Nomenclature (binary compounds)

Type I

Metal + nonmetal

The metal has only one charge and takes the name of the element

Ending changes to -ide

Example:
KCl Potassium chloride
$MgBr_2$ Magnesium bromide

Common Type I cations

Alkali,
Alkaline
Al^{3+},
Ag^{+},
Zn^{2+}

Type II

Metal + nonmetal

The metal has a variable oxidation state (different charge). A Roman number indicates the charge

Ending changes to -ide

Examples: CuBr Copper(I) bromide
FeS Iron(II) sulfide

Table 5.2 Common Type II Cations

Ion	Systematic Name
Fe^{3+}	iron(III)
Fe^{2+}	iron(II)
Cu^{2+}	copper(II)
Cu^{+}	copper(I)
Co^{3+}	cobalt(III)
Co^{2+}	cobalt(II)
Sn^{4+}	tin(IV)
Sn^{2+}	tin(II)
Pb^{4+}	lead(IV)
Pb^{2+}	lead(II)
Hg^{2+}	mercury(II)
Hg_2^{2+}*	mercury(I)

*Mercury(I) ions always occur bound together in p

Type III

nonmetal + nonmetal

For nonmetal+nonmetal, prefixes indicate the number of atoms.

Ending changes to -ide

Example: tetranitrogen nonachloride
Step 1: N_4
Step 2: N_4Cl_9

Example: O_2F
Step 1: dioxygen
Step 2: dioxygen monofluoride

Prefixes
1 – mono
2 – di
3 – tri
4 – tetra
5 – penta
6 – hexa
7 – hepta
8 – octa
9 – nona
10 - deca

1

Rules for Writing Lewis Structures

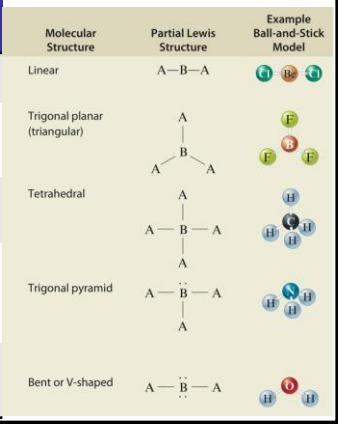
1) **Count the total number of valence e^-**
   Notes: Add one more electron for each negative charge in the composition. Subtract one electron for each positive charge in the composition.
2) **Write the skeleton structure**
   Notes: -Element that needs the most e^- go in the center
   -H are terminal atoms
   -Least electronegative atom go on the center
3) **Use two electrons to connect elements**
4) **Complete octets by distributing the remaining e^-**
5) **Make double or triple bonds if octets not complete**

2

Steps for Predicting Molecular Shape Using the VSEPR Model

1. Draw the Lewis structure for the molecule.
2. Determine # of lone pair of electrons and bonded atoms

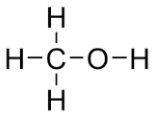
	Lone pair of electrons	Bonded atoms	Molecular Structure
Polar if asymmetric	0	2	Linear
	0	3	Trigonal Planar
	0	4	Tetrahedral
Polar	1	3	Trigonal pyramidal
	2 or 1	2	bent

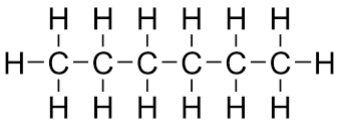


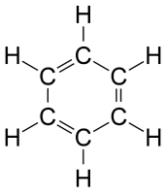
3

Like Dissolves Like Rule

- Polar solvents dissolve in one another.
- Nonpolar solvents dissolve in one another.
- This is the **like dissolves like *rule***.
- Methanol dissolves in water, but hexane does not dissolve in water.
- Hexane dissolves in benzene, but water does not dissolve in benzene.



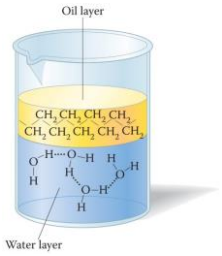




4

Polar and Nonpolar Solvents

- A liquid composed of polar molecules is a ***polar solvent***. Water is a polar solvent.
- A liquid composed of nonpolar molecules is a ***nonpolar solvent***. Hexane is a nonpolar solvent.



