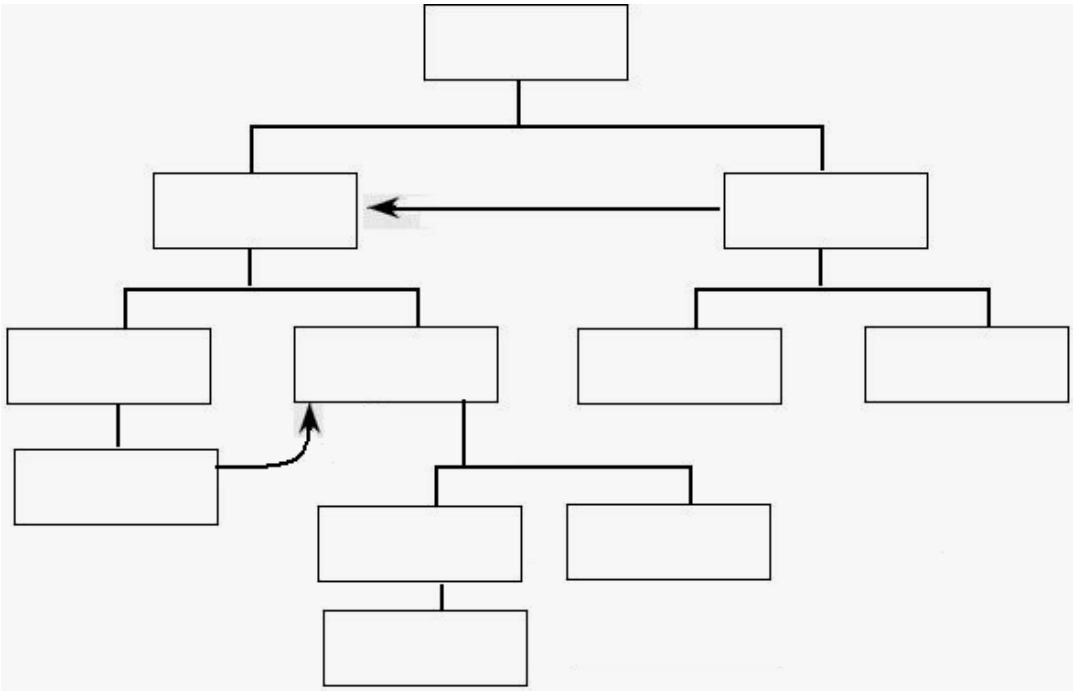
Name_____ Biol 211 - Group Number_____

Active Learning Exercise 2B: Chemistry of Life

Reference: Chapters 2-3 (*Biology* by Campbell/Reece, 8th ed.)

1. A curious student might ask, "Why are we studying chemistry in a biology class?" "What good will it do me to have some understanding of chemical concept as I learn about biology?" More importantly, what good will it do me as a citizen to have some understanding of chemical concepts?" These are good questions and deserve some thoughtful and creative answers. Come up with three convincing examples where understanding some chemistry is going to be of benefit. (You may wish to leave this question simmering while you go to other questions. But remember to return and answer this question-it's going to be interesting to pool your ideas with your group/the class.)

2. Often if a person can visualize a concept they will understand and remember the concept. Below are several chemical terms used regularly in biology that are important for you to understand. Complete the concept map below by either entering the correct term into each box or next to an arrow. Each term may be used only once: ***atoms, chemical process, compounds, covalent compound, elements, heterogeneous, homogeneous, ionic compound, matter, mixtures, molecules, physical process, pure substances*** *Hint*: This chart classifies matter!



3. What are the 4 most abundant elements in living things (by weight)? Think of a way to remember them.

4. Atoms consist primarily of three kinds of subatomic particles. Identify and describe particles by completing the table below.

Name of Subatomic particle	**Relative Electric Charge** (as compared to a proton)	**Relative Mass** (amu) (as compared to a proton)
		1.0
	0	
		0.0

5. To further describe the structure of atoms, fill in the blanks below.
   Every atom consists of a central mass called the _____and a surrounding region known (sometimes called the electron cloud) that contains one or more_____
   . The _____move around the_____at very high speed.

6. Draw a diagram of a helium atom, atomic number 2. Label the nucleus and all subatomic particles. Show the electric charge of each particle.

7. Atoms, by definition, are always electrically neutral, that is they are not positively of negatively charged. From this fact, how do the number of protons compare to the number of electrons in an atom.

