STUDY GUIDE - *Ch.2.4 - Chemical reactions make and break chemical bonds.* **NAME:** _____

- **PHYSICALLY PRINT OUT this PDF and HANDWRITE (with a black or blue pen) your answers directly on this PDF.** *Typed or digitally-written work is **not** be accepted. Do **not** answer questions on separate paper.*
- **Importantly, study guides are NOT GROUP PROJECTS!!!** *You, and you alone, are to answer the questions as you **read** your assigned textbook. You are **not** to share answers with other students. You are **not** to copy any answers from any other source, including the internet.*
- **Get in the habit of writing LEGIBLY, neatly, and in a medium-sized font.** *AP essay readers and I will skip grading anything that cannot be easily read so start perfect your handwriting, and don't write so large you can't add all the relevant details and key elaborations in the space provided.*
- **SCAN physical documents in color and with good resolution. Then, upload your final work as PDFs to Archie.** *Avoid uploading dark, shaded, washed out, side ways, or upside down scans of homework. Keep completed physical study guides organized in your biology binder to use as future study and review tools.*
- **READ FOR UNDERSTANDING and not merely to complete an assignment.** ***First**, read a section quickly to get an overview of the topic covered. Then, read it a **second** time slowly, paraphrasing each paragraph **out loud** and analyzing every figure. Finally, read it a **third** time as you answer the study guide questions if assigned and to start building your memory. Try to write answers out in your own words when possible and to purposefully and accurately use all new terminology introduced.*

1. a. What are **chemical reactions**?

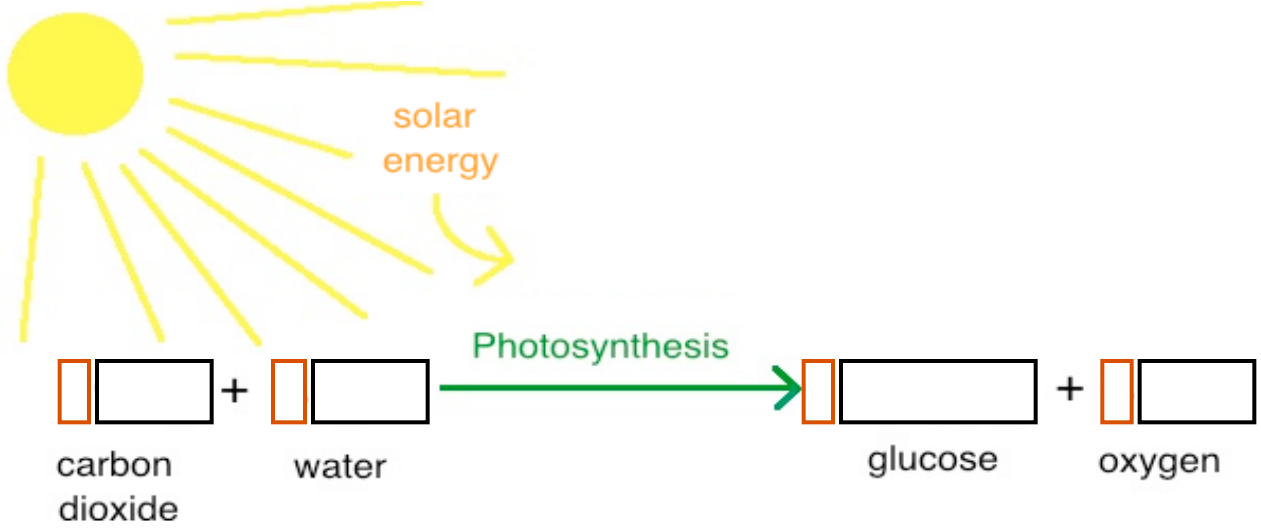
   b. What are the **reactants** in chemical reactions? (As you will learn later in the course, when these reactants interact with a biological catalyst, a type of protein, we often call them *substrates* instead).

   c. What are the **products** in chemical reactions?

   d. In front of the molecular formulas for each of the reactants and products in a chemical reactions, one may find numbers or **coefficients** written. What do these tell us?

