Unit #2, Chapters 1 and 2 Outline
Organic Chemistry: Organic Compounds and their Reactions

Lesson	Topics Covered	Reference	Homework Questions and Assignments
01	**Introduction to Organic Chemistry** • definitions **Hydrocarbons: The Alkanes** • structure • homologous series • branched alkanes • rules for naming (IUPAC) • structural isomers	**Note**: Intro to Organic Chemistry **Note**: The Alkanes **Text**: p 4-10 **Text**: p 14, Table 1.3	1. Read page xxxiv and understand the different ways of representing organic molecules 2. Complete homework on handout: Introduction to Organic Chemistry and Hydrocarbons
	Unit Test #1: Structure and Properties	Chapter 3 and Chapter 4 review questions on web page	1. Do last night's homework if it isn't done 2. Lab #1 (Properties of Solids) is due tomorrow
02	**Hydrocarbons: The Alkenes** • structure and naming • cis-trans isomers **Hydrocarbons: Alkynes** • structure and naming	**Note**: The Alkenes and Alkynes **Text**: p 12 – 19 (not "cyclos" yet) **Text**: p xxxv - xxxvi	1. Page 16-17, do Q 5a,c,d,e,g, 6 – 9 2. Page xxxv, Q 37 and 38 3. Page xxxvi, Q 39 - 40
03	**Hydrocarbons: Cyclic** • structure and naming **Hydrocarbons: Aromatics** • structure and naming • ortho, meta and para system of naming • toluene, phenol and benzoic acid **Physical Properties of Hydrocarbons** • inter-molecular attraction (London dispersion forces) • physical properties related to chain length and branching • density, melting and boiling points, solubility	**Note**: Cyclic and Aromatic Hydrocarbons **Handout**: Organic Compounds (org'n chart) **Text**: p 18 - 19 **Text**: p. 22 - 24 (Physical properties section)	1. Page 16, Q 5b, 5f 2. Page 19, Q 10 – 13 3. Page 20, Q 1 – 5, 7 4. Summarize the section in green- we will be discussing H-bonding, molecular polarity and dispersion forces for every type of organic compound 5. Do the "Thoughtlab" on page 24
04	**Chemical Reactions of Hydrocarbons** • reactivity of alkanes, alkenes & alkynes **1. Combustion reactions (all hydrocarbons)** **2. Reactions of alkanes** • substitution (halogenation)	**Note**: Reactions of Hydrocarbons Page 56 – 59 (not page 60, yet)	1. Do homework on **Handout**: Chemical Reactions of Hydrocarbons 2. Be prepared for a quiz on naming hydrocarbons, next class

Lesson	Topics Covered	Reference	Homework Questions and Assignments
05	**Reactions of Hydrocarbons (cont)** **3. Reactions of aromatics** • substitution with halogens **4. Reactions of Alkenes** • addition reactions (Br_2, HCl, H_2, H_2O) • Markovnikov's rule • slow oxidation reactions ($KMnO_4$) • tests for saturation **5. Reactions of Alkynes** • as for alkenes (above)	**Note**: Reactions of Hydrocarbons (cont.) **Handout**: Reactions of Hydrocarbons (Alkenes) **Handout**: Chemical Reactions of Hydrocarbons	1. Study for quiz: Naming and Classifying Hydrocarbons (review on webpage) 2. Do homework on **Handout**: Chemical Reactions of Hydrocarbons
06	**Quiz on Naming Hydrocarbons** **Prelab** for Lab #2: Observing and Comparing the Reactions of Hydrocarbons	**Handout**: Lab #2: Observing and Comparing the Reactions of Hydrocarbons	1. Prepare observation chart for Lab #2. Students may not begin the lab until the teacher has checked that their observation chart is ready.
07	**Do Lab #2: Reactivity and Some Reactions of Hydrocarbons**		Lab write-up due:
08	**Introduction to Substituted Hydrocarbon** • functional groups, alkyl chains (R) **1. Alkyl halides (R – X; X is a halogen)** • structure, naming and properties **2. Alcohols (R – OH)** • structure, naming and properties • 1°, 2°, and 3° alcohols **3. Aldehydes (R – CHO)** • structure, naming and properties **4. Ketones (R – CO – R')** • structure, naming and properties	**Handout**: Organic Compounds (org'n chart) **Note**: Intro to Substituted Hydrocarbons Page 28 Page 25 – 27 Page 35 – 37 Page 35 – 37	 Page 28, Q 18 – 21 (alkyl halides) Page 26-27, Q 14 – 17 (alcohols) Page 36, Q 30 – 33 (aldehydes and ketones)
09	**Substituted Hydrocarbons (continued)** **5. Carboxylic Acids (R – COOH)** • structure, naming and properties **6. Amines ($R – NH_2$)** • structure, naming and properties of primary amines only	Page 39 – 41 Page 31 – 33 **Handout**: Assignment #2: Naming Hydrocarbons & Hydrocarbon Derivatives	Page 40, Q 34 – 37 (carboxylic acids) Page 32, Q 26a,c, 27a,b, 29 (amines) Begin Assignment #2: Naming Hydrocarbons & Hydrocarbon Derivatives. Due:

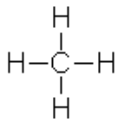
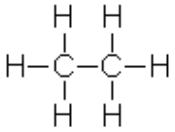
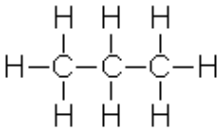
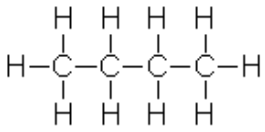
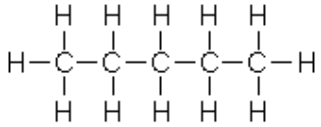
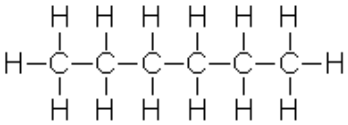
Unit #2, Chapter 1and 2 Outline
Organic Compounds and Reactions

Lesson	Topics Covered	Reference	Homework Questions and Assignments
10, 11	**Reactions of Alcohols** **1. Combustion Reactions** **2. Substitution Reactions** **3. Elimination Reactions** • Markovnikov's Rule **4. Oxidation and Reduction Reactions** • definitions • oxidation of 1º, 2º and 3º alcohols with $KMnO_4$ or other oxidizing agents [O] **5. Ethers (R – O – R')** • formation reaction (condensation) • structure, naming and properties **6. Esters (R – COO – R')** • formation reaction (condensation) • structure, naming and properties	**Note**: Reactions of Alcohols Page 29 – 31 Page 44 – 46 **Handout**: Summary Chart	1. Page 63, Q 1 – 4 2. Page 64, Q 1a,b,c, 2, 5 3. Page 67 to 68, Q 5 – 7 4. Page 30, Q 22, 24, 25 5. Page 45, Q 38 – 42 6. Page 50 – 51, Q 1, 2, 3a,b,d, 6, 9, 10 7. Page 73, Q 9 – 13 8. Page 78, Q 14 – 16a,c,d,f 9. Page 79 – 80, Q 1, 2, 3, 4, 6, 7 Complete **Handout**: Summary Chart of Reactions of Alcohols
11	**Pre-lab Notes for Lab #3: Reactions of Alcohols**	**Handout**: Lab #3: Reactions of Alcohols	Read through Lab #3 for next lesson
12	**Do Lab #3: Reactions of Alcohols**		Begin Organic Chemistry review on internet (this is your best preparation for the unit test)
13	**Polymers** • definition and examples • addition polymers • condensation polymers i) polyesters ii) polyamides (nylons)	Page 81 – 84 Page 88 - 92	Do questions on **Handout**: Polymers Work on Organic Chemistry review on internet (this is your best preparation for the unit test) Additional Textbook review: Page 105 – 107, Q 1 – 7, 9 – 12, 18, 19 (not e or h), 20 (not d or f), 21, 23a, 25a Page 112 – 115, Q 1 – 32, 34, 35 (in general), 36 – 40, 42 (optional)

The Alkanes

Alkanes are defined as open-chain (_____) hydrocarbons that do not contain any double or triple bonds. Because they contain the maximum number of hydrogen atoms, they are called _____ hydrocarbons.

The naming of all organic molecules is based on the naming system for alkanes. Alkanes are named by the number of _____ in their _____.

Structural formula	Molecular formula	Condensed formula	Stick Diagram	IUPAC name
			N/A	
			N/A	
				
				
				
				

Similarly, a seven-carbon alkane (C_7H_{16}) is called _____

- a eight-carbon alkane (C_8H_{18}) is called _____
- a nine-carbon alkane (C_9H_{20}) is called _____
- a ten-carbon alkane ($C_{10}H_{22}$) is called _____

The general molecular formula for an alkane is

The alkanes are a _____ series: a family of hydrocarbons that differ only in the number of _____ groups.

The alkanes may also be branched (have side chains). The side chains are called _____ and are named according to the number of carbon atoms:

-CH_3 has 1 carbon, it is _____

-CH_2CH_3 has 2 carbons, it is _____

-$CH_2CH_2CH_3$ has 3 carbons, it is _____

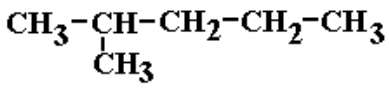
-$CH_2CH_2CH_2CH_3$ has 4 carbons, it is _____

-$CH_2CH_2CH_2CH_2CH_3$ has 5 carbons, it is _____

-$CH_2CH_2CH_2CH_2CH_2CH_3$ has 6 carbons, it is _____

To name branched chain alkanes:

1. Identify the longest continuous hydrocarbon chain. The number of carbon atoms in this chain determines the base-name of the hydrocarbon.
2. Number the carbon atoms along the main chain so that the side chains (alkyl groups) have the lowest possible position numbers.
3. If there is more than one ***type*** of side chain, name them in alphabetical order with their position number. Put a hyphen (dash) between the position number and the name of the side chain.
4. If there are two or more of the same side chain, write "diethyl" or "trimethyl", but name them in alphabetical order according to the name of the side chain (di**e**thyl or tri**m**ethyl), not the prefix. Indicate their position numbers, separated by a comma.



