

The hydrogen atom has two key components, that the proton is fixed	
P1	You 16:15 → 16:25
P2	16:30 → 16:35 16:25 → 16:30
P3	16:40 → 16:55 16:35 → 16:40 16:55 → END

P2: de Broglie [seminar]

- P1: a) • limitations \Rightarrow circular motion ✓
- proton fixed (Newtonian model)
 - $E_{\text{quantized}}$ stops beyond a certain point \rightarrow fails to take into account stat. nature
 - only provides answers hydrogen atom
 - no spin (fine-structure)
 - no reason to quantize angular momentum

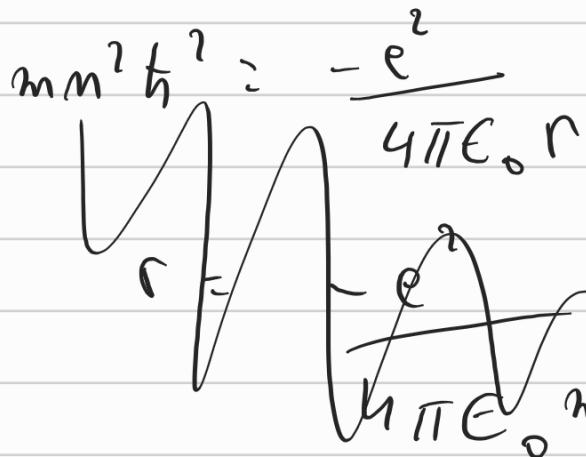
$$b) r = \frac{-ze^2}{4\pi\epsilon_0 V(r)}$$

$$= \frac{-ze^2}{4\pi\epsilon_0 n^2 r \hbar^2}$$

$$F = m \frac{v^2}{r} = mv^2$$

$$V = n^2 r \hbar^2$$

$$F = V(r)$$



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CENTRIPETAL ACC

$$|F| = e^2 / (4\pi\epsilon_0 r^2) \quad \text{COULOMB}$$

$$|F| = ma = m(\frac{v^2}{r})$$

$$v^2 = \frac{e^2}{4\pi\epsilon_0 mr}$$

rearranging

$$L = n \hbar = mv r$$

$$v = \frac{n \hbar}{mr}$$

$$\frac{e^2}{4\pi\epsilon_0 r^2} = \frac{n^2 \hbar^2}{r^2}$$

radius

$$P2: a) \lambda, r, n \quad a) C = 2\pi r = n\lambda$$

$$2\pi r = \lambda_n \quad b) \lambda = \frac{h}{p} \quad \leftarrow \text{de Broglie relationship}$$

$$2\pi r = \frac{nh}{p}$$

$$\left(\frac{rp}{n} = \frac{nh}{2\pi} \right) \quad \frac{h}{2\pi} = \hbar$$

$$P3. a) \Delta E = E_1 - E_n$$

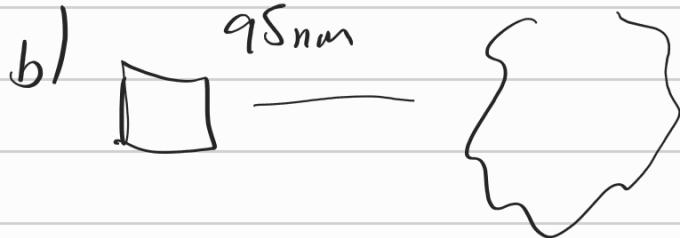
$$\frac{me^4}{32\pi^2\hbar^2 n^2} = E_1 - E_n$$

$$n = \sqrt{\frac{32\pi^2\hbar^2}{m e^4}} \frac{1}{(E_1 - E_n)}$$

$$\Delta E = \frac{1}{n^2} E_1 - \bar{E}_1$$

$$n = \sqrt{1 - \frac{\Delta E}{E_1}}$$

$$n^2 = \frac{1}{1 - \frac{\Delta E}{E_1}}$$



$$E_i hf = 2.05 \times 10^{-18} J$$

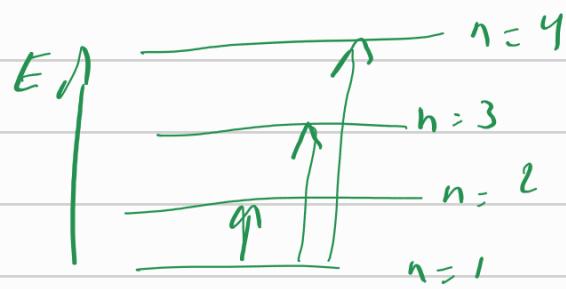
$$= 13 \text{ eV}$$

~~Yttrium~~ Nd

c) ~~Periodic Table~~ 4, 5, 6

$$a) \quad \epsilon_n = \frac{|E_1|}{n^2}$$

$$\Delta\epsilon = \epsilon_n - \epsilon_1 \\ = |E_1| \left(1 - \frac{1}{n^2} \right)$$



Manage to get requested rels'

(exam 98°)

b)

$n = \frac{1}{\sqrt{1 - \frac{\Delta E}{|E_1|}}}$

where $|E_1|$ is the absolute value of the energy of the ground $n = 1$ state. [2]

A little testing. Must take the normal equation of the energy and convert into the energy difference. Should pose little difficulty for all but the weakest students.

$$E_n = -\frac{|E_1|}{n^2}$$

$$\Delta E = E_n - E_1$$

$$= |E_1| \left(1 - \frac{1}{n^2} \right)$$

rearrange to get requested relationship.

(b) A laser with well defined wavelength 95 nm is fired at a gas of hydrogen atoms in their ground state. Can the gas absorb this light? If not why not? [2]

Quantum mechanics states that atoms can only absorb light with specific energies, i.e., wavelength that correspond to some transition within the atom. For a wavelength of 95 nm question is, does this correspond to a transition energy? From the first part around $n = 4.82$ which is not an integer. So no this wavelength of light is not absorbed.

$E_{phot} = \frac{hc}{\lambda} = 13.01 \text{ eV}$

10

write what U

do:
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results

c)

the question is, does this correspond to a transition energy? From the first part around gives $n = 4.82$ which is not an integer. So no this wavelength of light is not absorbed.

(c) To generate a range of energies a pulse of laser light, with central wavelength 95 nm and pulse duration $\Delta t = 2 \times 10^{-15} \text{ s}$, is fired at the hydrogen atom gas. Can the gas absorb this light? If so, what range of states can be strongly excited? [3]

Now the more able students should see that reducing the time of the pulse will increase the energy uncertainty through (as covered in lectures, though in a slightly different use)

$\Delta E \sim h$

$\Delta E \sim \frac{h}{\Delta t}$

$\Delta E \sim \frac{h}{\Delta t}$

$\approx 0.33 \text{ eV}$

ave a range of photon energies from $13.01 - 0.33 \text{ eV}$ to $13.01 + 0.33 \text{ eV}$, we just have the what energy levels they correspond to

$13.01 - 0.33 \text{ eV} = 12.68$

$13.01 + 0.33 \text{ eV} = 13.34$

Within the spread of energies we can populate the

1

9, 13, 6, + 80 others

d)

