**Chemistry Unit 4 Atomic Structure Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Quantum Numbers Worksheet Period: \_\_\_\_**

Quantum mechanics describes the motions of electrons using *atomic* *orbitals*.

Orbitals gives us information about the *probability* of an electron being in a particular place around the nucleus. Orbitals have different shapes and sizes, depending on the energy of the electron.

To understand how orbitals work, we use *quantum numbers*. Each electron has a set of four quantum numbers, each describing a certain property. There are four quantum numbers:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Quantum Number** | **Name** | **Allowed Values** | **Determines** | **Specifies** | **Common labels** |
| **n** | Principle | 1, 2, 3, 4….. | Size and Energy | Shell | 1,2,3,4…  (Period #) |
| ***l*** | Angular Momentum | 0, 1, 2… (only up to n-1) | Shape | Subshell | s, p, d, f |
| **m*l*** | Magnetic |  | Orientation | Orbital (also # orbitals in subshell) | Subscripts (x, y, z, xy, yz etc… |
| **ms** | Spin | +½ or -½ | Spin | Electron | Up ↑, Down ↓ |

* *l*  = 0 means an ***s* subshell** = **1 sphere** **shape**
* *l*  = 1 means a ***p* subshell = 2 lobe dumbbell shape**
* *l* = 2 means a ***d* subshell = 4 lobe clover shape or dumbbell with a donut**
* *l* = 3 means an ***f* subshell** = **8 or 6 lobe shape or dumbbell with double donuts**

1. Sketch a) an *s* orbital, b) a *p* orbital, c) a *dz2* orbital and d) a typical *d* orbital.

1. Which quantum number identifies the shape of an orbital?
2. For each value of *n* = 1, 2, and 3, what are the possible values for *l*, and what labels correspond to these orbitals?

|  |  |  |
| --- | --- | --- |
| ***n*** | **Possible *l* values** | **Possible subshell labels** |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4, 5… |  |  |

1. For each value of *l* = 0, 1, 2, what are the possible values for *ml*? For each value of *l*, how many values can *ml* have? Complete the first 3 columns in the table below.
2. Complete the 4th column in the table below.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ***l*** | **Possible *ml* values** | **Number of values of *ml*** | **Number of orbitals** | **Maximum number of electrons** |
| 0  *s* |  |  |  |  |
| 1  *p* |  |  |  |  |
| 2  *d* |  |  |  |  |
| 3  *f* |  |  |  |  |

6. How many electrons can each of the following hold? Explain your answer by listing the orbitals involved.

a) The *n* = 2 shell.

b) The *3p* subshell.

c) The *4s* orbital.

d) The *4d* subshell.

7. For each of the following sets of four quantum numbers (*n, l, ml*, *ms*) decide if the values are allowed or prohibited. If they are prohibited explain which number(s) is/are not valid.

a) 1, 1, 1, +1/2

b) 1, 0, 0, -1/2

c) 3, -2, 0, -1/2

d) 3, 1, 0, +1/2

e) 2, 1, -1, +1/2