Chemistry: Form Ls11.1A

Name _____

ORGANIC CHEMISTRY

Date _____ Period _____

Nature of Carbon and Hydrocarbons

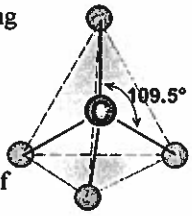
Aim

- to describe bonding in carbon and the type of compounds it typically forms

Notes

Nature of Carbon

★ Family - Group group 14
  ☆ Metalloid - can bond with metals and nonmetals
  ☆ Most active member of family
  ☆ Electron configuration
    ★ 4 valence electrons
    ★ can bond with up to four elements at once
★ Bonding
  ☆ forms compounds by covalent bonding
    ★ single bond - one shared pair of electrons –C–
    ★ forms a regular tetrahedron



    ★ double bond - two shared pairs of electrons \C=C/
    ★ triple bond - three shared pairs of electrons –C≡C–
  ☆ forms bonds with other elements or with other carbons
  ☆ can form chains of carbon of unlimited length
    ★ chains can be straight
    ★ chains can be branched
    ★ chains can be closed to form rings
★ The variety and complexity of carbon compounds is unlimited

Characteristics of organic compounds

★ Formed as a result almost exclusively of covalent bonding
★ Generally nonpolar
★ Generally insoluble in water
  ★ usually soluble in nonpolar solvents (other organic compounds)
★ Nonelectrolytes except organic acids which are weak electrolytes
★ Have low melting points (due to weak intermolecular forces that hold them together)
★ Have slower reaction rates than inorganic compounds
  ★ covalent bonds within organic molecules are strong
  ★ activation energies are high
  ★ catalysts are often used to increase reaction rates

Hydrocarbons

★ Definition - compounds composed of only hydrogen and carbon
★ Homologous series - group of organic compounds with similar properties and related structures (differ from each other by CH_2)
  ☆ Aliphatic - hydrocarbon chains
    ★ Saturated
      ★ Definition - has no bonds that can be broken to add extra hydrogens
      ★ called **Alkanes**
        - family of hydrocarbons with all single bonds
        - general formula C_nH_{2n+1}
        - named with suffix **"ANE"**
    ★ Unsaturated - has double or triple bonds that can be broken to add more hydrogens
      ★ **Alkenes**
        - family of hydrocarbons with one double bond
        - general formula C_nH2_n
        - named with suffix **"ENE"**
      ★ **Alkynes**
        - family of hydrocarbons with one triple bond
        - general formula C_nH_{2n-2}
        - named with suffix **"YNE"**

Answer the questions below by circling the number of the correct response

1. Which formula may represent an unsaturated hydrocarbon? (1) C_2H_6 (2) C_3H_6 (3) C_4H_{10} (4) C_5H_{12}
2. In an homologous series, the second member has the formula C_3H_6. What is the formula of the fourth member of this series. (1) C_4H_8 (2) C_4H_{10} (3) C_5H_{10} (4) C_5H_{12}
3. As the molecular mass of the compounds of the alkane series increases, their boiling point (1) decreases (2) increases (3) remains the same
4. Which represents an unsaturated hydrocarbon? (1) C_2H_4 (2) C_2H_6 (3) C_3H_8 (4) C_4H_{10}
5. Which is a saturated hydrocarbon? (1) C_3H_8 (2) C_6H_6 (3) C_2H_5OH (4) $C_2H_4O_2$
6. Which compound is a hydrocarbon? (1) R–CH_3 (2) R–OH (3) R–COOH (4) R–Cl
7. Which molecule contains a triple covalent bond? (1) C_2H_2 (2) C_2H_4 (3) C_3H_6 (4) C_3H_8
8. Which compound is a member of the alkane series? (1) C_2H_6 (2) C_3H_6 (3) C_4H_6 (4) C_6H_6
9. The general formula for the alkyne series is (1) C_nH_n (2) C_nH_{n-2} (3) C_nH_{2n} (4) C_nH_{2n-2}
10. Which is the formula of a saturated hydrocarbon? (1) C_2H_2 (2) C_2H_4 (3) C_5H_8 (4) C_5H_{12}
11. Which formula represents an unsaturated hydrocarbon? (1) C_3H_8 (2) C_3H_7Cl (3) C_3H_6 (4) CCl_4
12. The compound $CH_3CH_2CH_2CH_3$ belongs to the series that has the general formula (1) C_nH_{2n-2}, (2) C_nH_{2n+2}, (3) C_nH_{n-6}, (4) C_nH_{n+6}
13. Which molecule contains a triple covalent bond between adjacent carbon atoms? (1) C_2H_4 (2) C_2H_2 (3) C_3H_6 (4) C_3H_8
14. Each member of the alkane series differs from the preceding member by one additional carbon atom and (1) 1 hydrogen atom (2) 2 hydrogen atoms (3) 3 hydrogen atoms (4) 4 hydrogen atoms
15. Which formula represents a saturated hydrocarbon? (1) C_2H_2 (2) C_2H_4 (3) C_3H_6 (4) C_3H_8
16. Which formula represents a hydrocarbon with a double covalent bond? (1) CH_3Cl (2) C_2H_3Cl (3) C_2H_2 (4) C_2H_4
17. Organic compounds differ from inorganic compounds in that organic compounds generally have (1) high melting points and are electrolytes, (2) high melting points and are nonelectrolytes, (3) low melting points and are electrolytes, (4) low melting points and are nonelectrolytes
18. The compound C_2H_2 belongs to the series of hydrocarbons with the general formula (1) C_nH_n (2) $C_{2n}H_{2n}$ (3) C_nH_{2n-2} (4) $C_{2n}H_{2n-2}$
19. Which normal alkane has the highest boiling point at 1 atmosphere? (1) C_2H_4 (2) C_3H_6 (3) C_4H_8 (4) C_5H_{10}
20. Which element is composed of atoms that can form more than one covalent bond with each other? (1) hydrogen (2) helium (3) carbon (4) calcium

