Name _____ Class _____ Date _____

Quantum Numbers and Atomic Orbitals

Section Review 4.2

DIRECTIONS: Write on the line at the right of each statement the letter preceding the word or expression that best completes the statement.

1. How many quantum numbers are used to describe the energy state of an electron in an atom? (a) 1 (b) 2 (c) 3 (d) 4 _____ 1
2. A spherical electron cloud surrounding an atomic nucleus would best represent (a) an *s* orbital; (b) a p_x orbital; (c) a combination of p_x and p_y orbitals; (d) a combination of an *s* and a p_x orbital. _____ 2
3. The letter designations for the first four orbital quantum numbers with the number of electrons per orbital at each sublevel are (a) *s*:1, *p*:3, *d*:10, and *f*:14; (b) *s*:1, *p*:3, *d*:5, and *f*:7; (c) *s*:2, *p*:6, *d*:10, and *f*:14, (d) *s*:1, *p*:2, *d*:3, and *f*:4. _____ 3
4. The number of possible orbital shapes for the third energy level is (a) 1; (b) 2; (c) 3; (d) 4. _____ 4
5. The maximum number of electrons that can occupy the *s* orbitals at each energy level is (a) two, if they have opposite spins; (b) two, if they have the same spin; (c) one; (d) no more than eight. _____ 5
6. The spin quantum number indicates that the number of possible orientations for an electron in an orbital is (a) 1; (b) 2; (c) 3; (d) 5. _____ 6
7. The values $+\frac{1}{2}$ and $-\frac{1}{2}$ specify an electron's (a) charge; (b) main energy level; (c) speed; (d) possible orientation in an orbital. _____ 7
8. When *n* represents the principal quantum number of an energy level, the number of electrons per energy level is (a) *n*; (b) 2*n*; (c) n^2; (d) $2n^2$. _____ 8
9. At $n = 1$, the total number of electrons that could be found is (a) 1; (b) 2; (c) 6; (d) 18. _____ 9

DIRECTIONS: Write on the line at the right of each statement the word or expression that best completes the meaning when substituted for the corresponding number.

10. The quantum number that indicates the position of an orbital about the three axes in space is the __(10)__ quantum number. _____ 10
11. The __(11)__ orbitals are dumbbell-shaped and directed along the x, y, and z axes. _____ 11
12. The number of different sublevels within each energy level of an atom is equal to the value of the __(12)__ quantum number. _____ 12
13. There are __(13)__ orbitals for the *d* sublevel. _____ 13
14. __(14)__ electrons are needed to completely fill the fourth energy level. _____ 14
15. A particular main energy level can hold 18 electrons. In this case, *n* equals __(15)__ . _____ 15

Name _____ Date _____ Class _____

 Text Reference: **Section 13-11**

Quantum Mechanics and Electron Configurations

Choose words from the list to fill in the blanks in the paragraphs.

Word List

classical mechanics	orbitals
de Broglie	principal quantum number
electron configuration	probability
energy level	quantum mechanics
excited state	radiation
ground state	spectrum
Heisenberg	uncertainty principle
Newton	valence shell

The term __(1)__ refers to the laws of motion that were worked out by the 17th-century English scientist __(2)__. A mathematical description of the behavior of electrons inside the atom, developed during the 1920s, is called __(3)__. This theory of electron behavior was based in part on the theory, proposed by __(4)__, that particles can have wave-like properties. Then, in 1927, __(5)__ proposed, in his __(6)__, that it is impossible to know simultaneously both the precise location and the precise velocity of an electron. One can state only the __(7)__ or chance of finding an electron at a particular place at a particular time.

Letters and numbers are used to identify the energy level of an electron in an atom. The symbol n stands for the __(8)__. Each energy level represented by n has sublevels indicated by the letters, s, p, d, and f. Each such sublevel contains one or more __(9)__, which are regions of space in which an electron of a certain energy may be found.

