Name: _____ Period: _____

Chemistry Lab Manual

LM-2

Unit Ø

PL : Lab # 1

Safety First

What practices are followed to ensure safety in the laboratory?

Why?

Academic laboratory accidents are estimated to occur 10–50 times more frequently than chemical plant accidents. Laboratory accidents often have unexpected outcomes that may result in permanent injury. Dressing appropriately and following laboratory safety rules will reduce the incidence and severity of accidents and help keep students safe.

1. Create a laboratory safety diagram in the space below by doing the following:
   a. Sketch the outline of your laboratory room including all doors and windows
   b. Mark and label the position of the following laboratory safety equipment.
      1. Fire blanket
      2. Fire extinguisher
      3. Safety shower
      4. Eyewash station
      5. Fume hood
      6. Chemical disposal area
      7. Broken glassware disposal
      8. Chemical spill clean-up kit
      9. Location of goggles
      10. Location of gloves
   c. Locate and read the evacuation instructions that are posted in your laboratory. Describe how you should evacuate in case of an accident.

   d. Label the fire exits in the diagram and add the evacuation route to your picture (this should be posted in your room).

Laboratory Safety Diagram

2. Biohazard materials are disposed of in biohazard bags when you are finished working with them.
   a. On the diagram above, label where the bags are generally located.
   b. What color are the bags?

Model 1 – Laboratory Attire

This student is dressed **inappropriately** for laboratory work.	This student is dressed **appropriately** for laboratory work.
	

3. Look at the two students in the model above.

   a. List at least three inappropriate items of dress for the student on the left.

   b. List at least three appropriate items of dress for the student on the right.

4. Why wear goggles while working with chemicals and glassware?

5. When working with a Bunsen burner what precautions should be taken with respect to your clothing and hair?

6. Why should one avoid wearing shorts or skirts while working with chemicals and with glassware?

7. What type of shoes should a student wear while working with chemicals and with glassware?

8. If an accident occurred in the laboratory, which of the two students in the model would have protection provided by their clothing? Why?

LM-4

Unit 0

PL: lab #2

Name: _____ Section: _____

Becoming Familiar with Lab Equipment

Directions: Below you will find the names of different kinds of lab equipment you may encounter this year. Additionally, the functions associated with these various types of equipment are listed on the reverse side of this sheet. Using whatever resources possible, complete the attached chart by matching the name and function of the equipment with the appropriate visual. Number the equipment and write the number next to its function (on the next page) (on this page). See below.

Lab Equipment - *Names*

- Graduated Cylinder #1
- Glass Stirring Rod #2
- Erlenmeyer Flask
- Thermometer
- Forceps or Tweezers
- Beaker
- Test Tube Brush
- Triple Beam Balance
- Funnel
- Florence Flask
- Medicine/Eye Dropper
- Spring Scale
- Test Tube
- Wire Gauze
- Ruler or Meter Stick
- Test Tube Clamp
- Test Tube Rack
- Beaker Tongs
- Goggles
- Ring Stand
- Bunsen Burner
- Ring Clamp
- Test Tube Holder

Lab Equipment - *Functions*

to protect the eyes

for cleaning the inside of a test tube

for measuring temperature

for measuring mass

for removing and holding a hot beaker

to protect the bottom of a beaker or flask from flame; to support a beaker or flask on a ring clamp

for holding a flask, a beaker, or a test tube on a ring stand

platform holds heating unit; pole holds clamps

for holding an individual test tube

for holding one or more test tubes

for measuring and pouring liquids; **not** for heating or mixing substances #1

for measuring and pouring liquids; for heating or mixing substances

to aid in pouring a liquid from a wide-mouth container to a small-mouth container; to filter substances when filter paper is used

for heating a small amount of substance

for measuring length or distance

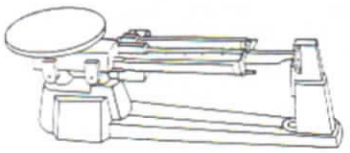
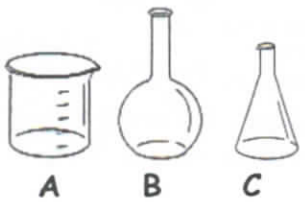
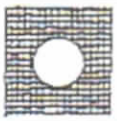
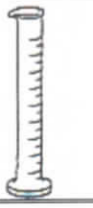
for measuring weight (or force)

for transferring a small amount (drops) of liquid

to mix or stir substances; made of glass to resist heat, stains, corrosion #2

for plucking or handling small objects

for heating, sterilization, and combustion

Visual	Name	Function
		
		
		
		
 A B C	A - B - C -	
		
		
		
		

LM-7

pL: lab #3

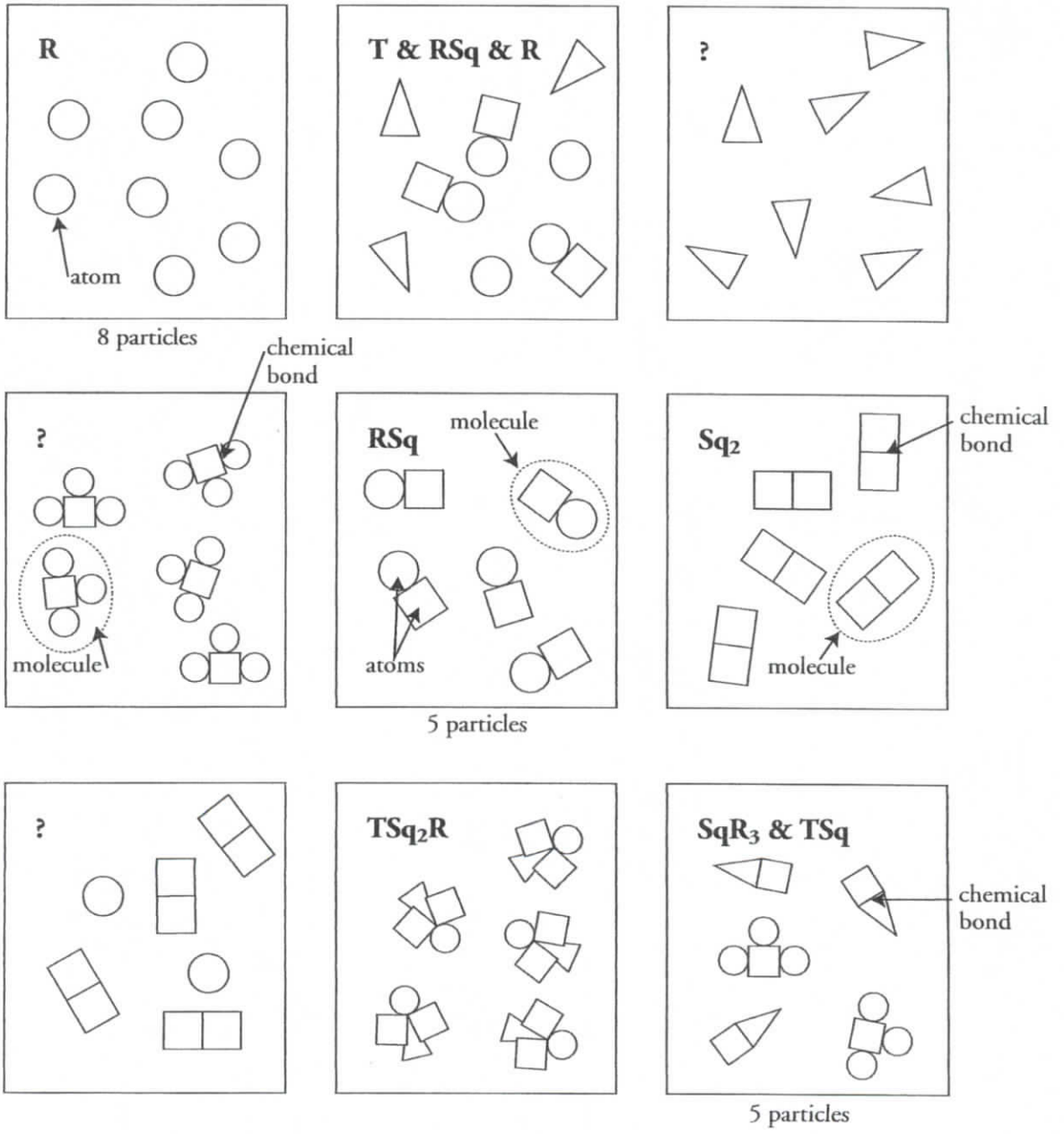
Classification of Matter

How do atoms combine to make different types of matter?

Why?

Look at the things in this room. They are all matter. That matter may be pure or it may be a mixture. Can you tell by looking at it? What if you looked at it under a microscope? Then could you tell? Something that looks pure may not really be pure. It depends on what type of particles an object or substance is made of. In this activity we will explore how the smallest chemical units of matter determine whether something is classified as an element, a compound, or a mixture.

Model 1 — Atoms, Particles, and Molecules



LM-8

Use the page for question #7 for cut out.

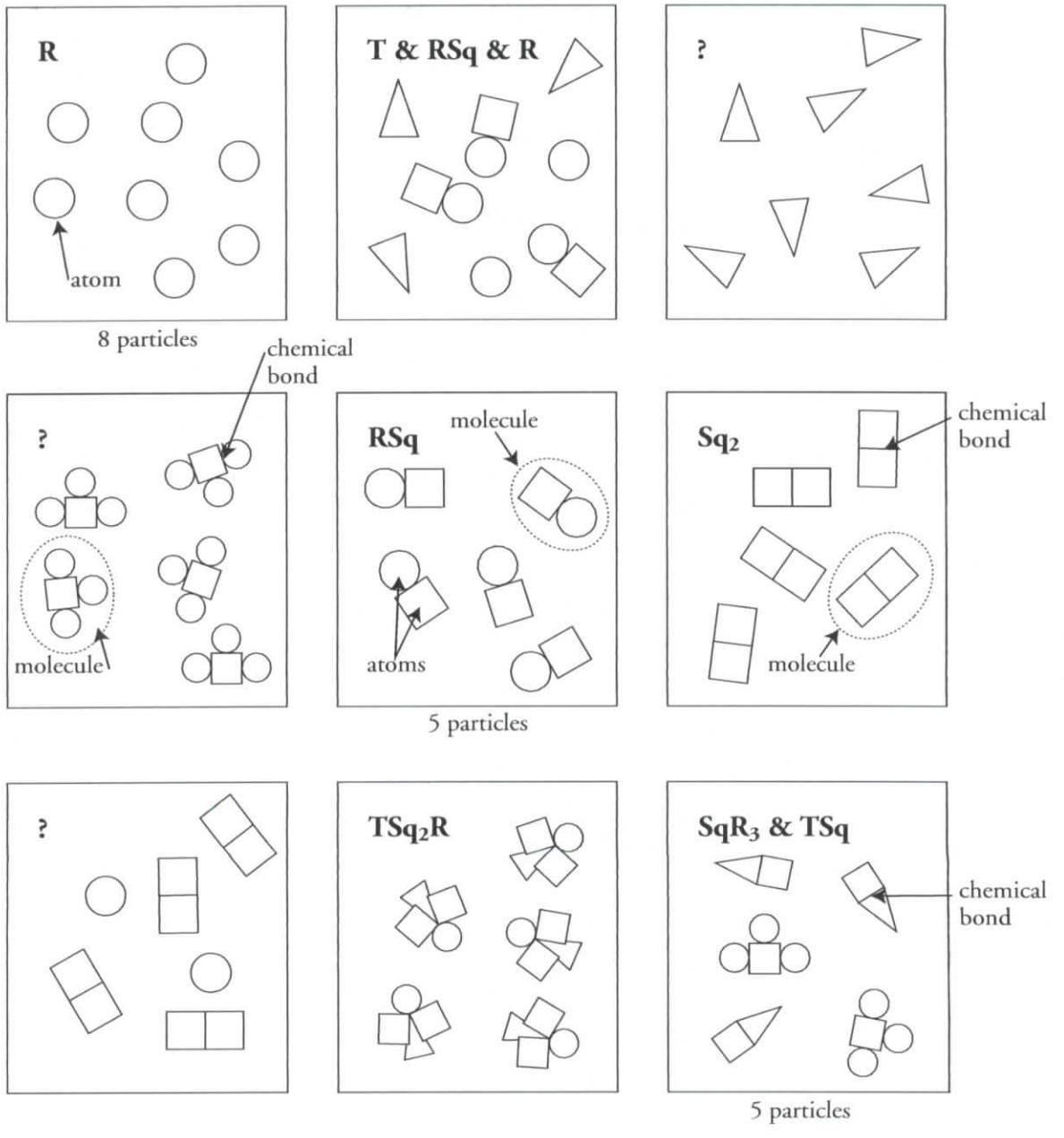
Classification of Matter

How do atoms combine to make different types of matter?

Why?

Look at the things in this room. They are all matter. That matter may be pure or it may be a mixture. Can you tell by looking at it? What if you looked at it under a microscope? Then could you tell? Something that looks pure may not really be pure. It depends on what type of particles an object or substance is made of. In this activity we will explore how the smallest chemical units of matter determine whether something is classified as an element, a compound, or a mixture.

Model 1 — Atoms, Particles, and Molecules



1. Locate the circled molecule of **RSq** in Model 1.
   a. Find a second **RSq** molecule and circle it.
   b. How many atoms are in a molecule of **RSq**?

2. Find and circle a molecule of **TSq_2R** in Model 1.
   a. How many different types of atoms are found in a molecule of **TSq_2R**?

   b. How many Sq atoms are in a molecule of **TSq_2R**?

3. Locate the drawing labeled **SqR_3 & TSq** in Model 1.
   a. How many different types of atoms are found in the sample of **SqR_3 & TSq**?

   b. How many different types of molecules are found in the sample of **SqR_3 & TSq**?

4. When two atoms are touching in the drawings of Model 1, what is holding the atoms together?

5. As a group, discuss the following questions and record your answers:
   a. Can a *particle* be a single atom?

   b. Can a *particle* be a molecule?

   c. How many particles are in the drawing representing **T & RSq & R** in Model 1?

   d. What is your group's definition of the word "particle" as it is used in chemistry?

6. Compare the codes listed at the top of each drawing in Model 1 with the shapes in that box.
   a. What do the letters **R**, **Sq,** and **T** in the codes represent?

   b. What do the small numbers (subscripts) in the codes represent?

   c. When atoms are touching, how is that communicated in the code?

   d. What is the common characteristic of the samples in which an ampersand (&) is used?

   e. In Model 1 there are three drawings that are labeled with a question mark. Write codes to properly label these drawings.

7. Appoint one group member to cut apart Model 1 to separate the nine drawings. As a team, sort the drawings into two groups—one group where all the particles in the drawing are identical, and a second group in which the drawings contain more than one type of particle.

Read This!

Matter is classified as a **pure substance** when all of the particles are identical. Matter is classified as a **mixture** if there are different types of particles present.

8. Identify which drawings from Question 7 are pure substances and which are mixtures. List the codes for the drawings in the appropriate places below.

Pure Substances		Mixtures
_____	_____	_____
_____	_____	_____
_____	_____	_____

9. How are the codes (chemical formulas) for pure substances different from those for mixtures?

10. As a team, take the set of pure substances drawings from Question 8 and sort them into two new groups, those containing only one type of atom and those with two or more types of atoms.

Read This!

Elements are defined as pure substances made from only one type of atom. **Compounds** are defined as pure substances made from two or more types of atoms.

11. Identify which drawings from Question 10 are elements and which are compounds. List the codes for the drawings in the appropriate places below.

Elements	Compounds
_____	_____
_____	_____
_____	_____

12. How are the codes (chemical formulas) for elements different from those for compounds?

13. Use what you have just learned about chemical formulas to identify each of the following as an element, a compound or a mixture.

a. Br_2 *b.* $NaHCO_3$ *c.* $C_6H_{12}O_6$ & H_2O

d. Cu & Zn *e.* CO_2 *f.* Al

Extension Questions

15. It is often useful to separate matter. Physical methods of separation (filtering, distillation) do not require a chemical change. In other words, no chemical bonds are broken or formed during the separation. Chemical methods of separation (decomposition, electrolysis) require a chemical change. In other words, chemical bonds are broken and/or formed during the separation.

    a. Is straining cooked pasta from water a physical or chemical separation?

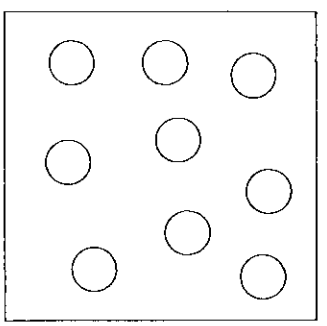
    b. Is using a fuel cell to separate water into hydrogen and oxygen a physical or chemical separation?

    c. Which type(s) of matter (mixtures/compounds/elements) could be separated by physical methods?

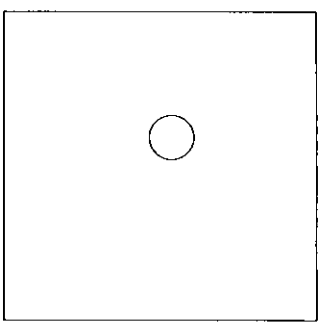
    d. Which type(s) of matter (mixtures/compounds/elements) would need to be separated by chemical methods?

16. Students in a chemistry course were asked the following question on a unit exam: "Draw a diagram representing an element using circles as atoms."

    a. The following diagrams represent two typical answers given by students. Which drawing is the best representation of an element? Explain.



Drawing A



Drawing B

    b. Imagine that the atom in Drawing B had been removed by physical separation from one of the substances in Model 1. What substances could have been the source of the atom in Drawing B?

Name _____ Period: ____

PL lab #4

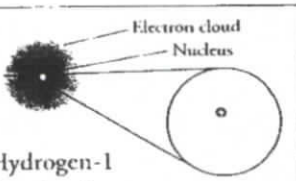
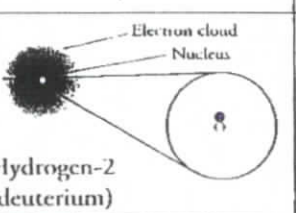
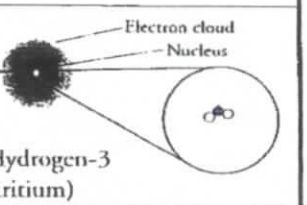
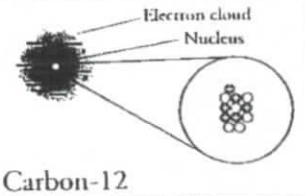
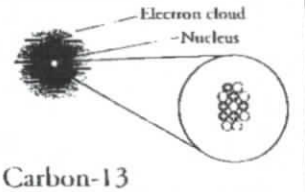
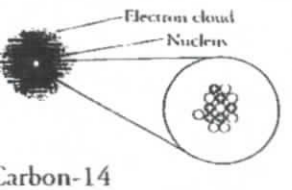
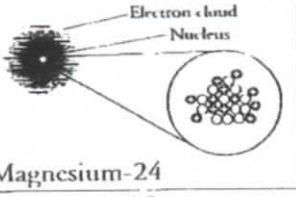
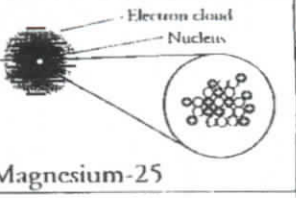
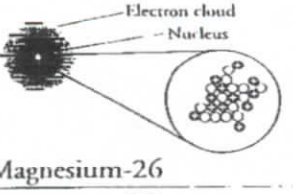
Isotopes

Are all atoms of an element alike?

