NAME (Print): ________________________________

SIGNATURE: ________________________________

EID: ________________________________

Chemistry 320M/328M
Dr. Brent Iverson
1st Homework
August 25, 2022

Please print the first three letters of your last name in the three boxes

(5 pts) Fill in the blank with the most appropriate word(s) or number(s).

1. The most important question in chemisty is: ____Where are the electrons____?

2. Atoms prefer a ____filled____ valence shell of electrons. The vast majority of stable ____bonding____ in molecules takes place in such a way that this is accomplished.

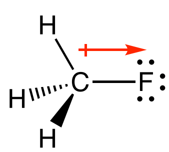
3. Neutral Oxygen atoms take part in __2__ bond(s) and has __2__ pair(s) of electrons.

4. An Oxygen atom with a negative 1 formal charge (-1) takes part in __1__ bond(s) and has __3__ pair(s) of electrons.

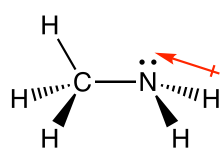
5. When two atoms of different electronegativities form a covalent bond, the majority of shared electron density is found around the ____more____ electronegative atom.

6. (4 pts) Use the $+\!\!\longrightarrow$ symbol to indicate on the structure the direction of the bond dipole moment of the bond listed.

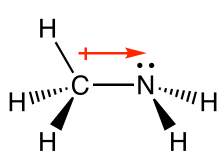
A. C-F



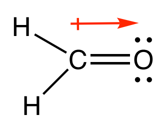
C. N-H



B. C-N



D. C=O

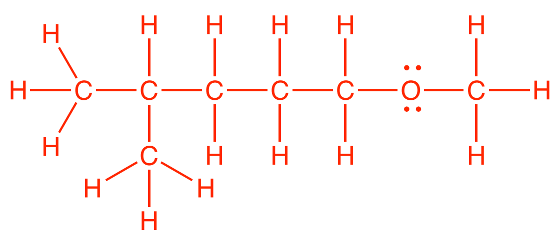


7. (1 pt) As I said in class, the most important thing is to find the most important thing. Well, here it is for empahsis, one more time. What is the most important question in Chemistry?

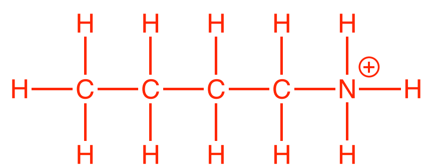
Where are the electrons?

8. (14 pts) For the following molecular formulas, draw complete Lewis structures in which all atoms (even H atoms) are drawn, lines are used as bonds, and all lone pairs and formal charges are drawn.

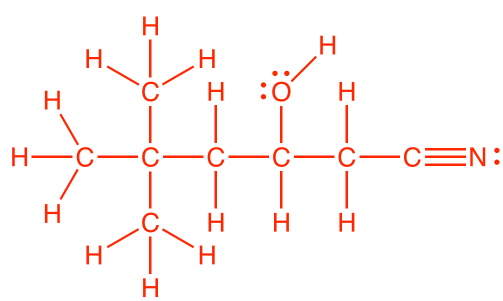
A. $(CH_3)_2CHCH_2CH_2CH_2OCH_3$



B. $CH_3CH_2CH_2CH_2NH_3$

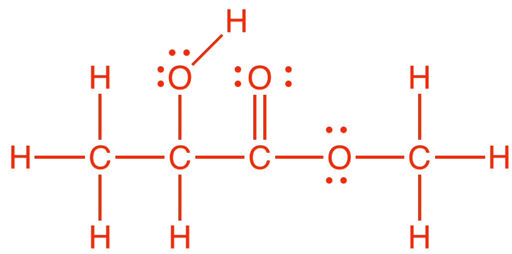


C. $(CH_3)_3CCH_2CHOHCH_2CN$

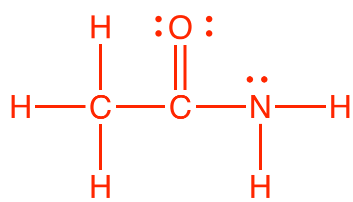


8 (cont.)

