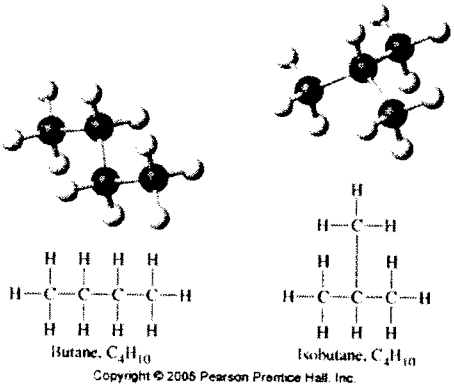
Organic Chemistry

1. Introduction
    a. Carbon (C) and Silicon (Si) are the basis for most natural substances.
    b. Si is used in rocks
    c. C is the basis for all organic matter
        i. C can form strong bonds to itself and form long chains, which can include a large number of other elements
        ii. Forms millions of compounds
        iii. **Biomolecules** – molecules responsible for maintaining and reproducing life
    d. **Organic Chemistry** – the study of C containing compounds and their properties
    e. Organic compounds are in a lot of everyday things
        i. Clothes – polymer blended fabrics
        ii. Pharmaceuticals – drugs are often organic in nature
        iii. Plastics
        iv. Food – sweeteners, sugars, etc.
    f. Naming is based on the number of carbons in the compound, and follows the Latin prefixes like covalent bonds except with the first four (**Me** **E**at **P**eanut **B**utter).

1 Carbon = **Meth-**	6 Carbons = Hex-
2 Carbons = **Eth-**	7 Carbons = Hept-
3 Carbons = **Prop-**	8 Carbons = Oct-
4 Carbons = **But-**	9 Carbons = Non-
5 Carbons = Pent-	10 arbons = Dec-

2. **Alkanes** – Saturated hydrocarbons
    a. Suffix: *-ane*
    b. Formula:
        i. C_nH_{2n+2}
        ii. Formula can be condensed into $CH_3(CH_2)_nCH_3$
    c. IMFs: VERY Weak (London dispersion forces) therefore they have very low BP and MP
    d. **Saturated hydrocarbon** – a compound composed of hydrogen and carbon in which each C – C bond is a single bond, and each carbon is attached to 4 atoms.
    e. **unsaturated hydrocarbon** – a compound composed of hydrogen and carbon in which at least one C – C bond is a double or triple bond
    f. Called straight chain / unbranched hydrocarbons but are drawn as a zigzag since all the bonds angles are 109.5°.
    g. Structural Isomerism
        i. When 2 molecules have the same atoms but different bonds
        ii. Possible for all alkanes after butane



iii. Ex: isobutene is a structural isomer of n-butane

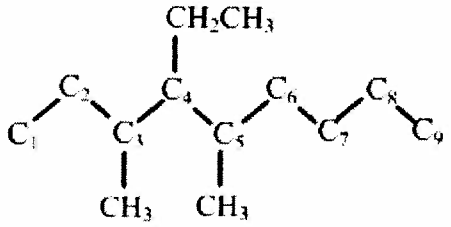
h. NOMENCLATURE

i. Count the number of C in the longest chain, add the suffix **-ane**

ii. Substitutes for H are named by adding **–yl** to the root for how many C are in the branch

iii. Branch position is noted by numbering the longest C chain so that branching occurs at the lowest numbers.

iv. The substitutes are listed in alphabetical order and the greek prefixes (di, tri,...) are used for multiples of the identical substitute



4-ethyl-3,5-dimethylnonane

i. Reactions of Alkanes

i. Inert at low temperatures – often used as lubricants and plastics

ii. At high temperatures they combust therefore are used as fuels

iii. Can undergo substitutions with halogens (Halogen replaces 1 H)

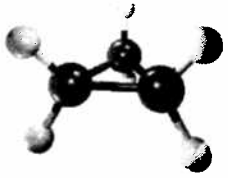
1. Chlorofluorocarbons (CF_xCl_{4-x}), also known as *freons*, are extremely inert and are used as coolants.

iv. Dehydrogenation reactions – hydrogen atoms are removed and they hydrocarbon becomes unsaturated (forms a double bond)

j. Cyclic Alkanes

i. Formula

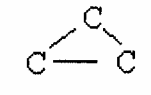
1. C_nH_{2n}

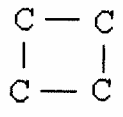


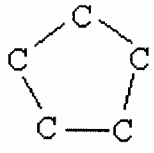
ii. ***Nominclature:*** prefix **cyclo-** before root name

