Name ANSWERS Date _____ Class _____

22.1 HYDROCARBONS

Section Review

Objectives

- Describe the relationship between number of valence electrons and bonding in carbon
- Define and describe *alkanes*
- Relate the polarity of hydrocarbons to their solubility

Vocabulary

- hydrocarbons
- alkanes
- straight-chain alkanes
- homologous series
- condensed structural formulas
- substituent
- alkyl group
- branched-chain alkane

Part A Completion

Use this completion exercise to check your understanding of the concepts and terms that are introduced in this section. Each blank can be completed with a term, short phrase, or number.

The branch of chemistry that deals with __1__ compounds is called __2__ chemistry. Organic compounds that contain only carbon and hydrogen are __3__. Carbon always forms __4__ covalent bonds.

Alkanes contain only carbon-carbon __5__ bonds. The carbons can be arranged in a __6__ chain or in a chain that has __7__. A hydrocarbon substituent is called an __8__ group. The first step in naming branched-chain alkanes is to find the __9__ chain of carbons in the molecule. This chain is the __10__ structure.

1. Carbon
2. organic
3. hydrocarbon
4. 4
5. single
6. straight
7. branches
8. alkyl
9. longest
10. (parent

Part B True-False

Classify each of these statements as always true, AT; sometimes true, ST; or never true, NT.

NT 11. Because a carbon atom contains 6 valence electrons, it forms 3 covalent bonds.

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ST **12.** Straight-chain alkanes contain 10 carbon atoms.

AT **13.** A substituent can take the place of a hydrogen atom on a parent hydrocarbon molecule.

ST **14.** Hydrocarbon structural formulas are numbered from right to left.

AT **15.** When naming branched-chain hydrocarbons, the names of the substituent alkyl groups are listed in alphabetical order.

Part C Matching

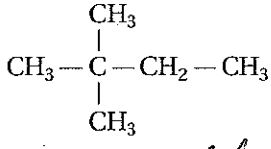
Match each description in Column B to the correct term in Column A.

Column A	Column B
D **16.** hydrocarbons	**a.** hydrocarbons that contain only single covalent bonds
A **17.** alkanes	**b.** a hydrocarbon substituent
E **18.** straight-chain alkanes	**c.** alkanes that contain one or more alkyl substituents
F **19.** substituent	**d.** organic compounds that contain only carbon and hydrogen
B **20.** alkyl group	**e.** alkanes that contain any number of carbons one after another in a chain
C **21.** branched-chain alkanes	**f.** atom or group of atoms that take the place of a hydrogen atom in a hydrocarbon molecule

Part D Questions and Problems

Answer the following in the space provided.

22. Name this compound, using the IUPAC system.



2,2-dimethylbutane

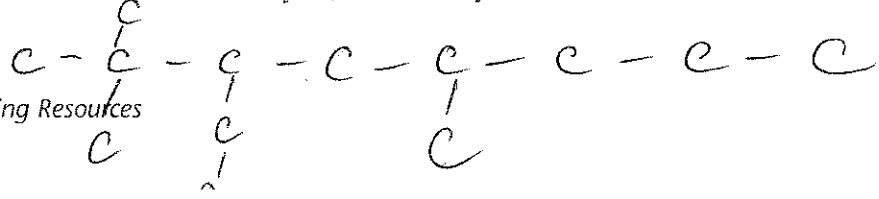
23. a. What is the total number of single bonds in a molecule of pentane, C_5H_{12}?

16

b. What is the total number of single bonds in a molecule of 2,2-dimethylpropane?

16

24. Write the structural formula for 3-ethyl-2,2,5-trimethyloctane.



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Name _____ Date _____ Class _____

22.2 UNSATURATED HYDROCARBONS

Section Review

Objectives

- Describe the difference between unsaturated and saturated hydrocarbons
- Distinguish the structures of alkenes and alkynes

Vocabulary

- saturated compounds
- unsaturated compounds
- alkenes
- alkynes
- aliphatic hydrocarbons

Part A Completion

Use this completion exercise to check your understanding of the concepts and terms that are introduced in this section. Each blank can be completed with a term, short phrase, or number.

Alkenes are __1__ hydrocarbons. That is, they contain one or more carbon-carbon __2__ bonds. Alkynes are also unsaturated compounds. They contain one or more carbon-carbon __3__ bonds. Rotation is restricted about the multiple bonds of alkenes and alkynes.

