Name _____ Date _____ Class _____

CHAPTER 5 CHALLENGE PROBLEMS

Quantum Numbers

Use with Chapter 5, Section 5.2

The state of an electron in an atom can be completely described by four quantum numbers, designated as n, ℓ, m_ℓ, and m_s. The first, or principal, quantum number, n, indicates the electron's approximate distance from the nucleus. The second quantum number, ℓ, describes the shape of the electron's orbit around the nucleus. The third quantum number, m_ℓ, describes the orientation of the electron's orbit compared to the plane of the atom. The fourth quantum number, m_s, tells the direction of the electron's spin (clockwise or counterclockwise).

The Schrödinger wave equation imposes certain mathematical restrictions on the quantum numbers. They are as follows:

n can be any integer (whole number),

ℓ can be any integer from 0 to $n - 1$,

m_ℓ can be any integer from $-\ell$ to $+\ell$, and

m_s can be $+\frac{1}{2}$ or $-\frac{1}{2}$

As an example, consider electrons in the first energy level of an atom, that is, $n = 1$. In this case, ℓ can have any integral value from 0 to $(n - 1)$, or 0 to $(1 - 1)$. In other words, ℓ must be 0 for these electrons. Also, the only value that m_ℓ can have is 0. The electrons in this energy level can have values of $+\frac{1}{2}$ or $-\frac{1}{2}$ for m_s. These restrictions agree with the observation that the first energy level can have only two electrons. Their quantum numbers are 1, 0, 0, $+\frac{1}{2}$ and 1, 0, 0 $-\frac{1}{2}$.

Use the rules given above to complete the table listing the quantum numbers for each electron in a boron atom. The correct quantum numbers for one electron in the atom is provided as an example.

Boron (B)				
Electron	n	ℓ	m_ℓ	m_s
1	1	0	0	$+\frac{1}{2}$
2				
3				
4				
5				

Name _____ Date _____ Class _____

CHAPTER 6 CHALLENGE PROBLEMS

Döbereiner's Triads

Use with Chapter 6, Section 6.2

One of the first somewhat successful attempts to arrange the elements in a systematic way was made by the German chemist Johann Wolfgang Döbereiner (1780–1849). In 1816, Döbereiner noticed that the then accepted atomic mass of strontium (50) was midway between the atomic masses of calcium (27.5) and barium (72.5). Note that the accepted atomic masses for these elements today are very different from their accepted atomic masses at the time Döbereiner made his observations. Döbereiner also observed that strontium, calcium, and barium showed a gradual gradation in their properties, with the values of some of strontium's properties being about midway between the values of calcium and barium. Döbereiner eventually found four other sets of three elements, which he called triads, that followed the same pattern. In each triad, the atomic mass of the middle element was about midway between the atomic masses of the other two elements. Unfortunately, because Döbereiner's system did not turn out to be very useful, it was largely ignored.

Had Döbereiner actually discovered a way of identifying trends among the elements? Listed below are six three-element groups in which the elements in each group are consecutive members of the same group in the periodic table. The elements in each set show a gradation in their properties. Values for the first and third element in each set are given. Determine the missing value in each set by calculating the average of the two given values. Then, compare the values you obtained with those given in the *Handbook of Chemistry and Physics*. Record the actual values below your calculated values. Is the value of the property of the middle element in each set midway between the values of the other two elements in the set?

_____

_____

Set 1	
Element	**Melting Point (°C)**
Fluorine	−219.6
Chlorine	Calculated:
	Actual:
Bromine	−7.2

Set 2	
Element	**Atomic Mass**
Lithium	6.941
Sodium	Calculated:
	Actual:
Potassium	39.098

Set 3	
Element	**Boiling Point (°C)**
Magnesium	1107
Calcium	Calculated:
	Actual:
Strontium	1384

Set 4	
Element	**Boiling Point (°C)**
Krypton	−153
Xenon	Calculated:
	Actual:
Radon	−62

Set 5	
Element	**Melting Point (°C)**
Germanium	937
Tin	Calculated:
	Actual:
Lead	327

Set 6	
Element	**Boiling Point (°C)**
Beryllium	1285
Magnesium	Calculated:
	Actual:
Calcium	851