Name:______________________________ Block:__________ Date:____________________

PACKET #1

Unit 1: Chemistry of Life, Part I

***Reading**: BSCS Text Chapter 1, 2.9, 2.10*

Learning Objectives:

Topic 1: Basic Chemistry and Bonding

1. Explain the relationships among atoms and molecules (1.1).
2. Describe and diagram the structure of an atom, including protons, neutrons, electrons (1.2).
3. Use atomic number on the periodic table to determine number of protons and electrons in an atom (class).
4. Explain why atoms form covalent bonds and use a Bohr model/HONC rule to predict bonding behavior(1.4).
5. Define and draw an ion, and provide examples (1.4).
6. Explain why atoms form ionic bonds. Given the number of valence electrons in an atom, predict whether the atom is likely to participate in ionic bonding.

Topic 2: Properties of water

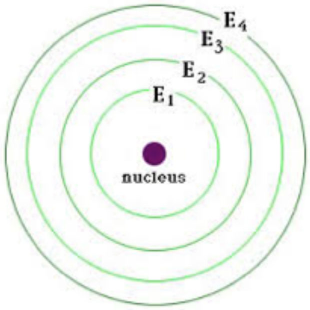
7. Explain why water molecules are considered polar and how this helps hydrogen "bonds" form (1.4)
8. How is an **inter**molecular force (like a hydrogen "bond") different from a **intra**molecular force (like a covalent bond)?
9. *Explain* the following properties of water (including how these are biologically relevant): high surface tension, high specific heat, solid water is less dense than liquid water, water as the "universal solvent," and capillary action. Along the way, be sure to address cohesion and adhesion (p.189, teacher notes).
10. Differentiate between acids and bases on a pH scale.

Key Terms/Concepts

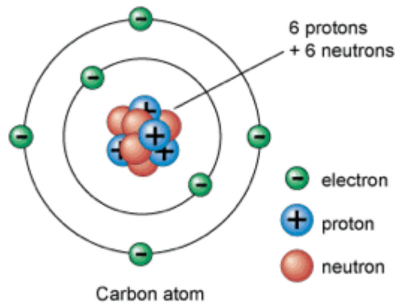
Molecules	Covalent Bond	Intermolecular force
Atoms	Ionic Bond	Intramolecular force
Element	Ion	Cohesion
Subatomic particles	Ionization	Adhesion
Proton	Hydrogen bond	Capillary action
Neutron	Polar molecule	Surface tension
Electron	Atomic number	Specific heat
Solution	Solute	Salt
Acid	Base	Solvent

Topic 1: Basic Chemistry and Bonding (POGIL)

Model 1: The Bohr Model of the Atom



The Bohr model includes a central nucleus surrounded by discreet energy levels (displayed as rings).



1. Which subatomic particles are located in the nucleus? Which is not?

2. What is the charge on each of the following subatomic particles:

   a. Proton

   b. Electron

   c. Neutron

> **Read This:** The term **atom** refers to an electrically **neutral** particle; It is neither positive nor negative. This occurs when positive and negative charges occur in equal numbers, so they balance one another out. If a particle has unequal numbers of positive and negative charges, it is known as an **ion**. Both atoms and ions are important in biology, and you will see many examples of each throughout the course.

