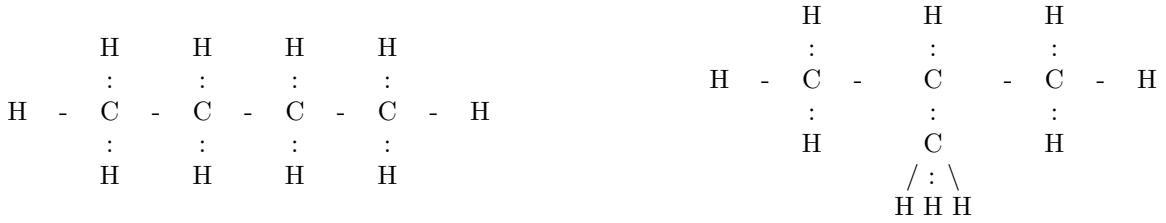
Chemistry 105
Solutions for Sample Exam 3

1. There are two different structural isomers of butane, C_4H_{10}. Draw them.



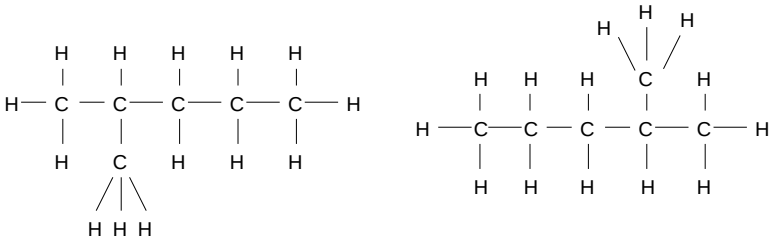
2. What is the difference between an alkene and an alkane?

   Alkenes are hydrocarbons containing double carbon-carbon bonds. Alkanes are hydrocarbons containing only single bonds.

3. How do the properties of alkanes change as the number of carbons incleases?

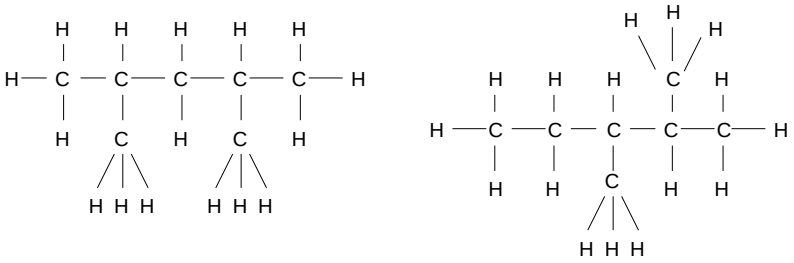
   Boiling points and melting points increase as the number of carbons increase, thus alkanes with 1-4 carbons are gases at room temperature, whereas those with 5 or more are liquids and those with >20 or so are solids.

4. Are the following compounds isomers, identical, or neither?



   Identical - they each have a five carbon chain with a single 1-carbon branch off the second carbon from the end. Put another way, rotating the molecule 180° gives the same structure.

5. Are the following compounds isomers, identical, or neither?



   Isomers - they each have the formula C_7H_{14} but their structures are different. They each have a five carbon chain with two 1-carbon branches, homever, the structure on the right has the branches off neighboring carbon atoms, whereas the one on left does not.

6. What is the difference between the ground electronic state and an excited electronic state of a molecule?

   In the electronic ground state, all the electrons are in the lowest energy orbitals possible. In an excited state, one or more electrons has been promoted to a higher level.

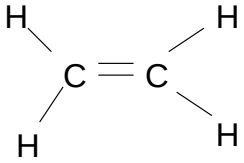
7. Name two common photosynthetic pigments found in plants.

   Chlorophyll a, chlorophyll b, carotenoids or carotenes and xanthophylls are the ones we spoke of, but there are other possibilities as well.

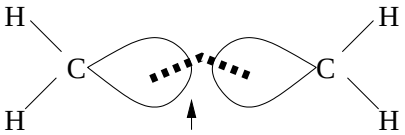
8. Methane, CH_4, is a tetrahedral molecule. Based on this information, what hybridization would you expect the carbon atom to have?

   Tetrahedral carbons are sp^3.

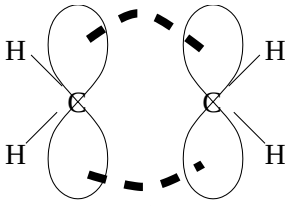
9. Describe the carbon-carbon bonding in ethylene using the hybridization model:



   Each of the carbons is sp^2 hydridized. One of the sp^2 hydrids on each carbon come together to form a carbon-carbon single bond. This is called a σ bond. The remaining unhybrided p orbitals on the carbons come together to form a second bond. This is a π type bond.



sigma−type bond
From 2 sp2 hybrids

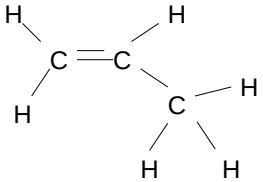


pi−type bond from
2 unhybridized P orbitals

10. What is a molecular orbital? How does the concept of a molecular orbital relate to atomic orbitals?

    A molecular orbital provides a description of the average location of electrons in a molecule. Molecular orbitals in molecules are analogous to atomic orbitals in atoms. Molecular orbitals can be thought of as combinations of these atomic orbitals.