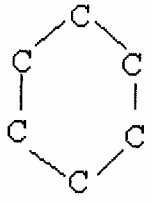
iii. Simplest is cyclopropane (C3H6)

iv. Typically more reactive than their chained forms (especially when there are few carbons)

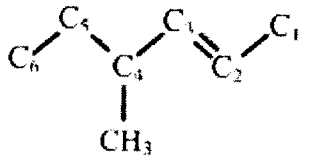

cyclopropane


cyclobutane

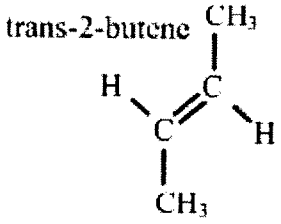

cyclopentane

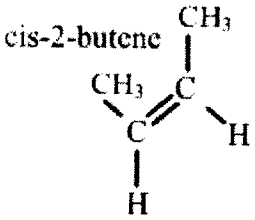

cyclohexane

3. Alkenes
    a. ***Nominclature:*** replaces **–ane** with **-ene**

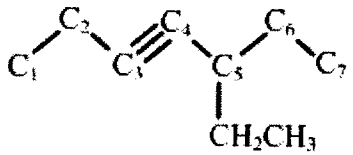


4-methyl-2 hexene



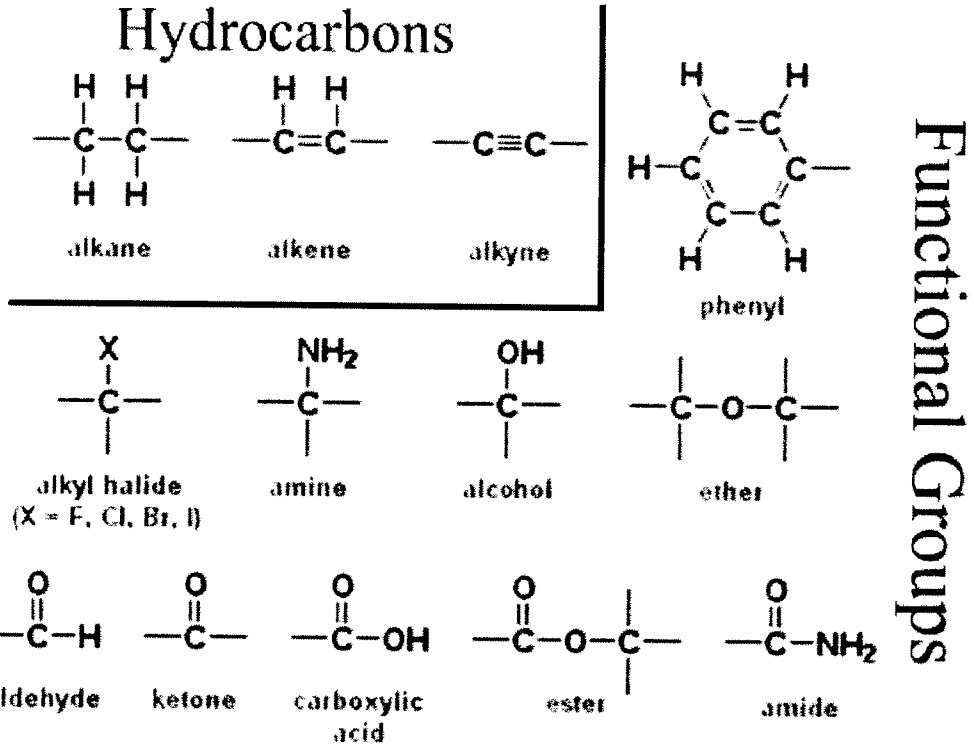


    b. Formula: C_nH_{2n}
    c. Contain at least 1 C=C double bond
    d. Cis-trans geometry
        i. Cis – identical substitutes on the same side of the double bond are designated cis.
        ii. Trans – Substitutes are on opposite sides
        iii. Locked in place because of C=C, and e^-/e^- repulsion (no free rotation)
    e. Can form aromatic rings as well (cyclopentene)
    f. Double bond can be broken to form a substitution on either carbon involved
        i. Hydrogenation rxns- add H to the double bound carbons
        ii. Halogenation rxns – add halogens (Cl, Br, I, F) to the double bound carbons
4. Alkynes
    a. ***Nominclature:*** suffix changes to **-yne**

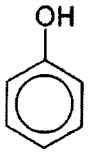


5-ethyl-3-heptyne

    b. Contain at least 1 C≡C triple bond
    c. Can form aromatic rings as well (cylcohexyne)
    d. Triple bond can be broken to form a substitution on either carbon involved
    e. Can undergo hydrogenation and halogenations
5. **Functional groups** – an atom or group of atoms in a hydrocarbon derivative that contains elements in addition to C and H



