Unit 2 – Atomic Structure

Progress Tracker

Test Date: _____

Webassign Due *Score*

_____ _____

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_____ _____

Packet Progress Checks

_____ _____

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_____ _____

Test Readiness Checks:

- ☐ My webassign scores indicate I am ready for the test.
- ☐ I went to ASP for Webassign help when needed.
- ☐ I have completed the unit review AND checked my answers.
- ☐ I am aware that I cannot retake the test unless my webaassign and packet progress checks are all above 80%.

Learning Objectives

2.1 Atomic Structure

2.2 Periodic Table

2.3 Electron Configuration

2.1 Atomic Structure and Ion Structure

- Determine the number of **protons**, **electrons**, and **neutrons** from a complete atomic symbol ($^{15}_{7}N$) or isotope symbol (nitrogen-15).
- Generate a **drawing** or **description** that demonstrates an understanding of the location, charge, and relative size of the 3 subatomic particles.
- Define an **isotope** and be able to identify when two atoms are isotopes. (You need to be able to do this from isotope symbols, atomic drawings, or descriptions of the atoms.)
- Calculate average atomic mass given relative abundance and amu.
- Predict which isotope will be more abundant based on the average atomic mass.
- Describe the difference between **atomic mass** and **mass number** and explain why atomic mass is never a whole number.
- Determine the charge of an **ion** from a description of the numbers of atomic particles or from an atomic symbol with a charge.
- Label an ion as a **cation** or **anion**.
- Determine if two ions or atoms are **isoelectronic**. (Have the same number of electrons.)
- Evaluate inaccuracies that exist in most drawings of atoms. (size of electrons relative to protons, relative distance of electrons from the nucleus.)
- Demonstrate an understanding of why isotopes went unrecognized by chemists for so long.

2.2 Periodic Table and Periodic Trends

- Use the periodic table to identify elements as:
  - **Metals**, **non-metals**, or **metalloids**
  - Solids, liquids, or gases
  - Members of a particular family (**alkali metals, alkaline earth metals, transition metals, halogens, noble gases, lanthanides, and actinides**.)
- Describe the physical and electronic properties that distinguish metals from. non-metals
- Identify an element based on **group** number and **period** number.
- Define **ionization energy**. (Distinguish 1st I.E from 2nd I.E., etc.)
- Define **atomic radius**.
- Explain the trends in ionization energy and atomic radius in terms of **effective nuclear charge, electron-electron repulsion,** and **electron shielding**. (Be able to communicate an understanding of the meaning of these terms and use them appropriately in explanations of atomic structure.)
- Explain why electrons are lost more easily from high energy orbitals (as opposed to low energy orbitals) when forming ions.
- Synthesize periodic table understandings (i.e – Which halogen has the most protons?)

2.3 Electron Configuration

- Place electrons in a Bohr model of the atom.
- Identify the number of **valence electrons** in an atom using either a Bohr model or the periodic table.
- Explain the importance of valence electrons
- Explain the role of the octet rule in the creation of ions and be able to predict which ion will be formed by a particular atom.
- Properly place electrons in a quantum (**filling) model** of the atom.
- Write the long or short hand **electron configuration** of atoms and know the meaning of the symbols.
- Explain/evaluate what additional information is available in the quantum model (as opposed to the Bohr model).
- Identify an atom as having a ground or excited electron state.
- Be able to describe how atoms get into an excited state and the role light in electron transitions.
- Understand the subtleties of model symbols. (What does the up versus down arrow indicate about the electron?)

Periodic Table Notes

Elements and Atoms

1. Look at your periodic table and find at least 5 elements that you have heard of. Write the names and symbols of the 5 elements below:

Element Name	Element Symbol	What element number is it?	Do you think it is a solid, liquid or gas?

2. On the big wall mounted periodic table, you can tell if an element is a solid, liquid, or gas by color:

- Solids are colored _____
- Gases are colored _____
- Liquids are colored _____

3. Find at least 2 elements that you have never heard of. One must be a gas and one a solid.

Element Name	Element Symbol	What element number is it?	Do you think it is a solid, liquid or gas?

4. The periodic table arranges elements by a number. This number is called the **atomic number** and tells you how many _____ an atom has. Each element has a special number of protons.

5. Define the term **subatomic** _____

Subatomic Particle	**Location**	**Charge**	**Symbol**	**Mass**
Proton				
Electron				
Neutron				

6. If the nucleus is like a football, the electron is like a _____.

Complete Atomic Symbols

_____ → 19

_____ → 9

F

Fluorine	How many?
Protons	
Electrons	
Neutrons	

Drawing:

$^{15}_{8}O$

Oxygen	How many?
Protons	
Electrons	
Neutrons	

Drawing:

$^{15}_{7}N$

Nitrogen	How many?
Protons	
Electrons	
Neutrons	

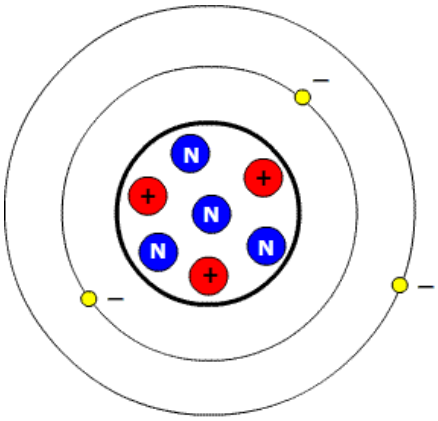
Drawing:

Atomic Structure Practice

Fill out each empty space with the appropriate value.

Question	Substance	Symbol	Atomic Number	Mass Number	Protons	Neutrons	Electrons
1	Helium	$^{5}_{2}He$					
	Draw this helium atom						
2	Magnesium	$^{22}_{12}Mg$	12			10	
	Draw this magnesium atom						
3	Zinc	$^{\_\_}_{\_\_}Zn$	30	65			
4	Chlorine	$^{37}_{17}Cl$		37			

5. Using this drawing of the atom:



How many electrons does it have? _____

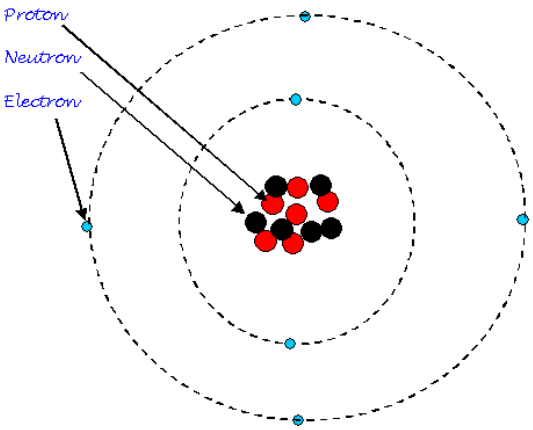
How many neutrons? _____

How many protons? _____

What element is this? _____

Draw its complete atomic symbol:

