The Workshop Project Newsletter

PROGRESSIONS:
PEER-LED TEAM LEARNING

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Module 1: Chemistry of Life

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I. Introduction

Living systems obey chemical and physical laws. This module focuses on chemical principles that are necessary for understanding life processes. For example, energy transformations in the cell occur by the formation and breaking of chemical bonds. These chemical reactions result in the reorganization of sub-atomic particles. We begin this module with investigations of matter, elements and compounds.

Prepare for your workshop by reading in your textbook (ex., Audesirk, et al. 6th edition, Chapter 2; Campbell, 4th edition, Chapter 2) and completing the Pre-Workshop Activities below. Show your work in these pages.

II. Pre-Workshop Activities

Activity 1. Define each of the following:

1. acid
2. anion
3. atom
4. atomic mass
5. atomic nucleus
6. atomic number
7. base
8. cation
9. chemical reaction
10. compound
11. covalent bond
12. electron
13. electron shell

14. element
15. hydrogen bond
16. hydrophilic
17. hydrophobic
18. ion
19. ionic bond
20. isotope
21. molecule
22. neutron
23. orbitals
24. pH
25. polar covalent bond
26. proton
27. reactants
28. reaction products
29. solute
30. solvent
31. valence shell

Activity 2.

The symbolism used in biology and chemistry is often like trying to learn a new "foreign" language. In the table below are the symbols for most of the common elements found in the human body. Life requires only about 25 chemical elements with carbon, oxygen, hydrogen, and nitrogen making 96% of living matter. Fill in the names of the elements in Table 1 and then list a biological molecule known to contain that element or a biological function for that element; here's where you can test your base of knowledge.

Symbol	Element	Biological Molecule or Function
O		
C		

H		
N		
Ca		
P		
K		
S		
Na		
Cl		
Mg		

Activity 3.

A. **Fill in the blanks: The difference between the mass number and the atomic number of an atom is equal to the number of ________________.**
An atom of phosphorus contains _________ protons, _________ electrons, and ________ neutrons. The atomic weight of phosphorus is __________?

B. **Fill in the following chart for the major subatomic particles of an atom.**

Particle	Charge	Mass	Location

Table 2. The Major Subatomic Particles.

III. Workshop Activities

Activity 1. Subatomic structure

A. Each pair of students should select one of the elements below. First draw the nucleus and add the appropriate number of protons and neutrons. Second, draw the electrons in shells around the nucleus. Make sure the distribution follows the correct pattern of filling.

Element	Atomic number	Atomic mass
Hydrogen (H)	1	1
Carbon (C)	6	12
Nitrogen (N)	7	14
Oxygen (O)	8	16
Chlorine (Cl)	17	35
Sodium (Na)	11	22
Phosphorus (P)	15	31

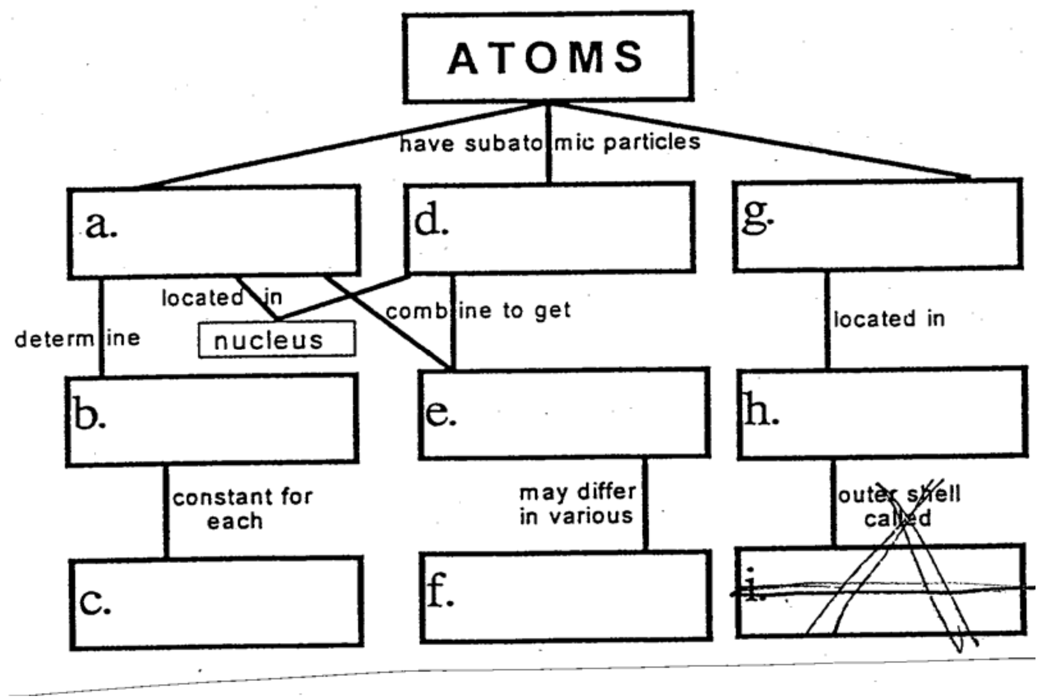
B. Isotopes. Three versions of the carbon atom are called ^{12}C, ^{13}C, and ^{14}C.

