TABLE 1.2 Classes and functional groups of organic compounds

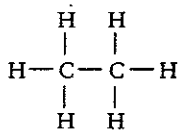
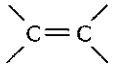
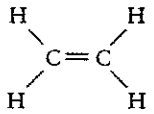
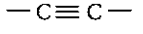
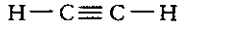
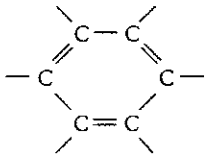
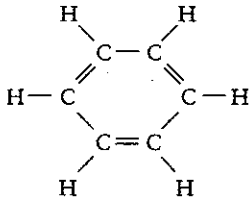
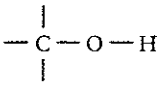
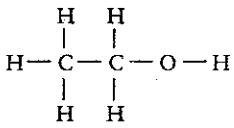
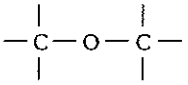
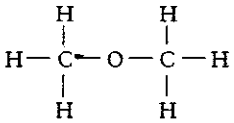
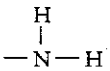
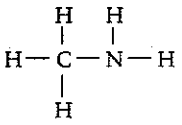
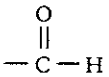
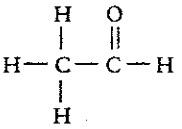
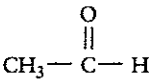
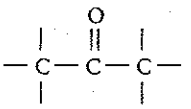
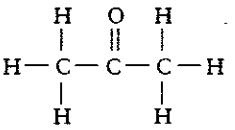
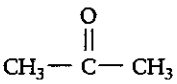
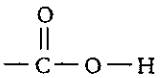
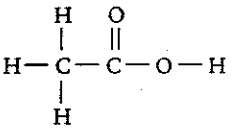
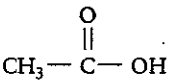
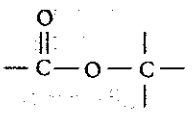
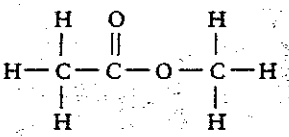
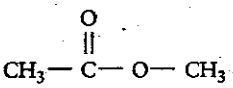
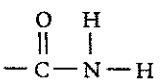
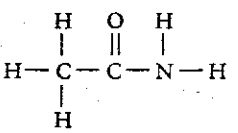
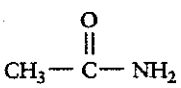
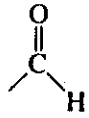
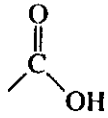
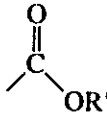
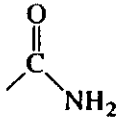
Class	Functional group	Example of expanded structural formula	Example of condensed structural formula	Common name
Alkane	None		CH_3CH_3	ethane
Alkene			$H_2C{=}CH_2$	ethylene
Alkyne			$HC{\equiv}CH$	acetylene
Aromatic				benzene
Alcohol			$CH_3CH_2{-}OH$	ethyl alcohol
Ether			$CH_3{-}O{-}CH_3$	dimethyl ether
Amine			$CH_3{-}NH_2$	methylamine
Aldehyde				acetaldehyde
Ketone				acetone
Carboxylic acid				acetic acid
Ester				methyl acetate
Amide				acetamide

Table 21.5
Classes of Organic Compounds

Compound Class	General Formula	Functional Group	Names*
Alcohol	R—OH	—OH	Alkyl group + *alcohol;* methyl alcohol Alkane prefix + *-ol:* methanol
Ether	R—O—R′		Name both alkyl groups + *ether:* ethyl methyl ether Alkyl group + *-oxy-* + alkane: methoxyethane
Aldehyde	R—CHO		Common prefix + *-aldehyde:* formaldehyde Alkane prefix + *-al:* methanal
Ketone	R—CO—R′		Name both alkyl groups + *ketone:* methyl ethyl ketone; methyl *n*-propyl ketone (Number carbonyl carbon) + alkane prefix + *-one:* butanone; 2-pentanone
Acid	R—COOH		Common name + acid: formic acid Alkane prefix + *-oic* + *acid:* methanoic acid
Ester	R—CO—OR′		Alcohol alkyl group + acid anion: methyl acetate Alcohol alkyl group + acid alkane prefix + *-oate:* methyl ethanoate
Amine	RNH_2 R_2NH R_3N		Name alkyl group(s) + *-amine:* methylamine *Amino-* + alkane: aminomethane
Amide	$R—CONH_2$		Common acid prefix + *-amide:* formamide Alkane prefix + *-amide:* methanamide

*Common name followed by IUPAC name.