6. Using this drawing of the atom:



How many electrons does it have? _____

How many neutrons? _____

How many protons? _____

What element is this? _____

Draw its complete symbol:

7. Write the complete symbol for atoms containing the indicated number of subatomic particles. (Remember: You can use the P.T. for the element symbol, but the mass must be determined from the information here.)

a. 92 p^+, 92 e^-, 142 n^o _____

b. 6 p^+, 6 e^-, 8 n^o _____

c. 88 p^+, 88 e^-, 138 n^o _____

Symbol and Isotope Notes

Different Types of Symbols

Chemists sometimes use a different symbol to represent an atom. Compare these two symbols:

$^{15}_{7}N$ **Nitrogen-15**

Complete atomic symbol *Element Name Symbol*

1. What information is missing in the new symbol? _____

2. Why do we use a symbol without all of the information?
_____
_____
_____
_____

3. Using Element Name Symbols: Find the number of electrons protons and neutrons in these atoms:

Element Name Symbol	Complete Atomic Symbol	Number of protons	Number of Neutrons	Number of Electrons
Carbon-14				
Lithium-6				
Calcium-42				
Tin-118	Hint: Tin is not "Ti"			
Fluorine-18				
Sodium-24	Hint: sodium is not "S"			

4. What would be the **element name symbol** of these atoms?

Information	Element Name Symbol
Protons = 10, Neutrons = 9, Electrons = 10	
Protons = 4, Neutrons = 5, Electrons = 4	
Protons = 4, Neutrons = 5, Electrons = 4	
Protons = 12, Neutrons = 12, Electrons = 12	
Protons = 36, Neutrons = 40, Electrons = 36	

What are Isotopes? (From Tyler Dewitt's Isotope Video)

Describe the metaphor that Tyler uses to give us a feeling for isotopes?

How do isotopes **differ**? (Electrons, Protons, Neutrons?)

What must isotopes **have in common**?

Come up with your own metaphor for an isotope. They must have something important in common, but must be different in a less important way.

Carbon work area:

Calcium work area:

Isotope Practice

1. Boron has two isotopes: $^{10}_{5}B$ and $^{11}_{5}B$

   How many protons does each isotope have? _____ and _____

   How many neutrons does each isotope have? _____and _____

   How many electrons does each isotope have? _____ and _____

2. $^{10}_{5}B$ and $^{11}_{5}B$ are isotopes of each other because they have the same number of _____ and different numbers of _____.

3. $^{40}_{19}K$ has an isotope. Which of the following mystery compounds could be an isotope of $^{40}_{19}K$?

$^{40}_{18}?$

protons	
electron	
neutrons	

$^{42}_{19}?$

protons	
electron	
neutrons	

$^{42}_{18}?$

protons	
electron	
neutrons	

Hint: Fill out this table for each element to help you.

4. An atom has 16 protons and a mass number of 34. Which of the following is an isotope of this element?

protons	
electron	
neutrons	

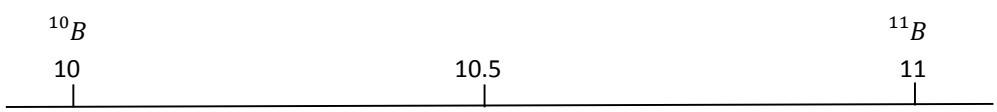
Use this work area!

a. An element with protons=15 mass number=34
b. An element with protons=16 neutrons= 19
c. An element with protons=16 neutrons=18
d. An element with protons=15 mass number=19

A question with a new concept to stretch your thinking a little:

5. Bromine has two isotopes: ${}^{10}_{5}B$ and ${}^{11}_{5}B$

The **mass** of the two elements is represented on a number line below



Find the **average mass of boron on the periodic table** and record it here: _____.
Put an "x" on the number line showing where the average mass would be.

Which isotope of boron is the most common? Explain why you think so.

6. Chlorine has two isotopes: $^{35}_{17}Cl$ and $^{37}_{17}Cl$

Make a number line showing the **mass** of the two isotopes of chlorine (just like was done above.)

What numbers could you put on your number line?

the average mass of chlorine on the periodic table _____. Put an "x" on the number line showing where the average mass would be.

Which isotope of chlorine is the most common? Explain.

7. Copper has two isotopes: copper-63 and copper-65
Write the complete atomic symbol for each copper isotope (just like was drawn for chlorine above).

Find the average mass of copper on the periodic table _____.
Which isotope of copper do you think is the most common? Explain. (Draw a number line!)

Average Atomic Mass Practice

1. Explain the difference between the atomic mass and mass number.

2. Why is the atomic mass on the periodic table never a whole number despite the fact that atoms always have whole number masses?

3. Naturally occurring europium (Eu) consists of two isotopes was a mass of 151 and 153. Europium-151 has an abundance of 48.03% and Europium-153 has an abundance of 51.97%. What is the atomic mass of europium?

4. The element Neon is found to have two naturally occurring isotopes, ${}^{20}_{10}Ne$ and ${}^{21}_{10}Ne$. Using the atomic mass of Neon from the periodic table, predict which isotope is the most abundant and **explain how you arrived at your answer.**

5. Element X (a mystery element!) has two naturally occurring isotopes, ${}^{10}_{?}X$ and ${}^{11}_{?}X$. The two isotopes have abundances of 20.0% and 80.0%, respectively. Calculate the exact atomic mass of the element and determine its identity. Show your calculations!

6. Circle each pair below that represent isotopes.

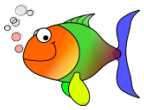
   ${}^{128}_{52}X$ and ${}^{128}_{52}X$

   ${}^{70}_{30}Y$ and ${}^{68}_{30}Y$

   Atom Q with 35 p^+, 35e^-, and 17n^o and Atom Z with 34 p^+, 35e^-, and 45n^o

   Atom R with an atomic number of 28 and a mass number of 58 and
   Atom M with 28 protons, 28 electrons, and 30 neutrons

Periodic Families ChemGIL



Key Skill: Identifying elements as metals, non-metals, and metalloids.