Why?

The following activity will help you learn the important structural characteristics of an atom. How do we classify atoms? How does the combination of subatomic particles affect the mass and charge of an atom? What are isotopes? This is just a sampling of what we will address. Throughout this activity you will want to keep both Model 1 and a periodic table handy.

Model 1

Isotopes of Hydrogen			
Symbol	$^{1}_{1}H$	$^{2}_{1}H$	$^{3}_{1}H$
Atomic Diagram with Name	 Hydrogen-1 (protium)	 Hydrogen-2 (deuterium)	 Hydrogen-3 (tritium)
Number of Protons ⊕	1	1	1
Number of Neutrons ○	0	1	2
Isotopes of Carbon			
Symbol	$^{12}_{6}C$	$^{13}_{6}C$	$^{14}_{6}C$
Atomic Diagram with Name	 Carbon-12	 Carbon-13	 Carbon-14
Number of Protons ⊕			
Number of Neutrons ○			8
Isotopes of Magnesium			
Symbol	$^{24}_{12}Mg$	$^{25}_{12}Mg$	$^{26}_{12}Mg$
Atomic Diagram with Name	 Magnesium-24	 Magnesium-25	 Magnesium-26
Number of Protons ⊕	12	12	12
Number of Neutrons ○			14

1. Refer to Model 1. What subatomic particles do the following symbols represent in the Atomic Diagrams?

Electron *Proton* *Neutron*

2. Complete the table in Model 1 by counting the protons and neutrons in each atomic diagram. Divide the work evenly among group members.

See Model 1.

3. Find the three elements shown in Model 1 on your periodic table.

   a. What whole number shown in Model 1 for each element is also found in the periodic table for that element?

   Hydrogen — *1* Carbon - _____ Magnesium - _____

   b. The whole number in each box of the periodic table is the atomic number of the element. What does the **atomic number** of an element represent?

   c. Refer to the isotope symbols in Model 1. Relative to the atomic symbol (H, C, or Mg), where is the atomic number located in the isotope symbol?

4. Refer to your periodic table.

   a. How many protons are in all chlorine (Cl) atoms?

   b. A student says "I think that some chlorine atoms have 16 protons." Explain why this student is not correct.

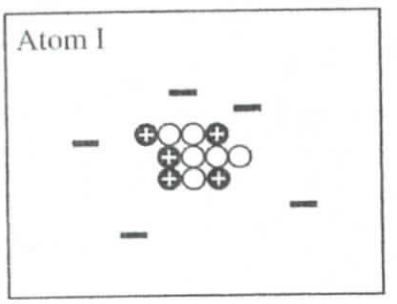
5. Refer again to Model 1. In the isotope symbol of each atom, there is a superscripted (raised) number. This number is also used in the name of the atom (*i.e.*, carbon-12). It is called the **mass number**.

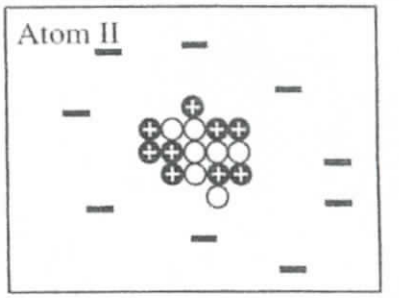
   a. How is the mass number determined?

   b. Why is this number called a "mass" number?

6. Fill in the table for Atom I and Atom II shown below.

	Atom I	Atom II
Number of Protons ⊕	5	
Number of Neutrons ○		
Mass Number		16





7. Refer to Model 1.

   a. Which corner of the isotope symbol contains the mass number?

   The mass number is in the _____

   b. How is the mass number of an isotope expressed in the name of an atom?

   → *The mass number is shown as a numeral following the name of the atom, separated by a hyphen. Examples: carbon-12 or hydrogen-3).*

8. Write an isotope symbol (similar to those in Model 1) for each of the atoms in Question 6.

9. Write the name of the atom (similar to those in Model 1) for each of the atoms in Question 6.

STOP

10. Fill in the following table.

Isotope Symbol	$^{40}_{19}K$	$^{18}_{9}F$	$^{31}_{16}S$
Atomic Number		9	
Mass Number	40		
Number of Protons			16
Number of Neutrons		9	

11. Consider the examples in Model 1.

   a. Do all isotopes of an element have the same atomic number? Give at least one example or counter-example from Model 1 that supports your answer.

LM-15

Name: _____ PL: lab#5 period: ____

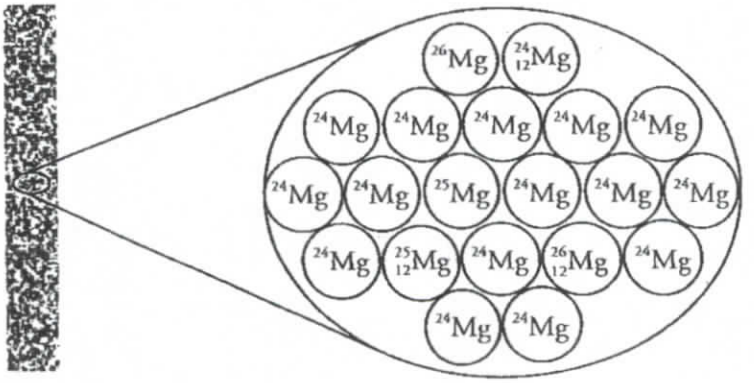
Average Atomic Mass

How are the masses on the periodic table determined?

Why?

Most elements have more than one naturally occurring isotope. As you learned previously, the atoms of those isotopes have the same atomic number (number of protons), making them belong to the same element, but they have different mass numbers (total number of protons and neutrons) giving them different atomic masses. So which mass is put on the periodic table for each element? Is it the most common isotope's mass? The heaviest mass? This activity will help answer that question.

Model 1 – A Strip of Magnesium Metal



1. Write in the atomic number for each Mg atom in Model 1.

2. What are the mass numbers of the naturally occurring isotopes of magnesium shown in Model 1?

3. Do all of the atoms of magnesium in Model 1 have the same atomic mass? Explain.

→ *No—since the mass numbers of the atoms are different, their atomic masses also differ.*

4. For the sample of 20 atoms of magnesium shown in Model 1, draw a table indicating the mass numbers of the three isotopes and the number of atoms of each isotope present.

	^{24}Mg	^{25}Mg	^{26}Mg
Number of Atoms			

5. Which isotope of magnesium is the most common in Model 1?

6. Based on Model 1 and the table you created in Question 4, for every 10 atoms of magnesium, approximately how many atoms of each isotope will be found?

→ *In a goup of 10 magnesium atoms, there will be approximately one ^{25}Mg, one ^{26}Mg, and eight ^{24}Mg atoms.*

Model 2 – Natural Abundance Information for Magnesium

Isotope	Natural Abundance on Earth (%)	Atomic Mass (amu)
^{24}Mg	78.99	23.9850
^{25}Mg	10.00	24.9858
^{26}Mg	11.01	25.9826

7. Consider the natural abundance information given in Model 2.
   a. Calculate the expected number of atoms of each isotope that will be found in a sample of 20 atoms of Mg. *Hint:* The number of atoms must be a whole number!

   78.99% of 20 atoms = _____ *10.00% of 20 atoms* = _____

   11.01% of 20 atoms = _____

   b. Is Model 1 accurate in its representation of magnesium at the atomic level? Explain.

8. If you could pick up a single atom of magnesium and put it on a balance, the mass of that atom would most likely be ___23.9850___ amu. Explain your reasoning.

   7

9. Refer to a periodic table and find the box for magnesium.
   a. Write down the decimal number shown in that box.

   b. Does the decimal number shown on the periodic table for magnesium match any of the atomic masses listed in Model 2?

10. The periodic table does not show the atomic mass of every isotope for an element.
   a. Explain why this would be an impractical goal for the periodic table.

   b. Is it important to the average scientist to have information about a particular isotope of an element? Explain.

   → *No. In most cases a scientist will be working with a mixture of all the isotopes so information about individual isotopes is not necessary.*

11. What would be a practical way of showing the mass of magnesium atoms on the periodic table given that most elements occur as a mixture of isotopes?

12. Propose a possible way to calculate the average atomic mass of 100 magnesium atoms. Your answer may include a mathematical equation, but it is not required.

STOP

Model 3 – Proposed Average Atomic Mass Calculations

Mary's Method

$$\frac{(78.99)(23.9850 \text{ amu}) + (10.00)(24.9858 \text{ amu}) + (11.01)(25.9826 \text{ amu})}{100} = 24.305 \text{ amu}$$

Jack's Method

$$(0.7899)(23.9850 \text{ amu}) + (0.1000)(24.9858 \text{ amu}) + (0.1101)(25.9826 \text{ amu}) = 24.305 \text{ amu}$$

Alan's Method

$$\frac{23.9850 \text{ amu} + 24.9858 \text{ amu} + 25.9826 \text{ amu}}{3} = 24.984 \text{ amu}$$

13. Complete the three proposed calculations for the average atomic mass of magnesium in Model 3.
14. Consider the calculations in Model 3.

    a. Which methods shown in Model 3 give an answer for average atomic mass that matches the mass of magnesium on the periodic table?

    b. Explain why the mathematical reasoning was incorrect for any method(s) in Model 3 that did not give the correct answer for average atomic mass (the one on the periodic table).

    c. For the methods in Model 3 that gave the correct answer for average atomic mass, show that they are mathematically equivalent methods.

$$\frac{(78.99)(23.9850 \text{ amu}) + (10.00)(24.9858 \text{ amu}) + (11.01)(25.9826 \text{ amu})}{100} =$$

$$\frac{(78.99)(23.9850 \text{ amu})}{100} + \frac{(10.00)(24.9858 \text{ amu})}{100} + \frac{(11.01)(25.9826 \text{ amu})}{100} =$$

$$(0.7899)(23.9850 \text{ amu}) + (0.1000)(24.9858 \text{ amu}) + (0.1101)(25.9826 \text{ amu})$$

15. Use one of the methods in Model 3 that gave the correct answer for average atomic mass to calculate the average atomic mass for oxygen. Isotope information is provided below. Show all of your work and check your answer against the mass listed on the periodic table.

Isotope	Natural Abundance on Earth (%)	Atomic Mass (amu)
^{16}O	99.76	15.9949
^{17}O	0.04	16.9991
^{18}O	0.20	17.9992

$$(0.9976)(15.9949 \text{ amu}) +$$
$$(0.0004)(16.9991 \text{ amu}) +$$
$$(0.0020)(17.9992 \text{ amu}) = 15.999 \text{ amu}$$

STOP

Name: _____ PL: lab #6 per: _____

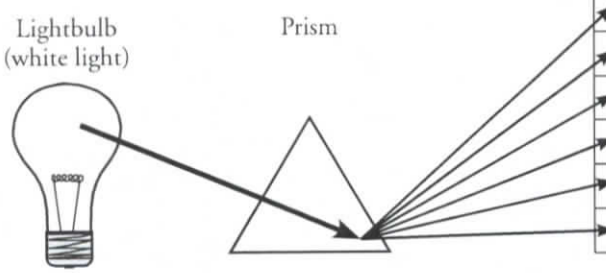
Electron Energy and Light

How does light reveal the behavior of electrons in an atom?

Why?

From fireworks to stars, the color of light is useful in finding out what's in matter. The emission of light by hydrogen and other atoms has played a key role in understanding the electronic structure of atoms. Trace materials, such as evidence from a crime scene, lead in paint or mercury in drinking water, can be identified by heating or burning the materials and examining the color(s) of light given off in the form of bright-line spectra.

Model 1 – White Light



Color	Photon Energy ($\times 10^{-21}$) (J)	Wavelength Range (nm)	Speed (m/s)
Reds	269–318	625–740	3.00×10^8
Oranges	318–337	590–625	3.00×10^8
Yellows	337–352	565–590	3.00×10^8
Greens	352–382	520–565	3.00×10^8
Blues	382–452	440–520	3.00×10^8
Violets	452–523	380–440	3.00×10^8

1. Trace the arrows in Model 1 and shade in the table with colored pencils where appropriate.
2. What happens to white light when it passes through a prism?

3. Why are the color labels in the table in Model 1 plural (*i.e.*, "Reds" rather than "Red")?

4. Do all colors of light travel at the same speed?

5. Do all colors of light have the same energy? If no, which colors have the highest energy and the least energy, respectively?

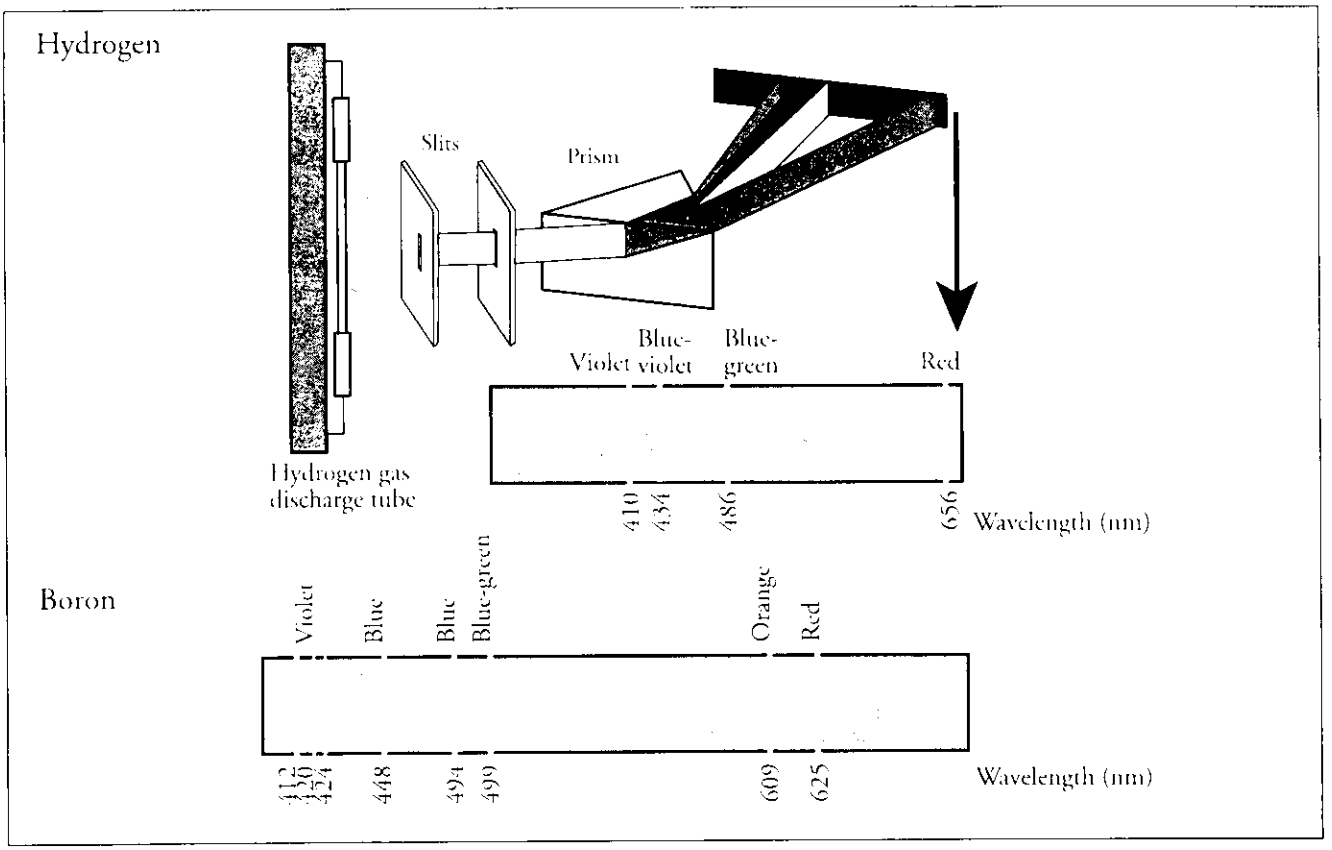
6. Consider the light illustrated in Model 1.
   a. Which color corresponds to the longest wavelengths?

   b. Which color corresponds to the shortest wavelengths?

   c. Write a sentence that describes the relationship between wavelength and energy of light.

STOP

Model 2 – Emission Spectra for Hydrogen and Boron Atoms



7. Use colored pencils to color the hydrogen and boron spectral lines within their respective spectra in Model 2.
8. List the spectral lines for hydrogen gas by color and corresponding wavelength.

9. The spectral lines for boron were produced using the same method as hydrogen. List three of the colors and corresponding wavelengths for boron's spectral lines as its light passes through a prism.

10. Consider the hydrogen spectrum in Model 2.
    a. Which color of light corresponds to the shortest wavelength?

    b. Which color of light corresponds to the longest wavelength?

11. Consider the hydrogen spectrum in Model 2.

    a. Which color of light has the most energy?

    b. Which color of light has the least energy?

12. Does a gas discharge tube filled with boron emit the same wavelengths of light as a tube filled with hydrogen? Use evidence from Model 2 to support your answer.

13. "The spectral lines for atoms are like fingerprints for humans." How do the spectral lines for hydrogen and boron support this statement?

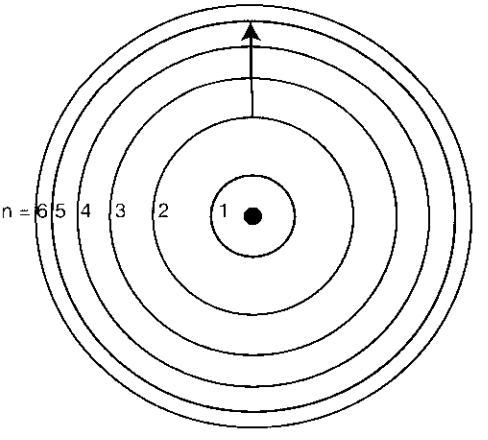
Circle the appropriate word to complete each statement in Questions 14–17.

14. Electrons and protons (attract/repel) each other.
15. As an electron gets closer to the nucleus the (attraction/repulsion) to the nucleus gets (stronger/weaker).
16. For an electron to move from an energy level close to the nucleus to an energy level far from the nucleus it would need to (gain/lose) energy.
17. For an electron to move from an energy level far from the nucleus to an energy level close to the nucleus it would need to (gain/lose) energy.