11. Describe the hybridization of each of the carbons in the following molecule:



    Carbon 1 (left most): sp^2; carbon 2 (middle): sp^2; carbon 3 (right most): sp^3.

12. A double bond consists of:

    (a) One "sigma" (σ) bond
    (b) One "pi" (π)
    (c) Two "sigma" (σ) bonds
    (d) Two "pi" (π) bonds
    (e) One "sigma" (σ) and one "pi" (π) bond *****CORRECT**

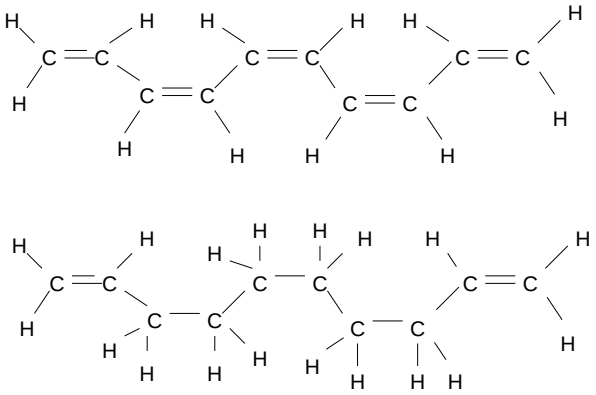
13. Describe the process of fluorescence.

    In fluorescence, a molecule in the ground electronic state absorbs a photon and is promoted to an excited electronic state. Generally, the molecule ends up in an excited vibrational state as well. This excess vibrational energy is dissipated through Non-radiative processes (processes that don't involve light). Once the molecule is in the lowest vibrational state of the excited electronic state, it releases the remaining energy as a photon light. This photon has a longer wavelength than the original photon absorbed.

14. How does the process of phosphorescence differ from fluorescence? What consequences does this have for the timescale on which phosphorescence happens?

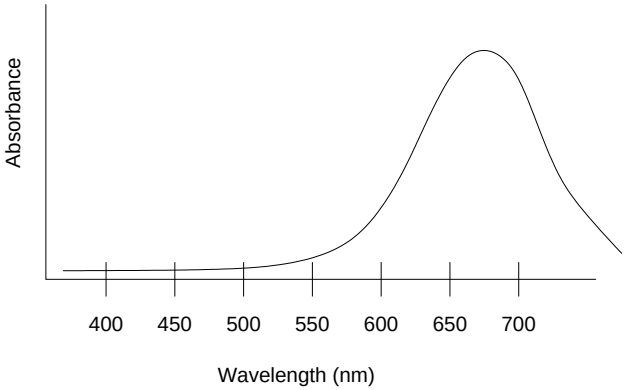
    Phosphorescence is similar to fluorescence, except that once the molecule is excited, it crosses over into another excited electronic state. The transition between this excited state and the ground state is forbidden and therefor takes place slowly. Thus, light is emitted over a longer time period than fluorescence.

15. Consider the description of early theories of organic dyes from discussion 10. Which of the following molecules do you think would be more likely to absorb light in the visible region of the spectrum and why?



    The first molecule. It has more double bonds and furthermore, the double bonds are conjugated (alternating). Both of these factors lead to a smaller energy gap between filled molecular orbital energy levels and unfilled ones. The smaller energy gap is more likely to result in the absorption of visible light.

16. Given the following spectrum of a substance dissolved in water, what colors of light does the solution absorb? What color might you expect the solution to be?



    The solutions is absorbing primarily orange-red light, with a little yellow and green. It is likely to appear blue or violet.

17. Why must indigo be reduced to leucoindigo in order to dye fabric?

    Indigo is insoluble - it does not dissolve in water. Reducing it to the soluble leucoindigo is necessary to enable it to dissolve and adhere to fabrics.

18. What is chromatography used for?

    Chromatography is a process used to separate individual components from a mixture.

19. Essay Questions: Here are a selection of essay questions that may appear on the exam. In general, you will be given a choice of at least two questions to answer for each essay.

(a) Why are tree leaves green in the spring and summer, but turn bright colors (red, orange, yellow) in the fall?

(b) Describe how indigo was obtained prior to the availability of the synthetic version and describe at least two ways ingido was used.

(c) Describe why organic molecules containing double bonds are more likely to be brightly colored than those containing only single bonds.

(d) Describe the concept of resonance and its consequences using a model molecule like benzene.

(e) In general terms, describe bioluminescence and more specifically, the process that makes fireflies glow.

(f) How do fluorescent whitening agents work? (How do they make white clothes so bright?)

Various answers possible. Please note that the last four of these will require specific references to (1) energy levels in molecules and (2) transitions between them and (3) releasing or absorbing energy as light.