Go to our class website. Click on Periodic Families Assignment. (or go to **http://www.phschool.com/atschool/phsciexp/active_art/periodic_table/index.html**)

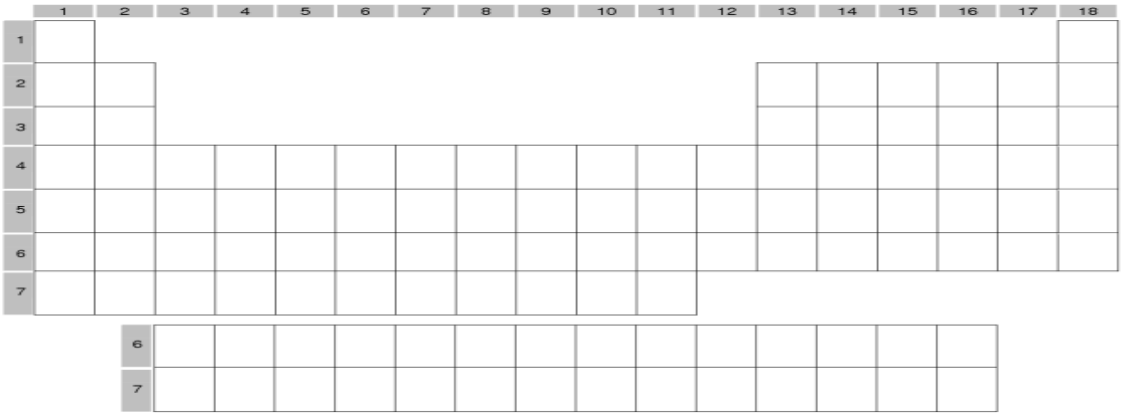
1. What do the **blue** elements in the table represent? (See the key)

2. What do the **green** elements in the table represent?

3. What do the **yellow** elements in the table represent?

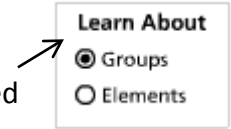
4. "Metalloid" is a word that means "a little bit like a **metal** and a little bit like a **non-metal**". A person that is not yet an *adult* and not a *child* would be called a _____ .

5. Label the blank periodic table with the words metal, non-metal, and metalloid and outline each section of the periodic table.



6. For each of the following elements, label it as a *metal*, *non-metal*, or *metalloid*.
   a. Carbon _____
   b. Lithium _____
   c. Tungsten _____
   d. Silicon _____
   e. Krypton _____

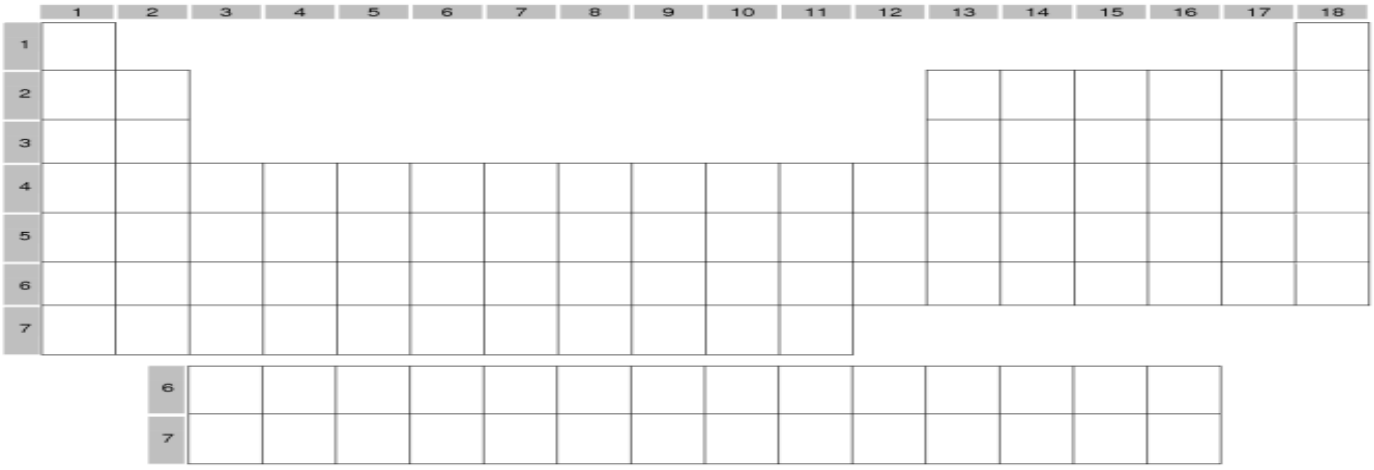
Key Skill: Identifying an elements periodic family



1. Before you start, make sure that the Groups button is clicked
2. For each element, click on it to learn what its family name is.

Element	Family Name	Group number	List 2 other elements that are in the same family
Magnesium			
Chlorine			
Titanium			
Potassium			
Argon			

3. Label each family in this blank periodic table so that you have a study guide. Most will be in a column.



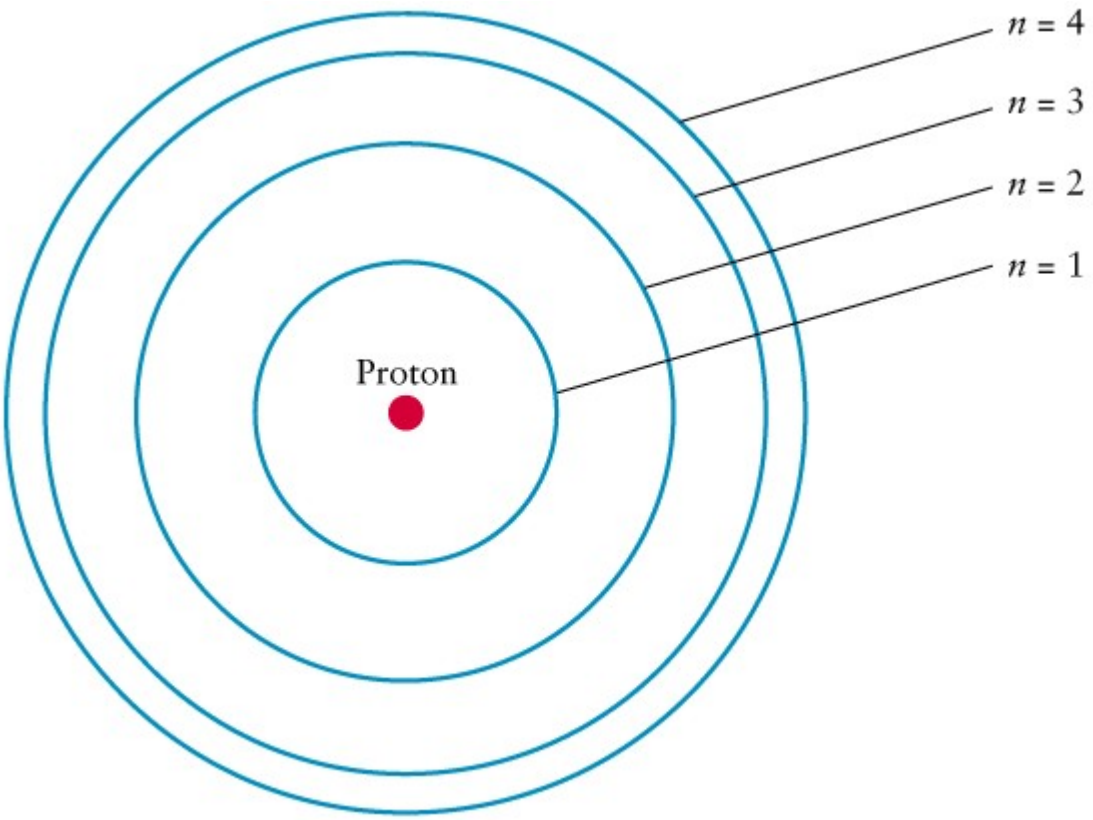
4. For each of these elements, find which family it belongs to.
   a. Tungsten_____
   b. Strontium_____
   c. Iodine _____