1. What are the differences among them with respect to protons, neutrons and electrons?

2. How can ^{14}C be converted to ^{12}C?

3. How is this conversion related to radioactivity?

C. Concept Map. Complete the following using the vocabulary from the pre-workshop.



Activity 2: Chemical Bonding

A. Answer the following questions to review your knowledge of chemical bonding.

1. In chemical bonds, what electrons are involved for each atom?

2. What are the valences of the 4 most common elements of living matter?
   a. hydrogen____ 2. oxygen ____ 3. nitrogen ____ 4. carbon ____

3. What is the significance of the valence electrons?

4. What happens to the valence electrons in non-polar covalent bonds, polar covalent bonds and ionic bonds?

5. What chemical structures are formed as a result of each type of bonding?

6. Give at least one example of each kind of chemical structure in living things.

7. What are the electrical properties of each chemical structure?

8. Distinguish between a single and double covalent bond.

B. Solve each of the following based on your understanding of chemical bonding.

1. Carbon and hydrogen can combine to for a gas, methane. Based upon the number of electrons in the valence shells of each, what would the molecular formula be? Draw the molecule showing the arrangement of electrons. What kind of chemical structure results? (covalent, ionic, etc.)

2. Calcium ($_{20}Ca$) and chlorine ($_{17}Cl$) can combine to form the chemical compound, calcium chloride. Based upon the number of electrons in the valence shells of each, what would the molecular formula be? Draw the molecule showing the arrangement of electrons. What kind of chemical structure results? (covalent, ionic, etc.)

3. Sulfur ($_{16}S$) and hydrogen can combine to form a compound, hydrogen sulfide? Based upon the number of electrons in the valence shells of each, what would the molecular formula be? Draw the molecule showing the arrangement of electrons. What kind of chemical structure results? (covalent, ionic, etc.)

4. Potassium ($_{19}K$) and chlorine ($_{17}Cl$) can combine to form a compound, potassium chloride. Based upon the number of electrons in the valence shells of each, what would the molecular formula be? Draw the molecule showing the arrangement of electrons. What kind of chemical structure results? (covalent, ionic, etc.)

Activity 3. Water and Hydrogen bonding

1. What kind of chemical structure is water H_2O?

2. Draw the shell model of the structure?

3. Describe the distribution of electrons in the structure and relate it to its electrical properties.

4. a. In a solution, what role does water play? b. What is the other role in a solution? c. What chemical structures might take that role?

5. Why is water an excellent solvent for some compounds and not for others? Explain.

6. a. Distinguish between a covalent bond and a hydrogen bonds? b. Between an ion bond and a hydrogen bond? c. What are the key differences? d. Give examples.

7. Draw several water molecules labeling the covalent bonds and the hydrogen bond. Make sure the alignment of the molecules is consistent with electrical attractions among the molecules.

8. Which of the following chemical structures can form hydrogen bonds with water? NaCl, methane (CH_4), hydrogen sulfide, molecular oxygen (O_2), carbon dioxide (CO_2), hydrochloric acid (HCl). Explain.

9. Why do water molecules form a column when you suck them up through a straw? Explain the chemical and electrical basis for this observation.

10. Certain insects (water striders) can walk across the surface of a stream without sinking. Based upon your knowledge of properties of water, explain this phenomenon.

