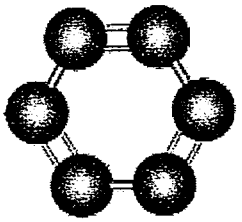
Basic Organic Nomenclature Packet

Chemistry Level II



Benzene
C_6H_6

Name:_____

Period:_____

Use this packet and your book to answer the questions throughout this packet.

Organic Nomenclature - Alkanes, Alkenes, Alkynes

Naming organic compounds can be a challenge to any chemist at any level. Historically, chemists developed names for new compounds without any systematic guidelines. In this century, the need for standardization was recognized. For simple molecules, the nomenclature system worked out by the International Union of Pure and Applied Chemists (IUPAC) works well. For complex molecules, the IUPAC names are so long that no one in their right mind would use them. The net result is that a hodgepodge of IUPAC names and historic or common names is used. Any one compound may have five or six different names.

So, what we want to accomplish in this module is simply to establish the fundamentals of the IUPAC system and apply them to naming **alkanes, alkenes and alkynes**. These groups are **hydrocarbons**, compounds made of the elements carbon and hydrogen.

Numerical Prefixes = Number of Backbone Carbon Atoms

The prefix in the name of an organic molecule indicates the number of carbon atoms found in the longest continuous chain of carbon atoms in the molecule. You need to memorize the following prefixes:

Prefix	# C atoms
meth-	1
eth-	2
prop-	3
but-	4
pent-	5
hex-	6
hept-	7
oct-	8
non-	9
dec-	10

Alkanes = -ane ending

The alkanes are the least complex hydrocarbons. The alkane family uses the *prefix for the number of carbon*s and an *-ane ending*. An alkane can be recognized by its general formula, C_nH_{2n+2}, where n is the number of carbon atoms in the compound. For example, C_5H_{12} has five carbon atoms pentane. Each member of the alkane family differs from the next by a $—CH_2—$ group, and all the carbons are connected by single bonds.

Example 1:

Name the following compounds:

a. CH_4
b. C_2H_6 or CH_3CH_3
c. C_3H_8 or $CH_3CH_2CH_3$
d. C_4H_{10} or $CH_3\ CH_2CH_2CH_3$

Solution 1:

All of the formulas fit into general formula, C_nH_{2n+2}, therefore the bonds in these compounds are single bonds; they are alkanes. Use the numerical prefix for the number of carbon atoms with the -ane ending.

a. one C atom = methane
b. two C atoms = ethane
c. three C atoms = propane
d. four C atoms = butane

Alkenes = -ene ending

Hydrocarbons that contain multiple bonds are called **unsaturated hydrocarbons**. If the hydrocarbon has **one double bond**, its general formula will be C_nH_{2n}, where n is the number of carbon atoms in the compound. The alkene family uses the *-ene ending*. The double bond is stronger than a single bond, and the bond length between the carbon atoms is shorter in the double bond. It is also more reactive than a single bond since the π bond (the second pair of electrons) is farther from the nuclei.

Naming is a little bit more complex for alkenes than alkanes. Since the double bond could appear at various sites in a typical molecule, we have to specify where it is. To do so, number the carbon backbone so that the **lowest possible number** is used to describe the double bond position. The lowest number of the two C atoms involved in the double bond is used in front of the name to indicate the C=C position. The number is place at the beginning of the name and is separated with a dash.

In the expanded structure formulas shown below, it is understood that since H only forms one bond, any double bonds are between carbon atoms. The expanded structures give a bit more information about how many H atoms are attached to each C atom.

