Chem 151 Name: KEY

Quiz 4 *April 3, 2012*

$$\lambda = \frac{h}{mv} \qquad \Delta x \Delta mv \geq \frac{h}{4\pi}$$

h = 6.63 X 10^{-34} kg m^2 s^{-1}
mass of an electron = 9.1 X 10^{-31} kg

1) deBroglie and Heisenberg concepts. You want to use electrons to measure the crystal lattice spacing in a novel crystal solid synthesized in your advisor's lab (10 pts)

a) The electrons diffract and cause an interference pattern at a detector. From the diffraction pattern you determine that the spacing between molecules in the crystal is about 10^{-10} m. If the electrons striking the crystal have a wavelength equal to the crystal spacing, what is their approximate velocity?

$10^{-10}\,m = \frac{h}{mv}$

10^{-7}m/s 10^{4}m/s 10^{-5}m/s

10^{10}m/s **10^{7}m/s** 10^{2}m/s

$v = \frac{h}{m(10^{-10}\,m)}$ 7×10^{6} m/s closest to

$v = 7.3 \times 10^{6}$ m/s

b) What would happen if you tried to take this measurement with electrons with a wavelength of 100 nm?

$100\,nm = 10^{-7}\,m$

This wavelength is 1000 times longer than the distance we want to measure. No usable diffraction pattern will be generated.

c) If the error in the speed was 10%, calculate the approximate error in the position of the matter wave used to image the crystal. ~~Would this have an effect on what you were trying to measure?~~

$\Delta mv = m_e v_2 - m_e v_1 = m_e(v_2 - v_1) = m_e \Delta v$

Δv: 7.3×10^{6} m/s $\cdot 10\% = 7.3 \times 10^{5}$ m/s

$\Delta x = \frac{h}{4(\pi)(m\Delta v)} = 7.9 \times 10^{-11}\,m$

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2) The Schrodinger Equation (5pts)

a) Complete the Schrodinger equation: $\hat{H}\Psi =$ $E\Psi$

b) In one sentence describe each of the symbols used in this equation.

$\hat{H}$ operator, a set of mathematical instructions to determine the energy of an electron in Ψ the wave function. E the energy of the electron.

c) What do we call the first three quantum numbers and what information does each contain?

n: principle quantum # – size and energy of orbital

l: angular momentum quantum # – shape

m_l: magnetic quantum # – orientation of orbital (ie. xyz)

3) Understanding Wave Functions: (Circle the correct answer for a, b and c) (10 pts)

$$\Psi_{---} = \frac{1}{4\sqrt{2\pi}}\left(\frac{Z}{a_0}\right)^{3/2}(2-\sigma)e^{-\sigma/2} \qquad \text{Where } \sigma = Zr/a_0 \quad \sigma = \frac{Zr}{a_0}$$

a) What is true about the constant a_0 when considering one electron systems?

(*Same for all elements*) *Different for each element*

b) Remembering that this wave function uses the polar coordinate system, what can you say knowing that the intensity of the described wave is dependent only on r?

The intensity is infinite at long distances (*Wave function is symmetrical*)

Wave function is not symmetrical *Wave function is square*

c) Is it possible for this function to equal zero? If so, how many values of r would result in this?

Possible, three values of r *Not possible*

(*Possible, one value of r*) *Possible, two values of r*

d) Remembering your answers to b and c, what are the values for the three quantum numbers that match this wave function?

Ψ_{200}