Activity 4. pH

1. A very small percentage of water molecules break apart. What are the products of this breakdown?

2. How would the breakdown products be attracted to intact water molecules? Be specific.

3. What will be the pH of a solution when the number of H+ ions equals the number of OH- ions? This is called the neutral point on the pH scale.

4. If you dissolved HCl in water, what would happen to the balance between H+ ions and OH- ions? What would happen to the pH value of the solution?

5. What happens to the balance and pH when NaOH is dissolved in water?

6. The normal pH in human fluids like blood is 7.4. What is the balance between H+ (hydrogen ions) and OH- (hydroxyl ions)?

Activity 5. Chemical Reactions.

1. What are the key factors that differentiate chemical reactions from other interactions (like hydrogen bonding) between molecules or ions? In your answer be sure to refer to valence electrons and other atomic particles the may participate.

2. Chemical reactions are represented by equations. For the equations below, identify the reactants and the products.

$$2\ H_2 + O_2 \rightarrow 2\ H_2O$$

3. The following equation has arrows going in both directions. Explain what this means. What are the reactants and products in each case? Be careful!

$$H_20 + CO_2 \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO_3^-$$

4. The following are **not** chemical reactions. Explain what is occurring.

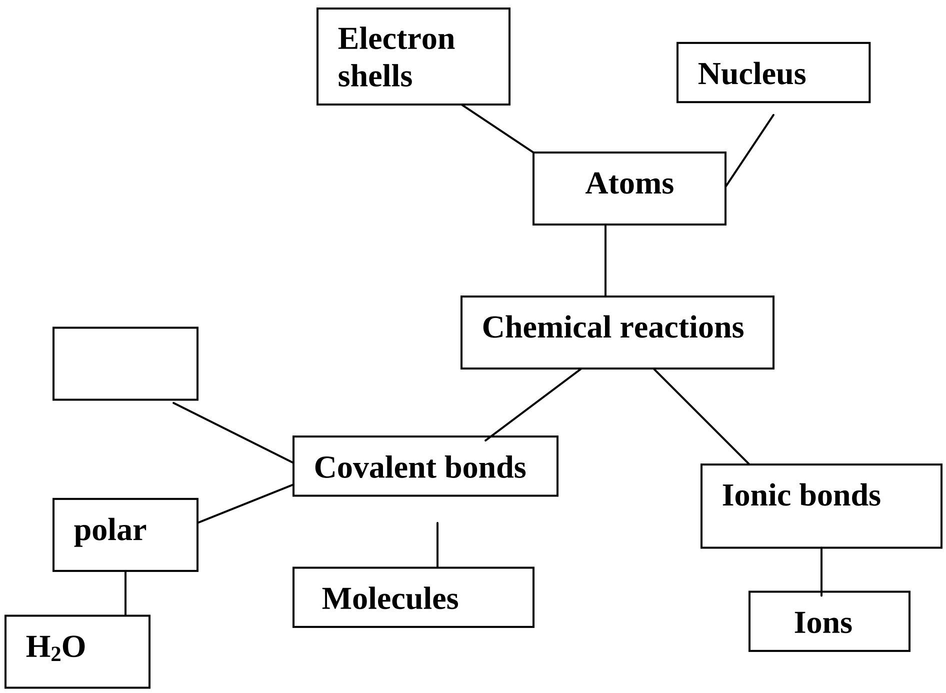
$$NH_3 + H^+ \leftrightarrow NH_4^+$$
$$H_20 + H^+ \leftrightarrow H_30^+$$

Activity 6. The Big Picture.

Work in groups of 2-4 students for this activity. Complete as much of the following activity as you can in the time allotted.

A. Use the skeleton of a concept map shown on the next page:
1. Add connecting statements for the concepts that are listed.
2. Build on the skeleton by adding the concepts listed below along with connecting statements that show relationships among the concepts.
3. Compare your concept map with other groups. Make additions and corrections.

Concept Map: Formation of Simple Molecules



Concepts to add:

electrons	**protons**	**neutrons**
atomic mass	**atomic number**	**elements**
pH	**cation**	**anion**
base	**acid**	**hydrogen ion (H+)**
hydroxyl ion (OH-)	**methane (CH4)**	**non-polar (bonds)**
reactants	**products**	**hydrogen bonds**
sodium ion (Na+)	**chloride ion (Cl-)**	**NaCl**
solute	**solvent**	**solution**

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