unit I (Exercise ... springer (

Q.1 A ~~tyre~~ bicycle wheel of mass 2kg and radius 0.32m is spinning freely on its axle at 2 rev/sec. When you place your hand against the tyre the wheel decelerates ~~ates~~ ~~and~~ uniformly and comes to stop in 8 sec. What was the torque of your hand against the wheel?

solution here.

mass of wheel $(m) = 2kg$

radius of wheel $(r) = 0.32m$

The moment of inertia of wheel $I = mr^2$

$= 2 \times (0.32)^2$

$= 2 \times 0.1024$

$= 0.2048 \ Kgm^2$

Now,

initial angular velocity $\omega_0 = 2\pi \times 2$ rad/sec

$= 4\pi$ rad/sec

final angular velocity $\omega = 0$

time $(t) = 8sec$

Now acceleration of wheel $(\alpha) = \dfrac{\omega - \omega_0}{t}$

$= -\dfrac{4\pi}{8}$

$= -1.57 \ rad/sec^2$

Now Torque $\tau = I\alpha$

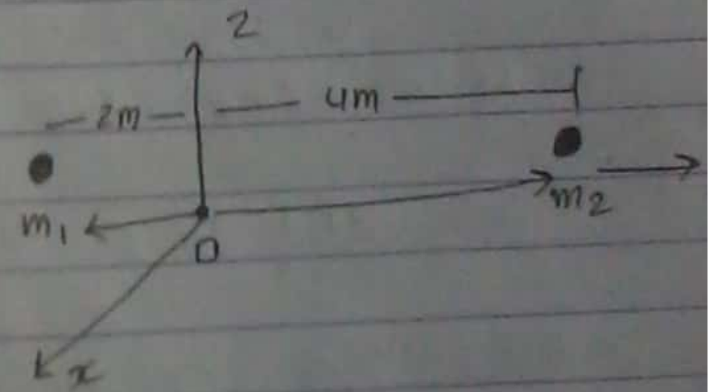
$= 0.2048 \times 1.57$

$= 0.821536 \ Nm$

Q.2 Two masses $m_1 = 1kg$ and $m_2 = 5kg$, are connected by a rigid rod of negligible weight. The system is pivoted about point O. The gravitational forces acts in the negative z-direction.

(a) Express the position vectors and forces on the masses in terms of unit vectors and calculate the torque on the system.

(b) What is the angular acceleration of the system at the instant shown in fig



solution here

given masses are $m_1 = 1kg$

$m_2 = 5kg$

position vector.

8.13. A children's merry go round of radius 4m and mass 100kg has an 80kg man standing at the rim. The merry-go-round coasts on a frictionless bearing at 0.2 rev/sec. The man walks inward 2 m towards the center. what is the new rotational speed of the merry go round? what is the source of this energy? (The M.I of solid disk is $I = \frac{1}{2}mr^2$)

solution, here.

The moment of inertia of solid disc about an axis $I_0 = \frac{1}{2} mr^2$

$$= \frac{1}{2} \times 100 \times (4)^2$$
$$= 800$$

The moment of inertia of the man at 4m from the axis on a rim $I_1 = mr^2$

$$= 80 \times 16$$
$$= 1280$$

The speed of merry go round $n_1 = 0.2$ rev/sec

Now from the principle of conservation of Angular momentum

$$I_0\omega_0 = I\omega_1$$
$$I_0\omega_0 = (I_0 + I_1)\omega_1$$
$$800 \times 2\pi \times n_0 = (800+1280) \times 2\pi \times n_1$$

$$n_0 = \frac{(800+1280) \times 0.2}{800}$$

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$\therefore n_0 = 0.52$

This is the angular frequency of the freely rotating disc.

Now in the second case if man moves towards the center 2m from its axis then new angular frequency can be calculated again by using the principle of conservation of angular momentum ie.

$$I_0 \omega_0 = (I_0 + I_2)\omega_2$$

Here $I_0 = 800 \text{ kgm}^2$

and $I_2 = 80 \times (2)^2$

$= 80 \times 4 = 320 \text{ kgm}^2$

$\therefore$

$$800 \times 2\pi \times n_0 = (800 + 320) \times 2\pi \times n_2$$

$$800 \times 0.52 = 1120 \times n_2$$

$$\therefore n_2 = \frac{416}{1120}$$

$$= 0.37 \text{ rev/sec}$$

which is the required new angular frequency of rotation.

