Announcements – 10/27/00

- ***Quiz today*** (last 15 minutes of class)
- **Special *Demo* today**

1

Wave Properties of Matter

- **de Broglie:** "If EMR waves can act like *particles*, why not treat *matter* like a **wave**?"

Based on his hypothesis:

$$\lambda = h/mv$$

Characteristic wavelength of the object

Momentum of object

RESULT:

-macroscopic things have wavelengths that are *incredibly tiny* (10^{-30} m or so)

-sub-atomic sized things have wavelengths that are of the same order as their physical size (Å for an e-)!

2

The Uncertainty Principle

- German physicist Werner Heisenberg:

  *There are <u>limits</u> to which we can know both the **momentum** and the **location** of ANY object.*

<u>Quantitatively</u>: $(\Delta p)(\Delta x) \geq h/4\pi$

-so, the better we know the *position* of an object, the *worse* we know the *velocity* (p = mv) of the object

-not an issue in the macroscopic world, but the limitation is profound for objects like electrons!

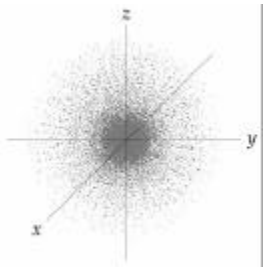
3

Quantum Mechanics

- 1926: Erwin Schrödinger describes electrons in an atom as having **both** wave and particle properties:

  <u>The Schrödinger Wave Equation</u>!

  <u>Results:</u>
  - Solutions to the wave equation are called: *<u>wave functions</u>* (ψ)
  - For hydrogen, get the same *electron energies* as Bohr did
  - The square of the *wave function* (ψ^2) gives a *<u>probability density</u>* for an electron in a specified energy state
  - The *probability densities* define what are called ***orbitals***



Lowest energy *orbital* for the hydrogen atom

4

Orbitals and Quantum Numbers

- Each solution to the wave equation can be *uniquely* specified by **three quantum numbers:**

1. **The Principal Quantum Number (n)**
   -can have *integer values* (1, 2, 3, 4, etc.)
   -corresponds to the principal energy level
   -same as the quantum number in Bohr's model
   -defines the *electron shell*

2. **The Azimuthal Quantum Number (l)**
   -can have *integer values* from **0 to n-1** for each value of n
   -defines the orbital shape
   -value of *l* determines the letter used to specify the orbital shape (*l= 0, 1, 2, 3* $\rightarrow$ **s, p, d, f orbitals**)
   -defines the *subshell*

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More QN and Orbitals

3. **The Magnetic Quantum Number (m_l)**
   -can have integer values from *l* ® *-l*
   -describes the orientation of the orbital in space

So, some examples:

n=1: only one value of *l* possible (0) **1s orbital**
only one value of m_l possible (0)

n=2: *l = 0, 1* (s and p orbitals)
For **l = 1:** m_l = 1, 0, -1 (**$2p_x$, $2p_y$, $2p_z$ orbitals**)

n=3: *l = 0, 1, 2* (s, p and d orbitals)
For **l = 2**: m_l = 2, 1, 0, -1, -2 (**five 3d orbitals**)

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