Part 2

1. In the previous assignment you wrote down 2 member of each family in the table. For each of these elements, learn about how they are used in real life bv first changing the button from groups to elements.

Group	What were your two elements?	What cool information did you learn when you clicked on them?
Alkali metal		
Alkaline earth metal		
Halogens		
Transition metals		
Noble Gases		

Electrons in Atoms Notes



- What are other, more specific ways of referring to the ring of an atom?

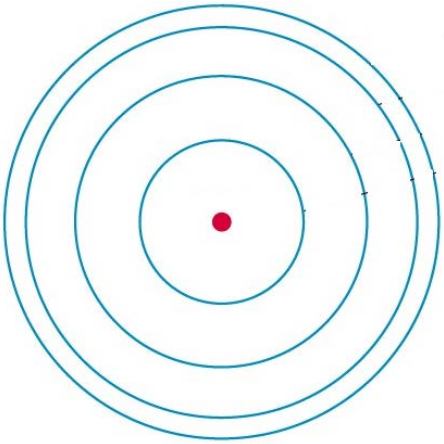
  _____ and _____ and _____

- How many electrons can be in : N = 1 _____ N=2 _____ N = 3 _____

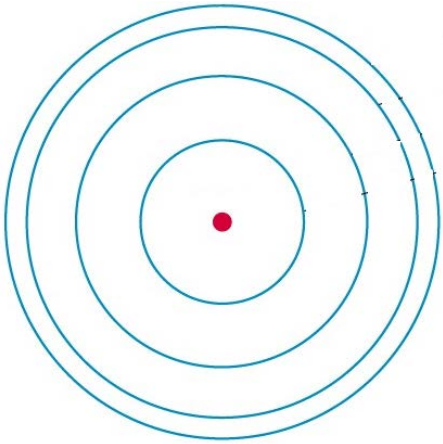
- Which shell has the lowest energy level?

- What is the **valence shell** and why is it important?

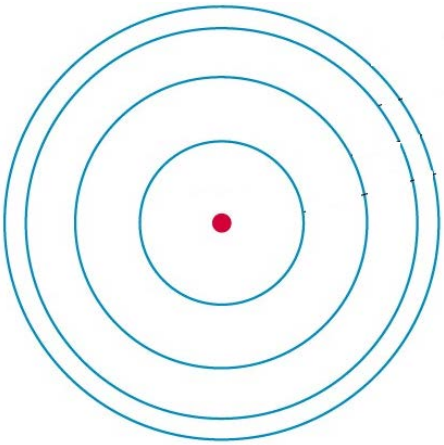
Drawing the Electronic Structure of Atoms



