Name:________________

Quest for Quantum – If you find it let me know!

1. Match each term with the description that it best fits:

a)	light travels in wavey packages called photons that have properties of frequency, wavelength energy and mass	j	absorption spectra
b)	light is produced in spectra lines whenever electrons move to lower values of n	i	Aufbau Principle
c)	the discovery of the nucleus was the an indirect result of bombardment of thin gold foil with radioactive alpha particles	m	Bohr's postulate
d)	fast moving small particles of matter (such as electrons, protons, neutrons and atomic nuclei) exhibit a wave particle duality	d	de Broglie matter waves
e)	orbitals of equal energy fill one electron at a time first	b	emission spectra
f)	no two electron in a atom can have all four quantum numbers in common, at least one quantum number must be different	n	Heisenberg uncertainty principle
g)	property of a guitar string that causes it to vibrate a specific frequency for a given length, tension and thickness of the string	e	Hund's Rule
h)	energy can be converted to mass and mass can be converted into energy	h	Law of conservation of mass energy
i)	when electrons are added to an atomic nucleus to build an atom, the electrons will fill the innermost lowest energy orbitals first	a	wave particle duality of light
j)	light is absorbed in a spectra line pattern whenever electrons move to a higher value of n	f	Pauli Exclusion Principle
k)	the discovery of the electron was the result of experimentation with high voltage and vacuum technology	o	photoelectric effect
l)	total light energy is the sum of small packages of energy, rather than a smooth uninterrupted continuum	l	quantum hypothesis
m)	electrons orbiting a nucleus appear to do so in a wave-like pattern that will be some integer multiple of the fundamental wave pattern for an electron confined to an atom	c	Rutherford
n)	it is not possible to know both the location and the momentum of an electron to a high degree of accuracy	g	standing wave pattern
o)	when a photon of sufficient energy strikes the surface of a metal, an electron will be liberated from the surface of the metal, any extra photon energy shows up as added kinetic energy in the electron	k	Thomson

2. Do you know your quantum numbers? List in the order that the quantum numbers were presented in class.

Symbol	Allowed Values (Use Set Notation)	Physical Properties And/or Name
n	**$\{n \in I \mid n>0\}$**	**principle Q.N., # of de Broglie**
l	**$\{l \in I \mid 0 \le l < n\}$**	**angular momentum Q.N.**
m_l	**$\{m_l \in I \mid -l \le m_l \le l\}$**	**magnetic Q.N.**
m_s	**$\{m_s \in R \mid m_s = \pm 1/2\}$**	**spin Q.N.**

3. Suppose the spin quantum number, m_s had allowed values of –5/2, –3/2, –1/2, 1/2, 3/2 & 5/2. If this was the case how wide would each "block" be on the periodic table (Each block is defined by quantum number l) Assume that the other three quantum numbers behave the same as usual. How wide would the periodic table be in total? (Present width is 32 elements.)

l – Value	Proposed Width
s	**6**
p	**18**
d	**30**
f	**42**

periodic table would be 96 elements wide

4. For the quantum number l (i.e. angular momentum) it has been suggested that there is the possibility of l=4. If this is so, how many different l=4 elements could exist. What is the minimum number of de Broglie wavelengths that are required to produce an l=4? Make clear and concise reference to the other three quantum numbers in your answer.

- for l=4 there would be 9 different ml values $\{ml \in I \mid -l \le ml \le l\}$ ranging from –4 to 4
- each ml value in turn can have 2 ms values $\{ms \in R \mid ms = \pm 1/2\}$
- $\{-4,-3,-2,-1,0,1,2,3,4\} \times \{-½, +½\} \therefore 9 \times 2 = 18$
- n must be 5 or more because l must be less than n $\{l \in I \mid 0 \le l < n\}$ therefore at least 5 deBroglie wavelengths

5. Fill out the following table to show the possible quantum numbers in the first three principle energy levels for a one electron hydrogen.

n	l	m_l	m_s	# e^- per energy level	# e^- per energy shell
1	0	0	−1/2	2	2
1	0	0	+1/2		
2	0	0	−1/2	2	8
2	0	0	+1/2		
2	1	−1	−1/2	6	
2	1	−1	+1/2		
2	1	0	−1/2		
2	1	0	+1/2		
2	1	1	−1/2		
2	1	1	+1/2		
3	0	0	−1/2	2	18
3	0	0	+1/2		
3	1	−1	−1/2	6	
3	1	−1	+1/2		
3	1	0	−1/2		
3	1	0	+1/2		
3	1	1	−1/2		
3	1	1	+1/2		
3	1	−2	−1/2	10	
3	2	−2	+1/2		
3	2	−1	−1/2		
3	2	−1	+1/2		
3	2	0	−1/2		
3	2	0	+1/2		
3	2	1	−1/2		
3	2	1	+1/2		
3	2	2	−1/2		
3	2	2	+1/2		