The lowest energy state of an atom is called its __(10)__. The outermost principal energy level is called the __(11)__. Atoms are said to be in a(n) __(12)__ when one or more electrons are in a(n) __(13)__ higher than the ground state. When an electron in an excited atom falls to a lower energy level, __(14)__ is emitted whose energy is equal to the energy difference between the higher and lower energy levels. When the radiation emitted is visible, a line of color will appear in the __(15)__ of the element. The arrangement of the electrons in the various levels and sublevels of an atom may be written out in the form of a(n) __(16)__.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____

Name _____
Date _____
Per. _____

The charge cloud model

Refinements in the analysis of emission spectra provided for improvements in the model of the atom. The result is a probability plot of electron location. These plots are called orbitals. The charge cloud model is sometimes called the orbital model.

9. According to the charge cloud model, electrons are arranged in _____, _____, and orbitals.

10. When the energy level is identified by the principal quantum number, *n*,
    a. the number of sublevels in that energy level is equal to _____.
    b. the number of orbitals in that energy level is equal to _____.
    c. the electron capacity of that energy level is equal to _____.

11. a. What letters are used to identify the first four energy sublevels? _____, _____, _____, _____
    b. What is the number of orbitals in each of these sublevels? _____, _____, _____, _____

12. What is the electron capacity of any orbital? _____

13. What is the difference between two electrons in different energy levels of the same atom?

_____

_____

_____

14. What is the difference between two electrons in different sublevels of the same energy level in the same atom? _____

_____

_____

15. What is the difference between two electrons that occupy the same orbital in the same atom?

_____

_____

_____

Write the notation that gives the ~~electron configuration~~ orbital diagram of each of the following.

16. $_{8}O$ _____

17. $_{23}V$ _____

18. $_{20}Ca$ _____

For the atoms indicated below, complete the orbital diagrams given. Use a single arrow ↑ to represent an unpaired electron. Use a double arrow ↑↓ to represent a pair of electrons with opposite spins.

	1s	2s	2p	3s	3p	3d	4s	4p
19. $_{12}Mg$	☐	☐	☐☐☐	☐	☐☐☐	☐☐☐☐☐	☐	☐☐☐
20. $_{33}As$	☐	☐	☐☐☐	☐	☐☐☐	☐☐☐☐☐	☐	☐☐☐
21. $_{28}Ni$	☐	☐	☐☐☐	☐	☐☐☐	☐☐☐☐☐	☐	☐☐☐

Name _____ Date _____ per. _____

Worksheet II: (Cont'd) Electron Configurations and Notations

Symbol	Atomic Number	Orbital Notation (1s 2s 2p x y z 3s 3p 3d 4s 4p)	Electron-dot Notation
H	1		
He	2		
Li	3		
Be	4		
B	5		
C	6		
N	7		
O	8		
F	9		
Ne	10		
Na	11		
Mg	12		
Al	13		
Si	14		
P	15		
S	16		
Cl	17		
Ar	18		
K	19		
Ca	20		
Sc	21		
Ti	22		
V	23		
Cr	24		
Mn	25		
Fe	26		
Co	27		
Ni	28		
Cu	29		
Zn	30		
Ga	31		

Name _____ Date _____ Class _____

Chapter 6

RETEACHING

ELECTRON CONFIGURATIONS

Atoms are made of protons, electrons, and neutrons. The atomic number of an element indicates the number of protons in the nucleus of each atom of the element, as well as the number of electrons in the atom. Different numbers of electrons fill different energy sublevels within an atom. Each *s* sublevel can hold a maximum of two electrons. Each *p* sublevel can hold up to six electrons. Each *d* sublevel can hold up to ten electrons. Each *f* sublevel can hold a maximum of 14 electrons. Electrons are placed into orbitals and energy levels in a definite filling order; 1*s*, then 2*s*, then 2*p*, and so on, as shown by the arrow diagram you studied in an earlier chapter.