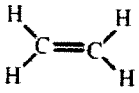
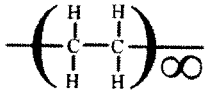
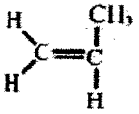
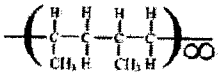
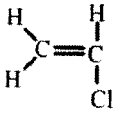
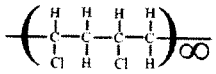
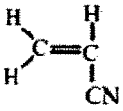
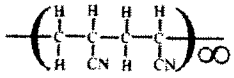
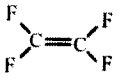
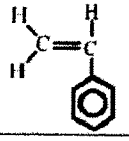
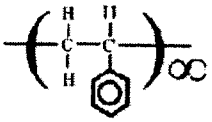
6. **Alcohols**
    a. Replace a --H with a –OH
    b. ***Nomenclature:*** replaces the final **–e** in the root hydrocarbon name with **–ol**
    c. Higher MP and BP b/c of H-bonding
    d. When bound to a ring they are called **phenols**



7. **Aldehydes** and **ketones**
    a. Ketones – C=O sandwiched between to chains
        i. ***Nominclature:*** remove the final **–e** from the parent chain and add **–al**
        ii. Often used as a solvent to clean up waste
    b. Aldehydes – CH=O bound to the first cabon (always C_1)
        i. ***Nominclature :*** remove the final **–e** from the parent chain and add **–one**
        ii. Produces odors
8. **Carboxylic acids** and **esters**
    a. Carboxylic acids – R'-COOH
        i. Weak acids
        ii. ***Nomenclature:*** replaces the final **–e** in the root name with **–oic acid**
        iii. Reacts with alcohols to produce esters
    b. Esters – R-O-R
        i. Have a sweet odor (bananas)
9. **Amines** – R-NH_2, R'-NH-R", R'-N-R"
    a. ***Nominclature:*** Root of number of carbons + amine
    b. Primary – one H in NH_3 has been replaced with a C chain
    c. Secondary – 2 H in NH_3 have been replaced with a C chain

d. Tertiary – All H in NH_3 have been replaced with a C chain

10. Polymers
    a. Large chainlike molecules that are built from small molecules (monomers)
    b. Used in EVERYTHING!
    c. Properties
        i. Very different then just strain chain carbons
        ii. Varies based on the length of the chain, the substitutes involved, and the bonds formed.
        iii. *Thermoset polymer* – a polymer that can be molded at high temperatures and pressures but once cooled cannot be softened or melted.
        iv. *Thermoplastic polymer* – a polymer that retains its shape but can be remolded if heated.
        v. **Crosslinking** – covalent bonds that form between adjacent chains of a polymer.
            1. Increases strength and toughness
            2. Seen in rubber, Bakelite, PVC pipe etc.
            3. Vulcanization – adding sulfur to a polymer that increases the crosslinking, and increases the strength of the polymer.

Monomer		Polymer		
Name	**Formula**	**Name**	**Formula**	**Uses**
Ethylene		Polyethylene		Plastic, piping, bottles, electrical insulation, toys
Propylene		Polypropylene		Film for packaging, carpets, lab wares, toys
Vinyl Chloride		Polyvinyl chloride (PVC)		Piping, siding, floor tile, clothing, toys
Acrylonitrile		Polyacrylonitrile (PAN)		Carpets, Fabrics
Tetrafluoroethylene		Teflon		Cooking utensils, electrical insulation, bearings
Styrene		Polystyrene		Containers, thermal insulation, toys

d. Types of polymers
    i. Addition polymers – monomers simply "add together" to produce the polymer (see table of ethylene based polymers)
        1. Formation begins with a free radical (something with an unpaired e^-)
        2. Causes the double bond to break and form a radical which can bond with other monomers
        3. Reaction ends when 2 radicals react to form a bond
    ii. Condensation polymers – small molecules form for each extension of the polymer chain
    iii. Copolymer – 2 or more monomers in the polymer
    iv. Homopolymer – 1 monomer forms the polymer
    v. Dimer – when 2 monomers join
e. Can be synthetic – made in the lab
f. Can be natural – made in the body.
    i. Proteins – many monomers form a structure that performs a particular task in the body
    ii. DNA – Chromosomes are make up of several monomers
        1. adenine, guanine, thymine, and cytosine are all monomers that come together to form DNA

Name _____ Date _____ Class _____

CHAPTER 22 STUDY GUIDE FOR CONTENT MASTERY

Hydrocarbons

Section 22.1 Alkanes

In your textbook, read about organic chemistry, hydrocarbons, and straight-chain alkanes.