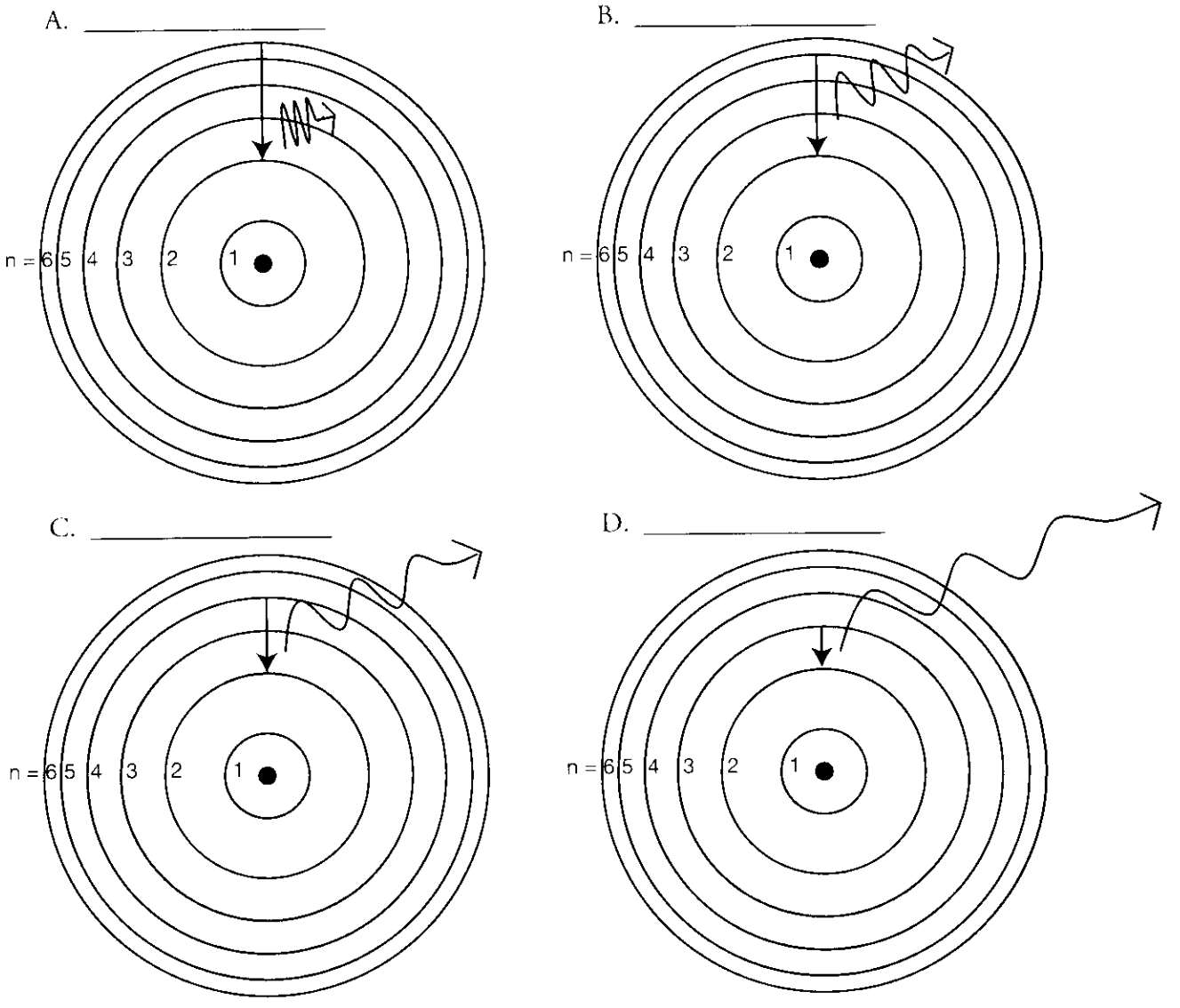
Read This!

Niels Bohr modified Rutherford's Nuclear Atom model to explain how light interacted with the electrons in an atom to produce spectral lines. His model included electrons orbiting the nucleus at specific energy levels. Electrons absorb energy from various sources (electricity) when they move from lower energy levels (ground state) to higher energy levels (excited states). Energy is released as electrons return to their lower energy levels.

18. Is energy absorbed or released for the electron transition shown in the diagram to the right? Explain.



Model 3 – Bohr Model of a Hydrogen Atom



19. Identify the drawing in Model 3 that depicts a hydrogen atom with an electron moving from energy level 5 to energy level 2. Refer to Models 1 and 2 for the following questions.

    a. Label the picture with "n=5 to n=2" and list the corresponding color of light emitted.

    b. This electron transition (absorbs/releases) energy.

    c. This electron moves from a (lower/higher) energy state to a (lower/higher) energy state.

    d. Is light absorbed or released in the electron transition?

20. Label the remaining drawings in Model 3 with the electron transitions that are occurring (n=? to n=?), the wavelengths, and the corresponding colors as given in example A in Model 3. See Model 2 in order to identify the color of spectral lines produced in each of the hydrogen atom electron transitions shown in Model 3. Use colored pencils to trace the light wave in each of the four pictures with the appropriate color.

21. Consider the electron transitions in Model 3.

    a. Which of the electron transitions involves the most energy?

    b. Explain why this transition involves the most energy based on your understanding of the attractive forces between the electrons and protons in the atom.

22. Explain why a single atom of hydrogen cannot produce all four hydrogen spectral lines simultaneously.

23. If Question 22 is true, how can we see all four colors from a hydrogen gas discharge tube simultaneously?

LM-23

Name: _____ Period ____

PL: Lab #.7

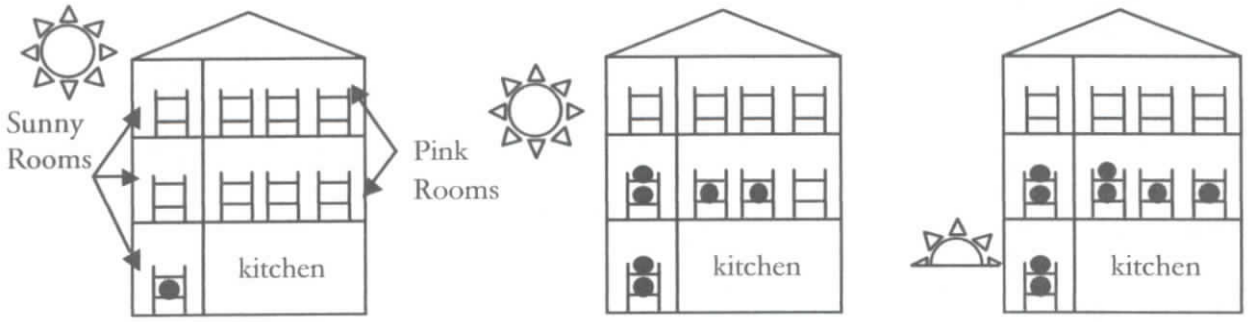
Electron Configurations

What is the electron structure in an atom?

Why?

The electron structure of an atom is very important. Scientists use the electronic structure of atoms to predict bonding in molecules, the charge(s) an atom might have, and the physical properties of elements. In order for scientists to describe the electron structure in an atom, they give the electrons "addresses." Just like your address might include your house number, street, city, and state, an electron's "address" has multiple parts. In this activity, you will learn how the electrons fill up the available spaces in an atom and how their "addresses" or configurations are assigned.

Model 1 – The Boarding House



Time: 1:00 pm
Manager's Code: $1s^1$

3:00 pm
$1s^2\ 2s^2\ 2p^2$

5:00 pm
$1s^2\ 2s^2\ 2p^4$

Time: 7:00 pm
Manager's Code: $1s^2\ 2s^2\ 2p^6\ 3s^1$

9:00 pm
$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$

11:00 pm
$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$

1. Examine the boarding house diagrams in Model 1. Match each symbol below with its most likely meaning.

____*a.*	●	I. Bunk bed for boarders
____*b.*		II. Manager's code for the number of boarders in the house and their room assignments.
____*c.*	$1s^2\ 2s^2\ 2p^6\ 3s^1$	III. Boarder

2. Refer to Model 1.

   a. How many boarders were in the boarding house at 5:00 pm?

   b. Describe how you determined your answer to part *a*.

3. Examine each diagram in Model 1 and the corresponding manager's code. Using the following manager's code:

   $$1s^2\ \ 2s^2\ \ 2p^4$$

   a. Underline the floor numbers.

   b. Circle the types of rooms.

   c. Draw a box around the numbers of boarders.

4. The manager of the boarding house has some very strict rules on how beds will be rented out for the night. Examine the diagrams in Model 1 and the statements below to determine the phrase that best describes the manager's set of rules. Circle the correct answer.

   a. The boarding house will rent out beds on the _____ floor first.

   1st 2nd 3rd

   b. Boarders are only allowed to double up in a bunk in a room when _____.

   there is an even number of boarders in the room all bottom bunks are occupied

   c. The next floor of rooms will be opened for boarders only when _____ on the floor below are occupied.

   half of the bunks at least one of the rooms all of the bunks

   d. The pink room on a floor will be opened for boarders only when _____.

   all of the lower bunks in the sunny room on that floor are occupied

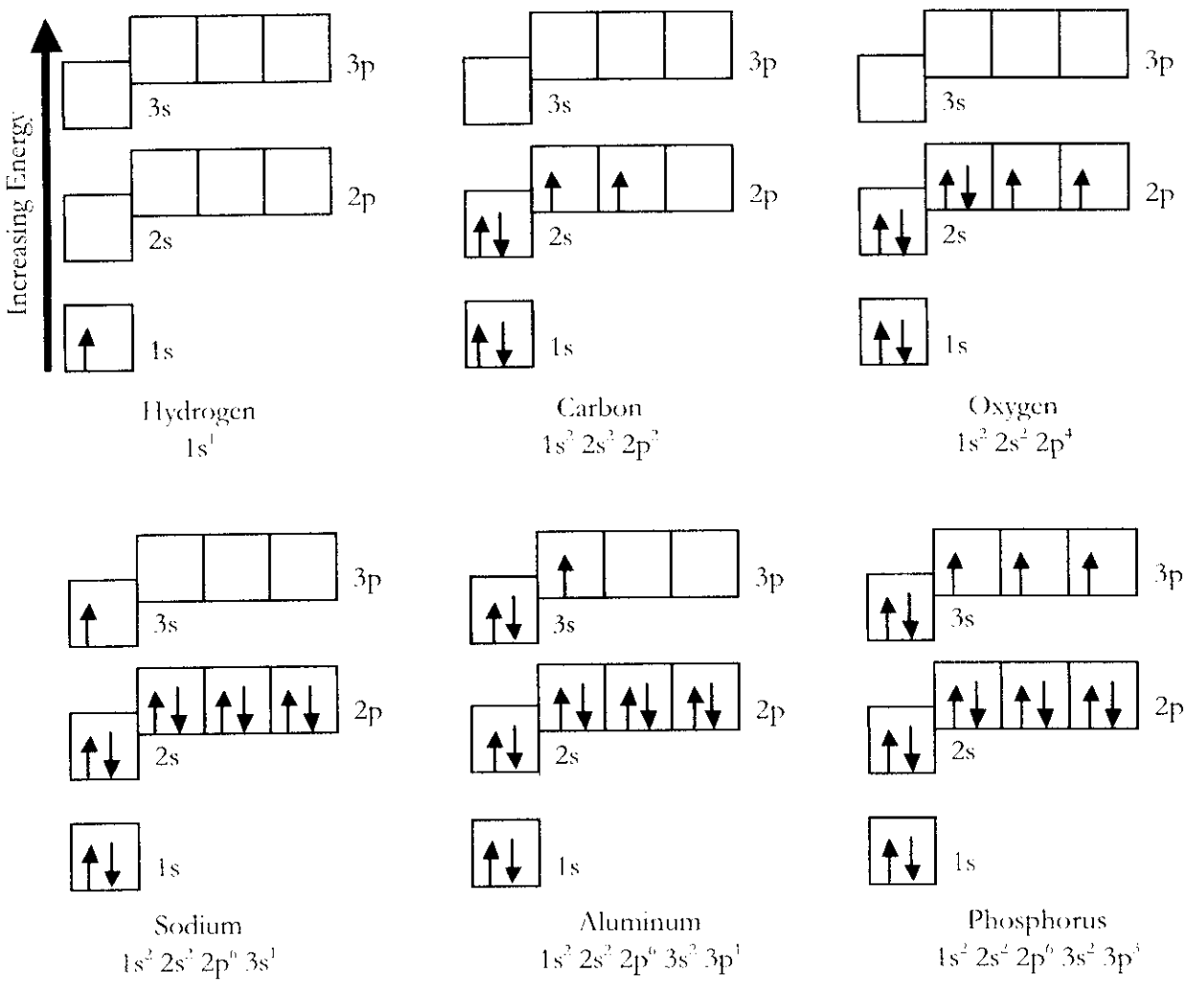
   all of the bunks in the sunny room on that floor are occupied

   the sunny room on that floor is open

5. Provide (a) the manager's code and (b) a boarding house diagram showing 12 boarders present.

   a. *b.*

Model 2 – Ground State Orbital Diagrams and Electron Configurations



6. Examine the orbital diagrams and electron configurations in Model 2. Match each symbol below with its meaning.

____*a.*		I. Single electron
____*b.*		II. Pair of electrons with opposite spins
____*c.*		III. Atomic orbital (region of space where an electron is likely to be found)
____*d.*		IV. Sublevel (set of orbitals having equivalent energy)
____*e.*	$1s^2\ 2s^2\ 2p^4$	V. Electron configuration

7. Consider the orbital diagram for oxygen in Model 2.

   a. How many electrons are present in the orbital diagram?

   b. Based on its position in the periodic table, explain how you know that your answer to part *a* is the *correct* number of electrons for oxygen.

8. Examine the orbital diagrams and electron configurations in Model 2. Using the following electron configuration:

$$1s^2\ \ 2s^2\ \ 2p^4$$

   a. Underline the energy levels.

   b. Circle the sublevels.

   c. Draw a box around the numbers of electrons.

9. The 2s and 2p sublevels are very close in energy, as are the 3s and 3p sublevels. Explain how the orbital diagram for sodium confirms that the 3s sublevel is lower in energy than the 3p sublevel.

10. The lowest potential energy arrangement of electrons in an atom is called the **ground state**. Ground state electron configurations can be predicted by a strict set of rules known as the **Aufbau principle** ("aufbau" means filling up). Examine the diagrams in Model 2 and the statements below to determine the phrase that best describes each rule. Circle the correct answer.

   a. Based on where a single electron is placed, the lowest potential energy electron in an atom is found in the _____ sublevel.

   1s 2s 3s

   b. Electrons will occupy a p-orbital only after _____ .

   the previous s-orbital is half full

   the previous s-orbital is completely full

   the previous s-orbital is empty

   c. Electrons can begin to occupy energy levels with the next highest integer designation (e.g., 2 vs. 1, 3 vs. 2) only after _____ on the energy level below it are occupied.

   half of the orbitals at least one of the orbitals all of the orbitals

11. The **Pauli exclusion principle** describes the restriction on the placement of electrons into the same orbital. The Pauli exclusion principle can be expressed as: "If two electrons occupy the same orbital, they must have _____." Circle the correct answer.

    the same spin opposite spins

12. **Hund's rule** describes how electrons are distributed among orbitals of the same sublevel when there is more than one way to distribute them. Hund's rule consists of two important ideas. Based on Model 2, circle the correct answer to each statement.

    a. Electrons will pair up in an orbital only when _____

    there is an even number of electrons in the sublevel

    all orbitals in the same sublevel have one electron

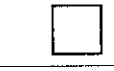
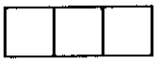
    b. When single electrons occupy different orbitals of the same sublevel, _____.

    they all have the same spin

    they all have different spins

    their spins are random

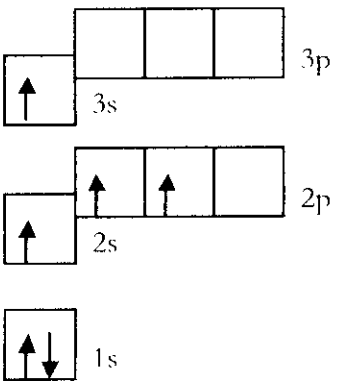
13. For each of the symbols below from Model 2, provide the name or description of the analogous

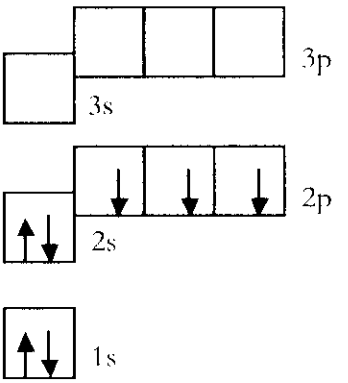
	
	
	
	
$1s^2\ 2s^2\ 2p^4$	

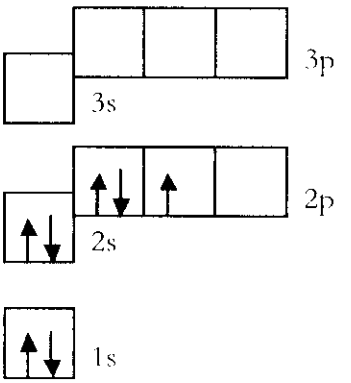
b. What characteristic of electrons is *not* well represented by the boarding house model?

c. How could the boarding house model be modified to better represent the relative energies of s and p sublevels?

14. Below are three answers generated by students in response to the prompt: "Provide an orbital energy level diagram for the ground state of a nitrogen atom." In each case, indicate whether the answer is right or wrong, and if it is wrong, explain the error.



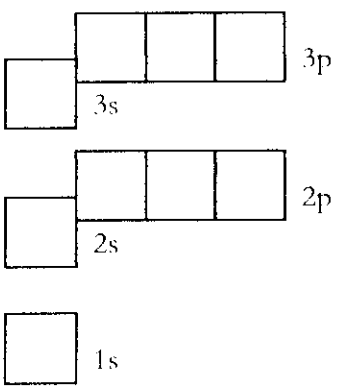




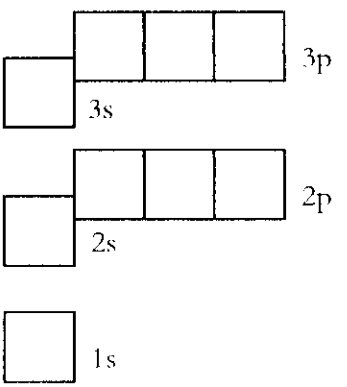
a.	b.	c.

15. Complete the ground state orbital energy level diagrams and write the corresponding electron configurations for:

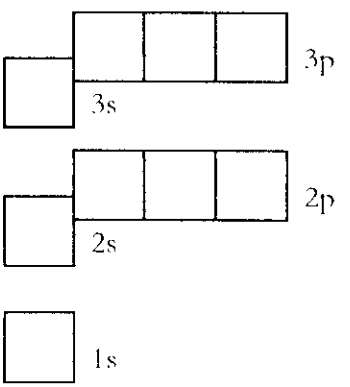
Sulfur



Silicon



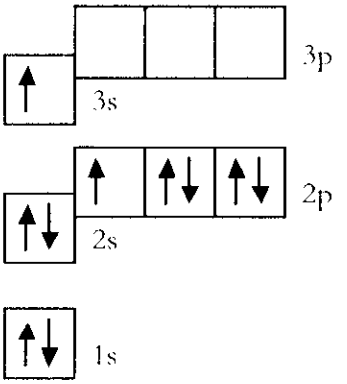
Neon



Sulfur	Silicon	Neon

Extension Questions

Model 3 – Orbital Diagram for an Atom of Element X



16. Consider the orbital diagram in Model 3.

    a. How many electrons are there in one atom of element X?

    b. Identify element X and provide its ground state electron configuration. Assume the atom is neutral.

    c. Is the arrangement of electrons in the orbital diagram in Model 3 higher in total potential energy or lower in total potential energy than the ground state electron configuration of element X? Explain your reasoning.

Read This!

An **excited state electron configuration** is *any* electron configuration for an atom that contains the correct total number of electrons but has a higher total electron potential energy than the ground state electron configuration.

17. Write an electron configuration for element X that shows the atom in a different excited state than the one illustrated in Model 3.