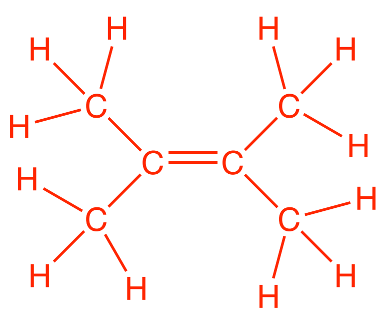
D. $CH_3CHOHCO_2CH_3$



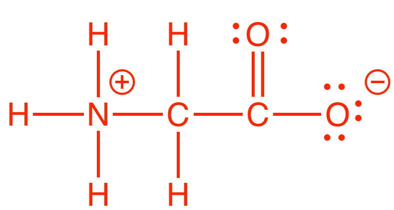
E. CH_3CONH_2



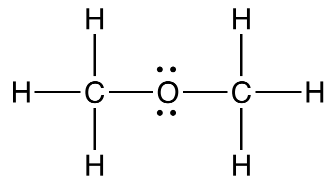
F. $(CH_3)_2CC(CH_3)_2$

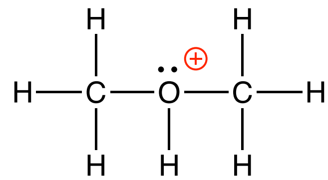


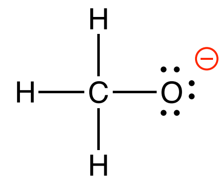
F. $NH_3CH_2CO_2$

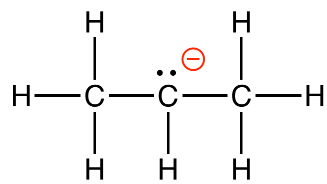


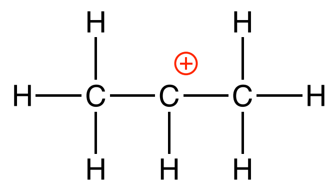
9. (8 pt) Put all appropriate formal charges on the following molecules.

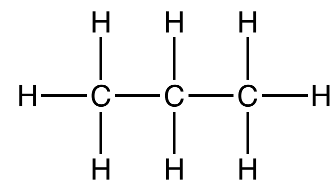


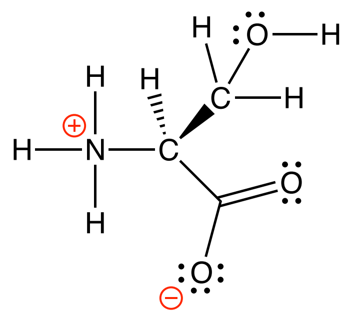












10. (1 pts each) Fill in each blank with the word or words that best completes the sentences.

For organic chemistry, it is best to think of electrons as ______waves______.

The electron density in molecules can be described mathematically by adding the wave functions of all the atomic orbitals for all the atoms in the entire molecule, an approach refered to as ______molecular______ ______orbital______ theory.

The wave functions for the valence atomic orbitals on each atom can be added together first, a process referred to as ______hybridization______ , before looking for overlap with orbitals from other atoms. This aproach is called ______valence______ ______bond______ theory.

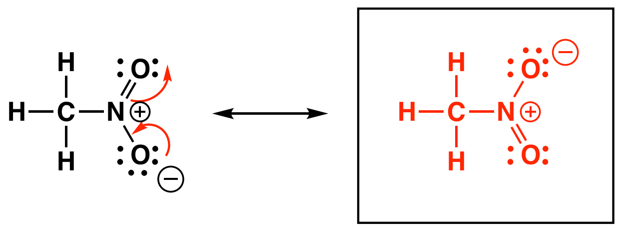
You need to be able to think about all ______sigma______ bonding in molecules as being derived from the overlap of ______hybridized______ orbitals and all pi bonding as being derived from overlap of unhybridized ______2p______ orbitals.

Three (or more) atom "pi-ways" are the situation resonance ______contributing______ structures are usually trying to describe. Individual ______Lewis______ structures can only describe pi bonding between ______two______atoms, not ______three______or more, explaining why the ______contributing______ structures are needed for these situations.