Use each of the terms below just once to complete the passage.

hydrocarbons	homologous series	organic compounds	straight-chain alkanes

Most compounds that contain carbon are known as **(1)**_____. The simplest group of such compounds are **(2)**_____, which contain only carbon and hydrogen. If all of the carbon atoms are linked by single covalent bonds and there are no branches, the compounds are called **(3)**_____. Ethane, propane, and butane are three examples. They are members of one **(4)**_____ because they differ from each other by a repeating unit (— CH_2 —).

In your textbook, read about branched-chain alkanes and naming them.

For each statement below, write *true* or *false*.

_____ **5.** The ability of carbon atoms to bond to two, three, or four other carbon atoms makes possible a variety of branched-chain alkanes.

_____ **6.** A carbon atom or group of carbon atoms that branch off the main hydrocarbon chain of an alkane is a substituent group.

_____ **7.** A skeletal formula is a way of representing an organic compound by showing only the hydrogen atoms.

Use the IUPAC rules to name the following structures.

8. $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_3$

_____

9. $CH_3CHCH_2CH_2CH_2CHCH_3$ (with CH_3 on the first carbon and CH_3 on the sixth carbon)

_____

Draw the structure of each of the following alkanes.

10. 2-methylheptane

11. 2,3,4-trimethylpentane

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CHAPTER STUDY GUIDE FOR CONTENT MASTERY

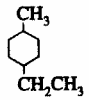
Section 22.2 Cyclic Alkanes and Alkane Properties

In your textbook, read about cycloalkanes.

For each item in Column A, write the letter of the matching item in Column B.

Column A	Column B
_____ **1.** A simplified way of representing an organic compound by showing only the carbon-carbon bonds	**a.** *cyclo-*
_____ **2.** A way of representing an organic compound that saves space by not showing how the hydrogen atoms branch off the carbon atoms	**b.** condensed structural formula
_____ **3.** Indicates that a hydrocarbon has a ring structure	**c.** line structure
_____ **4.** A hydrocarbon that has a ring of carbon atoms in its structure	**d.** cyclic hydrocarbon

Use the IUPAC rules to name the following structure.

5. 

_____

Draw the structure of the following cycloalkane.

6. 1-ethyl, 2-propylcyclobutane

In your textbook, read about the properties of alkanes and multiple carbon-carbon bonds.

In the space at the left, write the word or phrase in parentheses that correctly completes the statement.

_____ **7.** All the bonds in an alkane are (polar, nonpolar).

_____ **8.** The attractive forces between alkane molecules are (stronger, weaker) than the attractive forces between alkane and water molecules.

_____ **9.** Alkanes are (very, not very) soluble in water.

_____ **10.** The boiling points of alkanes (increase, decrease) with increasing molecular mass.

_____ **11.** The chief chemical property of alkanes is their (low, high) reactivity.

_____ **12.** Alkanes are often used as (solvents, fuels) because they readily undergo combustion in oxygen.

_____ **13.** Alkanes are (saturated, unsaturated) hydrocarbons because they have only single bonds.

me _____ Date _____ Class _____

ection 22.3 Alkenes and Alkynes

your textbook, read about alkenes, alkynes, and naming alkynes.

se the following words to complete the statements.

alkene	alkyne	electron density	ethene	ethyne

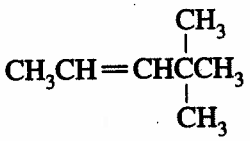
1. An _____ is a hydrocarbon that has one or more triple covalent bonds between carbon atoms.
2. The unsaturated hydrocarbon _____ is the starting material for the synthesis of the plastic polyethylene.
3. An _____ is a hydrocarbon that has one or more double covalent bonds between carbon atoms.
4. Torches used in welding burn _____, which is commonly called acetylene.
5. Alkenes and alkynes are more reactive than alkanes because double and triple bonds have greater _____ than single bonds have.

Circle the letter of the correct name for each of the following structures.

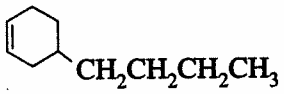
6. $CH_3CH_2CH{=}CHCH_2CH_2CH{=}CH_2$
   - **a.** 1,5-octadiene
   - **b.** 3,7-octadiene
   - **c.** 4,8-dioctene

7. $CH_3CH_2C{\equiv}CCH_2CH_3$
   - **a.** 3-hexene
   - **b.** 3-hexyne
   - **c.** 3-pentyne

Use the IUPAC rules to name the following structures.

8. 

