambda = \frac{12.27}{\sqrt{V}} A^o$$

$$= \frac{12.27}{\sqrt{3000}}$$

$$\lambda = 0.224 A^o$$

2. $$\lambda = \frac{h}{P}$$

$$P = \frac{h}{\lambda} = \frac{6.63 \times 10^{-34}}{0.224 \times 10^{-10}}$$

$$P = 2.96 \times 10^{-23} \text{ kg-m/s}$$

4. A proton and α particle accelerated by same potential difference. ST the ratio of de brogile wavelength associated with them $2\sqrt{2}$. The mass of α-particle to be 4 times the mass of proton.

Given

The charge of proton is (e) and that of an α-particle is 2e.

$m_\alpha = 4m_p$

Formula = $\lambda = \dfrac{h}{\sqrt{2meV}}$

Solution

For proton : $\lambda_p = \dfrac{h}{\sqrt{2m_p eV}}$ - - - - - - 1

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for α-particle: $\lambda\alpha = \frac{h}{\sqrt{2(4mp)(2e)V}}$ — — 2

from 1 and 2

$$\frac{\lambda p}{\lambda \alpha} = \frac{h}{\sqrt{2mpeV}} \times \frac{\sqrt{2(4mp)(2e)V}}{h}$$

$$\frac{\lambda p}{\lambda \alpha} = 2\sqrt{2}$$

Q5. Calculate the velocity and de brogile wavelength of an α-particle of energy 1keV.

Mass of α-particle = 6.68×10^{-27} kg.

Given

$h = 6.63 \times 10^{-34}$ J-s

$m = 6.68 \times 10^{-27}$ kg

$E = 1keV = 1.6 \times 10^{-16}$ J

formula

$$\lambda = \frac{h}{\sqrt{2mE}} \qquad \lambda = \frac{h}{mv}$$

Solution

$$\lambda = \frac{6.63 \times 10^{-34}}{\sqrt{2 \times 6.68 \times 10^{-27} \times 1.6 \times 10^{-16}}}$$

$$\lambda = 4.535 \times 10^{-13} \text{ m}$$

$$\lambda = 4.535 \times 10^{-3} \text{ A°}$$

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

$$\lambda = \frac{6.63 \times 10^{-34}}{6.68 \times 10^{-27} \times \cancel{4.535 \times 10^{-13}} V}$$

$$V = \frac{h}{m\lambda} = \frac{6.63 \times 10^{-34}}{6.68 \times 10^{-27} \times 4.535 \times 10^{-13}}$$

$$V = 2.19 \times 10^5 \text{ m/s}$$

Which has shorter wavelength 1eV proton, 1eV electron. Caluate the value and explain.

Given

$h = 6.63 \times 10^{-34}$ Js

$c = 3 \times 10^{8}$ m/s

$E = 1eV = 1.6 \times 10^{-19}$ J

Formula

The energy of photon is given by $E = h\nu = \frac{hc}{\lambda}$

For an electron with energy (E) $\lambda e = \frac{h}{\sqrt{2mE}}$

$$\lambda ph = \frac{hc}{E}$$

$$= \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{1.6 \times 10^{-19}}$$

$$= 1.2431 \times 10^{6} m$$

$$\lambda ph = 12431 A^{o}$$

$$\lambda e = \frac{h}{\sqrt{2mE}} = \frac{6.63 \times 10^{-34}}{\sqrt{2 \times 9.1 \times 10^{-31} \times 1.6 \times 10^{-19}}}$$

$$= 1.229 \times 10^{-9} m$$

$$\lambda e = 12.29 A^{o}$$

The wavelength of electron is shorter than the photon. This is bcz of the larger momentum of electron (mV ~~or~~, $\sqrt{2mE}$) compared to photon $\left(\frac{h\nu}{c}, \frac{E}{c}\right)$

An electron has KE equal to ~~+~~ rest mass energy. Calculate de brogile wavelength associated with it.

