Activity 26 - Electronic Configuration Worksheet

Name Key

Section__________ **Date**______

Scientists have learned that electrons in atoms occupy specific energy levels. These levels form an orderly pattern, and we can use these to figure out where the electrons are (i.e., which energy levels they occupy). This allows us to predict a great deal about how these electrons will behave in chemical reactions. This is a cornerstone of chemistry.

There are principal energy levels, called shells, numbered consecutively 1, 2, 3, … . As the shell number increases, the size and energy of the shell increases.

The first shell consists of a single sublevel; the second, two; the third, three; and so on. The sublevels are designated by letters: s, p, d, f, g, h, … , and the energy of each sublevel within an energy level increases in this order (for multi-electron atoms). Also note that as the energy increases, the levels generally become more and more closely spaced (see figure 1 on page 251).

Exercise:

1. For the principal shell 4, complete the list of sublevels: 4_s_, 4_p_, 4_d_, 4_f_
2. For the principal shell 6, complete the list of sublevels: _6s_, _6p_, _6d_, _6f_, _6g_, _6h_

Because the spacing between energy levels becomes smaller and smaller as energy increases, the sublevels of different energy levels overlap each other. For example, the energy of the 4s sublevel is lower than the 3d.

The next step is to figure out how many electrons can fit into each sublevel. Sublevels are divided into orbitals, which are mathematically defined regions in space in an atom, molecule, or ion, within which and electron can be found about 90% of the time. Each subshell contains a different number of orbitals: s has one; p, 3; d, 5; f, 7, … , but electrons in orbitals in a given sublevel have the same energy.

Exercise:

3. Fill in the answers (number of orbitals and the lines that represent orbitals), for the f, g, and h sublevels:

subshell	Number of orbital(s)	Diagram
s	1	___
p	3	___ ___ ___
d	5	___ ___ ___ ___ ___
f	7	___ ___ ___ ___ ___ ___ ___
g	9	___ ___ ___ ___ ___ ___ ___ ___ ___
h	11	___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___

Experiments show that each orbital may hold a maximum of 2 electrons. When two electrons are in a single orbital, their spins are aligned in opposite directions _↑↓_. Thus, an orbital may have no electrons (empty) ____; one electron _↑_; or two electrons _↑↓_.