10.5. An oscillating block of mass 250g takes 0.15sec to move between the endpoints of motion, which are 40cm apart. (a) what is the frequency of the motion? (b) what is the amplitude of the motion? (c) what is the force constant of the spring?

solution here.

The time period of oscillation $T = 0.15 sec$

we know that frequency of oscillation

$$= \frac{1}{T} = \frac{1}{0.15}$$

$$= 6.67 \, Hz$$

Now, Angular velocity $\omega = 2\pi f$

$$= 2 \times 3.14 \times 6.67 \, rad/s$$

$$= 41.89 \, rad/s$$

we know the relation

$$\omega = \sqrt{\frac{k}{m}}$$

$$\therefore \omega^2 m = k$$

$$k = (41.89)^2 \times (250) \times 10^{-3}$$

again maximum displacement

$$x = A\omega$$

$$\left[\therefore A = \frac{x}{\omega}\right]$$ where A is amplitude.

10.13 A block is oscillating with an amplitude of 20cm. The spring constant is 150 N/m. (a) what is the energy of the system? (b) when the displacement is 5cm, what is the kinetic energy of the block and the potential energy of the spring?

solution here

The amplitude of oscillation $A = 20cm$

The spring constant $k = 150\ N/m$

we know the relation

$$\omega = \sqrt{\frac{k}{m}}$$

$$\therefore k = m\omega^2$$

(a) The energy of the system is given by

$$E = \frac{1}{2} m\omega^2 A^2$$

$$= \frac{1}{2} k A^2$$

$$= \frac{1}{2} \times 150 \times (0.2)^2$$

$$= 3\ J$$

(b) when the displacement $x = 5cm$ then kinetic energy of block

$$K.E = \frac{1}{2} mv^2$$

where $v = \omega\sqrt{A^2 - x^2}$

$\therefore$ $K{:}E = \frac{1}{2} m\omega^2 (A^2 - x^2)$

$= \frac{1}{2} K (A^2 - x^2)$

$= \frac{1}{2} \times 150 \times (0.04 - 2.5 \times 10^{-3})$

$= 2.8125 \text{ J}$

and potential energy is

$P{:}E = \frac{1}{2} K x^2$

$= \frac{1}{2} \times 150 \times 2.5 \times 10^{-3}$

$= 0.1875 \text{ J}.$

10.18 A spring ($K = 200$ N/m) is compressed 10cm between two blocks of mass $m_1 = 1.5$ kg and $m_2 = 4.5$ kg. The spring is not connected to the blocks and table is frictionless. What are the velocities of the blocks after they released and loose contact with the spring? Assume that the spring falls straight down to table.

solution, here

The spring constant $K = 200$ N/m.

For mass $m_1 = 1.5$ kg.

$$\omega_1 = \sqrt{\frac{K}{m_1}} = \sqrt{\frac{200}{1.5}}$$

$$= 11.55$$

$\therefore$ velocity $(v) = \cancel{x}\omega_1$

$= 0.1 \times 11.55$

$= 1.155$

[similarly for mass m_2]

Unity Numerical (Exercise problems]
(springer)

QN 20.1

show by direct subsitution into the time dependent schrödinger equation for the free particle that $\psi(x,t) = A\cos(kx-\omega t)$ is not a solution.

solution

Here, we have

given $\psi(x,t) = A\cos(kx-\omega t)$ —— ①

we know that the time dependent schrödinger equation for the free particle is.

$$-\frac{\hbar^2}{2m}\frac{\partial^2\psi}{\partial x^2} = i\hbar\frac{\partial\psi}{\partial t} \quad \text{—— ②}$$