— Given

$E = m_0 c^2$, $m_0 = 9.1 \times 10^{-31}$ kg $c = 3 \times 10^8$ m/s

Formula

$$\lambda = \frac{h}{\sqrt{2mE}}$$

$$E = 9.1 \times 10^{-31} \times (3 \times 10^8)^2$$

$$E = 8.19 \times 10^{-14} J$$

$$\lambda = \frac{6.63 \times 10^{-34}}{\sqrt{2 \times 9.1 \times 10^{-31} \times 8.19 \times 10^{-19}}}$$

$$= 1.717 \times 10^{-12} m$$

$$\lambda = 1.717 \times 10^{-2} A^{o}.$$

88. In a TV set, electrons are accelerated by a potential difference of 10kV. What is wavelength associated with electrons

— Given

$m = 1.67 \times 10^{-27}$ kg $E = 1 MeV = 1.6 \times 10^{-13}$ J

$$\lambda = \frac{h}{\sqrt{2mE}}$$

$$\lambda = \frac{6.63 \times 10^{-34}}{\sqrt{2 \times 1.67 \times 10^{-27} \times 1.6 \times 10^{-13}}}$$

$$\lambda = 2.87 \times 10^{-14} m$$

9. Find de broglie wavelength associated with monoenergetic electron beam having momentum 10^{-23} kg m/s.

— Given

$h = 6.63 \times 10^{-34}$ J-s $p = 10^{-23}$ kg-m/s

Formula.

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

Calculate de brogile wavelength associated with 1M[illegible] proton ($m_p = 1.67 \times 10^{-27}$ kg)

Given

$h = 6.63 \times 10^{-34}$ Js $\quad m = 1.67 \times 10^{-27}$ kg

$E = 1MeV = 1.6 \times 10^{-13}$ J

Formula

$$\lambda = \frac{h}{\sqrt{2mE}}$$

$$\lambda = \frac{6.63 \times 10^{-34}}{\sqrt{2 \times 1.67 \times 10^{-27} \times 1.6 \times 10^{-13}}}$$

$$\lambda = 2.87 \times 10^{-14} m$$

Calculate de brogile wavelength of electron having K.E 1keV.

Given

$h = 6.63 \times 10^{-34}$ Js $\quad m = 9.1 \times 10^{-31}$ kg $\quad E = 1keV = 1.6 \times 10^{-18}$ J

Formula

$$\lambda = \frac{h}{\sqrt{2mE}}$$

$$= \frac{6.63 \times 10^{-34}}{\sqrt{2 \times 9.1 \times 10^{-31} \times 1.6 \times 10^{-16}}}$$

$$= 3.89 \times 10^{-11} m$$

$$\lambda = 0.39 A^\circ$$

Calculate de brogile λ for proton moving with velocity 1 percent of velocity of light.

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

$h = 6.63 \times 10^{-34}$ Js

$m = 9.1 \times 10^{-31}$ kg

$$\lambda = \frac{6.63 \times 10^{-34}}{10^{-23}}$$

$\lambda = 6.63 \times 10^{-11}$ m

$\lambda = 0.663$ A°.

Calculate de brogile wavelength of 10keV protons in A°.

Given

$h = 6.63 \times 10^{-34}$ J-s $\quad m = 1.67 \times 10^{-27}$ kg

$E = 10$ KeV $= 10 \times 1.6 \times 10^{-16}$ J $= 1.6 \times 10^{-15}$ J

Formula

$$\lambda = \frac{h}{\sqrt{2mE}}$$

$$= \frac{6.63 \times 10^{-34}}{\sqrt{2 \times 1.67 \times 10^{-27} \times 1.6 \times 10^{-15}}}$$

$= 2.868 \times 10^{-13}$ m

$\lambda = 2.868 \times 10^{-3}$ A°

At what KE on electron will have λ of 5000A°.

Given

$\lambda = 5000$A° $= 5000 \times 10^{-10}$ m

Formula

$$\lambda = \frac{h}{\sqrt{2mE}}$$

$$E = \frac{h^2}{2m\lambda^2} = \frac{(6.63 \times 10^{-34})^2}{2 \times (9.1 \times 10^{-31})(5000 \times 10^{-10})^2}$$

$= 9.66 \times 10^{25}$ J

$$= \frac{9.66 \times 10^{-25}}{1.6 \times 10^{-19}} \text{ eV}$$

$E = 6.038 \times 10^{-6}$ eV

$$V = \frac{1}{100} \times 3\times10^{8} = 3\times10^{6}\ m/s$$

$$\lambda = \frac{6.63\times10^{-34}}{\sqrt{1.673\times10^{-27}\times3\times10^{6}}}$$

$$\lambda = 1.32\times10^{-13}\ m$$

An electron beam is accelerated from rest through potential of 200V. calculate the associated λ.

For electrons accelerated through potential difference of V (volts)

$$\lambda = \frac{12.27}{\sqrt{V}}\ A^\circ$$

$$V = 200V$$

$$\lambda = \frac{12.27}{\sqrt{200}}$$

$$\lambda = 0.868\ A^\circ$$

Calculate the energy (eV) with which a proton has to acquire de brogile λ of $0.1 A^\circ$.