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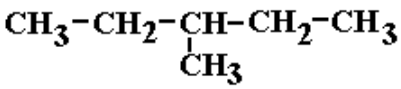

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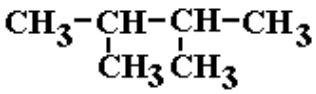

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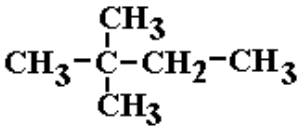

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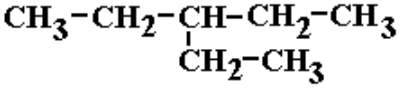

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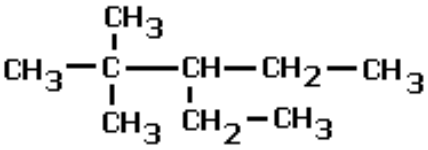

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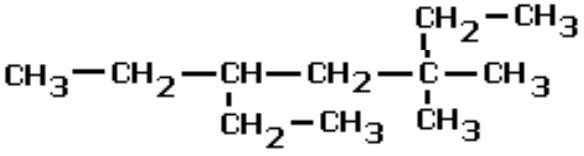

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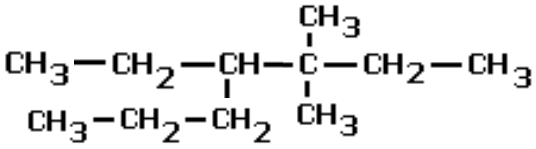

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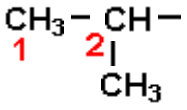
Compounds that have the same molecular formulas but different structural formulas are called _____. ("iso" means _____ and "mer" means _____).

Structural isomers may have very different physical properties, depending on the amount of branching.

Side chains (alkyl groups) can also be branched. You need to know the following:



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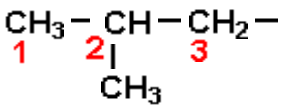

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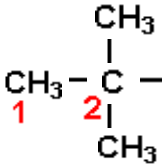

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To draw hydrocarbons:

eg. Using the example: 3-ethyl-2,2-dimethylpentane

1. Determine the main carbon chain and draw a "skeleton"
   eg. the base name for the hydrocarbon is pentane, so draw __ carbons:
2. Use the names and position numbers of the side chains, draw them in
   eg. there is an ethyl group on the third carbon
   there are two methyl groups on the second carbon
3. Fill in the molecule with hydrogen atoms to complete stable octets
4. Double-check your structure by naming it:

Unit 2, Lesson 01: Introduction to Organic Chemistry and Hydrocarbons

Homework:

1. Read pages 4 – 9
2. Define: organic compounds.
3. What did Friedrich Wohler discover and why was it significant?
4. On page 10, do questions 1 – 4. On page 11, do questions 1 – 4.
5. All of the following compounds contain carbon. Classify and name them. An ion chart may help.

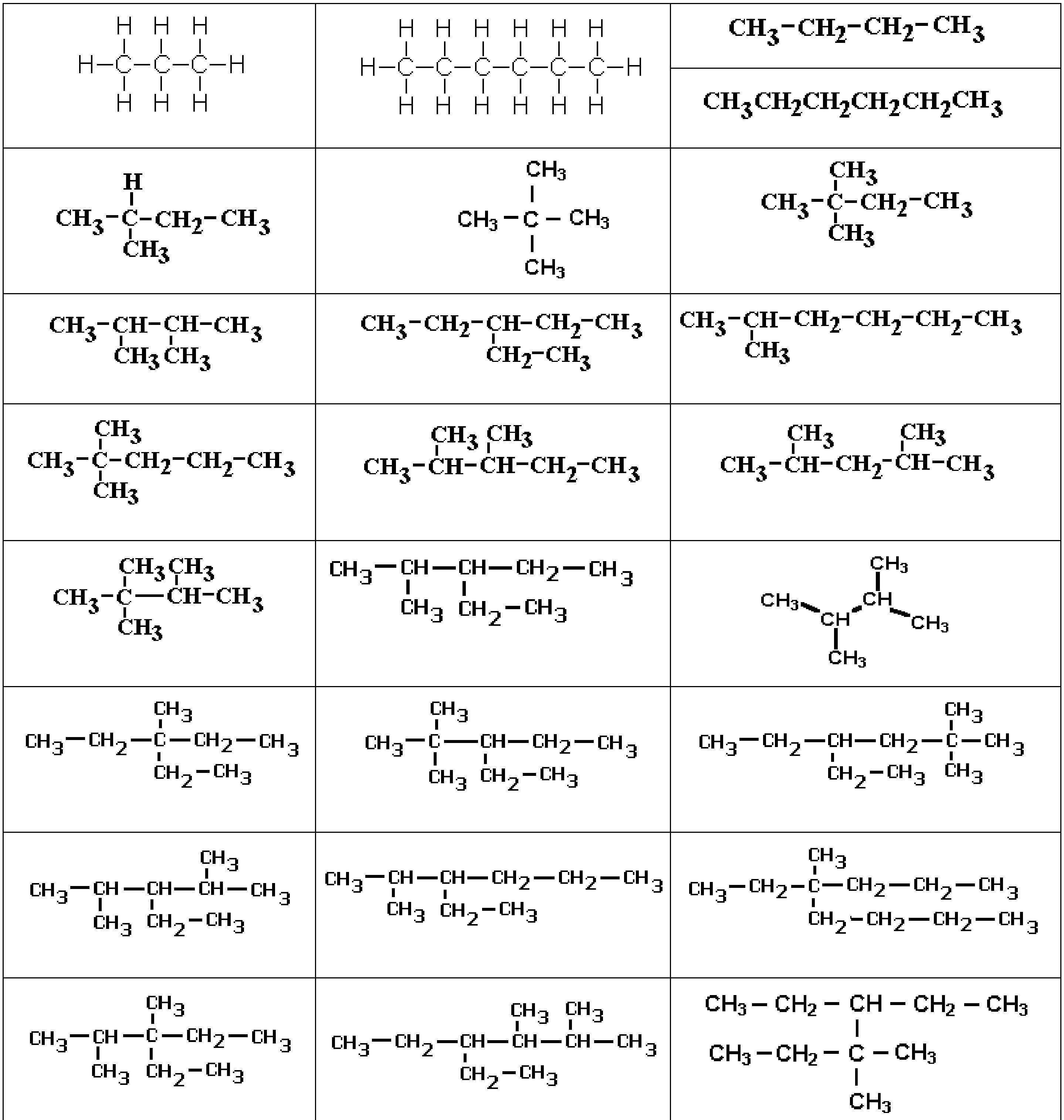
Compound	Ionic or Covalent	Organic or Inorganic	Name of Compound
CO_2			
$Ca(CN)_2$			
C_3H_8			
CH_3COOH			
KSCN			
Na_4C			
C_6H_{14}			
$SrCO_3$			
$C_6H_{12}O_6$			
C_8H_{18}			
CO			

6. Why are the straight chain alkanes called a "homologous series"?
7. What is the general formula for the molecular formula of alkanes? What does "n" represent?
8. Write the molecular formulas of the alkanes with:
   a) 15 carbon atoms
   b) 20 carbon atoms
   c) 72 hydrogen atoms
9. Is $C_{18}H_{36}$ an alkane? Explain.
10. Write the molecular formula for dodecane (12 carbon atoms).
11. What is meant by a "saturated" hydrocarbon?
12. What is the significance of the mnemonic "monkeys eat peeled bananas"?
13. Are hydrocarbons polar or pure covalent compounds? Justify your answer with reference to electronegativity values. Based on your answer, predict four physical properties of hydrocarbons.
14. What is meant by an "alkyl group"?
15. What would you name an ***alkyl group*** that contains 5 carbon atoms?
16. Define structural isomer. Draw four structural isomers of hexane. Name each isomer.
17. Draw the condensed structural formulas for the following:

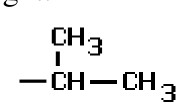
a) 3,4-dimethyl hexane
b) 3-ethyl-3-methyl pentane
c) 4-ethyl-2-methyl hexane
d) 3,3-diethyl-4,5-dimethyl heptane
e) 2,3-dimethyl-4-propyl octane

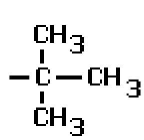
18. For each of the following organic molecules:

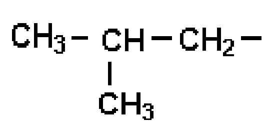
a) write it's IUPAC name
b) write its molecular formula
c) identify all molecules which are structural isomers

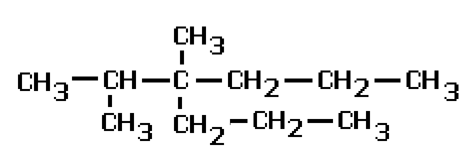


Name each sidechain (text page 14), then name the molecule to the right:





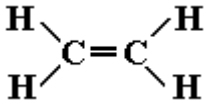
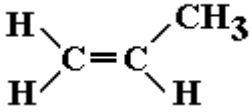
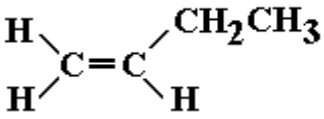
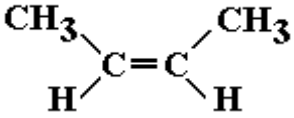




Unit 2, Lesson 02: The Alkenes and Alkynes

Alkenes are defined as open-chain hydrocarbons that contain at least one _____ (_____).
Alkynes are defined as open-chain hydrocarbons that contain at least one _____ (_____).
Because they contain less than the maximum number of hydrogen atoms, they are called "_____" hydrocarbons.