Now subsituiting equation ① in equation ② we get

Here L.H.S $= -\frac{\hbar^2}{2m}\frac{\partial^2\psi}{\partial x^2}$

$$= -\frac{\hbar^2}{2m}\frac{\partial}{\partial x}\left(\frac{\partial}{\partial x}(A\cos(kx-\omega t))\right]$$

$$= -\frac{\hbar^2}{2m}\frac{\partial}{\partial x}\left[-\sin(kx-\omega t)\times kA\right]$$

$$= \frac{\hbar^2}{2m}\cos(kx-\omega t)\times k^2A$$

$$= \frac{\hbar^2k^2}{2m}\psi(x,t)$$

Again,

$$R.H.S = i\hbar \frac{\partial \psi}{\partial t}$$

$$= i\hbar \frac{\partial}{\partial t}\left(A \cos(kx - \omega t)\right)$$

$$= i\hbar \left[-A \sin(kx - \omega t) \times (-\omega)\right]$$

$$= i\hbar\omega A \sin(kx - \omega t)$$

Now from equation (2)

$$\frac{\hbar^2 k^2}{2m} A\cos(kx - \omega t) = i\hbar\omega A \sin(kx - \omega t) \quad \text{--- (3)}$$

This is not the solution of time dependent schrödinger wave equation.

In equation (3) sine and cosine function are equal only for certain angles so this cannot be satisfied for all x and t.

20.2 Show by direct substitution that the wavefunction $\psi(x,t) = A\cos kx\, e^{-i\omega t}$ satisfies the time dependent schrödinger equation for the free particle

solution, here,

given wavefunction

$$\psi(x,t) = A\cos kx\, e^{-i\omega t} \quad \text{—— (1)}$$

we know that the time dependent schrödinger wave equation is given by

$$-\frac{\hbar^2}{2m}\frac{\partial^2\psi}{\partial x^2} = i\hbar\frac{\partial\psi}{\partial t} \quad \text{—— (2)}$$

from equation (2)

$$L.H.S = -\frac{\hbar^2}{2m}\frac{\partial^2\psi}{\partial x^2}$$

$$= -\frac{\hbar^2}{2m}\frac{\partial}{\partial x}\left(\frac{\partial}{\partial x}\left(A\cos kx\, e^{-i\omega t}\right)\right]$$

$$= -\frac{\hbar^2}{2m}\frac{\partial}{\partial x}\left[A e^{-i\omega t}(-\sin kx] \times k\right]$$

$$= \frac{\hbar^2}{2m} A e^{-i\omega t} \cos kx \times k^2$$

$$= \frac{\hbar^2 k^2}{2m} A e^{-i\omega t} \cos kx$$

Again R.H.S = $i\hbar \frac{\partial}{\partial t} (A\cos kx \, e^{-i\omega t})$

$= i\hbar \left[A\cos kx \, e^{-i\omega t} (-i\omega) \right]$

$= \hbar\omega A\cos kx \, e^{-i\omega t}.$

$\therefore$

equation (2) becomes

$$\frac{\hbar^2 k^2}{2m} A e^{-i\omega t} \cos kx = \hbar\omega A\cos kx \, e^{-i\omega t}$$

$$\therefore \frac{\hbar^2 k^2}{2m} = \hbar\omega \quad \text{— (3)}$$

This shows that equation (1) is the solution of equation (2) because in equation (3) both quantity in L.H.S and R.H.S are equal to each other. ie.

$$\frac{\hbar^2 k^2}{2m} = \hbar\omega = E$$

$$E = h\nu = h\frac{\omega}{2\pi} = \hbar\omega$$

Ily similarly $E = \frac{p^2}{2m}$ where $p = \frac{h}{\lambda} = \frac{h}{\frac{2\pi}{k}} = \hbar k$

$$\therefore E = \frac{\hbar^2 k^2}{2m}$$

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20.3 Explain why the following eigenfunctions are not acceptable solutions of the schrödinger equation.

(a) $\psi(x) = 0$ for $x \leq 0$

$\psi(x) = A\cos kx$ for $x \geq 0$.

In the above case the function and its derivative are not finite and single valued so it is not an acceptable solution.

(b) $\psi(x) = A\frac{e^{ikx}}{x}$

The given function is infinite at $x = 0$ so it is not acceptable solution.