_____

9. 

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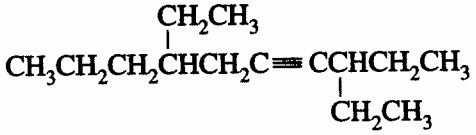
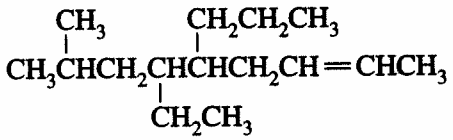
10. 

_____

11. 

_____

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CHAPTER STUDY GUIDE FOR CONTENT MASTERY

Section 23.2 Alcohols, Ethers, and Amines

In your textbook, read about the structure and properties of alcohols.

Circle the letter of the choice that best completes the statement or answers the question.

1. An alcohol is an organic compound in which a hydrogen atom of a hydrocarbon has been replaced by
   a. a hydroxyl group. **b.** an oxygen atom. **c.** an NH_2 group. **d.** a COOH group.
2. Which of the following suffixes is used in naming alcohols?
   a. *-al* **b.** *-oic* **c.** *-ol* **d.** *-ane*
3. The alcohol produced commercially in largest quantity is
   a. methanol. **b.** isopropyl. **c.** ether. **d.** ethanol.
4. Alcohol molecules are generally
   a. nonpolar. **b.** ionic. **c.** very slightly polar. **d.** moderately polar.
5. The alcohol produced by yeasts is
   a. methanol. **b.** ethanol. **c.** isopropanol. **d.** cyclohexanol.
6. The simplest alcohol is
   a. methanol. **b.** ethanol. **c.** isopropanol. **d.** butanol.
7. A poisonous alcohol used as a solvent for certain plastics and in the manufacture of insecticides is
   a. butanol. **b.** ethanol. **c.** cyclohexanol. **d.** isopropanol.
8. Which of the following describes the solubility of ethanol in water?
   a. completely insoluble **b.** slightly soluble **c.** immiscible **d.** completely miscible
9. What intermolecular attraction gives alcohols many of their physical properties?
   a. London forces **b.** hydrogen bonds **c.** ionic forces **d.** dipole-dipole forces
10. Denatured alcohol is
    a. a mixture of two alcohols.
    b. ethanol to which noxious solvents have been added.
    c. ethanol that has been distilled.
    d. ethanol diluted with water.
11. How is ethanol generally removed from a water solution?
    a. filtration **b.** distillation **c.** adsorption **d.** precipitation
12. The position of the functional group in an alcohol is indicated in its name by a
    a. letter at the end. **c.** number and dash at the end.
    b. letter at the beginning. **d.** number and dash at the beginning.

Name _____ Date _____ Class _____

CHAPTER STUDY GUIDE FOR CONTENT MASTERY

Section 23.2 *continued*

In your textbook, read about the structure and properties of ethers and amines.

For each statement below, write *true* or *false*.

_____ **13.** An ether contains an oxygen atom bonded to two carbon atoms.

_____ **14.** Ethers generally have much lower boiling points than alcohols of the same size.

_____ **15.** Ethers generally are more soluble in water than are alcohols.

_____ **16.** Ether molecules form hydrogen bonds with each other.

_____ **17.** Amines contain nitrogen bonded to carbon.

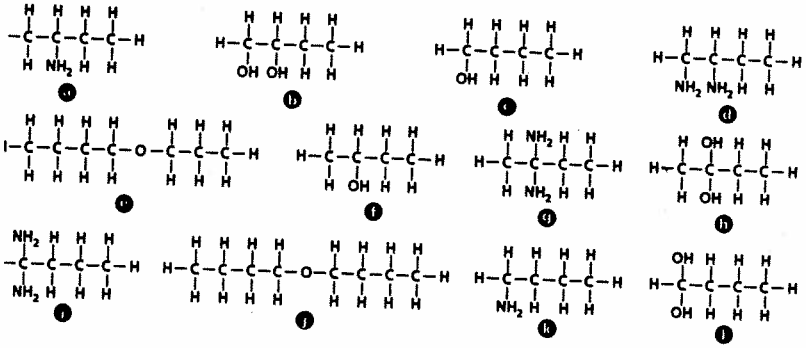
_____ **18.** More than one amino group can be present in an amine molecule.

_____ **19.** Amines are typically acids.

_____ **20.** Volatile amines tend to have pleasant odors.

In your textbook, read about naming alcohols, amines, and ethers.