SELECTED POLAR AND NONPOLAR SOLVENTS

POLAR SOLVENTS	NONPOLAR SOLVENTS
water, H_2O	hexane, C_6H_{14}
methanol, CH_3OH	heptane, C_7H_{16}
ethanol, C_2H_5OH	toluene, C_7H_8
acetone, C_3H_6O	carbon tetrachloride, CCl_4
methyl ethyl ketone, C_4H_8O	chloroform, $CHCl_3$
formic acid, HCOOH	methylene chloride, CH_2Cl_2
acetic acid, CH_3COOH	ethyl ether, $C_4H_{10}O$*

*The general rule that oxygen-containing solvents are polar has some exceptions. For example, ethyl ether contains oxygen and is a nonpolar solvent.

5

How Substances Dissolve

"–like dissolves like–"

Polar + Polar

Nonpolar + nonpolar

6

How Substances Dissolve

Which of the following solutes will generally not dissolve in the specified solvent? Choose the best answer. (Assume all of the compounds are in the liquid state.)

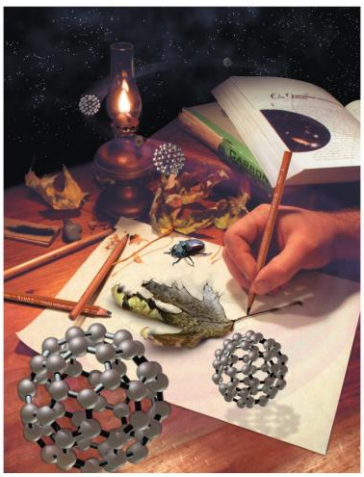
A) CCl_4 mixed with water (H_2O)
B) NH_3 mixed with water (H_2O)
C) OCl_2 mixed with water (H_2O)
D) N_2 mixed with methane (CH_4)

7

Organic Chemistry

Chapter 19

- **Organic chemistry**
  - The study of carbon-based molecules



8

Introduction

- ***Organic chemistry*** is the study of carbon and its compounds.
- Currently, about 50 million organic compounds account for about 90% of all known substances.
- Each year, over 100,000 new organic compounds are synthesized.
- The major sources of carbon are the fossil fuels petroleum, natural gas, and coal.

9

Carbon—A Unique Element

- The element carbon
  - Most abundant isotope has six protons, six neutrons, and six electrons
  - Has four valence shell electrons

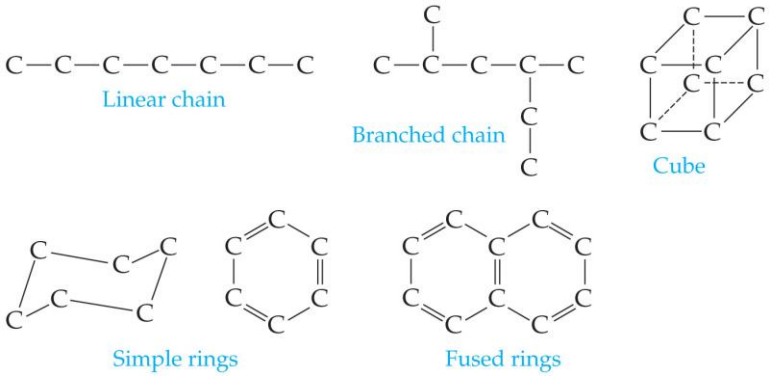
Carbon bonds via its four valence electrons. 

  - Is very good at bonding to itself to form chains and rings and other structures
    - **Catenation**—the ability of an element to bond to itself

10

Carbon—A Unique Element

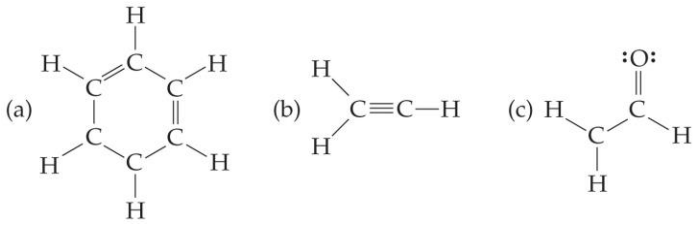
Carbon Structures



11

Carbon—A Unique Element

Explain the error in each of the following molecules:



12

Hydrocarbons

A ***hydrocarbon*** is a compound that contains *only* carbon and hydrogen.

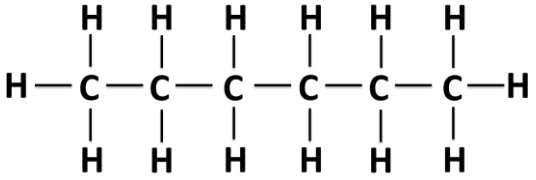
There are two types of hydrocarbons:

1. Saturated hydrocarbons
2. Unsaturated hydrocarbons

13

Saturated Hydrocarbons

- A ***saturated hydrocarbon*** has only single bonds between the carbon atoms.
- Carbon can form four single covalent bonds to other atoms.
- A saturated hydrocarbon with only single bonds belongs to the *alkane* family.