Naming for alkenes and alkynes is generally the same as for the alkanes, but with two changes:
1. the position of the double or triple bond(s) is included in the name, and
2. the suffix (ending) of the name is changed to _____ for alkenes or _____ for alkynes

Structural formula	Molecular formula	Condensed formula	Stick diagram	IUPAC name
			N/A	
				
				
				

Note:
- For the first two examples, the naming rules require that double bond will be found on the _____ carbon. Because the position of the double bond is known, no position number is needed in the name.
- For the second two examples, the double bond can be found in different positions. These molecules are _____ of each other (they have the same _____ formulas but different structural formulas). The position of the double bond is indicated with a position number.

Similarly, a five-carbon alkene (C_5H_{10}) is called _____
- a six-carbon alkene (C_6H_{12}) is called _____
- a seven-carbon alkene (C_7H_{14}) is called _____
- a eight-carbon alkene (C_8H_{16}) is called _____

The general molecular formula for an alkene is

The alkenes are a **homologous series**: a family of hydrocarbons that differ only in the # of _____ groups.

If an alkene contains only one double bond, it is _____ (mono means "one")

If an alkene contains two or more double bonds, it is _____ (poly means "many")
- the name of poly-unsaturated alkenes includes the position numbers of all double bonds. The suffix at the end of the base name is changed to indicate the number of double bonds

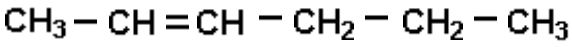
eg. a six carbon chain with double bonds on C-1 and C-3 would be named _____

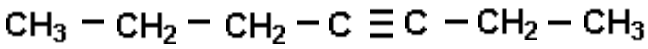
To name alkenes**:**

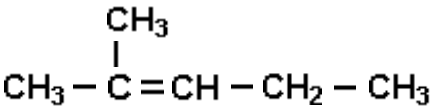
1. Identify the longest continuous hydrocarbon chain that contains the double bond(s). The number of carbon atoms in this chain determines the base-name of the hydrocarbon.
2. The double bond gets priority in naming- the carbon chain is numbered in the direction that will give the double bond the lowest possible number (then number any side chains accordingly).
3. If the double bond is the same distance from both ends, number in the direction that will give the side chains the lowest overall position numbers.
4. The ***suffix*** of the base name tells us how many double bonds there are:

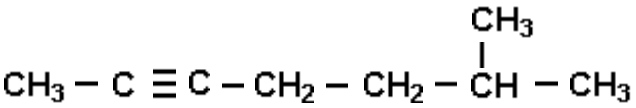
- If there is one double bond, the suffix of the base name is "…_____"
- If there are two double bonds, the suffix of the base name is "…_____"
- If there are three double bonds, the suffix of the parent name is "…_____" etc

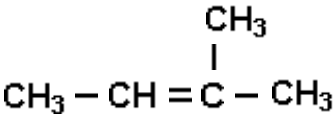
5. Use the same naming rules for side chains (alkyl groups) that were discussed for the alkanes. Combine the numbers and names of all side chains with the parent name to form one word. Use hyphens to separate numbers from names. Use commas to separate numbers.

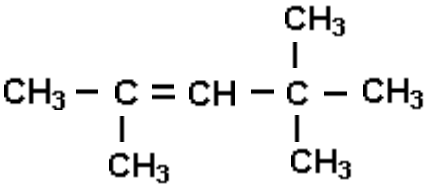


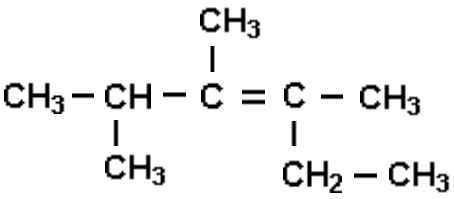


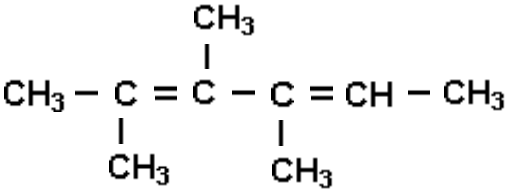


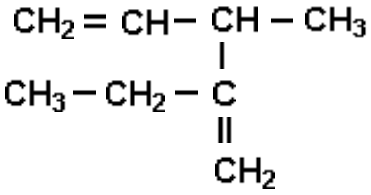


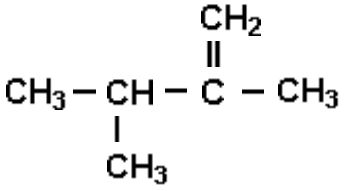








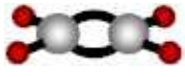




Geometric Isomers of Alkenes (cis-trans)

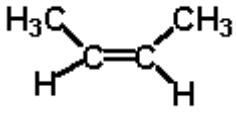
Atoms can rotate around a single bond, so all positions around are a single bond are _____. Alkanes do not form geometric isomers.

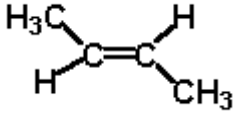
Atoms can **not** rotate around a double bond. Double bonds "lock" the molecule into a certain arrangement.



If the largest side chains of an alkene are "locked into" the same side of the double bond, then the molecule is called the "_____" isomer. Most molecules in living systems are "_____" isomers.

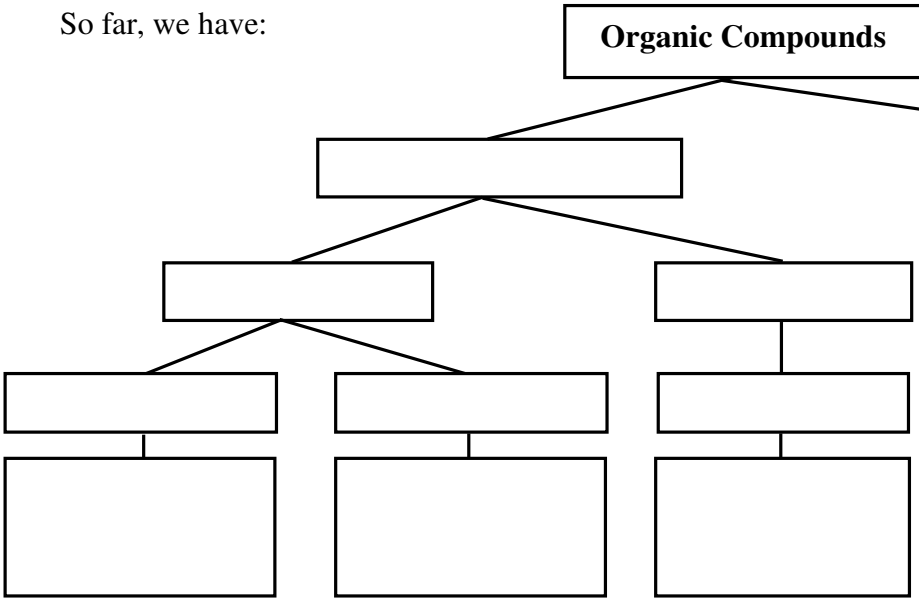
If the largest side chains of an alkene are "locked into" opposite sides of the double bond, then the molecule is called the "_____" isomer.

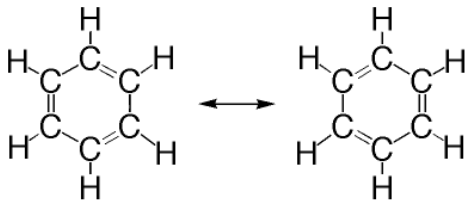




You can only identify cis/trans isomers if you are given an expanded structural formula.

So far, we have:





benzene rings (resonance structures)

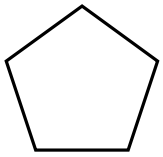
Unit 2, Lesson 03: Cyclic and Aromatic Hydrocarbons

Aliphatic hydrocarbons are hydrocarbons that do not contain a _____

- include both acyclic (straight chain) and "cyclic" hydrocarbons

Cycloalkanes are aliphatic, saturated hydrocarbons that are joined in a ring-structure

- formation of a ring structure is called _____
- commonly drawn using stick diagrams, each "corner" represents one carbon atom
- have the general molecular formula _____

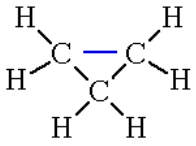


cyclopentane

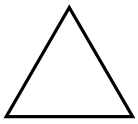
To name a cycloalkane:

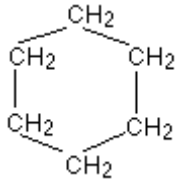
1. the number of carbon atoms in the ring structure determines the base name of the molecule. The name begins with _____:
   eg. a seven carbon ring is _____, a nine carbon ring is _____
2. name the side chains attached to the ring structure

- if there is only one side chain present, no position number is needed because all of the carbon atoms in the ring are considered to be equivalent
- if there is more than one side chain present, number the carbons in the ring according to the priority of the side chain. The longest side chain has the highest priority so it should get the _____ number. Number the ring in whichever direction will give the lowest numbers overall.