Chemistry: Form Ls11.2A Name _____

ORGANIC CHEMISTRY Date _____ Period _____

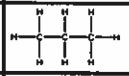
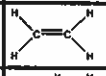
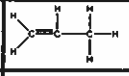
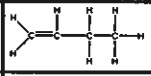
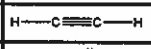
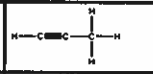
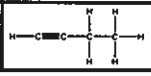
Structural Formulas and Isomers

Aim

- to interpret organic formulas

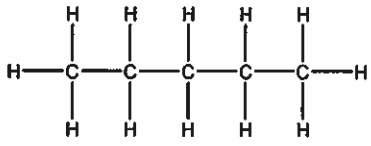
Notes

Types of formulas

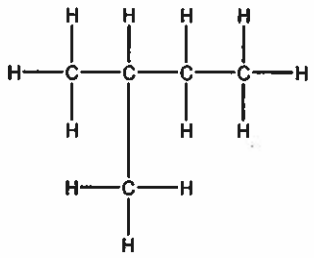
Type of Compound	Simple formula	Structural formula	Graphic formula
Alkanes	CH_4		CH_4
	C_2H_6		CH_3CH_3
	C_3H_8		$CH_3CH_2CH_3$
Alkenes	C_2H_4		CH_2CH_2
	C_3H_6		CH_2CHCH_3
	C_4H_8		$CH_2CHCH_2CH_3$
Alkynes	C_2H_2		CHCH
	C_3H_4		$CHCCH_3$
	C_4H_6		$CHCCH_2CH_3$

- Isomers - compounds with the same simple formula but different structures

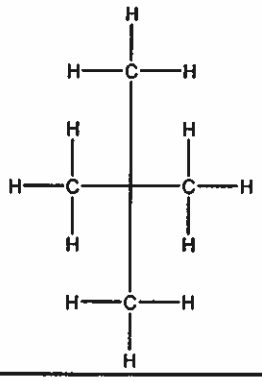
C_5H_{12}



Pentane



2-methyl butane



2,2-dimethyl propane

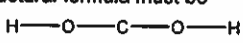
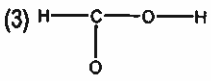
- structures must actually be different (looking different on paper is not always enough)
- branches of different isomers are attached on non-equivalent carbons

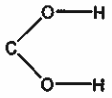
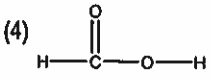
Answer the questions below by circling the number of the correct response

1. The compounds $CH_3CH_2OCH_2CH_3$ and $CH_3CH_2CH_2CH_2OH$ are (1) hydrocarbons (2) isomers (3) allotropes (4) carbohydrates