Example 2:

Name the following compounds.

a. C_2H_4 or $H_2C{=}CH_2$

b. C_3H_6 or $CH_3CH{=}CH_2$

c. C_4H_8 or $H_2C{=}CHCH_2CH_3$

d. C_4H_8 or $CH_3CH_2{=}CH_2CH_3$

e. C_5H_{10} or $CH_3CH_2CH_2CH{=}CH_2$

Solution 2:

a. 2 C atoms = ethene (since there are no options for the position of the C=C, we do not need to specify the position, as in 1-ethene)

b. 3 C atoms = propene (again, since there are no options for the position of the C=C, we do not need to specify 1-propene. Convince yourself that 1-propene and 2-propene are really the same molecule.)

c. 4 C atoms with the C=C after the #1 C atom = 1-butene

d. 4 C atoms with the C=C after the #2 C atom = 2-butene

e. 5 C atoms with the C=C after the #1 C atom = 1-pentene (Did you say 4-pentene? Remember that we want to number the backbone of C atoms so that the lowest numbers are used in the name. In this case, you want to number the C backbone from right to left. This same molecule could also be written $H_2C{=}CHCH_2CH_2CH_3$).

Alkynes = -yne ending

The alkyne family contains a **triple bond** between two C atoms. If the hydrocarbon has one triple bond, its general formula will be C_nH_{2n-2}, where n is the number of carbon atoms in the compound. The alkyne family uses the -yne ending. The triple bond is stronger than either the double or single bond, therefore it is also shorter and more reactive than the single or double bond.

Just as in the alkene family, the position of the triple bond is specified with a number at the beginning of the name.

Example 3:

Name the following compounds.

a. $CH{\equiv}CH$

b. $CH{\equiv}CCH_2CH_2CH_2CH_3$

c. $CH_3C{\equiv}CCH_2CH_2CH_3$

d. $CH_3CH_2C{\equiv}CCH_2CH_3$

e. $CH_3CH_2CH_2C{\equiv}CCH_3$

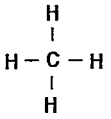
f. $CH_3CH_2CH_2CH_2C{\equiv}CH$

Solution 3:

a. 2 C atoms = ethyne (this compound is commonly known as acetylene)
b. 6 C atoms, triple bond after the #1 C atom = 1-hexyne
c. 6 C atoms, triple bond after the #2 C atom = 2-hexyne
d. 6 C atoms, triple bond after the #3 C atom = 3-hexyne
e. 6 C atoms, triple bond after the #2 C atom = 2-hexyne (number the backbone from right to left)
f. 6 C atoms, triple bond after the #1 C atom = 1-hexyne (number the backbone from right to left)

NOMENCLATURE Worksheet

Draw the following organic molecules like the example.

Methane: 

1. Ethane

2. Propane

3. Decane

4. Propyne

5. 3-Octyne

6. 1-Propene

7. 2-Nonene

8. Nonane

9. 4-Nonyne

10. 3-Hexene

11. How many ways can you write butene? Draw them.

12. Why is 6-decene not possible? What would it be called? Draw it.

Name the following compounds.

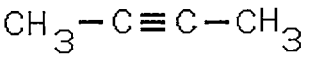
13. CH_3-CH_2-CH=CH-CH_2-CH_2-CH_3

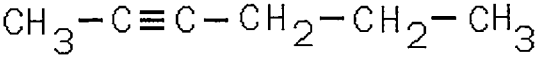
14. CH_3-CH=CH-CH_2-CH_2-CH_3

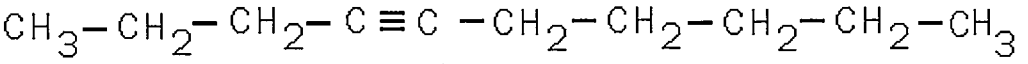
15. CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_3

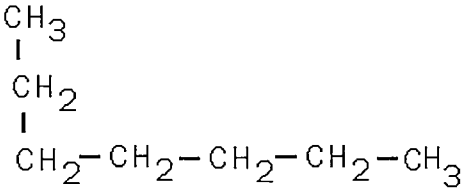
16. CH_3-CH_2-CH=CH-CH_2-CH_2-CH_2-CH_3

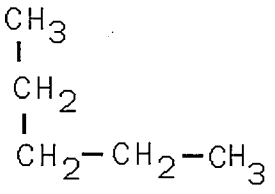
17. CH_3-CH_3

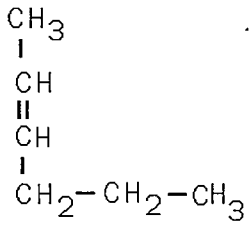
18. 