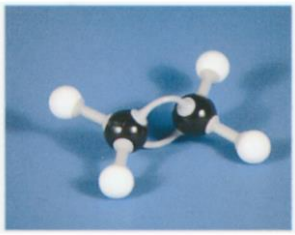


Hexane (C_6H_{14})

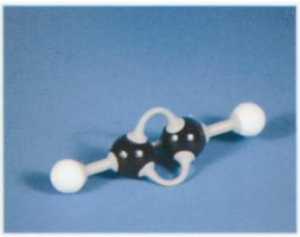
14

Unsaturated Hydrocarbons

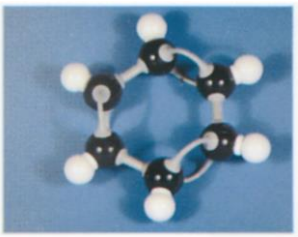
- An ***unsaturated hydrocarbon*** has either a double or triple bond between two carbon atoms.
  - If it has a double bond, it is an *alkene* (a).
  - If it has a triple bond, it is an *alkyne* (b).
- An *aromatic hydrocarbon* (c) has a benzene ring.



(a)



(b)



(c)

15

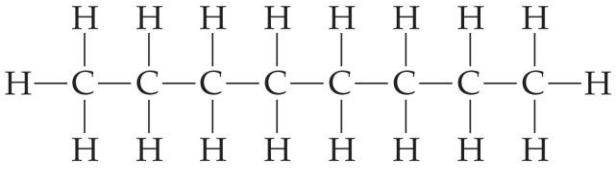
Alkanes (Saturated Hydrocarbons)

- Alkanes are a family of compounds whose names end in the suffix –***ane***. They are saturated hydrocarbons.
- They each have the same general molecular formula: C_nH_{2n+2}.
  - The fifth member of the alkane family, pentane, has 5 carbon atoms and 12 ($2 \times 5 + 2 = 12$) hydrogen atoms, C_5H_{12}.

16

Naturally Occurring Compounds of Carbon and Hydrogen—Hydrocarbons

- Chains of carbon
  - **Chain length**—number of carbon atoms in the longest continuous chain



Chain length of eight

17

Alkane Family

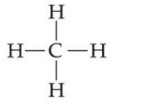
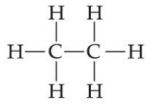
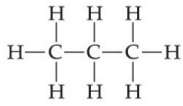
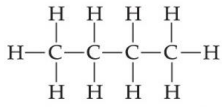
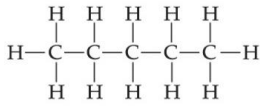
- The lighter alkanes (1–10 carbons) are used as fuels, whereas the larger alkanes (20–40 carbons) are solids used to make waxes and candles.

Table 17.6 Boiling Points for Some Linear Alkanes (at 1 atm pressure)

Chain length *n*	Alkane	Boiling point (°C)	
1	Methane, CH_4	−164	Gas at 25 °C
2	Ethane, CH_3CH_3	−88.6	
3	Propane, $CH_3CH_2CH_3$	−42.1	
4	Butane, $CH_3CH_2CH_2CH_3$	−0.5	
5	Pentane, $CH_3CH_2CH_2CH_2CH_3$	36.1	Liquid at 25 °C
6	Hexane, $CH_3CH_2CH_2CH_2CH_2CH_3$	69.0	
7	Heptane, $CH_3CH_2CH_2CH_2CH_2CH_2CH_3$	98.4	
8	Octane, $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_3$	124.7	
9	Nonane, $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_3$	150.8	
10	Decane, $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_3$	174.1	
20	Eicosane, $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_3$	343	Solid at 25 °C

18

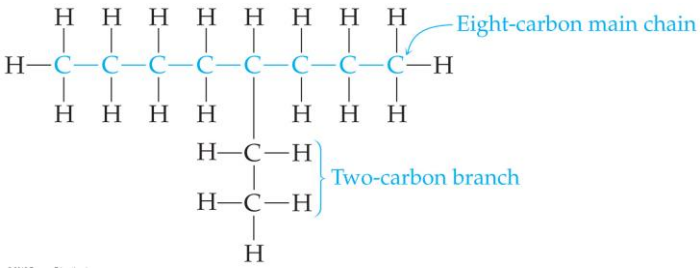
Naming Alkanes

Chain length *n*		
1		Methane, CH_4
2		Ethane, C_2H_6
3		Propane, C_3H_8
4		Butane, C_4H_{10}
5		Pentane, C_5H_{12}

