Name:___________

A Quest for Quantum

1. Match each definition or description with the best word

C	responsible for the "discovery" of the principle quantum number	A	absorption spectra
K	responsible for the discovery of the nucleus	B	Aufbau Principle
G	distinct wavelengths of light either emitted or absorbed (from a continuous spectra wavelength light source)	C	Bohr
H	no two electron may share the same set of all four quantum numbers, at least one quantum number must be different	D	emission spectra
I	gradual increase in photon energy can be used to determine the binding energy of an electron to metal atoms on the surface of a metal target	E	Heisenberg uncertainty principle
B	when electrons are added to a bare nucleus they will position themselves as close to the nucleus as possible	F	Hund's Rule
D	caused be multiple different combinations of $n_i \rightarrow n_f$ transitions such that $n_f < n_i$	G	line spectra
J	the energy contained in atoms is not continuous (any value possible), but instead exists as simple multiples of small discrete amounts of energy	H	Pauli Exclusion Principle
L	responsible for the discovery of the electron	I	photoelectric effect
A	can be observed whenever a continuous spectra light source is placed behind a gas phase sample of an element or compound or any combination there of	J	quantum hypothesis
F	electronic states that have the same value for n and l will fill one electron per m_l value first in order to reduce electron-electron repulsion	K	Rutherford
E	it is not possible to know both the position and momentum of any small particle	L	Thomson

2. Fill out the following table to show the possible quantum numbers in the first three princple energy levels for a one electron hydrogen. Be sure to use the Aufbau principle (as well as the Pauli exclusion principle)

n	l	m_l	m_s	# e^- per energy level	# e^- per energy shell
1	**0**	**0**	**-1/2**	**s**	**2**
1	**0**	**0**	**+1/2**		
2	**0**	**0**	**-1/2**	**s**	**2**
2	**0**	**0**	**+1/2**		
2	**1**	**-1**	**-1/2**	**p**	**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**	**s**	**2**
3	**0**	**0**	**+1/2**		
3	**1**	**-1**	**-1/2**	**p**	**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	**2**	**-2**	**-1/2**	**d**	**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**		

3. Do you know your quantum numbers?

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

4. For the second 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 (i.e what would the width of the "g" block be). 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.

- **if l = 4, then $m_l = \{-4,-3,-2,-1,0,+1,+2,+3,+4\}$ which is 9 possible values (i.e. m_l follows the pattern of 1,3,5,7,9,etc)**

- **for each m_l possibility, there are 2 possible m_s values i.e. $m_s = \{-½,+½\}$**

- **therefore 9 x 2 = 18 gives the width of the "g" block**

- **the "g" block cannot occur until n = 5 because the value of l must be less than the value of n (see above allowed values)**

5. Write the complete electron configuration for the newly discovered element, Breenium, symbol Bn. The atomic number of this element is 117, making it a member of the halogen group.

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

6. Complete the following table.

element	n	l	m_l	m_s	end of config.
Os	**5**	**2**	**0**	**+1/2**	$5d^6$
$_{56}$Ba	**6**	**0**	**0**	**+1/2**	**$6s^2$**
Y	4	2	−2	−1/2	**$4d^1$**
I	**5**	**1**	**+1**	**−1/2**	$5p^5$
$_{59}$Pr	**4**	**3**	**−2**	**−1/2**	**$4f^3$**
Np	5	3	−1	−1/2	**$5f^5$**
Lr	**6**	**2**	**−2**	**−1/2**	$6d^1$
$_{58}$Ce	**4**	**3**	**−3**	**+1/2**	**$4f^2$**
Tm	4	**3**	+3	−1/2	**$4f^{13}$**
Ho	**4**	**3**	**+2**	**−1/2**	$4f^{11}$

7. If m_s = −7/2, −5/2, −3/2, −1/2, 0, +1/2, +3/2, +5/2, +7/2 (in other words there are 9 possible values for m_s). Use this information to predict the width of the s,p,d and f block and then use this information to determine the entire width of the periodic table.

