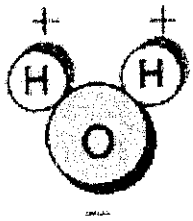
Name_____Block_____

Organic Lab 5: Functional Groups of Oxygen: Alcohols and Ethers

Oxygen is a relatively close neighbor of the halogens, being located in the adjacent column to the halogens. Oxygen has **six valence electrons**, and will usually share **two** electrons with other atoms. Like the halogens, oxygen has a great appetite for electrons (**high electronegativity**) and will tend to hog the electrons. With atoms of hydrogen or carbon, it will share two of its electrons, but unequally. The oxygen gets a greater share of the electrons than the other atom, making it *slightly negative*. The carbon or hydrogen is weaker (**less electronegativity**) and is *slightly positive*. This leaves the molecule with positive and negative parts – known as **dipoles**. These dipoles have profound effects on the physical properties of organic molecules, as we shall see.

For example, if we look at a water molecule, the central oxygen shares two electrons with two hydrogen atoms. The relationship is not equal, however, because the two electrons that originated with the hydrogen spend most of their time near the oxygen:



The hydrogens have a slight positive charge, while the oxygen atom has a slight negative charge. The presence of positive and negative ends (dipoles) leads to *strong intermolecular attractions* between molecules. Compare the boiling point of water to the hydrocarbons you have looked at so far. Compounds that are composed of atoms which share electrons equally have low melting and boiling points. **Polar compounds** such as water, or organic compounds containing carbon and oxygen, have much higher melting points and boiling points than their hydrocarbon cousins. Hydocarbons containing only carbon and hydrogen are considered **non-polar compounds** because they do not have these partial positive and negative charges.

You have probably had the experience of mixing polar and non-polar molecules yourself when you use salad dressing. It is clear that water and oil don't like each other much; they will not dissolve in one another. There is a phrase that chemists use,

"Like dissolves like."

Simply put, polar molecules dissolve in compounds that are polar, much like themselves. Non-polar molecules will only dissolve in compounds that are non-polar, like other hydrocarbons.

Alcohols

The word alcohol is doubtless familiar to you. In chemistry it refers to a **polar functional group** composed of an oxygen atom bonded to a hydrogen atom. This –OH group is connected to carbon atoms. It acts much the same way that water does, with the oxygen having a partial negative charge because it claims a greater share of the electrons from carbon and hydrogen. H and C have partial positive charges. It is easy to spot an alcohol

in a chemical name – they all end in –ol. You simply put this suffix on the end of the parent chain. In our model sets, oxygen atoms are the red ones.

How many valence electrons does oxygen have? _____

How many bonds can an oxygen atom make? _____

Make models of the first two alcohols, methanol and ethanol (ethyl alcohol). You are doubtless familiar to some degree with the latter alcohol; the former one is even more poisonous. Draw their structural formulas and chemical formulas in the box below.

What are the shapes of these molecules? _____

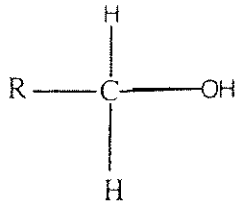
_____

Take a hydrogen off of the methyl group of ethanol and add another alcohol group. You have now created a model of **ethylene glycol**, or antifreeze. Draw its structural formula and write its chemical formula in the box below, and name the compound using **IUPAC** rules. You must put a di- prefix before the –ol but after the parent alkane name.

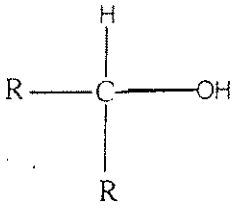
Another alcohol you've heard of is **isopropyl alcohol**, or rubbing alcohol. The –OH group is on the second carbon. Draw the structural formula below, its condensed structural formula, write its chemical formula, and name it according to IUPAC rules.