LM-30

Name: _____ PL lab #8 period: ____

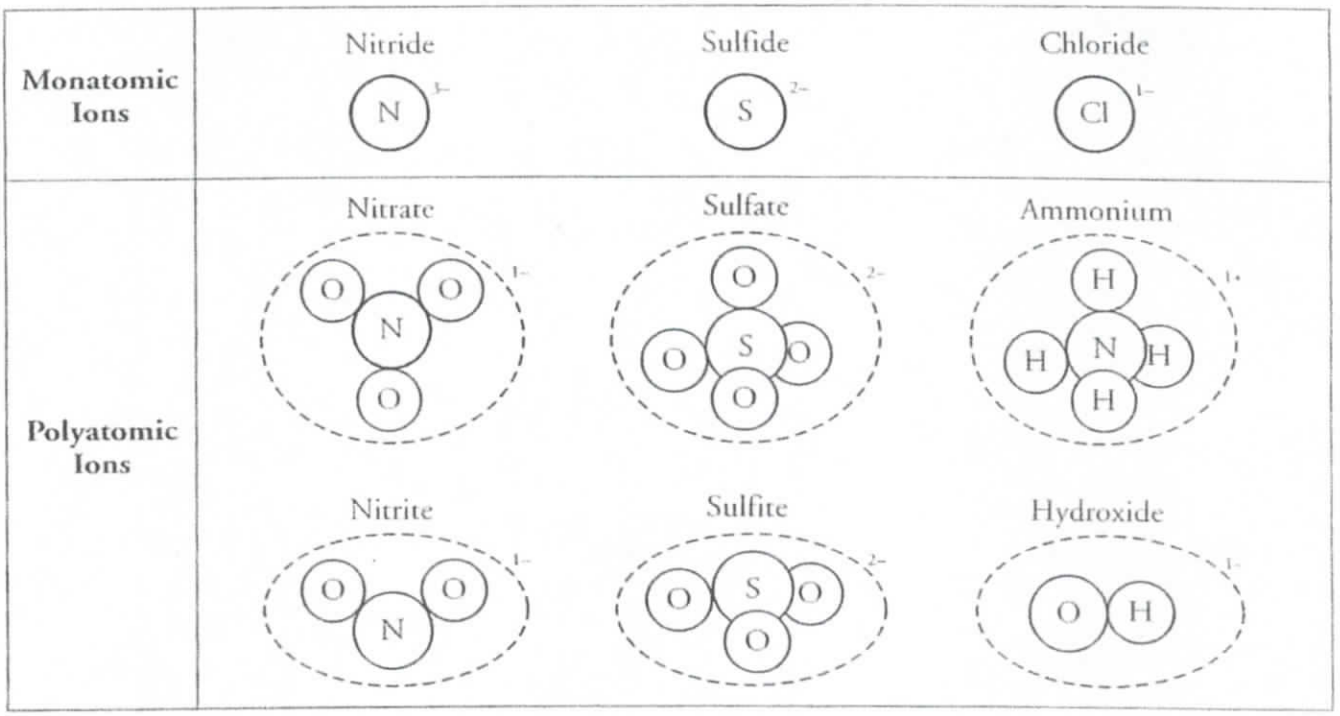
Polyatomic Ions

Can a group of atoms have a charge?

Why?

Do you know you eat a lot of "-ates"? Next time you look at a food label, read the ingredients and you will likely find a number of ingredients that end with "-ate," such as sodium phosphate or calcium carbonate. Did you ever wonder what the chemical formulas of these ingredients look like? In this activity we will explore polyatomic ions, which are groups of atoms that carry a charge. These ions are found in our food ingredients, natural waterways, and many other chemical compounds you encounter every day.

Model 1 – Types of Ions



1. Use Model 1 to complete the table below.

Name of Ion	Nitride	Nitrate	Sulfate	Sulfite	Ammonium
Charge on Ion	*–3*		*–2*		*+1*
Type and Number of Atoms	*1 nitrogen*	*1 nitrogen* *3 oxygen*	1 sulfur 4 oxygen		
Chemical Formula		NO_3^{1-}		SO_3^{2-}	NH_4^{1+}

LM-31

2. Consider the terms "monatomic" and "polyatomic" as they are used in Model 1. Write a definition for each of these terms. It may be helpful to break the words apart (*i.e.*, poly – atomic). Make sure your group comes to consensus.

3. What types of elements (metals or nonmetals) are shown in the polyatomic ions in Model 1?

4. What types of bonds (ionic or covalent) hold the atoms together in polyatomic ions? Explain your reasoning.

5. The net charge on a sulfide ion (S^{2-}) is –2. Explain how this ion obtains its charge. Your answer should include a discussion of subatomic particles.

6. The dotted line around each polyatomic ion in Model 1 shows that the group of atoms has a charge. The charge is not on any one atom, but rather on the group of atoms as a whole. Based on your knowledge of monatomic ions, propose an explanation for the net charge on a polyatomic ion. Your answer should include a discussion of subatomic particles.

   Somewhere in the ion there are either extra (in the case of an ion) or fewer electrons (in the case of a cation) compared to the total number of protons in the atoms involved.

7. What are the similarities and differences between the nitrate and nitrite ions in Model 1?

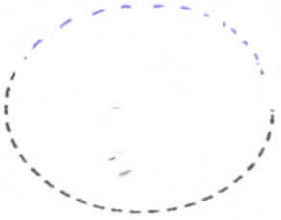
   Both ions have a –1 charge, and each ion includes both nitrogen and oxygen atoms.

   Nitrate has three oxygen atoms; nitrite only has two.

8. What are the similarities and differences between the sulfate and sulfite ions in Model 1?

9. The "chlorate" polyatomic ion has a charge of –1 and is composed of one chlorine atom (the central atom) and three oxygen atoms.

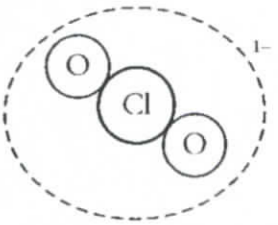
   a. Draw a model of a chlorate ion. in the dotted circle.



b. Write the chemical formula for the chlorate ion, including its charge.

10. In your group discuss what "chlorite" would look like.

a. Draw a model of a chlorite ion.



b. Write the chemical formula for the chlorite ion, including its charge.

STOP

Model 2 – Common Polyatomic Ions

1+		1–		2–		3–	
ammonium	NH_4^{1+}	acetate	CH_3COO^{1-}	sulfate	SO_4^{2-}	phosphate	PO_4^{3-}
		hydroxide	OH^{1-}	sulfite	SO_3^{2-}		
		nitrate	NO_3^{1-}	carbonate	CO_3^{2-}		
		nitrite	NO_2^{1-}	chromate	CrO_4^{2-}		
		bicarbonate	HCO_3^{1-}	dichromate	$Cr_2O_7^{2-}$		
		permanganate	MnO_4^{1-}				
		perchlorate	ClO_4^{1-}				
		chlorate	ClO_3^{1-}				
		chlorite	ClO_2^{1-}				
		hypochlorite	ClO^{1-}				

11. What is the only polyatomic ion that is a cation?

12. How are bicarbonate and carbonate related?

13. Predict the chemical formula and charge for the bisulfate ion.

14. How are chromate and dichromate related?

Both ions have chromium and oxygen atoms, but dichromate has two chromium atoms and more oxygen atoms than chromate. They both have a –2 charge.

LM-33

Name _____ Date _____

Unit 2 p2 : #9 # Lab: Periodic Trends

Define:

Group/Family _____

Period _____

Metal _____

Alkali Metal _____

Alkaline Earth Metal _____

Transition Metal _____

Heavy Metal _____

Metalloid _____

Non-Metal _____

Halogen _____

Noble Gas _____

Electronegativity _____

Ionization energy _____

Atomic Radius _____

Ionic Radius _____

Reactivity _____

Metallic and Non-metallic Character _____

(Honors Only) Electron Affinity _____

Complete the following:

H	Valence Electrons															He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn					Br	Kr
Rb	Sr															I	Xe
Cs	Ba															At	
Fr																	

Questions:

1. Explain what happens to the number of valence electrons within a group

---

2. Explain what happens to the number of valence electrons within a period.

Electronegativity

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn					Br	Kr
Rb	Sr															I	Xe
Cs	Ba															At	
Fr																	

Questions:

3. Explain the trend in electronegativity within a group. What is causing this trend?

4. Explain the trend in electronegativity within a period. What is causing this trend?

Atomic Radius

H																He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn					Br	Kr
Rb	Sr															I	Xe
Cs	Ba															At	
Fr																	

Questions:

5. Explain what happens to the atomic radius within a group. What causes this to happen?

6. Explain what happens to the atomic radius within a period. What causes this to happen?

7. What happens to the radius of an atom when it gains electrons?

8. What happens to the radius of an atom when it loses electrons?

9. Which types of elements like to lose electrons? Why?

10. Which types of elements like to gain electrons? Why?

H	First Ionization Energy																He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn					Br	Kr
Rb	Sr															I	Xe
Cs	Ba															At	
Fr																	

11. Explain what happens to the ionization energy within a group. What causes this to happen?

12. Explain what happens to the ionization energy within a period. What causes this to happen?

Melting Point

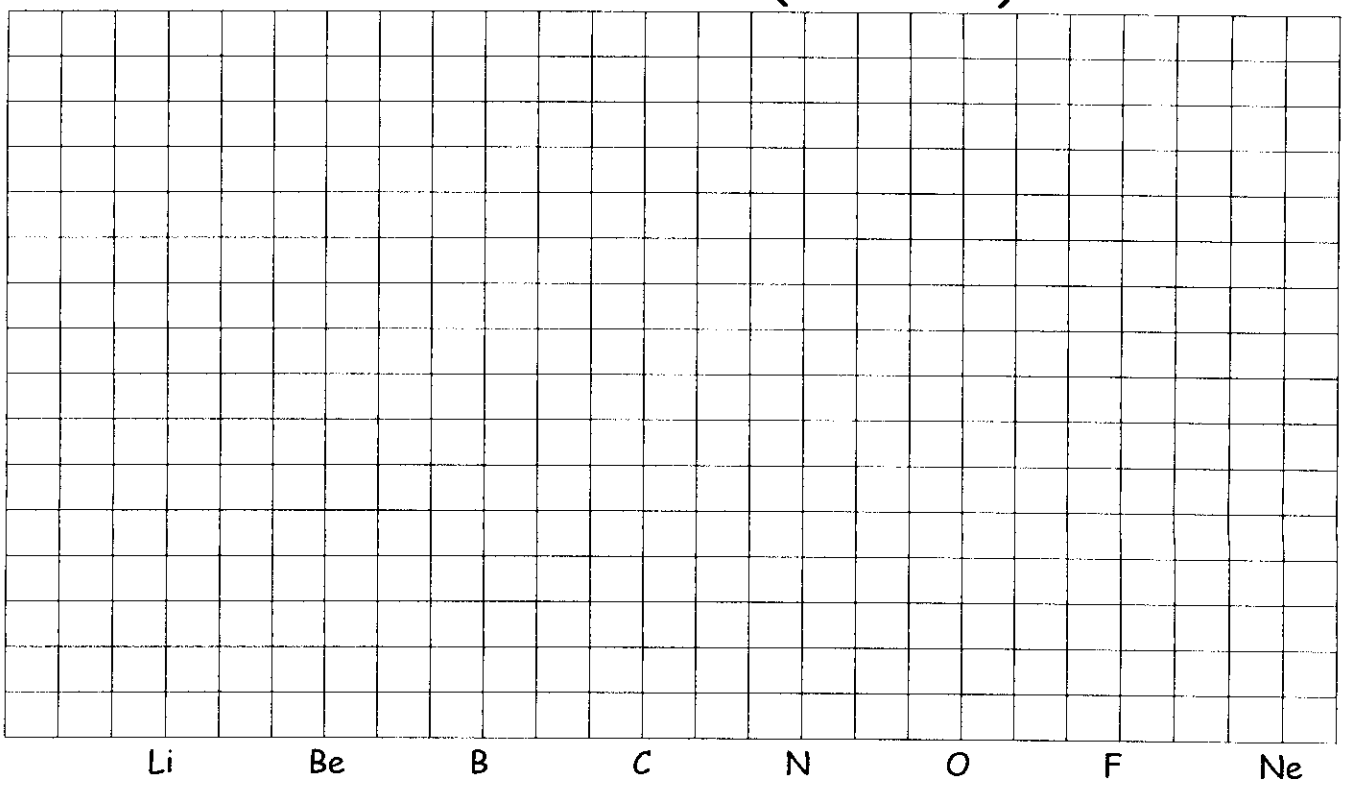
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn					Br	Kr
Rb	Sr															I	Xe
Cs	Ba															At	
Fr																	

Boiling Point

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn					Br	Kr
Rb	Sr															I	Xe
Cs	Ba															At	
Fr																	

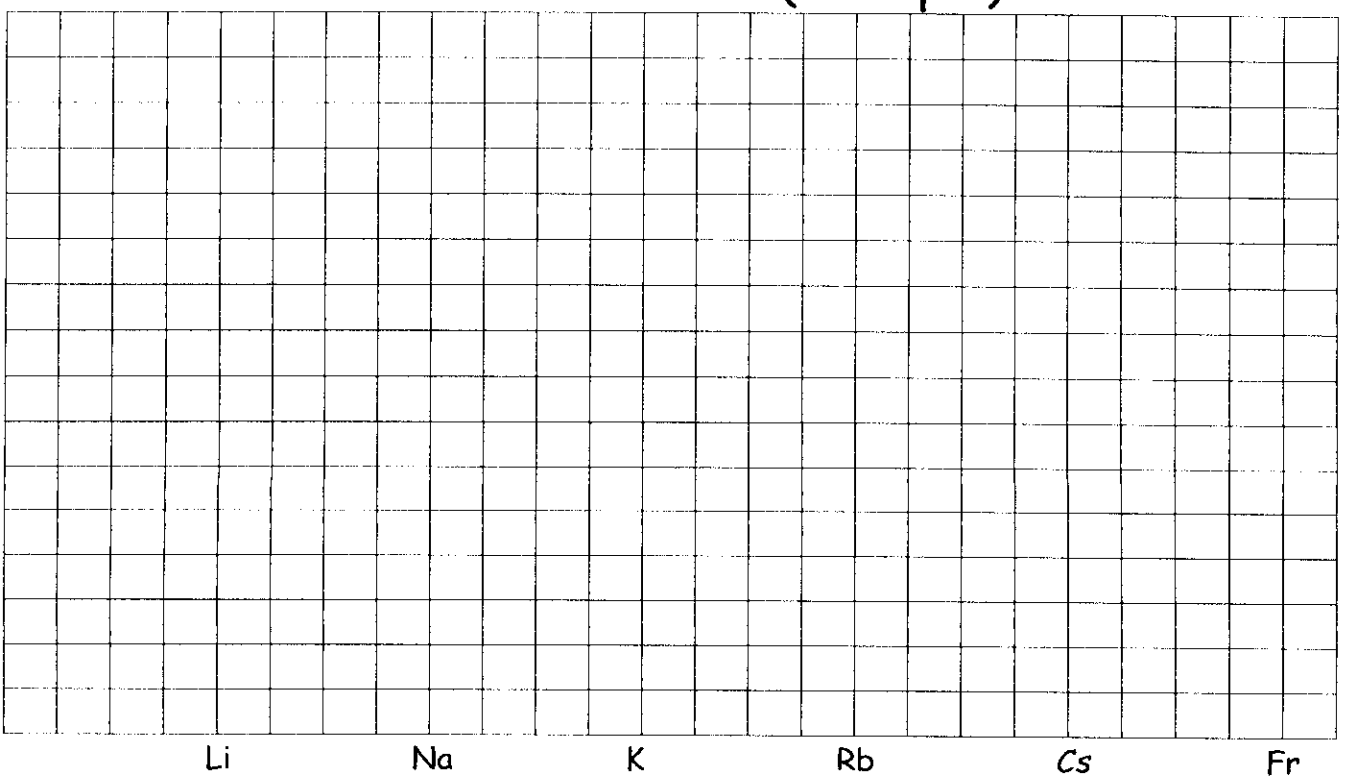
For each of the tables in this lab graph GROUP 1 and PERIOD 2

Valence Electrons (Period 2)



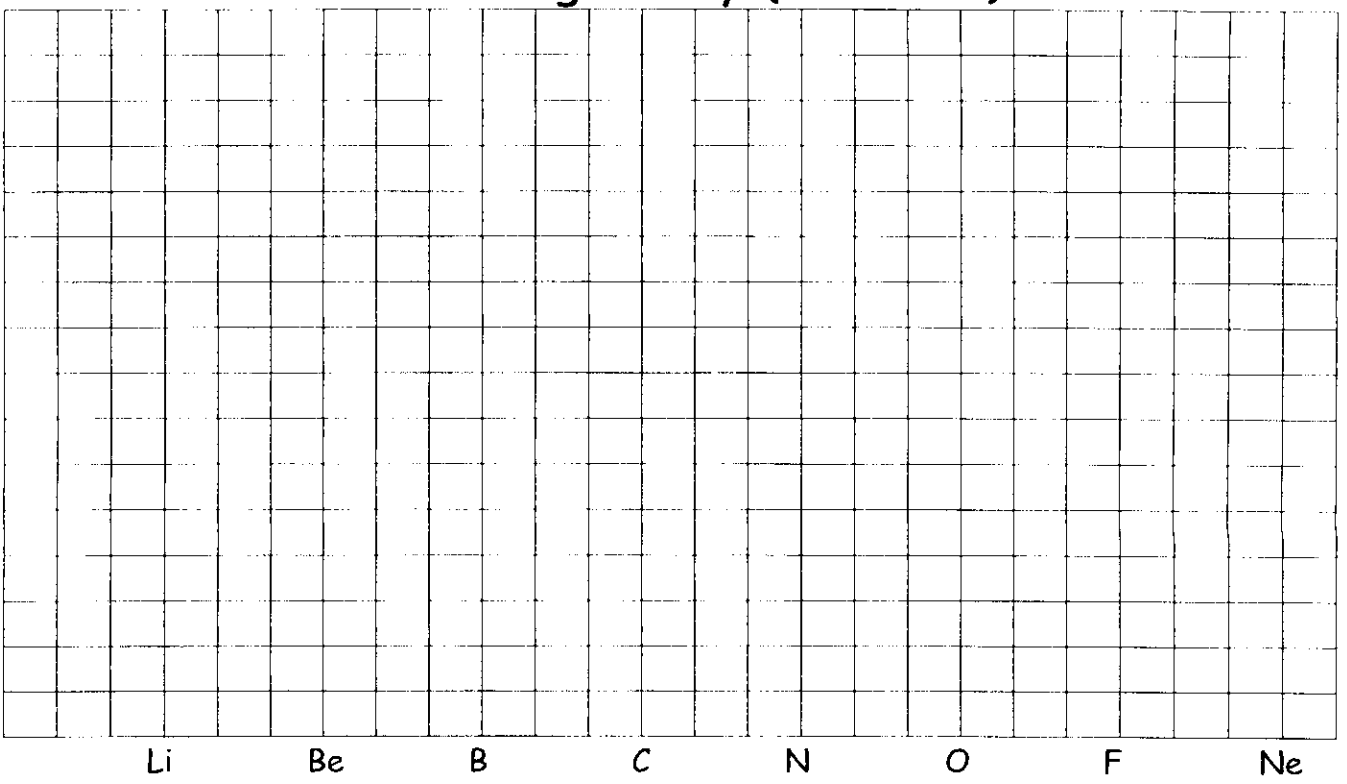
13. What is the trend for valence electrons in period 2? _____

Valence Electrons (Group 1)