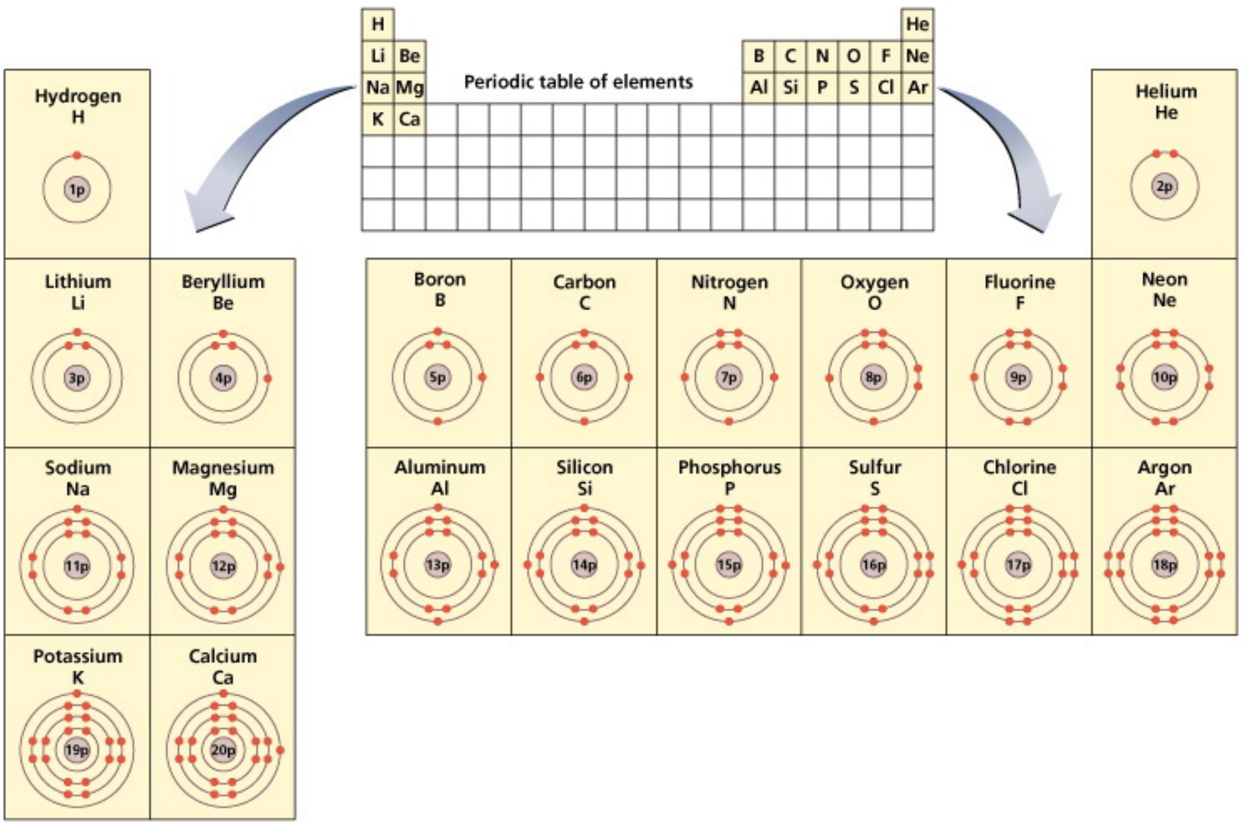
3. Based on the reading above, which two subatomic particles *must* be found in equal amounts in an atom?

4. What do you know must be true about the amount of protons and electrons found in an ion?

5 a. In a positive ion, ex Na+, which subatomic particle would you have more of? Explain.

5 b. In a negative ion, ex: Cl-, which subatomic particle would you have more of? Explain.

Model 2: Electron Configuration of Atoms



6. How many electron energy levels (rings) do atoms in the top row have? The middle row? The third row?

7. How do the numbers of electrons in the outer level of each atom change as you move across a row from left to right?

8. How do the numbers of electrons in the inner level(s) of each atom change as you move across a row from left to right?

9.What is the maximum number of electrons that can be held in each ring?

10. Given an atom's position on the periodic table, explain how you would figure out how many electrons are found at each energy level.

11. Given the number of elections present in an atom, explain how you would figure out the atom's position on the periodic table.

Model 3: Atoms in the Periodic Table

Each atom/element is displayed in a box on the periodic table.

6 C 12

A portion of the periodic table (the portion most commonly used by biologists) is shown below. Compare the information here to the figures in Model 2 to answer the questions.

Groups

Periods	1	2	3	4	5	6	7	8
	1 H 1.008							2 He 4.003
	3 Li 6.941	4 Be 9.012	5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
	11 Na 22.99	12 Mg 24.31	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
	19 K 39.10	20 Ca 40.08	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.60

We can describe an atom in several ways. Here are some vocabulary terms relating to atoms:

Atomic Number: The number of protons in an atom.

Chemical Symbol: A 1- or 2-letter abbreviation for an element.

Atomic Mass/Mass Number: The combined number of protons and neutrons in an atom.

8. On the periodic table box depicting oxygen, (a) Circle the atomic number. (b) Draw an arrow to the chemical symbol, (c) highlight the atomic mass.

8
O
16

9. How many protons does a calcium atom have? How many neutrons? Explain your answer.

10. Draw Bohr models of the following atoms:

12	20
Mg	Ca
24	40

11. What is similar about your models? What is different? Consider electron numbers and formation.

Read This! The Rule of Eight:

Atoms are most stable when their outer electron shell is filled. This means that atoms tend to gain or lose electrons to attain a full outer (valence) shell. Most of the time, atoms gain or lose electrons to get to eight in their outer shell (or two if they are H or He and only have the first mini-shell). We can tell how many bonds an atom is likely to form by looking at how many electrons need to be gained or lost in order to fill their valence shell and get to that stable formation of eight electrons.