19

Hydrocarbons

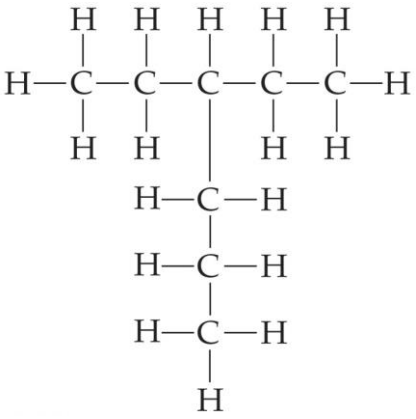
- **Branched hydrocarbon**
  - At least one carbon atom is attached to more than two other carbon atoms.
  - Small branch forming off the main carbon chain



20

—Hydrocarbons

For the following molecule, what is the length of the main chain and what is the length of the branch chain?



Main chain: six carbons

Branch chain: two carbons

21

Alkyl and Aryl Groups

- When a hydrogen is removed from an alkane, an ***alkyl group*** results.

$CH_4 - H$ = CH_3-
methane — methyl group

$CH_3-CH_3 - H$ = CH_3-CH_2-
ethane — ethyl group

- When we remove the hydrogen atom, the name *–ane* suffix is changed to ***–yl***.

22

Naming Hydrocarbons

- Naming of branches
  - Name the alkane branch it is similar to and then replace the -*ane* with -*yl*.

Chain (alk*ane*)	**Branch (alk*yl*)**
Methane, CH_4	Methyl, $-CH_3$
Ethane, CH_3CH_3	Ethyl, $-CH_2CH_3$
Propane, $CH_3CH_2CH_3$	Propyl, $-CH_2CH_2CH_3$

23

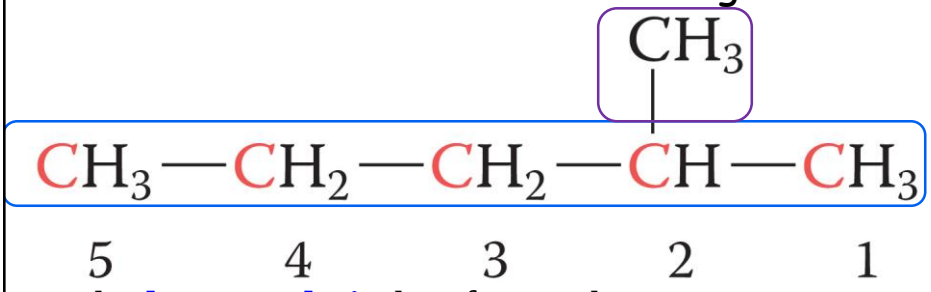
Guidelines for Naming Alkanes

1. Name an alkane for its longest continuous carbon chain regardless of the branches.
2. Number the longest continuous chain starting from the end closest to the first branch on the chain.
3. Indicate the position of the alkyl groups (the branches) by name and number.
4. If there are two or more of the same group attached to the chain, use the prefixes *di–*, *tri–*, *tetra–*, etc.

24

Nomenclature of Alkanes

- What is the name of the following alkane?

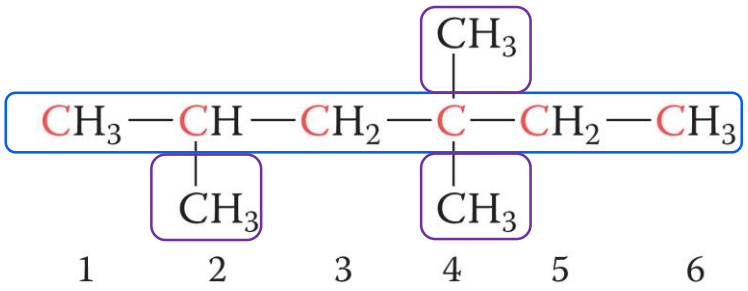


- The **longest chain** has five carbons, so it is a *pentane* derivative. The **methyl group** is in the 2 position.
- The name is 2-methylpentane.

25

Nomenclature of Alkanes, Continued

- What is the name of the following alkane?