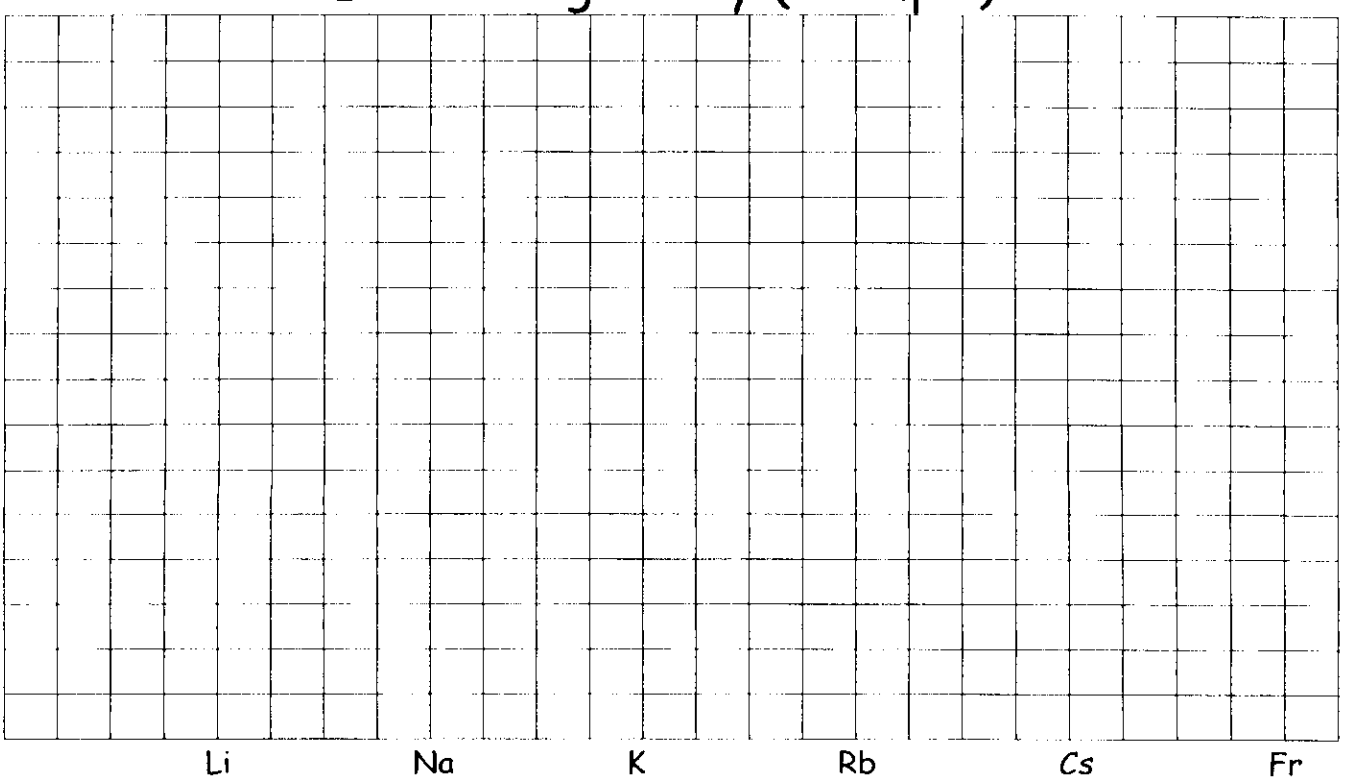
14. What is the trend for valence electrons in Group 1? _____

Electronegativity (Period 2)



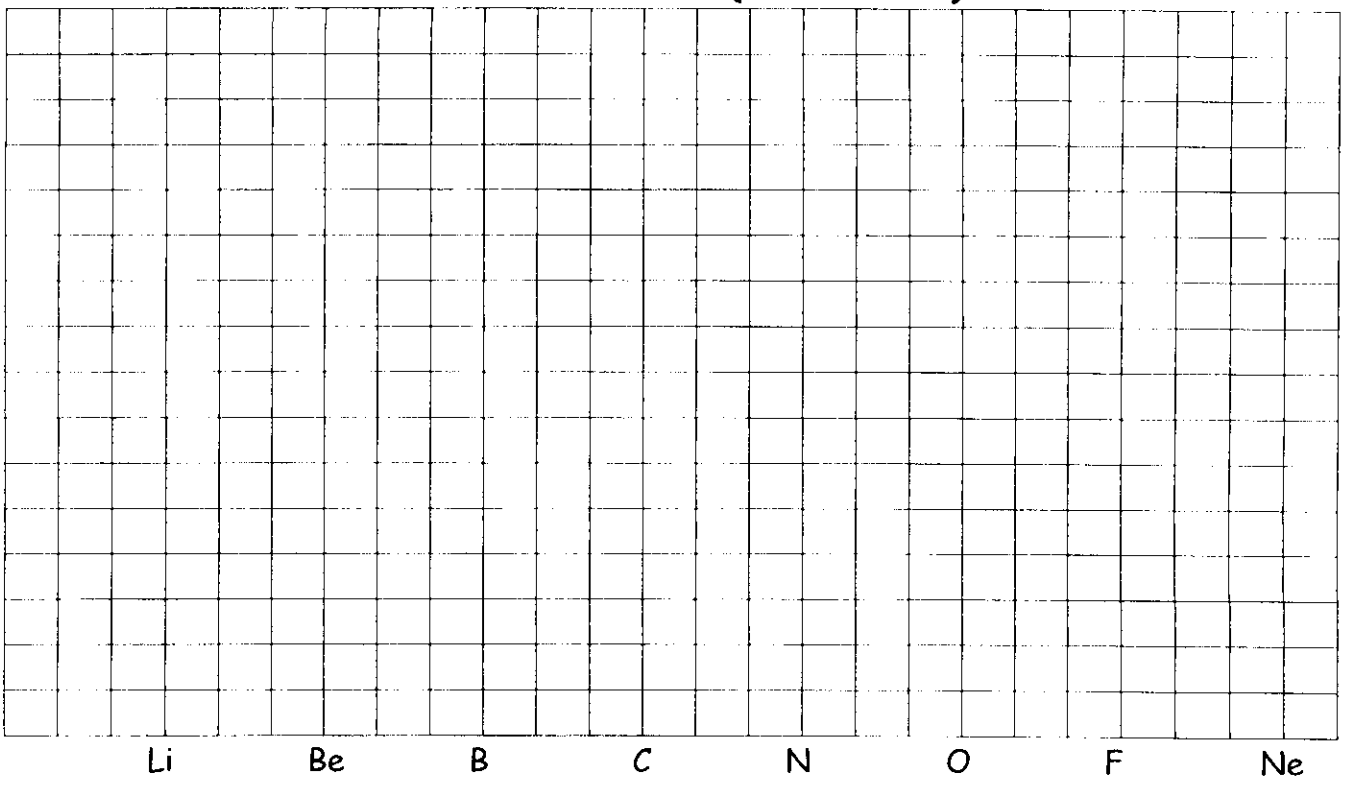
15. What is the trend for electronegativity in period 2? _____

Electronegativity (Group 1)



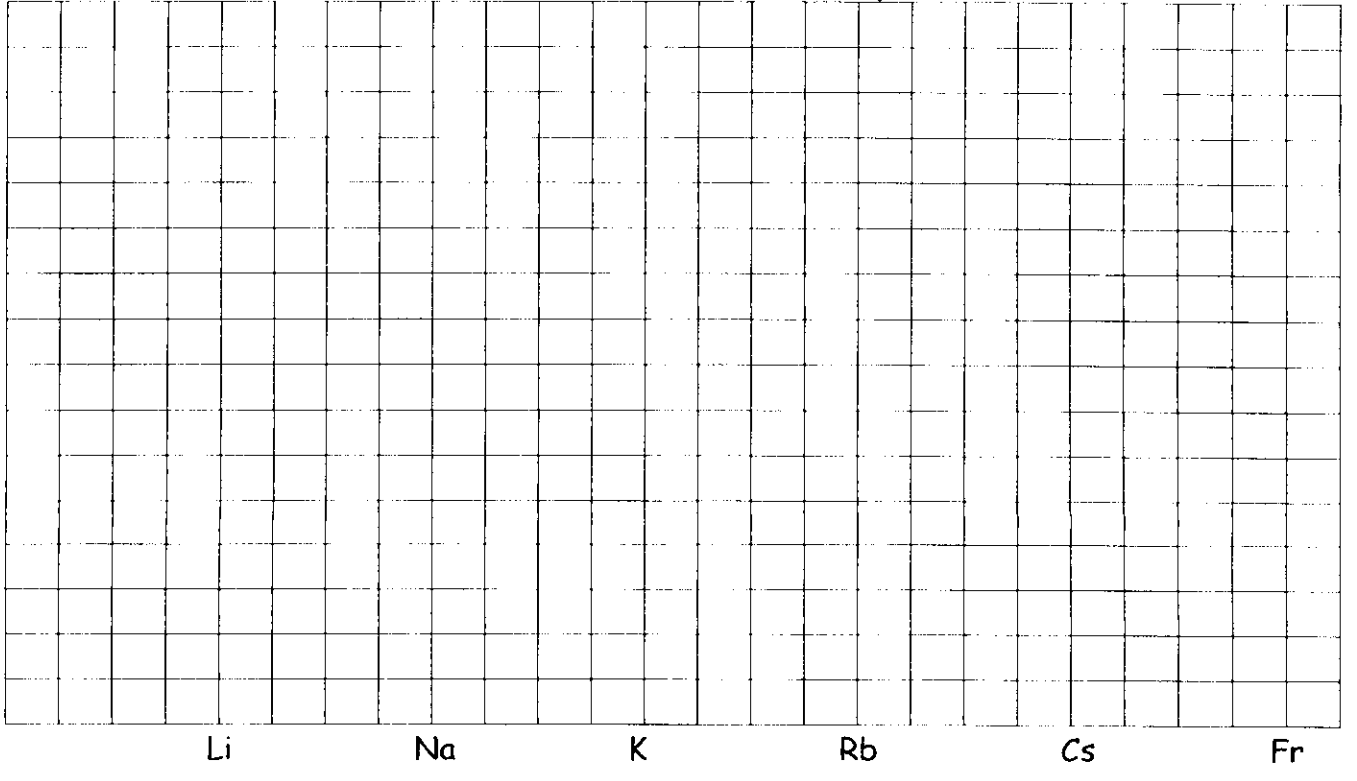
16. What is the trend for electronegativity in Group 1? _____

Atomic Radius (Period 2)



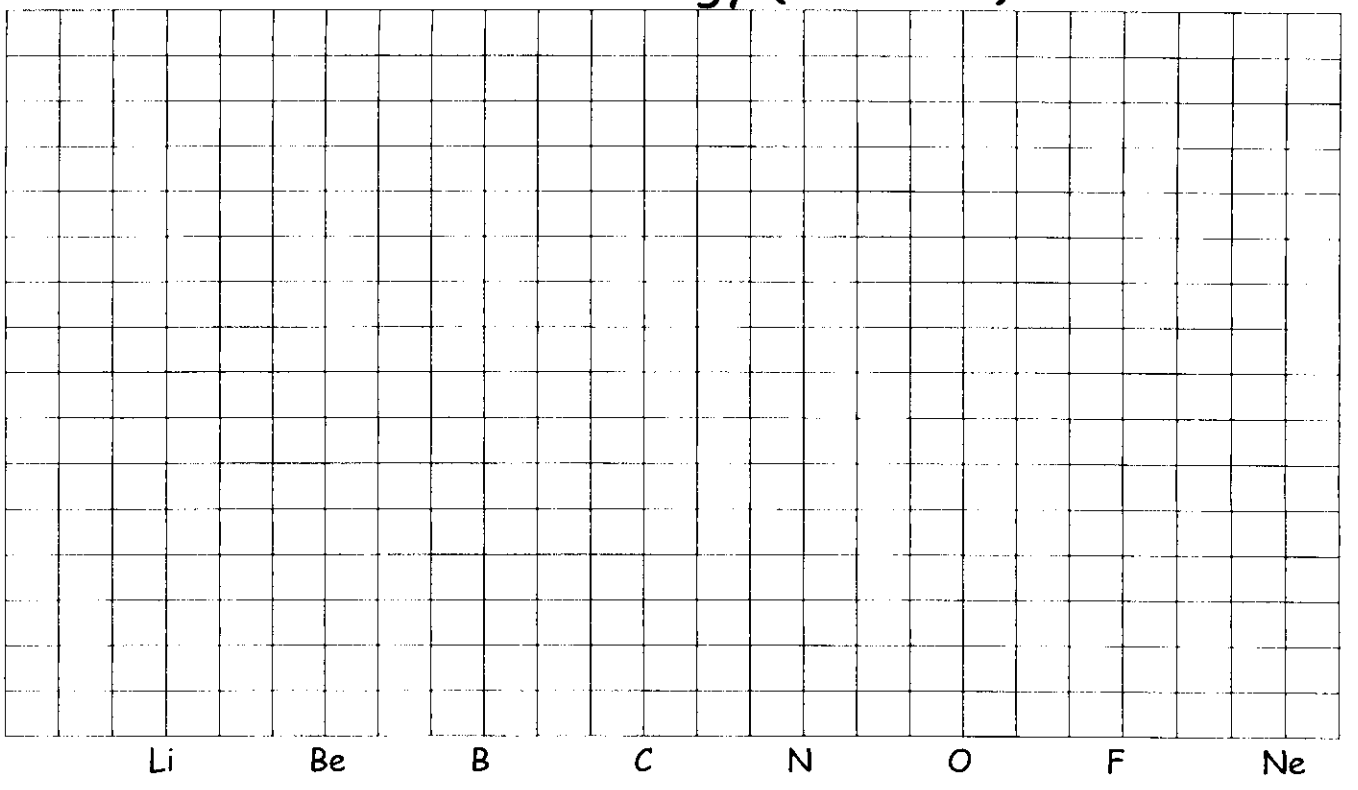
17. What is the trend for atomic radius in period 2? _____

Atomic Radius (Group 1)



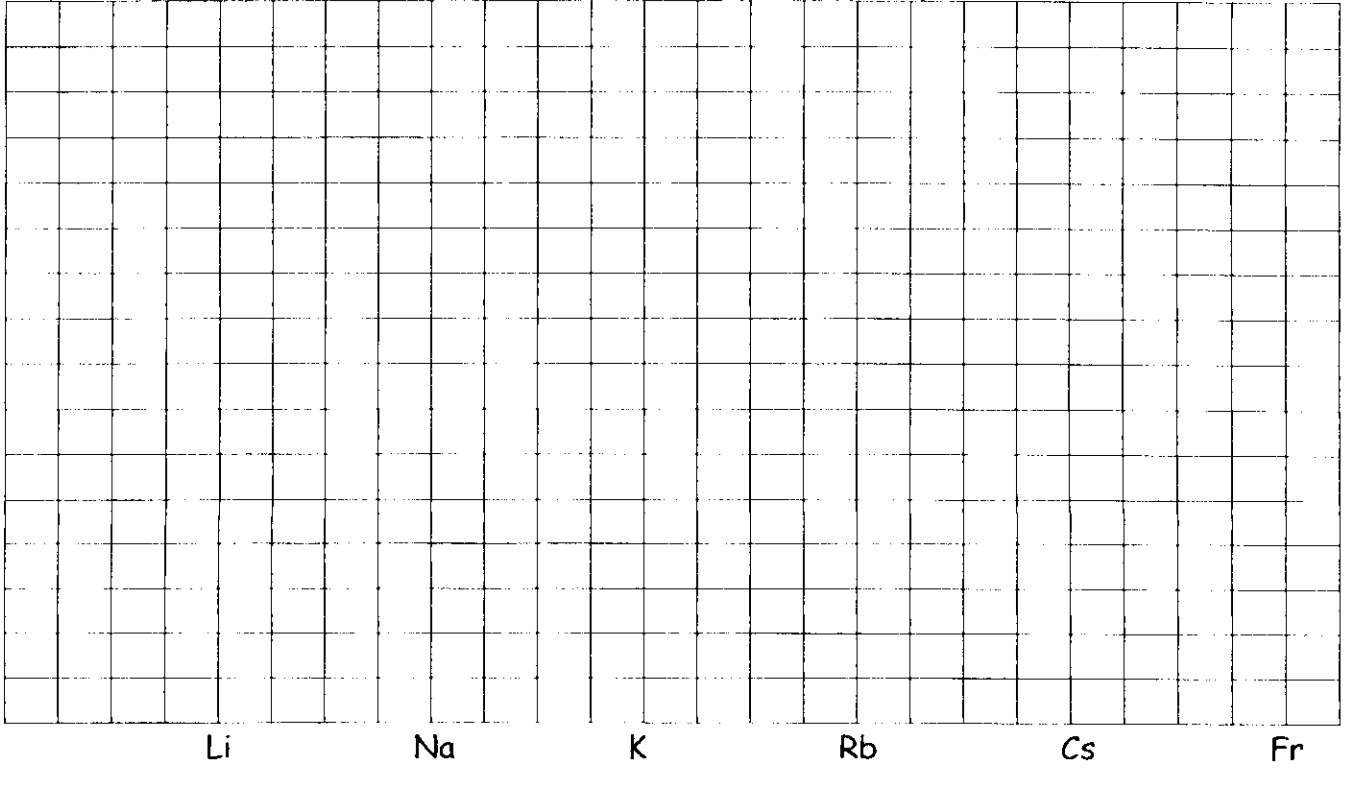
18. What is the trend for atomic radius in group 1? _____

Ionization Energy (Period 2)



19. What is the trend for the ionization energy in period 2? _____

Ionization Energy (Group 1)



20. What is the trend for the ionization energy in group 1? _____

Unit 8 PL lab #10

Lab Acitivty: Particle Diagrams

This should be completed in your lab notebook.