19. 

20. 

21. 

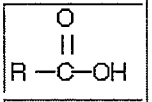
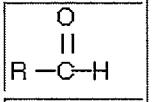
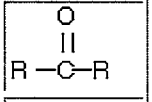
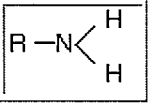
22. 

23. 

EXTRA CREDIT: Additional Enrichment:

Functional Groups and Nomenclature

A functional group in an organic molecule is an atom or a group of atoms that replaces a hydrogen atom in a hydrocarbon. These replacement groups are much more reactive than the hydrogen atom that was replaced. They give the molecule its functionality, or its reactivity. You need to memorize the names and structural formulas of the following functional groups. The R stands for the hydrocarbon that makes up the rest of the molecule.

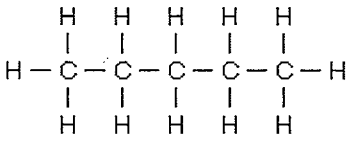
Name	Structure
alcohol	R - OH
carboxylic acid	
aldehyde	
ketone	
amine	

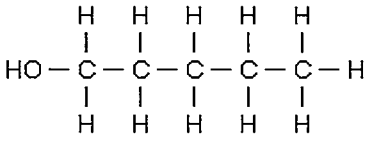
Naming Alcohols (-OH group) = -ol ending

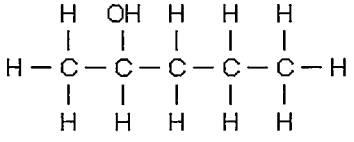
Alcohols are named just like alkanes, but with an **-ol ending.** You also need to put a number in front of the name, separated with a dash, to indicate which carbon atom the **-OH group** is attached to.

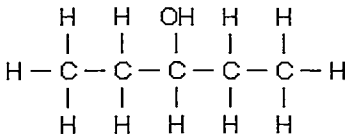
Example 1:

Name the following compounds.

a. 

b. 

c. 

d. 

Solution 1:

a. It contains only C and H with all single bonds => alkane. It contains 5 C atoms => pentane

b. It is pentane with one H on the #1 C replaced by -OH => 1-pentanol
(Since the -OH functional group bonds to the rest of the molecule through the oxygen atom, you will frequently see the alcohol functional group written backwards HO- to indicate the attachment through the O atom.)

c. It is pentane with the H on the #2 C replaced by -OH => 2-pentanol

d. It is pentane with the H on the #3 C replaced by -OH => 3-pentanol

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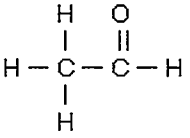
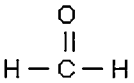
Naming Aldehydes (— C(=O)H group or –CHO group) = -al ending

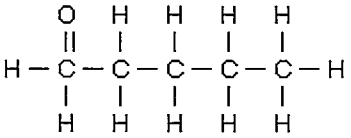
An aldehyde is an organic molecule that has an oxygen atom doubly bonded to the terminal carbon of the backbone carbon chain. An alcohol is named with the **-al ending**. Since the **CHO** must be on the terminal #1 carbon atom, the position of the CHO is not specified in the name.

Example 2:

Name the following molecules.

a. 

b. 

c. 

Solution 2:

a. There are 2 C's with a -CHO on the end => ethanal

b. There is 1 C with a -CHO => methanal (The common name for this compound is formaldehyde.)

