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PH 212

HIP 9

You want to trap an electron in a thin open-closed box such that when an electron falls from the 3rd energy level to the 1st energy level, a green photon is emitted. What length of open-closed box do you need?

$m = 9.11 \times 10^{-31}$ kg $\qquad c = 3.00 \times 10^{8}$ m/s

$h = 6.63 \times 10^{-34}$ Js $\qquad \lambda = 5.17 \times 10^{-7}$ m

$E = hf \qquad f = \frac{c}{\lambda} \qquad \lambda = \frac{h}{mv} \qquad E = \frac{1}{2}mv^2$

$\frac{1}{4}\lambda = L \qquad \frac{3}{4}\lambda = L \qquad \frac{5}{4}\lambda = L$

$\rightarrow \frac{n}{4}\lambda = L$ For $n = 1, 3, 5, \ldots$

1st Energy State $\qquad$ 2nd Energy State $\qquad$ 3rd Energy State

$\frac{n}{4}\lambda = L \rightarrow \frac{nh}{4mv} = L \rightarrow$ plug in $v = \sqrt{\frac{2E}{m}} \rightarrow L = \frac{nh}{4m\sqrt{\frac{2E}{m}}}$

$\rightarrow$ square both sides $\rightarrow L^2 = \frac{n^2h^2}{16m^2 \cdot \frac{2E}{m}} \rightarrow \boxed{E_n = \frac{n^2h^2}{32mL^2} \text{ For } n = 1, 3, 5, \ldots}$

Now that we know the energy an electron has at any $n = 1, 3, 5, \ldots$ in our open-closed box, we must find how much energy a photon of wavelength λ has. This will then be the ΔE required between the 3rd and 1st energy level.

$E = hf \rightarrow \boxed{E = \frac{hc}{\lambda}} \rightarrow E = \Delta E = E_1 - E_5 \rightarrow \frac{hc}{\lambda} = \frac{1^2h^2}{32mL^2} - \frac{5^2h^2}{32mL^2}$

$\rightarrow \frac{hc}{\lambda} = \frac{-3h^2}{4mL^2} \rightarrow$ this is a negative because the electron is losing energy - this is our emitted photon. We can use the absolute value to find L.

$$\frac{hc}{\lambda} = \frac{3h^2}{4mL^2} \longrightarrow \text{solve for } L \longrightarrow \boxed{L = \sqrt{\frac{3h\lambda}{4cm}}}$$

The length of our open-closed box is .97 nm.

This is reasonable based on the following unit check.

$$\sqrt{\frac{\cancel{kg}\, m^2\, \cancel{m}\, \cancel{s^2}}{\cancel{m}\, \cancel{s^2}\, \cancel{kg}}} \longrightarrow \sqrt{m^2} \longrightarrow m \ \checkmark$$

Lecture Time: Name:

CATEGORY	EXEMPLARY (1.5)	ACCOMPLISHED (1)	DEVELOPING (0.5)	EMERGENT (0)
Problem Statement and Introduction	A new learning tool for our class is written	The problem is clearly presented for reader in your own words.	The problem is directly copied or is hard to follow.	You jump into some calculation
Picture	Your sketch could be dropped into a graphic novel as it stands.	There is a clear sketch, larger than a credit card, of the problem set up with important features and data noted	There is some sketch of the problem setup	What sketch?
Physics Tools	Appropriate physics tools are correlated to the exercise in textbook quality and size	Appropriate physics tools are correlated to the exercise. Appropriate tools include: pictures, FBDs, conservational laws utilized, etc...	Some physics tools are correlated to the exercise.	There are a few equations written.
Problem Solution Presentation	Solution is very clearly presented with intriguing asides or annotations	Solution is complete and clearly presented making no significant intuitive demands on the reader.	In your solution I have to read between the lines	Cliff notes version of solution with only high points present
Form	Your solution can serve as solution manual.	Drawing is larger than a credit card, organization is fluid, notation used is clear.	I could figure the path of your solution with effort.	You can read it.
Units		All units correctly given	Calculations & quantities are presented with units	Some units at the results
Solution		Correct	You are close	None/Not reasonable
Significant Figures		Correct Sig Figs	Makes effort to use correct significant figures	Copies the number from the calculator
Reasonableness	Provides more than one type of Reasonableness check.	Gives one clear rationale for appropriateness of the solution in the setting	Asserts that the answer is reasonable but really hasn't given any evidence	No discussion
All Self Graded		Done	Not Done	Done, but your self-assessment is different from mine by at least two steps.