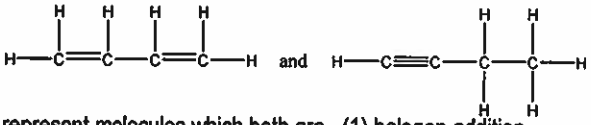
2. The compound C_4H_9OH is an isomer of (1) $C_3H_7COCH_3$ (2) $CH_3COOC_2H_5$ (3) $C_2H_5OC_2H_5$ (4) CH_3COOH

3. If a compound has a molecular formula of CH_2O_2, then its structural formula must be

(1)  (3) 

(2)  (4) 

4. The structural formulas



represent molecules which both are (1) halogen addition products (2) unsaturated hydrocarbons (3) members of alkynes (4) isomers of butane

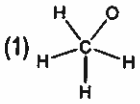
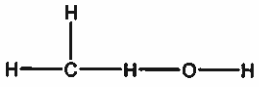
5. Compounds which have the same molecular formula but different molecular structures are called (1) isomers (2) allotropes (3) isotopes (4) homologs

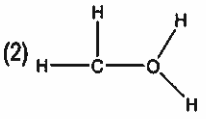
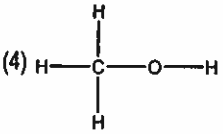
6. Which compound is an isomer of CH_3CH_2OH? (1) CH_3CHO (2) CH_3COCH_3 (3) CH_3OCH_3 (4) CH_3CH_2COOH

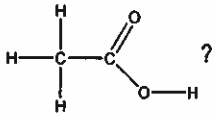
7. Which compound is an isomer of CH_3COOCH_3? (1) CH_3OCH_3 (2) CH_3COCH_3 (3) CH_3CH_2COOH (4) $CH_3CH_2CH_2OH$

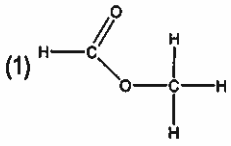
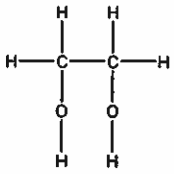
8. Which compound is an isomer of CH_3COOH? (1) $HCOOCH_3$ (2) CH_3CH_2COOH (3)CH_3CH_2OH (4) CH_3COOCH_3

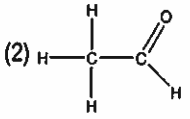
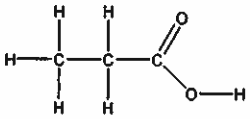
9. Which is the correct structural formula of a compound whose molecular formula is CH_4O?

(1)  (3) 

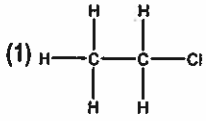
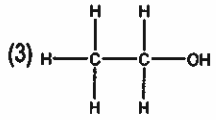
(2)  (4) 

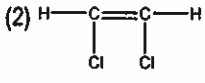
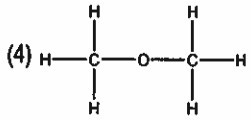
10. Which compound is an isomer of  ?

(1)  (3) 

(2)  (4) 

11. Which is the structural formula for an unsaturated compound?

(1)  (3) 

(2)  (4) 

Naming Hydrocarbons and Substituted Hydrocarbons

Aim

- to apply the IUPAC rules for naming organic compounds

Notes

Naming hydrocarbons

★ family: alkane, alkene, or alkyne - use suffix ANE, ENE, or YNE

★ Length of chain, length of side chain, number of side chains or functional groups, location of side chains or functional groups - use prefixes

Number	Prefix			
	Carbons in Main Chain	Carbons in side chain	Number of side chains or groups	Location of side chains or groups
1	meth	methyl	-	1
2	eth	ethyl	di	2
3	prop	propyl	tri	3
4	but	butyl	tetra	4
5	pent	pentyl	penta	5
6	hex	hexyl	hexa	6
7	hept	heptyl	hepta	7
8	oct	octyl	octa	8
9	non	nonyl	nona	9
10	dec	decyl	deca	10

Substituted hydrocarbons

★ Halogenated hydrocarbons - prefix in name
  ☆ fluorine = fluoro; chlorine = chloro; bromine = bromo; iodine = iodo

example: $CH_3CH_2CHClCH_2CH_3$ (3-chlorobutane)

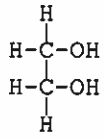
★ Alcohols
  ☆ general formula: R-OH
  ☆ suffix: ol
  ☆ monohydroxy alcohols: one -OH
    ★ primary alcohols: the -OH is attached to one end of a hydrocarbon chain
      ★ general formula: $R\text{-}CH_2OH$
      ★ example: $CH_3CH_2CH_2OH$ (propanol)
    ★ secondary alcohols: the OH is attached to a carbon that is attached to two other carbons
      ★ general formula:

      ★ example: $CH_3CHOHCH_3$ (2-propanol)

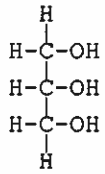
    ★ tertiary alcohols: the OH is attached to a carbon that is attached to three other carbons
      ★ general formula:

      ★ example: $CH_3CH_3COHCH_3$ (tertiary butanol or 2 methyl-2 propanol)

  ☆ important monohydroxy alcohols
    ★ ethanol - beverage alcohol
    ★ 2-propanol - rubbing alcohol
  ☆ dihydroxy alcohols (glycols): with two -OH groups
    ★ example: ethylene glycol or 1,2 ethanediol (active ingredient in antifreeze)



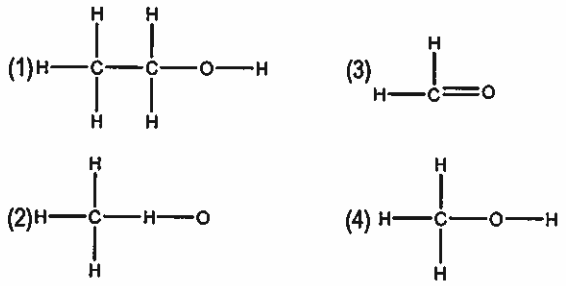
  ☆ trihydroxy (trihydric) alcohols: with three -OH groups
    ★ example: glycerol or 1,2,3 propanetriol (product of digestion of fat)



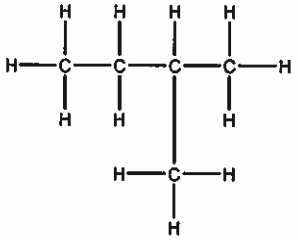
★ Aldehydes - produced by oxidation of primary alcohols
  ☆ $2CH_3OH + O_2 \rightarrow 2H\text{-}CHO + 2H_2O$
  ☆ general formula: R-CHO
  ☆ suffix: al
  ☆ example: CH_3CH_2CHO (propanal)
  ☆ important aldehydes: methanal - formaldehyde
★ Ketones - produced by the oxidation of secondary alcohols
  ☆ general formula: RCOR
  ☆ suffix: one
  ☆ example: CH_3COCH_3 (propanone)
  ☆ important ketones: propanone - (acetone, dimethyl ketone)
★ Acids
  ☆ general formula: RCOOH
  ☆ suffix: oic acid
  ☆ example: CH_3CH_2COOH (propanoic acid)
  ☆ important acids: ethanoic acid-acetic acid (vinegar)
★ Ethers - produced by dehydration synthesis of two primary alcohols [$R\text{-}OH + HO\text{-}R \rightarrow R\text{-}O\text{-}R + H_2O$]
  ☆ general formula: R-O-R
  ☆ example: diethyl ether ($C_2H_5OC_2H_5$) or ethoxyethane
    ★ use: anesthetic and solvent
★ Esters R–COOR (fragrances)
  ☆ example: CH_3COOCH_3 methyl methanoate
★ Amines - derivatives of ammonia
★ Amino acids $R\text{–}C(NH_2)COOH$
★ Amides - dehydration synthesis of amino acids