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



___ **21.** 1-butanol

___ **22.** 2-butanol

___ **23.** 1,1-butanediol

___ **24.** 2,2-butanediol

___ **25.** 1,2-butanediol

___ **26.** butyl ether

_____ **27.** butylpropyl ether

_____ **28.** 1-butylamine

_____ **29.** 2-butylamine

_____ **30.** 1,1-butyldiamine

_____ **31.** 2,2-butyldiamine

_____ **32.** 1,2-butyldiamine

Name _____ Date _____ Class _____

Section 23.5 Polymers

In your textbook, read about monomers and polymers.

Use each of the terms below just once to complete the passage.

addition	catalyst	cellulose	condensation	celluloid
monomer	polymer	water	polymerization	

A large molecule consisting of many repeating structural units is called a(n) **(1)**_____. A reaction in which such a compound is produced is called a(n) **(2)**_____ reaction. Each of the unit molecules from which such a large molecule is made is called a(n) **(3)**_____. The natural polymer **(4)**_____, which is found in wood fiber, was treated with nitric acid to produce the first plastic, **(5)**_____.

A substance called a(n) **(6)**_____ is often required to make a polymerization proceed at a reasonable rate. In a(n) **(7)**_____ polymerization, all the atoms present in the monomers are present in the product. In a(n) **(8)**_____ polymerization, the product is formed with the loss of a small by-product, usually **(9)**_____.

In your textbook, read about polymerization and the properties of polymers.

For each statement below, write *true* or *false*.

_____ **10.** The repeating group of atoms formed by the bonding of monomers is called the structural unit of the polymer.

_____ **11.** The number of structural units in a polymer chain is represented by the letter *n*.

_____ **12.** Nylon is made by means of an addition polymerization.

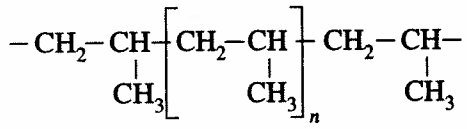
_____ **13.** Polymers do not differ greatly in their properties.

_____ **14.** Thermosetting plastics are generally more difficult to recycle than are thermoplastic polymers.

_____ **15.** Most of the plastic waste produced in the United States is recycled.

Draw the following structure.

16. The monomer that reacts to make the polymer shown below

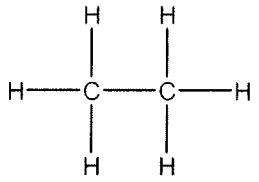


Name _____ Period _____

Alkane Functional Groups – Worksheet #1

Classify the following compounds according to their functional group(s). You do not need to name the compounds. Choose from the following list:

Alcohol, Aldehyde, Alkane, Alkene, Alkyne, Amine, Aromatic, Carboxylic Acid, Ester, Ether, or Ketone

1. 

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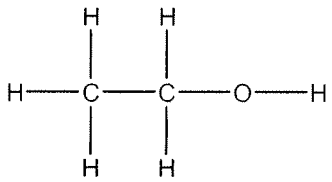
2. 

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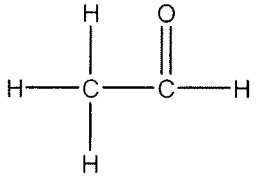
3. 

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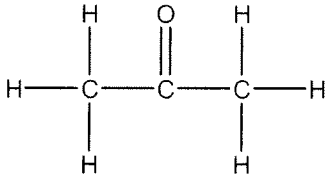
4. 

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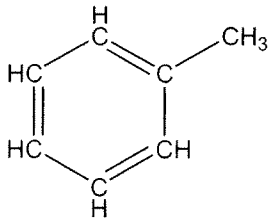
5. 

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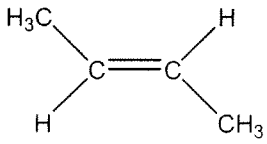
6. 

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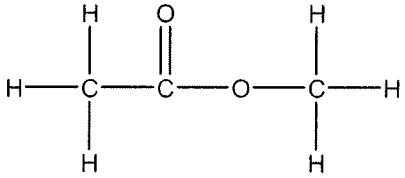
7. 

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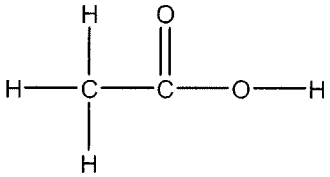
8. 