By de brogiles,

$$\lambda = \frac{h}{\sqrt{2mE}}$$

$$E = \frac{h^2}{2m\lambda^2}$$

$h = 6.63\times10^{-34}$ J-s $\qquad m = 1.673\times10^{-27}$ kg

$\lambda = 0.1 A^\circ = 0.1\times10^{-10}$ m

$$E = \frac{(6.63\times10^{-34})^2}{2\times1.673\times10^{-27}\times(0.1\times10^{-10})^2}$$

$$E = 1.314\times10^{-18}$$

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$$= \frac{1.314 \times 10^{-18}}{1.6 \times 10^{-19}} \ eV$$

$$E = 8.2 \ eV$$

16. — In an electron microscope when an electron is accelerated through potential of V, the de brogile wavelength $\lambda = \frac{12.3}{\sqrt{V}} A^{\circ}$

Given = $\lambda = 0.3 A^{\circ}$

$$0.3 = \frac{12.3}{\sqrt{V}}$$

$$\sqrt{V} = \frac{12.3}{0.3} = 41$$

$$V = 1681 V$$

17. An electron has speed of 600m/s with an accuracy of 0.005. calculate the uncertainity with which we can locate the position of electron.

— Given

$$\Delta V = \frac{0.005}{100} \times 600 = 0.03 m/s$$

$h = 6.63 \times 10^{-34} J\text{-}s$ $m = 9.1 \times 10^{-31} kg$

Formula

$$\Delta x \Delta p = h$$

$$\Delta x = \frac{h}{\Delta p} = \frac{h}{m \Delta V}$$

$$\Delta x = \frac{6.63 \times 10^{-34}}{9.1 \times 10^{-31} \times 0.03}$$

$$\Delta x = 0.0243 m$$

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18. A bullet of mass 25gm is moving with a speed of 400m/s. The speed measured accurate upto 0.02 Calculate the certainty with which position of the bullet can be located.

— Given

$h = 6.63 \times 10^{-34}$ J·S $m = 9.1 \times 10^{-31}$ Kg

$\Delta V = \frac{0.02}{100} \times 400 = 0.08$ m/s

formula

$$\Delta x \Delta p = h$$

$$\Delta x = \frac{h}{\Delta p} = \frac{h}{m \Delta V}$$

$$\Delta x = \frac{6.63 \times 10^{-34}}{25 \times 10^{-3} \times 0.08}$$

$$\Delta x = 3.315 \times 10^{-31} \, m$$

19. If the uncertainty in location of particle is equal to de brogile λ, the uncertainity in velocity is equal to its velocity.

— Given = $\Delta x = \lambda$

Formula = $\Delta x \Delta p = h$

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

$$\Delta P = m \Delta V$$

$$\frac{h}{mv} \cdot m \Delta V = h$$

$$\Delta V = V$$

20. An electron is confined to box of length 2A°. Ca[lculate] the minimum uncertainty in velocity.

— Given

$h = 6.63 \times 10^{-34}$ J-S $m = 9.1 \times 10^{-34}$ kg

$(\Delta x)_{max} = 2A^{\circ} = 2 \times 10^{-10}$ m

Formula

$$\Delta x \Delta p = h$$

$$p = m\Delta V$$

$$\Delta x \cdot m\Delta V = h$$

$$\Delta V = \frac{h}{m\Delta x}$$

for minimum uncertainty in velocity, the uncertainty in position is maximum

$$(\Delta V)_{min} = \frac{h}{m(\Delta x)_{max}}$$

$$= \frac{6.63 \times 10^{-34}}{9.1 \times 10^{-31} \times 2 \times 10^{-10}}$$

$$(\Delta v)_{min} = 3.643 \times 10^{6} \text{ m/s}$$

21. An electron is bound by a potential with closely approaches on infinite well of width $1A^{\circ}$. calculate the lowest three permissible energies (in eV) that electrons can have.