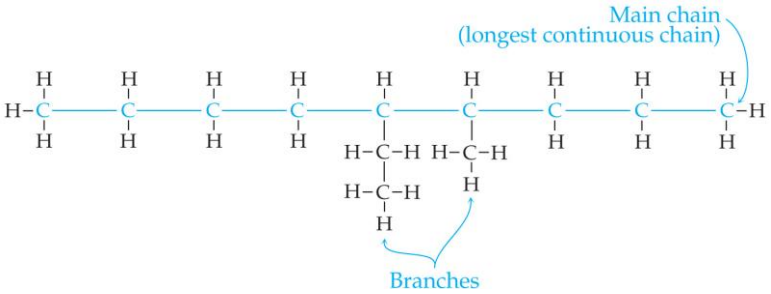


- The longest chain has six carbons, so it is a *hexane* derivative. The methyl groups are in the 2, 4, and 4 positions.
- The name is 2,4,4-trimethylhexane.

26

Naming Alkanes

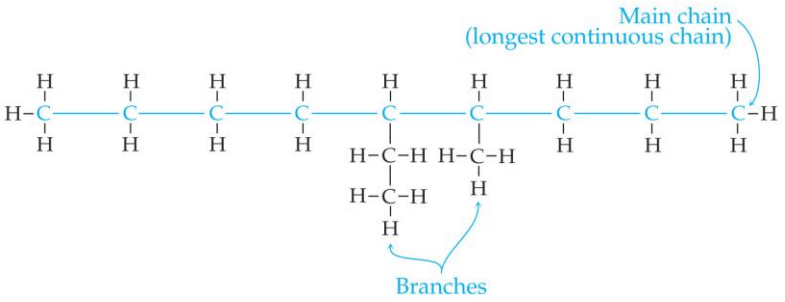
- Naming of branches



  - Step 1: Nonane
  - Step 2: Methyl branch and an ethyl branch
  - Step 3: Methyl branch is at position 4 and ethyl branch is at position 5.

27

Naming Alkanes



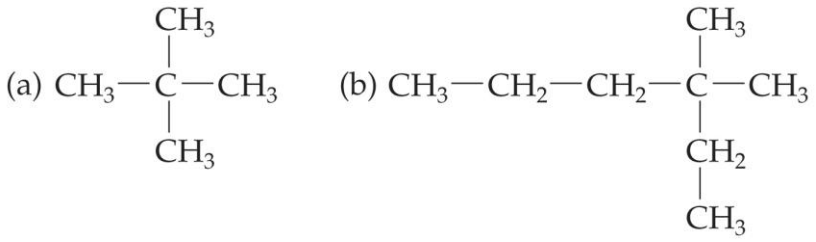
5-Ethyl-4-methylnonane

- The position number precedes the branch name and is separated by hyphens.
- Branches are listed in alphabetical order, not in numerical order.

28

Naming Alkanes

Name the following molecules:



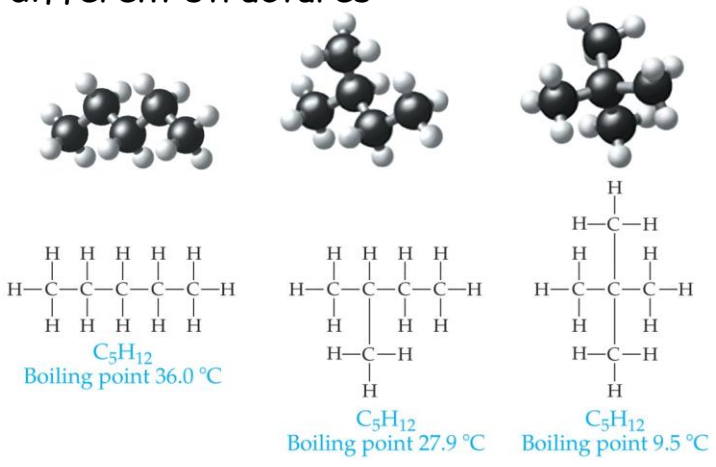
(a) 2,2-Dimethylpropane

(b) 3,3-Dimethylhexane

29

Naming Hydrocarbons

- **Isomers**
  - Compounds with the same formula but different structures



30

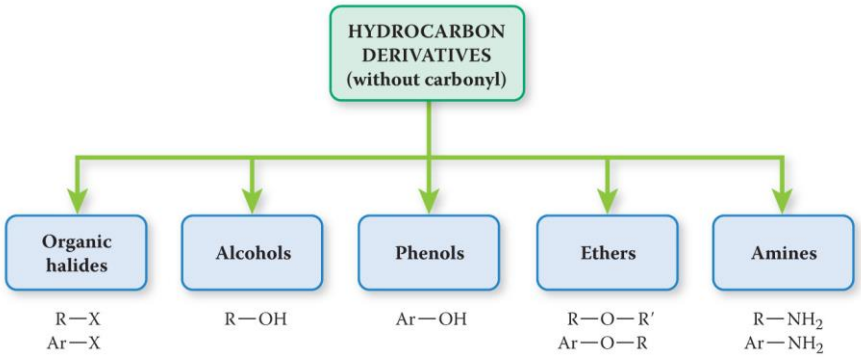
Hydrocarbon Derivatives

- Formed when one or more hydrogen atoms are replaced by another element or group of elements
- We can categorize them into ***classes of compounds***.
- Each of the classes has a specific functional group. A ***functional group*** is a set of atoms that gives a class of compounds its characteristics.
- There are 10 classes: five without a carbonyl group and five with a carbonyl group (C=O).

31

Non-Carbonyl Hydrocarbon Derivatives

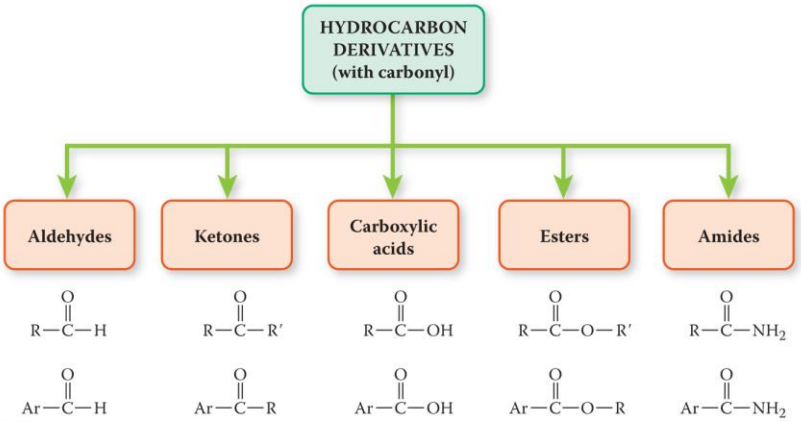
- Here are the basic hydrocarbon classes without carbonyl groups. R is an alkyl group and Ar is an aryl group.



32

Carbonyl Hydrocarbon Derivatives

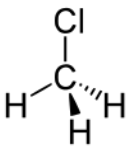
- Here are the basic hydrocarbon classes with carbonyl groups. R is an alkyl group and Ar is an aryl group.



33

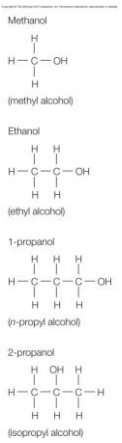
Organic Halides

- If a halogen atom (F, Cl, Br, and I) replaces a hydrogen atom in a hydrocarbon, the new compound is an *organic halide*.
- Organic halides are used primarily as household and industrial solvents.
- They are found in many pesticides.



34

Alcohols

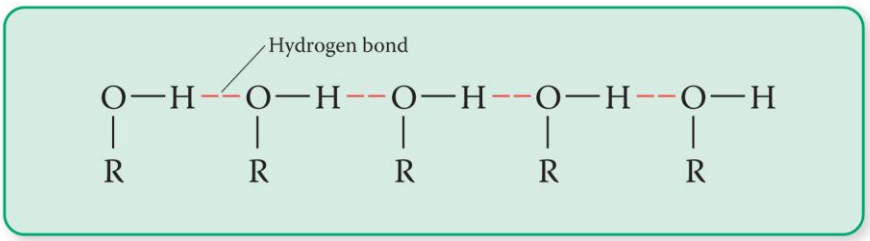


- One or more hydroxyl (-OH) functional groups
- Gasohol - solution of ethanol and gasoline

35

Alcohols and Phenols, Continued

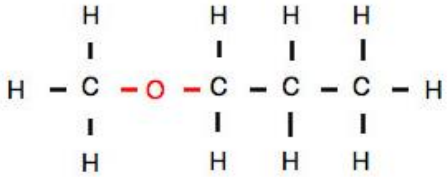
- Most alcohols are quite water soluble because of the polar —OH group, which allows for hydrogen bonding.