12. Refer back to Model 2. How many bonds would you expect each of the following atoms to make? Explain your answer using the rule of eight.

1. Oxygen: _______

____

2. Carbon: _______

____

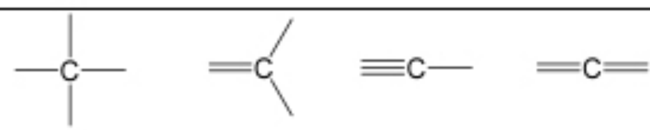
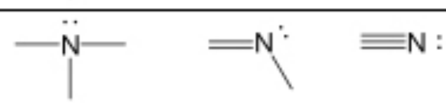
3. Nitrogen: _______

____

4. Hydrogen: ________

____

Model 4: HONC1234 and Structural Formulas

Atom	Number of bonds	Examples
H	1	
C	4	
N	3	
O	2	

Read this! You determined in the last model how many bonds each of the four most common elements in biological systems can form. If you re-arrange your work, you can come up with an easy way to remember the number of bonds each of the elements makes. This can help you figure out structural formulas.

H	O	N	C
1	2	3	4

In your own words, describe what the HONC 1-2-3-4 rule means:

____

____

____

Using the HONC 1-2-3-4 rule, represent the following molecules using structural formulas. Remember: the atoms MUST have the correct number of bonds each time.

a. H_2

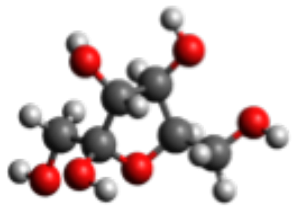
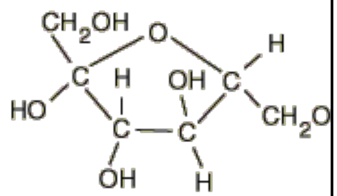
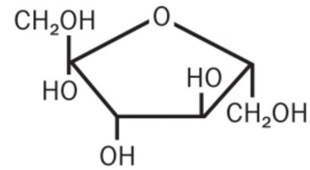
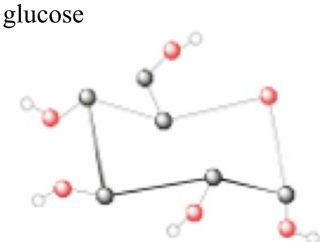
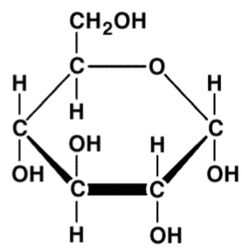
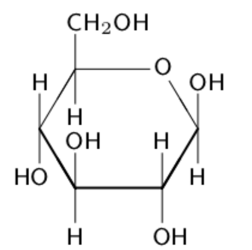
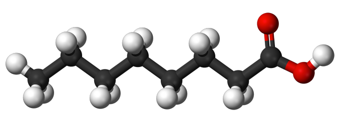
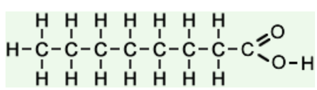
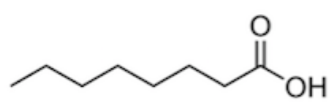
b. NH_3

c. CO_2

d. N_2

e. O_2

Model 5: Molecular Drawings

Ball and stick model of fructose 	Structural formula of fructose 	Line drawing of fructose 	Chemical formula of fructose $C_6H_{12}O_6$
Ball and stick model of glucose 	Structural formula of glucose 	Line drawing of glucose 	Chemical formula of glucose $C_6H_{12}O_6$
Ball and stick model of saturated fatty acid 	Structural of saturated fatty acid 	Line drawing of saturated fatty acid 	Chemical formula of saturated fatty acid $C_8H_{16}O_2$

6. Name the three molecules that are illustrated in Model 5.

7. Name the three types of drawings that are used to illustrate the molecules in Model 5.

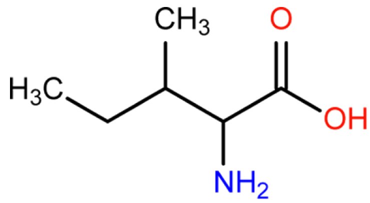
8. How many bonds are typically formed by each of the following atoms?

