

Name: _____ Date: _____ Period: _____

POGIL: INTRODUCTION TO CHEMISTRY

Model 1: Atomic Structure

Why?

Atoms make up everything around us—from the food on our plate to the materials that make up buildings. How do we know what to make those substances out of? How do we know what nutrients are in our food? The answer is that we know about the properties of the atoms that make them up. In order to get to that point, we must first understand the composition of atoms and how to determine that based upon the information provided to us on the periodic table.

Particle	Symbol	Relative Charge	Absolute Mass	Relative Mass	Location in the atom
Electron	e ⁻	-1	9.109x10 ⁻³¹ kg	0	Electron Cloud
Proton	p ⁺	+1	1.673x10 ⁻²⁷ kg	1	Nucleus
Neutron	n ⁰	0	1.675x10 ⁻²⁷ kg	1	Nucleus

Memory Clues:

Protons: Positive

3 N's for Neutrons: Neutrons, Neutral, Nucleus

1. A quantum model of the atom is a drawing that represents the nucleus and the electron cloud. Draw the quantum model of the atom, labeling the three subatomic particles described above and labeling the name of their location.
2. What do you notice about the relative mass of the proton and neutron? What about the electron?

Since the masses of the subatomic particles are so small, we use another unit to discuss their mass: **atomic mass unit (amu)**. One amu is the mass of a proton. In this way, we can discuss and use the masses of protons (which, relatively speaking, is the same as the mass of a neutron) to determine the **atomic mass** of a particular atom. The atomic mass is the total number of protons + neutrons in the nucleus of the atom. The atomic mass is the average of all of the masses of the different isotopes of elements (isotopes will be discussed later).

3. Is the mass of an electron taken into account for the atomic mass? Why or why not?
4. 1 amu is equivalent to how many protons?

Model 2: Reading the Periodic Table

The numbers on the periodic table have significance! As pictured above, the periodic table tells you an element's atomic number, atomic mass, and symbol. But what do those all mean?

The **atomic number** tells you the number of protons an element has. Notice how no two elements have the same atomic number. As a result, you can identify an element's identity based upon the number of protons it contains. If an element is neutral, meaning it has no charge, then the atomic number can tell you the number of electrons as well. However, the atomic number can only tell you the number of protons 100% of the time.

Mass number is not represented on the periodic table. However, it tells us the number of protons plus neutrons for a particular atom of an element.

The **atomic mass** is the average of the mass numbers of all isotopes (isotopes have the same number of protons, but a different number of neutrons) of an element found in nature. The unit for atomic mass is amu.

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5. What can knowing the number of protons allow you to do?

 6. An unknown element has an atomic number of 8. What element is it?

 7. What can the atomic number ALWAYS tell you? What conditions allow it to tell you the number of electrons as well?

Model 3: Defining Elements and Compounds

The Model:

Fe is the elemental form of iron.

C is the elemental form of carbon.

Cl₂ is the elemental form of chlorine.

FeCl₃ is a compound formed from the elements iron and chlorine

1. What does the subscript 2 indicate in Cl₂?
2. What is implied when there is no subscript?
3. Evaluate the statement, "The formulas for elements never contain a subscript." Is this statement true?
4. From the two examples provided, would you expect the formula S₈ to represent a compound to an element?
5. Using examples from the Model, explain how you classified S₈.

Exercising Your Knowledge

6. Classify each formula below as an element or a compound:

a. Co _____

f. SiO₂ _____

b. CaCl₂ _____

g. PF₅ _____

c. CsOH _____

h. P₄ _____

d. Br₂ _____

i. OF₂ _____

e. NaBr _____

j. C₆H₁₂O₆ _____

Summarizing Your Thoughts

7. What clues are given in chemical formulas that allow you to differentiate between an element and a compound?

Model 4: Introduction to Chemical Bonding

Directions: Use the chart below and your periodic table to answer the questions that follow.