Alkenes are named by finding the __4__ chain in the molecule that contains a __5__ bond. The root name of the corresponding __6__ is used, plus the ending __7__. Atoms are numbered so that the carbon atoms of the __8__ have the lowest possible numbers. Alkynes are named in the same way, except that the ending __9__ is added to the alkane root.

1. unsaturated
2. double
3. triple
4. longest
5. double
6. alkane
7. -ene
8. double bond
9. -yne

Part B True-False

Classify each of these statements as always true, AT; sometimes true, ST; or never true, NT.

NT **10.** An alkane with one or more alkyl groups is called an alkyne.

ST **11.** Hydrocarbons are saturated.

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AT 12. Parent alkene chains are numbered so that the carbons of the double bond have the lowest possible numbers.

ST 13. Unsaturated hydrocarbons contain double bonds.

Part C Matching

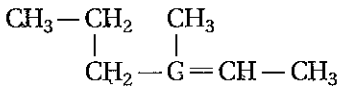
Match each description in Column B to the correct term in Column A.

	Column A	Column B
C	14. unsaturated compounds	a. contain at least one carbon-carbon double bond
D	15. saturated compounds	b. contain at least one carbon-carbon triple bond
A	16. alkenes	c. organic compounds that contain double or triple carbon-carbon bonds
B	17. alkynes	d. hydrocarbons that contain the maximum number of hydrogen atoms per carbon atom

Part D Questions and Problems

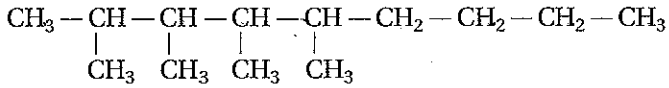
Answer the following in the space provided.

18. Name this compound using the IUPAC system.



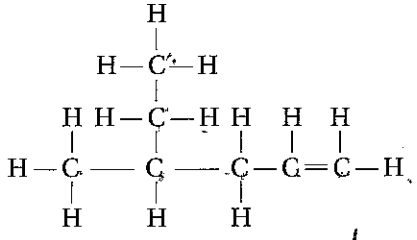
3methyl-2-hexene

19. Name this compound, using the IUPAC system.



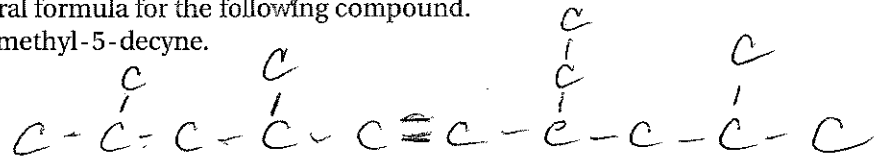
2,3,4,5-tetramethylnonane

20. Name the following compound, using the IUPAC system.



4-methyl-1-hexene

21. Draw the structural formula for the following compound.
7-ethyl-2,4,9-trimethyl-5-decyne.



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22.3 ISOMERS

Section Review

Objectives

- Explain why structural isomers have different properties
- Describe the conditions under which geometric isomers are possible
- Identify optical isomers

Vocabulary

- isomers
- structural isomers
- stereoisomers
- geometric isomers
- *trans* configuration
- *cis* configuration
- asymmetric carbon
- optical isomers

Part A Completion

Use this completion exercise to check your understanding of the concepts and terms that are introduced in this section. Each blank can be completed with a term, short phrase, or number.

Isomers have the same __1__ formula but different molecular __2__. For example, 2–methylpropane is a structural isomer of __3__. Isomers are different compounds with different __4__.

__5__ isomers differ in the orientation of groups around a double bond. The two possible double-bond configurations are the __6__ configuration and the __7__ configuration.

Geometric isomers are one type of __8__. The other type contains a carbon atom with four different groups attached, which is called an __9__ carbon. Isomers with an asymmetric carbon are __10__ isomers.

Models of optical isomers are like __11__ images, which cannot be __12__.

1. molecular
2. structure
3. butane
4. properties
5. Geometric
6. Cis
7. trans
8. stereoisomers
9. asymmetric
10. optical
11. mirror
12. superimposed

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Part B True-False

Classify each of these statements as always true, AT; sometimes true, ST; or never true, NT.