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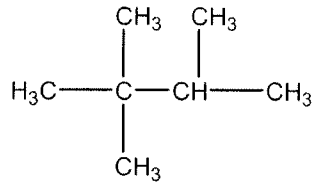
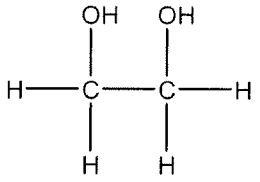
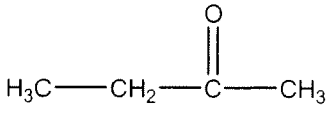
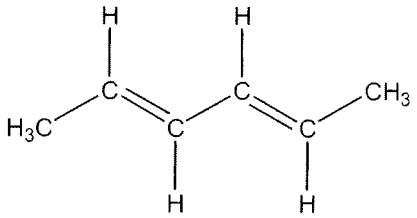
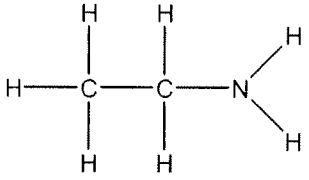
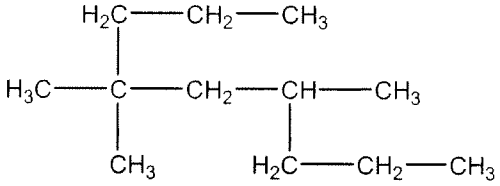
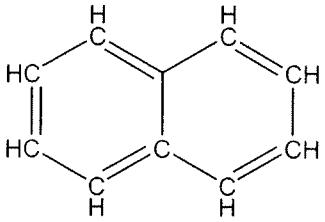
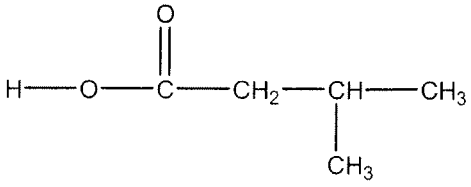
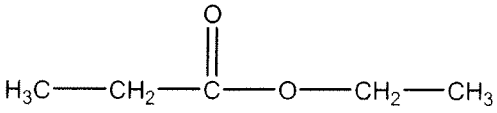
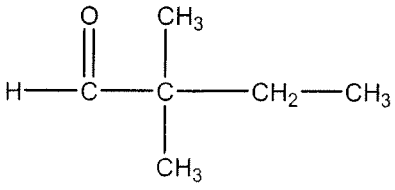
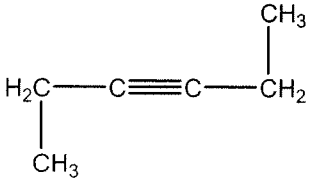
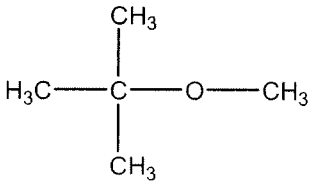
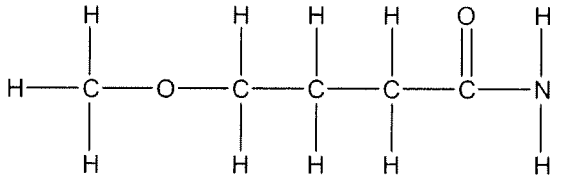
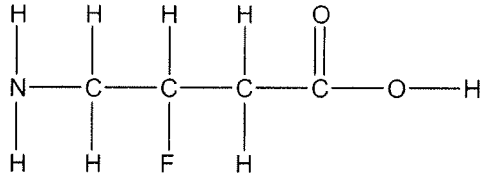
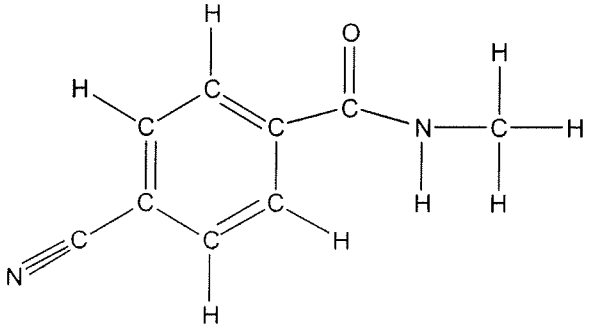
 9. _____	 10. _____
 11. _____	 12. _____
 13. _____	 14. _____
 15. _____	 16. _____
 17. _____	 18. _____
 19. _____	 20. _____