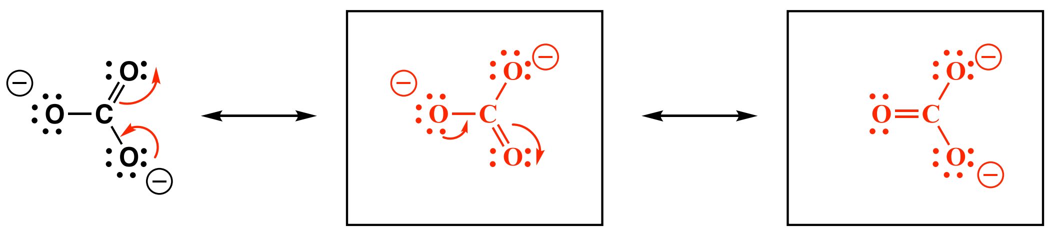
For pi bonding and therefore pi delocalization to occur over more than ______two______ atoms (i.e. pi-ways), parallel ______2p______ orbitals are needed on ALL of the adjacent atoms involved, explaining why ALL of these atoms must be ______sp^2______(or ______sp______) hybridized and why these sytems are planar.

11. (1 or 2 pts each) The following molecules are best represented as the hybrid of contributing structures. **Draw the most important contributing structures** in the spaces provided, including all lone pairs and formal charges. **For all but the structures on the right in each problem, use arrows to indicate the movement of electrons to give the structures you drew.** You might want to read these directions again to make sure you know what we want.

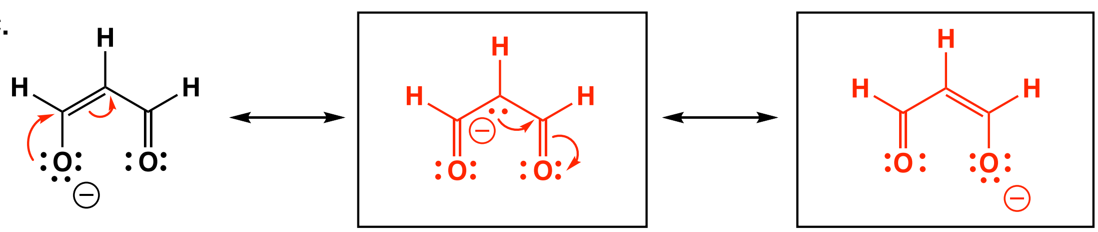
A.



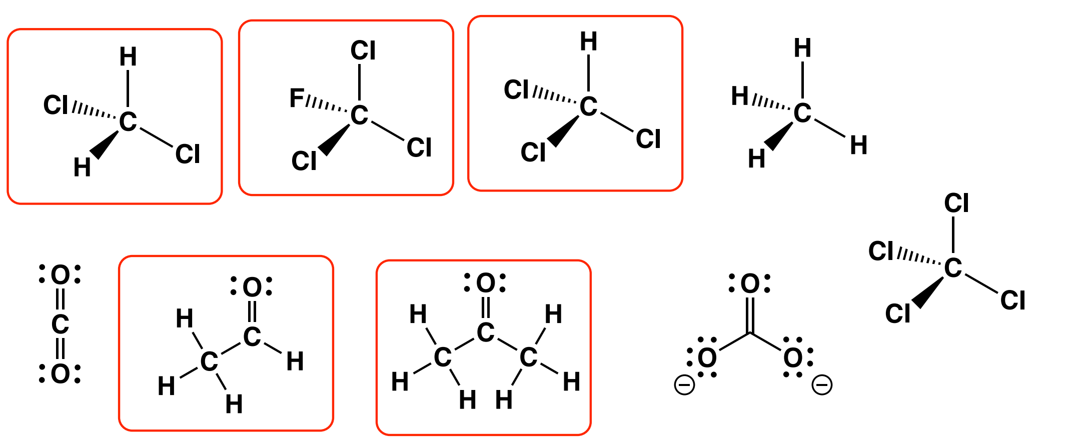
B.



C.