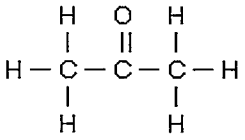
c. There are 5 C's with a -CHO on the end => pentanal

Naming Ketones (–C=O group) = -one ending

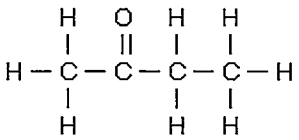
Ketones are very similar to aldehydes. The only difference is that the C=O in a ketone is in the middle of a chain - not on the terminal carbon. To name a ketone, use the **-one ending** and specify the position of the C=O with a number at the beginning of the name.

Example 3:
Name the following compounds.

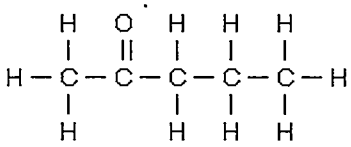
a.



b.



c.



Solution 3:
a. 3 C ketone => propanone (Why do you not need to specify the position of the C=O? If it were on either of the other 2 C atoms, it would be an aldehyde.) (The common name for propanone is acetone.)

b. 4 C ketone => butanone (Why do you not need to specify the position of the C=O?)

c. 5 C ketone with the C=O on the #2 carbon => 2-pentanone

COMPLETE NOMENCLATURE WORKSHEET –FUNCTIONAL GROUPS.

NOMENCLATURE Worksheet – Functional Groups

Draw the following organic molecules.

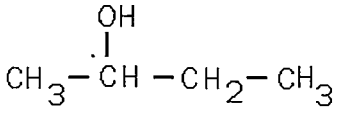
1. 2-pentanol

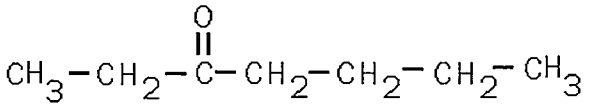
2. 1-butanol

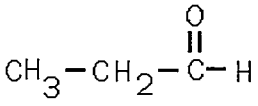
3. 3-pentanone

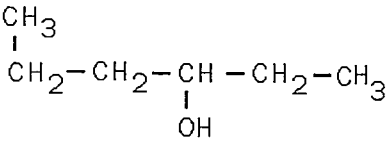
4. ethanal

Name the following compounds.

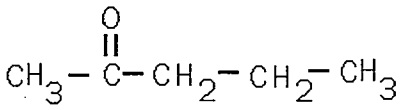
5. 

6. 

7. 

8. 

9. CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-OH

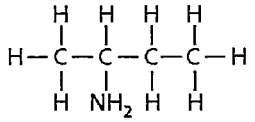
10. 

Chemistry Worksheet: Naming Compounds

Matching

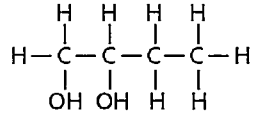
Match each of the lettered structures (a–l) to the following names.

A.



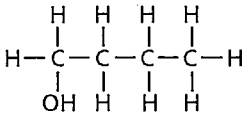
a

B.



b

C.



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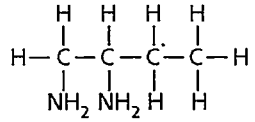
D.



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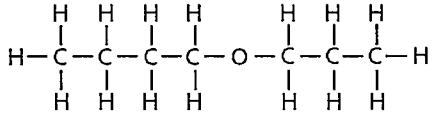
E.



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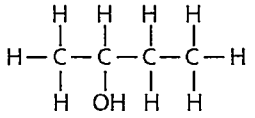
F.



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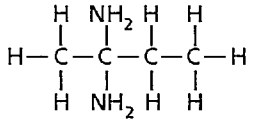
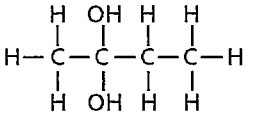
G.



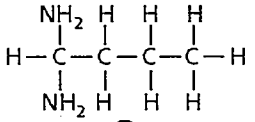
g

H.



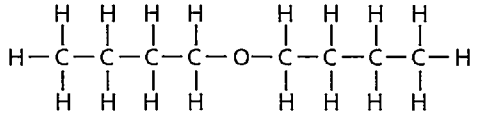
h

I.



i

J.