Carbon _____ Hydrogen _____ Oxygen ______

9. Which types of drawings in Model 1 provide more accurate images of the shape of a molecule?

10. Refer to Model 5. Symbols or atoms of what element(s) are missing from the line drawings? (Hint: They *are* seen in the structural model.)

11. Locate the carbon and hydrogen atoms missing from the line drawing below. Create a structural drawing of this molecule.



Isoleucine

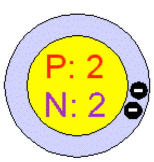
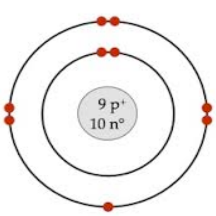
12. In a shorthand diagram like the one above, how do you determine where to place the hydrogen and carbon atoms?

13. What is the advantage to a scientist in using a line drawing rather than a ball-and-stick model or structural formula?

Basic Chemistry POGIL Homework Problems

1. Make a concept map using the following terms: atom, molecule, proton, neutron, electron, ion. Include relationships between each term. (Model 1)

2. How many bonds would be formed by each of the following? Explain your reasoning.

Molecule	Predicted # of Bonds	Reasoning
Carbon		
Hydrogen		
		
		
What element is this? 		

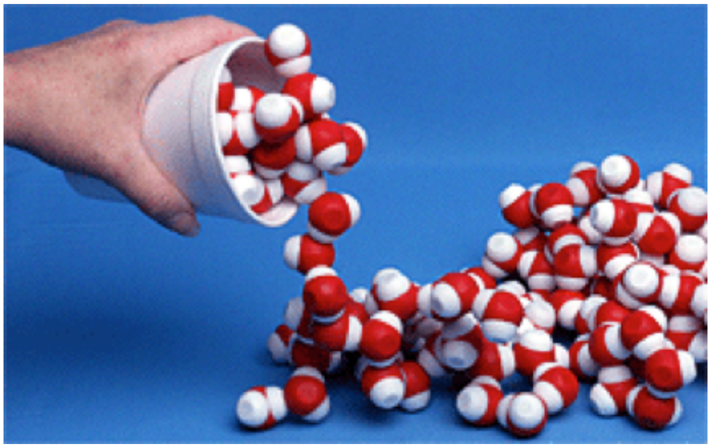
3. Do some independent reading/research. What are some limitations to the Bohr atomic model? Why do biologists use this model, considering this limitation? (Model 2)

4. What types of information does the periodic table of elements you were given provide? (Be aware: complete periodic tables contain much more information that you have seen) (Model 3).

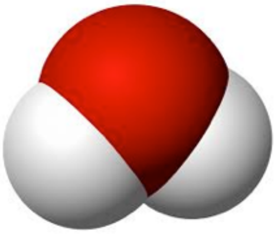
5. Draw the structural formula for following molecules: CH_4, H_2O, C_2H_6 (Model 4)

Topic 2: Properties of Water

Investigation Using 3-D Molecular Models



Introduction: Today you will be manipulating 3-dimensional molecular models. The object of this lesson is to develop an understanding of polarity, and of the properties of water.



Procedure: Begin with a single molecule of water. Answer the questions in this section using your model.

1. What is the chemical formula of water? ____

2. What do the letters and number in the chemical formula represent?

3. Label the hydrogen and oxygen atoms in the picture above.

4. Water is a **polar molecule** because oxygen has a greater pull on the shared electrons than hydrogen. Because of this, oxygen atoms in a water molecule take on a partially negative charge. Hydrogen atoms take on a partially positive charge. **Draw** these charges in the picture above.

> Remember, we use **models** like this because a single water molecule is too small to see, even with the most powerful microscopes. Conventionally, chemists use red spheres to illustrate oxygen, and white to show hydrogen. In nature, water molecules don't actually have these colors.

Make a hypothesis: What will happen when two water molecules bump into each other?

Obtain a second water molecule from your teacher. Test your prediction. *Draw* and *explain* your findings.

Helpful Information:

- Covalent bonds form between atoms in a molecule; they are *intra*molecular forces. Only covalent bonds can form molecules.
- Covalent bonds can be either polar (as in water), or non-polar.
- A Hydrogen "bond" is an *inter*molecular force; it is an attraction between two polar molecules.
- Hydrogen "bonds" will form between a hydrogen on one molecule, and an oxygen, nitrogen, or fluorine on a second molecule.
- Hydrogen "bonds" are about 1/20 as strong as covalent bonds.

