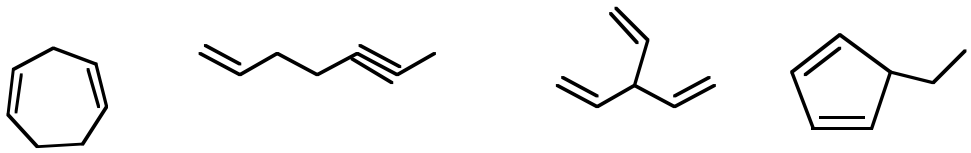
Exam 1
Organic Chemistry
NESA – Fall 2001
Answer Key

Collaborative section (28 points total)

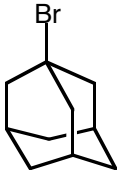
1. There are many possible compounds with this molecular formula. An easy way to analyze them is to think about degrees of unsaturation. The amount of unsaturation is measured by comparing the molecular formula of the molecule in question to that of an alkane with the same number of carbons. Comparing the compound in question (C_7H_{10}) to an alkane with the same number of carbons (C_7H_{16}), shows that the molecule has three degrees of unsaturation. Consider the following table and the number of units of unsaturation each type bond yields.

Double bond	1 unit
Triple bond	2 units
One cycle	1 unit

   So for us to have a molecule with the molecular formula C_7H_{10} we can have a molecule with: three double bonds; 2 double bonds and one triple bond; a ring with two double bonds…etc. Here are some examples:

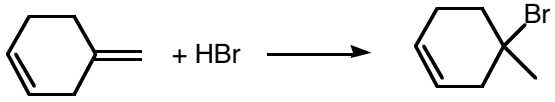


2. The compound pictured is adamantane, named because of its unreactive nature. The reaction pictured is the radical substitution of an alkane. Adamantane has only tertiary and secondary carbons. If you think about the mechanism of a radical substitution reaction you may remember that a radical intermediate is involved. A tertiary radical intermediate will be more stable than a secondary and more likely to react to form product. Therefore the most likely product will be a bromine atom on a tertiary carbon. A mono-brominated product is more likely since there are three of the tertiary carbon centers.



3.
   a. 5-(2-chloropropyl)-2,7-decadiene
   b. 3,6-diethyl-2-methyl-1,6-octadiene
   c. 4-(1-methylethyl)-2,6-octadiene or 4-*iso*-propyl-2,6-octadiene
   d. 2,7-dimethyl-5-(1-methylpropyl)- nonane or 5-*sec*-butyl-2,7-dimethylnonane

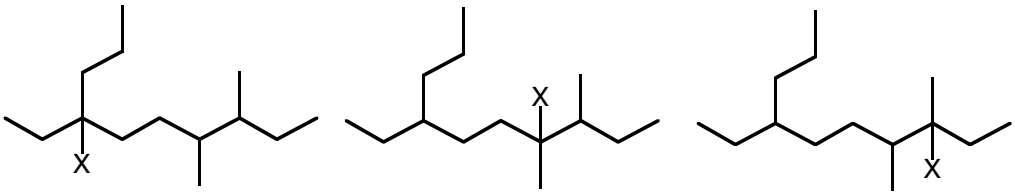
4. By Markovnikov's rule the bromine will attach to the least saturated carbon center. We explained this by considering that a tertiary carbocation intermediate would be more stable than a secondary or primary one.

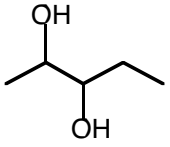


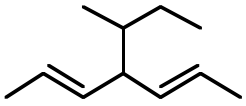
5.
   a. 3-pentanol>ethoxypropane>pentane (highest to lowest boiling point)
   b. All of these compounds have a similar molecular weight so we will cover their other differences. Alcohols have an OH group and therefore have the capacity to hydrogen bond with other alcohol molecules. This is a strong non-covalent interaction and additional energy must be applied to the system to overcome this. The ether, while it cannot hydrogen bond with itself, is polar and can form a weaker polar interaction with other molecules. Less energy is needed to overcome the stability added by this property compared to a hydrogen bond. Thus the alcohol will have a higher boiling point than the ether. The alkane is completely non-polar and cannot form hydrogen bonds. It has only London forces to act as an attractive force. These forces are the easiest to overcome and thus the alkane has the lowest boiling point.
   c. Same order as **a**.
   d. Solubility is affected by some of the same properties as the boiling point. The hydrogen bonding capacity of the alcohol will allow it to interact with water (the alcohol can also accept hydrogen bonds from the water). For smaller alcohols, water molecules can surround the alcohol molecule and solvate it. The ether has an oxygen atom and can accept hydrogen bonds from water, though it cannot donate hydrogen to a hydrogen bond. The alcohol is more soluble than the ether for this reason. The alkane cannot participate in a hydrogen bond, having only London forces to interact with water. It is hydrophobic and non-polar and of the three compounds will be the least soluble in water.

Individual section (52 points total)

1. $C_{13}H_{28} + 20\ O_2 \rightarrow 13\ CO_2 + 14\ H_2O$
2. b
3. The correct answer was not given and therefore this question was not counted in the grading. The correct answer was 6 secondary carbons
4. d
5. 22
6. b
7. b
8. I and III
9. c
10. c. The tertiary radical intermediate is the most stable, this molecule has three tertiary carbon centers.

11. 

12. $C_{13}H_{10}$
13. b. In a dehydration the double bond will tend to form on the carbon with is the most substituted (less saturated). Though compound **a** could give the desired product, a mixture would be obtained since the alcohol is on the most substituted carbon. Compound **b** may also give two products, but the major product will most likely be the desired one.
14. b. Following Markovnikov's rule with chlorine will attach to the most substituted carbon. The compound specified in **a** would put the double bond at the same carbon as the methyl group, giving a quaternary carbon. The major product would have the chlorine at carbon 2. A free radical halogenation might yield the desired product, but many other products would be obtained as well. The second compound would yield the desired product. One carbon is not favored over the other, but attachment to either one gives the same product.
15. c
16. II. The nitro (NO_2) group is meta directing.
17. Partial credit given for just drawing the structure when a structure was already given.
    a. 2,3-dimethylpentane
    b. 2-methyl-1-butene or 2-methylbutene
    c. 3-ethyl-4-methyl-2-hexene
    d. 1,3,6-cyclooctatriene or cycloocta-1,3,6-triene
    e. 2-bromo-3,4-diethyl-5-methylcycloheptene
    f. 3-ethyl-4-methyl-3-hexanol
    g. 

    h. 
    i.