PART I: COMPARING ELEMENTS

Group One and Group Two both show different compounds made by bonding different elements together. There are two types of bonding in food science, as shown in these two groupings. Let's take a closer look at the elements in each compound to see what makes a compound IONIC or COVALENT.

IONIC BONDS	COVALENT BONDS
NaCl (Sodium Chloride)	H ₂ O (Dihydrogen Monoxide)
MgO (Magnesium Oxide)	CH ₄ (Methane)
Li ₂ O (Lithium Oxide)	CO ₂ (Carbon Dioxide)
KF (Potassium Fluoride)	HF (Hydrofluoric Acid)
FeBr ₃ (Iron III Bromide)	NH ₃ (Ammonia)
CaCl ₂ (Calcium Chloride)	NO ₂ (Nitrogen Dioxide)
NiI ₂ (Nickel Iodide)	C ₆ H ₁₂ O ₆ (Glucose)
BaS (Barium Sulfide)	CF ₄ (Carbon Tetrafluoride)

1. List out the FIRST element in each of the GROUP ONE compounds.
2. What side of the periodic table do you find these FIRST elements on?
3. What is the name for elements on this side of the periodic table?
4. List out the SECOND element in each of the GROUP ONE compounds.
5. What side of the periodic table do you find these SECOND elements on?
6. What is the name for elements on this side of the periodic table?

**BIG IDEA #1: When a _____ and a _____
come together, they make an IONIC BOND.**

7. What do you notice about ALL of the elements in GROUP TWO?

8. What side of the periodic table do you find ALL of these elements on?

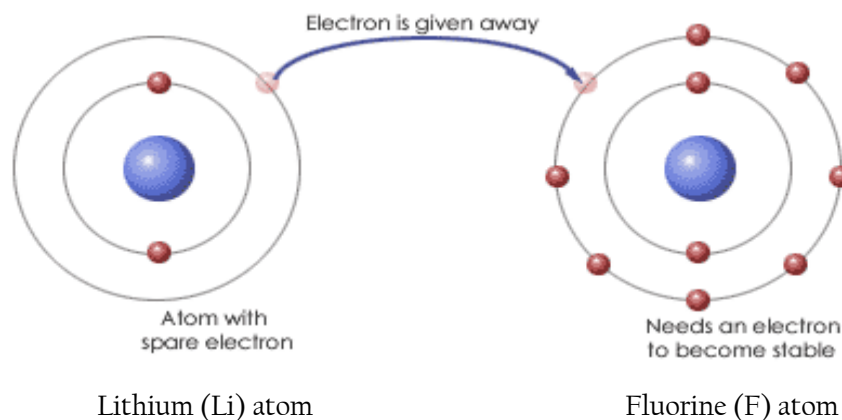
**BIG IDEA #2: When a _____ and another
_____ come together, they make a COVALENT BOND.**

PART II: COMPARING PROCESSES

Directions: Examine the following pictures of IONIC and COVALENT bonding.

BONDING PICTURE

ONE:



Explain what is happening in the picture in your own words:

9. What are the names of the two elements present in bonding picture one?
10. What TYPE of element is element one? Element two?
11. Therefore, bonding picture one must show the process for which type of bonding; ionic or covalent?

**BIG IDEA #3: In IONIC BONDING, the _____ TRANSFERS
it's electron(s) to the _____.**

12. Read the following and answer the questions that follow:

Imagine you are in a competition with 20 other people. Everyone starts out with a different number of basketballs in their container. The goal of the competition is to either have 8 OR 0 basketballs in your container by the end of 20 minutes. The prize is \$1,000,000. When the timer starts you notice that you have only 1 basketball in your container to start. Which would be easier?

a) Giving away your 1 basketball so that you have 0 at the end of 20 minutes?

OR

b) Trying to get 7 more basketballs so that you has 8 at the end of 20 minutes?