Objective: to make particle diagrams for each type of matter (element, compound, homogeneous mixture, heterogeneous mixture)

Procedure: Working in groups of 2 or 3 ONLY, cut out the dots. Glue/Tape the dots in your lab notebook to make the particle diagrams for:

Monatomic Elements
Diatomic *Elements*
Binary Compound
Ternary Compound
Heterogeneous Mixture of an:
- ***element and a compound,***
- ***two compounds***
- ***two elements***

***Homogenous Mixture* of an:**
- ***element and a compound***
- ***two compounds***
- ***two elements***

Questions: Answer in COMPLETE sentences

1. What is the difference between an element and a compound? Give two examples of each.

2. What is the difference between a homogeneous mixture and a heterogeneous mixture? Give two examples of each.

3. Which type of matter, pure substance or mixture can be physically separated?

4. Which type of matter, pure substance or mixture can only be chemically separated?

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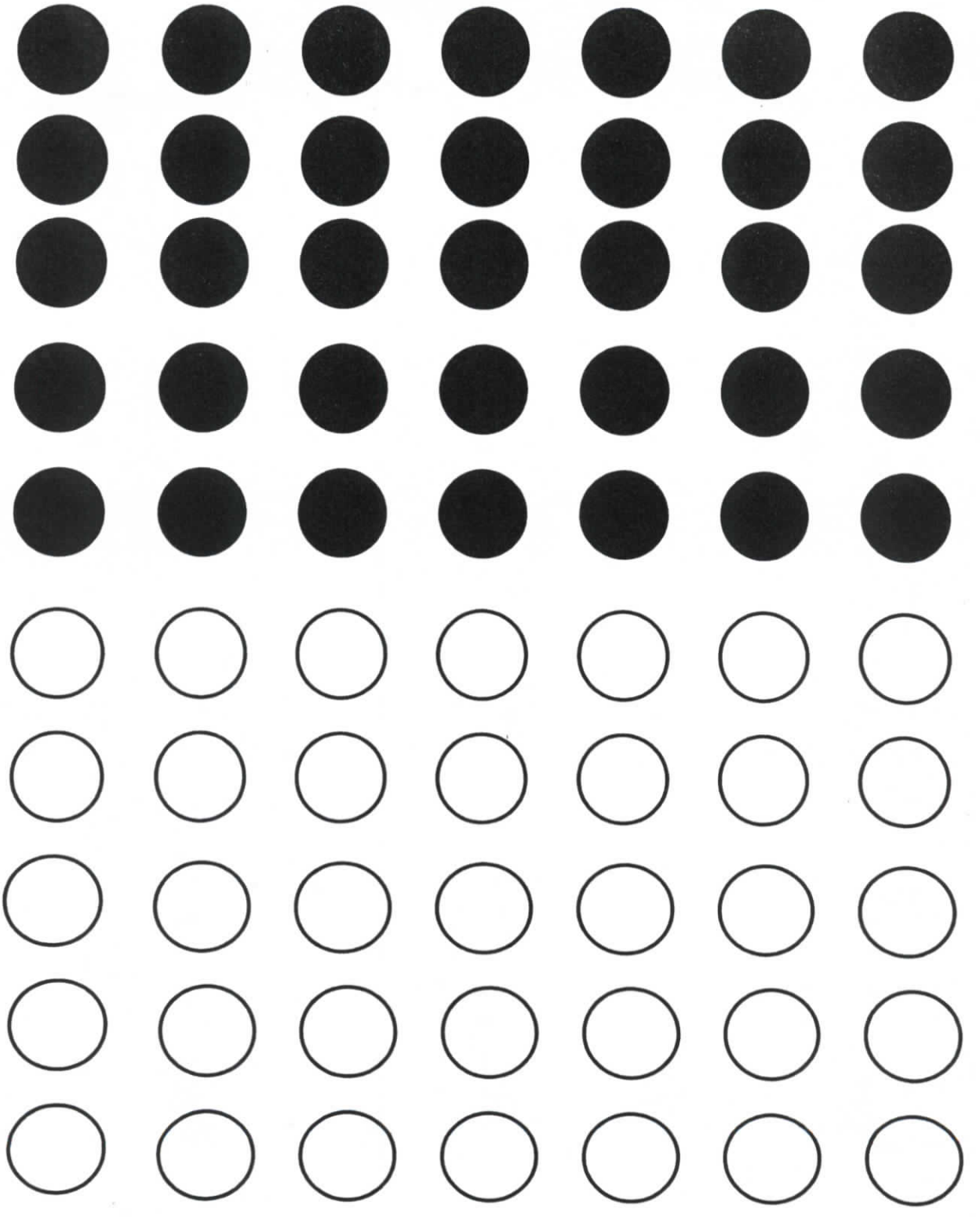

PL lab #11 (Single page, both sides)

Worksheet – Physical and Chemical changes,
Law of conservation of mass

Name _____
Period_____
Date_____

Classify the following as being a physical or chemical change.

1. _____Sodium hydroxide dissolves in water.
2. _____Hydrochloric acid reacts with potassium hydroxide to produce a salt, water and heat.
3. _____A pellet of sodium is sliced in two.
4. _____Water is heated and changed to steam.
5. _____Potassium chlorate decomposes to potassium chloride and oxygen gas.
6. _____When placed in water, a sodium pellet catches on fire as hydrogen gas is liberated and sodium hydroxide forms.
7. _____Evaporation
8. _____Ice melting
9. _____Milk sours
10. _____Sugar dissolves in water.
11. _____Wood rotting.
12. _____Grass growing in a lawn.
13. _____An Alka-Seltzer tablet releasing carbon dioxide gas when coming in contact with your stomach acid.
14. _____Water is absorbed by a paper towel.
15. _____Food is digested in the stomach.

Solve each of the following. Remember to follow rules of rounding and significant figures in your calculations.

16. In the complete reaction of 22.99 g of sodium with 35. 45g of chloride, what mass of sodium chloride is formed?

17. A 12.2 g sample of X reacts with a sample of Y to form 78.9 g of XY. What is the mass of Y that reacted?

18. A 10.0 g sample of magnesium reacts with oxygen to form 16.6 g of magnesium oxide. How many grams of oxygen reacted?

19. From a laboratory process designed to separate water into hydrogen and oxygen gas, a student collected 10.0 g of hydrogen and 79.4 g of oxygen. How much water was originally involved in the process?

20. A student carefully placed 15.6 g of sodium in a reactor supplied with an excess quantity of chloride gas. When the reaction was complete, the student obtained 39.7 g of sodium chloride. How many grams of chloride gas reacted? How many grams of sodium reacted?

21. In a flask, 10.3 g of aluminum reacted with 100.0 g of liquid bromine to form aluminum bromide. After the reaction, no aluminum remained and 8.5 grams of

22. A 3.5 kg iron shovel is left outside through the winter. The shovel, now orange with rust, is rediscovered in the spring. Its mass is 3.7 kg. How much oxygen combined with the iron?

23. When 5.0 g of tin reacts with hydrochloric acid, the mass of the products, tin chloride and hydrogen, totals 8.1 g. How many grams of hydrochloric acid were used?

24. Iron and oxygen combine to form iron oxide (rust). List the reactants and products of this reaction.

25. After burning for three hours, a candle has lost half of its mass. Explain why this example does not violate the law of conservation of mass.

Name _____ pL : Lab # 12 Date _____

Unit 1

Lab: Bright line Spectra

A link will be shared on Google classroom/team

Materials:

1. Spectrascopes
2. Light Sources
3. Gas Tubes

Part A: (Examining a Bright Line Spectra)

Procedure:

1. EXAMINE the bright line spectra of several gasses
2. **MAKE A COPY** of the spectra **YOU SEE** with **PROPER SPACING** and color (As best you can)

Name of Gas	Bright line Spectrum .....400.....500.....600.....700.....nm

Conclusion:

1. What is the difference between a continuous spectrum and a bright line spectrum

2. How are bright line spectra like finger prints for an atom?

3. How could the bright line spectrum of a star be used to determine what type of elements are in the star?

4. Describe how electron energy level changes create the lines in the bright line spectra?

5. Describe, IN DETAIL, the process that an electron will go through in order to emit light and produce a bright line spectra?

6. Draw an illustration of the process you described in question 5. Use A BOHR MODEL FOR AN ATOM!

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Unit 3

pL lab #13

Name _____ Date _____ Period _____

Creating Formulas and Naming Compounds Activity

The purpose of this activity is to help you determine the correct formulas for compounds. After putting together the correct compound formulas you will then name each compound using the names provided for each ion. There are "positive" metal ions and "negative" non-metal ions. Cut out the correct metal ion and the correct non-metal ions to create a stable compound. Glue the two together in the spaces provide. You are to make at least 8 different compounds from the paper cutouts provided. Give the ratio of the two parts of the compound, the name of the compound and the type of bond(s) in the compound.

or draw in the space provided.

1.) Formula: **Li I**
Ratio of Metal to Non-metal _____
Name of the Compound _____
Type of Bond _____

2.) Formula: **CaI_2**
Ratio of Metal to Non-metal _____
Name of Compound _____
Type of Bond _____

3.) Formula: **$Al_2(CO_3)_3$**
Ratio of Metal to Group _____
Name of Compound _____
Type of Bond _____

4.) Formula: **$Ca_3(PO_4)_2$**
Ratio of Metal to Group _____
Name of Compound _____
Type of Bond _____

Make your own compounds and name them in the following space: Make one simple formula of 1:1; one more complex formula of 1:2 or 2:1; one even more complex formula of 2:3 or 3:2 and one very complex formula using a couple of metal ions and a polyatomic ion.

5) Formula:

Ratio of Metal to Non-metal _____

Name of the compound _____

6) Formula:

Ratio of Metal to Non-metal _____

Name of the compound _____

7) Formula:

Ratio of Metal to Non-metal _____

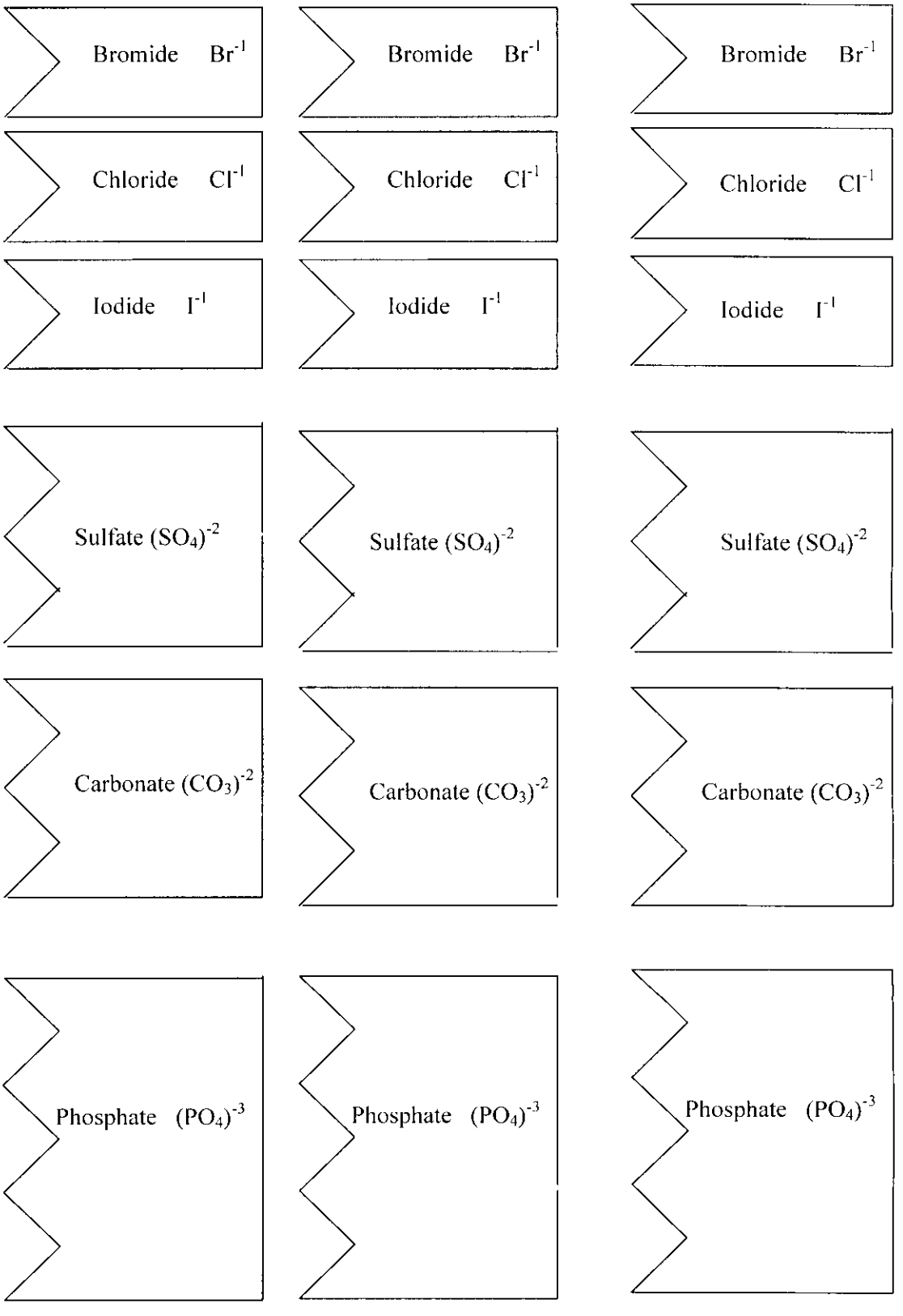
Name of the compound _____

8.) Formula:

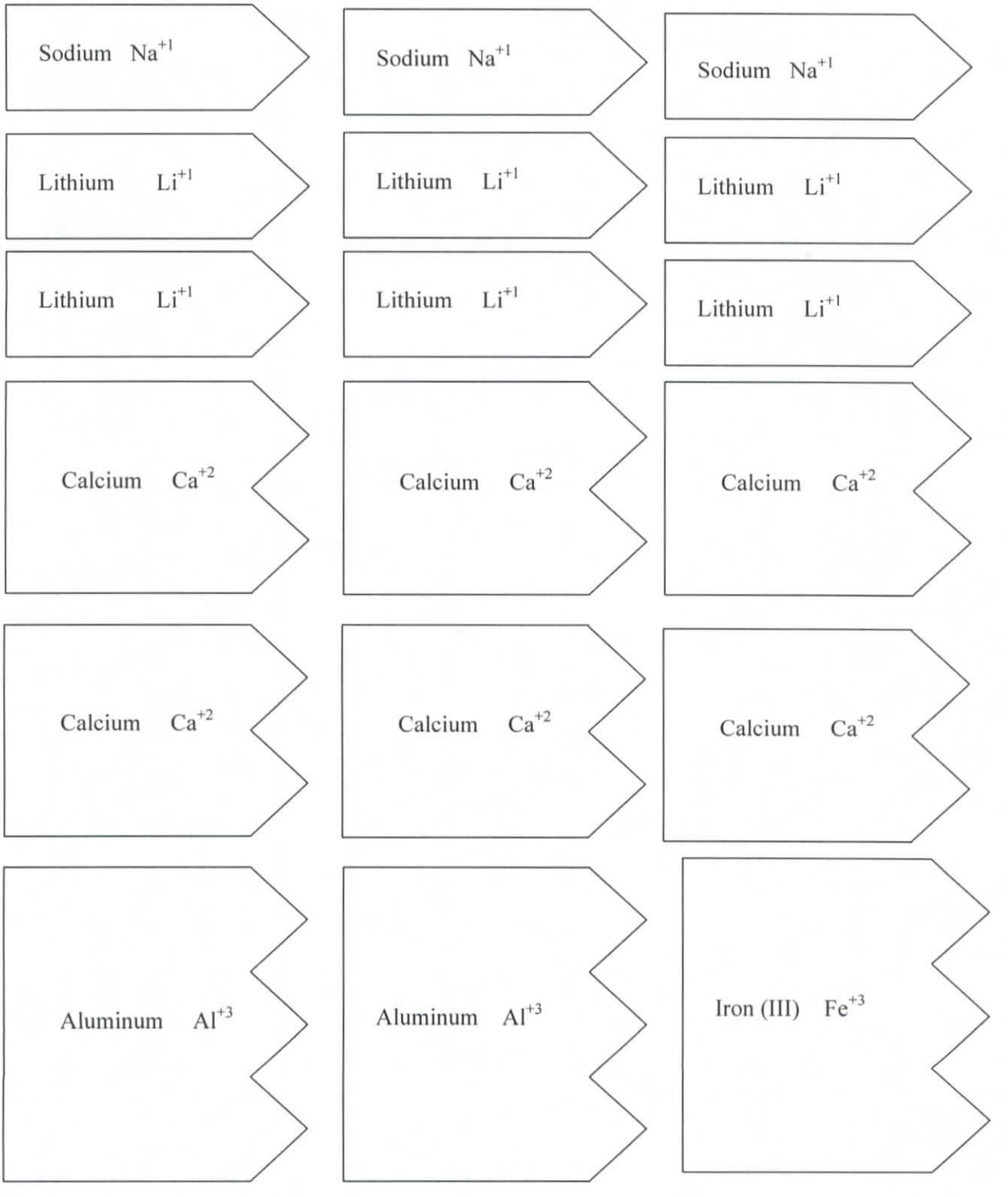
Ratio of Metal to Non-metal _____

Name of the compound _____

Negative Ions (anions)



Positive Ions (cations)



Name: _____ PL lab #14 Period: _____

Chemical or Physical Change

A link for these demos will be provided on Google classroom/team

Introduction: Chemistry is the study of matter and its change. These changes come in two categories, **physical** or **chemical**. In a physical change there is an alteration of the physical properties of a substance such as size, shape, color, and/or its phase. Grinding, cutting, dissolving and any phase change such as melting are a result of a physical change. The end substance is the same chemically and has the same chemical formula it starts with. For example, boiled water becomes steam which is still H_2O.

A chemical changes results in the formation of one or more new substances. These new substances are different both chemically (a different formula) and physically. Rusting and burning are examples of chemical changes; rusted Iron (Fe) is iron oxide, Fe_3O_4. It is not always easy to tell if a new substance is made. Usually physical changes can b easily reversed but chemical cannot.

Purpose: Recognize and distinguish between chemical and physical properties.

Procedure: For each demo please follow the link provided on Google classroom/team. There will be 3 of them.

I. Watch the video that adds salt water (NaCl added to H_2O) to silver nitrate ($AgNO_3$).

Observation: _____

II. Watch the video that adds magnesium (Mg) ribbon to hydrochloric acid (HCl).

Observation: _____

III. Watch the video that burns magnesium (Mg) ribbon in a Bunsen burner.

Observation : _____

Name _____ Date _____

Period _____

IV. QUESTIONS:

1. Tell whether the following changes are chemical or physical by writing C or P.
   _____ a. dissolving NaCl in water
   _____ b. mixing NaCl(aq) with $AgNO_3$(aq)
   _____ c. tearing Mg ribbon
   _____ d. adding 6M HCl to Mg
   _____ e. burning Mg ribbon
   _____ f. grinding $CuSO_4 \cdot 5H_2O$
   _____ g. heating $CuSO_4 \cdot 5H_2O$
   _____ h. mixing Fe with S
   _____ i. heating a mixture of Fe and S

2. Name two possible indications that a chemical change has taken place. Give an example of each from this experiment.

3. Chemical changes involve the formation of a new substance. For each **chemical** change in this lab, describe the new substance made.

V. CONCLUSION:

How can a chemical change be differentiated from a physical change. Give examples from the lab.

Name: _____ PL lab #15 period: ____

Types of Chemical Reactions

Do atoms rearrange in predictable patterns during chemical reactions?

Why?

Recognizing patterns allows us to predict future behavior. Weather experts use patterns to predict dangerous storms so people can get their families to safety. Political analysts use patterns to predict election outcomes. Similarly, chemists classify chemical equations according to their patterns to help predict products of unknown but similar chemical reactions.

Model 1 – Types of Reactions

Set A—*Synthesis Reactions*

$4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$

$MgO(s) + H_2O(l) \rightarrow Mg(OH)_2(aq)$

$P_2O_5(g) + 3H_2O(l) \rightarrow 2H_3PO_4(aq)$

$SO_3(g) + H_2O(l) \rightarrow H_2SO_4(aq)$

Set B—*Decomposition Reactions*

$MgCO_3(s) \rightarrow MgO(s) + CO_2(g)$

$8Li_2S(s) \rightarrow 16Li(s) + S_8(s)$

$2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$

$2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$

$2Na_2O_2(s) \rightarrow 2Na_2O(s) + O_2(g)$

$(NH_4)_2CO_3(s) \rightarrow 2NH_3(g) + H_2O(l) + CO_2(g)$

Set C—*Single Replacement Reactions*

$2FeCl_3(aq) + 3Zn(s) \rightarrow 2Fe(s) + 3ZnCl_2(aq)$

$2Al(NO_3)_3(aq) + 3Ca(s) \rightarrow 3Ca(NO_3)_2(aq) + 2Al(s)$

$Mg(s) + CuSO_4(aq) \rightarrow MgSO_4(aq) + Cu(s)$

$2Al(s) + 6HCl(aq) \rightarrow 2AlCl_3(aq) + 3H_2(g)$

$Cl_2(g) + 2NaBr(aq) \rightarrow 2NaCl(aq) + Br_2(l)$

$ZnBr_2(aq) + F_2(g) \rightarrow ZnF_2(aq) + Br_2(l)$

Set D—*Double Replacement Reactions*

$AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$

$2HNO_3(aq) + Mg(OH)_2(aq) \rightarrow Mg(NO_3)_2(aq) + 2H_2O(l)$

$Na_2CO_3(aq) + CaCl_2(aq) \rightarrow CaCO_3(s) + 2NaCl(aq)$

$FeS(s) + 2HCl(aq) \rightarrow H_2S(g) + FeCl_2(aq)$

$HCl(aq) + NaOH(aq) \rightarrow H_2O(l) + NaCl(aq)$

$FeBr_3(aq) + K_3PO_4(aq) \rightarrow FePO_4(s) + 3KBr(aq)$

1. The chemical equations in Model 1 contain the phase notations (s), (l), (g), and (aq). Match each symbol with its meaning.

   dissolved in water _____ liquid _____ solid _____ gas _____

   (aq)

2. Based on the examples provided, which set(s) of reactions in Model 1 typically involve ions in solution (A, B, C or D)?