NT 13. Structural isomers are compounds with identical molecular structures.

ST 14. Compounds containing double bonds have *cis, trans* isomers.

NT 15. Isomers with the atoms joined in the same order are structural isomers.

AT 16. A carbon with four different groups attached is an asymmetric carbon.

Part C Matching

Match each description in Column B to the correct term in Column A.

Column A	Column B
H 17. isomers	**a.** a carbon with four different groups attached
E 18. structural isomers	**b.** configuration with substituted groups on the same side of the double bond
D 19. stereoisomers	**c.** isomers that differ in the concentration of groups around a double bond
C 20. geometric isomers	**d.** molecules in which the atoms are joined in the same order, but the arrangements of the atoms in space are different
F 21. *trans* configuration	**e.** compounds that have the same molecular formula, but the atoms are joined in a different order
B 22. *cis* configuration	**f.** configuration with substituted groups on opposite sides of the double bond
A 23. asymmetric carbon	**g.** pairs of molecules that differ only in the way four different groups are arranged around a central carbon atom
G 24. optical isomers	**h.** compounds that have the same molecular formula but different molecular structures

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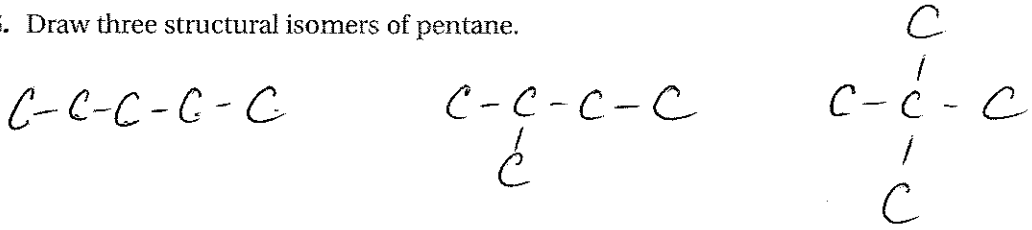
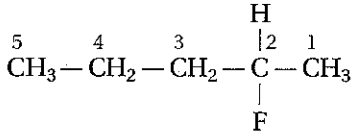
Part D Problems

Answer the following in the space provided.

25. Draw three structural isomers of pentane.

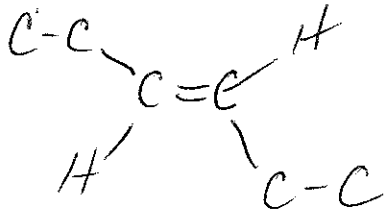


26. Identify the asymmetric carbon in this compound.

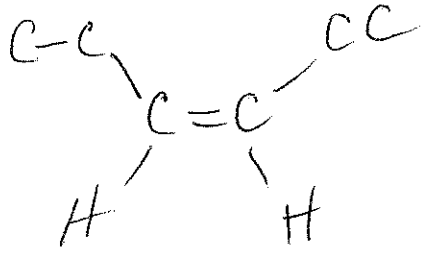


Carbon 2 is asymmetric

27. Draw the *cis* and *trans* isomers for 3-hexene.



trans-3-hexene



cis-3-hexene

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22.4 HYDROCARBON RINGS

Section Review

Objectives

- Identify cyclic ring structures
- Describe bonding in benzene

Vocabulary

- cyclic hydrocarbons
- aromatic compound

Part A Completion

Use this completion exercise to check your understanding of the concepts and terms that are introduced in this section. Each blank can be completed with a term, short phrase, or number.

Compounds with hydrocarbon rings are called __1__ hydrocarbons. Benzene is the simplest form of an __2__ compound. The benzene molecule consists of __3__ carbons joined in a ring with a __4__ atom attached to each carbon. Two different structures can be written for benzene in which __5__ and single bonds alternate. The actual bonding in benzene does not alternate between the __6__ structures.

Many substituted benzenes have common names. __7__ is also called toluene, while the dimethylbenzenes are known as __8__. 1,2–disubstitution on a benzene ring is also know as __9__ disubstitution, while 1,3 is known as __10__, and 1,4 is known as __11__ disubstitution.