36

Ethers

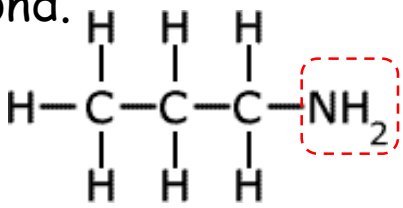
- Organic molecules with two hydrocarbon groups attached to an oxygen are *ethers*, R—O—R.
- Ethers are usually named by indicating the two groups attached to the oxygen.
- Ethers do not hydrogen bond, and their properties lie between those of alkanes and alcohols.



37

Amines

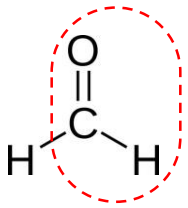
- If an alkyl or aryl group replaces a hydrogen in ammonia, an *amine* results: $R_2—NH_2$.
- Amines are often referred to by their common names, indicating the alkyl group present.
- Most amines are polar due to their ability to hydrogen bond.



38

Aldehydes

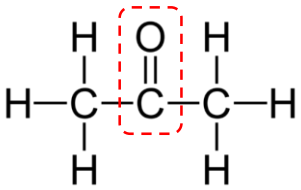
- ***Aldehydes*** contain a carbonyl (*C* = *O*) group and are polar.
- In an aldehyde, the carbonyl group is attached to a hydrogen and an alkyl or aryl group, RCHO.

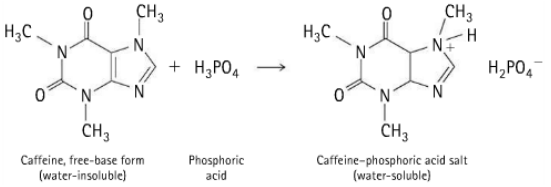


39

Ketones

- ***Ketones*** also contain the carbonyl group and are generally polar.
- Ketones have two alkyl or aryl groups attached to the carbonyl group, RCOR'.
- Ketones are named for their parent alkane.

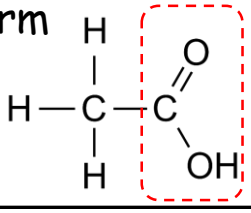




40

Carboxylic Acids

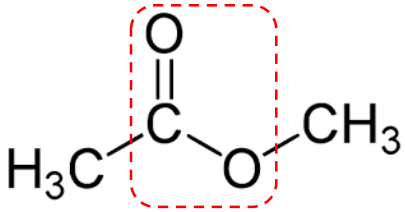
- In a ***carboxylic acid***, a hydroxyl group and alkyl or aryl group is bonded to a carbonyl group, R*COOH*.
- This group, —*COOH*, is a ***carboxyl group***.
- Acetic acid, CH_3COOH, is a major component of vinegar and gives it its sour taste.
- Carboxylic acids are polar since the carboxyl group, —*COOH*, can form hydrogen bonds.

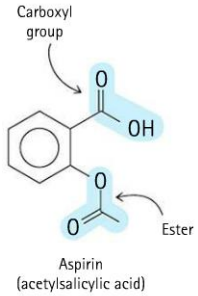


41

Esters

- An ***ester*** has an —R and an —OR group bonded to a carbonyl group, R*COO*R.
- Esters typically have a pleasant fruity odor.
- They are typically formed from the reaction of an alcohol with a carboxylic acid.

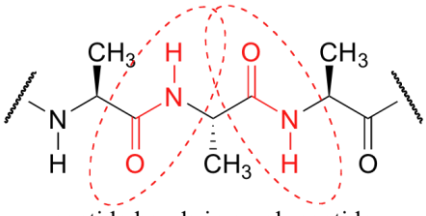




42

Amides

- In ***amides***, a carbonyl group is attached to an alkyl or aryl group and an —NH_2 group.
- Amides are formed from the reaction of a carboxylic acid with ammonia.
- They are polar molecules with properties similar to those of carboxylic acids.