Why did you choose this option?

You look over at your friend and notice that he has 7 basketballs in his container already.

What is the easiest way for him to reach the goal?

a) Trying to get rid of the 7 basketballs so that he have 0 at the end of 20 minutes?

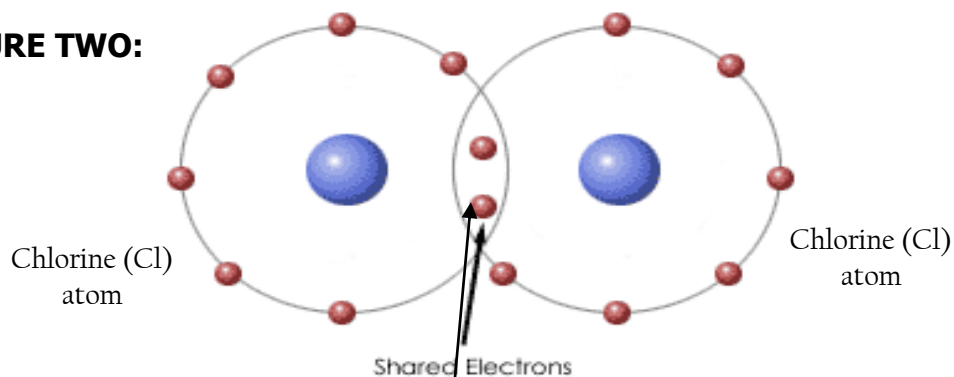
OR

b) Trying to get 1 more basketball (maybe from you!)so that he has 8 at the end of 20 minutes?

Why did you choose this option?

This is kind of like what happens in **IONIC BONDING**. The **METALS** have a small amount of electrons in their last shell so it is easier for them to get rid of them than try to gain a bunch. The **NONMETALS** almost have a full shell of eight so it is easier for them to get a few then get rid of all of theirs. This is why the **METALS TRANSFER ELECTRONS TO NONMETALS IN IONIC BONDING.**

BONDING PICTURE TWO:



Explain what is happening in the picture in your own words:

13. What are the names of the two elements present in bonding picture two?

14. What TYPE of element is element one? Element two?

15. Therefore, bonding picture two must show the process for which type of bonding; ionic or covalent?

BIG IDEA #3: In COVALENT BONDING, the _____ and the other _____ *SHARE* their electrons.

16. Imagine that you are still in that same basketball competition. You look in your container and see that you have 7 basketballs. You look next to you and notice that your twin brother has 7 also. Both of you have so many that you don't want to give them up, but you both need one more. No one around you is giving any of theirs away! You and your brother come up with a plan. At the end of the 20 minutes when the judges are checking how many basketballs everyone has, you share one of yours to him so he has 8. Then, once he is checked he gives yours back to you and shares one of his with you so you have 8 also. You both split the prize! Why is this a good option for both of you?

This is kind of like what happens in **COVALENT BONDING**. Both **NONMETALS** are almost to their happy eight, so neither wants to give anything away. This is why **NONMETALS SHARE ELECTRONS IN COVALENT BONDING.**

PRACTICE III: PRACTICE

Based on what you just learned, put the following into the chart as either IONIC or COVALENT COMPOUNDS.

KCl Rb₂S Cl₂ PH₃ CH₃Cl SO₂ MgCl₂
 Fe₂O₃ NaBr CaF₂ SCl₆ N₂O₅ CuF₂ CS₂

IONIC COMPOUNDS	COVALENT COMPOUNDS

*In IONIC BONDING metals _____ their electrons to nonmetals so they all have 8.