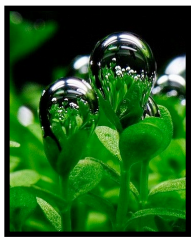
2. What is meant by **matter is conserved in chemical reactions**?

3. In the important process known as photosynthesis (which involves the completion of **a series of chemical reactions performed in sequence, a.k.a. a biochemical pathway**), plants convert molecules of carbon dioxide and water into the sugar glucose, $C_6H_{12}O_6$, a carbohydrate, and molecular oxygen (O_2 gas). Fill in the boxes with the missing details for the chemical reaction for photosynthesis shown below. *It is important that you memorize this chemical reaction.*



4. a. From where does the land plant obtain CO_2?

   b. From where does the land plant obtain H_2O?



   c. Bubbles can often be seen being produced by underwater plants in the daylight. What are these **underwater plant-produced bubbles of gas** often composed?

5. What is meant by **chemical reactions are reversible**?

6. **The concentration of the reactants or products affects the rate of the forward and reverse reactions.**

   a. Why does a chemical reaction proceed in the (net) **forwards direction**?

   b. Why does a chemical reaction proceed in the (net) **reverse direction**?

7. a. Explain what is meant by **dynamic chemical equilibrium** in terms of **BOTH 1.** the **concentration** (**not number**) of reactants and products in solution and **2.** the **rates** of forward and reverse reactions. *This is a critical concept!!!*

   b. Does dynamic equilibrium imply that we reach a state where the reactions and products occur in equal concentrations? **Explain** why or why not. *This is a critical concept!!!*

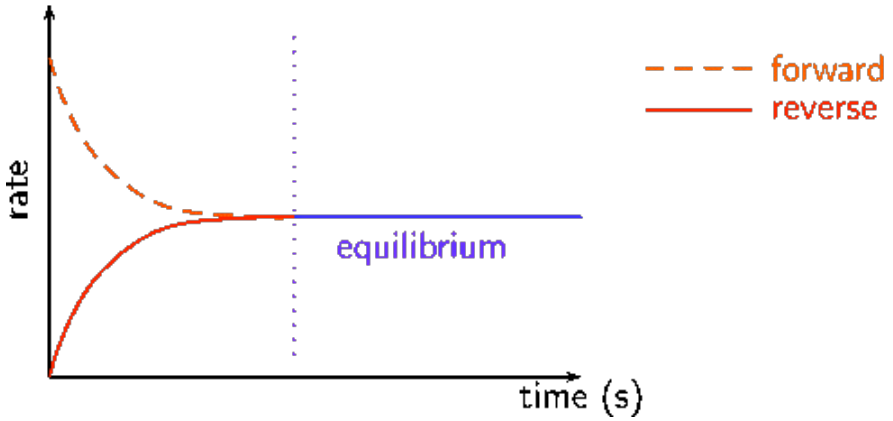
A Review of Chemical Equilibrium or Dynamic Equilibrium

Features of dynamic equilibrium:

1. The rate of both forward and backward reaction are equal
2. The amount of reactants and products are constant

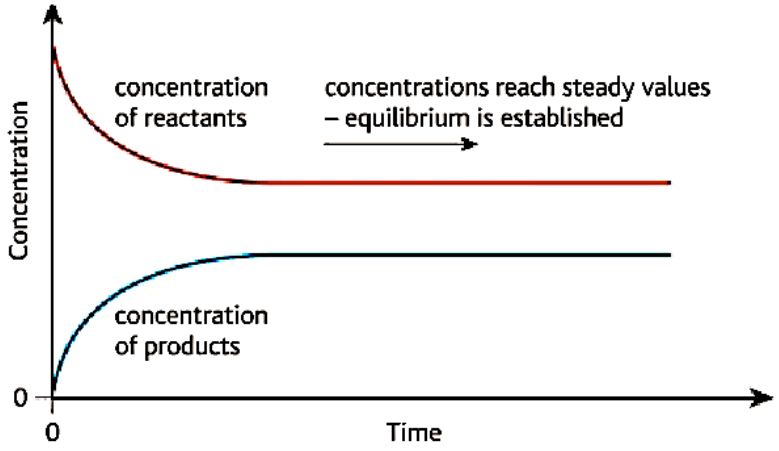
Regarding the rates of the forward and reverse chemical reaction:

- At first, the rate of forward reaction is the **highest** and the rate of the backward reaction is **zero**.
- As the reaction progresses the rate of forward reaction **decreases** and the rate of the backward reaction **increases**.
- The equilibrium is reached when the rate of both forward and backward reaction becomes **equal**.



Regarding the concentrations of reactants and products:

- At the beginning, the reactants are turning to products so the concentration of reactants is **decreasing**.
- The reactants are producing products so the concentration of product is **increasing**.
- When chemical equilibrium is reached, the rate of forward and backward reaction becomes **equal**.
- At this point, the concentration of reactants and products stays **constant** over time.



Example of a factor affecting the equilibrium position: **Concentration of Reactants vs Product**

- **Le Chatelier's Principle:** Whenever a system, which is in dynamic equilibrium, is disturbed (because the concentration of either a reactant or a product is altered), the system tends to respond in such a way as to oppose the disturbance and so restore chemical equilibrium.

$$A + B \leftrightarrow C + D$$

If the **concentration of B is increased**, the equilibrium would shift to the right (rate of forward reaction increases) in order to **decrease the concentration of B**

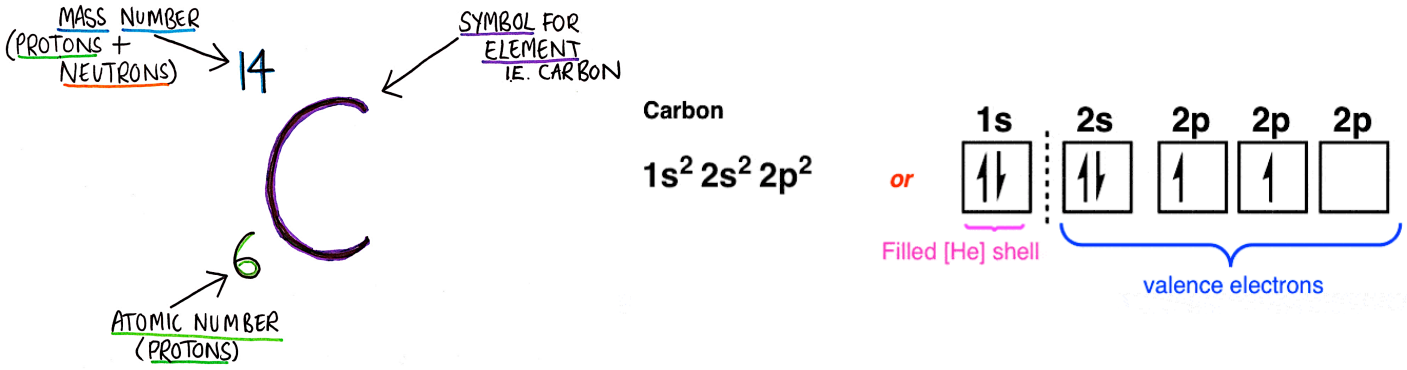
If the **concentration of C is increased**, the equilibrium position would shift to the left (rate of reverse reaction increases), to **decrease the concentration of C**

Recall: Atoms form chemical bonds to make their outer electron shells more stable

