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Objective: to familiarize ourselves with organic functional groups and to learn how to recognize them in organic chemical diagrams.

You will do all of this, which will take 3 class periods, and LOOK for the patterns. When you need to draw molecules, have table R open, and make sure your functional groups get drawn perfectly. Count, every single time.

You must use a pencil.
This is BIG, but you are bigger (and smarter). Do not slack off, this will take full effort.

Large Organic Molecules are so big, and so repetitive, that short cuts have been created to show them.
In medicines and common things like caffeine, what at first glance appear to be complex molecules to non-chemists, are easily recognizable to us. With shapes, like hexagons, each corner is a carbon atom. If nothing is bonded to the corner, since each carbon has to make 4 bonds, sufficient hydrogen atoms are present even though they aren't drawn. Any other atoms besides H or C must be drawn for you to see. Double bonds and even triple bonds are apparent. Look at the examples, then determine the generic chemical formulas.

By rule we will list the atoms of the chemical formula in this order: $\mathrm{C}, \mathrm{H}, \mathrm{N}, \mathrm{O}$, etc.

1. This is cyclohexane, six carbons single bonded in a ring shape. The hexagon next to it is the "shortcut" diagram. Each corner is a carbon, and since each carbon must make 4 bonds, the formula is $\mathrm{C}_{6} \mathrm{H}_{12}$.
2. This is called benzene. It's similar to the first molecule, but it has alternating double bonds. It can be simplified as the hexagon with three triple bonds. The formula here is $\mathrm{C}_{6} \mathrm{H}_{6}$.




On the next page are 6 molecules for you to examine, put the " C " atoms in place, and add in some " H " atoms too.
See if you can get the actual formulas (answers on the bottom of page 2, upside down.
3. Number 3 is caffeine (AKA theophylline). The nitrogen atoms are labeled, but the other corners are all carbon. The molecule also has three "dashes" that lead to "nothing". At the end of each dash is a really a carbon atom, each bonded to 3 atoms of H .
What is the formula for this molecule? Note the " $\mathrm{CH}_{3}$ " top left, as compared to in \#4, the N atom bonds to a single " H "
4. Fourth is theobromine (not bromine!), which is what makes chocolate taste so good. It's similar to caffeine, but not quite. What is that formula?
5. Aspirin (acetylsalicylic acid) for headaches is the fifth molecule. What is the formula?
6. Naphthalene is the stuff in moth balls that smells so bad! Your nose can detect it at levels of just 0.08 PPM! What's the formula?
7. The large multi-ringed molecule at the bottom is a type of cholesterol that clogs your arteries when you're old (eat well now!). Try that formula too. (don't miss that tiny - OH in the corner)
8. Methyl Phenylacetate is the fancy name for another wonderful smell called HONEY. (Pooh loves honey, U2 sings about "Wild Honey", the Beatles sang about "Honey Pie"). That funky hexagon ring with the circle means that the single and double bonds altername (and resonate), so the five corners there are all " C " single bonded to " H ". What is the formula?



8

${ }^{2} \mathrm{O}^{01} \mathrm{H}_{6}$ ว s! Кәuон 8


${ }^{\dagger} \mathrm{O}^{8} \mathrm{H}^{6} \mathrm{O}$ s! u!u!dsv §

${ }^{\tau} \mathrm{O}^{\dagger} \mathrm{N}^{01} \mathrm{H}^{8}$ ว s! әи!әృеว $\mathcal{L}$

Draw these compounds. Make them BIG, and put 8 per page.
You do NOT have to draw all of the hydrogen atoms.
You do have to draw every " H " if it's in a functional group, or if the molecule is a "meth"
(single carbon) molecule, that shows you KNOW what you're doing.
Use pencil, no big cross outs will be accepted!

| $\begin{gathered} \text { page } \\ 1 \end{gathered}$ | propane <br> 3-nonene ethanol di-propyl ether | pentane 2-butyne methanoic acid $1,1,2$ trifluoro ethane |
| :---: | :---: | :---: |
| $\begin{gathered} \text { page } \\ 2 \end{gathered}$ | 1-bromo-2-hexyne butane octane 2,3,6, tri-chlorodecane | 4-nonyne propene butyl methanoate ethyl propyl ether |
| $\begin{gathered} \text { page } \\ 3 \end{gathered}$ | 1-butanol methyl-propyl ether pentanal propanoic acid | tri-iodo methane 3-hexanone 2,4 dimethyl hexane ethanamide |
| $\begin{gathered} \text { page } \\ 4 \end{gathered}$ | ethanoic acid 1 bromo, 4 chloro 2-pentene chloromethane butyl hexyl ether | ethyl butanoate <br> heptanoic acid 3 pentanol <br> 1-bromo, 3-chloro, 4-fluro, 6-iodo-nonane |
| $\begin{gathered} \text { page } \\ 5 \end{gathered}$ | ethanal <br> 3-heptanone hexanimide methyl-ethyl ether | ethene propyl hexanoate 3,4 dibromol hexyne cyclo-pentane |
| $\begin{gathered} \text { page } \\ 6 \end{gathered}$ | 4 ethyl,2-methyl octane ethyl ethanoate 2-octene 2-butyne | 3-hexanamine pentanamide methyl pentanoate cyclo-butane |