1. cyclic
2. aromatic
3. six
4. hydrogen
5. double
6. resonance
7. methylbenzene
8. xylenes
9. ortho-o
10. meta-m
11. para-p

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Part B True-False

Classify each of these statements as always true, AT; sometimes true, ST; or never true, NT.

ST **12.** Aromatic compounds contain 6 carbon atoms.

AT **13.** Benzene is the simplest arene.

ST **14.** Compounds that contain rings are aromatic hydrocarbons.

AT **15.** Another name for 1,3-dimethylbenzene is *m*-xylene.

ST **16.** Aromatic compounds have pleasant odors.

Part C Matching

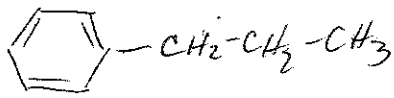
Match each description in Column B to the correct term in Column A.

Column A	Column B
D **17.** cyclic hydrocarbons	**a.** when two or more equally valid structures can be drawn for a molecule
A **18.** resonance	**b.** group of hydrocarbons that contain a benzene ring or a ring with bonding like that of benzene
C **19.** phenyl group	**c.** name given to a benzene ring when it is a substituent
B **20.** aromatic compounds	**d.** organic compounds that contain hydrocarbon rings

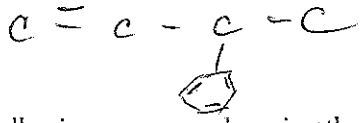
Part D Problems

Answer the following in the space provided.

21. Draw the structural formula for propylbenzene.

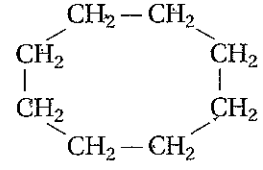


22. Draw the structural formula for 3-phenyl-1-butene.



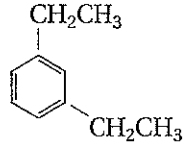
23. Name the following compounds, using the IUPAC system.

a.



cyclooctane

b.



1,3-diethylbenzene
or
m-diethylbenzene

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22.5 HYDROCARBONS FROM EARTH'S CRUST

Section Review

Objectives

- Identify three important fossil fuels and describe their origins
- Describe the composition of natural gas, petroleum, and coal
- Describe what happens when petroleum is refined

Vocabulary

- cracking

Part A Completion

Use this completion exercise to check your understanding of the concepts and terms that are introduced in this section. Each blank can be completed with a term, short phrase, or number.

The three fossil fuels are __1__, petroleum, and __2__. The majority of natural gas, about 80 percent, is __3__.

Most of the hydrocarbons in petroleum and natural gas are __4__ hydrocarbons. Petroleum is refined by __5__ it into fractions according to __6__.

Coal is produced when peat, which is derived from plant material, changes to __7__, or brown coal. This in turn becomes __8__, or soft coal, then __9__, or hard coal. Coal is made up largely of condensed __10__ compounds.

1. natural
2. coal
3. methane
4. aliphatic
5. distillation
6. boiling points
7. lignite
8. bituminous
9. anthracite
10. aromatic

Part B True-False

Classify each of these statements as always true, AT; sometimes true, ST; or never true, NT.

NT 11. Carbon monoxide is the product of the complete combustion of a hydrocarbon.

NT 12. Natural gas is composed mostly of aromatic hydrocarbons.

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AT 13. Among the various types of coal, anthracite has the highest carbon content.

ST 14. Hydrocarbons produce carbon monoxide when burned.

Part C Matching

Match each description in Column B to the correct term in Column A.

Column A	Column B
B 15. cracking	a. hard coal, which is high in carbon content
D 16. petroleum	b. process by which hydrocarbons are broken down into smaller molecules
E 17. distillation	c. brown coal, consisting of about 50 percent carbon
C 18. lignite	d. fossil fuel containing straight- and branched-chain alkanes
A 19. anthracite	e. process by which petroleum is separated into fractions

Part D Problems

Answer the following in the space provided.

20. Balance the equation for the incomplete combustion of pentane to form CO and H_2O.

$2\ C_5H_{12}(\ell) + 11\ O_2(g) \rightarrow 10\ CO(g) + 12\ H_2O(g)$

21. Balance the following equation.

$$C_6H_6 + O_2 \rightarrow CO_2 + H_2O$$

$2\ C_6H_6 + 15O_2 \rightarrow 12\ CO_2 + 6\ H_2O$

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