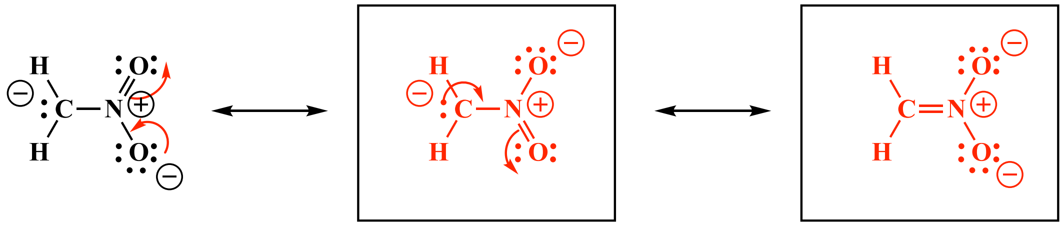


12. (1 pt each) Circle any molecule that has an overall molecular dipole moment (this one might be considered pretty hard, there is a lot to think about).

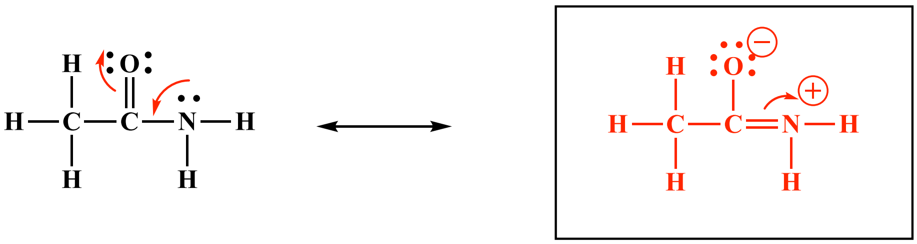


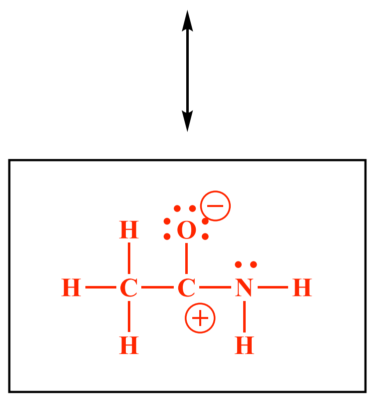
13. (2 pts each) The following molecules are best represented as the hybrid of three contributing structures. **Draw the second and third important contributing structures** in the spaces provided, including all lone pairs and formal charges. **For the two structures on the left in each problem, use arrows to indicate the movement of electrons to give the structures you drew.** You might want to read these directions again to make sure you know what we want.

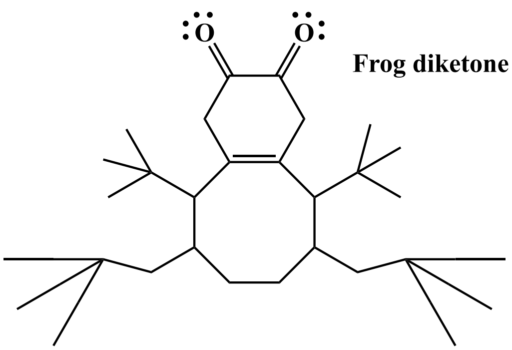
A



B.

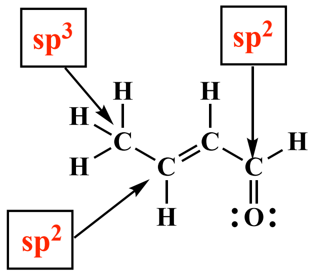


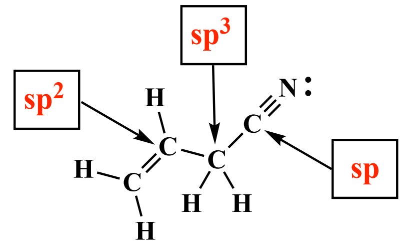


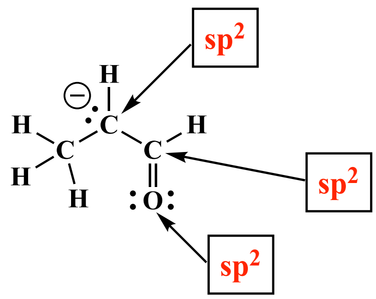


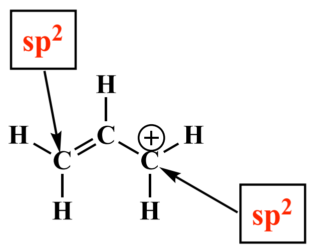
Frog diketone

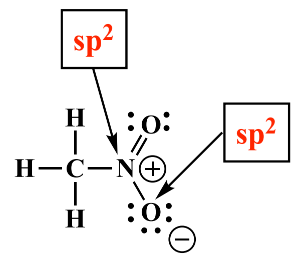
14. (20 pts) For the following molecules, write the hybridization state of each atom indicated by the arrow.