Draw out the structural diagrams for each: addition, substitution, polymerization, fermentation, esterification, and saponification.
page 1. Addition: 2 pentene $+\mathrm{Br}_{2}$ into one product
7 2. Substitution: propane $+\mathrm{Cl}_{2}$ form 2chloropropane + another product
3. Polymerization: tetrafluoroethene forms polytetrafluoroethane
4. Fermentation of GLUCOSE $\left(\mathrm{C}_{6} \mathrm{H}_{12} \mathrm{O}_{6}\right)$ into 2 products. Make sure to show yeast + water by the arrow.
5. Esterfication of 1-propanol and pentanoic acid (2 products, name both)
6. Saponification: write a word equation, not the structural molecules.

| SCENT | Circle the Functional Groups ONLY in these STRUCTURAL FORMULAS | Name all <br> Functional Groups in each molecule |
| :---: | :---: | :---: |
| banana |  | Name this compound |
| caraway (rye bread) |  | How many hydrogen atoms are hiding in this molecule? |
| cinnamon |  |  |
| coconut |  | How many carbon atoms in molecule? |
| geraniums (flowers) |  |  |

$\left.\begin{array}{|c|c|c|c|}\hline \text { SCENT }\end{array} \begin{array}{c}\text { Circle the Functional Groups ONLY } \\ \text { in these STRUCTURAL FORMULAS }\end{array} \quad \begin{array}{c}\text { Name all } \\ \text { Fyacinth } \\ \text { (flowers) } \\ \text { in each molecule }\end{array}\right]$

| SCENT | Circle the Functional Groups ONLY <br> in these STRUCTURAL FORMULAS | Name all <br> Functional Groups <br> in each molecule |
| :---: | :---: | :---: | :---: |
| peppermint |  |  |
| roses |  |  |


| SCENT | Circle the Functional Groups ONLY <br> in these STRUCTURAL FORMULAS | Name all <br> Functional Groups <br> in each molecule |
| :---: | :---: | :---: |
| Vinegar | $\mathrm{H}-\mathrm{C}$ |  |

crans

| Homologous <br> Series <br> Name <br> alkanes | general <br> formula <br> n= number of <br> carbon atoms |  | EXAMPLES |  |
| :---: | :---: | :---: | :---: | :---: |
|  |  | Name <br> (4 Carbon chains) | Structural Diagrams <br> with all hydrogen atoms showing <br> And condensed structural formulas |  |
| propane |  |  |  |  |
| alkenes |  | propene |  |  |
|  |  |  |  |  |


| Draw | Structural Diagrams of these BRANCHED HYDROCARBONS |
| :---: | :---: |
| 2methyl, 4ethyl, 3fluoroheptane |  |
| 5ethyl 3,6,7 trimethyl 1-octene |  |
| 1chloro 3,3 difluoro 4,5 dimethyl 1 hexyne |  |

$$
\mathrm{CH}_{4}+\mathrm{Cl}_{2} \rightarrow \mathrm{CH}_{3} \mathrm{Cl}+\mathrm{HCl}
$$



Name this reaction type


Name this reaction type

Draw out the molecules to show the addition reaction between 2 butyne + fluorine form into 2,3 difluro -2 butene

Name the reactants and products in this esterification reaction


Name the reactants and products in this esterification reaction




Balance

$$
ـ \mathrm{C}_{6} \mathrm{H}_{12} \mathrm{O}_{6(\mathrm{AQ})} \xrightarrow[+ \text { water }]{\xrightarrow{\text { Enzymes }}}
$$

$$
\ldots \mathrm{CO}_{2(\mathrm{G})}+
$$

$\square$

## Draw the structural diagrams AND condensed structural formulas showing these reactions.

Substitute in a fluorine atom with ethane, forming fluoro-ethane + HF

Substitute in a chlorine atom with propane, forming 1-chloropropane +HCl

Substitute in an iodine atom with propane, this time forming 2-iodo-propane +HI

Substitute in a bromine atom with pentane, this time forming 2-bromopentane +HBr

Substitute in a fluorine atom with 2-bromopentane, this time forming 1-fluror,2-bromopentane + HF

Addition reactions require you to start with an alkene or alkyne, an unsaturated hydrocarbon, and you will ADD both atoms of $\mathrm{F}_{2}, \mathrm{Cl}_{2}, \mathrm{Br}_{2}, \mathrm{I}_{2}$, or even $\mathrm{H}_{2}$.
With alkenes, the double bond becomes single. With alkynes, the triple bond becomes a double In both cases, ADD 2 ATOMS INTO THE NEW MOLECULE. In each box, draw structural formulas for each.

Add a bromine molecule to 2-pentene

Add a chlorine molecule to 2-butyne

Add a hydrogen molecule to propene

Add a hydrogen molecule to 1-butyne



## $+3 \mathrm{NaOH} \rightarrow$



$\underset{ }{\mathrm{CH}} \mathrm{O} \mathrm{OH}+3 \mathrm{CH}_{3}\left(\mathbf{C H}_{2}\right)_{14} \mathrm{CO}_{2} \mathrm{Na}^{+1}$

What type of reaction is shown in this bottom area?

Esterification is the process of combining organic acids to alcohols by the removal of $\mathrm{HOH}_{(\mathrm{L}}$, forming an ester.
In this reaction, the acid will lose the -OH part of the COOH group, and
the alcohol will lose just the H from its - OH group.
The removed H and OH forms water, and the rest of the molecules join into a COO group in the middle.

Draw and label the structural diagrams for propanoic acid and for ethanol, and the two products.
Circle the OH and the H that makes the water. NAME both products that form.

Combine methanol with hexanoic acid to produce the wonderful smell of bananas! Do the same as above, draw 2 diagrams for the acid and the alcohol, circle the -OH and the -H that forms water, then draw and properly name both products that form.