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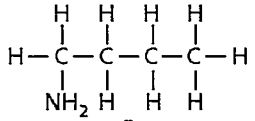
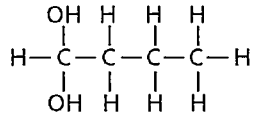
K.



k

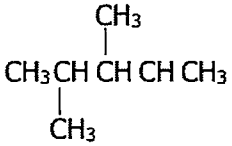
L.



l

1. 1-butanol
2. 2-butanol
3. 1,1-butanediol
4. 2,2-butanediol
5. 1,2-butanediol
6. butyl ether
7. butylpropyl ether
8. 1-butylamine
9. 2-butylamine
10. 1,1-butyldiamine
11. 2,2-butyldiamine
12. 1,2-butyldiamine

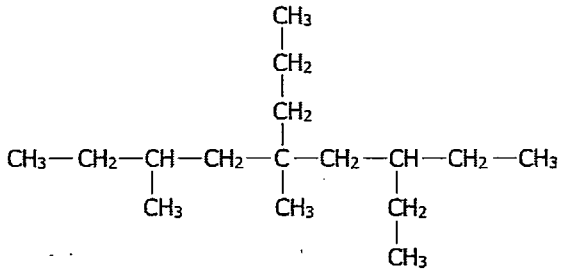
Multiple Choice

13. The correct IUPAC name of the compound  is ____.

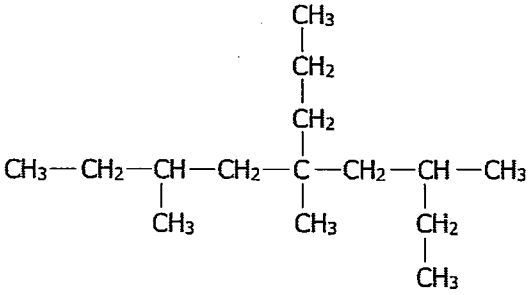
A. 3,4-dimethylpentane B. 2,3-dimethylbutane C. 2,3-dimethylpentane D. 2,2,3-dimethylbutane

14. The structure of 3-ethyl-5,7-dimethyl-5-propylnonane is ____.

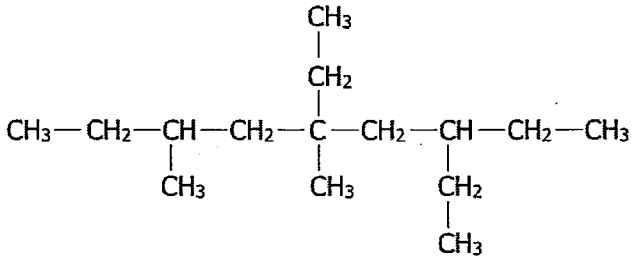
A.



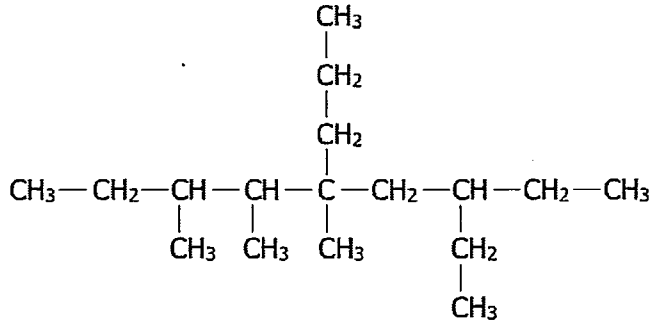
B.



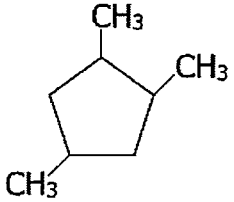
C.



D.