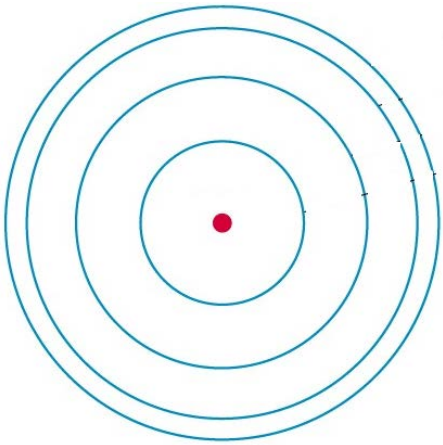
Lithium



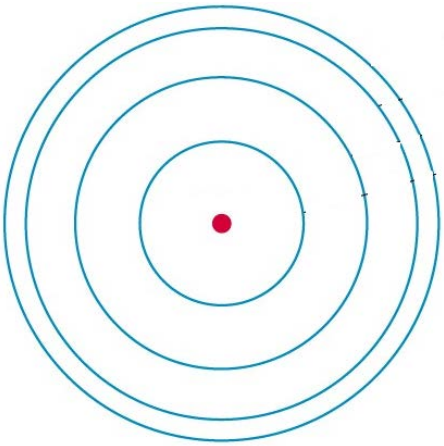
Oxygen



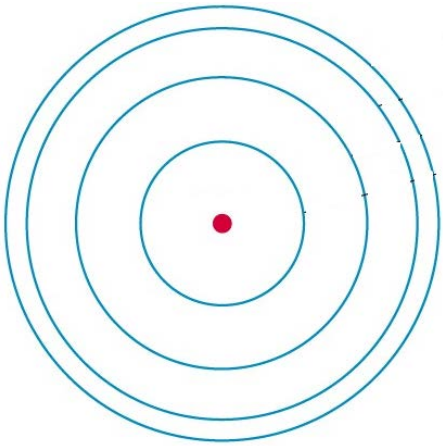
Berrylium



Phosphorus



Fluorine



Boron

Electrons Dot Structure Notes

7. Oxygen

8. Argon

9. Strontium

10. Boron

11. Iodine

12. Nitrogen

1. Bromine

2. Potassium

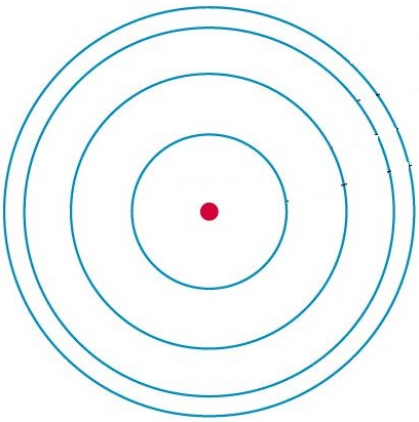
3. Hydrogen

4. Sodium

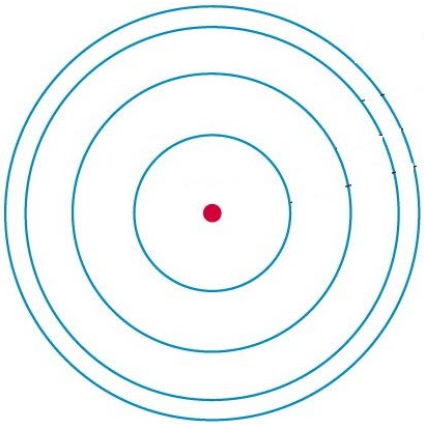
5. Radon

6. chlorine

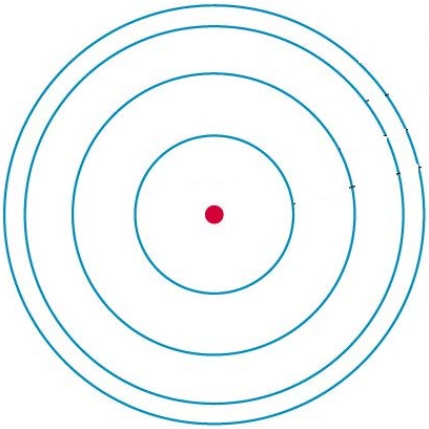
Ion Structure Notes



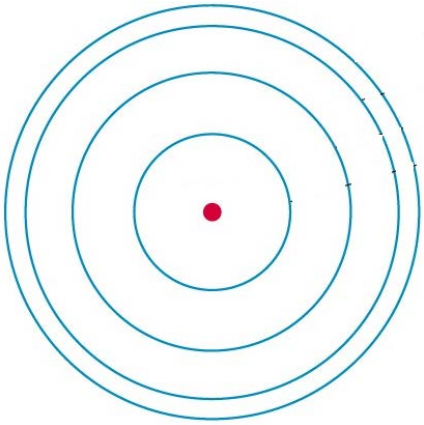
Li^+



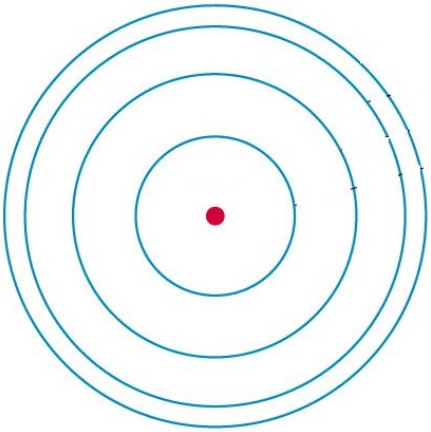
Na^+



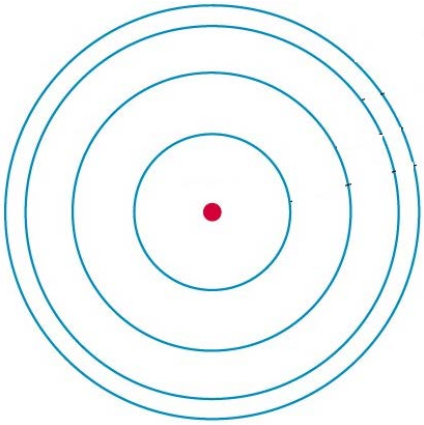
N^{3-}



S^{2-}



F^-



Mg^{2+}

Ion Practice

For each ion, complete the missing information. You may need to refer to periodic table to complete.

Substance	Symbol	Charge	Atomic Number	Atomic Mass (amu)	Protons	Electrons	Cation or Anion
Bromine ion	Br^-		35				anion
Aluminum ion	Al^{3+}					10	
Lithium ion	Li^+				3		
Sulfur ion		-2	16				
Magnesium ion			12			10	
Nitrogen ion	N^{3-}				7	10	
Potassium ion		+1	19			18	
Oxygen ion	O^{2-}				8		
Iodine ion			53			54	
Sodium ion		+1			11		cation
Boron ion					5	2	
Hydrogen ion	H^+					0	

More Practice with Ions

For each ion, complete the missing information. You have been given enough information for each ion to fill in all the blanks in each row.

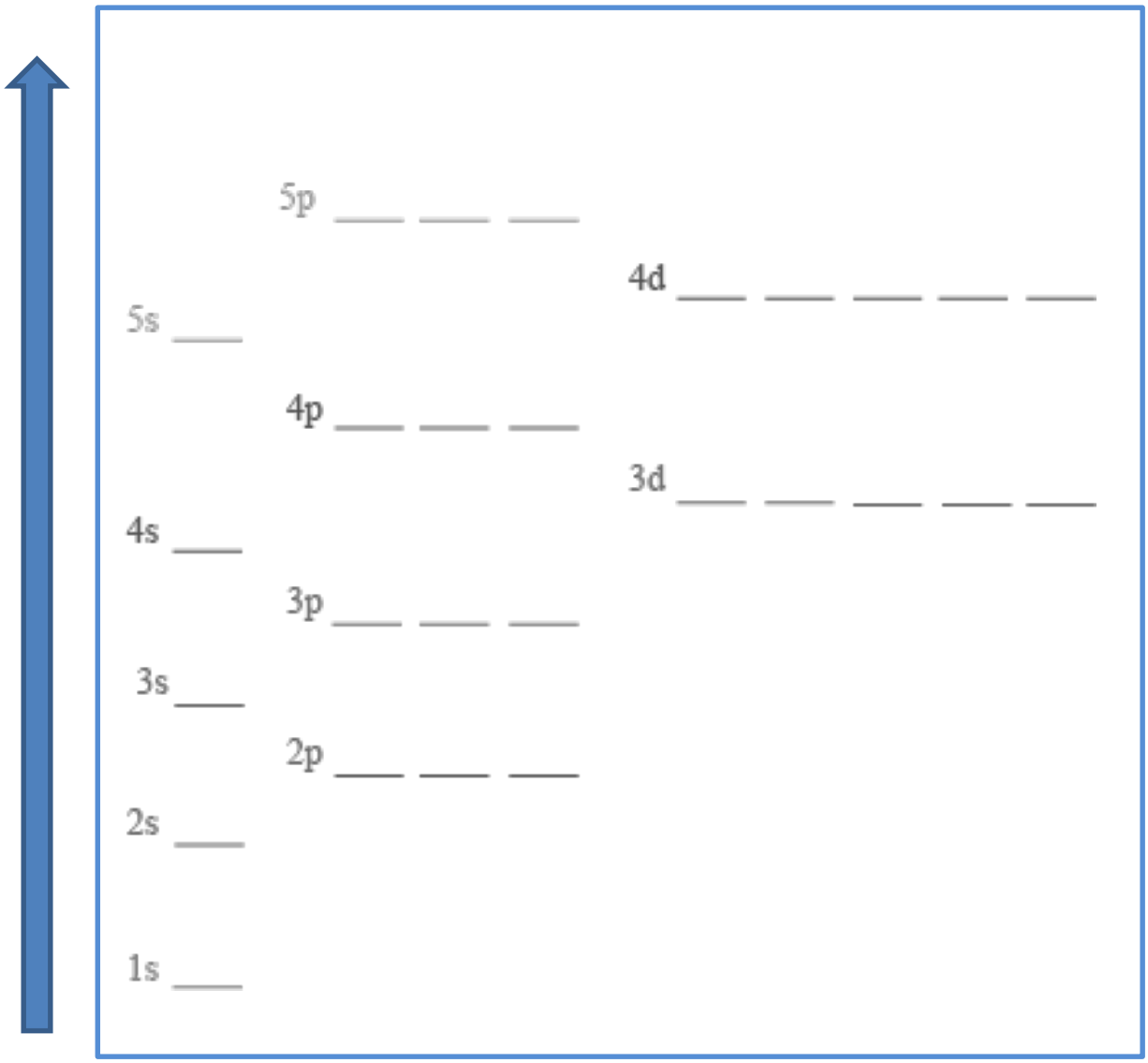
USE A PERIODIC TABLE TO FIND THE ATOMIC SYMBOL AND ATOMIC MASSES FOR THE NECESSARY ELEMENTS.