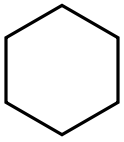


or

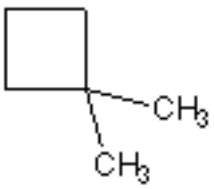


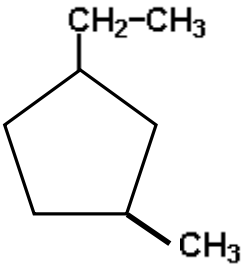


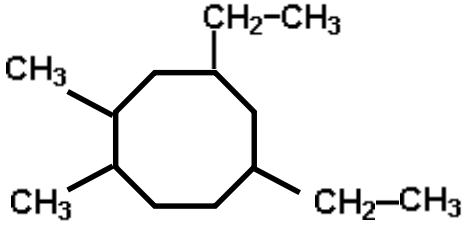
or



_____ _____

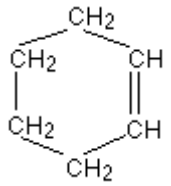


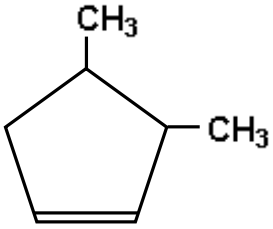


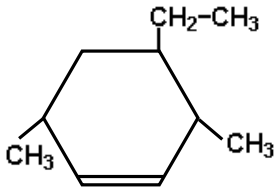


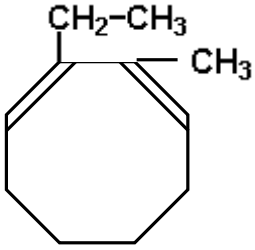
Cycloalkenes are aliphatic hydrocarbons that are joined in a ring-structure and contain at least one _____ (but are not _____)

- cycloalkenes are named according to the number of carbon atoms in the ring structure and are named "cyclo___ene"
- the carbon with the double bond is **ALWAYS** position number ____. When there is only one double bond, the position number does not need to be included in the name (it is on _____)
- positions of side chains are indicated relative to the double bond (_____). Number the ring in whichever direction will give the side chains the lowest position numbers overall
- cycloalkenes with two double bonds are named "cyclo_____diene". Position numbers for both double bonds must be given if a cycloalkene has more than one double bond



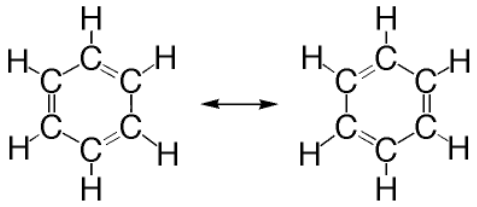






Aromatic Hydrocarbons are organic molecules that contain a _____ ring structure

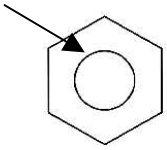
- benzene compounds often have _____ or "aromas", which is why they are called "aromatic"
- benzene is a ____-carbon ring that contains ____ double bonds, its molecular formula is _____
- the C – C bond length half-way between the length of a single and double bond ( )
- because of the double bonds, it forms a _____. The electrons in the double bonds move rapidly in an "_____" above and below the molecule
- the molecule is _____ (planar) and it is an extremely stable structure
- the benzene ring can be represented many ways:



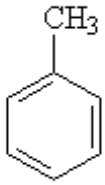
or

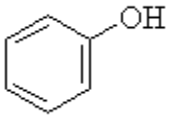
or

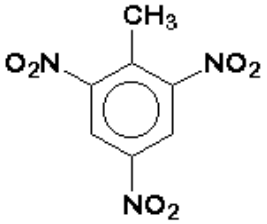
the circle represents the "electron cloud" resonance structures



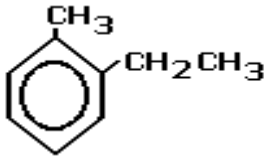
The hydrogen atoms on the benzene ring can be replaced with other groups, including alkyl side chains, hydroxyl groups, halogens and many others.

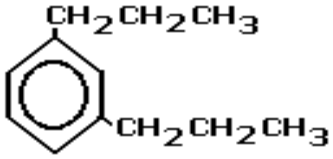


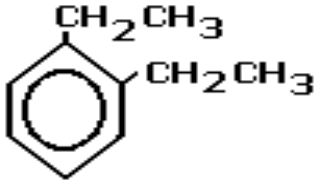




To name an aromatic compound using the IUPAC system, follow the same rules for cycloalkanes, but use _____ as the base name.

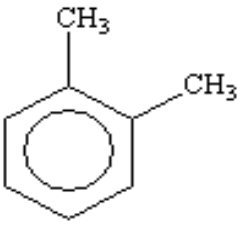


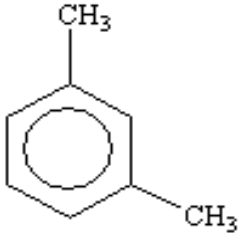


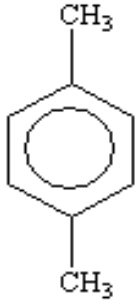


When there are two side chains attached to a benzene ring, the position of the side chains relative to one another can be indicated either using position numbers or using an older system:

- If the side chains are on C – 1 and C – 2, then the prefix _____ can be used
- If the side chains are on C – 1 and C – 3, then the prefix _____ can be used
- If the side chains are on C – 1 and C – 4, then the prefix _____ can be used







Physical Properties of Hydrocarbons

Hydrocarbons contain only carbon and hydrogen atoms, with no lone pairs, so they are all _____:

- they have only _____ between molecules, which are _____
- they are _____ in water (which is _____)
- they are soluble in _____ solvents (such as _____, _____)

1. As the length of the carbon chain increases, the melting and boiling points _____ because the London dispersion forces between molecules _____

   C_1-C_4 alkanes are _____ C_5-C_{16} alkanes are _____ C_{16}-C_{24} are _____

2. As branching increases, melting and boiling points _____
   because the molecules can not line up nicely beside one another,
   so LDFs _____

3. As the number of double bonds increases, the melting and boiling points _____
   - double bonds introduce a _____ in the carbon chain that makes the molecule "_____"

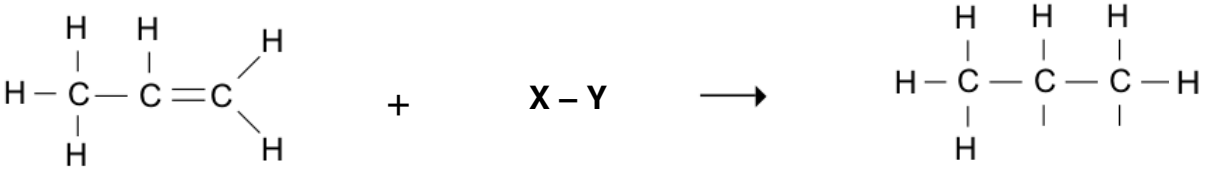
because of the "kinks", alkene molecules do not pack together as well as alkanes, so they have lower London dispersion forces and therefore, _____ melting and boiling points than alkanes

Unit 2, Lessons 04 and 05: Reactions of Hydrocarbons

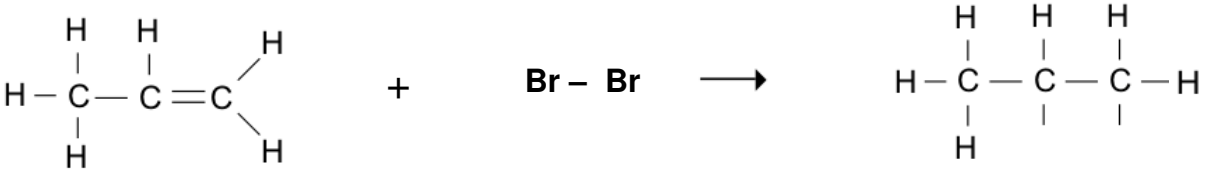
Summary of reactions of hydrocarbons:

1. all hydrocarbons undergo combustion reactions
2. alkanes are the least reactive and can undergo **substitution** reactions with HF, Cl_2 and Br_2
3. aromatics are in between alkanes and alkenes in reactivity and can undergo **substitution** reactions with halogens in the presence of $FeBr_3$ catalyst
4. alkenes are very reactive and can undergo **addition** reactions as follows:

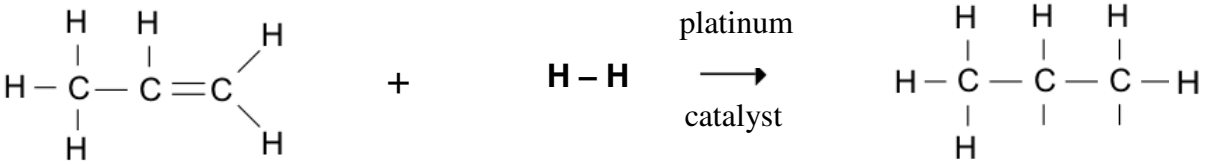
General addition reaction:



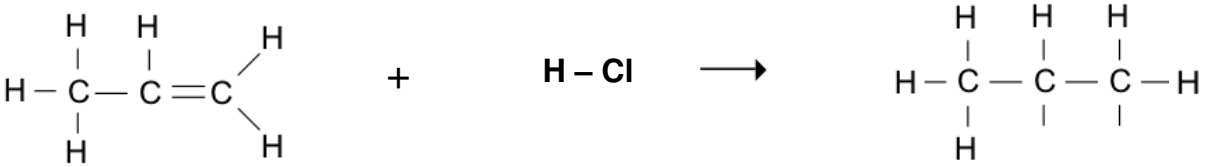
a) addition of halogens (_____):



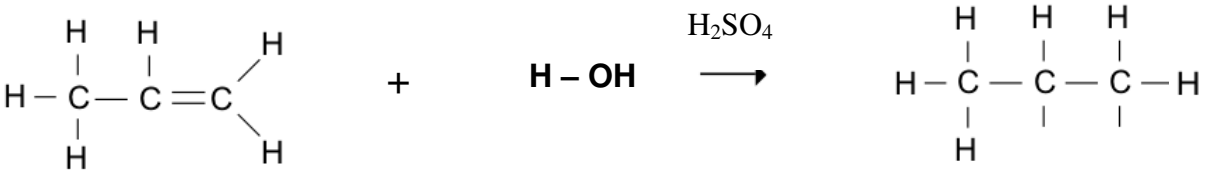
b) addition of hydrogen (_____):