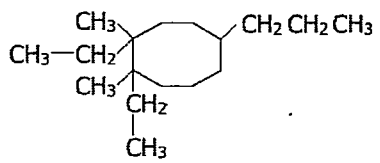
15. Name the cycloalkane given below.



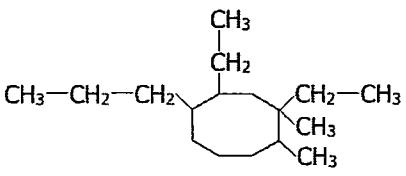
A. 1,2,4-trimethylcyclohexane B. 1,2,4-dimethylcyclopentane C. 1,2,4-trimethylcyclopentane
D. 1,3,5-trimethylcyclopentane

16. The correct structural formula of 1,2-diethyl-2,3-dimethyl-6-propylcyclooctane is ____.

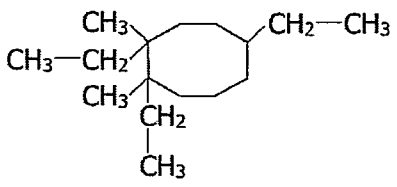
A.



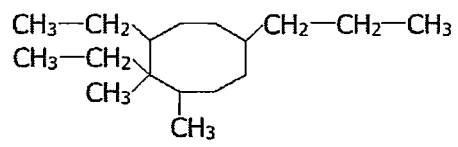
B.



C.

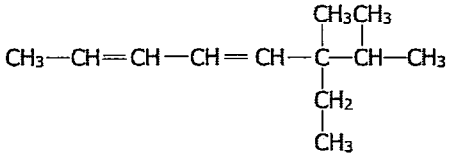


D.

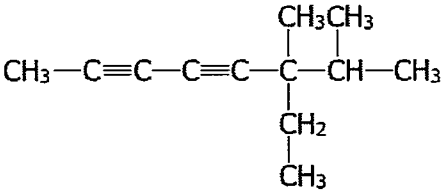


17. The correct condensed structure of a compound having the IUPAC name 6-ethyl-6,7-dimethyl-2,4-dioctyne is _____.

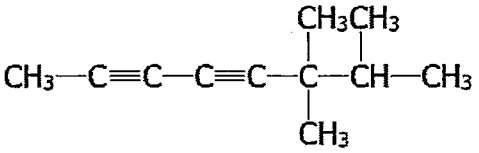
A.



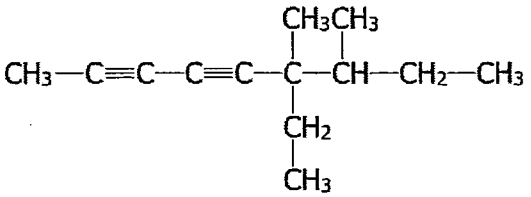
B.



C.



D.



Choose the letter of the correct name for each structure.

18. $CH_3CH_2CH_2CH_2CH_3$
A. propane B. pentane C. hexane

19. $CH_3CH{=}CHCH_2CH_3$
A. 2-pentene B. 3-pentene C. 4-pentene

20. $CH_3CH_2C{\equiv}CCH_3$
A. 4-pentyne B. 3-pentane C. 2-pentyne

21. $CH_3CH_2CH{=}CHCH_2CH_2CH{=}CH_2$
A. 1,5-octadiene B. 3,7-octadiene C. 4,8-dioctene

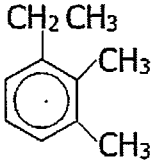
22. $CH_3CH_2C{\equiv}CCH_2CH_3$
A. 3-hexene B. 3-hexyne C. 3-pentyne

23. What is the molecular formula of benzene?
A. C_6H_6 B. C_6H_{12} C. C_6H_{14} D. $C_{12}H_{12}$

Completion

24. The IUPAC name of a compound represented by the line structure  is _____.

25. The IUPAC name of $CH_3C{\equiv}CCH_2CH_2CH_3$ is _____.

26. The IUPAC name of  is _____.