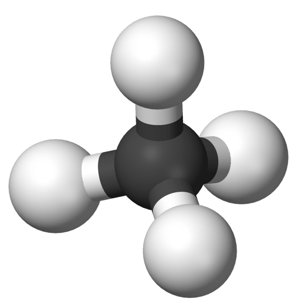
5. Break your water molecules apart from one another. Next, pull apart a single water molecule.

a. What force held the two water molecules together?

b. What force held the hydrogen atoms and oxygen atom within a water molecule?

c. Which was stronger?

Next, your teacher will give you a molecule of **methane.** Chemists use grey or black to represent carbon atoms.



6. Write the chemical structure of methane ______________________________________

7. Methane is an example of a class of molecules called hydrocarbons. These are extremely important in biology, as you will learn in future units. Why are molecules like methane called hydrocarbons?

8. Hold your methane molecule near another group's methane molecule. Is methane a polar molecule or a non-polar molecule? Explain your answer.

9. Does methane form hydrogen bonds with (use your models to test your answer):

a. other methane molecules

b. water molecules

Making Methanol: Remove one hydrogen from your water molecule. You now have a hydroxyl group. Break your methane in half and attach your hydroxyl. You now have a model of methanol.

10. How did adding the hydroxyl group change the properties of hydrocarbon? Be specific in your answer.

11. Does methanol form hydrogen bonds with

a. other methanol molecules

b. water molecules

c. methane molecules

12. Based on your observations so far, develop a rule to tell when molecules will form hydrogen bonds, and when they will not.

Sodium Chloride is also known as "table salt". Obtain a sodium chloride particle from your teacher. The blue particle represents a positive sodium ion (Na+), and the green particle represents a negative chlorine ion (Cl-). They stick together, because of opposite charges, by an ionic bond.

13. Write the chemical formula for sodium chloride.

14. Will a water molecule interact with sodium chloride?

15. Are chloride ions positively or negatively charged? Provide evidence for your answer.

16. Are sodium ions positively or negatively charged? Provide evidence for your answer.

17. Are the attractions between water and the Na+ and Cl- ions considered hydrogen bonds? Why or why not?

18. Will sodium chloride interact with methane? With methanol? Explain your answer.

Helpful Information

- When positive and negtive ions bond together, the substance formed is called a **salt**.
- In water, salts **dissociate**. This means the ions separate from one another.

19. What particles will sodium chloride dissociate into when added to water?

20. A particle of salt is dissolved into a cup of water. Use your models to show how this would look. Draw your model of a dissolved salt in the space below.

21. Will water dissolve methane?

22. Develop a rule for which types of particles/molecules water is able to dissolve.

Sneak Peek! Your next lab will look at how the polar nature of a water molecule gives it unique properties: adhesion, cohesion, surface tension, capillary action, ability to dissolve substances. In the time you have left in class, model as many of these concepts as possible. Record mini-drawings of your models in the space below. If time allows, you will share your favorite model of water's properties with the class.

Objective 7: Explain why water molecules are considered polar and how this helps hydrogen “bonds” form (1.4).

A. What does it mean for a molecule to be polar?
B. What is a hydrogen “bond”?
C. How does polarity help hydrogen “bonds” form?
D. How is an **inter**molecular force (like a hydrogen “bond”) different from a **intra**molecular force (like a covalent bond)?
E. Draw a water molecule and indicate which side is partially positive and which is partially negative. How does water fit with your above definition of a polar molecule?

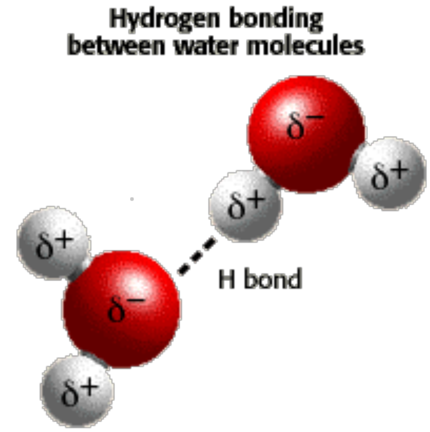
Objective 8: *Explain* the following properties of water (including how these are biologically relevant): high surface tension, high specific heat, solid water is less dense than liquid water, water as the “universal solvent,” and capillary action. Along the way, be sure to address cohesion and adhesion (p.189, teacher notes).