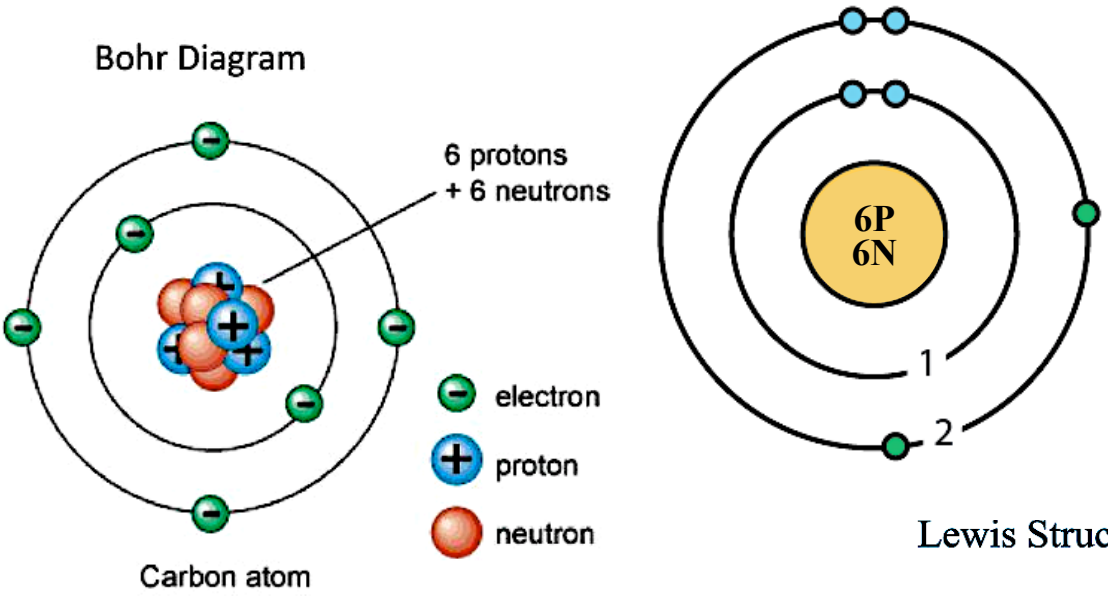
Remember, when analyzing a period table of elements (uploaded for you in Archie), **the atomic number listed for each element equals the number of protons** in the nucleus of atoms of that element. **Every proton attracts an electrons and so a neutral atom of that element will have the same number of electrons as protons, though that does mean that the atom is stable in this neutral forms.**

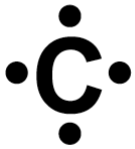
If the outer most energy level (valence shell) is not filled with the maximum number of electrons (if the outermost s and p orbitals are not filled with two electrons each), **most atom (with a few exceptions) are reactive and will interact wth other atoms in such a way to end up with a fully filled outermost valence shell** that has eight valence electrons (except for hydrogen, helium, and lithium that are stable with a maximum of two valence electrons in the 1s orbital (an orbital holding no more than two electrons and the existence of a p orbital being impossible in the first energy level so close to the nucleus).

We can represent atoms visually in various way. We can use a **symbol** to represent an atom of an element or write out an atoms electron electron configuration to indicate in which types of orbitals and which energy levels all the electrons in its electron cloud is located. For carbon, we can use the symbol **C** and write out its electron configuration as C $1s^2$ $2s^2$ $2p^2$



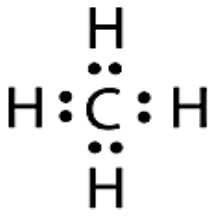
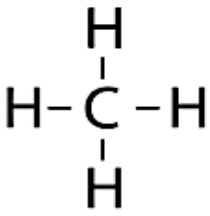
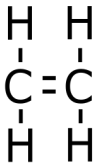
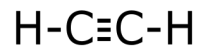
We can also draw the **Bohr Model** that shows which energy level every electron is found in within the electron cloud of an atom or we can draw an atom's **Lewis Dot Structure**, which highlights only the valence electrons of that atom, the electrons that determine the stability or reactiveness of that atom. A short cut exists to knowing the number of valence electrons an atom. **The number of valence electrons is equal to the group A number at the top of the periodic table. Carbon is in column, 4A, so it has 4 valence electrons. Atoms with the same number of valence electrons, so in the same row, exhibit similar chemical behaviors.**