Electron configurations reveal the number of electrons in each sublevel at each energy level. For example, lithium, with three electrons, has the configuration $1s^2 2s^1$.

Answer the following questions.

1. Write the electron configurations for the elements that have the following atomic numbers:
   a. 8 _____
   b. 10 _____
   c. 19 _____
   d. 26 _____
   e. 39 _____
   f. 48 _____

2. Complete the table below given the electron configurations shown.

Electron configuration	Group	Period	Metal, nonmetal, or metalloid	Number of electrons	Name
$1s^2 2s^2 2p^1$					
$1s^2 2s^2$					
$1s^2 2s^2 2p^6 3s^1$					
$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^3$					
$1s^2 2s^2 2p^6 3s^2 3p^5$					

Name _____ Class _____ Date _____

Electron Configurations

Section Review 4.3

DIRECTIONS: Write on the line at the right of each statement the letter preceding the word or expression that best completes the statement.

1. The correct sequence in ascending energies of atomic sublevels is (a) $4d$, $5s$, $5p$, $6s$; (b) $5s$, $4d$, $5p$, $6s$; (c) $5s$, $4d$, $6s$, $5p$; (d) $5s$, $5p$, $4d$, $6s$. _____ 1
2. The statement that an electron occupies the lowest energy orbital that can receive it is (a) Hund's rule; (b) the Aufbau principle; (c) Bohr's law; (d) the Pauli exclusion principle. _____ 2
3. In the correct electron-dot notation for the phosphorus atom (atomic number 15), the symbol P is surrounded by (a) two pairs of dots and a single dot; (b) three pairs of dots and a single dot; (c) one pair of dots and three single dots; (d) two pairs of dots. _____ 3
4. The electron-configuration notation for scandium (atomic number 21) would show the three highest energy electrons to have the notation (a) $3d^1 4s^2$; (b) $4s^2$; (c) $3d^3$; (d) $4s^2 4p^1$. _____ 4
5. The element with the electron-configuration notation $1s^2 2s^2 2p^6 3s^2 3p^2$ is (a) Mg ($z = 12$); (b) P ($z = 15$); (c) S ($z = 16$); (d) Si ($z = 14$). _____ 5
6. In the correct electron-dot notation for sulfur (atomic number 16), the symbol S is surrounded by (a) three pairs of dots; (b) two pairs of dots and two single dots; (c) four single dots; (d) two pairs of dots. _____ 6
7. If the highest main energy level of an atom has the s and p orbitals filled with electrons, it is said to have a(n) (a) electron pair; (b) octet; (c) ellipsoid; (d) circle. _____ 7
8. The noble gas configuration is an outer main energy level fully occupied by (a) 32 electrons; (b) 8 electrons; (c) 2 electrons; (d) 64 electrons. _____ 8

DIRECTIONS: Complete the following statements, forming accurate sentences.

9. The atomic sublevel with the next highest energy after $4p$ is _____. 9
10. "Orbitals of equal energy are each occupied by one electron before any one orbital is occupied by a second electron and all electrons in singly occupied orbitals must have the same spin" is a statement of _____. 10
11. The electron-dot notation for an element in the third period is represented by a symbol surrounded by a pair of dots and a single dot. The complete electron configuration for this element is $1s^2 2s^2 2p^6$ _____. 11
12. The electron configuration for the carbon atom (C) is $1s^2 2s^2 2p^2$. The atomic number of carbon is _____. 12
13. The electron-configuration notation for the element with atomic number 11 is _____. 13
14. The number of electrons in the highest energy level of the argon atom (atomic number 18) is _____. 14
15. An element with eight electrons in its outermost main energy level is called a(n) _____. 15

Name _____ Date _____ Class _____

Writing Electron Configurations

The filling order for electrons in energy sublevels is:

$1s, 2s, 2p, 3s, 3p, 4s, 3d, 4p, 5s, 4d,$
$5p, 6s, 4f, 5d, 6p, 7s, 5f, 6d, 7p$

Each s sublevel contains 1 orbital; each p contains 3; each d contains 5; and each f contains 7. Each orbital can contain at most 2 electrons.