*we should have done the class notes on this before you try this objective.

You may want to create a chart like this in your notes:

Property of Water	Explain/define	Biological relevance	Relation to adhesion and/ or cohesion

Investigation: Properties of Water



Pre-Lab Questions:

1. Define each of the following terms as they apply to water.
   - **A.** Polarity
   - **B.** Cohesion
   - **C.** Adhesion

2. Explain how each of the following occurs in water as a result of water's polarity.
   - **A.** Surface Tension
   - **B.** Capillary Action
   - **C.** Specific Heat
   - **D.** Universal Solvent
   - **E.** Water expands when it freezes

Purpose:

Design and conduct experiments to demonstrate properties of water that exist because of the polar nature of water molecules.

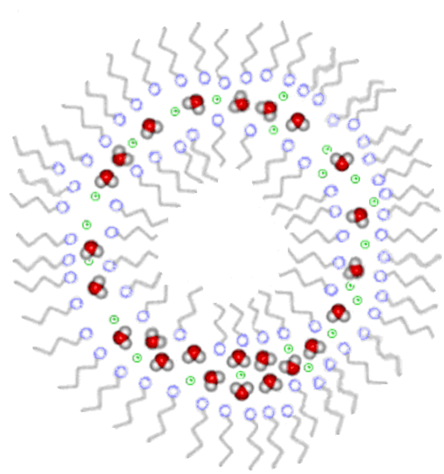
Background:

Water is a polar molecule. Because of this, water molecules are attracted (like magnets) to other water molecules, and other polar and charged molecules. (This should make sense: opposite charges attract one another. Since water has both positive and negative charges, it is attracted to anything with any type of charge!) The polar nature of a water molecule results in the many properties that make water ideally suited for life on Earth: cohesion, adhesion, surface tension, capillary action, high specific heat, etc.
We can compare properties of water to properties of other liquids in order to demonstrate the significance of hydrogen bonding.

Oils and other fats are non-polar. They will be repelled by water, and have little attraction to other non-polar substances.

When added to water, soaps and detergents can be used to disrupt hydrogen bonding. Molecules of detergent have both polar and non-polar regions. When added to water, the polar parts surround water molecules, while the non-polar parts cluster together. The result: hydrogen bonding occurs very little in some parts of the solution.

Isopropyl alcohol (although it is actually polar), engages in much less hydrogen bonding than water does; molecules of isopropyl alcohol demonstrate significantly lower cohesion than do water molecules.



WATER AND SOAP MOLECULES ARRANGED

Task:

Design and conduct an experiment to demonstrate the importance of hydrogen bonding in water.

1. Choose one of the following phenomena to address in your study
   - Adhesion
   - Cohesion
   - Surface tension
   - Capillary Action
   - Specific Heat
   - Universal solvent

2. Choose at least one of the following liquids to compare with water
   - Vegetable oil
   - Isopropyl (rubbing) alcohol
   - Soapy water

3. Record the following information:
   - Problem
   - Background. Define the vocabulary terms related to your investigation.
   - Hypothesis
   - Procedure. Stop here. Your teacher will check your experimental design before you go on.
   - Materials
   - Results/Data
   - Analysis and Conclusion

* * Like a scientist would, you should fix any errors in your procedure, and repeat your experiment. Do this several times until your experiment produces clear, predictable results. Record every change to your procedure, and results of **every** trial.

*

Use this chart to take notes (in class) on the properties of water

Objective 8: *Explain* the following properties of water (including how these are biologically relevant): high surface tension, high specific heat, solid water is less dense than liquid water, water as the "universal solvent," and capillary action. Along the way, be sure to address cohesion and adhesion.

Atomic Properties (O vs. H)

↓

Intramolecular Property

↓

Intermolecular Property

H-bonds:

Cohesion:

Adhesion:

Properties of Water

Surface Tension

Define:

Why does H-bonding allow this to occur?

Capillary Action

Define:

Why does H-bonding allow this to occur?

High Specific Heat; High Heat of Vaporization

High specific heat:

High heat of vaporization:

Why does H-bonding allow these to occur?

Water as the "Universal Solvent"

Solvent:

Solute:

Solution:

Density of Solid Water is Less Than Liquid Water

What does this mean?