Electronic Energy Levels

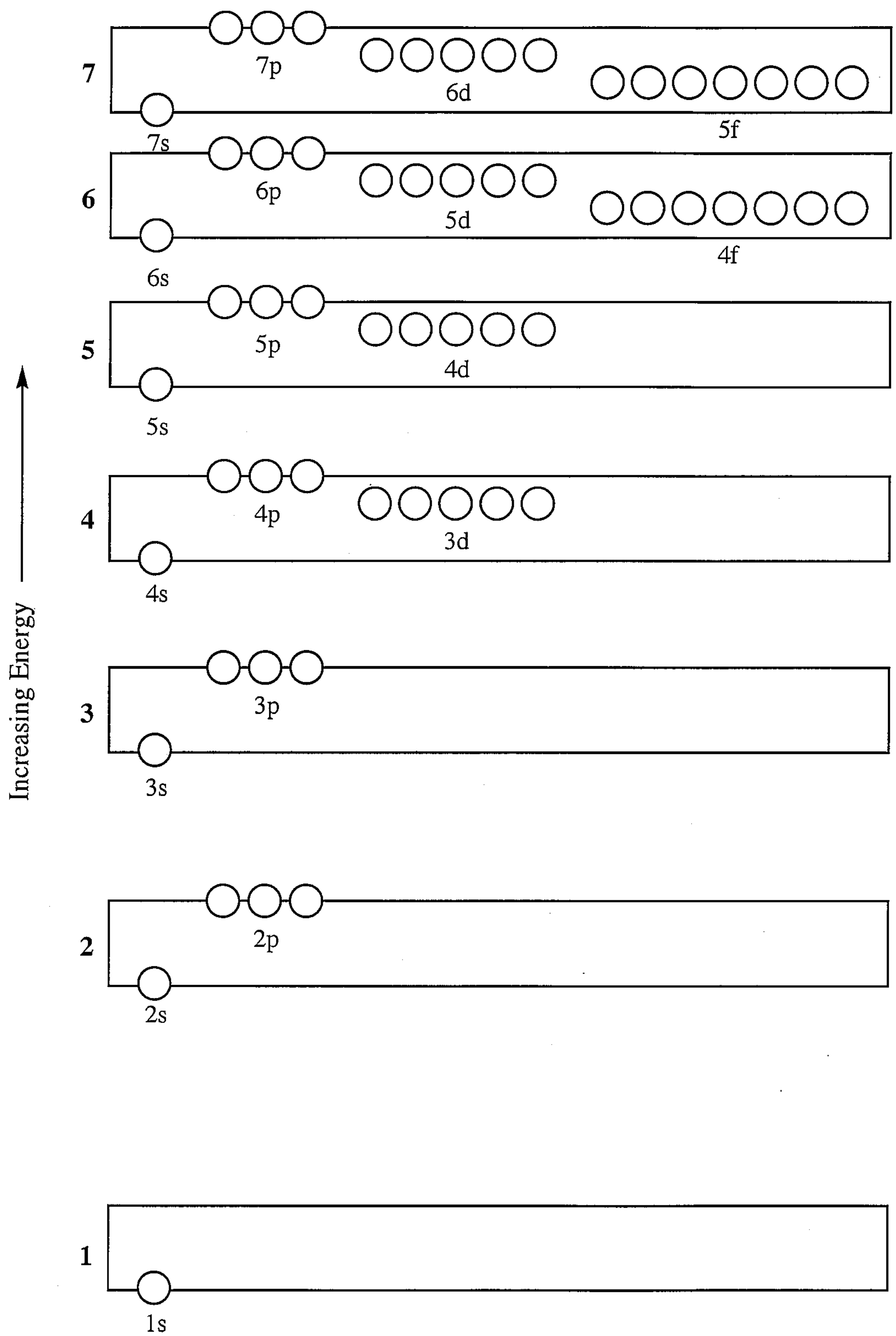

Figure 1. Schematic of the principal energy levels and sublevels through principal level 7.

Exercise:

4. Fill in the appropriate orbitals within these sublevels with the maximum number of electrons:

E.g.,	**2p**	↑↓ ↑↓ ↑↓	6 **electrons**
	2s	↑↓	2 electrons
	4p	↑↓ ↑↓ ↑↓	6 electrons
	3d	↑↓ ↑↓ ↑↓ ↑↓ ↑↓	10 electrons
	5f	↑↓ ↑↓ ↑↓ ↑↓ ↑↓ ↑↓ ↑↓	14 electrons
	6s	↑↓	2 electrons
	5g	↑↓ ↑↓ ↑↓ ↑↓ ↑↓ ↑↓ ↑↓ ↑↓ ↑↓	18 electrons
	6f	↑↓ ↑↓ ↑↓ ↑↓ ↑↓ ↑↓ ↑↓	14 electrons

5. What is the maximum number of electrons in the principal energy level 1? 2
6. What is the maximum number of electrons in the principal energy level 2? 8
7. What is the maximum number of electrons in the principal energy level 3? 18

We have basic rules. Now we will use this information to find the arrangement of electrons in different elements. These arrangements are called ***electron configurations*** when listed and ***orbital diagrams*** when drawn out.

Rules for drawing orbital diagrams:

a. The energy sequence of sublevels is the same for all elements.

b. Electrons go into the lowest energy orbital that has room available (Aufbau principle).

c. The maximum number of electrons in an orbital is 2.

d. Electrons fill orbitals within a sublevel with unpaired spins before spins are paired (Hund's rule).

Exercise:

8. Fill in the arrows representing electrons, as shown for H and He.

	H	**He**	Li	Be	B	C
2p	_ _ _	_ _ _	_ _ _	_ _ _	↑ _ _	↑ ↑ _
2s	_	_	↑	↑↓	↑↓	↑↓
1s	↑	↑↓	↑↓	↑↓	↑↓	↑↓

Exercise:

Problem 8 continued.

	N	O	F	Ne
2p	↑ ↑ ↑	↑↓ ↑ ↑	↑↓ ↑↓ ↑	↑↓ ↑↓ ↑↓
2s	↑↓	↑↓	↑↓	↑↓
1s	↑↓	↑↓	↑↓	↑↓

	Na	Mg	Al	Si	P	S
3p	__ __ __	__ __ __	↑ __ __	↑ ↑ __	↑ ↑ ↑	↑↓ ↑ ↑
3s	↑	↑↓	↑↓	↑↓	↑↓	↑↓
2p	↑↓ ↑↓ ↑↓	↑↓ ↑↓ ↑↓	↑↓ ↑↓ ↑↓	↑↓ ↑↓ ↑↓	↑↓ ↑↓ ↑↓	↑↓ ↑↓ ↑↓
2s	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓
1s	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓

	Cl	Ar
3p	↑↓ ↑↓ ↑	↑↓ ↑↓ ↑↓
3s	↑↓	↑↓
2p	↑↓ ↑↓ ↑↓	↑↓ ↑↓ ↑↓
2s	↑↓	↑↓
1s	↑↓	↑↓

The more compact list form (**electron configuration**) is:

H	He	Li	Be	B
$\mathbf{1s^1}$	$\mathbf{1s^2}$	$\mathbf{1s^2 2s^1}$	$\mathbf{1s^2 2s^2}$	$\mathbf{1s^2 2s^2 2p^1}$

Exercise:

9. Write the electron configuration for elements 6 – 18. Note: The last page of this handout includes step-by-step instructions for writing electron configurations. Note: Beginning with potassium, the fourth period elements fill in the 4s, 3d, and 4p sublevels **IN THAT ORDER** (see figure 1 on page 251).

C $1s^2 2s^2 2p^2$
N $1s^2 2s^2 2p^3$
O $1s^2 2s^2 2p^4$
F $1s^2 2s^2 2p^5$
Ne $1s^2 2s^2 2p^6$
Na $1s^2 2s^2 2p^6 3s^1$
Mg $1s^2 2s^2 2p^6 3s^2$
Al $1s^2 2s^2 2p^6 3s^2 3p^1$
Si $1s^2 2s^2 2p^6 3s^2 3p^2$
P $1s^2 2s^2 2p^6 3s^2 3p^3$
S $1s^2 2s^2 2p^6 3s^2 3p^4$
Cl $1s^2 2s^2 2p^6 3s^2 3p^5$
Ar $1s^2 2s^2 2p^6 3s^2 3p^6$

10. Fill in the electron "arrows" for the following orbital diagrams. Note that the first 18 electrons through 3p have been omitted for clarity. ***Cr and Cu are exceptions, with configurations of $4s^1 3d^5$ and $4s^1 3d^{10}$, respectively.** This is because half-filled and/or fully-filled sublevels are more stable than subshells that are neither. Both silver and gold follow the same exceptional pattern as copper.

	K	Ca	Sc	Ti
3d	_ _ _ _ _	_ _ _ _ _	↑ _ _ _ _	↑ ↑ _ _ _
4s	↑	↑↓	↑↓	↑↓

Star to remind about exception

	V	Cr*	Mn	Fe
3d	↑ ↑ ↑ _ _	↑ ↑ ↑ ↑ ↑	↑ ↑ ↑ ↑ ↑	↑↓ ↑ ↑ ↑ ↑
4s	↑↓	↑	↑↓	↑↓

Star to remind about exception

	Co	Ni	Cu*	Zn
3d	↑↓ ↑↓ ↑ ↑ ↑	↑↓ ↑↓ ↑↓ ↑ ↑	↑↓ ↑↓ ↑↓ ↑↓ ↑↓	↑↓ ↑↓ ↑↓ ↑↓ ↑↓
4s	↑↓	↑↓	↑	↑↓

	Ga	Ge	As (Error)	Se (Error)
4p	↑ _ _	↑ ↑ _	↑ ↑ ↑	↑↓ ↑ ↑
3d	↑↓ ↑↓ ↑↓ ↑↓ ↑↓	↑↓ ↑↓ ↑↓ ↑↓ ↑↓	↑↓ ↑↓ ↑↓ ↑↓ ↑↓	↑↓ ↑↓ ↑↓ ↑↓ ↑↓
4s	↑↓	↑↓	↑↓	↑↓

	Br	Kr
4p	↑↓ ↑↓ ↑	↑↓ ↑↓ ↑↓
3d	↑↓ ↑↓ ↑↓ ↑↓ ↑↓	↑↓ ↑↓ ↑↓ ↑↓ ↑↓
4s	↑↓	↑↓

* Representative is another term for main group

Exercise:

11. Which columns are *representative elements? IA – VIIIA or 1, 2, 13–18

12. Which subshells are being filled as you go across a row of representative elements? s & p

13. Which subshell is being filled as you go across a row of transition elements? d

14. Use the noble gas notation for the following electron configurations:

E.g.	**Si**	**[Ne]$3s^2 3p^2$**	Cd	[Kr] $5s^2 4d^{10}$
	Se	[Ar] $4s^2 3d^{10} 4p^4$	Br	[Ar] $4s^2 3d^{10} 4p^5$
	Sr	[Kr] $5s^2$	I	[Kr] $5s^2 4d^{10} 5p^5$
	Ba	[Xe] $6s^2$	Sb	[Kr] $5s^2 4d^{10} 5p^3$
	*Ag	~~[Kr] $5s^2 4d^9$~~ Remember to promote e⁻ [Kr] $5s^1 4d^{10}$		

star reminds about exception