Primary, secondary and tertiary alcohols

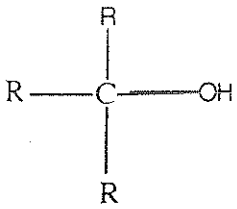
Alcohols are extremely common functional groups, and the position of the alcohol is often very important. An alcohol on the terminal carbon is called a primary alcohol. An alcohol on an interior carbon bonded to two other carbons is a secondary alcohol, and an alcohol on a carbon bonded to three other carbons is a tertiary alcohol:



primary alcohol



secondary alcohol



tertiary alcohol

Remember, the "R" group stands for a hydrocarbon chain. Looking at the alcohols we have created so far, classify the alcohols.

Methanol _____

Ethanol _____

Isopropyl alcohol _____

The first tertiary alcohol is an isomer of butanol. Build models of all of the isomers of butanol, draw them on the following page, name them, and classify them as 1°, 2°, or 3°.

Draw structural formulas for the following compounds. Classify each alcohol as primary secondary or tertiary.

1. 1,2,3 propantriol (glycerol or glycerine)
2. 3-pentanol
3. 2,2 dimethyl-1-butanol

Now consider the following list of compounds. Based on your knowledge of the polar and non-polar nature of these compounds, predict whether they will dissolve in water and/or vegetable oil:

Compound	Water	Vegetable Oil
Ethanol		
Benzene		
Propane		
Rubbing alcohol		
ethyne		
cyclohexane		
gasoline		
Chloromethane		
glycerol		

Ethers

These compounds are less common in nature, but still have many important uses. Ethers have the general formula

R-O-R'

Where R and R' are hydrocarbons. Essentially the hydrogen of the alcohol is replaced by a hydrocarbon. These molecules are less polar than alcohols. If the hydrocarbons are long, they behave like non-polar compounds. Naming them is easy: just write the hydrocarbon parent names, followed by the word "ether."

Build a model of diethyl ether, the first anesthetic. Draw its structural formula in the box below, along with its chemical formula.

Write the condensed structural formulas for the following ethers:

1. Methyl butyl ether _____

2. Ethyl pentyl ether _____

Write the names of the following ethers:

3. $CH_3CH_2CH_2CH_2CH_2CH_2OCH_2CH_2CH_3$ _____

4. CH_3OCH_3 _____

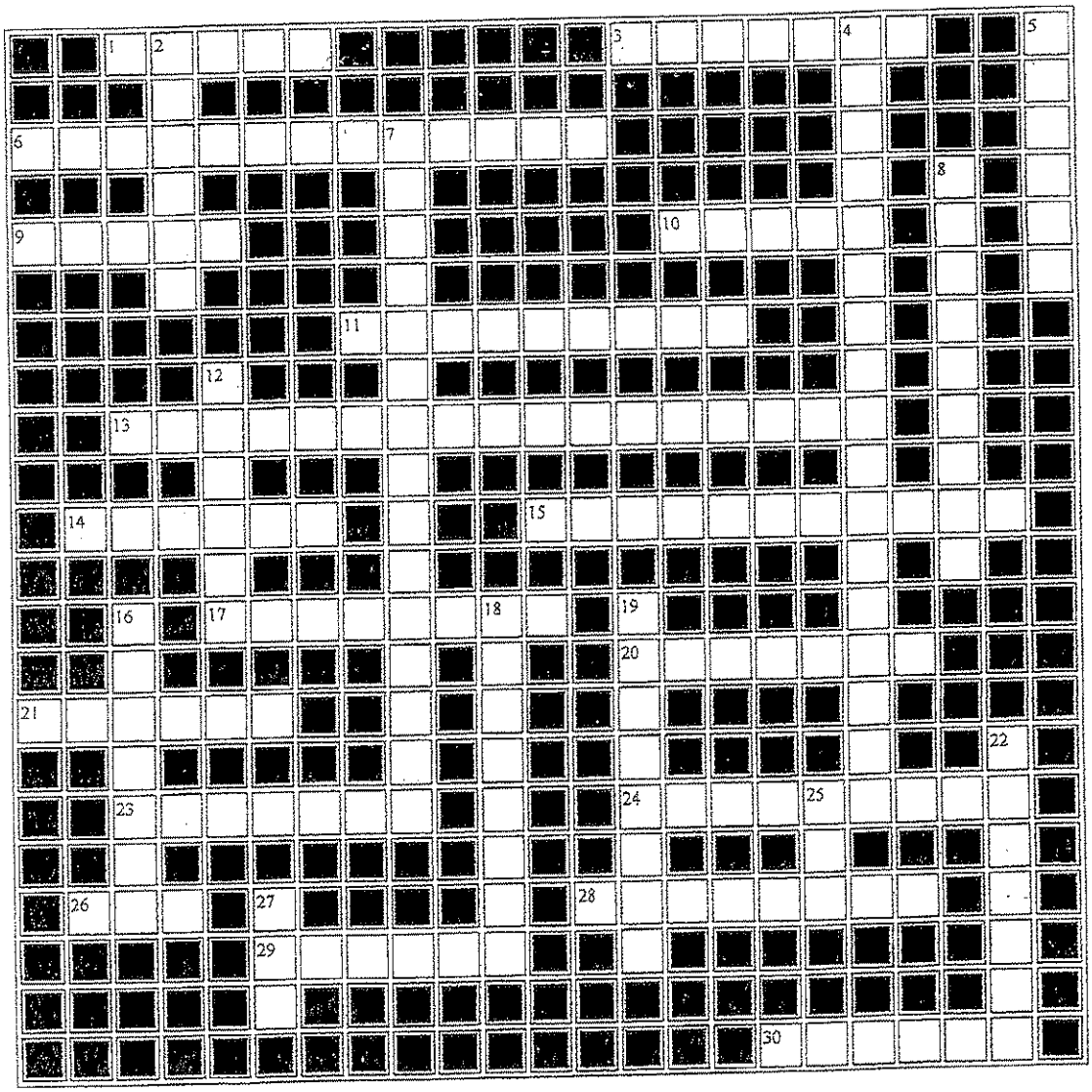
For your homework: In the assignment given, ethers are named somewhat differently, according to IUPAC rules (for some reason, the regents uses the older naming system for ethers). The longest parent chain prefix is named first, followed by "oxy" then the shorter one.

Organic Chemistry

Name: _____

Alkane, Alkene, Alkyne, Alcohols & Ethers
Crossword Puzzle

If the answer has two words leave a space between the words.



Alkanes, Alkenes, Alkynes, Alcohols & Ether Crossword Puzzle Clues

Across

1. One side of the molecule is (+) and the other side is(-) Ex: water

3. Compounds containing carbon and hydrogen

6. This is used to put people to sleep during surgery

9. This prefix means it is shaped like a chair

10. The general formula for this compound is R-O-R'

11. Refers to the structure being a chain of carbons

13. This is the chemical we used to make the gel in lab.

14. An Alkane with eight carbons

15. Compounds with double or triple bonds that are not filled with hydrogens

17. The simplest Alkene

20. The IUPAC name for the alcohol found in wine and beer

21. An Alkane with four carbons

23. This organic compound contains a hydroxyl group (-OH)

24. The common name for the chemical Ethyne

26. This prefix means six

28. In this type of bond elements share electrons

29. Chemicals with the same chemical formula but a different structure

30. Compounds containing only Cs and Hs with a double bond

Down

2. An Alkane with eight carbons

4. This compound is called Rubbing Alcohol

5. Compounds containing only Cs and Hs with a triple bond

7. The common chemical name of antifreeze

8. Compounds with all single bonds that are filled with hydrogens

12. Compounds containing only Cs and Hs with all single bonds

16. The simplest Alkane

18. This molecule is symmetrical so electrons are evenly distributed

19. A one carbon alcohol

22. This smelly molecule is a ring and has double bonds that move around.

25. This suffix tells you the compound has a triple bond

27. This prefix means it is shaped like a boat