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Assignment-4

UNIT-3

Ans-1. Consider a charge particle q of mass m through V.

$k = qV$, {qV is work done on charged particle by electric field}

We know that K.E, $k = \frac{1}{2} mv^2$

And momentum $p = mv$

$\Rightarrow k = \frac{p^2}{2m} \Rightarrow p = \sqrt{2mk}$

$k = qV$

$p = \sqrt{2mqV}$

de broglie wavelength (λ), $\lambda = \frac{h}{p}$

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

Expression for de-Broglie wavelength with a charged particle having charge & mass by potential V.

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Ans-2 The group velocity is simply derivative of frequency ω w.r.t cons^{n} $V_g = \frac{d\omega}{dk}$

$$V_g = \frac{d(2\pi\nu)}{d\left(\frac{2\pi}{\lambda}\right)} = \frac{d(\nu)}{d\left(\frac{1}{\lambda}\right)}$$

$$k = \frac{2\pi}{\lambda} \Rightarrow \frac{1}{V_g} = \frac{d(1/\lambda)}{d\nu} \quad \text{——— (1)}$$

If E and V represent that energy & p.E

$$\frac{1}{2}mv^2 = E - V$$

$$\therefore v = \left[\frac{2(E-V)}{m}\right]^{1/2}$$

Using de-broglie

$$\frac{1}{\lambda} = \frac{mv}{h} = \frac{m}{h}\left[\frac{2(E-V)}{m}\right]^{1/2}$$

$$\frac{1}{\lambda} = \frac{m}{h} = \left[\frac{2(h\nu - V)}{m}\right]^{1/2}$$

Substituting Eq^{n} (1)

$$\frac{1}{v_g} = \frac{d}{dv}\left[\frac{m}{h}\left(\frac{2(hv-V)}{m}\right)^{1/2}\right]$$

$$\frac{1}{v_g} = \frac{2m}{h}\left(\frac{2(hv-V)}{m}\right)^{-1/2}\frac{2h}{m}$$

$$\frac{1}{v_g} = \left(\frac{2(hv-V)}{m}\right)^{-1/2} = \frac{1}{v}$$

$$\boxed{\frac{1}{v_g} = \frac{1}{v}}$$

group velocity = particle velocity

Ans-3- $P = \frac{hc}{\lambda}$ = momentum of incident photon.

$P_1 = \frac{hc}{\lambda'}$ = momentum of scattering photon.

P_2 = momentum of scattered electron at angle ϕ.

Using law of Conversation of momentum

$$P = P_1 \cos\theta + P_2 \cos\theta$$

$$P_2 \cos\theta = P - P_1 \cos\theta$$

$$P_2 \sin\theta = P_1 \sin\phi$$

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Using law of Conversation of momentum.

*, taking ratio

$$\frac{P_2 \sin\phi}{P_2 \cos\phi} = \frac{P_1 \sin\theta}{\frac{hf}{c} - P_1 \cos\theta}$$

$$\tan\phi = \frac{1}{\frac{hf}{P_1 c \sin\theta} \cdot \cot\theta} = \frac{1}{\frac{\lambda'}{\lambda \sin\theta} - \cot\theta}$$

$$\tan\phi = \frac{\lambda \sin\theta}{\lambda' - \lambda\cos\theta} = \frac{\lambda \sin\theta}{(\lambda' - \lambda\cos\theta) + \Delta\lambda}$$

$$\tan\phi = \frac{\lambda \sin\theta}{\lambda(1-\cos\theta) + \frac{h}{mc}(1-\cos\theta)}$$

$$\tan\phi = \frac{\sin\theta}{(1-\cos\theta) + \frac{hf}{mc^2}(1-\cos\theta)}$$

$$\boxed{\tan\phi\left(1 + \frac{hf}{mc^2}\right) = \frac{\sin\theta}{1-\cos\theta}}$$

$$\Rightarrow \frac{2\sin\theta/2 \cos\theta/2}{1 - \cos^2\theta/2 + \sin^2\theta/2}$$

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$$\tan\phi \Rightarrow \frac{2\sin\theta/2 \cos\theta/2}{2\sin^2\theta/2} = \cot\theta/_2$$

$$\boxed{\tan\theta = \frac{\cot\theta}{1 + \frac{h\nu}{m_0c^2}}}$$

Ans-4- The photon must be near to nucleus in order to satisfy conversation of momentum as an e⁻ positron pair produced in free space coil satisfy convservation of both energy and momentum. Because of this when pair production occurs, atomic nucleus recives some recoil.

Ans-5- Hesinberg, Uncertainity principle:- It is also known as uncertainity principle It states that the posⁿ & velocity of an object can't be measured exactly at same time even in theory.

Radius of nucleus of order of 10^{-5} m

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& maximum uncertainity in posn of e⁻ ie Δx within the nucleus will be 10^{-5}m.

Now $\Delta x \cdot m \Delta v \geq \frac{h}{4\pi}$

$\Rightarrow \Delta v = \frac{6.62 \times 10^{-34}}{4 \times 3.14 \times 9.1 \times 10^{-31} \times 10^{-15}}$

$\Rightarrow \Delta v = 5.97 \times 10^{10}$ m/s

As this level of uncertainity in velocity is impossible to achieved hence e⁻ can't exist in nucleus.