Answer the questions below by circling the number of the correct response

1. Which is the correct structural formula for methanol?



2. What is the correct I.U.C. name of the compound represented by the following structural formula?

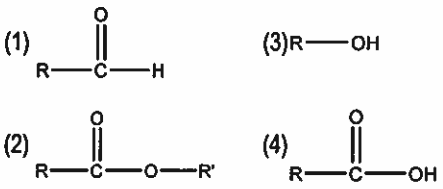


(1) n-pentane (3) 2-methylbutane
(2) isobutane (4) n-butane

3. Which is an isomer of 2,2-dimethylpropane?
(1) ethane (3) n-pentane
(2) propane (4) n-butane

4. Which molecule contains four carbon atoms?
(1) ethane (3) methane
(2) butane (4) propane

5. The general formula of organic acids can be represented as



6. How many carbon atoms are contained in an ethyl group?
(1) 1 (3) 3
(2) 2 (4) 4

7. Which is an isomer of 2-chloropropane?
(1) butane (3) 1-chlorobutane
(3) propane (4) 1-chloropropane

8. Which is an ester? (1) CH_3OH (2) CH_3COOH (3) CH_3OCH_3 (4) CH_3COOCH_3

9. The compound $CH_3CH_2COOCH_3$ is an example of
(1) an ester (3) an acid
(2) an alcohol (4) a polymer

10. The formula of methanoic acid is
(1) HCHO (3) CH_3OH
(2) HCOOH (4) $HCOOCH_3$

11. Which is the formula for ethanoic acid?
(1) CH_3COOH (3) CH_3CH_2COOH
(2) CH_3CH_2OH (4) $CH_3CH_2CH_2OH$

12. The compound CH_3COOCH_3 is classified as
(1) an acid (3) an ester
(2) an alcohol (4) a hydrocarbon

13. Which formula represents an organic acid?
(1) CH_3COOH (3) CH_3OCH_3
(2) CH_3OH (4) CH_3COOCH_3

14. The compound methanal, HCHO, is an example of an
(1) ether (3) alcohol
(2) aldehyde (4) acid

15. What could be the name of a compound that has the general formula R-OH?
(1) methanol (3) methyl methanoate
(2) methane (4) methanoic acid

16. Which organic compound is a ketone?
(1) CH_3OH (3) CH_3COOH
(2) CH_3COCH_3 (4) CH_3COOCH_3

Name _____

Date _____ Period _____

Organic Reactions

Aim

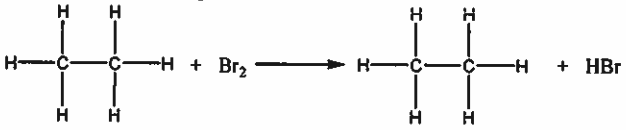
- to describe common reactions of organic compounds

Notes

Some reactions of hydrocarbons

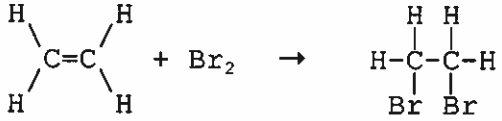
★ Combustion - burning
- ☆ with sufficient oxygen → CO_2 and water
  - ★ example: $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$
- ☆ with insufficient oxygen → CO and water
  - ★ example: $2C_3H_8 + 7O_2 \rightarrow 6CO + 8H_2O$

★ Substitution - replacement of hydrogen in saturated hydrocarbons
- ☆ example: halogen substitution



eth
ane + bromine → monobromoethane + hydrogen bromide

★ Addition
- ☆ Definition = Adding two or more atoms to carbon at a point of unsaturation
- ☆ Characteristics
  - ★ take place more easily than substitutions
  - ★ unsaturated bonds are more reactive than saturated bonds and alkynes are more reactive than alkenes
  - ★ results in the formation of a single product
- ☆ Examples
  - ★ halogenation - occurs at room temperature



- ☆ Hydrogenation
  - ★ Definition - addition of hydrogen to an alkene or an alkyne (or other carbon compounds with double or triple bonds)

★ Fermentation - enzymatic breakdown of organic molecules during anaerobic respiration

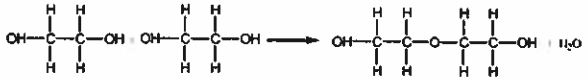
$$C_6H_{12}O_6 \xrightarrow{zymase} 2C_2H_5OH + 2CO_2$$

glucose → ethanol + carbon dioxide

★ Esterification - formation of esters
- ☆ General formula: RCOOR
- ☆ Formation: ROH + RCOOH → RCOOR + H_2O
- ☆ importance:
  - ★ fruit flavorings and aromas
  - ★ lipids are formed by esterification of glycerol by fatty acids

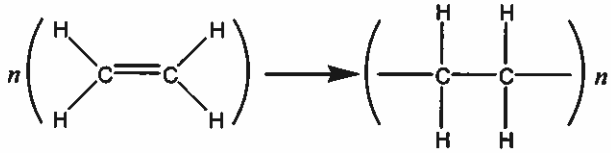
★ Saponification - hydrolysis of fats by bases
- ☆ produces organic salts called soaps
- ☆ forms glycerol as a byproduct