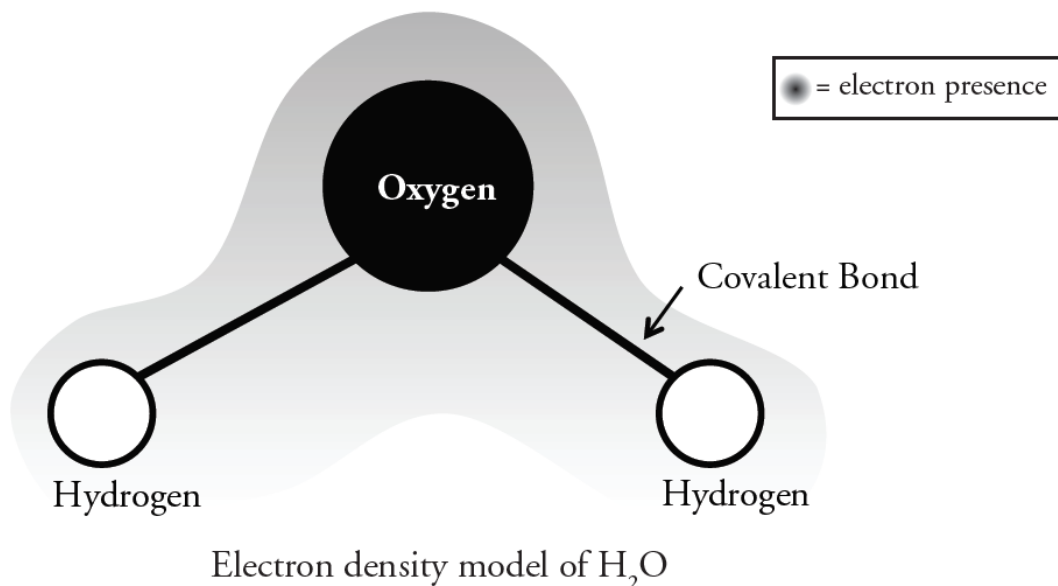
*In COVALENT BONDING nonmetals _____ their electrons so they all have 8.

Properties of Water

Why?

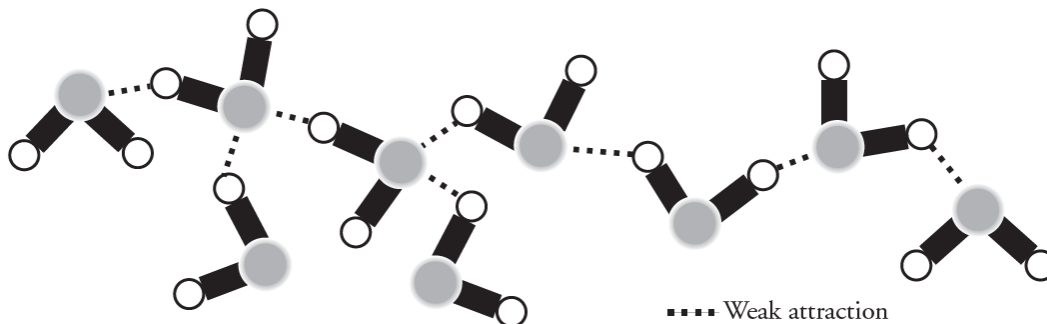
When you hear that NASA's space probes are looking for "evidence of life" on other planets, do you know what that means? They are looking for evidence of liquid water. Water is fundamental for all life; without it every living thing would die. Water covers about 70% of Earth's surface and it makes up 65–75% of our bodies (82% of our blood is water). Even if water might seem boring to you—no color, taste, or smell—it has amazing properties that make it necessary for supporting life.

Model 1 – The Molecular Structure of Water



1. How many hydrogen atoms are in a molecule of water?
2. How many oxygen atoms are in a molecule of water?
3. What holds the hydrogen atoms to the oxygen atom?
4. The shading around the molecule represents the relative density of electrons shared by the atoms. What does this indicate about the density of electrons around the oxygen atom as compared to the density of electrons around the hydrogen atoms?
5. Where is the majority of negative charge on the water molecule?

