Recitation 2

1. Bohr Model
Chapter 7: ***Exercise 50***
An electron is excited from n = 1 ground state to the n = 3 state in a hydrogen atom. Which of the following statements are true? Correct the false statements to make them true.
(a) It takes more energy to ionize (completely remove) to the electron from n = 3 than the ground state

(b) The electron is farther from the nucleus on average in the n = 3 state than in the n = 1 state

(c) The wavelength of light emitted if the electron drops from n = 3 to n =2 will be shorter than the wavelength of light emitted if the electron falls from n = 3 to n =1

(d) The wavelength of light emitted when the electron returns to the ground state from n = 3 will be the same as the wavelength of light absorbed to go from n = 1 to n = 3

(e) For n = 3, the electron is in the first excited state

Solution:
(a) False;
(b) True;
(c) False;
(d) True;
(e) False

<u>Chapter 7:</u> *Exercise 54*

An excited hydrogen atom emits light with a wavelength of 397.2 nm to reach the energy level for which n = 2. In which principal quantum level did the electron begin?

Solution:

$\lambda = hc/\Delta E = hc/\{R_H\ [(1/n^2_{final}) - (1/n^2_{initial})]\}$

$(1/n^2_{final}) - (1/n^2_{initial}) = hc/(R_H\ \lambda)$

Or, $(1/2^2) - (1/n^2_{initial})$

$= (6.626\text{x}10^{-34}\text{J.s x } 2.9979\text{x}10^{8}\text{ m/s})/(2.178\text{x}10^{-18}\text{J x } 397.2\text{x}10^{-9}\text{m})$

Or, $n_{initial} = 7$

2. The Heisenberg principle

<u>Chapter 7:</u> *Exercise 55*

Using Heisenberg uncertainty principle, calculate Δx for each of the following.

a. **an electron with $\Delta\nu$ = 0.100 m/s**
b. **a baseball (mass = 145 g) with $\Delta\nu$ = 0.100 m/s**
c. **How does the answer in part a compare with the size of hydrogen atom?**
d. **How does the answer in part b correspond to the size of a baseball?**

Solution:

(a) $\Delta\nu$ = 0.100 m/s, mass of electron = $m_e = 9.11\text{x}10^{-31}$kg

$\Delta x.\ \Delta(mv) = h/4\pi$,

Or, $\Delta x = h/(4\pi m\Delta\nu) = (6.62\text{x}10^{-34}\text{J.s})/\{4 \text{ x } 3.14 \text{ x } 0.100 \text{ m/s x } 9.11\text{x}10^{-31}\text{kg}\} = 5.79\text{x}10^{-4}\text{m}$

(b) $\Delta\nu$ = 0.100 m/s, mass of the baseball = m = 0.145 kg

$\Delta x.\ \Delta(mv) = h/4\pi$,

Or, $\Delta x = h/(4\pi m\Delta\nu) = (6.62\text{x}10^{-34}\text{J.s})/\{4 \text{ x } 3.14 \text{ x } 0.100 \text{ m/s x } 0.145 \text{ kg}\} = 3.64\text{x}10^{-33}\text{m}$

(c) The diameter of H-atom is roughly $1.0\text{x}10^{-8}$ cm. The uncertainty in position is much longer than the size of the atom.

(d) The uncertainty is insignificant to the size pf the baseball.

3. Radial nodes and angular nodes for 3s, 3p and 3d orbitals

The shapes of the orbitals with the mathematical form of the wave functions for 1s, 2s and $2p_z$ orbitals are:

$$\Psi_{1s} = \Psi_{1,0,0} = C\ e^{-r/a_0}$$

$$\Psi_{2s} = \Psi_{2,0,0} = C\,e^{-r/2a_0}\left(2 - \frac{r}{a_0}\right)$$

$$\Psi_{2p_z} = \Psi_{2,1,0} = Cr\,e^{-r/2a_0}\cos\theta$$

- **Why?**
  1. There is no node in 1s orbital
  2. There is one radial node in 2s orbital.
  3. There is no radial node in $2p_z$ orbital, but there is one angular node (when $cos\ \theta = 0$, $\theta = 90°$, yielding the *xy* plane).

- **Number of nodes:**
  1. Number of radial nodes in a given orbital: **n–ℓ–1**
  2. Number of angular nodes: **ℓ**
  3. Total number of nodes: **n–1**

Orbital	**Number of Radial Nodes**	**Number of Angular Nodes**	**Total Number of Nodes**
3s	2	0	2
$3p_x$	1	1	2
$3p_y$	1	1	2
$3p_z$	1	1	2
$3d_{xz}$	0	2	2
$3d_{yz}$	0	2	2
$3d_{xy}$	0	2	2
$3d_{x^2-y^2}$	0	2	2
$3d_{z^2}$	0	2	2