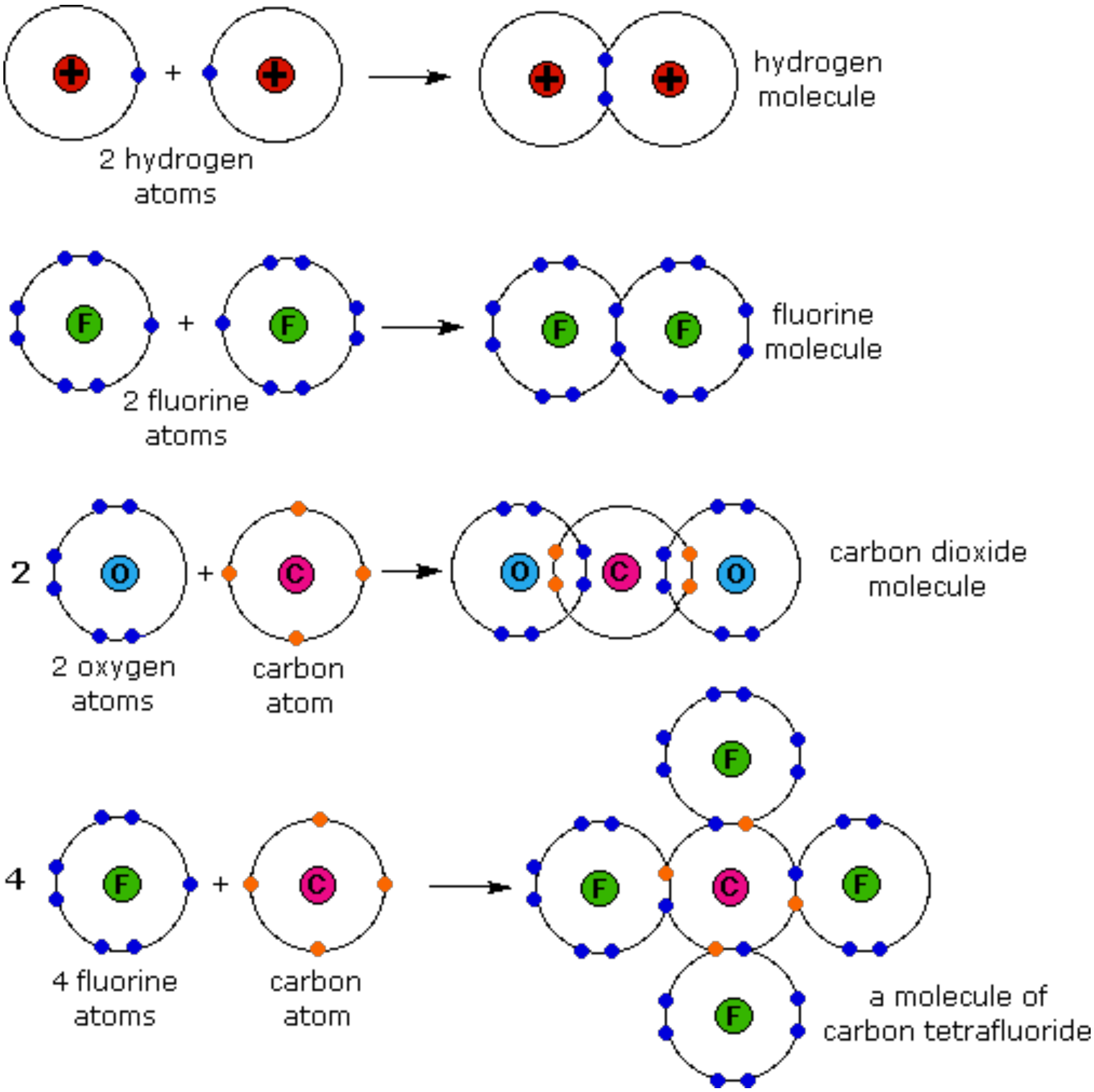
Why does H-bonding allow this to occur?

