Computer Lab Report Form #7:
Time Dependent Electron Waves

Student's Name: ____

BU ID____

Lab Section Day/Time/TF____________________________________

Investigation 1: The Trouble with Time

Circle the correct answers below in questions 1-7:

1. Does the electron wave vary with time (page 34)?

a)Yes b)No c) Cannot be determined

2. How is the electron wave sign indicated on the display (page 34)?

a) By the color; b) By the brightness of the color; c) No indication

3. How is the magnitude of the electron wave indicated in the display (page 34)?

a) By the different color; b) By the brightness of the color; c) No indication

4. Why is there only one color used for the display of the electron cloud for both the 1s and 2p orbitals (page 34)? Because:

a) The electron cloud density is always negative; b) The electron cloud density is always positive; c) The electron cloud density doesn't depend on time.

5. Describe what you observe for the electron wave as a function of time (page 35):

a) It changes sign from the positive to negative but never goes through zero value;

b) It doesn't depend on time;

c) It changes its value in cycles: from positive to zero, from zero to negative, from negative to zero and from zero to positive;

6. Describe what you observe for the electron cloud as a function of time (page 35):

a) It doesn't change with time; b) It changes with time; c) Cannot be determined

7. What kind of continuous function can change sign but never be zero (page 36)?

a) Sin x b) Cos x c) Complex function d) e^x

Investigation 2: Phasors Ready?

1. What color does the phasor point to for the following angles (page 38)?

a) $\theta = 0^o$ __________; b) $\theta = 90^o$ __________ ; c) $\theta = 180^o$ _________.

2. What kind of numbers can have values that are neither positive nor negative?

3. What is the phase angle for the following complex numbers (page 39):

a) 1 + i , θ = _________; b) 0.707 – 0.707i , θ = _________; c) 0 – i, θ = _________

4. Find $\Delta\theta$, the change in angle to flip the lobe colors, for the following cases (page 40):

a) θ= 45°, to flip the colors $\Delta\theta$ = __________;

b) θ= 180°, to flip the colors $\Delta\theta$ = _________;

c) θ = 270°, to flip the colors $\Delta\theta$ = ________.

Investigation 3: The Planck Relationship

1. What is the order of magnitude of the frequency of oscillation of the:

a) 1s orbital? ________ ; b) 2p orbital? __________ (page 44).

2. Please, find the following frequencies (page 45):

a) for 1s orbital ϕ_{1s} = ______________ Hz;

b) for 2p orbital ϕ_{2p} = _ ______________Hz;

c) what is the ratio (ϕ_{1s}/ϕ_{2p}) ? ≈_________

3. Please, complete the following table (page 46).

Orbital	ϕ (x 10^{15} Hz)	Ratio (ϕ_{1s} /$\phi_{orbital}$)
ϕ_{1s}	-3.288	1.0
ϕ_{2s}		
ϕ_{2p}	-0.8221	4.0
ϕ_{3s}		
ϕ_{3p}		
ϕ_{3d}		
ϕ_{4s}		
ϕ_{4p}		
ϕ_{4d}		

4. Please, write a general relationship between φ_{1s} and the frequency ϕ_n of any other orbital (page 46):

$\phi_n =$

5. Write the formula for energy of the hydrogen atom, which is similar to the above one (page 46)

$E_n =$

6. Complete the following table (page 47).

Orbital	ϕ (x 10^{15} Hz)	E_n (eV)
ϕ_{1s}	-3.288	-13.6
ϕ_{2s}		
ϕ_{2p}		
ϕ_{3s}	-0.365	-1.51
ϕ_{3p}		
ϕ_{3d}		
ϕ_{4s}		
ϕ_{4p}		
ϕ_{4d}		

7. What is the slope of the graph of $|E_n|$ versus $|\phi|$ (page 48)? ___________ eV·s

8. What is the name of the fundamental constant that has the slope value (page 48)?

It is ____________ constant

Investigation 4: Oscillating Dipoles and Radiation

1. Please, complete the following table for the frequency of several spectral lines of hydrogen with given wavelength (page 52:

λ (nm)	**ν (x10^{15}Hz)**
121.553	2.466
102.560	
97.242	
94.563	

2. Do the frequencies of the observed spectral lines of hydrogen match the frequencies of the atomic orbitals? Circle the right answer (page 53):

a) Yes   b) No   c) Some of them match

3. If the frequency of the emitted radiation is not that of any of the energy levels, what do you think is oscillating in the atom with the emission frequency (page 89)?

a) energy levels;   b) electron cloud must be oscillating;   c) it is unclear at that point.

4. Can you think of any examples from wave behavior in other systems that would allow for the combination of two frequencies to give a third, intermediate frequency (page 53)?

5. Measure the frequency of the electron cloud oscillation that results from adding the 1s and 2p orbitals (page 55):

Frequency of electron cloud oscillation = _____________ Hz.

6. Mix a 1s with a 2s orbital. Mix a 2p with a 3p orbital. Describe what you see. Is there a charge imbalance that sloshes from side to side? Which of these mixtures shows a dipole oscillating (page 56)? Circle the correct answer below:

a) The charge is always remains symmetric about the central nucleus. So, it is not a dipole oscillation;

b) There is a charge imbalance that sloshes from side to side around the central nuclease. Therefore, it is a dipole oscillation.

6. Find the electron cloud oscillations that correspond to spectral lines of hydrogen. Complete the following table by measuring the frequency for different dipole oscillations and determining which orbitals must be mixed (added) to produce the corresponding frequency of light (page 56).

Spectral line	**λ (nm)**	**ν (x 10^{15} Hz)**	**Lower Energy Orbital**	**Higher Energy Orbital**
First Lyman line	121.553	2.466	1s	2p
Second Lyman line	102.56	2.923		
Third Lyman line	97.242	3.083		
Red (first Balmer line)	656.386	0.457		
Green (second Balmer line)	486.212	0.617		
Blue (third Balmer line)	434.118	0.691		

7. What is the relationship between the energy of a spectral line $\Delta E_{quantum}$ and the energy levels of an atom, $\Delta E_{final\ orbital}$ and $\Delta E_{initial\ orbital}$ (page 56)?

$$\Delta E_{quantum} =$$

8. Complete the following table and verify that $\nu_{spectrum} = |\phi_{final} - \phi_{iniitial}|$. (page 57)

Spectral line	**ν (x 10^{15} Hz) (experimental)**	**Frequency of s orbital (x 10^{15} Hz)**	**Frequency of p orbital (x 10^{15} Hz)**	**$\lvert\phi_{final} - \phi_{iniitial}\rvert$ (x 10^{15} Hz)**
First Lyman line	2.466	-3.288	-0.822	2.466
Second Lyman line	2.923	-3.288		
Third Lyman line	3.083	-3.288		
Red (1st Balmer line)	0.457	-0.822		
Green (2^{nd} Balmer line)	0.617	-0.822		
Blue (third Balmer line)	0.691	-0.822		