Constants

Planck's constant, $h = 6.626x10^{-34}[Js]$

$$\tilde{h} = \frac{h}{2\pi} = 1.055x10^{-34}[Js]$$

Free electron mass, $m_0 = 9.11x10^{-31}[kg]$

Elementary charge, $q = 1.602x10^{-19}[C]$

Boltzmann constant, $k_b = 1.381x10^{-23}[J/K]$

Vacuum permittivity, $\epsilon_0 = 8.854x10^{-12}[F/m]$

Speed of light, $c = 3x10^8[m/s]$

1st Orbital radii of Hydrogen atom, $a_0 = 5.3x10^{-9}[m]$

Energy unit conversion, $E[eV] = \frac{E[J]}{q}$

Pendulum

$$\Delta E = h\nu = \tilde{h}\sqrt{\frac{k}{m}}$$

$$E = \frac{1}{2}k\Delta x$$

Whare k is the force applied to the system, equal to g if it's pendulum and Δx is the max deflection that spring can take, in pendulum, equal to elevation

Hydrogen atom - Bohr's model

$$\frac{Zq^2}{4\pi\epsilon_0 r^2} = \frac{m_0 v^2}{r}$$

Z is a Culomb forceand centriperal force (for us allways = 1)

$$L = mvr = n\tilde{h}$$

System frequency: $\nu = \frac{E_i - E_j}{h}$ Using properties that we just learned orbital velocity:

$$v_n = \frac{q^2}{4\pi\epsilon_0\tilde{h}} \cdot \frac{1}{n}$$

After calculating the v_1, just use: $v_n = \frac{v_1}{n}$ We can also derive:

$$r_n = \frac{4\pi\epsilon_0\tilde{h}^2}{m_0 q^2} \cdot n^2 = a_0 n^2$$

Useful for H atom: $E_1 = -2.18x10^{-18}[J] = -13.9[eV]$

Orbital Energies

$$E_{kin} = \frac{m_0 v^2}{2} = \frac{m_0 q^4}{2(4\pi\epsilon_0)^2\tilde{h}^2} \cdot \frac{1}{n^2}$$

$$E_{pot} = \int_r^\infty F(r)dr = -\frac{q^2}{4\pi\epsilon_0 r_n} = -\frac{m_0 q^4}{(4\pi\epsilon_0)^2\tilde{h}^2} \cdot \frac{1}{n^2}$$

$$E_n = E_{kin} + E_{pot} = -\frac{m_0 q^4}{2(4\pi\epsilon_0)^2\tilde{h}^2} \cdot \frac{1}{n^2} = -E_1 \cdot \frac{1}{n^2}$$

Orbital Transitions

$$\lambda_{n\to m} = \frac{hc}{\Delta E_{n\to m}}$$

$$\Delta E_{n\to m} = E_m - E_n = E_1(\frac{1}{m^2} - \frac{1}{m^2})$$

de Broglie wavelength

$$m v_n r_n = n\frac{h}{2\pi}$$

$$p r_n = n\frac{h}{2\pi}$$

$$2\pi r_n = n\lambda_{dB}$$

To calculate λ_{dB}

$$\lambda_{dB} = \frac{h}{p} = \frac{h}{m_0 v} = \frac{h}{\sqrt{2m_e E}}$$

$$\lambda_{dB} = \frac{2\pi r_n}{n} = 2\pi a_0 n$$

Remember, if $\lambda_{dB} << L$ then system can be treated as **classical** Termal: $E_{kin} = \frac{3}{2}k_b T$ Electical:

$$I = q\rho A v$$

$$v = \frac{I}{q\rho A}$$

Where q is a constant, ρ is given in the task, and A is area (crossection) so πr^2

Reflection despite higher Energy

$$k = \frac{\sqrt{2m^*(E - V)}}{\tilde{h}}$$

$$P = \frac{4k_1k_3}{(k_1 + k_3)^2 cos^2(k_b b) + \left(\frac{k_1 k_3}{k_b} + k_b\right) sin^2(k_b b)}$$

Getting $P_m ax$:

$$2k_b b = n2\pi$$

$$P_m ax = \frac{4k_1k_3}{(k_1 + k_3)^2}$$

Energy for which the tranition P is max?

$$E_n = V_b + \frac{\tilde{h}^2 \pi^2 n^2}{2m^* b^2}$$

Tunneling

$$k = \frac{\sqrt{2m^*(E - V_0)}}{\tilde{h}}$$

$$\kappa_b = \frac{\sqrt{2m^*(V_b - E)}}{\tilde{h}}$$

$$P_0 = 16 \frac{(k\kappa_b)^2}{(k^2 + \kappa_b^2)^2}$$

$$P = P_0 exp(-2\kappa_b b)$$

Rectangular quantum well

$$E_n = \frac{\tilde{h}^2 \pi^2 n^2}{2m_e L^2}$$

to find a well length such that N number of energy levels are located below E we can use the following:

$$L > \frac{\tilde{h} \pi N}{\sqrt{2m_e E}}$$

Heisenberg's uncertainty principle

$$\Delta p = m \Delta v$$

$$\Delta x \cdot \Delta p \geq h$$

To get the required time to know the velocity of the pariclesup to some precision:

$$\Delta t \geq \frac{h}{prec \cdot m\ cdotv^2}$$

Photoelectric effect

Stopping freq, $V_0 = \frac{hv}{e} - \frac{W_0}{e}$