8. Use a periodic table and your text as needed to fill this chart:

Name of Element	Atomic Number	Number of Protons	Number of Electrons
Hydrogen			
Carbon			
Nitrogen			
Oxygen			

   Write a sentence that states a relationship between atomic number, protons, and electrons.

9. A lump of the element gold has different properties than a lump of the element carbon. An atom of gold has different properties than an atom of carbon. On the other hand, sodium atoms react with water explosively, while sodium ions are essential for life.
   a.) Why do atoms of gold and carbon have different physical and chemical properties if all atoms consist of the same subatomic particles?

   b.) Why do atoms of sodium have completely different chemical properties than sodium ions, Na^+?

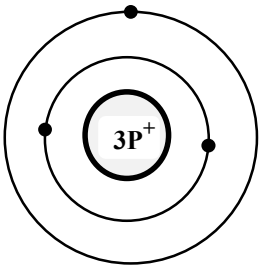
   c.) What determines the *identity* of an atom or ion?

   d.) What determines the *Chemical* properties of an atom or ion?

10. A simple model of how electrons are arranged in an atom (e.g. text figure 2.9) shows that there is "room" for only_____electrons in the area nearest the nucleus. This area is called the first energy level (or the first electron shell). Further away from the nucleus is located the second energy level. How many electrons can the second energy level hold?_____The third energy level?_____

    Note: Recall from chemistry…. **The maximum number of electrons per energy level = $2n^2$** ; Where ***n*** = energy level or the principle quantum number. The 3rd energy level consists of the three subshells or sublevels: ***s*-sublevel** (holds a max. of 2 electrons), ***p*-sublevel** (holds a max. of 6 electrons); and the ***d*-sublevel** (holds a max. of 10 electrons). Also recall that because of the order in which electrons fill each of the sublevels, the d sublevel is always the next to the outer most shell or energy level (e.g. the 3d fills after the 4s, the 4d fills after the 4s, etc.). Hence, the d sublevel will almost never be the valence shell.

11. Below is a simple diagram of lithium, atomic number 3. The neutrons are omitted for simplicity. Each ring represents an energy level (shell). In the indicated spaces make diagrams of the atoms listed. To fill in the missing names use your knowledge of atomic structure and atomic number. Don't copy from the textbook!



Hydrogen	Lithium	_____	_____	_____
at. no. 1	at. no. 3	at. no. 8	at. no. 10	at. no.11

12. Of the more than 100 different kinds of atoms, most readily react with other kinds of atoms. However, there are a few kinds of atoms, the noble gases: helium, neon, argon, krypton, xenon and radon, which rarely react with other atoms.
    a.) In what column of the periodic table are the noble gases found and what feature of their electronic structures do all noble gases have in common?

    b.) The outer shell of helium with its 2 electrons is full (complete) and is stable. What do you notice about the outer shell of all the other inert gases?

    c.) Apparently there is something about having an outer shell either full with _____ or _____ electrons that makes a very stable atom, an atom that does not easily react with other atoms.

Now let's leave the noble gases and consider all the other atoms. These other atoms have incomplete outer shells; an incomplete outer shell is a less stable arrangement of electrons. Atoms with incomplete outer shells can achieve a more stable arrangement of electrons if they can interact with other atoms. In some cases the interaction involves atoms sharing electrons while other cases atoms may transfer electrons from one to another

13. a.) Fluorine has an atomic number of 9. Sodium has an atomic number of 11. Make orbital diagrams (as in question 11) to represent each atom in the spaces below.

Fluorine Sodium

    b.) Do these atoms have a stable arrangement of electrons? Explain.

    c.) Use *orbital diagrams* like those above to show what will happen when sodium atoms and fluorine atoms come close together. i.) Use arrows to indicate electron transfer; ii.) Name the kind of bonding involved; iii.) Use orbital diagrams to depict the product; iv.) Write the formula of the resulting compound.

→

Sodium atom Fluoride atom Sodium fluoride

14. a.) What is an ion?

b.) Why do ions form?

c.) Write a sentence that describes the change that would turn an atom into a negative ion (anion) or into a positive ion (cation)

15. a.) Oxygen has an atomic number of 8. Hydrogen has an atomic number of 1. Use *Lewis Structures* to show *how* water forms from 2 hydrogen atoms and one oxygen atom.

Hydrogen atom	Oxygen atom	Hydrogen atom	→	Water molecule

b.) Why do hydrogen atoms and oxygen atoms react to form water and why do they always react in a 2 to 1 ratio?