FUNCTIONAL GROUP KEY

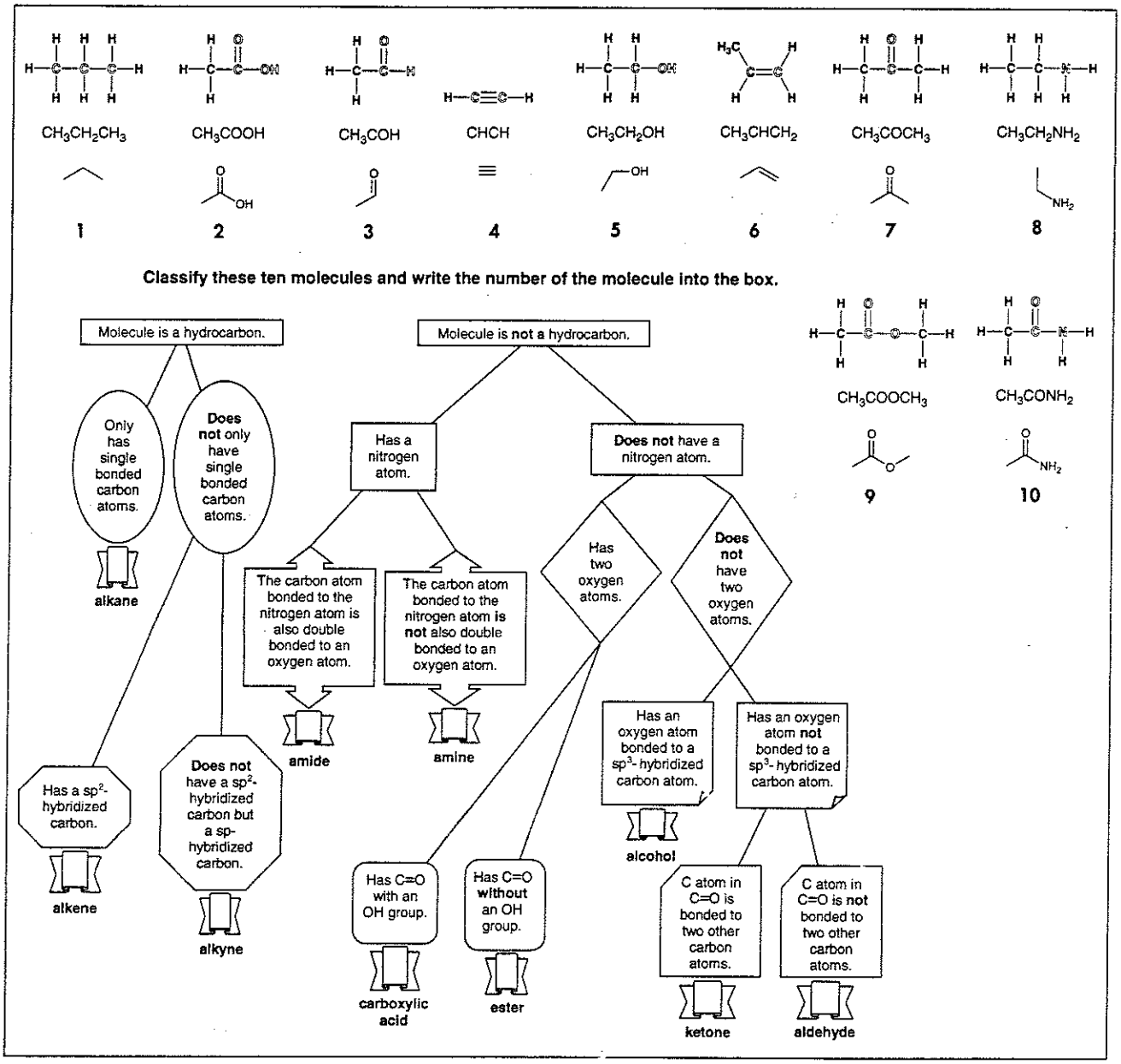


Figure 1. The classification key and exercise for functional groups.

Appendix

Glossary

Hydrocarbon—a molecule that contains only hydrogen (H) and carbon (C) atoms.

sp^2-Hybridized—consists of double bonds, e.g. C=C. Only two of the three p orbitals are used to form sp^2 hybrid orbitals; bond angle is 120°; consists of one sigma (σ) bond and one pi (π) bond.

sp^3-Hybridized—consists of single bonds, e.g. C–C. A set of hybrid orbitals constructed from one s orbital and three p orbitals; bond angle is 109.5°; consists of one σ bond.

sp-Hybridized—consists of triple bonds, e.g. C≡C. The hybrid orbital consists of only one of the three p orbitals; consists of one σ bond and two π bonds; bond angle is 180°.