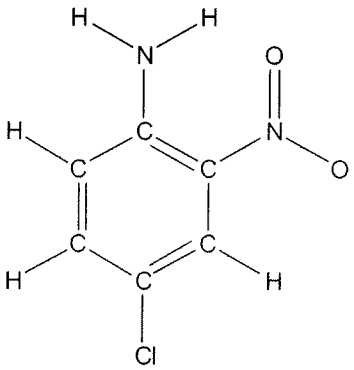
Functional Group Worksheet

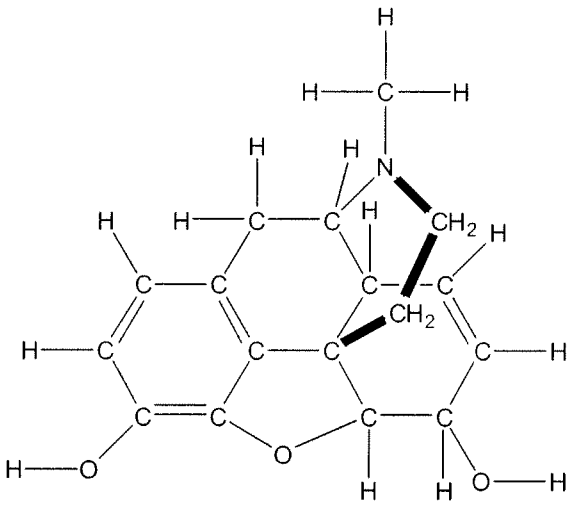
Circle and name the functional groups in the following molecules.

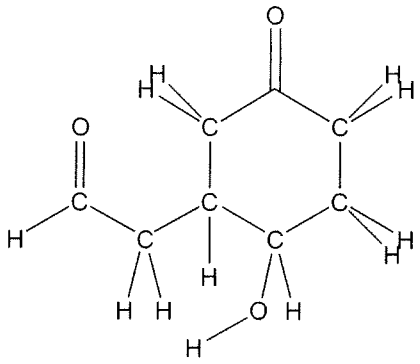


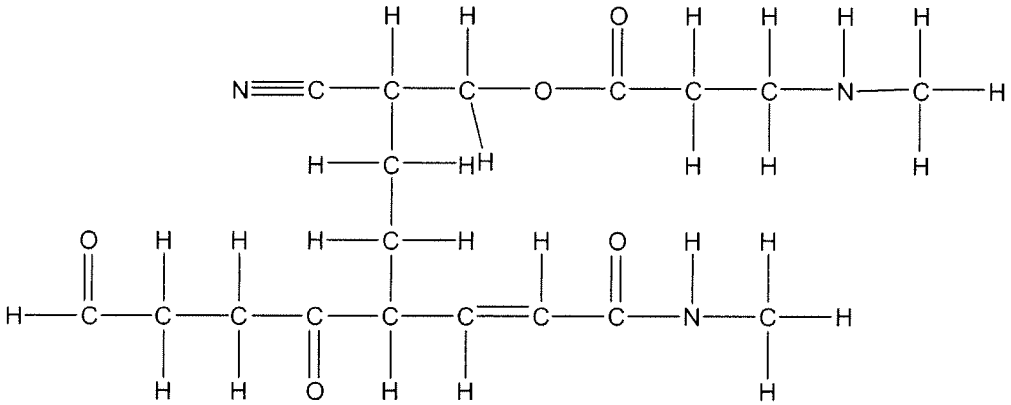






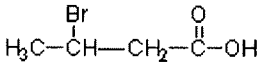


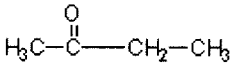


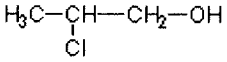


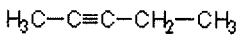
Name the following compounds:

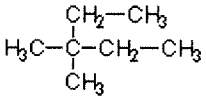
1. 

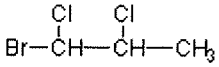
2. 

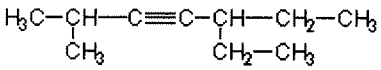
3. 

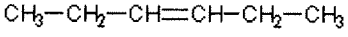
4. 

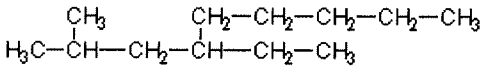
5. 

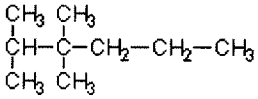
6. 

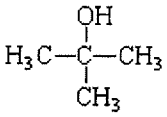
7. 

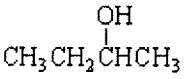
8. 

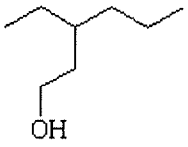
9. 

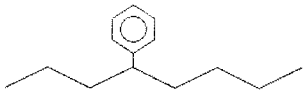
10. 

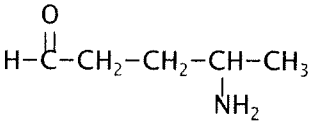
11. 

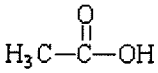
12. 

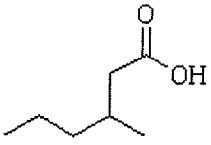
13. 

14. 

15. 

16. 

17. 

18. 

19.