

Quantum Numbers

Ck12 Science

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CHAPTER

1

Quantum Numbers

- Define the four quantum numbers.
- Determine quantum numbers for specific electrons when given appropriate data.



Can you guess how many people are in this stadium?

If you attend a college or professional football game, you need a ticket to get in. It is very likely that your ticket may specify a gate number, a section number, a row, and a seat number. No other ticket can have the same four parts to it. It may have the same gate, section, and seat number, but it would have to be in a different row. Each seat is unique and allows only one occupant to fill it.

Quantum Numbers

We use a series of specific numbers, called **quantum numbers**, to describe the location of an electron in an associated atom. Quantum numbers specify the properties of the atomic orbitals and the electrons in those orbitals. An electron in an atom or ion has four quantum numbers to describe its state. Think of them as important variables in an equation which describes the three-dimensional position of electrons in a given atom.

Principal Quantum Number

The **principal quantum number**, signified by (n), is the main energy level occupied by the electron. Energy levels are fixed distances from the nucleus of a given atom. They are described in whole number increments (e.g., 1, 2, 3, 4, 5, 6, ...). At location $n = 1$, an electron would be closest to the nucleus, while $n = 2$ the electron would be farther, and $n = 3$ farther yet. As we will see, the principal quantum number corresponds to the row number for an atom on the periodic table.

Angular Momentum Quantum Number

The **angular momentum quantum number**, signified as (l), describes the general shape or region an electron occupies –its orbital shape. The value of l depends on the value of the principle quantum number n . The angular momentum quantum number can have positive values of zero to $(n - 1)$. If $n = 2$, l could be either 0 or 1.

Magnetic Quantum Number

The **magnetic quantum number**, signified as (m_l), describes the orbital orientation in space. Electrons can be situated in one of three planes in three dimensional space around a given nucleus (x, y , and z). For a given value of the angular momentum quantum number l , there can be $(2l + 1)$ values for m_l . As an example:

$$n = 2$$

$$l = 0 \text{ or } 1$$

$$\text{for } l = 0, m_l = 0$$

$$\text{for } l = 1, m_l = -1, 0, +1$$

TABLE 1.1: Principal Energy Levels and Sublevels

Principal energy level	Number of possible sub-levels	Possible Angular Momentum Quantum Numbers	Orbital Designation by Principal Energy Level and Sublevel
$n = 1$	1	$l = 0$	1s
$n = 2$	2	$l = 0$ $l = 1$	2s 2p
$n = 3$	3	$l = 0$ $l = 1$ $l = 2$	3s 3p 3d
$n = 4$	4	$l = 0$ $l = 1$ $l = 2$ $l = 3$	4s 4p 4d 4f

Table 1.1 shows the possible magnetic quantum number values (m_l) for the corresponding angular momentum quantum numbers (l) of $l = 0$, $l = 1$, $l = 2$, and $l = 3$.

Spin Quantum Number

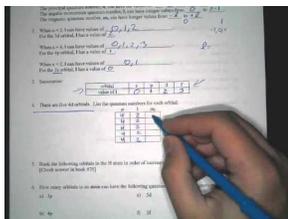
The **spin quantum number** describes the spin for a given electron. An electron can have one of two associated spins, $(+\frac{1}{2})$ spin, or $(-\frac{1}{2})$ spin. An electron cannot have zero spin. We also represent spin with arrows \uparrow or \downarrow . A single orbital can hold a maximum of two electrons and each must have opposite spin.

Summary

- Quantum numbers specify the arrangements of electrons in orbitals.
- There are four quantum numbers that provide information about various aspects of electron behavior.

Practice

Watch the video, pause at each question and try to calculate the quantum number before you see the answer written in. Do not try to answer the orbital questions, just the quantum number ones.



MEDIA

Click image to the left for more content.

<http://www.youtube.com/watch?v=DvlfMO3QIQw>

Review

Questions

1. What do quantum numbers do?
2. What is the principal quantum number?
3. What does the spin quantum number represent?

- **angular momentum quantum number (l):** Describes the general region occupied by the electron.
- **magnetic quantum number (m):** Describes the orbital orientation of the electron in space.
- **principal quantum number (n):** Specifies the main energy level occupied by the electron.
- **quantum numbers:** Describe the location of an electron in an atom.
- **spin quantum number (m_s):** Describes the spin for a given electron.

References

1. Enoch Lai. http://commons.wikimedia.org/wiki/File:Texas_Memorial_Stadium.jpg .