(c) $\psi(x) = A\ln kx$

Here $\psi'(x) = A\frac{1}{kx}$ which is infinite at $x = 0$ so it is not an acceptable solution.

20.12 what is the probability of finding particle in a well of width 'a' at a position a/4 from the wall if n = 1, if n = 2, if n = 3. Use the normalized wavefunction

$$\psi(x,t) = \left(\frac{2}{a}\right)^{1/2} \sin\frac{n\pi x}{a}\, e^{-iEt/\hbar}$$

solution here

we have

given wavefunction is

$$\psi(x,t) = \left(\frac{2}{a}\right)^{1/2} \sin\frac{n\pi x}{a}\, e^{-iEt/\hbar}$$

For The probability of finding particle at a position $x = a/4$ from th wall if n = 1 is

$$= \psi\psi^*$$

$$= \left(\frac{2}{a}\right)^{1/2} \sin\left(\frac{n\pi x}{a}\right) e^{-iEt/\hbar} \times \left(\frac{2}{a}\right)^{1/2} \sin\left(\frac{n\pi x}{a}\right) \cdot e^{iEt/\hbar}$$

$$= \left(\frac{2}{a}\right) \sin^2\left(\frac{n\pi x}{a}\right) e^0$$

$$= \left(\frac{2}{a}\right) \sin^2\left[\frac{1\times\pi\times a}{4\times a}\right]$$

$$= \frac{2}{a}\times\left(\frac{1}{\sqrt{2}}\right)^2 = \frac{2}{a}\times\frac{1}{2} = \frac{1}{a}$$

Similarly the probability of finding particle at position $x = a/4$ if $n = 2$ is

$$= \psi\psi^*$$

$$= \left(\frac{2}{a}\right)\sin^2\left(\frac{n\pi x}{a}\right)$$

$$= \frac{2}{a}\sin^2\left[\frac{2\times\pi\times a}{4\times a}\right]$$

$$= \frac{2}{a}\sin^2\left(\frac{\pi}{2}\right) = \frac{2}{a}$$

Again the probability of finding particle at position $x = a/4$ if $n = 3$ is

$$= \psi\psi^*$$

$$= \left(\frac{2}{a}\right)\sin^2\left(\frac{n\pi x}{a}\right)$$

$$= \left(\frac{2}{a}\right)\sin^2\left(\frac{3\times\pi\times a}{4\times a}\right)$$

$$= \left(\frac{2}{a}\right)\sin^2\left(\frac{3\pi}{4}\right)$$

$$= \frac{2}{a}\times\frac{1}{2} = 1/a$$

Unit 3 (Exercise problem springer)

18.1 Calculate the shortest and the longest wavelength of the Balmer series of hydrogen.

solution here we know that

$$\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \quad \text{——} \quad (1)$$

For family of Balmer series $n_1 = 2$
and $n_2 = 3, 4, 5$

Therefore

$$\frac{1}{\lambda_{longest}} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$$

$$= 1.0968 \times 10^7 \times \left[\frac{1}{4} - \frac{1}{9}\right]$$

$$\lambda_{long} = 6564\ A^o$$

Ily

$$\frac{1}{\lambda_{shortest}} = R\left[\frac{1}{2^2} - \frac{1}{8}\right]$$

$$= 1.0968 \times 10^7 \times 1/4$$

$$= 3646\ A^o$$

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18.2 what are the energy, momentum and wavelength the photon that is emitted when a hydrogen atom undergoes a transition from the state n=3 to n=1

Solution, here

$$\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$= 1.097 \times 10^{-7} \left(\frac{1}{1} - \frac{1}{9}\right]$$

$$= 1.097 \times 10^{7} \left[\frac{8}{9}\right]$$

$$= 0.98 \times 10^{7}$$

$$\lambda = 1.020 \times 10^{-7}\ m$$

we know energy

$$E = h\nu = \frac{hc}{\lambda}$$

$$= \frac{6.64 \times 10^{-34} \times 3 \times 10^{8}}{1.020 \times 10^{-7}}$$

momentum $P = \frac{h}{\lambda}$

$$= \frac{6.64 \times 10^{-34}}{1.020 \times 10^{-7}}$$

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8.19 The ground state and the first excited state energies of potassium atoms are -4.3 eV and -2.7 eV respectively. If we use potassium vapour in the Franck hertz experiment at what voltages would we see the drops in the plot of current versus voltage?

solution here

The ground state $E_0 = -4.3\,eV$

The first excited state $E_1 = -2.7\,eV$

If electron absorbs energy of

$= E_1 - E_0$

$= -2.7 + 4.3$

$= 1.6\,eV$

we see the drops in the plot of current versus voltage.