Model 2 – Attraction of Water Molecules

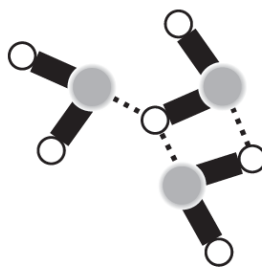


6. Looking at your answers to Questions 1 and 2 from Model 1, tell what atoms are represented by:
 - a. The small, unshaded circles in Model 2.
 - b. The larger gray shaded circles in Model 2.
7. What do the solid lines between the small and large circles represent?
8. According to Model 2, what is represented by the dotted lines?
9. 9. Remember that electrons in a water molecule are more dense around the oxygen atom and less dense around the hydrogen atoms.
 - a. What kind of charge would the oxygen atom have compared to the hydrogen atoms?
 - b. What kind of charge would the hydrogen atoms have compared to the oxygen?
10. Describe the arrangement of the water molecules in Model 2 with one another.
11. Describe the cause of the attractions between molecules of water.
12. If another water molecule was added to the group in Model 2 at the upper right side, which of its atoms would be connected to the existing molecule with a dotted line? Describe your group's reasoning.

Read This!

The bonding electrons in some molecules are not equally shared between the atoms. These neutral molecules with a difference of charge across the molecule are called **polar molecules**. Because of the arrangement of the atoms and electrons in a water molecule, there are two differently charged areas of the molecule even though the molecule is neutral overall. The hydrogen molecules are slightly positive, while the oxygen is slightly negative. The positive area charge (hydrogen) of one water molecule is attracted to the negative area (oxygen) of a different water molecule. This weak attraction is often referred to as **hydrogen bonding**.

13. In the space below, draw an additional 10 water molecules to create a cluster. Be sure to indicate the hydrogen bonds that link the water molecules.





Properties of Water Station Lab

Station 1

Water is everywhere. It makes up about 3/4ths of the surface of the earth. It makes up 50-95% of the weight of living organisms. It is in the air we breathe, the sinks we use and in every cell of the body.

Water has special properties that make it unusual and complex.

Water has the ability to be a liquid, solid or gas depending on the temperature at which it is found.

Each molecule of water is made up of 2 hydrogen molecules and 1 oxygen molecule bonded together.

Water is a **polar molecule** because the oxygen molecule has a slightly negative charge and the hydrogen molecules have a slightly positive charge. This polarity results in **hydrogen bonds** forming between water molecules

Questions:

1. How does water rise from the roots of a tree to the very top?
2. How do insects walk on the water?
3. Why does ice float rather than sink?
4. Why do people become seriously ill, or die, if they go without liquid for a week or so?
5. How would life in a lake be affected if ice sank and lakes froze from the bottom up?
6. If $\frac{3}{4}$ of our planet are covered in water why should we be worried about conserving water?



Properties of Water Station Lab

Station 2

Water is attracted to other water molecules like magnets. This is called **cohesion**.

Part 1

Materials:

Penny Water Medicine Dropper

1. **Predict how many drops you will be able to put on the penny before it overflows by having each person at your table guess.**

Now, let's see how many drops of water you can place on the surface of the penny before it overflows. Drop water from the dropper onto the penny, keeping a careful count of each drop.

2. **Draw a diagram showing the shape of the water on the penny after one drop, when the penny is half full and just before it looks like it is going to overflow.**
3. **How many total drops did you get on the penny?**

4. **If the number of drops is different from your prediction, explain your results in terms of cohesion.**



Properties of Water Station Lab

Station 2

Related to cohesion is **surface tension**, a measure of how difficult it is to stretch or break the surface of a liquid.

Part 2

Materials:

Penny Water Medicine Dropper Detergent

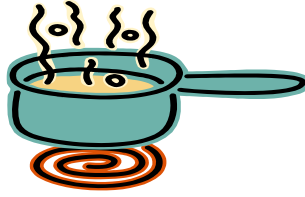
Procedures

With your finger, spread one drop of detergent on the surface of a dry penny.