— Given

$h = 6.63 \times 10^{-34}$ J-s $m = 9.1 \times 10^{-31}$ kg $l = 1A^{\circ} = 10^{-10}$ m

formula

$$E_n = \frac{n^2 h^2}{8mL^2}$$

$$E_n = \frac{n^2 \times (6.63 \times 10^{-34})^2}{8 \times 9.1 \times 10^{-31} \times (10^{-10})^2} \text{ J}$$

$$= n^2 \times 6.038 \times 10^{-18} \text{ J}$$

$$= \frac{n^2 \times 6.038 \times 10^{-18}}{1.6 \times 10^{-19}} \text{ eV}$$

$$E_n = 37.74 \times n^2 \, eV$$

The lowest three permissible energies are

$$E_1 = 37.74 \, eV$$

$$E_2 = 37.74 \times 2^2 = 150.96 \, eV$$

$$E_3 = 37.74 \times 3^2 = 339.66 \, eV$$

22. An electron is trapped in rigid box of width 2A°. Find lowest energy level and momentum. Hence find energy of third energy level.

— Given

For lowest energy, $n = 1$

$h = 6.63 \times 10^{-34}$ J.s

$m = 9.1 \times 10^{-31}$ kg

$L = 2 A^\circ = 2 \times 10^{-10}$ m

Formula

$$E_n = \frac{n^2 h^2}{8 m L^2} \qquad p = \sqrt{2mE}$$

$$E_1 = \frac{(6.63 \times 10^{-34})^2}{8 \times 9.1 \times 10^{-31} \times (2 \times 10^{-10})^2} \, J$$

$$= 1.5095 \times 10^{-18} \, J$$

$$= \frac{1.5095 \times 10^{-18}}{1.6 \times 10^{-19}} \, eV$$

$$E_1 = 9.434 \, eV$$

$$P_1 = \sqrt{2mE_1}$$

$$= \sqrt{2 \times 9.1 \times 10^{-31} \times 1.5095 \times 10^{-18}}$$

$$P_1 = 1.66 \times 10^{-24} \, kg\, m/s$$

The third energy is,

$E_n = 37.74 \times n^2$ eV

The lowest three permissible energies are

$E_1 = 37.74$ eV

$E_2 = 37.74 \times 2^2 = 150.96$ eV

$E_3 = 37.74 \times 3^2 = 339.66$ eV

An electron is tropped in rigid box of width 2A°. Find lowest energy level and momentum. Hence find energy of third energy level.

Given

For lowest energy, $n = 1$

$h = 6.63 \times 10^{-34}$ J.s

$m = 9.1 \times 10^{-31}$ kg

$L = 2 A^o = 2 \times 10^{-10}$ m

Formula

$$E_n = \frac{n^2 h^2}{8 m L^2} \qquad p = \sqrt{2mE}$$

$$E_1 = \frac{(6.63 \times 10^{-34})^2}{8 \times 9.1 \times 10^{-31} \times (2 \times 10^{-10})^2} \text{ J}$$

$= 1.5095 \times 10^{-18}$ J

$= \frac{1.5095 \times 10^{-18}}{1.6 \times 10^{-19}}$ eV

$E_1 = 9.434$ eV

$P_1 = \sqrt{2mE_1}$

$= \sqrt{2 \times 9.1 \times 10^{-31} \times 1.5095 \times 10^{-18}}$

$P_1 = 1.66 \times 10^{-24}$ Kg m/s

The third energy is,

$$E_3 = E_1 \times 3^2$$
$$= 9.434 \times 3^2$$
$$E_3 = 84.906 \text{ eV}$$

23. An electron is confined in potential well of width 5 A°. Calculate the energy and λ of emitted photon if the electron makes a transition from n=2 to n=1.

Given

$h = 6.63 \times 10^{-34}$ J-S $m = 9.1 \times 10^{-31}$ kg

$L = 5A^0 = 5 \times 10^{-10}$ m

Formula

$$E = \frac{n^2 h^2}{8mL}$$

For n=1, $E_1 = \frac{h^2}{8mL^2}$

For n=2, $E_2 = \frac{4h^2}{8mL^2}$

The energy of emitted photon is, $E_2 - E_1$

$$E_2 - E_1 = \frac{3h^2}{8mL^2}$$

$$E_2 - E_1 = \frac{3 \times (6.63 \times 10^{-34})^2}{8 \times 9.1 \times 10^{-31} \times (5 \times 10^{-10})^2}$$
$$= 7.246 \times 10^{-19} \text{ J}$$
$$= \frac{7.246 \times 10^{-19}}{1.6 \times 10^{-19}} \text{ eV}$$
$$E_2 - E_1 = 4.53 \text{ eV}$$

The energy of photon in terms of wavelength is $\frac{hc}{\lambda}$

$$\frac{hc}{\lambda} = 7.246 \times 10^{-19} \text{ J}$$

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$$\lambda = \frac{6.63\times10^{-34}\times3\times10^{8}}{7.246\times10^{-19}}$$

$$\lambda = 2.745\times10^{-7}\,m$$

Compare energy difference btw ground state and first excited state for an electron in a 1-D rigid box of length of 10^{-8} cm.