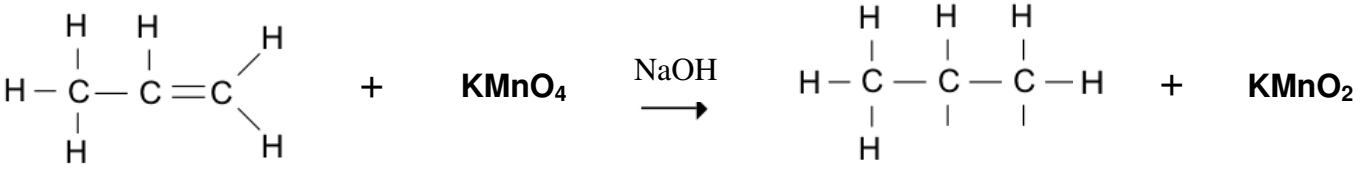
c) addition of hydrogen halides (HCl, HF, HBr, HI). Follows **Markovnikov's Rule**: when hydrogen halides or water are added across a double bond, the hydrogen atom is added to whichever carbon atom has the _____ hydrogen atoms already ("the _____ get _____")



d) addition of water (_____, follows Markovnikov's Rule):



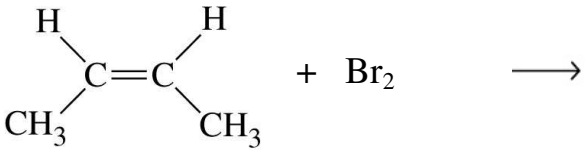
e) slow oxidation with an oxidizing agent, [O], such as $KMnO_4$:



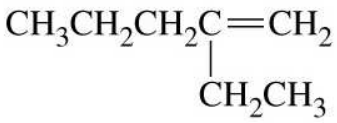
Unit 2, Lessons 04 and 05: Homework on Chemical Reactions of Hydrocarbons

Homework:

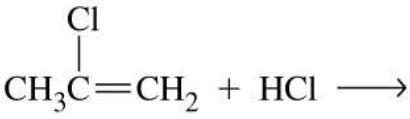
1. Read pages 57 – 60 and 65 – 70.
2. On page 68, do questions 7 and 8
3. Draw the products of the following reactions. Use Markovnikov's Rule where applicable.

a)  + Br_2 ⟶

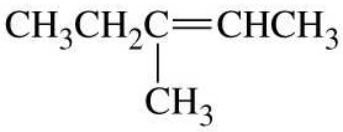
b) $CH_3CH_2CH{=}CH_2$ + $KMnO_4$ $\xrightarrow{NaOH}$

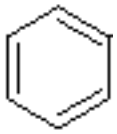
c)  + H_2 $\xrightarrow{Pt\ catalyst}$

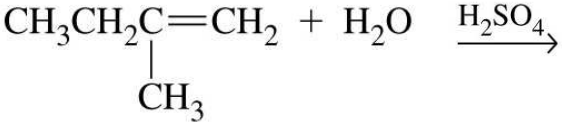
d) $CH_3CH_2CH_2CH_3$ + HF $\xrightarrow{\lambda}$

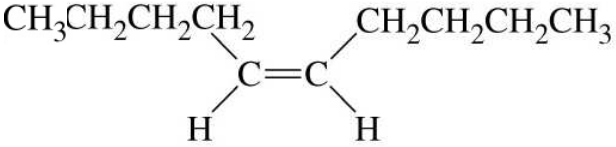
e) 

f) $CH_3CH{=}CH_2 + H_2O \xrightarrow{H_2SO_4}$

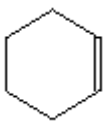
g)  + $KMnO_4$ $\xrightarrow{NaOH}$

h)  + Br_2 $\xrightarrow{FeBr_3}$

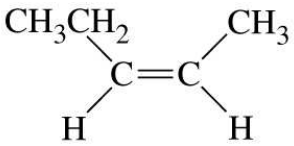
i) 

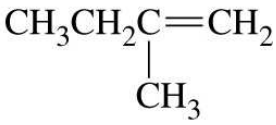
j)  + Br_2 ⟶

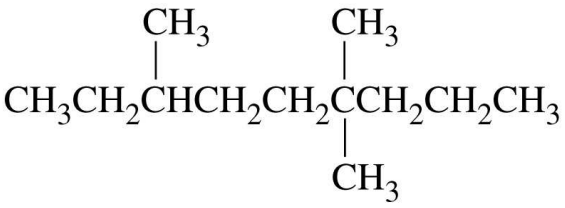
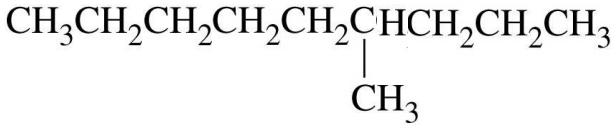
k) $CH_3CH_2{-}C{\equiv}C{-}CH_2CH_2CH_3$ + Cl_2 (excess) ⟶

l)  + Br_2 ⟶

4. Which of the following pairs of molecules will have a higher melting point? Explain for each pair.

a)  or $CH_3CH_2CH_2CH_2CH_3$

b)  or $CH_3CH_2CH_2CH_2CH_3$

c)  or 

d) $CH_3CH_2CH_2CH_2CH_2CH_2CH_3$ or $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_3$

5. Write the balanced chemical reactions for the combustion of the following hydrocarbons. Include the states of all reactants and products.

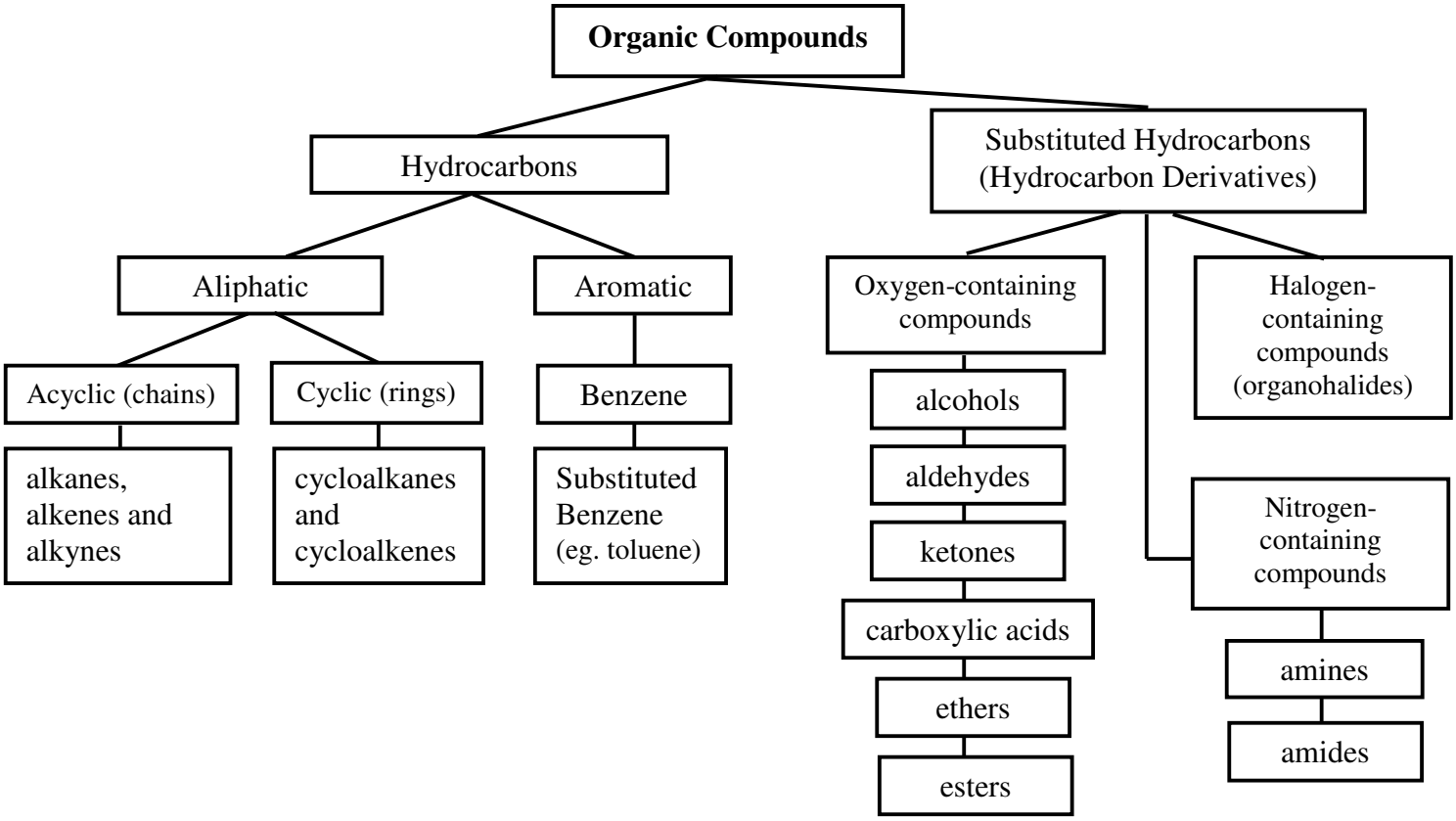
a) octane
b) 2-pentene
c) cyclopropane
d) 3-heptyne

6. Arrange the following compounds in order of increasing reactivity. Explain why you put them in this order:

a) cyclohexene
b) cyclohexane
c) benzene

7. Describe two different chemical tests you could perform to distinguish between butane and 1-butene. What are three different physical properties of these substances that could be used to distinguish them?