★ Polymerization - formation of large molecules from repeating units of smaller ones
- ☆ Polymer - large molecule formed from many smaller, repeating units or *monomers*
- ☆ Condensation - joining monomers by dehydration synthesis



monomer monomer dimer

  - ★ condensation polymers must have at least two functional groups
  - ★ the process can be repeated to form long chain polymers
  - ★ examples: silicones, polyesters, polyamides, phenolic plastics, and nylons
- ☆ Addition polymerization - involves opening up double and triple bonds of unsaturated hydrocarbons
  - ★ examples: vinyl plastics - polyethylene, polystyrene



ethylene monomer polyethylene

Answer the questions below by circling the number of the correct response

1. One of the products produced by the reaction between CH_3COOH and CH_3OH is
   (1) HOH (3) HCOOH
   (2) H_2SO_4 (4) CH_3CH_2OH

2. A fermentation reaction and a sponification reaction are similar in that they both can produce
   (1) an ester (3) an acid
   (2) an alcohol (4) a soap

3. The product of a reaction between a hydrocarbon and chlorine was 1,2-dichloropropane. The hydrocarbon must have been
   (1) C_5H_{10} (3) C_3H_6
   (2) C_2H_4 (4) C_4H_8

4. The product of a reaction between a hydrocarbon and chlorine was 1,2-dichloropropane. The hydrocarbon must have been
   (1) C_5H_{10} (3) C_3H_6
   (2) C_2H_4 (4) C_4H_8

5. The reaction $C_3H_6 + H_2 \rightarrow C_3H_8$ is an example of
   (1) substitution (3) polymerization
   (2) addition (4) esterification

6. The reaction $C_2H_4 + H_2 \rightarrow C_2H_6$ is an example of
   (1) addition (3) saponification
   (2) substitution (4) esterification

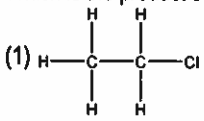
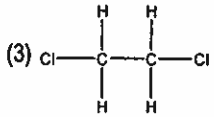
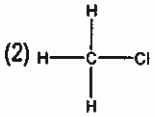
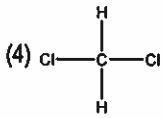
7. A reaction between an acid and an alcohol produces an ester and
   (1) carbon dioxide (3) glycerol
   (2) water (4) ethanol

8. The fermentation of $C_6H_{12}O_6$ will produce carbon dioxide and
   (1) a polymer (3) an ester
   (2) a soap (4) an alcohol

9. The reaction: $C_4H_8 + Cl_2 \rightarrow C_4H_8Cl_2$ is an example of
   (1) substitution (3) polymerization
   (2) addition (4) fermentation

10. A reaction between CH_3COOH and an alcohol produced water and an ester CH_3COOCH_3. Which alcohol was used in the reaction?
    (1) CH_3OH (3) C_3H_7OH
    (2) C_2H_5OH (4) C_4H_9OH

11. The hydrolysis of fat by a base is called
    (1) saponification (3) polymerization
    (2) esterification (4) neutralization

12. Which is the product of the reaction between ethene and chlorine?
    (1) 
    (3) 
    (2) 
    (4) 

13. Which equation represents an esterification reaction?
    (1) $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + CO_2$
    (2) $C_5H_{10} + H_2 \rightarrow C_5H_{12}$
    (3) $C_3H_8 + Cl_2 \rightarrow C_3H_7Cl + HCl$
    (4) $HCOOH + CH_3OH \rightarrow HCOOCH_3 + HOH$

14. In a condensation polymerization, a product always formed is
    (1) water (3) oxygen
    (2) hydrogen (4) carbon dioxide

15. The organic reaction,
    $HCOOH + CH_3CH_2CH_2CH_2OH \rightarrow HCOOCH_2CH_2CH_2CH_3 + HOH$,
    is an example of
    (1) fermentation (3) polymerization
    (2) esterification (4) saponification

16. Which compound will undergo a substitution reaction with chlorine?
    (1) CH_4 (3) C_3H_6
    (2) C_2H_4 (4) C_4H_8

17. The reaction represented by the equation $nC_2H_4 \rightarrow (-C_2H_4-)_n$ is called
    (1) saponification (3) esterification
    (2) fermentation (4) polymerization

18. Which organic reaction involves the bonding of monomers by a dehydration process?
    (1) substitution (3) addition polymerization
    (2) oxidation (4) condensation polymerization

19. The reaction $CH_3OH + HCOOH \rightarrow HCOOCH_3 + H_2O$ is an example of
    (1) hydrogenation (3) esterification
    (2) polymerization (4) addition

20. The reaction $C_4H_{10} + Br_2 \rightarrow C_4H_9Br + HBr$ is an example of
    (1) substitution (3) fermentation
    (2) addition (4) polymerization