19.2 The de-broglie wavelength of a proton is 10^{-13} m (a) What is the speed of the proton (b) Through what potential difference must the proton be accelerated to acquire such a speed?

Solution here

(a) The de-broglie wavelength of proton is

$$\lambda = 10^{-13} m$$

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

$$\therefore v = \frac{h}{m \times \lambda}$$

where
$h = 6.67 \times 10^{-34}$
$m = 1.67 \times 10^{-27}$

$$= - - - - -$$

(b) Again

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

$$\therefore V = \frac{mv^2}{2e}$$

19.7 solution

we know that kinetic energy of α-particle is

$$\frac{1}{2}mv^2 = 5\times10^6 \, eV$$

$$\frac{p^2}{2m} = 5\times10^6 \, eV$$

$$P = \sqrt{2\times6.64\times10^{-27}\times5\times10^6\times1.6\times10^{-19}}$$

$$= 10.30\times10^{-20}$$

Now,

from de-broglie relation

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

$$= \frac{6.67\times10^{-34}}{10.30\times10^{-20}}$$

$$= 0.64\times10^{-14}$$

$$= 6.4\times10^{-15} \, m$$

From above relation value of λ we can say that the wavelength is comparable to the size of the emitting nucleus.

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19.11 In neutron spectroscopy a beam of monochromatic energetic neutrons is obtained by reflecting reactor neutrons from a beryllium crystal. If the separation between the atomic planes of the beryllium crystal is 0.732 A°, what is the angle between the incident neutron beam and atomic planes that will yield a monochromatic beam of neutrons of wavelength 0.1 A°?

~~we know~~ Here

separation of atomic plane (d) = 0.732 A°

wavelength of beam (λ) = 0.1 A°

angle (θ) = ?

we know that from Bragg's diffraction condition

$$2d\sin\theta = n\lambda$$

$$\sin\theta = \frac{\lambda}{2d}$$

$$= \frac{0.1}{2\times 0.732}$$

$$\therefore \theta = \sin^{-1}\left(\frac{0.1}{2\times 0.732}\right)$$

$$= 3.9^\circ$$ //

19.16 A small particle of mass 10^{-6} g moves along the x-axis, its speed is uncertain by 10^{-6} m/sec (a) what is the uncertainity in the x-co-ordinate of the particle? (b) Repeat the calculation for an electron assuming that the uncertainity in its velocity is also 10^{-6} m/s.

Solution, here.

In 1st case

mass of particle $m = 10^{-6} g = 10^{-9} kg$

speed of particle $\Delta V = 10^{-6}$ m/s

we know from Heisenberg uncertainity principle

$$\Delta x \cdot \Delta P_x = \hbar$$

$$\Delta x \cdot m\Delta V = \frac{h}{2\pi}$$

$$\Delta x = \frac{h}{2\pi \times m \times \Delta V}$$

$$= \frac{6.64 \times 10^{-34}}{2 \times 3.14 \times 10^{-9} \times 10^{-6}}$$

$$= 1.05 \times 10^{-19} \ m$$

In 2nd case for electron. $\Delta V = 10^{-6}$ m/s and $m = 9.1 \times 10^{-31}$

$$\Delta x \cdot \Delta P_x = \frac{h}{2\pi}$$

$$\Delta x = \frac{h}{2\pi \times m \times \Delta V}$$

$$= \frac{6.64 \times 10^{-34}}{2 \times 3.14 \times 9.1 \times 10^{-31} \times 10^{-6}} = 112 m$$