Unit 2, Lesson 08: Classification of Organic Compounds



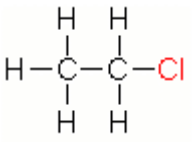
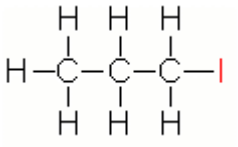
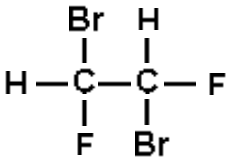
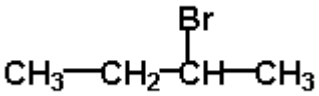
Definitions

Hydrocarbons: molecules that contain only carbon and hydrogen	**Substituted Hydrocarbons (Hydrocarbon Derivatives)**: contain carbon, hydrogen and at least one other element (O, N, S or a halogen)
Aliphatic: hydrocarbons that do not contain a benzene ring	**Alcohols**: substituted hydrocarbons that contain a hydroxyl (-OH) functional group (R – OH)
Aromatic: hydrocarbons that contain a benzene ring	**Aldehydes**: substituted hydrocarbons that contain a C = O group on a terminal carbon (R = CHO)
Acyclic: (the prefix "a" means without) open chain hydrocarbons that do not contain a ring structure	**Ketones**: substituted hydrocarbons that contain a C = O group on a non-terminal carbon (R – CO – R')
Cyclic: hydrocarbons that contain a ring structure (but not a benzene ring)	**Carboxylic Acids:** substituted hydrocarbons that contain a -COOH (carboxyl) group (R – COOH)
Alkanes: open chain hydrocarbons that do not have any double or triple bonds; they are saturated	**Ethers**: substituted hydrocarbons that contain a C – O – C functional group (R – O – R')
Alkenes: open chain hydrocarbons that contain at least one carbon-carbon double bond; they are unsaturated	**Esters**: substituted hydrocarbons that contain a – COO functional group (R – COO– R')
Alkynes: open chain hydrocarbons that contain at least one carbon-carbon triple bond; unsaturated	**Amines**: substituted hydrocarbons that contain a - NH_2 (amine) functional group (R – NH_2)
Cycloalkanes: saturated hydrocarbons that contain a carbon ring structure, but not a benzene ring	**Amides**: substituted hydrocarbons that contain a - CON functional group (R – CO – N – R')
Cycloalkenes: alkenes that contain a carbon ring structure, but not a benzene ring	**Organohalides**: substituted hydrocarbons that contain one or more halogen atoms (eg. R – Cl or R – Br)

Unit 2, Lessons 08 and 09: Substituted Hydrocarbons

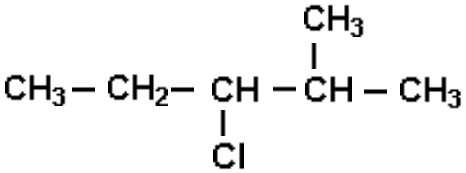
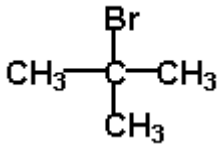
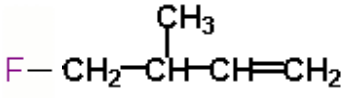
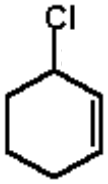
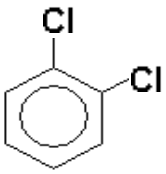
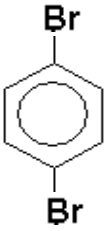
1. **Alkyl Halides** (also known as _____)

- contain one or more halogen atoms (_____) attached to an alkyl (hydrocarbon) chain
- abbreviated _____, where _____ is a halogen atom

Naming Rules for Alkyl Halides:

- number the alkyl chain so that the halogen atoms have the lowest possible position numbers
- name the halogen atoms in alphabetical order. Change the ending of the halogen from _____ to "___" (eg. bromine becomes _____, chlorine becomes _____, iodine becomes _____)
- indicate how many of each type of halogen are present with the prefixes _____
- if a molecule also has alkyl side chains (methyl, ethyl etc), name these side chains in alphabetical order along with the halogens, include their position numbers
- name the parent alkyl molecule
- if the molecule is an alkene or alkyne, the double or triple bond gets _____ in naming. The multiple bond is assigned the _____ possible position number

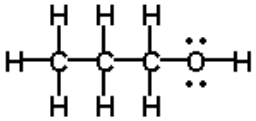







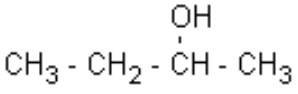
Physical Properties of Alkyl Halides:

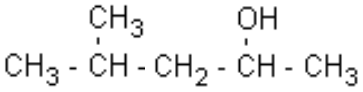
- the addition of halogens makes the molecule _____, but the degree of polarity depends on which halogen is present
- the F – C bond is significantly _____, so fluoro-hydrocarbons are _____ in water and their melting and boiling points are significantly _____ than their parent alkane
- CFCs (_____) such as _____ destroy _____
- other alkyl halides (chloro, bromo and iodo) are only _____, so they are only _____ miscible in water and their melting and boiling points are only _____ _____ than their parent alkane
- because they are polar, many alkyl halides are _____ at SATP (small molecules are _____)
- the longer the alkyl chain ("R"), the _____ the solubility in water

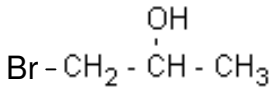
2. Alcohols

- contain one or more _____ (_____) functional groups
- abbreviated _____

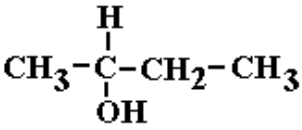
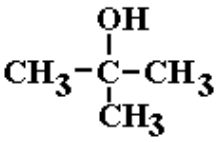






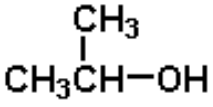


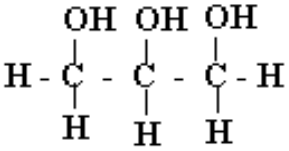
Alcohols may be classified as primary ( ), secondary ( ) or tertiary ( ) alcohols:

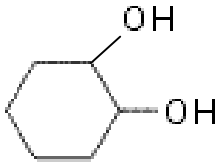
A primary (1°) alcohol:	**A secondary (2°) alcohol:**	**A tertiary (3°) alcohol:**
		
– OH group is attached to a carbon that is attached to ____ other carbon atom	– OH group is attached to a carbon that is attached to ____ other carbon atoms	– OH group is attached to a carbon that is attached to ____ other carbon atoms

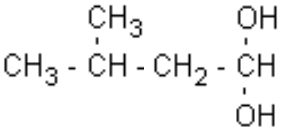
Naming Rules for Alcohols:

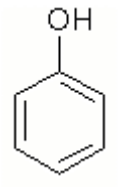
- the base name is determined by the longest carbon chain that includes the _____ group
- remove the "e" from the hydrocarbon base name and add the suffix _____ (_____)
- number the alkyl chain to give the hydroxyl group(s) the _____ possible position numbers
- name any halogen atoms and alkyl side chains in alphabetical order, include their position numbers
- indicate the position number of the – OH group(s), except for cyclic structures with only one – OH
- if there are two hydroxyl groups, add the suffix _____ to the end of the alkane base name
- if there are three hydroxyl groups, add the suffix _____ to the end of the alkane base name

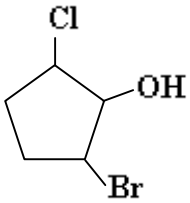








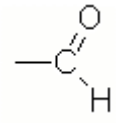




Physical Properties of Alcohols:

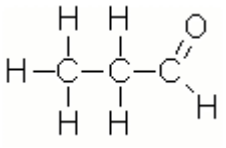
- the – OH group is _____ and is capable of _____, so:
  - alcohols are _____ in water
  - most alcohols are _____ at SATP
  - alcohols have relatively _____ melting points
- the longer the alkyl chain ("R"), the _____ the solubility in water

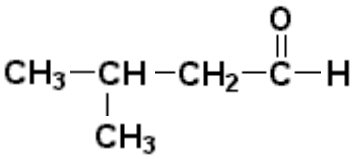
3. Aldehydes

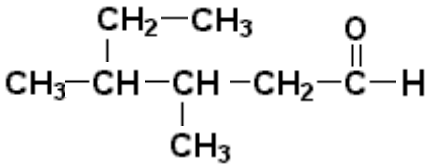


- have a _____ group (_____) on a primary carbon (the _____ carbon of a carbon chain)
- abbreviated _____
- do not confuse aldehydes (_____) with alcohols (_____)

e.g.





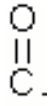


Naming Rules for Aldehydes:

- the aldehyde group is always the _____ carbon, so _____ position number is needed
- the base name is determined by the longest carbon chain that begins with the _____ group
- remove the "e" from the base name; add the suffix _____ (_____)
- the chain numbering starts from **and includes** the **C**HO carbon atom of the aldehyde group
- name any side chains in alphabetical order and give their position numbers

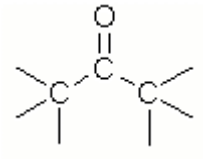
4. Ketones

- a ketone is an organic molecule that has a _____ group (_____) on a _____ (non-terminal) carbon of a carbon chain
- abbreviated:



or R – CO – R'

R— C— R'



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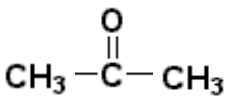
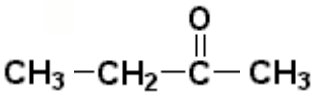
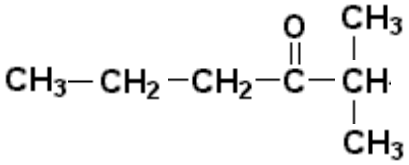
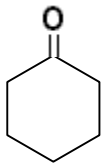








Naming Rules for Ketones:

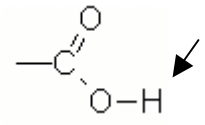
- the base name is determined by the longest carbon chain that contains the carbonyl (_____) group
- remove the "e" from the base name; add the suffix _____ (_____)
- number the carbon chain so that the carbonyl group has the _____ possible position number
- if the location of the carbonyl group is ambiguous, identify its position number
- name any other side chains in alphabetical order, include their position numbers

Physical Properties of Aldehydes and Ketones:

- the C = O group is _____, but there is no _____, so:
  - aldehydes and ketones are generally _____ in water
  - many aldehydes and ketones are _____ at SATP
  - aldehydes and ketones have relatively _____ melting and boiling points
- the longer the alkyl chain, the _____ the solubility in water

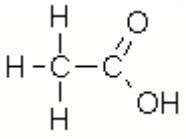
5. Carboxylic Acids

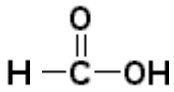
- a carboxylic acid is an organic molecule that has one or more _____ groups on an alkyl chain

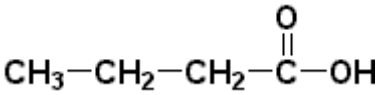


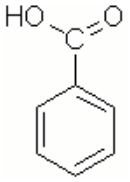
- abbreviated _____

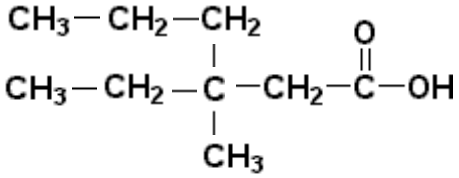
eg.