3. Based on the examples provided, which set(s) of reactions in Model 1 typically involve gases and/or solids?

4. Match each description below to one of the reactions sets (A, B, C or D) from Model 1.

_____ Ionic compounds dissolved in water switch partners.

_____ One compound breaks into elements or smaller compounds.

_____ Two or more elements or compounds combine to form one product.

_____ _____ Part of an ionic compound is removed and replaced by a new element.

5. Define the following terms as they are commonly used in the English language.

Synthesis—

Decomposition—

Replacement—

6. The four sets of chemical reactions shown in Model 1 have the following general names. Discuss within your group which name belongs to which set of chemical reactions. Write the name in the appropriate place in Model 1.

Single Replacement Reaction *Set C* Synthesis Reaction _____

Double Replacement Reaction _____ Decomposition Reaction _____

7. Can two elements be used as reactants for a synthesis reaction? If yes, give at least one example from Model 1 to support your answer.

8. Can two compounds be used as reactants for a synthesis reaction? If yes, give at least one example from Model 1 to support your answer.

9. What types of substances (elements or compounds) are seen in the products of decomposition reactions? Use examples from Model 1 to support your answer.

Both elements and compounds can be seen in the products of decomposition reactions.

$MgCO_3(s) \rightarrow MgO(s) + CO_2(g)$ $8Li_2S(s) \rightarrow 16Li(s) + S_8(s)$

10. In single replacement reactions, do any of the atoms change their charge? If yes, use an example from Model 1 to describe the changes that take place.

11. In double replacement reactions, do any of the atoms change their charge? If yes, use an example from Model 1 to describe the changes that take place.

12. Choose one example from the set of synthesis reactions in Model 1.

a. Write the chemical reaction in reverse.

b. Label the reaction written in part *a* with one of the reaction types in Model 1.

13. Identify each of the reactions below as synthesis (S), decomposition (D), single replacement (SR) or double replacement (DR).

___ $K_2O(s) + H_2O(l) \rightarrow 2KOH(aq)$

___ $2MgCl_2(aq) + Na_2CO_3(aq) \rightarrow 2NaCl(aq) + MgCO_3(s)$

___ $2Al_2O_3(s) \rightarrow 4Al(s) + 3O_2(g)$

___ $Cu(NO_3)_2(aq) + Zn(s) \rightarrow Cu(s) + Zn(NO_3)_2(aq)$

___ $H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$

___ $2K(s) + 2H_2O(l) \rightarrow 2KOH(aq) + H_2(g)$

___ $2O_2(g) + N_2(g) \rightarrow N_2O_4(g)$

___ $2NaF(s) \rightarrow 2Na(s) + F_2(g)$

STOP

14. A student writes the following incorrect chemical equation for the synthesis of magnesium oxide.

$Mg + O_2 \rightarrow MgO_2$

Another student writes the following incorrect synthesis reaction.

$Mg + O \rightarrow MgO$

a. What is the correct formula for magnesium oxide? *Hint:* Magnesium oxide is an ionic compound.

b. What is the correct formula for elemental oxygen?

c. Describe the error made by the first student.

d. Describe the error made by the second student.

Knowing only one oxygen is needed in magnesium oxide, the student disregarded the correct formula for elemental oxygen.

e. Write the correct balanced chemical equation for the synthesis of magnesium oxide.

15. A student writes the following *incorrect* chemical equation for a single replacement reaction between lithium bromide and fluorine.

$2LiBr(aq) + F_2(g) \rightarrow 2Li(s) + 2FBr(g)$

a. In a single replacement reaction, part of an ionic compound is removed and replaced by a new element. What element will fluorine replace in lithium bromide? *Hint:* What is the most common ionic form of fluorine?

b. What is wrong with the student's prediction of the products in the above reaction?

The compound FBr is not an ionic compound and is not likely to form in a single replacement reaction.

NOTE: *Interhalogen molecular compounds of the type ICl, BrF, etc. can be prepared by combining the halogens at very high temperatures. They are covalent compounds and tend to be very unstable.*

c. Predict the products and write the correct balanced equation for the single replacement reaction between lithium bromide and fluorine.

16. A student writes the following incorrect chemical equation for a double replacement reaction between iron(III) bromide and sodium hydroxide solutions.

$FeBr_3(aq) + NaOH(aq) \rightarrow FeOH(s) + NaBr_3(aq)$

a. What is wrong with the chemical formula(s) of the product(s) predicted by this student?

b. Write the correct equation for the double replacement reaction between iron(III) bromide and sodium hydroxide.

17. Consider the following chemical reaction written as a **word equation**.

diphosphorus pentoxide + water → phosphoric acid

$$P_2O_5 + 3H_2O \rightarrow H_3PO_4$$

a. Identify the type of chemical reaction from Model 1 that would describe this reaction.

b. Write chemical formulas under the names of the substances in the word equation.

c. Balance the chemical equation.

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Name _____

pL : Lab #16

Balancing Equations Lab

1. Follow the MINOH order
2. First, balance elements which appear only once on both sides of an equation
3. When a pair of add (exception number 1) and even numbers appear assign a number which can be divided by both of these numbers (2 and 3 can divide 6)
4. Elements by itself on the left side balance us the last one

Copy and balance the equations in to the lab notebook. Under each equation, draw a vertical line to keep a count of atoms of the elements on both side of an equation.

$NaBr + H_3PO_4 = Na_3PO_4 + HBr$

$Ca(OH)_2 + Al_2(SO_4)_3 = CaSO_4 + Al(OH)_3$

$Mg + Fe_2O_3 = Fe + MgO$

$C_2H_4 + O_2 = CO_2 + H_2O$

$PbSO_4 = PbSO_3 + O_2$

$NH_3 + I_2 = N_2I_6 + H_2$

$H_2O + SO_3 = H_2SO_4$

$H_2SO_4 + NH_4OH = H_2O + (NH_4)_2SO_4$

$N_2 + H_2 = NH_3$

$H_2SO_4 + NaNO_2 = HNO_2 + Na_2SO_4$

$NaBr + CaF_2 = NaF + CaBr_2$

$H_2O + O_2 = H_2O_2$

$HNO_3 + NaHCO_3 = NaNO_3 + H_2O + CO_2$

$CO_2 + H_2O = C_6H_{12}O_6 + O_2$

$S_8 + O_2 = SO_3$

$Ag_2O = Ag + O_2$

$Na + H_2O = NaOH + H_2$

$P + O_2 = P_2O_5$

$Pb(OH)_2 + HCl = H_2O + PbCl_2$

Report:

1. There are 5 types of different reactions: synthesis, decomposition, single replacement, double replacement, and combustion. Classified above reactions to one of those categories.
2. How do you understand the conservation of mass?
3. What are the coefficients and what do they represent?

Balancing Equations Practice

Instructions:
Balance each equation and identify the type of chemical reaction.

1) $\_H_2 + \_O_2 \rightarrow \_H_2O$

2) $\_H_2O_2 \rightarrow \_H_2O + \_O_2$

3) $\_CH_4 + \_O_2 \rightarrow \_CO_2 + \_H_2O$

4) $\_KClO_3 \rightarrow \_KCl + \_O_2$

5) $\_HCl + \_Zn \rightarrow \_ZnCl_2 + \_H_2$

Balancing Equations Worksheet

1) _____ Na_3PO_4 + _____ KOH → _____ NaOH + _____ K_3PO_4

2) _____ MgF_2 + _____ Li_2CO_3 → _____ $MgCO_3$ + _____ LiF

3) _____ P_4 + _____ O_2 → _____ P_2O_3

4) _____ $RbNO_3$ + _____ BeF_2 → _____ $Be(NO_3)_2$ + _____ RbF

5) _____ $AgNO_3$ + _____ Cu → _____ $Cu(NO_3)_2$ + _____ Ag

6) _____ CF_4 + _____ Br_2 → _____ CBr_4 + _____ F_2

7) _____ HCN + _____ $CuSO_4$ → _____ H_2SO_4 + _____ $Cu(CN)_2$

8) _____ GaF_3 + _____ Cs → _____ CsF + _____ Ga

9) _____ BaS + _____ PtF_2 → _____ BaF_2 + _____ PtS

10) _____ N_2 + _____ H_2 → _____ NH_3

11) _____ NaF + _____ Br_2 → _____ NaBr + _____ F_2

12) _____ $Pb(OH)_2$ + _____ HCl → _____ H_2O + _____ $PbCl_2$

13) _____ $AlBr_3$ + _____ K_2SO_4 → _____ KBr + _____ $Al_2(SO_4)_3$

14) _____ CH_4 + _____ O_2 → _____ CO_2 + _____ H_2O

15) _____ Na_3PO_4 + _____ $CaCl_2$ → _____ NaCl + _____ $Ca_3(PO_4)_2$

16) _____ K + _____ Cl_2 → _____ KCl

17) _____ Al + _____ HCl → _____ H_2 + _____ $AlCl_3$

18) _____ N_2 + _____ F_2 → _____ NF_3

19) _____ SO_2 + _____ Li_2Se → _____ SSe_2 + _____ Li_2O

20) _____ NH_3 + _____ H_2SO_4 → _____ $(NH_4)_2SO_4$

Balancing Equations Race

1) ___ C_3H_8 + ___ O_2 → ___ CO_2 + ___ H_2O

2) ___ Al + ___ Fe_3N_2 → ___ AlN + ___ Fe

3) ___ Na + ___ Cl_2 → ___ NaCl

4) ___ H_2O_2 → ___ H_2O + ___ O_2

5) ___ $C_6H_{12}O_6$ + ___ O_2 → ___ H_2O + ___ CO_2

6) ___ H_2O + ___ CO_2 → ___ C_7H_8 + ___ O_2

7) ___ $NaClO_3$ → ___ NaCl + ___ O_2

8) ___ $(NH_4)_3PO_4$ + ___ $Pb(NO_3)_4$ → ___ $Pb_3(PO_4)_4$ + ___ NH_4NO_3

9) ___ BF_3 + ___ Li_2SO_3 → ___ $B_2(SO_3)_3$ + ___ LiF

10) ___ C_7H_{17} + ___ O_2 → ___ CO_2 + ___ H_2O

11) ___ $CaCO_3$ + ___ H_3PO_4 → ___ $Ca_3(PO_4)_2$ + ___ H_2CO_3

12) ___ Ag_2S → ___ Ag + ___ S_8

13) ___ KBr + ___ $Fe(OH)_3$ → ___ KOH + ___ $FeBr_3$

14) ___ KNO_3 + ___ H_2CO_3 → ___ K_2CO_3 + ___ HNO_3

15) ___ $Pb(OH)_4$ + ___ Cu_2O → ___ PbO_2 + ___ CuOH

16) ___ $Cr(NO_2)_2$ + ___ $(NH_4)_2SO_4$ → ___ $CrSO_4$ + ___ NH_4NO_2

17) ___ KOH + ___ $Co_3(PO_4)_2$ → ___ K_3PO_4 + ___ $Co(OH)_2$

18) ___ $Sn(NO_2)_4$ + ___ Pt_3N_4 → ___ Sn_3N_4 + ___ $Pt(NO_2)_4$

19) ___ B_2Br_6 + ___ HNO_3 → ___ $B(NO_3)_3$ + ___ HBr

20) ___ ZnS + ___ AlP → ___ Zn_3P_2 + ___ Al_2S_3

Name: _____ PL: lab # 17 Period: _____

Single Replacement /Redox lab

A link will be shared on Google classroom/team.

A single replacement reaction is a type of reaction where the more active metal replaces the less reactive metal dissolved in the solution. Aluminum reacts with copper (II) chloride, $CuCl_2$, to form copper metal and aluminum chloride, $AlCl_3$.

Observation: _____

_____

Post observation question:

1. What eventually happens when aluminum is added to copper (II) chloride? _____

   _____

2. Is the reaction exothermic or endothermic? _____

3. When aluminum (Al) reacts with copper (II) chloride ($CuCl_2$) to form copper metal and aluminum chloride ($AlCl_3$). Identify the reactant for this reaction: _____

   Identify the product of this reaction: _____.

4. Write the word equation for this reaction base on the above experiment.

   _____

5. Balance the above equation using formula for the reactants and products.

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Name _____ Date _____

Period _____ PL: lab #18

Unit 1

Flame Test Lab

A link will be shared on Google classroom / Team

Background:

The normal electron configuration of atoms or ions of an element is known as the "ground state." In this most stable energy state, all electrons are in the lowest energy levels available. When atoms or ions in the "ground state" are heated to high temperatures, some electrons may absorb enough energy to allow them to "jump" to higher energy levels. The element is then said to be in the "excited state." This excited configuration is unstable, and the electrons "fall" back to their normal positions of lower energy (ground state). As the electrons return to their normal levels, the energy that was absorbed is emitted in the form of electromagnetic energy. Some of this energy may be in the form of visible light. The color of this light can be used as a means of identifying the elements involved. Such analysis is known as a flame test.

To do a flame test on a metallic element, the metal is first dissolved in a solution and the solution is then held in the hot, blue flame of a Bunsen burner. This test works well for metal ions, and was perfected by Robert Bunsen (1811 – 1899). Many metallic ions exhibit characteristic colors when vaporized in the burner flame.

Purpose:

The purpose is to observe the characteristic colors produced by certain metallic ions when vaporized in a flame and then to identify an unknown metallic ion by means of its flame test.

Materials:

Set of metal chloride solutions ($NaCl$, $CuCl_2$, KCl, $CaCl_2$, $SrCl_2$, $LiCl$, $CoCl_2$, $BaCl_2$)
Bunsen Burner
8 – 10 Q-tips
Unknown solution (for each student)
Cobalt glass plates

Safety: Be sure to wear goggles and an apron at all times

Procedure:

- Dip the popsicle stick in water.
- Dip the wetted popsicle stick into the first substance
- Place the popsicle stick into a flame. What color does the flame produce?
- Dip another popsicle stick in water.
- Cover the wetted popsicle stick with the next substance
- Again, place the popsicle into a flame. What color does the tartar flame produce?-
- When you have tested all the known solutions and can distinguish the color of each metal ion, obtain unknown solutions and determine which metal ions are present by performing a flame test and comparing this data to your previous data.

Name _____ Date _____

Period _____

Data table:

Metal ion	Compound	Color of Flame
sodium		
lithium		
strontium		
calcium		
barium		
potassium		
copper		
cobalt		
sodium and potassium		
Unknown # ____		
Unknown # ____		

Based on your observations, identify two unknowns you examined:

Unknown # _____ is _____

Unknown # _____ is _____

Questions:

1. What problems may be involved when using flame tests for identification purposes.

2. Which ions produce similar colors in the flame tests?

3. Explain how the colors observed in the flame tests are produced.

Name: _____ PL lab # 20 period: _____

Naming Molecular Compounds

How are the chemical formula and name of a molecular compound related?

Why?

When you began chemistry class this year, you probably already knew that the chemical formula for carbon dioxide was CO_2. Today you will find out why CO_2 is named that way. Naming chemical compounds correctly is of paramount importance. The slight difference between the names carbon monoxide (CO, a poisonous, deadly gas) and carbon dioxide (CO_2, a greenhouse gas that we exhale when we breathe out) can be the difference between life and death! In this activity you will learn the naming system for molecular compounds.

Model 1 – Molecular Compounds

Molecular Formula	Number of Atoms of First Element	Number of Atoms of Second Element	Name of Compound
ClF	*1*		Chlorine monofluoride
ClF_5		5	
CO	*1*		Carbon monoxide
CO_2			
Cl_2O	*2*		
PCl_5			Phosphorus pentachlroride
N_2O_5		5	

1. Fill in the table to indicate the number of atoms of each type in the molecular formula.

2. Examine the molecular formulas given in Model 1 for various molecular compounds.
   a. How many different *elements* are present in each compound shown?

   b. Do the compounds combine metals with metals, metals with nonmetals, or nonmetals with nonmetals?

   c. Based on your answer to *b*, what type of bonding must be involved in molecular compounds?

3. Find all of the compounds in Model 1 that have chlorine and fluorine in them. Explain why the name "chlorine fluoride" is not sufficient to identify a specific compound.

   There are two compounds with chlorine and fluorine. The name "chlorine fluoride" does not indicate which compound it refers to. It could be the one with one fluorine atom, or the one with five fluorine atoms.

4. Assuming that the name of the compound gives a clue to its molecular formula, predict how many atoms each of these prefixes indicates, and provide two examples.

mono-	*one*	*Carbon monoxide or chlorine monofluoride.*
di-	*two*	*Carbon dioxide or dinitrogen pentoxide.*
penta-	*five*	*Chlorine pentafluoride or phosphorus pentachloride.*

Model 2 – Prefixes and Suffixes

Prefix	Numerical Value
mono-	*1*
di-	
tri-	
tetra-	*4*
penta-	
hexa-	*6*
hepta-	
octa-	
nona-	*9*
deca-	

Molecular Formula	Name of Compound
	Boron trichloride
SF_6	
IF_7	Iodine heptafluoride
NI_3	
	Dinitrogen tetroxide
Cl_2O	
	Tetraphosphorus decoxide
	Pentaboron nonahydride
Br_3O_8	
	Chlorine monofluoride

5. Examine the prefixes in Model 2. Fill in the numerical value that corresponds to each prefix.

6. What suffix (ending) do all the compound names in Model 2 have in common?

7. Carefully examine the names of the compounds in Model 2. When is a prefix NOT used in front of the name of an element?

8. Consider the compound NO.

   a. Which element, nitrogen or oxygen, would require a prefix in the molecule name? Explain your answer.

   The element O would require a prefix (mono-). The element N would not. A prefix is not used when there is one atom of the element that appears first in the formula, but it is used to indicate the number of atoms of each element in a molecule at all other times.

   b. Name the molecule NO.

STOP

9. Find two compounds in Model 2 that contain a subscript of "4" in their molecular formula.

   a. List the formulas and names for the two compounds.

   b. What is different about the spelling of the prefix meaning "four" in these two names?

Extension Questions

19. This activity focused on molecular (covalent) compounds, while an earlier activity addressed ionic compounds. Notice that the formulas for both types of compounds can look very similar, even though their names are quite different:

Chemical Formula	Type of Compound/Bonding	Compound Name
MgF_2	Ionic	
CuF_2		Copper(II) fluoride
SF_2		
NaBr		Sodium bromide
AuBr	Ionic	
IBr	Molecular (covalent)	

Identify two differences between the names or formulas for ionic compounds versus those for binary molecular compounds. Also identify two similarities.

