2

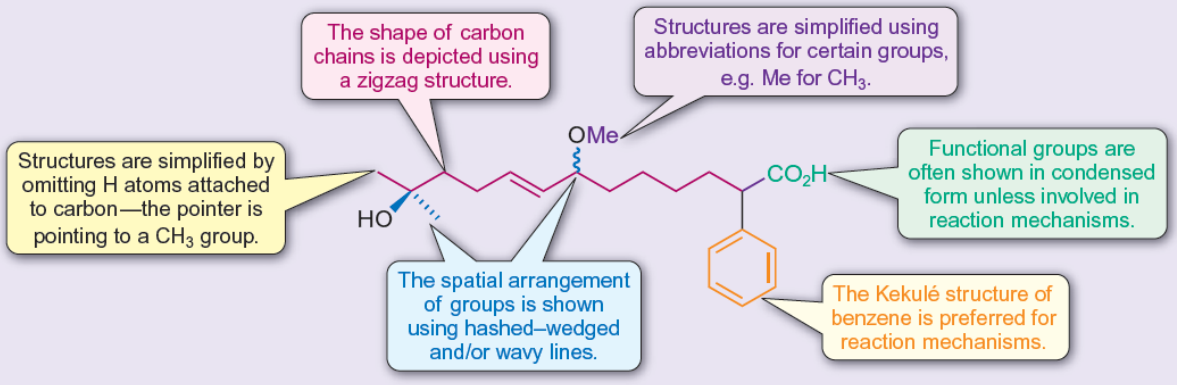
The language of organic chemistry

2.1 Why are organic compounds important?

- Organic chemistry is the study of carbon compounds.
- Organic molecules are central to life.
- Organic chemists prepare synthetic compounds in the laboratory.

2.2 Drawing organic compounds

- Organic compounds are drawn using full structural formulae, condensed structures, and skeletal structures.
- The three-dimensional structure of a molecule is represented using hashed–wedged notation.
- Skeletal structures are generally preferred with important parts of the molecule drawn in full.



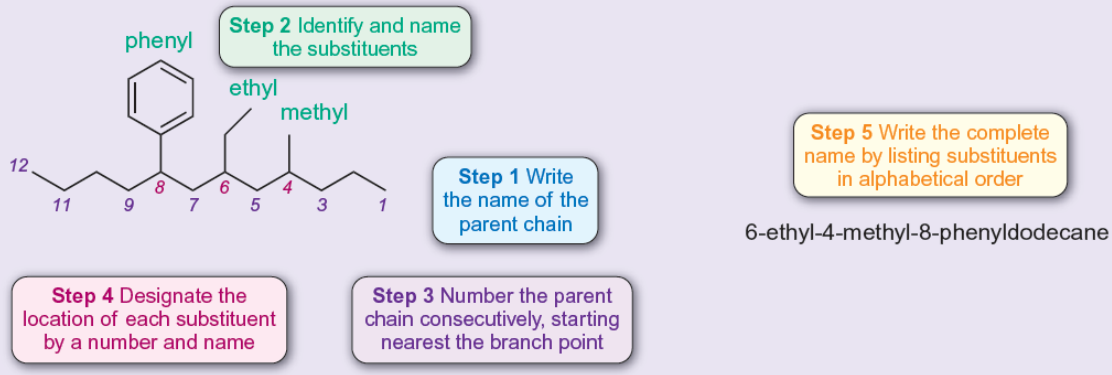
For practice questions on these topics, see questions 1–3 at the end of this chapter (p.109).

2.4 Carbon framework and functional groups

- Organic compounds are classified by their functional groups.
- A functional group is a group of atoms in a compound that is responsible for the characteristic chemical reactions of the compound.

2.5 Naming organic compounds

- Organic compounds are classified by their functional groups, which are groups of atoms that give the compound characteristic chemical properties.
- The IUPAC names of organic compounds are determined from the longest continuous carbon chain, called the parent chain. A prefix is added before the parent name to indicate any substituents. These are listed in alphabetical order and their positions given by numbers. A functional group suffix is included after the parent name to indicate the major functional group: -ane for alkane; -ene for alkene; and -yne for alkyne.



- A compound can have a systematic (IUPAC) name and common names, but a name must specify only one compound.
- A primary carbon atom is bonded to one other carbon atom, a secondary carbon is bonded to two carbons, a tertiary carbon is bonded to three carbons, and a quaternary carbon is bonded to four carbons.

For practice questions on these topics, see questions 1–2 at the end of this chapter (p.109).

2.6 Functional groups containing one or more heteroatoms

- Important functional groups containing a single heteroatom include halogenoalkanes (RX), alcohols (ROH), phenols (e.g. PhOH), ethers (ROR), enols (e.g. RCH=CH–OH), thiols (RSH), amines (e.g. RNH_2), enamines (e.g. $RCH{=}CH{-}NH_2$), and nitriles (RCN).
- The general formulae and IUPAC names of the most important functional groups containing one heteroatom are shown in the table.

Compound class	General formula	IUPAC name
Halogenoalkane	RX	haloalkane
Alcohol	ROH	alkanol
Ether	ROR	alkoxyalkane
Thiol	RSH	alkanethiol
Amine	RNH_2, R_2NH, R_3N	alkanamine
Nitrile	RCN	alkanenitrile

- Related functional groups containing more than one heteroatom include 1,1-diols (e.g. $R_2C(OH)_2$), hemiacetals ($R_2C(OH)OR$), acetals ($R_2C(OR)_2$), thioacetals ($R_2C(SR)_2$), nitro compounds (nitroalkanes or nitrobenzenes, RNO_2 or $ArNO_2$), diazonium ions (RN_2^+), and azo compounds (RN=NR).