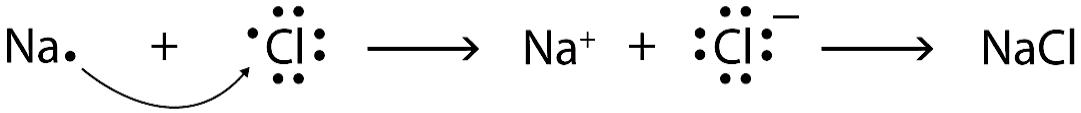
Lewis Structure: 

# of dots represent number of total valence electrons and not which orbital they are in.

Lewis Dot Structures of atoms allow you to visually represent the status of the valence shell of that electron. **You can also draw Lewis Dot Diagram for molecules**, indicating where electrons are being shared between two atoms to form a single, double, or even triple bond. In **Structural Formulas** each pair of electrons in a covalent bond is represented by a line between atoms.

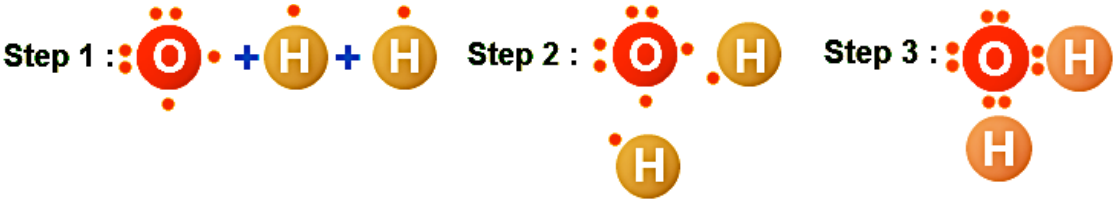
Electron Dot Diagram	Structural Formula			
		Ethylene		
		Acetylene		

Remember, atoms will react together in such a way that they fill their valence shell. **When a metal atom meets a nonmetal atom, the nonmetal's electronegativity may be so strong in comparison to that of the metal that the nonmetal steels the metal's electron entirely, resulting in the creation of two ions of opposite charge.** These will attract each other through an **ionic bond** and form an **ionic compound**.



When two nonmetals interact, they share electrons to fill their valence shells because neither has a strong enough electronegativity in comparison to the other to steal an electron permanently from the other. The sharing of electrons may or may not be equal, forming a **non-polar or a polar covalent bond**, respectively. **Atoms held together by covalent bonds form molecules.** Within the molecule, each atom can now be seen to have access to the number of valence electrons they needed to fill their valence shell.

In the example below, oxygen has 6 valence electrons but wants 8. Hydrogens have 1 but want 2. If these atoms are allowed to interact, they can arrange themselves in such a way so as to share their valence electrons. In the molecule of water that results, the oxygen now has access to a total of 8 valence electrons and each hydrogen now has access to 2 valance electrons. **The atoms are now more stable in this close association together (when covalently bonding) than they were on their own.**



8. Proceed to the TEST YOUR UNDERSTANDING section at the end of the chapter. **Study your chapter sections and all Ch.2 study guides first!** Then, do your best to try to answer these from memory first in order to test how well you grasped the material before. If you are unsure, return to the relevant section of your chapter and restudy any pertinent material to refresh your memory. *(Check some of your answers by going to the Ch.9 Test Your Understanding answers in Appendix A of your textbook)*

1. _____ 2. _____ 3. _____ 4. _____ 5. _____ 6. _____ 7. _____ 8. _____

9.