	Names and Formulas of Ionic Compounds	Names and Formulas of Molecular (Covalent) Compounds
Differences	• *Contain metals and nonmetals.* • *No prefixes are used in naming, but sometimes Roman numerals are used (for transition metals with variable charges).* • *In writing formulas, charges must be taken into account.*	• *Contain nonmetals with nonmetals.* • *Prefixes are used in naming.* • *Charges do not need to be considered when writing formulas.*
Similarities	•	

20. Use complete sentences to explain why $AlCl_3$ is called "aluminum chloride" (no prefix required), but BCl_3 is called "boron trichloride."

Aluminum chloride is an ionic compound. It is understood that the empirical formula must contain a 1:3 ratio of ions because the ion charges are +3 for aluminum and −1 for chloride. Boron trichloride is a molecular (covalent) compound, which is named using a prefix system.

21. In the table below, first identify the type of bonding present in each compound. Then fill in the missing name or formula for each compound using the appropriate set of rules.

Chemical Formula	Type of Compound/Bonding	Compound Name
CS_2	*Molecular (covalent)*	
PbI_2		*Lead(II) iodide*
$BaCl_2$		*Barium chloride*
Se_2S_6	*Molecular (covalent)*	
XeF_4		Xenon tetrafluoride
Na_3P	*Ionic*	
N_2O_5	*Molecular (covalent)*	Dinitrogen pentoxide
$CoBr_3$		Cobalt(III) bromide

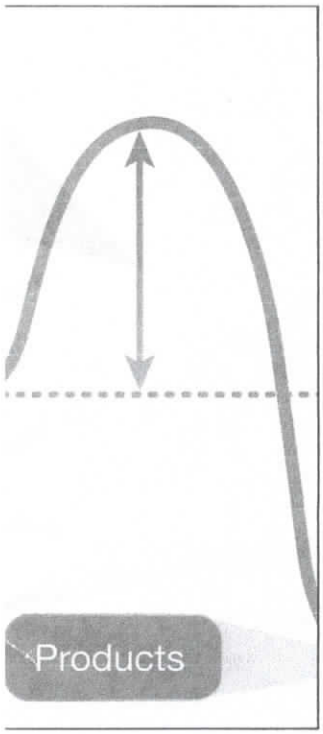
LM-70

Name: _____

PL: lab #21

Carbon Snake

A link will be shared on Google classroom/teams



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The reaction between sucrose ($C_{12}H_{22}O_{11}$) with concentrated sulfuric acid (H_2SO_4) is an exothermic reaction. Specifically, this reaction has two exothermic processes.

The first exothermic reaction is the dilution of concentrated sulfuric acid with water. This highly exothermic reaction provides the heat to kickstart the decomposition of sucrose.

$$H_2SO_4 + H_2O \rightarrow HSO_4^- + H_3O^+ + \text{heat}$$

The second exothermic reaction is the dehydration of sucrose, producing elemental carbon and water. Due to the highly exothermic nature of the reaction, some of the water is vaporized, creating enough pressure to force a porous black column of carbon to rise above the top of the beaker. Most sources only list this equation for sucrose decomposition.

$$C_{12}H_{22}O_{11} \rightarrow 12C + 11H_2O + \text{heat}$$

Some of the sulfuric acid oxidizes the carbon to produce carbon dioxide. Sulfur dioxide and water are the other two products. The overall net reaction for the entire process is represented as follows:

$$2C_{12}H_{22}O_{11} + 2H_2SO_4 + O_2 \rightarrow 22C + 24H_2O + 2CO_2 + 2SO_2 + \text{heat}$$

Caution: *The porous column will not be completely carbon. Water and unreacted sulfuric acid will be present on the surface and within the column. This is why students should not be allowed to touch the column.*

Chemonstration Protocol

1. Distribute the Student Guide to each student.
2. Discuss real-world and career applications.
3. Address common student misconceptions.
4. Make curriculum connections and incorporate the suggested discussion questions into the class discussion.
5. Have students record their observations in the Observations box in the Student Guide or in their notebook. If applicable, invite students to prepare their video devices to record the demo.
6. Pour 30 grams of sucrose into a 150-mL reaction beaker.
7. Using a graduated pipet, transfer 1 mL of tap water from the 600-mL beaker to the reaction beaker.
8. Stir the sugar and water with a glass stirring rod. Leave the rod in the beaker.
9. Place the beaker on a heat-resistant surface.
10. Check the fit of your goggles and acid-resistant gloves prior to pouring the concentrated sulfuric acid.
11. Pour one bottle of concentrated sulfuric acid (30 mL) into the reaction beaker, and then submerge the empty bottle into the 600-mL beaker of water to dilute any residual acid.
12. Stir the contents with the glass stirring rod until the acid is distributed throughout the sugar.
13. Remove the glass stirring rod and place it in the beaker of water. Stand back from the reaction and observe.
    Note: It might take several minutes for the reaction to begin. If applicable, cue students to start their video recording devices.
14. After the reaction is complete, leave the reaction beaker in the fume hood to cool. The carbon tower may have residual sulfuric acid on it. It should never be handled without acid-resistant gloves, and only then while wearing goggles.

Student Guide

Name _____ **Date** _____

Observations

Your teacher will perform the demonstration. Watch carefully and record your observations.

Model (Particle-level Explanation)

Use a balanced chemical equation to model what happened in the reaction at a molecular level for the dehydration of sucrose molecules ($C_{12}H_{22}O_{11}$).

Asking Scientific Questions

Write down one or two good scientific questions you have about the demonstration you observed. A good scientific question (a) builds on what you already know; (b) can be tested by an experiment or data that you can collect; and (c) leads to other good questions. A good scientific question usually starts with "What" or "How."

Analysis and Discussion

1. Chemical reactions can be classified into types by the way heat energy flows in them. In an exothermic reaction, heat energy is emitted during the reaction. In an endothermic reaction, heat energy is absorbed. Classify the dehydration of sucrose by concentrated sulfuric acid as either endothermic or exothermic. Provide evidence to support your answer.

2. Did energy flow from the system (reaction beaker and chemicals) to the surroundings or from the surroundings to the system? Provide evidence to support your answer. Use an illustration to show the direction of energy flow.

Crosscutting Concepts: Energy and Matter

Draw and label an energy diagram graph for the decomposition of sucrose that you observed in class. Label the y-axis "Energy" and the x-axis, "Time." Include formulas for the reactants and products located at the proper locations on the graph. Also include labels for the energy of activation (E_a) and the overall change in energy for the reaction (ΔE_{rxn}).

PL: Lab #22

Name: _____ period: ____

Molecular Compounds

	Formula	Electron Dot Diagram representing molecular formula	Structural formula	3D sketch of molecule Molecular Shape Molecule polarity
1	H_2		H — H	Linear Non polar
2	H_2S			
3	CH_4			
4	F_2			
5	NH_3			
6	HBr			

7	N_2			
8	O_2			
9	C_2H_4			
10	CO_2			

Analysis:

1. How is the formation of a covalent bond different from ionic bonds?

2. What is a double bond and what is a triple bond?

3. What is the octet rule and how does it related to bonding?

4. **List** the compounds from this lab that contained double and triple bonds.

Bond Type	Compounds
Double bond(s)	
Triple Bond(s)	

5. What is an obvious way to know a molecule is non-polar? List 4 examples of non-polar molecules from this lab.

Name : _____ pL: lab #23

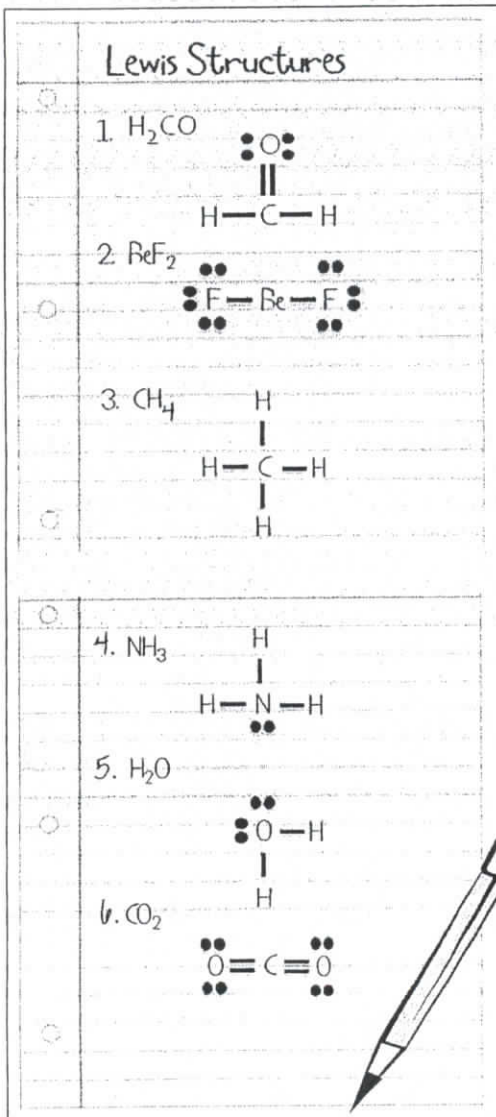
Molecular Geometry

How can molecular shapes be predicted using the VSEPR theory?

Why?

When you draw a Lewis structure for a molecule on paper, you are making a two-dimensional representation of the atoms. In reality however, molecules are not flat—they are *three*-dimensional. The true shape of a molecule is important because it determines many physical and chemical properties for the substance. In this activity you will learn how to predict molecular shapes.

Model 1 – Lewis Structures



Lone pair = ••

	3-D Molecular Shape
H_2CO 3 electron domains (3 bonding, 0 nonbonding)	
BeF_2 2 electron domains (2 bonding, 0 nonbonding)	
CH_4 4 electron domains (4 bonding, 0 nonbonding)	
NH_3 4 electron domains (3 bonding, 1 nonbonding)	
H_2O 4 electron domains (2 bonding, 2 nonbonding)	
CO_2 2 electron domains (2 bonding, 0 nonbonding)	

1. Name the type of structures shown in the left-hand column of Model 1.

2. Examine the drawings in Model 1.

   a. What does a solid line between two element symbols represent in the drawings of the molecules?

   b. What subatomic particles (protons, neutrons or electrons) make up these solid lines?

   c. What does a pair of dots represent in the drawing of the molecules?

   d. What subatomic particle (protons, neutrons or electrons) makes up each dot?

3. In the English language, what does the word "domain" mean? (Your group must come to consensus on this question.)

4. Which molecules in Model 1 have four electron domains? Circle or highlight the four electron domains in the Lewis structure for each molecule that you identified.

5. Which molecules in Model 1 have two electron domains? Circle or highlight the two electron domains in the Lewis structure for each molecule that you identified.

6. Which molecule in Model 1 has three electron domains? Circle or highlight the three electron domains in the Lewis structure for the molecule that you identified.

7. When determining the number of electron domains in a Lewis structure, which of the following should you count? Find evidence from Model 1 to support your answers.

   a. Bonds on the center atom

   b. Lone pairs on the center atom

   c. Total number of atoms in the molecule

   d. Lone pairs on peripheral atoms

8. When determining the number of electron domains in a Lewis structure, do you count double bonds as one domain or two domains? Find evidence to support your answer from Model 1.

9. Explain the difference between a **bonding electron domain** and a **nonbonding electron domain** using the examples in Model 1.

10. Circle the correct word or phrase to complete the sentences:

    Pairs of electrons will (attract/repel) each other.

    Two bonds on the same atom will try to get as (close to/far from) each other as possible.

    A lone pair of electrons and a bonded pair of electrons will (push away from/move toward) each other.

STOP

Read This!

The **VSEPR (Valence Shell Electron Pair Repulsion) Theory** helps predict the shapes of molecules and is based on the premise that electrons around a central atom repel each other. **Electron domains** are areas of high electron density such as bonds (single, double or triple) and lone-pairs of electrons. In simple terms VSEPR means that all electron bonding domains and electron nonbonding domains around a central atom need to be positioned as far apart as possible in *three-dimensional* space.

11. VSEPR theory specifies "valence shell" electrons. Explain why these are the most critical electrons for determining molecular shape based on your exploration of Model 1.

12. In the VSEPR theory, what is repelling what?

13. Based on the information in the *Read This!* section, sketch one of the molecular shapes shown below in each of the boxes provided in Model 1.

Three-Dimensional Molecular Shapes	Linear 180°	Trigonal planar 120°
Tetrahedral 109.5°	Pyramidal 107°	Bent 104.5°

STOP

14. Often we draw Lewis structures with 90° bond angles. Do any of the molecular shapes in Model 1 have 90° bond angles?

15. Are the bond angles in the three-dimensional molecules generally larger or smaller than those shown in the Lewis structures drawn on notebook paper?

16. Why is it possible to get larger angles separating electron domains in three-dimensions versus two-dimensions?

17. Identify the three molecules shown in Model 1 that have four electron domains each.

    a. What happens to the size of the bond angle(s) in a molecule as the number of lone pairs on the central atom increases?

    b. Discuss in your group some possible explanations for the trend in part *a*. Your presenter should be ready to present to the class one or two of your hypotheses for full class discussion.

18. A student does not "waste" his time drawing a Lewis structure before determining the shape of PF_3. The student thinks that the shape of PF_3 must be trigonal planar because there are three fluorine atoms bonded to the central phosphorus atom.

    a. Draw the Lewis structure for PF_3.

    b. Was the student's answer for the shape of a PF_3 molecule correct? Explain.

    c. Why is it important to draw the Lewis structure for a molecule before identifying the shape of the molecule?

19. Complete the following chart:

Molecule	Lewis Structure	3-D Drawing	Name of 3-D Shape	Bond Angle
H_2S				
PH_3				
CCl_4				
CS_2				

Extension Question

20. Ozone, O_3, is not a linear molecule. Actually it is bent with an angle that is a little less than 120°.

a. Draw the Lewis structure of ozone, O_3.

b. Describe why ozone has a bent shape instead of a linear shape.

c. Describe why ozone's bond angle is larger than that of water, H_2O.

Name: _____ period: ___

pL Lab #24

NEO/SCI TEACHER'S GUIDE

NEO SCI

New ideas for teaching science

Lab Activity Procedures & Notes

ACTIVITY 4

Testing the pH of Common Substances

The following table outlines the pH values of various common solutions.

Substance	Condition	pH	H+	OH-
Hydrochloric acid (4%)	acid	0	10^{0}	10^{-14}
Battery acid	acid	0.8	10^{-1}	10^{-13}
Lemon juice	acid	2.3	10^{-2}	10^{-12}
Vinegar	acid	2.8	10^{-3}	10^{-11}
Aspirin	acid	2.8	10^{-3}	10^{-11}
Soft drink	acid	3.0-4.0	10^{-3}-10^{-4}	10^{-11}-10^{-10}
Fruit juices	acid	3.3-3.5	10^{-3}-10^{-4}	10^{-11}-10^{-10}
Alka Selzer	acid	6.3	10^{-6}	10^{-8}
Milk	acid	6.4	10^{-6}	10^{-8}
Pure distilled water	neutral	7	10^{-7}	10^{-7}
Blood	base	7.5	10^{-8}	10^{-6}
Baking soda ($NaHCO_3$)	base	8.2	10^{-8}	10^{-6}
Chlorine bleach	base	9.5	10^{-10}	10^{-4}
Milk of magnesia	base	10.5	10^{-11}	10^{-3}
Household ammonia	base	11	10^{-11}	10^{-3}
Washing soda (Na_2CO_3)	base	12	10^{-12}	10^{-3}
Hair remover	base	12.8	10^{-13}	10^{-1}
Sodium hydroxide (4%)	base	13	10^{-13}	10^{-1}
Oven cleaner	base	13.8	10^{-14}	10^{0}

Increasing Acidity

Neutrality

Increasing Alkalinity

pH lab questions:

1. Why does even the smallest change in pH represent large change in hydrogen ion concentration? _____

   _____

2. What makes an acid strong or weak? _____

   _____

3. What makes a base strong or weak? _____

   _____

4. Why do carbonated beverage tastes acidic? _____

   _____

5. Why does drink milk make you feel better when you have an upset stomach?

   _____

Name: _____ PL lab #25 period: ____

Naming Acids

What makes an acid unique and how are acids named?

Why?

A variety of acids are used in foods, industry, and research. Acids are covalently bonded molecules, but when they are put into water they produce ions. One of the ions produced is always H^+, which immediately combines with a water molecule to form the hydronium ion (H_3O^+). The H_3O^+ ion is what defines the acidic properties of a substance. Because of their special classification, acids have a naming system different from ionic or other molecular (covalent) compounds.

Model 1 – Binary Acids

Acid	Name of acid in aqueous solution	Cation (+)*	Anion (–)
HCl	Hydrochloric acid	H_3O^+	Cl^{1-}
HBr	Hydrobromic acid		Br^{1-}
H_2S		$2H_3O^+$	
HF			

*Hydrogen ions (H^+) join with water molecules in solution to form hydronium ions, H_3O^+.

1. Complete the cation and anion columns of the table in Model 1. Be careful to show the charges on the ions.
2. Why does hydrosulfuric acid contain two hydrogens?
3. Look at the formulas and names of the binary acids in Model 1.
   a. What prefix is used at the beginning of the name for all binary acids?
   b. What suffix is used at the end of the name for all binary acids?
4. The prefix "bi" means "two." Propose a reason that the acids in Model 1 are all referred to as "binary" acids.
5. Write a rule for naming binary acids.

   All binary acids begin with the prefix hydro-, which precedes the name of any nonmetal other than hydrogen, in the compound. The name of this nonmetal is modified to end with the suffix -ic.

   Example: hydro_____ic acid.

STOP

Model 2 – Ternary Acids (Oxyacids)

Acid	Name of Acid in Aqueous Solution	Cation (+)	Polyatomic Anion (–)	Polyatomic Anion Name
$HClO_3$		H_3O^+		*Chlorate*
H_2SO_3	Sulfurous acid		SO_3^{2-}	
	Sulfuric acid			Sulfate
H_3PO_3		H_3O^+	PO_3^{3-}	
	Phosphoric acid			*Phosphate*
HNO_3			NO_3^{1-}	
	Nitrous acid			Nitrite
H_2CO_3	Carbonic acid		CO_3^{2-}	

6. Look at the formulas of the ternary acids in Model 2.

   a. How are ternary acids different from binary acids in their structure?

   Ternary acids contain polyatomic anions—oxygen is part of the polyatomic anion in each case.

   Ternary acids have three different elements, while binary acids have only two.

   b. What number do you think the prefix "ter-" refers to?

7. When ternary acids are mixed with water, ions will form. Fill in the table above with the formulas and names of the anions.

8. Examine the pairs of ternary acids in Model 2 that contain sulfur, phosphorus, and nitrogen. Each pair has one acid that ends in "-ic" and another that ends in "-ous." These endings are related to the name of the polyatomic anion found in the acid ("-ate" or "-ite"). Complete the statements below with the correct acid name ending.

   Polyatomic anion ending is "-ate" → acid name ending is _____.

   Polyatomic anion ending is "-ite" → acid name ending is _____.

9. If the prefix "hydro-" were used to name a ternary acid, what problem would this create when naming $HClO_3$?

   The name could be confused with HCl, the binary acid that is also named hydrochloric acid.

10. Write a rule for naming ternary acids.

    Ternary acids do not use the prefix hydro- in front of the polyatomic anion name.

    Ternary acids end in -ic if the polyatomic anion ends in -ate.

    Ternary acids end in -ous if the polyatomic anion ends in -ite.

11. Predict the formula for chlorous acid.

12. Circle the acid(s) below that would be named beginning with the prefix "hydro-."

    H_2SO_3 (HF) (H_2S) H_2CO_3 HNO_2

STOP