6. Write the complete electron configuration of Newellium, element number 111 (also known as unununium).

$1s^2$
$2s^2\ 2p^6$
$3s^2\ 3p^6$
$4s^2\ 3d^{10}\ 4p^6$
$5s^2\ 4d^{10}\ 5p^6$
$6s^2\ 4f^{14}\ 5d^{10}\ 6p^6$
$7s^2\ 5f^{14}\ 6d^9$

7. Complete the following table by filling in whatever is missing:

element	n	l	m_l	m_s	end of config.
Te	**5**	**1**	**0**	**+1/2**	$5p^4$
$_{23}V$	**3**	**2**	**−1**	**−1/2**	**$3d^3$**
Ac	5	**3**	−3	−1/2	**$5f^1$**
Lr	**6**	**2**	**−2**	**−1/2**	$6d^1$
He	1	0	0	+1/2	**$1s^2$**
Ga	**4**	**1**	**−1**	**−1/2**	$4p^1$
Hg	**5**	**2**	**+2**	**+1/2**	$5d^{10}$
Yb	**4**	**3**	**+3**	**+1/2**	$4f^{14}$

8. Determine the value of a constant that can be used in place of the values in the brackets. Perform a complete unit analysis for this. Finally, use this constant to determine the radius of the orbit that corresponds to n=5 in Å
(1 m = 1 x 10^{10} Å)

$$r = \left(\frac{h^2\varepsilon_o}{\pi e^2 m}\right) n^2$$

h = 6.626 x 10^{-34} Js
ε^o = 8.854 x 10^{-12} $C^2N^{-1}m^{-2}$
n = principle quantum number (no units)
e = 1.6022 x 10^{-19} C
m = 9.110 x10^{-31} kg
π = 3.1415926536

Note: $J = \frac{kgm^2}{s^2}$ $N = \frac{kgm}{s^2}$

$$r = \frac{(6.626\times10^{-34})^2(8.854\times10^{-12})}{(3.1415)(1.6022\times10^{-19})^2(9.11\times10^{-31})}\times 5^2$$

$$r = 5.291\times10^{-11}\times 25$$

$$r = 1.323\times10^{-9}\ m$$

$$1.323\times10^{-9}\ m \times \frac{1\times10^{10}\ Å}{1m} = 13.23\ Å$$

$$\text{units} = \frac{(Js)^2(C^2N^{-1}m^{-2})}{C^2\ Kg}$$

$$= \frac{J^2s^2\ C^2\ N^{-1}\ m^{-2}}{C^2\ kg}$$

$$= \frac{J^2s^2}{N\ m^2\ kg}$$

$$= \frac{\left(\frac{Kg\ m^2}{s^2}\right)^2\left(\frac{s^2}{1}\right)}{\frac{Kg\ m}{s^2}\times\frac{m^2}{1}\times\frac{Kg}{1}}$$

$$= \frac{Kg^2\ m^4}{s^4}\times\frac{s^2}{1}\times\frac{s^2}{Kg\ m}\times\frac{1}{m^2}\times\frac{1}{kg}$$

$$= m$$

9.

$$\frac{1}{\lambda} = 1.09737 \text{ x } 10^7 \text{ m}^{-1} \left[\left(\frac{1}{n_i^2} \right) - \left(\frac{1}{n_f^2} \right) \right]$$

Use the above equation to find the wavelength of light in nm created by an electronic transition from an n = 6 to n = 2 transition. Use the conversion of
1 m = 1 x 10^9 nm

$$\frac{1}{\lambda} = 1.09737 \text{ x } 10^7 \text{ m}^{-1} \left[\left(\frac{1}{n_i^2} \right) - \left(\frac{1}{n_f^2} \right) \right]$$

$$\frac{1}{\lambda} = 1.09737 \text{ x } 10^7 \text{ m}^{-1} \left[\left(\frac{1}{6^2} \right) - \left(\frac{1}{2^2} \right) \right]$$

$$\frac{1}{\lambda} = 1.09737 \text{ x } 10^7 \text{ m}^{-1} [-0.222222]$$

$$\frac{1}{\lambda} = -2438607 \text{ m}^{-1}$$

$$\lambda = -4.1007 \text{ x } 10^{-7} \text{ m}$$

$$-4.1007 \text{ x } 10^{-7} \text{ m x } \frac{1 \text{ x } 10^9 \text{ nm}}{1 \text{ m}} = -410.07 \text{ nm}$$

10. Using the equation from question #9, determine the initial and final states for:

a) emission of 97.20 nm 4 ➜ 1

b) absorption of 388.81 nm 2 ➜ 8