Hybrid orbitals—orbitals used to describe bonding, obtained by taking combinations of atomic orbitals of the isolated atoms.

Sigma (σ) bond—has a cylindrical shape about the bond axis. Formed either when two s orbitals overlap or when an orbital with directional character, such as a p orbital or a hybrid orbital, overlaps another orbital along the interatomic axis.

Pi (π) bond—has an electron distribution above and below the bond axis.

OH—hydroxyl group.

C=O—carbonyl group.

$–NH_2$—amino group.

Annotated Answer Key

A. *Alkane*
- A1. example is propane [C_3H_8], **1**
- A2. single-bonded C atoms
- A3. saturated C atoms
- A4. carbon atoms can be bonded in chains or rings
- A5. sp^3-hybridized carbon atoms
- A6. bonded either to other carbon atoms or to hydrogen atoms
- A7. each compound's name has suffix -ane
- A8. have densities between 0.6 and 0.8 g cm^{-3}
- A9. pure alkanes are colorless, tasteless, and nearly odorless
- A10. nonpolar
- A11. not soluble in water
- A12. general formula C_nH_{2n+2} when bonded in a chain
- A13. low-molecular-weight alkanes are gaseous fuels at room temperature (methane, propane, ethane, butane)
- A14. rotate freely when bonded in a chain
- A15. undergo halogenation and oxidation reactions

B. *Alkene*
- B1. example is propene (methylethylene) [C_3H_6 or $CH_3–CH=CH_2$], **6**
- B2. unsaturated carbon atoms
- B3. double-bonded carbon atoms
- B4. general formula C_nH_{2n}
- B5. insoluble in water
- B6. soluble in nonpolar solvents
- B7. each compound's name has suffix -ene
- B8. restricted rotation
- B9. geometric isomers
- B10. undergo addition of HX to the double bond and hydrogenation

C. *Alkyne*
- C1. example is ethyne [C_2H_2], **4**
- C2. each compound's name has suffix -yne
- C3. triple-bonded carbon atoms
- C4. sp-hybridized
- C5. bond angle 180°
- C6. unsaturated carbon atoms
- C7. undergo hydrogenation and halogenation
- C8. general formula C_nH_{2n-2}

D. *Amide*
- D1. example is ethanamide [CH_3CONH_2], **10**
- D2. form strong intermolecular hydrogen bonds between the amide hydrogen atom of one molecule and the carbonyl oxygen atom of a second molecule, resulting in high melting and boiling points
- D3. amides with low molecular weights dissolve in water
- D4. nitrogen atom is bonded to an sp^2-hybridized carbon atom

E. *Amine*
- E1. example is ethanamine or ethylamine [$CH_3CH_2NH_2$], **8**
- E2. derivative of ammonia in which one or more hydrogen atoms are replaced by alkyl or aryl groups
- E3. nitrogen atom is bonded to an sp^3-hybridized carbon atom
- E4. smells like dead fish

F. *Carboxylic acid*
- F1. example is ethanoic (acetic) acid [CH_3COOH], **2**
- F2. contains carbonyl group and –OH group attached to the carbonyl carbon
- F3. each compound's name has suffix -oic and term acid
- F4. undergo neutralization of base, esterification, and high-temperature decomposition reactions

G. *Ester*
- G1. example is methyl ethanoate [CH_3COOCH_3], **9**
- G2. the carbonyl carbon atom is bonded to an alkoxy group such as $–OCH_3$
- G3. undergo acid hydrolysis and saponification reactions
- G4. smells sweet

H. *Alcohol*
- H1. example is ethanol [CH_3CH_2OH], **5**
- H2. each compound's name has suffix -ol
- H3. organic compound with hydroxyl group bonded to sp^3-hybridized carbon atom
- H4. undergo oxidation to form aldehydes or ketones, dehydration to form alkenes, formation of esters, conversion to halides

I. *Ketone*
- I1. example is propanone [CH_3COCH_3], **7**
- I2. carbonyl group C=O
- I3. each compound's name has suffix -one
- I4. undergo reactions with Grignard reagents, HCN, and alcohols

J. *Aldehyde*
- J1. example given is ethanal (acetaldehyde) [CH_3CHO], **3**
- J2. contains carbonyl group
- J3. compound's name has suffix -al
- J4. bond angles around the carbonyl carbon atom are approximately 120°; sp^2-hybridized C
- J5. the lower-molecular-weight compounds dissolve in water in all proportions
- J6. undergo reactions with Grignard reagents, HCN, and alcohols