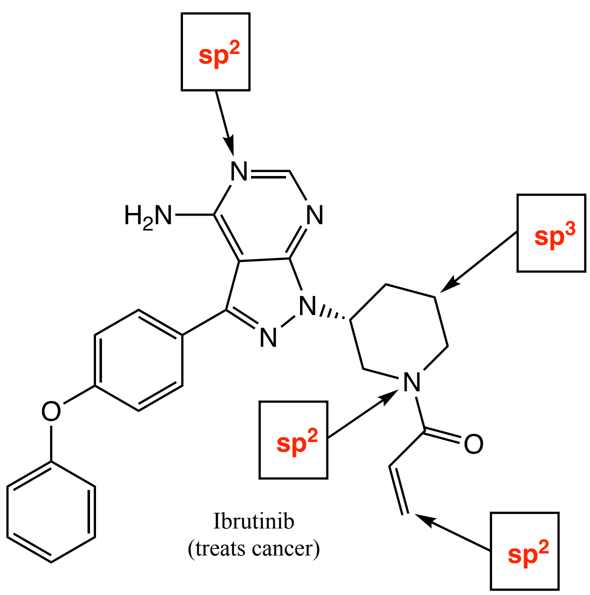




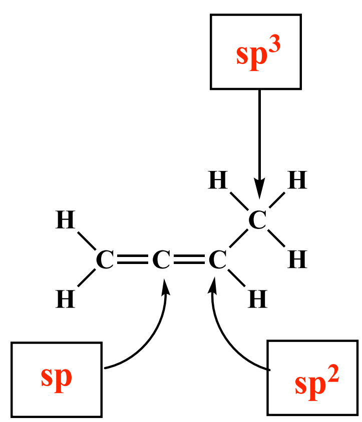




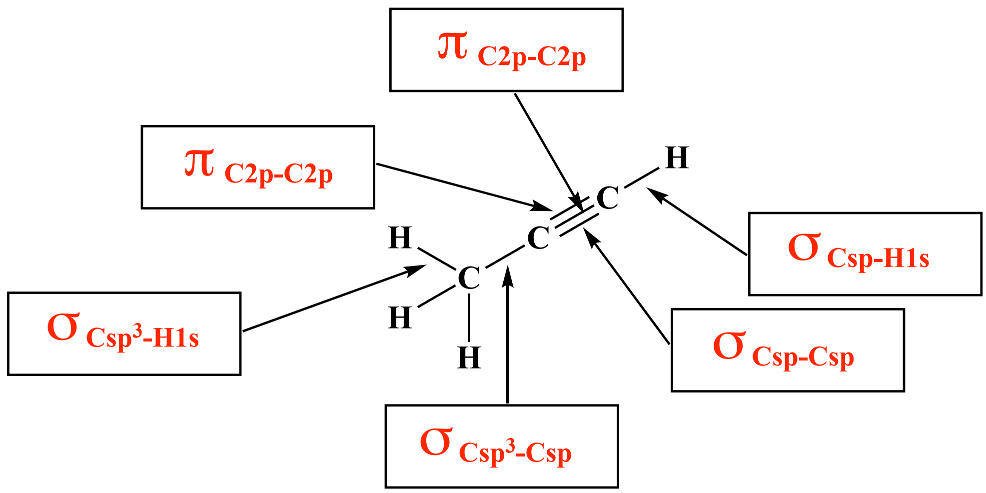


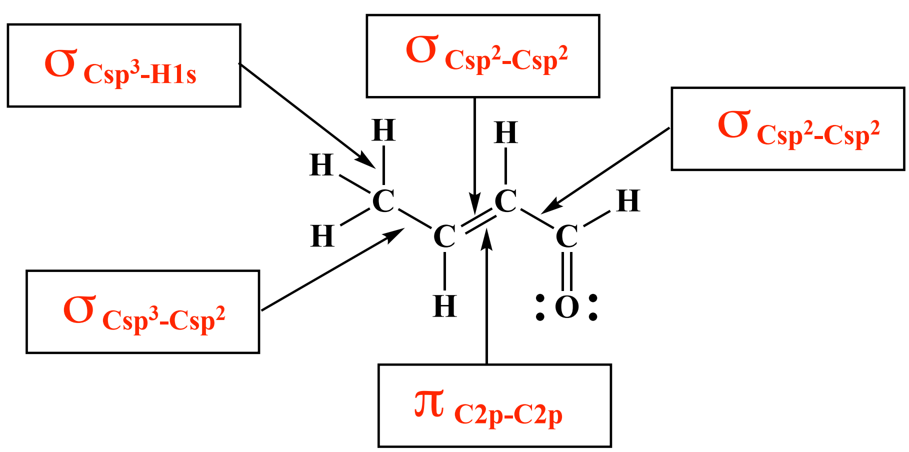


Ibrutinib
(treats cancer)

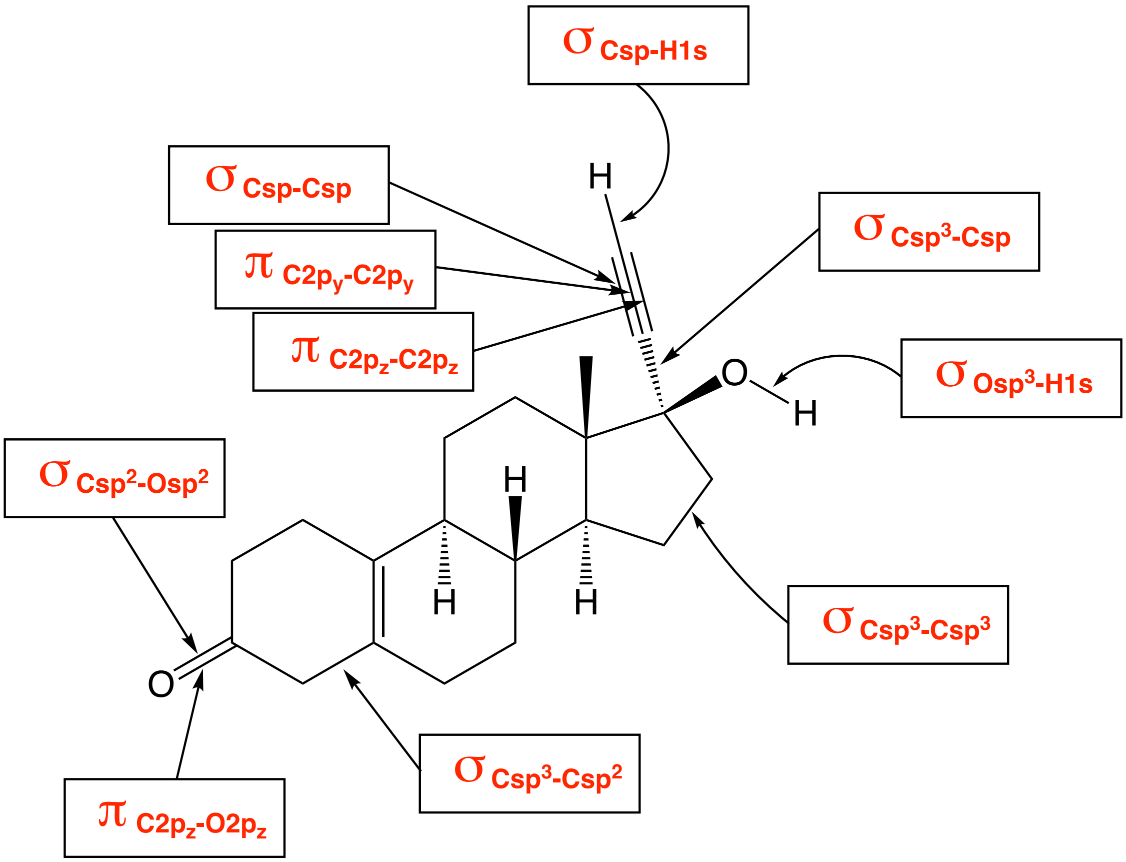


15. (11 pts) Describe each bond indicated with an arrow as the overlap of orbitals. For example, an answer might be **σ Csp^3-Csp^3.**





15 (cont). (10 pts)



Noretynodrel (a contraceptive)

16. (3 pts) Write the first three "Golden Rules of Chemistry" that we have presented in this class (I want the first three I presented so far). Hint: These are not the first three listed the website, we jump around with the rules!

