Name:________________

Quest for Quantum

(i.e. a quiz that is larger than a quiz, but smaller than a test, hence a quest, which is a search for something)

1. Provide the name of the concept that is outlined by each point:

a) In an experiment it is not possible to know both the location and momentum of a particle with a high degree of accuracy. One could know the momentum or the location, but not both at the same time

Heisenberg Uncertainty Principle

b) Looks like a continuous spectra with dark lines through it. Results when atoms located between a continuous light source and the point of spectal observation, interact with the continuous light source. Very useful in astromony.

Absorption Spectra

c) For a given atom, it is not possible that all four quantum numbers be the same. This would mean that the electrons being described are exactly the same and therefore must occupy the exact same space (not possible).

Pauli Exclusion Principle

d) If one shines photons on the surface of a metal, and gradually increases the energy of the photons, an energy is reached when the metal will start to emit electrons. This energy of the photon at this point is known as the threshold value for the given metal. If photons of greater energy are used, the energy difference between the photon and the threshold value will show up as extra kinetic energy in the electron.

Photoelectric Effect

e) When analyzing the light emitted by a sodium vapour lamp (the type of street light that make the pleasant orange colour) two very prominent spectral lines can be observed in the orange-yellow portion of the electromagetic spectrum.

Emission Spectra

f) The fellow who first suggested the existence of the nucleus.

Ernst Rutherford

2. Fill out the following table to show the possible quantum numbers in the first three principle energy levels for a one electron hydrogen atom. Be sure to use the Aufbau principle and the Pauli exclusion principle to help organize your answer.

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**		

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**
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. Suppose that the laws of physics were different in our universe and that the periodic table was exact half as wide as the one that we all know and love (and hence had only half the elements). Based on your knowledge of quantum numbers, what is likely to be the difference in this supposed universe? Explain (point form is good).

either m_s has only one value or there is no m_s quantum number

both possibilities would make each block (s,p,d,f) half as wide (i.e. there would not be a an m_s = –½ and m_s = +½ for each m_l value , hence the periodic table would be l

5. Demonstrate a working knowledge of how allowed values work by explaining why the f-block is 14 columns long and cannot appear until n ≥ 4. Make reference to **all four** quantum numbers. Use point form.

- **for the f-block, l=3 therefore there are 7 different m_l values**
- **each m_l value in turn can have 2 m_s values**
- **{-3,-2,-1,0,1,2,3} x {–½, +½} ➔ 7 x 2 = 14**
- **n must be 4 or more because l must be less than n**

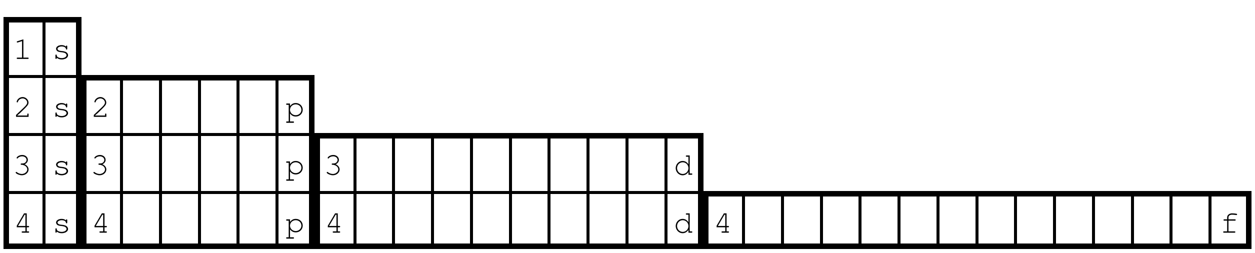
6. Write the complete electron configuration for the newly discovered element, Cruickshankium, symbol Crk. The atomic number of this element is 115, making it a relative of nitrogen.

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

7. Complete the following table. The first line is done as an example:

Element Symbol	n	l	m_l	m_s	Electon Configutration Ending
$_{56}$Ba	6	0	0	+1/2	$6s^2$
$_{21}$Sc	**3**	**2**	**−2**	**−1/2**	$3d^1$
$_{50}$Sn	**5**	**1**	**−1**	**+1/2**	**$5p^2$**
(odd) **Ir**	5	2	+1	**−1/2**	**$5d^7$**
$_{89}$Ac	**5**	**3**	**−3**	**−1/2**	**$5f^1$**
$_{89}$Ac	5	**3**	−3	−1/2	**$5f^1$**
H	1	0	0	−1/2	**$1s^1$**
Crk	7	1	0	−1/2	**$7p^3$**
$_{103}$Lr	**6**	**2**	**−2**	**−1/2**	**$6d^1$**

8. Suggest a possible shape for the periodic table if electrons did not repel each other. In other words, what would the electron filling arrangement and hence periodic table shape look like if electron-electron repulsions had no effect on relative electron energy.



9. The Rydberg constant is itself a combination of different constants.

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

Using the constants listed below, the value of R works out to be 1.0963 x 10^7 m^{-1}, where m^{-1} is reciprocal meters (not the resting mass of an electron). Perform a complete unit analysis to prove that the unit for R is indeed m^{-1}. Be sure to start with the format "units ="

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

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

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

$$R = 1.096833522\times10^7\ m^{-1}$$

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

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

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

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

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

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

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

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

$$= m^{-1}$$

10.

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

Look what light through yonder window duth break! Is it the sun? Is it the moon? No of course not, it is the fourth line in the Paschen 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 Paschen Series is the third major series (after Lyman and Balmer). Show a separate conversion to express your final answer in nanometers ($1 \text{ x } 10^9$ nm = 1 m).

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

$$\frac{1}{\lambda} = 1.09737 \text{ x } 10^{7} \text{ m}^{-1}\left[\left(\frac{1}{7^2}\right) - \left(\frac{1}{3^2}\right)\right]$$

$$\frac{1}{\lambda} = 1.09737 \text{ x } 10^{7} \text{ m}^{-1}\left[-0.090702947\right]$$

$$\frac{1}{\lambda} = -995346 \text{ m}^{-1}$$

$$\lambda = -1.0047 \text{ x } 10^{-6} \text{ m}$$

$$-1.0047 \text{ x } 10^{-6} \text{ m x } \frac{1 \text{ x } 10^{9} \text{ nm}}{1 \text{ m}} = -1004.67 \text{ nm}$$

11. Guess what the value of n_i and n_f are for:

wavelength	emitted or absorbed	n_i	n_f
92.27 nm	absorbed	**1**	**9**
388.81 nm	emitted	**8**	**2**
1874.61 nm	emitted	**4**	**3**