9.19 The uncertainity in the position of a particle is equal to the de-broglie wavelength of the particle calculate the uncertainity in the velocity of the particle in terms of the velocity of the de-broglie wave associated with the particle.

solution here.

uncertainty in position of particle $\Delta x = \lambda$

uncertainity in velocity of particle $\Delta v = ?$

According to the heisenberg's uncertainty principle

$$\Delta x \cdot \Delta p = \frac{h}{2\pi}$$

$$\lambda \cdot m \Delta v = \frac{h}{2\pi}$$

$$\Delta v = \frac{h}{2\pi m \lambda}$$

$$\Delta v = \frac{h}{2\pi m \frac{h}{p}} \qquad \left[\frac{v_{particle}}{2} = V_{wav} \right.$$

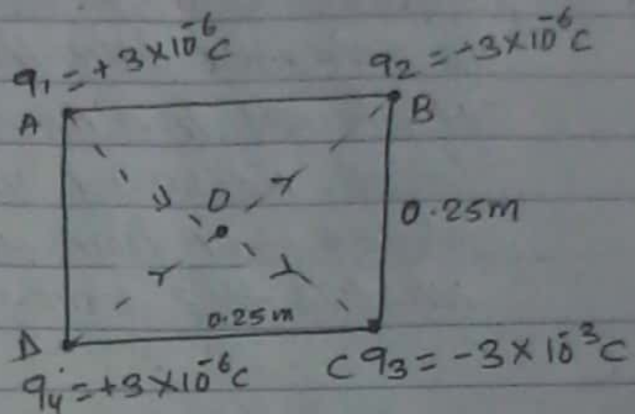
$$= \frac{p}{2\pi m}$$

$$= \frac{\cancel{m} v}{2\pi \cancel{m}} = \frac{v}{2\pi}$$

$$= \frac{2 V_{wave}}{2\pi} = \frac{V_{wave}}{\pi} \; //$$

Unit 2

14.6 Four charges of equal magnitude are placed at the corners of a square as shown in figure. What is the electric field at the center of the square point O?



From figure.

$$AC = \sqrt{AB^2 + BC^2}$$

$$= \sqrt{(0.25)^2 + (0.25)^2}$$

$$= 0.82$$

Electric field at point O due to these charges is

$$E_{net} = E_1 + E_3 + E_2 + E_4$$

$$= \frac{q_1}{4\pi\epsilon_0 r^2} + \frac{q_2}{4\pi\epsilon_0 r^2} + \frac{q_3}{4\pi\epsilon_0 r^2} + \frac{q_4}{4\pi\epsilon_0 r^2}$$

$$= \frac{1}{4\pi\epsilon_0}\left[\frac{3\times10^{-6}}{(0.82)^2} + \frac{3\times10^{-6}}{(0.82)^2} + \frac{3\times10^{-6}}{(0.82)^2} + \frac{3\times10^{-6}}{(0.82)^2}\right]$$

$$= \frac{9\times10^9 \times 4 \times 3\times10^{-6}}{(0.82)^2} = 160.61\times10^3 \, N/C$$

14.3 Two large parallel plates are separated by a distance of 5cm. The plates have equal but opposite charges that create an electric field in the region between the plates. An α-particle ($q = 3.2 \times 10^{-19} C$, $m = 6.68 \times 10^{-27} kg$) is released from the positively charged plate, and it strikes the negatively charged plate 2×10^{-6} sec later. Assuming that the electric field between the plates is uniform and perpendicular to the plates what is the strength of electric field.

solution here

we know that for α-particle its kinetic energy is given by

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

$$\frac{1}{2} mv^2 = qEd \quad \left[\text{since } E = \frac{V}{d}\right] \quad \text{— (1)}$$

Again the force experienced by α-particle is

$$F = qE$$

$$ma = qE$$

$$m\frac{v}{t} = qE$$

$$v = \frac{qEt}{m} \quad \text{— (2)}$$

Now from equation (1) and (2)

$$\frac{1}{2} m \cdot \frac{q^2E^2t^2}{m^2} = qEd$$

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$$\therefore E = \frac{2md}{qt^2} = \frac{2 \times 6.68 \times 10^{-27} \times 0.05}{3.2 \times 10^{-19} \times 4 \times 10^{-12}}$$

$$= 521.875 \text{ N/C}.$$

solution

14.21

The electric potential due to q_1 at a distance of 90cm from it is given by.

