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(Short solutions to HW on Quantum mechanics)

① Straightforward

ans : $\lambda = 1.04 \times 10^{-12}$ m

② Straightforward

ans : $V = 2.4 \times 10^{6}$ volt

③ Get mass of single C-60 molecule as $m = \frac{M}{N_0}$

$\lambda = 2.52 \times 10^{-12}$ m

since this value is well-within the experimental limits of measurement, the claim is verifiable experimentally. (It is been verified, actually)

④ Angular momentum $L = mvr$ so $\Delta L = m \Delta v r$
assume radius with no uncertainty. Get $\Delta \theta$ by uncertainty principle $\Delta L \Delta \theta \geq \frac{h}{4\pi}$

ans : $\Delta \theta \simeq 2189$ rad

⑤ Get Δp first. $\Delta p \simeq m \Delta v$ and then $\Delta x = \Delta v t$

ans $\Delta x = 4.15 \times 10^{-7}$ m

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(6) Note: solution for this problem exists on internet but that uses Bohr's theory. Here, we'll get it using the uncertainty principle.

first get $\Delta E \approx 5.28 \times 10^{-27}$ J

let $E \approx \Delta E$; $E = p^2/2m$

and $v = \frac{p}{m} = \frac{\sqrt{2mE}}{m}$

$v \approx 107.7$ m/s

Dist to cover in 2^{nd} orbit $= 2\pi r_2$

$r_n \propto n^2$ i.e $r_n = n^2 r_1$; $n = 2$

r_1: radius of first orbit $= 0.53 \times 10^{-10}$ m

time taken for 1 rev $= \frac{2\pi \times (2)^2 r_1}{v}$

$\approx 1.236 \times 10^{-11}$ sec

time it stays in $n=2$ is 10^{-8} sec

$\therefore$ no of rev. $= \frac{10^{-8}}{1.236 \times 10^{-11}} \approx 809$

This is the minimum no. of revolution the electron makes before jumping to $n=1$

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(7) $\Delta E = 1.056 \times 10^{-17} J \approx 66 eV$

$\Delta \nu = \frac{1}{4\pi \Delta t} \approx 1.6 \times 10^{16} Hz$

This is huge bandwidth covers all the way from UV to visible to IR region of EM spectrum
The broadened bandwidth is due to very short time pulse.

(8) Use wavefunction of particle in a box

$$\phi(x) = \sqrt{\frac{\pi}{L}} \cdot \sin\left(\frac{n\pi x}{L}\right)$$

for ground state, $n=1$

solve like # 15 of solved examples on QM

ans : probability $\approx 39.25\%$

(9) $E_n = \frac{n^2 h^2}{8 m L^2}$ $E = E_2 - E_1$

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

ans : 20.1 nm

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(10) This can be quantitatively solved by taking some value of L say 1 nm

~~let~~ then $\Delta L = \pm 0.1$ nm

L varies from 0.9 nm to 1.1 nm

$$E = \frac{n^2 h^2}{8mL^2}$$

get variation in E for these values and for L = 1 nm

% variation goes from 17.2% to 28.9%.

— x —

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