For the next 3 Questions: Match each of the following bonds with the phrase that describes it below.

a. Hydrogen bond b. Ionic bond c. Covalent bond

16. Sharing of a pair of valence electrons by two atoms: _____

17. Attraction of a hydrogen atom covalently bonded to one electronegative atom to another electronegative atom: _____

18. The attraction between a strongly electronegative atom that stripped an electron from a less electronegative atom: _____

19. What kinds of elements generally form ionic bonds?

20. What kinds of elements generally form covalent bonds?

21. Complete the table below. The first two, Carbon-14, a radioactive isotope of carbon, and the iron (III) ion have been completed as examples

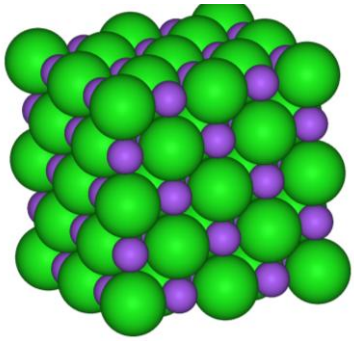
Isotopic Symbol	# of electrons	# of protons	# of neutrons	Mass number
$^{14}_{6}C$	6	6	8	14
$^{56}_{26}Fe^{3+}$	23	26	30	56
$^{32}_{16}S^{2-}$				
	40	42	56	
	48	50	70	
$^{32}_{15}P^{3-}$				

22. a.) Why do water molecules form hydrogen bonds, but hydrogen sulfide, H_2S, does not?

b.) Illustrate hydrogen bond formation between *four* different water molecules.

23. Would life would be possible if water were not a polar molecule? ***Justify your answer in light of the emergent properties of water***

24. a.) A portion of a sodium chloride salt crystal (e.g. NaCl) is illustrated below—large spheres represent chloride ions, small spheres sodium ions. Show how the crystal would dissociate and dissolve in water to form *hydrated ions*.



b.) What special property of water allows it to dissolve ionic compounds such as sodium chloride? What is the importance of this to all living things?

c.) Why don't some ionic compounds (e.g. limestone, $CaCO_3$) dissolve well in water? Explain in terms of the relative strength of the bonds involved.

25. Dogs can cool themselves by panting because of:
    a. Water's high surface tension
    b. The response of water molecules to changes in atmospheric pressure
    c. Adhesion of water molecules to other kinds of molecules
    d. The formation of covalent bonds between water molecules
    e. Water's high heat of vaporization

26. A paper towel can pick up a puddle of water because of:
    a. Water's high surface tension
    b. The response of water molecules to changes in atmospheric pressure
    c. Adhesion of water molecules to other kinds of molecules
    d. The formation of covalent bonds between water molecules
    e. Water's high heat of vaporization

27. A water strider can walk on water because of:
    a. Water's high surface tension
    b. The response of water molecules to changes in atmospheric pressure
    c. Adhesion of water molecules to other kinds of molecules
    d. The formation of covalent bonds between water molecules
    e. Water's high heat of vaporization

28. Define the following, giving an example of each:
    a.) acid

    b.) base

    c.) buffer.

29. Complete the following table concerning pH. Note: Concentrations of hydrogen and hydroxide ions are in moles per liter, molarity; Recall that for all solutions**:** ***pH* = -log [H^+]** and ***pH* + *pOH* = 14**

[H^+]	**[OH^-]**	**pH**	**Acidic, basic, or neutral Solution?**
10^{-4}	10^{-10}	4	acidic solution
10^{-9}		9	
	10^{-3}		
10^{-13}			
	10^{-7}		
		2	

30. The fluids of all living things contain one or more different kinds of buffers. Why is this so? What would be the consequences if living things lacked buffers in their tissues and/or cells? (Note: We will study this in more detail when we study enzyme action later in the course.)

31. Write balanced chemical equation that will show why the addition of hydrogen chloride gas, $HCl_{(g)}$, to water results in an <u>*acidic*</u> solution (called hydrochloric acid, $HCl_{(aq)}$). i.e. Complete and <u>*balance by both charge and mass*</u> the equation below for the *ionization* of HCl in water to form hydronium ions, H_3O^+ and chloride ions.

$HCl_{(g)}$ + $H_2O_{(l)}$ → _____ + _____

<u>Recall from past chemistry classes</u>: Some polar covalent compounds like HCl ionize (form ions) when dissolved in water.

Also, show how adding of the solid ionic compound sodium hydroxide, $NaOH_{(s)}$, to water will result in a <u>*basic*</u> solution. i.e. Complete and <u>*balance by both charge and mass*</u> the equation below for the *dissociation* of solid NaOH in water.

$NaOH_{(s)}$ $\xrightarrow{H_2O}$ _____ + _____