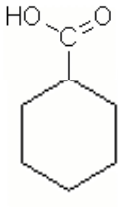












Naming Rules for Carboxylic Acids with one Carboxyl Group:

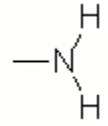
- the base name is determined by the longest carbon chain that begins with the _____
- remove the "e" from the base name; add the suffix _____
- the carboxyl group (- COOH) is always _____, so _____ position number is needed
- the chain numbering starts from and includes the C<u>O</u>OH carbon atom of the carboxyl group
- name any side chains in alphabetical order and give their position numbers

Physical Properties of Carboxylic Acids:

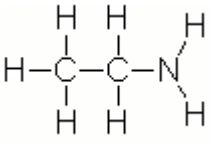
- the carboxyl group is _____ and capable of _____, so:
  - carboxylic acids are very _____ (_____) in water
  - are _____ or soft _____ at SATP
  - have relatively _____ melting and boiling points
- the longer the alkyl chain, the _____ the solubility in water

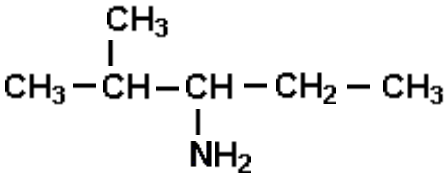
6. Amines

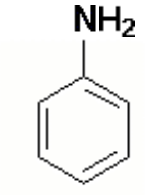
- an amine is an organic molecule that contains at least one _____(_____) group, bonded to an alkyl chain

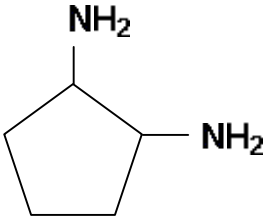


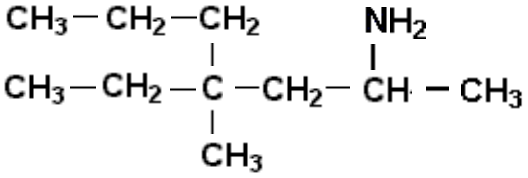
- abbreviated _____
- for the purposes of this course, we will discuss only primary amines











Naming Rules for Primary Amines:

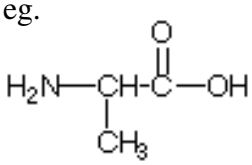
- are very similar to the naming rules for alcohols
- the base name is determined by the longest carbon chain that contains the _____ group
- remove the "e" from the base name; add the suffix _____
- include a position number to indicate the location of the amine group on the alkyl chain
- if there are other side chains or groups, name them in alphabetical order and indicate their position numbers

Physical Properties of Amines:

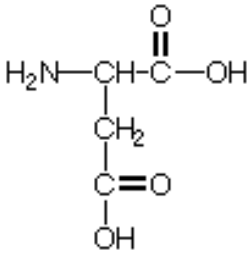
- primary amines are _____ and capable of _____, so
  - amines are generally _____ in water
  - are _____ at SATP
  - have relatively _____ melting and boiling points (but not as high as _____)
  - amines often have distinctive _____ odours
- the longer the alkyl chain, the _____ the solubility in water

FYI: In biology, you have discussed amino acids. These are organic molecules that have at least one amine and at least one carboxylic acid group. They are known by their common (not IUPAC) names:

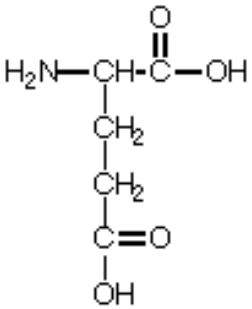
eg.



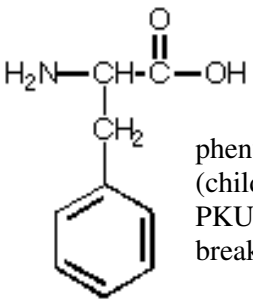
alanine



aspartate
(combined with phenylalanine to make aspartame or "Nutrasweet")



glutamate
(part of MSG)



phenylalanine
(children with PKU can not break this down)

Unit 2, Lesson 10: Reactions of Alcohols

Functional groups are groups of atoms that are chemically bonded together in a specific arrangement.

- functional groups give a molecule predictable _____ and _____ properties
- the alcohol functional group (_____) undergoes many types of reactions:

1. Combustion reactions (rapid oxidation) of alcohols:

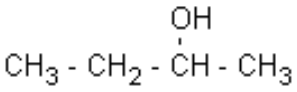
- produce _____ and _____

CH_3OH (l) + O_2 (g) →

$CH_3CH_2CH_2OH$ (l) + O_2 (g) →

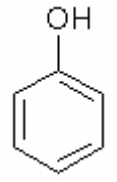
2. Substitution reactions of alcohols:

- the –OH group is _____ by another functional group (eg. a halogen, amine or nitro group)



+ HBr (aq) →

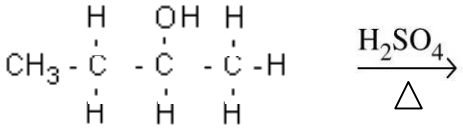
+ NH_3 (g) →

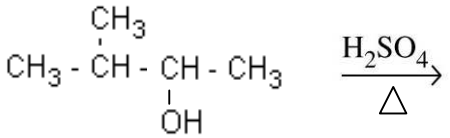


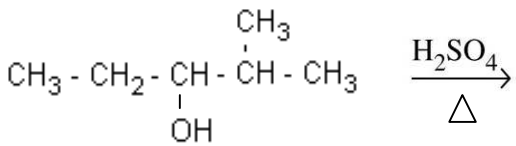
+ HNO_2 (aq) →

3. Elimination reactions of alcohols:

- the reverse of _____ reactions
- _____ is removed and a _____ is formed
- because water is removed, these reactions can also be classified as _____ reactions
- Markovnikov's Rule applies in reverse: "the _____ get _____". The carbon atom with the _____ H atoms that is adjacent to the –OH group will _____ its H atom to form the double bond







4. Oxidation reactions of alcohols with an oxidizing agent [O]

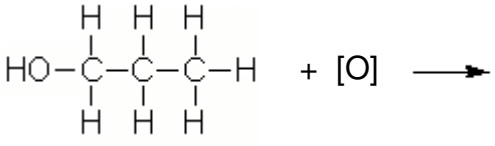
- oxidation has occurred if:
  - i) a carbon atom forms _____ bonds with oxygen atoms (including the formation of _____ double bonds, this counts as a carbon atom with _____ bonds to oxygen)
  - ii) a carbon atom ends up with _____ bonds to hydrogen atoms

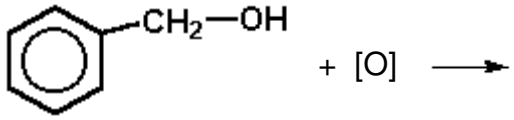
- reduction has occurred if:
  - i) a carbon atom forms _____ bonds with oxygen atoms
  - ii) a carbon atom ends up with _____ bonds to H atoms

- each class of alcohol (_____) undergoes different oxidation reactions
- common oxidizing agents _____ include: _____
- you do not need to balance these reactions

a) Oxidation of primary alcohols:

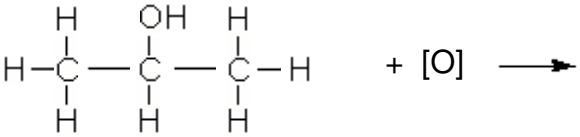
- the –OH group is attached to a carbon atom that is attached to _____ other C atom
- the reaction occurs in two steps:

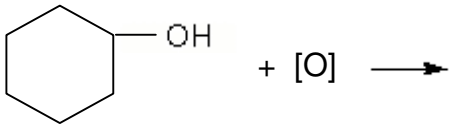




b) Oxidation of secondary alcohols:

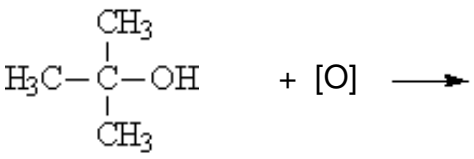
- the –OH group is attached to a carbon atom that is attached to _____ other C atoms
- occurs in only one step:





c) Oxidation of tertiary alcohols:

- the –OH group is attached to a carbon atom that is attached to _____ other C atoms
- _____ oxidation reaction occurs

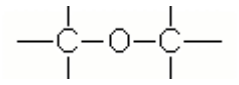


5. Condensation Reactions:

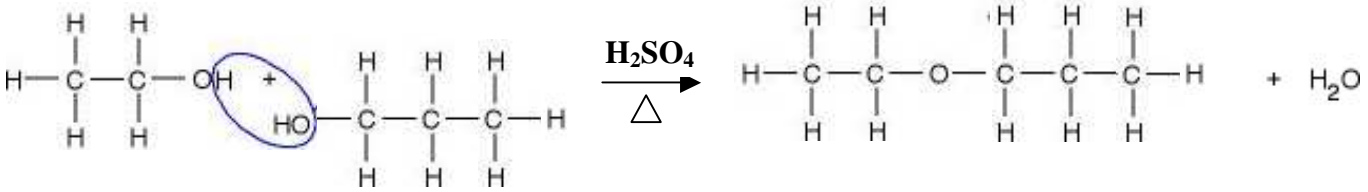
- condensation reactions occur when _____ molecules combine to form _____
- a molecule of _____ is released, so these reactions are also _____ reactions

