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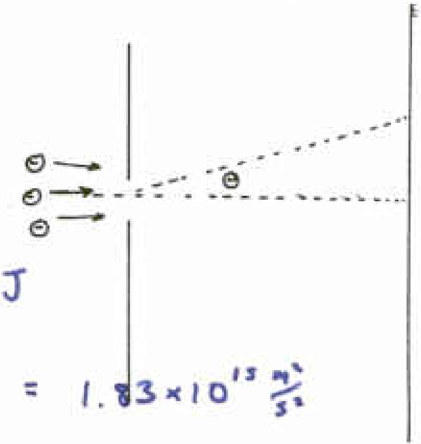
Phys 122 — Section 1
Quiz #6

1. A beam of electrons having 5200 eV of kinetic energy is incident up on a single slit (of width w). They pass through the slit and are detected as they strike as distant screen.



a) What is the speed of the electrons?

$$5200\ \text{eV} = (5200\ \text{eV})\left(\frac{1.602\times10^{-19}\ \text{J}}{\text{eV}}\right) = 8.33\times10^{-16}\ \text{J}$$

$$\tfrac{1}{2}mv^2 = KE \qquad v^2 = \frac{2(KE)}{m} = \frac{2(8.33\times10^{-16}\ \text{J})}{(9.109\times10^{-31}\ \text{kg})} = 1.83\times10^{15}\ \frac{\text{m}^2}{\text{s}^2}$$

$$v = 4.28\times10^{7}\ \frac{\text{m}}{\text{s}}$$

b) What is the momentum of the electrons?

$$p = mv = (9.109\times10^{-31}\ \text{kg})(4.28\times10^{7}\ \tfrac{\text{m}}{\text{s}}) = 3.90\times10^{-23}\ \frac{\text{kg}\cdot\text{m}}{\text{s}}$$

c) What is the wavelength of the electrons?

$$\lambda = \frac{h}{p} = \frac{6.63\times10^{-34}\ \text{J}\cdot\text{s}}{3.90\times10^{-23}\ \frac{\text{kg}\cdot\text{m}}{\text{s}}} = 1.70\times10^{-11}\ \text{m}$$

d) If the first "dark" fringe of the electron diffraction pattern on the screen occurs at 0.428° away from the central maximum, what is the width of the slit?

First dark fringe is at $\sin\theta = (1)\dfrac{\lambda}{W}$

Solve for W:

$$W = \frac{\lambda}{\sin\theta} = \frac{(1.70\times10^{-11}\ \text{m})}{\sin(0.428^\circ)} = 2.30\times10^{-9}\ \text{m}$$

2. The work function for a metal surface is 3.12 eV.

a) What is the minimum frequency that an electromagnetic wave can have and still eject electrons from this surface?

Min. freq is when ejected electrons are given no KE and so $E_{ph} = hf = W_0$

Since $W_0 = 3.12\,\text{eV}\left(\frac{1.602\times10^{-19}\,\text{J}}{\text{eV}}\right) = 5.00\times10^{-19}\,\text{J}$

we get $f = W_0/h = 5.00\times10^{-19}\,\text{J} / 6.63\times10^{-34}\,\text{J}\cdot\text{s} = 7.54\times10^{14}\,\text{s}^{-1}$

b) What is the wavelength of the radiation from part (a)?

Use

$$\lambda = c/f = \frac{2.998\times10^{8}\,\frac{\text{m}}{\text{s}}}{7.54\times10^{14}\,\text{s}^{-1}} = 3.97\times10^{-7}\,\text{m} = 397\,\text{nm}$$

c) What is the momentum of a single photon of this radiation?

$$p = h/\lambda = \frac{6.63\times10^{-34}\,\text{J}\cdot\text{s}}{3.97\times10^{-7}\,\text{m}} = 1.67\times10^{-27}\,\text{kg}\cdot\text{m/s}$$

3. What did Rutherford's 1911 experiment (α particles scattered on gold foil) demonstrate about the nature of the atom?

Suggested a "nuclear" model; the positively charged part is small and dense and is surrounded by electrons which orbit the nucleus.

You must show all your work!

$$1\text{ eV} = 1.602\times10^{-19}\text{ J} \qquad m_e = 9.11\times10^{-31}\text{ kg} \qquad h = 6.63\times10^{-34}\text{ J}\cdot\text{s}$$

$$c = 2.998\times10^{8}\,\tfrac{\text{m}}{\text{s}} \qquad \frac{h}{m_e c} = 2.43\times10^{-12}\text{ m} \qquad k = 1.38\times10^{-23}\,\tfrac{\text{J}}{\text{K}}$$

$$\lambda f = c \qquad \text{Dark fringe:}\quad \sin\theta = m\frac{\lambda}{w} \quad m = 1,\ 2,\ 3,\ldots$$

$$E = hf \qquad E_{\text{phot}} = hf = \text{KE}_{\text{max}} + W_0 \qquad p = \frac{h}{\lambda} \qquad \lambda = \frac{h}{p} \qquad \lambda' - \lambda = \frac{h}{mc}(1-\cos\theta)$$

$$(\Delta p_y)(\Delta y) \geq \frac{h}{2\pi} \qquad \text{PE} = mgh \qquad \text{PE} = \tfrac{1}{2}kx^2 \qquad \text{KE} = \tfrac{1}{2}mv^2 \qquad p = mv$$