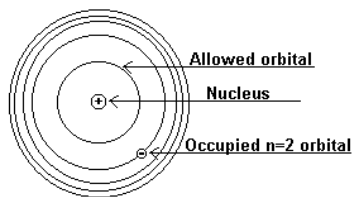


State Any Assumptions You Need To Make -- Show All Work -- Circle Any Final Answers
Your Choice to Work on This *Before, During or After Break* - Be Sure to Write Down Equations
BOLDFACE Variables Are Vectors - Feel Free to Ask Any Questions

This Problem is a Bohr (40,000 points)

1.) (a) The Bohr atom assumes planetary orbitals. Write down the equation for the energy and solve it for $n = 2$. Write down the equation for the radius of the orbit and solve it for $n = 2$.



(b) Since the electron has a mass, m_e , which is located a distance r_2 from the nucleus, and is going around in a circle held in place by the Coulomb Force (this is Uniform Circular Motion), find the speed, v , of the electron for $n = 2$. Show whether this speed is relativistic.

(c) Find the kinetic energy, K , of the $n = 2$ electron, using the speed v from (b). Compare your answer to the energy found in (a). Are they the same? Should they be? Why or why not?

Still Bohr'ed with this Problem (Problem 1 - con't.)

(d) Assuming a circular orbit, write a general equation for the angular momentum, L , of the electron in the Bohr atom. Show whether L is quantized in terms of h or \hbar . For $n = 2$, find the angular momentum L of the electron.

(e) The angular momentum quantum number for the Schrödinger hydrogen atom is $l = 0$ for an s-orbital. Does this mean that L is zero for an s-orbital? If it does, why should the angular momentum be zero? Either way, compare the answer from (d) with the angular momentum L for 2s and 2p orbitals for the Schrödinger hydrogen atom.

Psi's and Whispers (60,000 points)

2.) (a) Assuming a Schrödinger hydrogen atom, find the energies of the first five levels, $n = 1$ to $n = 5$.

(b) On a piece of graph paper (or plotted with a spreadsheet or other plotting package), construct an energy level diagram for the electrons from $n = 1$ to $n = 5$, with E as the vertical axis. That would include 1s, 2s, 2p, 3s, etc.

(c) Identify all the legal transitions from 5s \rightarrow 1s. Using your energies from (a), identify the photons by wavelength that might be emitted from the transitions. Indicate which ones would be in visible light, on the UV side of visible light, on the IR side of visible light.

High Ang-Psi-Ety (Problem 2 - con't.)

(d) Of course, the world doesn't really look like a single Hydrogen atom. So let's try a quick simulation of what something else might look like. Repeat parts (b) & (c) with the following adjustment to the rules:

Orbital	Energy
s	$1.0 \times E_n$
p	$0.9 \times E_n$
d	$0.5 \times E_n$
f	$0.4 \times E_n$
g	$0.3 \times E_n$

(e) Below are the functional forms of the hydrogenic atom solutions through $n = 3$. Show, in any reasonable argument or fashion, that it is not possible to construct the $n = 3$ function from linear combinations of $n = 1$ and $n = 2$ functions. From the structure of the functions for $n = 1, 2, 3$, construct the form for function $n = 8, l = 7, m_l = \pm 7, Z = 17$. What electron orbital is this?

n	l	m_l	Eigenfunction
1	0	0	$A_{100} e^{-Zr/a_0}$
2	0	0	$A_{200} \left(2 - \frac{Zr}{a_0} \right) e^{-Zr/2a_0}$
2	1	0	$A_{210} \left(\frac{Zr}{a_0} \right) e^{-Zr/2a_0} \cos \theta$
2	1	± 1	$A_{21\pm 1} \left(\frac{Zr}{a_0} \right) e^{-Zr/2a_0} \sin \theta e^{\pm i\theta}$
3	0	0	$A_{300} \left(27 - 18 \frac{Zr}{a_0} + 2 \frac{Z^2 r^2}{a_0^2} \right) e^{-Zr/3a_0}$
3	1	0	$A_{310} \left(6 - \frac{Zr}{a_0} \right) \frac{Zr}{a_0} e^{-Zr/3a_0} \cos \theta$
3	1	± 1	$A_{31\pm 1} \left(6 - \frac{Zr}{a_0} \right) \frac{Zr}{a_0} e^{-Zr/3a_0} \sin \theta e^{\pm i\theta}$
3	2	0	$A_{320} \frac{Z^2 r^2}{a_0^2} e^{-Zr/3a_0} (3 \cos^2 \theta - 1)$
3	2	± 1	$A_{32\pm 1} \frac{Z^2 r^2}{a_0^2} e^{-Zr/3a_0} \sin \theta \cos \theta e^{\pm i\theta}$
3	2	± 2	$A_{32\pm 2} \frac{Z^2 r^2}{a_0^2} e^{-Zr/3a_0} \sin^2 \theta e^{\pm 2i\theta}$

Source: Quantum Physics of Atoms, Molecules, Nuclei and Particles / Robert Eisberg and Robert Resnick. New York: John Wiley & Sons, 1974. aka "The Silver Bullet".