- 1. Predict how many drops you think this penny will hold after being smeared with detergent.**

Using the same dropper as before, add drops of water to the penny surface. Keep a careful count of each drop.

- 2. Draw a diagram showing the shape of the water on the penny after one drop, when the penny is half full and just before it looks like it is going to overflow.**
- 3. Did the detergent have an effect on the outcome?**
- 4. How does the detergent affect the water? (Look back at the definition for surface tension)**
- 5. Explain how detergents act as cleaning agents.**



Properties of Water Station Lab

Station 3

Water has a **high heat of vaporization** - the energy required to convert liquid water to a gas. Water's high heat of vaporization helps moderate the earth's climate.

Part 1

Evaporation rates of water versus ethanol

Let's examine the relative heats of vaporization of water and ethanol as follows:

1. Simultaneously stick one cotton swab into a beaker of water while doing the same with a second cotton swab in a beaker of ethanol
2. Gently draw thin lines of liquid (a few cm long) with each swab on your bench top and record how long it takes for each line to evaporate.

Questions:

1. **Which substance had the higher heat of vaporization?**
2. **Based on your results explain why water is a much more effective coolant than alcohol for the body.**

Part 2

Water has a **high specific heat capacity**. Specific heat is a measure of heat capacity, is the heat required to raise the temperature of 1 gram of water 1°C. Water, with its high heat capacity, therefore, changes temperature more slowly than other compounds.

Questions:

3. **Think about what happens when you boil water for pasta. Which becomes hot first, the pot or the water in the pot?**
4. **Explain why this property of water is important to living organisms?**



Properties of Water Station Lab

Station 4

Universal Solvent

Because of its high polarity, water is called the universal solvent. A solvent is a substance that dissolves, or breaks apart, another substance (known as a solute). A general rule that determines whether a substance will dissolve in a solvent depends upon its polarity. Polar solvents dissolve polar solutes and nonpolar solvents dissolve nonpolar solutes.

Part 1

Solubility of various solutes in water

To observe how water behaves as a solvent, you will attempt to dissolve a variety of substances in liquid water. To do so, measure 50 ml of deionized water into each of four 100 ml beakers and attempt to dissolve each substance by thoroughly stirring or swirling. Record the results in your lab notebook, noting whether each substance is polar, non-polar or ionic:

Beaker #1 – 0.5 grams of NaCl, also known as “table salt” (ionic)

Beaker #2 – 0.5 grams of sucrose, also known as “table sugar” (polar)

Beaker #3 – 1 squeeze from a transfer pipet of vegetable oil (non-polar)

Beaker #4 – 1 squeeze from a transfer pipet of ethanol (polar)

Questions:

- 1. Which substance(s) did not dissolve completely in water? Why?**
- 2. Compare and contrast terms polar and non-polar.**



Properties of Water Station Lab

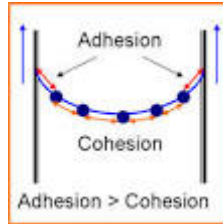
Station 5

Density

Water is one of the few substances that are less dense as a solid than as a liquid. While most substances contract when they solidify, water expands. This property is due to the hydrogen bonding between water molecules.

Part 1

- 1. Place the ice cube in the water.**
- 2. Describe what happened.**
- 3. Explain why this property is important to aquatic organisms.**



Properties of Water Station Lab

Station 6

Adhesion

Water clings to non-polar molecules.

Questions:

1. Describe what happens when you place a straw in a drink.
2. Relate this phenomenon to the water property of adhesion.
3. What organism(s) depend on this property of water? Why?

Properties of Water Station Lab

Station 7

Summary

Pulling it all Together

1. List three things that you discovered about water?
2. How do the characteristics of water help the body?
3. Review your answers to the questions from Station 1. Which property of water is represented by each question? Explain your answers.