Given

$h=6.63\times10^{-34}\,J.s$ $m=9.1\times10^{-31}\,kg$ $l=10^{-8}\,cm=10^{-10}\,m$

Formula

$$E_1 = \frac{h^2}{8mL^2}$$

and in first excited state, $E_2 = \frac{4h^2}{8mL^2}$

The difference in energy is,

$$E_2-E_1 = \frac{3h^2}{8mL^2}$$

$$= \frac{3\times(6.63\times10^{-34})^2}{8\times(9.1\times10^{-31})(10^{-10})^2}$$

$$=1.8116\times10^{-17}\,J$$

$$=\frac{1.8116\times10^{-17}}{1.6\times10^{-19}}\,eV$$

$$E_2-E_1 = 113.21\,eV$$

The lowest energy of electron trapped in rigid box 4.19 eV. Find width of box in AU.

$E_1 = 4.19\,eV = 4.19\times1.6\times10^{-19}\,J$

$h=6.63\times10^{-34}\,Js$ $m=9.1\times10^{-31}\,kg$

$$E_1 = \frac{h^2}{8mL^2}$$

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$$~~E_1 = \frac{(6.63 \times 10^{-34})^2}{2 \times 1.675 \times 10^{-27}}~~$$

$$4.19 \times 1.6 \times 10^{-19} = \frac{(6.63 \times 10^{-34})^2}{8 \times 9.1 \times 10^{-31} \times L^2}$$

$$L = 3 \times 10^{-10} m$$

26. A neutron trapped in ~~rigid box~~ potential well of 10^{-14}m. Calculate its first energy eigen value in eV.

— Given

$h = 6.63 \times 10^{-34}$ J-S $m = 1.675 \times 10^{-27}$ kg $L = 10^{-14}$ m

Formula = $E_1 = \frac{h^2}{8mL^2}$

$$E_1 = \frac{(6.63 \times 10^{-34})^2}{8 \times 1.675 \times 10^{-27} \times (10^{-14})^2}$$

$$= 3.28 \times 10^{-13} J$$

$$= \frac{3.28 \times 10^{-13}}{1.6 \times 10^{-19}} eV$$

$$E_1 = 2.05 \times 10^{6} eV$$

27. Calculate the energy required to excite the electron from its ground state to fourth excited state in rigid box of length 0.1nm.

— $h = 6.63 \times 10^{-34}$ m $m = 9.1 \times 10^{-31}$ kg $L = 0.1nm = 0.1 \times 10^{-9}$m

Formula

$$E_n = \frac{n^2 h^2}{8mL^2}$$

For ground state, $E_1 = \frac{h^2}{8mL^2}$

For fourth excited state, $E_5 = \frac{5^2 h^2}{8mL^2} = \frac{25h^2}{8mL^2}$

Energy required to excite the electron is,

$$E_5 - E_1 = \frac{25h^2}{8mL^2} - \frac{h^2}{8mL^2} = \frac{3h^2}{8mL^2}$$

$$= \frac{3 \times (6.63 \times 10^{-34})^2}{8 \times 9.1 \times 10^{-31} \times (0.1 \times 10^{-9})^2}$$

$$= 1.81 \times 10^{-17} \text{ J}$$

$$= \frac{1.81 \times 10^{-17}}{1.6 \times 10^{-19}} \text{ eV}$$

$$E_5 - E_1 = 113.125 \text{ eV}.$$

28. A neutron is trapped in inifinite potential well of width 1A. Calculate the values of energy and momentum in its ground state.

Given

$h = 6.63 \times 10^{-34}$ J-S $\quad m = 1.675 \times 10^{-27}$ kg $\quad L = 1A^\circ = 1 \times 10^{-10}$ m

$$E = \frac{h^2}{8mL^2} \qquad p = \sqrt{2mE}$$

$$E = \frac{(6.63 \times 10^{-34})^2}{8 \times 1.675 \times 10^{-27} \times (10^{-10})^2}$$

$$E = 3.28 \times 10^{-21} \text{ J}$$

$$p = \sqrt{2mE}$$

$$= \sqrt{2 \times 1.675 \times 10^{-27} \times 3.28 \times 10^{-21}}$$

$$p = 3.315 \times 10^{-24} \text{ kg m/s}$$