1. In most stable molecules, all the atoms will have filled valence shells. This means that C, N, O and the halogens will have 8 electrons in their valence shells, and H atoms will have 2 electrons in their valence shells. This simple yet powerful principle predicts the type of bonds created (single, double or triple) and how many lone pairs are found around the different atoms of a molecule. In general, an atom surrounded by 4 atoms/lone pairs will have a tetrahedral geometry, an atom surrounded by 3 atoms/lone pairs will have a trigonal planar geometry and an atom surrounded by two atoms/lone pairs will have a linear geometry. You will encounter a small number of molecules containing an atom such as a C atom with only 6 or 7 electrons in its valence shell. Atoms such as this with only a partially filled valence shell are noteworthy and highly reactive. Note, however, that you can never overfill the valence shell of any atom in a molecule such as placing more than 8 electrons in the valence shells of C, N, or O.

5. Delocalization of charge over a larger area is stabilizing. The majority of molecules you will encounter will be neutral, but some carry negative or positive charges because they contain an imbalance in their total number of electrons and protons. In general, charges are destabilizing (higher Gibbs free energy), increasing the reactivity of the molecules that possess them. Localized charges are the most destabilizing (highest Gibbs free energy). Delocalizing the charge over a larger area through interactions such as resonance, inductive effects, and hyperconjugation is stabilizing (lowering the Gibbs free energy). In addition, it is more stabilizing to have more negative charge on a more electronegative atom (e.g. O), and more positive charge on a less electronegative atom (e.g. C).

7. Delocalization of pi electron density over a larger area is stabilizing. Pi electron density delocalization occurs through overlapping 2*p* orbitals, so to take part in pi electron density delocalization atoms must be *sp2* or *sp* hybridized and reside in the same plane. Pi electron delocalization can involve even large numbers of such atoms. Pi electron density cannot delocalize onto or through *sp3* hybridized atoms because an *sp3* atom has no 2*p* orbital. Aromaticity is a special type of pi electron density delocalization involving rings and a specific number of pi electrons, and is the most stabilizing form of pi electron density delocalization.

17. (5 pts) One of the most difficult aspects of organic chemistry is learning how to think creatively about synthesis, which is the construction of valuable complex molecules from cheap simpler ones. To be successful, one must be able to look at a final molecule, recognize the right details, then work backwards using known reactions until reaching the beginning, namely a simpler starting molecule. This type of thinking is new to most students and many find it very difficult to master at first. Based on conversations with previous students, we are trying something new this year in an attempt to prepare you long before we hit actual synthesis problems. What we are going to do is provide a brief situation for you to analyze. We want you think about ways that scenario could have come about, working backwards to the beginning.

The following is a two-sentence description of a specific scenario. Think creatively, then provide a brief description of a sequence of events that could have lead to the situation described in the scenario.

"The last man on Earth sat alone in a room. There was a knock on the door."

Of course, there is no single answer here, we want you to think up your own scenario. I took these intriguing sentences from a classic science fiction story by the writer Fredric Brown dating back to 1948. Here is a brief description of that full story taken from the Wikipedia summary:

> “The Zan have killed off all life on Earth other than pairs of specimens for their zoo of exotic Earth fauna. Walter Phelan is the last man on Earth, but Grace Evans, the last woman, is not overly impressed with him and maintains her distance.
>
> The Zan, who are ageless, become disturbed when, one by one, the other animals begin to die. They turn to Walter for advice. He tells them that the creatures have perished from lack of affection, suggesting that they pet the survivors regularly to keep them alive. He demonstrates with one of them. When the Zan begin to die, they depart the planet in fear. It is then revealed that the creature Walter advised them to pet was a poisonous snake.
>
> Then Walter discusses the future of the human race with Grace. She is shocked by his proposal and leaves. The narrative then ends as it began:
>
> "The last man on Earth sat alone in a room. There was a knock on the door..."

I hope you came up with even better stories!!