Substance	Symbol	Charge	Atomic Number	Atomic Mass (amu)	Protons	Electrons	Cation or Anion?
Fluorine ion	F^-		9				anion
Titanium ion	Ti^{4+}					18	
Barium ion	Ba^{2+}				56		
Selenium ion		-2	34				
Phosphorus ion			15			18	
Tin ion	Sn^{2+}				50	48	cation
Iron ion		+3	26			23	
Copper ion	Cu^{1+}				29		
Lead ion			82			80	
Carbon ion		+4			6		cation
Bromine ion					35	36	
Calcium ion	Ca^{2+}					18	

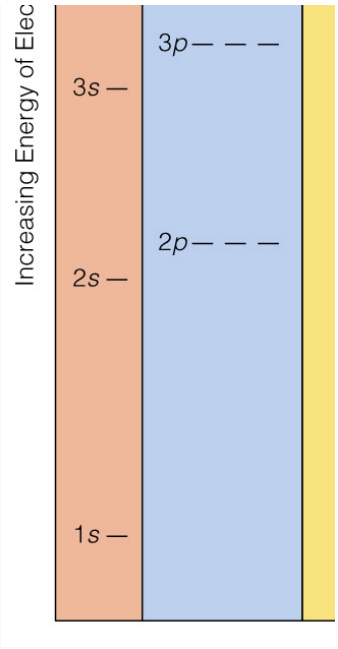
Write the correct atomic symbol, complete with atomic number, mass number and charge for atoms containing the following subatomic particles:

1. $7\ p^+, 10\ e^-, 7\ n^o$ _____
2. $20\ p^+, 18\ e^-, 20\ n^o$ _____
3. $30\ p^+, 28\ e^-, 34\ n^o$ _____
4. $6\ p^+, 10\ e^-, 6\ n^o$ _____
5. $17\ p^+, 18\ e^-, 18\ n^o$ _____
6. $24\ p^+, 18\ e^-, 28\ n^o$ _____

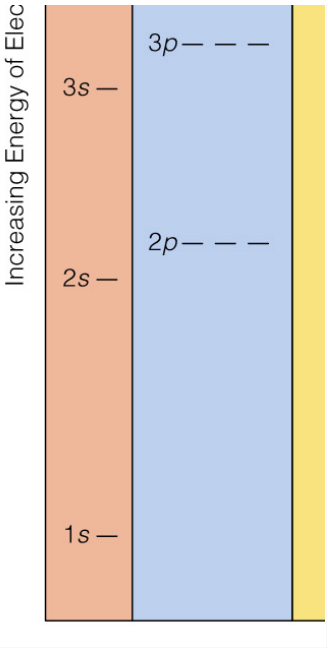
Quantum Model Notes



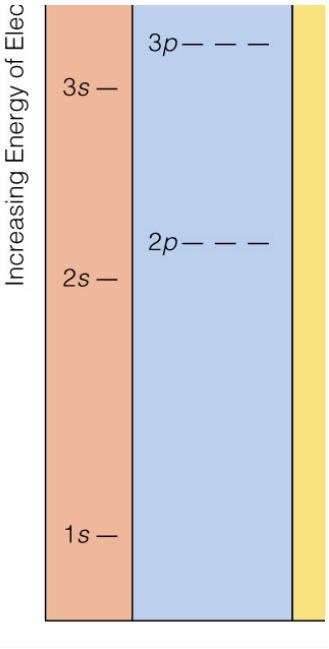
Mg



Al

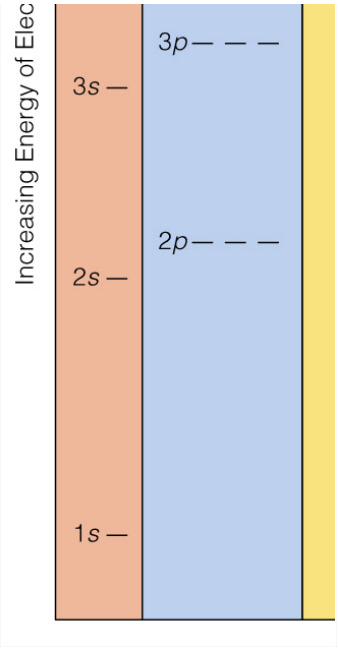


H

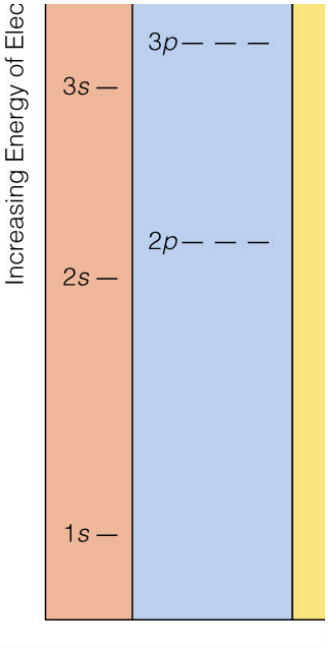


EC:

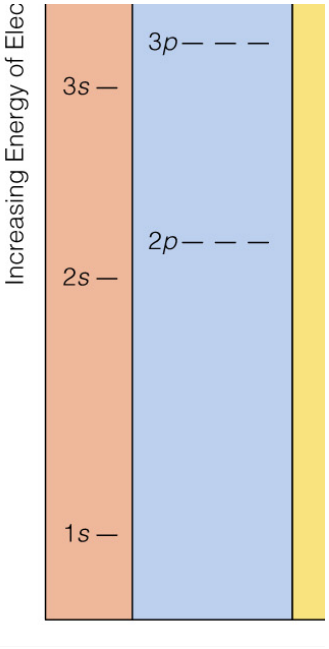
C



Cl



Ne



EC:

Quantum Model Practice

1. Which orbital will be filled first, a 2s orbital or a 2p orbital?

2. How many electrons are required to completely fill the 3s orbital?

3. How many orbitals are in the 3d sublevel?

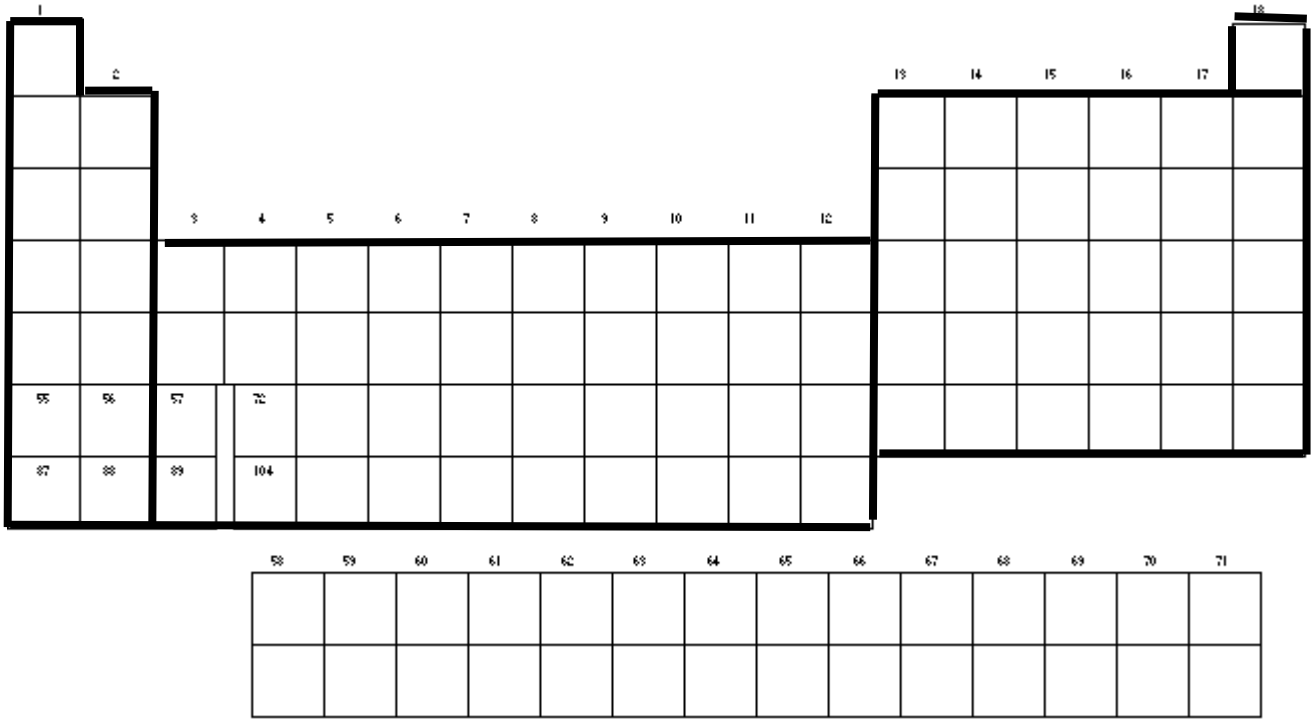
4. Which orbital is higher energy, a 3d or a 4s?

5. What does it mean for two orbitals to be “degenerate”?

6. How many electrons are required to completely fill the 3d orbital?

7. What is the highest occupied orbital in a bromine atom?

Use 4 different colors to represent the location of the s, p, d, and f blocks:



Electron Configuration Practice

Write the electron configuration for each of the following atoms.

1. Oxygen

2. Phosphorus

3. Strontium

4. Indium

Identify the elements that have these electron configurations.

5. $1s^2\ 2s^2\ 2p^6$

6. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^2$

7. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1$

1. In the problems on the previous page, you very likely wrote $2p^4$ during one of your answers.

   What does the number "2" represent about the orbital?

   What does the number "4" represent about the orbital?

Write the SHORT HAND electron configuration for these elements.

2. Bromine

3. Copper

4. Calcium

5. Zinc

Identify the mistakes made in each of these electron configurations.

6. Silicon: $3s^2\ 3p^2$

7. Iodine: [Rb] $5s^2\ 4d^{10}\ 5p^7$

Bean Isotopes Lab

Goal: To learn how average atomic mass is determined by using beans as an analogy for atoms!

Procedure:

1. Determine the relative abundance of each type of bean:
   - Sort the beans into 3 piles that each have one type of bean.
   - Count the number of beans of each type and record it in the table below.
   - Determine what percentage out of all of the beans are white beans. (Hint: you will have to know how many total beans you have.) This is the relative abundance of white beans in your bag.
   - Now do the same to figure out the percentage of light brown beans that were in the bag of beans. Finish by completing the table for dark brown beans.

	White beans	Light Brown Beans	Dark Brown Beans	Total Beans
Number of beans				
Relative abundance				100 %
Show how you calculate relative abundance for the white beans:				

2. Determine the mass of each type of bean:
   - Find the mass of **one** white bean. Record it in the table below.
   - Now find the mass of **one** light brown bean and **one** dark brown bean.

	White Beans	Light Brown Beans	Dark Brown Beans
Mass (g)			

3. Calculate the average atomic mass of your bean element in the empty parentheses. Use this one as a guide:

$$\left(\textbf{abundance}_{\text{white}} \times \textbf{mass}_{\text{white}}\right) + \left(\textbf{abundance}_{\text{Lbrown}} \times \textbf{mass}_{\text{Lbrown}}\right) + \left(\textbf{abundance}_{\text{Dbrown}} \times \textbf{mass}_{\text{Dbrown}}\right) =$$

$$\left(\qquad\qquad\qquad\qquad\right) + \left(\qquad\qquad\qquad\qquad\right) + \left(\qquad\qquad\qquad\qquad\right) =$$

Reminder: Change % abundance like this before putting into your equation above:

(examples: 72 % = 0.72 14 % = 0.14 7 % = 0.07)

Post Lab Questions:

4. Check your answer for "reasonableness". What is the heaviest of your bean atoms? _____ (what color bean and what mass?) What is the lightest of your bean atoms? _____ (what color bean and what mass?) Does your "average atomic mass" fall between these two?

5. How many of your beans have a mass that is **exactly** the same as your average atomic mass?

6. According to the periodic table, what is the average atomic mass of bromine? _____. How many bromine atoms in the world have a mass that is the same as the average atomic mass of bromine? Consider your answers to #4 and #5 while you are explaining.