s ➜	1 (pos. m_l) x 9 (pos. m_s) = 9
p ➜	3 (pos. m_l) x 9 (pos. m_s) = 27
d ➜	5 (pos. m_l) x 9 (pos. m_s) = 45
f ➜	7 (pos. m_l) x 9 (pos. m_s) = 63
total ➜	144

8. The Rydberg constant is itself a combination of different constants. Use the constants listed to determine the correct value of the Rydberg constant. Then perform a complete unit analysis. Be sure to start with the format "units ="

$$R = \frac{-e^4 m}{8\varepsilon_o^2 h^3 c}$$

$e = 1.6022 \times 10^{-19}$ C (fundamental unit of charge)
$m = 9.110 \times 10^{-31}$ kg (resting mass of an electron)
$\pi = 3.1415926536$ (circumference / diameter for a circle)
$\varepsilon_o = 8.854 \times 10^{-12}$ $C^2N^{-1}m^{-2}$ (dielectric constant)
$h = 6.626 \times 10^{-34}$ Js (Planck's constant
$c = 3.00 \times 10^8$ ms^{-1} (speed of light)

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

$$R = \frac{-(1.6022\times10^{-19})^4\, 9.11\times10^{-31}}{8(8.854\times10^{-12})^2(6.626\times10^{-34})^3(3\times10^8)}$$

$R = 1.096833522 \times 10^7\ m^{-1}$

$$\text{units} = \frac{C^4\, kg}{(C^2N^{-1}m^{-2})^2(Js)^3\, ms^{-1}}$$

$$= \frac{C^4\, kg}{C^4 N^{-2} m^{-4} J^3 s^3\, m s^{-1}}$$

$$= \frac{Kg\, N^2\, m^3}{J^3\, s^2}$$

$$= \frac{\frac{Kg}{1} \times \left(\frac{Kg\, m}{s^2}\right)^2 \times \frac{m^3}{1}}{\left(\frac{kg\, m^2}{s^2}\right)^3 \left(\frac{s^2}{1}\right)}$$

$$= \frac{\frac{Kg}{1} \times \frac{Kg^2 m^2}{s^4} \times \frac{m^3}{1}}{\frac{Kg^3 m^6}{s^6} \times \frac{s^2}{1}}$$

$$= \frac{\frac{Kg^3 m^5}{s^4}}{\frac{Kg^3 m^6}{s^4}}$$

$$= \frac{Kg^3 m^5}{s^4} \times \frac{s^4}{Kg^3 m^6}$$

$$= \frac{1}{m}$$

$$= m^{-1}$$

9.

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

Show a calculation for the ninth line in the Balmer series. Show your calculation for a situation in which the atom absorbs the energy of an incoming photon. Show either a separate conversion to express your final answer in nanometers (1 x 10^9 nm = 1 m) OR a conversion factor that adjusts the unit in the above equation to nm^{-1}. Be sure to use proper format for all parts of this question.

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

$$\frac{1}{\lambda} = 1.09737 \text{ x } 10^7 \text{ m}^{-1} \left[\left(\frac{1}{2^2} \right) - \left(\frac{1}{11^2} \right) \right]$$

$$\frac{1}{\lambda} = 1.09737 \text{ x } 10^7 \text{ m}^{-1} [0.24173]$$

$$\frac{1}{\lambda} = 2652733 \text{ m}^{-1}$$

$$\lambda = 3.7697 \text{ x } 10^{-7} \text{ m}$$

$$3.7697 \text{ x } 10^{-7} \text{ m x } \frac{1 \text{ x } 10^9 \text{ nm}}{1 \text{ m}} = 376.97 \text{ nm}$$

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

a) emission of 97.20 nm
b) absorption of 1944.04 nm
c) absorption of 396.91 nm
d) emission of 1004.67 nm

wavelength	emitted or absorbed	n_i	n_f
97.20 nm	emitted	4	1
1944.04 nm	absorbed	4	8
396.91 nm	absorbed	2	7
1004.67 nm	emitted	7	3