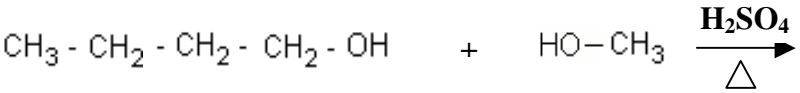
a) Formation of Ethers

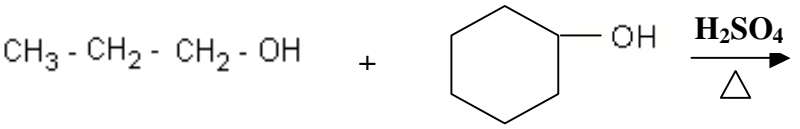
- two _____ molecules condense (combine) to form an _____ and a molecule of _____
- the ether functional group is drawn structurally as:



or **R'— O — R**, where R and R' are alkyl groups

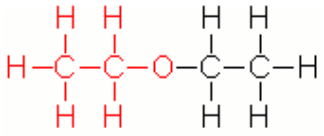


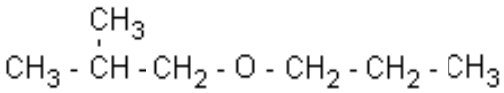


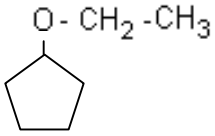


Naming Rules for Ethers:

1. look at the two alkyl (R) groups that are attached to the oxygen atom
2. the base name for the molecule comes from the _____ R group
3. treat the shorter alkyl chain and the oxygen atom as one group. Change the "yl" suffix of the alkyl group to "_____" (methyl becomes _____, ethyl to _____, propyl to _____)
4. treat the ether group as just another side chain on the larger alkyl chain. Name it, along with any other side chains, in alphabetical order. Include position numbers as needed.
5. the ether group has the _____ priority as a alkyl side chain







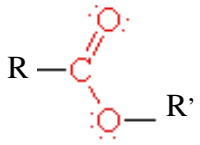
Physical Properties of Ethers:

- the C – O – C group bent, so it is _____, but there is no _____ so:
  - ethers are generally _____ in water
  - many ethers are _____ or _____ at SATP
  - because the O atom is "buried" in the middle of the molecule, ethers are only slightly more polar than the alkanes, so the have very _____ melting and boiling points
- the longer the alkyl chains, the _____ the solubility in water

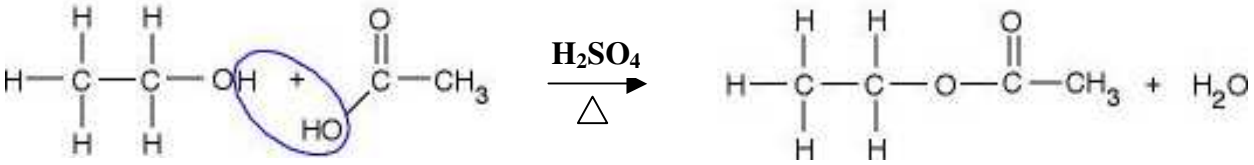
5. Condensation Reactions:

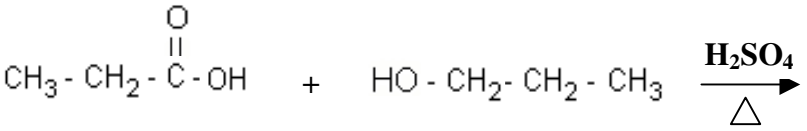
b) Formation of Esters

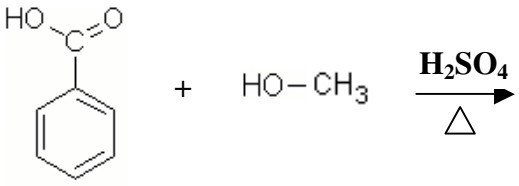
- an _____ and a _____ condense (combine) to form an _____
- a molecule of _____ is released, so these reactions are also _____ reactions
- the ester functional group is drawn structurally as:



or **R— COO — R'** where R and R' are alkyl groups
(R could be hydrogen in the case of methanoic acid)

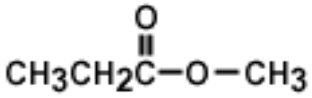


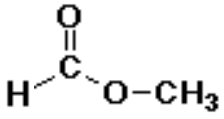


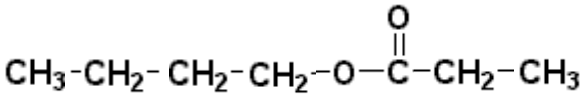


Naming Rules for Esters:

1. identify the carboxylic acid portion of the molecule; this contains the _____ group
2. name the carboxylic acid according to the number of carbons (including the C=O carbon). Change the ending of the carboxylic acid from "oic acid" to "_____". The "oate" suffix indicates an _____.
3. identify the alkyl group that is attached to the oxygen atom. Name this alkyl group.
4. combine the names of the alkyl group and the carboxylic acid (ending in "oate"). The name of the alkyl group comes first and is separated from the second word by a space.



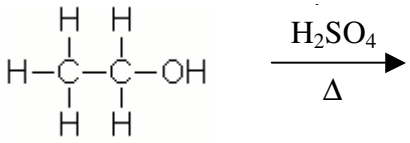
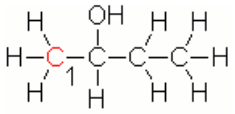
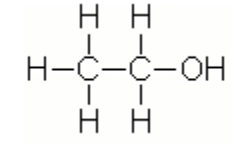
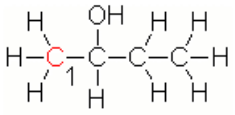
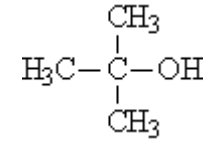
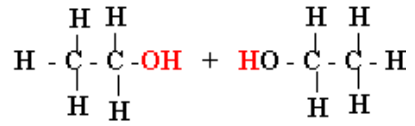
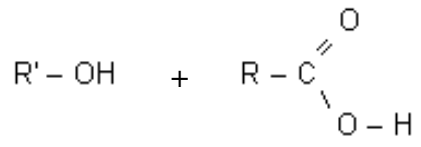




Physical Properties of Esters:

- the C – O – C and C = O groups are _____, but there is no _____ so:
  - esters are generally _____ in water
  - many esters are _____ at SATP
  - because the C = O (carbonyl) group is exposed, the melting and boiling points of esters are slightly higher than the corresponding ether
  - many esters have distinctive _____ odours and are used for flavourings
- the longer the alkyl chains, the _____ the solubility in water

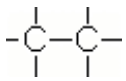
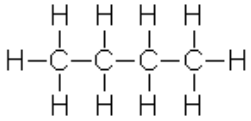
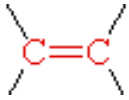
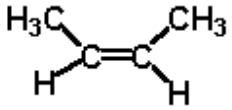
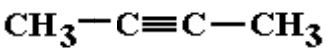
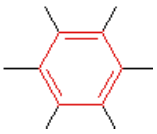
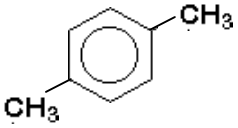
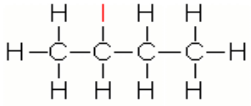
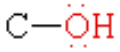
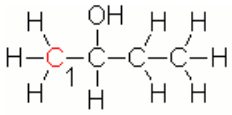
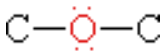
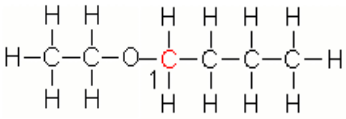
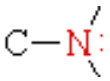
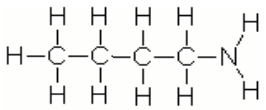
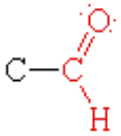
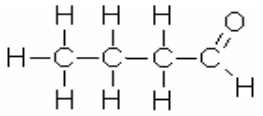
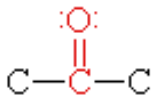
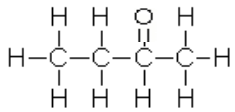
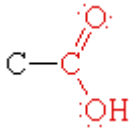
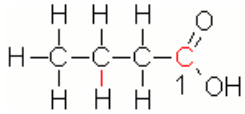
Unit 2, Lesson 10: Summary of Reactions of Alcohols

Reactants and/or Reaction Conditions	Products	Type of Reaction	How to Recognize this type of reaction
An alcohol 			
Any alcohol and a halide  + HI			
A primary alcohol  + [O] What is [O]? Give two examples			
A secondary alcohol  + [O]			
A tertiary alcohol  + [O]			
An alcohol and an alcohol 			
An alcohol and a carboxylic acid 			

Unit 2, Lesson 13: Homework on Polymers

1. Read pages 81 – 84 and 88 – 92.
2. Define: polymer, monomer.
3. Give three examples of synthetic (man-made) polymers. Identify the monomer from which each synthetic polymer is made.
4. Define addition polymerization. What functional group must the monomer have in order to form an addition polymer?
5. Define condensation polymer. What two types of bonds hold condensation polymers together?
6. Draw an amide bond.
7. What is the common name for a condensation polymer that contains amide bonds (an amine bonded to a carboxylic acid)?
8. What is the common name for a condensation polymer that contains ester bonds (an alcohol bonded to a carboxylic acid)?
9. What type of bond (linkage) holds glucose molecules together to form the starch polymer? (page 90 or 91)
10. On pages 84 – 85, do questions 18, 19, 20a,b,c, 21
11. On page 95 – 96, do questions 1, 2, 3a

Summary Chart: Functional Groups and their Properties

Type of Compound	Functional Group	Example with Structural Formula & Name	Notes and Properties
Alkane			
Alkene			
Alkyne			
Aromatic			
Alkyl Halide			
Alcohol			
Ether			
Primary Amine			
Aldehyde			
Ketone			
Carboxylic Acid			
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