An electron configuration can be written out by assigning electrons to the sublevels in the order listed, until the number of electrons assigned equals the atomic number *(N)* of the atom.

Examples

Determine the configurations of these elements.

Beryllium ($N = 4$)	$1s^2 2s^2$
Aluminum ($N = 13$)	$1s^2 2s^2 2p^6 3s^2 3p^1$
Bromine ($N = 35$)	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^5$

Write the electron configuration for each of the following elements.

1. Calcium ($N = 20$)	**1.** _____
2. Lithium ($N = 3$)	**2.** _____
3. Argon ($N = 18$)	**3.** _____
4. Iron ($N = 26$)	**4.** _____
5. Sodium ($N = 11$)	**5.** _____
6. Oxygen ($N = 8$)	**6.** _____
7. Iodine ($N = 53$)	**7.** _____
8. Dysprosium ($N = 66$)	**8.** _____
9. Radium ($N = 88$)	**9.** _____
10. Fermium ($N = 100$)	**10.** _____

Worksheet II: Electron Configurations and Notations

Symbol	Atomic Number	Electrons in Energy Levels					Electron-configuration Notation
		1	2	3	4	5	
H	1						
He	2						
Li	3						
Be	4						
B	5						
C	6						
N	7						
O	8						
F	9						
Ne	10						
Na	11						
Mg	12						
Al	13						
Si	14						
P	15						
S	16						
Cl	17						
Ar	18						
K	19						
Ca	20						
Sc	21						
Ti	22						
V	23						
Cr	24						
Mn	25						
Fe	26						
Co	27						
Ni	28						
Cu	29						
Zn	30						
Ga	31						

Mr. Stone

Name_____

Date_____

Period_____

ELECTRON CONFIGURATIONS / VALENCE ELECTRONS WORKSHEET

Write both the simplified electron configuration notation + shorthand notations, and indicate the number of valence electrons for each of the following elements:

	#of valence electrons	Lewis Dot Diagram
1. $_{11}Na$	_____	_____
2. $_{37}Rb$	_____	_____
3. $_{87}Fr$	_____	_____
4. $_{20}Ca$	_____	_____
5. $_{38}Sr$	_____	_____
6. $_{56}Ba$	_____	_____
7. $_{42}Mo$	_____	_____

Lewis Dot Diagram

8. $_{76}Os$

9. $_{30}Zn$

10. $_{48}Cd$

11. $_{84}Po$

12. $_{10}Ne$

13. $_{18}Ar$

14. $_{36}Kr$

15. $_{54}Xe$

16. $_{86}Rn$

17. $_{17}Cl$

18. $_{35}Br$

19. $_{29}Cu$

20. $_{24}Cr$

Name _____ Date _____ Class _____

4–5 Practice Problems

1. Write out the electron configurations for (a) potassium and (b) cobalt. How many unpaired electrons does each possess?

2. Which element has the following electron configuration: $1s^2 2s^2 2p^3$?

3. Write out the electron configurations for (a) silicon and (b) lithium. How many unpaired electrons does each possess?

4. Which element has the following electron configuration: $1s^2 2s^2 2p^6 3s^2 3p^3$?

5. Write out the electron configurations for (a) iridium and (b) selenium. How many unpaired electrons does each possess?

6. Which element has the following electron configuration: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^1$?

7. Write out the electron configurations for (a) bismuth and (b) vanadium. How many unpaired electrons does each possess?

8. Which element has the following electron configuration: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10}$?

9. Write out the electron configurations for (a) sulfur and (b) mercury. How many unpaired electrons does each possess?

10. Which element has the following electron configuration: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 4f^{14} 5d^6$?