Biological Significance

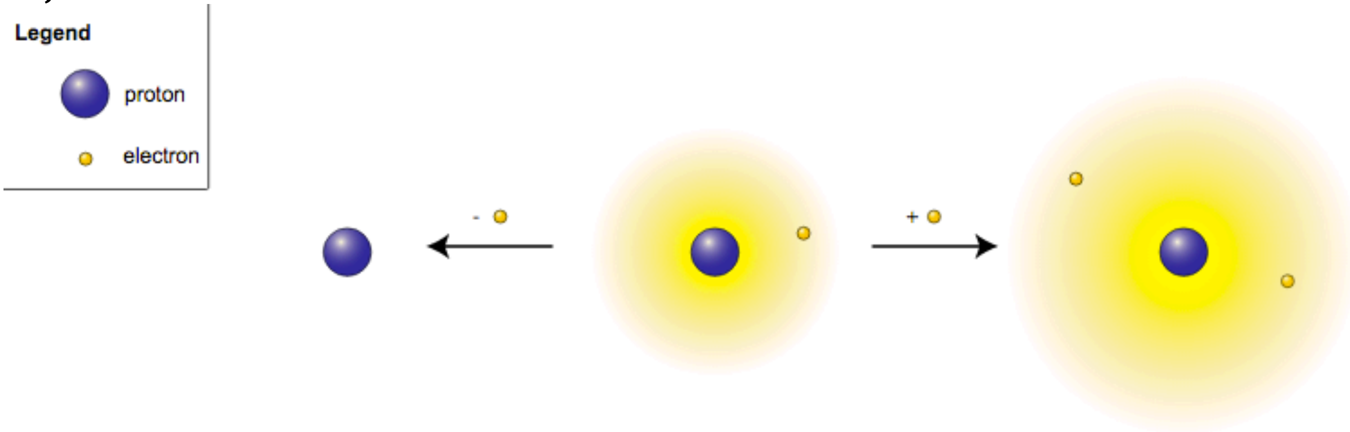
What does "universal solvent" mean?

Cutouts: Glue into your notes as you complete your objectives. Your notes must <u>thoroughly explain</u> the information shown in the diagram.

Objective 4: Covalent Bonding

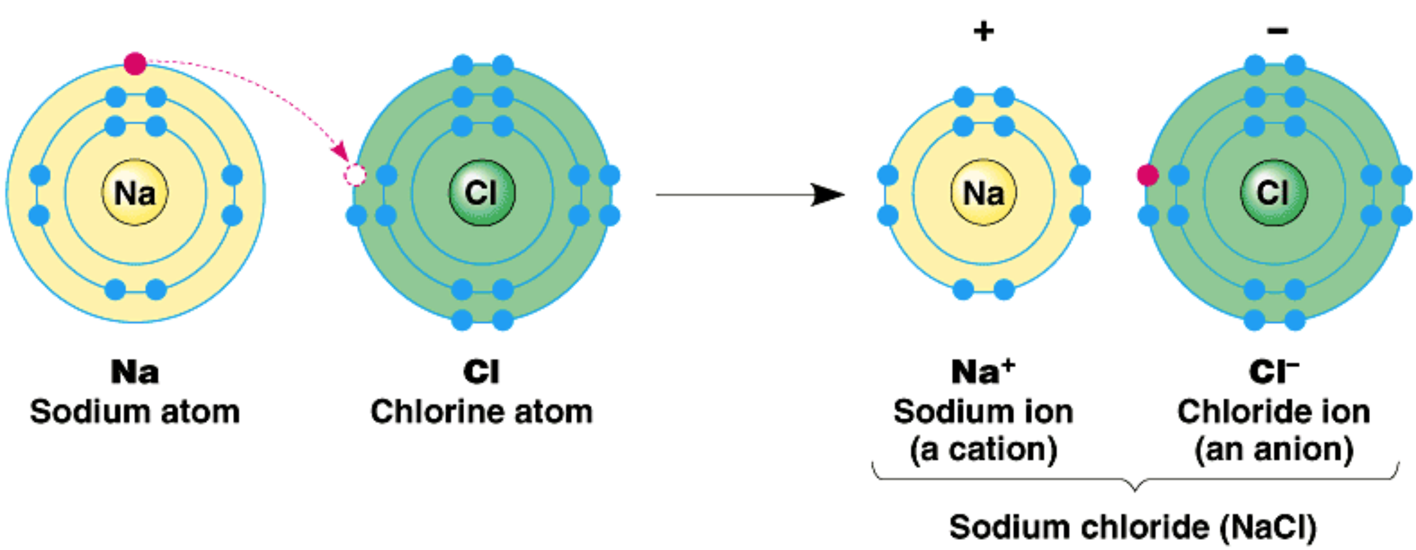


Objective 5: Ions



No. of protons	1	1	1
No. of electrons	0	1	2
Charge	+1	0	-1
Notation	H^+	H	H^-
Classification	cation	neutral (not an ion)	anion

Objective 6: Ionic Bonds



Objective 7: Water is Polar