$$V_1 = \frac{q_1}{4\pi\epsilon_0 r}$$

$$= \frac{2.5\times10^{-10}\times 9\cdot\times10^{9}}{0\cdot9}$$

$$= 2\cdot5\ V$$

lly the electric potential due to q_2 at a distance of 10 cm from it is given by

$$V_2 = \frac{q_2}{4\pi\epsilon_0 r} = \frac{5\times10^{-10}\times9\times10^{9}}{0\cdot1}$$

$$= 45\ V$$

Net ~~electric fi~~ potential $V_{net} = (45+2\cdot5)$

$$= (47\cdot5)\ V.$$

Now for an electron,

$$\frac{1}{2}mv^2 = eV_{net}$$

$$v^2 = \frac{2eV_{net}}{m}$$

$$v = \sqrt{\frac{2eV_{net}}{m}}$$

16.1 What force is experienced by a wire of length $l = 0.08m$ at an angle of $20°$ to the magnetic field direction carrying a current of 2A in a magnetic field of 1.4 T

solution here.

length of wire $(l) = 0.08m$

Angle $(\theta) = 20°$

current $(I) = 2A$

magnetic field $(B) = 1.4 T.$

Now, force $F = BIl \sin\theta$

$= 1.4 \times 2 \times 0.08 \times \sin(20°)$

$= 0.08N$

26.12 A proton is moving with velocity $V = (3\times10^5 i + 7\times10^5 k)$ m/sec in a region where there is a magnetic field of strength $B = 0.4 j$ T. what is the force experienced by the proton?

solution here,

velocity of the proton $V = (3\times10^5 i + 7\times10^5 k)$ m/s

magnetic field $B = 0.4 j$ T

we know that the magnetic force on a moving charge particle is given by.

$$F = \cancel{BEV}\ q(\vec{V}\times\vec{B})$$

$$= 1.6\times10^{-19}\left[(3\times10^5 i + 7\times10^5 k)\times 0.4 j\right]$$

$$= 1.6\times10^{-19}\left[1.2\times10^5 k - 2.8\times10^5 i\right]$$

$$= [1.92k - 4.48 i]\times10^{-14}\ N$$

16.18 A proton is accelerated through a potential difference of 200V. It then enters a region where there is a magnetic field $B = 0.5T$. The magnetic field is perpendicular to the direction of motion of the proton what is the force experienced by the proton?

solution, here

The potential difference $V = 200V$

The magnetic field $B = 0.5T$

Here for proton.

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

$$\frac{1}{2} 1.67 \times 10^{-27} \times v^2 = 1.6 \times 10^{-19} \times 200$$

$$v^2 = \frac{2 \times 1.6 \times 10^{-19} \times 200}{1.67 \times 10^{-27}}$$

$$= 383.23 \times 10^{8}$$

$$\therefore v = 19.58 \times 10^{4} \ m/s$$

Now, Force experienced by the proton is

$$F = Bqv \sin 90$$

$$= 0.5 \times 1.6 \times 10^{-19} \times 19.58 \times 10^{4}$$

$$= 15.664 \times 10^{-15} \ N$$

problems 22.1, 22.3, 22.4, 22.5, 22.9

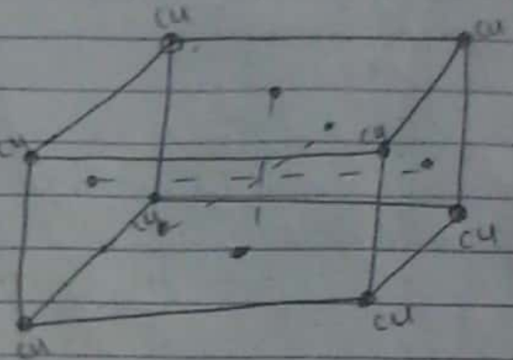
22.1) copper has a face centered cubic structure with a one atom basis. The density of copper is 8.96g/cm³ and its atomic weight is 63.5 g/mole. what is the length of the unit cube of the structure?

