Physics 2D   Quiz 4 Solutions   Winter 2025

Problem 1

The classical amplitude is given by $x_0 = A$, satisfying

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

In the ground state, $E = E_0 = \frac{\hbar\omega}{2}$, so , with $A =$

$\hbar\omega =$

Harmonic oscillator only absorbs photons of frequency ω, wavelength λ, with $\frac{hc}{\lambda} = \hbar\omega \Rightarrow$

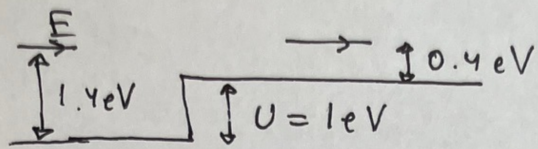
(b) Before absorbing radiation, electron is in ground state with

$\Psi_0(x) = C_0 e^{-x^2/2A^2}$ $\Rightarrow$ most likely to be found at

After absorbing a photon, electron is in state

$\Psi_1(x) = C_1 x e^{-x^2/2A^2}$. Probability is

Problem 2



incident energy is $E = 1.4\,eV$

Reflection coef $R = \dfrac{(k_1 - k_2)^2}{(k_1 + k_2)^2}$

$k_1 = \sqrt{\dfrac{2 m_e E}{\hbar^2}} =$

$k_2 = \sqrt{\dfrac{2 m_e (E-U)}{\hbar^2}} =$

$R =$

transmission coef $= T = 1 - R =$

If 1000 electrons were transmitted, the number of incident electrons was N such that $N \cdot T = 1000 \Rightarrow$

Problem 3

According to the Rutherford formula, # of α particles scattered at angle θ is proportional to $\dfrac{1}{\sin^4 \theta/2}$

$$\Rightarrow \quad \frac{N(\theta=90^\circ)}{N(\theta=180^\circ)} = \frac{\sin^4(90^\circ)}{\sin^4(45^\circ)}$$

so according to the problem, this is what is observed for kinetic energy of α particle $K_\alpha = 4\,\text{MeV}$.

The distance of closest approach to the center of the nucleus for impact parameter $b = 0$ is r, satisfying

$$K_\alpha = \frac{2Ze^2}{4\pi\varepsilon_0 r} \Rightarrow$$

$\Rightarrow r =$. For the kinetic energies given in the problem

K_α	r	Is Rutherford law satisfied? i.e. is if α particles don't penetrate the nucleus
3.5 MeV		yes
4 MeV		
4.5 MeV		
5 MeV		no

(a) From the fact that Rutherford law is satisfied for $K_\alpha = 4\,\text{MeV}$ and not satisfied for $K_\alpha = 5\,\text{MeV}$ we deduce that the radius of the nucleus of Ag, r_{Ag}, satisfie

(b) For $K_\alpha = 3.5\,\text{MeV}$, the α particles stay outside nucleus $\Rightarrow N(90^\circ)$

For $K_\alpha = 4.5\,\text{MeV}$

Problem 4

$$E = -13.6\,eV = -E_0, \quad r = 0.2116\,nm = 4a_0$$

We know that:

$$E_n = -\frac{E_0 Z^2}{n^2} = -E_0 \Rightarrow$$

and that $r_n = \frac{a_0}{Z} n^2 = 4a_0 =$

$=$

(a) angular momentum is $\boxed{L_n = n\hbar}$

(b) The shortest wavelength is for the transition $n =$

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

Problem 5

$F = -kr \Rightarrow$

$kr = \frac{m_e v^2}{r} \Rightarrow \boxed{kr^2 = m_e v^2}$

$\Rightarrow$ $K =$

(b) Assuming $L = n\hbar$ as in the Bohr atom,

$L = m_e v r = n\hbar \Rightarrow L^2 = m_e^2 v^2 r^2 = n^2 \hbar^2 \Rightarrow$

smallest orbit is for $n = 1$

$r_1^4 =$

For $k = \frac{1 eV}{nm^2}$, r_1