Name:________________

Quest of Quantum - A Discrete form of Test! - SCH 4U

ANSWER USING POINT FORM AS MUCH AS POSSIBLE - DO NOT USE SENTENCES!!!!

1. What does the first principle quantum number explicitly tell you about the orbiting electron (why are the allow values whole numbers only)!

   - **the number of deBroglie wavelengths for the standing wave pattern of the orbiting electron**

   - **wavelengths must be complete wavelengths, therefore only a whole number of wavelengths is allowed (cannot have a fraction of a wavelength)**

2. What is the Pauli Exclusion Principle? Give an example of how this works.

   - **no two electrons can have all four quantum numbers the same**

   - **for two electrons with the same value for n, l and m_l, the spin value (m_s) must be different (i.e. −1/2 or +1/2)**

3. In the photoelectric effect, X-rays are shone on the surface of a metal. If one starts with lower energy X-rays and gradually increases the energy of the X-rays at some point a threshold value is reached and electrons become freed (or ejected) from the surface of the metal. This threshold value is representative of how strongly the metal atoms attract their bonding electrons. If an X-rays of greater energy than this threshold value is used, what happens to the excess energy above the threshold value?

   - **shows up as kinetic energy in the ejected electron**

4. What is the Heisenberg Uncertainty Principle?

   - **it is not possible to know both the position and the momentum of a given particle to an accurate degree**

5. 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 wavelength**
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.**

6. With reference to all four quantum numbers explain why the p-block is 6 elements wide, and why there is no such thing as a $1p^4$ element.

- **for the p-block, l=1 therefore there are 3 different m_l values ➔ $\{m_l \in I \mid -1 \le m_l \le 1\}$**
- **each m_l value in turn can have 2 m_s values $\{m_s \in R \mid m_s = \pm 1/2\}$**
- **$\{-1, 0, +1\} \times \{-½, +½\}$ ➔ $3 \times 2 = 6$**
- **n must be 2 or more because l must be less than n $\{l \in I \mid 0 \le l < n\}$**

7. How wide would the periodic table be (compared to our 32 element wide version) if the allowed values for m_l were given as follows:

$$\{m_l \in I \mid -(l+1) \le m_l \le (l+1)\}$$

s (l=0) ➔	**(m_l = −1,0,+1)**	**x (m_s = ±½)**	**6**
p (l=1) ➔	**(m_l = −2,−1,0,+1,+2)**	**x (m_s = ±½)**	**10**
d (l=2) ➔	**(m_l = −3,−2,−1,0,+1,+2,+3)**	**x (m_s = ±½)**	**14**
f (l=3) ➔	**(m_l = −4,−3,−2,−1,0,+1,+2,+3,+4)**	**x (m_s = ±½)**	**18**
		TOTAL ➔	**48**

8. Write the complete electron configuration for Hendersonium, element number 120 (a new member of the alkaline earth metal group)!

$1s^2$
$2s^2$ $2p^6$
$3s^2$ $3p^6$
$4s^2$ $3d^{10}$ $4p^6$
$5s^2$ $4d^{10}$ $5p^6$
$6s^2$ $4f^{14}$ $5d^{10}$ $6p^6$
$7s^2$ $5f^{14}$ $6d^{10}$ $7p^6$
$8s^2$

9. Complete this table:

element symbol	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**	$4f^{14}$

10. Complete to show all quantum numbers in accordance with the Aufbau principle

n	l	m_l	m_s	orbital type (use letter notation)	# e^- per energy level	# e^- per energy shell
1	**0**	**0**	**−1/2**	**s**	**2**	**2**
1	**0**	**0**	**+1/2**			
2	**0**	**0**	**−1/2**	**s**	**2**	**8**
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**	**18**
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	**1**	**−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**			

11. 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

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

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

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

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

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

$= m$

12.

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

Look! What light through yonder spectroscope duth break! Is it Thorium? Is excited Gadolinium? No of course not, it is the eighth line in the Balmer Series of Hydrogen. And what is the wavelength of yonder light? To figure that out, show a calculation for the appropriate transition. Remember that the Balmer series is the second major series (Lyman, Balmer, Paschen, Brackett, Pfund). Show a separate conversion to express your final answer in nanometers ($1 \text{ x } 10^9$ nm = 1 m).

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

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

$$\frac{1}{\lambda} = 1.09737 \text{ x } 10^7 \text{ m}^{-1} \left[-0.24\right]$$

$$\frac{1}{\lambda} = -2633696 \text{ m}^{-1}$$

$$\lambda = -3.7970 \text{ x } 10^{-7} \text{ m}$$

$$-3.7970 \text{ x } 10^{-7} \text{ m x } \frac{1 \text{ x } 10^9 \text{ nm}}{1 \text{ m}} = -3.7970 \text{ nm}$$

13. Guess what the value of n_i and n_f are for and state the series that this set of n values belongs to (see last question for ideas):

wavelength	emitted or absorbed	n_i	n_f	series
376.97 nm	emitted	**11**	**2**	**Balmer**
1093.52 nm	absorbed	**3**	**6**	**Paschen**
91.127 nm	emitted	**∞**	**1**	**Lyman**