The density of copper

$\rho = 8.96\ g/cm^3$

Atomic weight

$M_{at} = 63.5\ g/mole$



since $\rho = \dfrac{\text{~~mass of unit cell~~ all atoms in unit cell}}{\text{Volume of unit cell}}$

$= \dfrac{\text{numbers of atoms per unit cell} \times \text{mass of one atom}}{\text{volume of unit cell}}$

$$\rho = \frac{4 \times \frac{63.5}{N}}{a^3}$$

for calculation of no of atoms per unit cell.

$$\boxed{N = N_i + \frac{N_f}{2} + \frac{N_c}{8}}$$

Volume of unit cell $= a \times a \times a = a^3$

$$a^3 = \frac{4 \times 63.5}{8.96 \times 6.022 \times 10^{23}}$$

$$= \frac{4 \times 63.5 \times 10^{-3}}{8.96 \times 6.022 \times 10^{23} \times 10^{-3} \times 10^{6}}$$

$$= \frac{254 \times 10^{-3}}{53.95712 \times 10^{26}}$$

$$= 4.7074 \times 10^{-29}$$

$$= 3.61\ A^{o}$$

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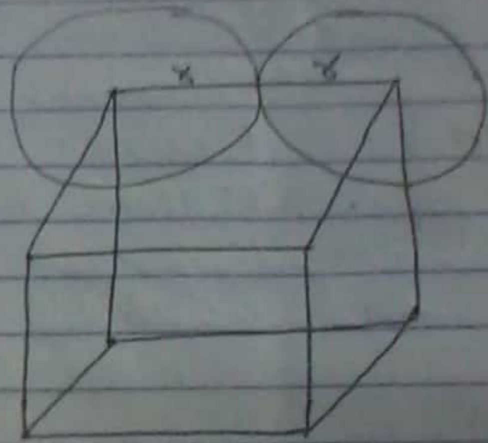
22.3 Assuming that atoms in a crystal structure are arranged as a closed packed spheres what is the ratio of the volume of the atoms to the volume avialable for the simple cubic structure? Assume a one-atom basis.



Here,
In simple cubic structure we have no of atoms per unit cell

$$N = N_i + \frac{N_f}{2} + \frac{N_c}{8}$$

$$= 0 + 0 + \frac{8}{8}$$

$$N = 1$$

Now,

$$\text{Packing fraction} = \frac{\text{volume of atom}}{\text{volume of unit cell}} = \frac{1 \times \frac{4}{3}\pi r^3}{a^3}$$

$$= \frac{\frac{4}{3}\pi r^3}{(2r)^3}$$

$$= \frac{\pi}{6} = 0.52 = 52\%$$

H.W Calculate it for bcc and fcc

28.9 The dissociation energy of the KF molecule is 5.12eV. The ionization energy for K is 4.34eV, and the electron affinity of F is 4.07eV. what is the equilibrium separation constant for KF molecule?

Solution

The dissociation energy of KF molecule

$E_d = 5.12\,eV$

The ionization energy of K is 4.34 eV so

$K + 4.34eV \longrightarrow K^+ + e^-$

on the other hand electron affinity of F is 4.07eV

$F + e^- \longrightarrow F^- + 4.07\,eV$

when K^+ and F^- atoms are brought together then

$$E = -\frac{e^2}{4\pi\epsilon_0 r} \quad \text{—— (1)}$$

we know that dissociation energy

$E_d = E + 4.07 - 4.34$

$5.12 + 0.27 = E$

$E = 5.39\,eV$

from eqn (1)

$$1.6\times10^{-19}\times5.39 = -\frac{(1.6\times10^{-19})^2}{4\pi\epsilon_0 r}$$

$$r = -\frac{(1.6\times10^{-19})^2\times9\times10^9}{5.39\times1.6\times10^{-19}}$$

$$= \frac{1.6\times10^{-19}\times9\times10^9}{5.39} = 2.67\,A^0$$

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