7. In a sample of Lithium there are 2,840 atoms of Li-7 and 16 atoms of Li-6.

   - What is the relative abundance of Li-7 in this sample? _____ (show your work)

   - What is the relative abundance of Li-6 in this sample? _____

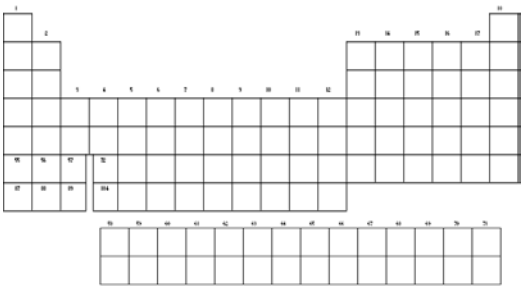
   - What is the average atomic mass of Lithium in this sample? _____ (show your work)

Periodic Trend Notes

Atomic Radius:

Definition:

Trend:

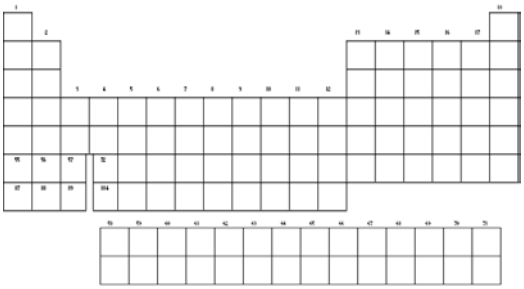


Ionization Energy

Definition:

1st I.E. vs. 2nd i.E.:

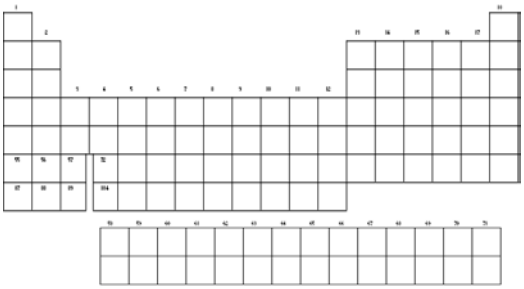
Trend:



Reactivity

Definition:

Trend:



Explaining the Periodic Trends

Inner Shell Shielding

1. Many periodic trends are influenced by **inner-shell shielding**. Define inner-shell shielding:

   _____
   _____
   _____
   _____

2. Think of a metaphor or simile for shielding that would help others get a good mental picture of what it is. (Good examples are in sports, love, orchestras, you name it!)

   Your simile or metaphor: Shielding is like

   _____
   _____
   _____
   _____

In each of the following groups, circle the atom that would have electrons experiencing the most shielding. (One of the pairs experiences the same amount of shielding.)

3. Cs or Na
4. F or Cl
5. Hg or Au
6. Mg or Be or Sr
7. N or P

Effective Nuclear Charge

1. Many periodic trends are influenced by **Effective Nuclear Charge**. Explain why sulfur would experience more effective nuclear charge than phosphorus

   _____

   _____

   _____

   _____

2. Draw a picture that would represent sulfur having more effective nuclear charge than phosphorus. (Should you be drawing sulfur or phosphorus larger? Why?)

In each of the following groups, circle the atom that would have electrons experiencing the effective nuclear charge. (One of the pairs experiences the same amount of effective nuclear charge.)

3. Li or Na

4. F or N

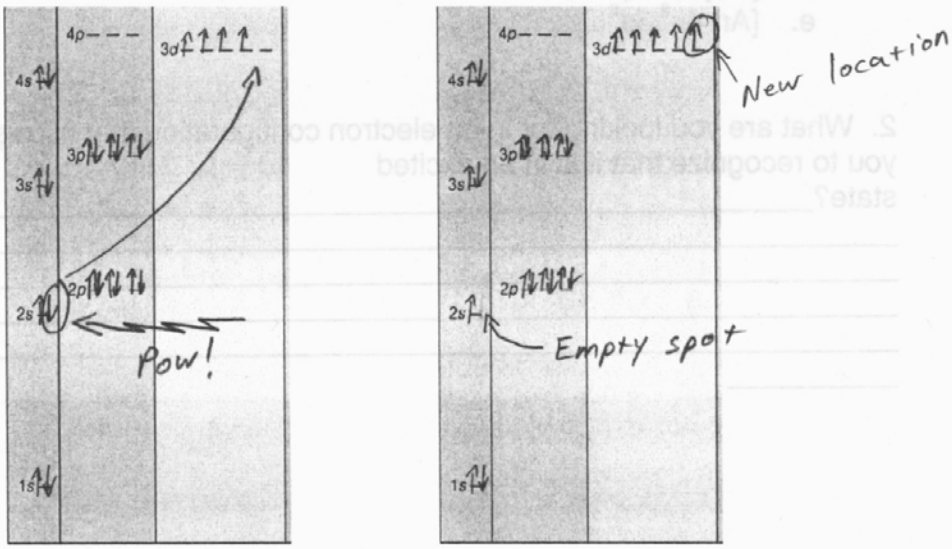
5. Hg or Au

6. Ca or Sr

Excited and Relaxed Electrons ChemGIL

Excited State Electron Configurations

- Excited state electrons have absorbed energy and have "jumped" to a higher energy orbital. (See the example below)



Ground State **Excited State**

- We can write electron configurations for excited state atoms just like with any other atom:

EC of the **ground** state atom: $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,4s^2\,3d^4$
EC of the **excited** state atom: $1s^2\,\mathbf{2s^1}\,2p^6\,3s^2\,3p^6\,4s^2\,3d^5$

Here are a few more examples:

Ground state atoms:	Excited state atoms:
$1s^2\,2s^2\,2p^6\,3s^2$	$1s^2\,\mathbf{2s^1}\,2p^6$
$1s^2\,2s^2\,2p^5$	$1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,4s^2\,\mathbf{3d^9}\,4p^5$
$1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,4s^2\,3d^{10}\,4p^2$	$1s^2\,2s^2\,2p^6\,\mathbf{3s^1}\,3p^2$

1. In the questions below, circle the atoms that contain excited state electrons:

   a. $1s^2\,2s^2\,2p^6\,3s^2\,3p^6$
   b. $1s^1\,2s^2\,2p^6\,3s^2\,3p^6\,4s^2\,3d^{10}\,4p^2$
   c. $1s^2\,2s^2\,2p^5\,3s^2\,3p^6\,4s^1$
   d. $[Ne]\,3s^2\,3p^5\,5s^1$
   e. $[Ar]\,4s^2\,3d^8$

2. What are you looking for in an electron configuration that allows you to recognize that it is in an excited state?_____