peptide bonds in a polypeptide

43

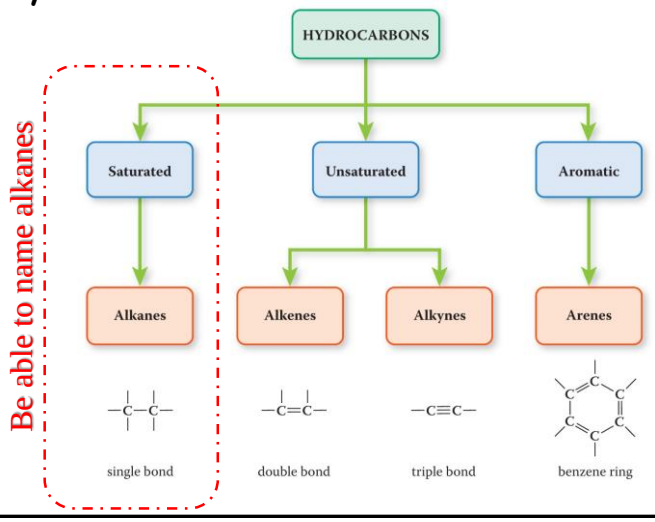
Chapter Summary

- ***Organic chemistry*** is the study of compounds that contain carbon.
- ***Hydrocarbons*** contain only hydrogen and carbon.
- ***Saturated hydrocarbons*** have only single carbon–carbon bonds.
- ***Unsaturated hydrocarbons*** have double or triple carbon–carbon bonds.
- Aromatic hydrocarbons have a benzene ring.

44

Chapter Summary, Continued

- Below is a flowchart for the classification of hydrocarbons.



45

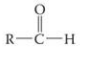
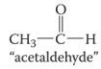
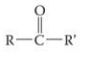
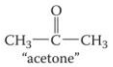
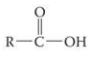
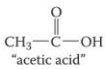
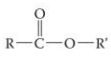
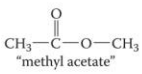
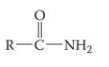
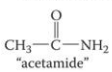
Chapter Summary, Continued

- Alkenes have at least one carbon–carbon double bond.
- Alkynes have at least one carbon–carbon triple bonds.
- Arenes contain a benzene ring.
- Hydrocarbon derivatives have a functional group in addition to the hydrocarbon function. They are summarized on the next slide.

46

Be able to identify the functional group

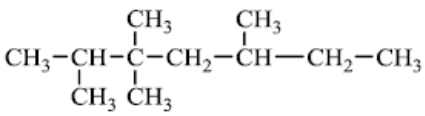
SUMMARY OF HYDROCARBON DERIVATIVES

FAMILY NAME	GENERAL FORMULA	FUNCTIONAL GROUP	EXAMPLE
Organic halide	R—X	—X	$CH_3—CH_2—Cl$ "ethyl chloride"
Alcohol	R—OH	—OH	$CH_3—CH_2—OH$ "ethyl alcohol"
Phenol	Ar—OH	—OH	 phenol
Ether	R—O—R'	—O—	$CH_3—O—CH_3$ "dimethyl ether"
Amine	$R—NH_2$	$—NH_2$	$CH_3—CH_2—NH_2$ "ethyl amine"
Aldehyde			 "acetaldehyde"
Ketone			 "acetone"
Carboxylic acid			 "acetic acid"
Ester			 "methyl acetate"
Amide			 "acetamide"

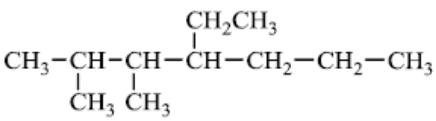
47

Sample problems

Name the following alkane:



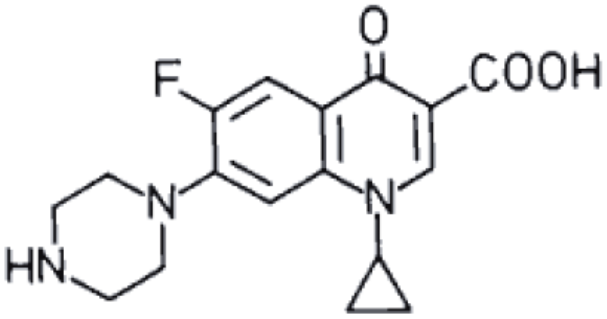
Name the following alkane:



48

Sample problems

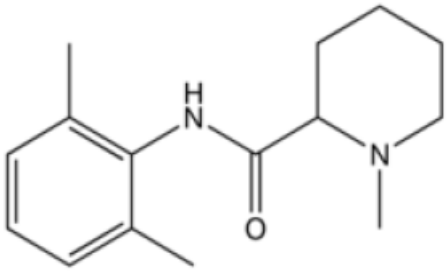
Label the functional groups in the molecule of ciprofloxacin (Cipro), an antibiotic



49

Sample problems

Label the functional groups in mepivicaine, a local anesthetic.



50