For practice questions on these topics, see questions 3–4 at the end of this chapter (p.109).

2.7 Functional groups containing carbonyl atoms

- All carbonyl compounds contain the C=O group.
- Aldehydes (RCHO), ketones (RCOR), and carboxylic acids (RCO_2H) are named from the parent alkane.
- Acyl halides (RCOX), acid anhydrides (RCO_2COR), esters (RCO_2R), and amides ($RCONH_2$, RCONHR, and $RCONR_2$) are named from the parent carboxylic acid.

Compound class	General formula	IUPAC name
Aldehyde	RCHO	alkanal
Ketone	RCOR	alkanone
Carboxylic acid	RCO_2H	alkanoic acid
Acyl chloride or bromide	RCOCl or RCOBr	alkanoyl chloride or bromide
Acid anhydride	$(RCO)_2O$	alkanoic anhydride
Ester	RCO_2R	alkyl alkanoate
Amide	$RCONR_2$, RCONHR, $RCONH_2$	alkanamide

- Cyclic esters are known as lactones and cyclic amides as lactams.
- Imines ($R_2C{=}N{-}R$), oximes ($R_2C{=}N{-}OH$), and hydrazones ($R_2C{=}N{-}NH_2$) have a C=N rather than a C=O double bond.
- Amides ($RCONH_2$), imides (RCONHCOR), carbamates ($RNHCO_2R$), and ureas (RNHCONHR) all contain the N–C=O group.

For practice questions on these topics, see questions 3–4 at the end of this chapter (p.109).

2.8 Naming compounds with more than one functional group

Organic compounds with more than one functional group are named as follows.

Step 1 Find the longest carbon chain and name this as the parent alkane.

Step 2 Identify the major functional group and replace -ane with a suffix (see Table 2.3).

Step 3 Number the chain starting nearest the major functional group.

Step 4 Identify any substituents, including minor functional groups on the chain and their number. The names and numbers are given in the prefix in alphabetical order.

For practice questions on this topic, see questions 5–7 at the end of this chapter (p.109).

Concept review

By the end of this chapter, you should be able to do the following.

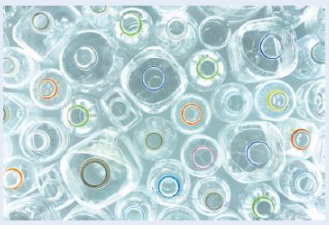
- Draw the structures of organic molecules in different ways, using full structural, condensed, and skeletal structures and hashed–wedged notation.
- Recognize and use common abbreviations in chemical structures (Table 2.4). This includes the use of R and Ar to represent alkyl and aryl groups, respectively.
- Recognize important organic functional groups (see Section 2.3, p.78).
- Name organic compounds using IUPAC nomenclature.
- Know the common names for a number of well-known organic solvents and reagents that have been accepted into the IUPAC system (Table 2.5).
- Classify carbon atoms as primary, secondary, tertiary, or quaternary.

Table 2.4 Common abbreviations

Abbreviation	Name	Substituent
Ac	acetyl (ethanoyl)	CH_3CO–
Bn	benzyl	$PhCH_2$–
Bu	butyl	$CH_3CH_2CH_2CH_2$–
^{i}Bu	isobutyl	$(CH_3)_2CHCH_2$–
^{t}Bu	*tert*-butyl	$(CH_3)_3C$–
Bz	benzoyl	C_6H_5CO–
Et	ethyl	CH_3CH_2–
Me	methyl	CH_3–
Ph	phenyl	C_6H_5–
Pr	propyl	$CH_3CH_2CH_2$–
^{i}Pr	isopropyl	$(CH_3)_2CH$–

Table 2.5 Names and condensed structures for some well-known compounds

Common name	IUPAC name	Condensed structure
Acetaldehyde	ethanal	CH_3CHO
Acetic acid	ethanoic acid	CH_3CO_2H
Acetone	propanone	CH_3COCH_3
Acetonitrile	ethanenitrile	CH_3CN
Acetyl chloride	ethanoyl chloride	CH_3COCl
Acetylene	ethyne	$HC{\equiv}CH$
Aniline	phenylamine	$C_6H_5NH_2$
Anisole	methoxybenzene	$C_6H_5OCH_3$
Benzaldehyde	benzenecarbaldehyde	C_6H_5CHO
Benzoic acid	benzenecarboxylic acid	$C_6H_5CO_2H$
Chloroform	trichloromethane	$CHCl_3$
Dimethylformamide	*N*,*N*-dimethylmethanamide	$(H_3C)_2NCHO$
Ethyl acetate	ethyl ethanoate	$CH_3CO_2CH_2CH_3$
Formaldehyde	methanal	$HCHO$
Phenol	hydroxybenzene	C_6H_5OH
Toluene	methylbenzene	$C_6H_5CH_3$
ortho-Xylene	1,2-dimethylbenzene	$1,2\text{-}(CH_3)_2C_6H_4$



1,3-Dimethylbenzene and 1,4-dimethylbenzene are commonly called *meta*-xylene and *para*-xylene, respectively. In industry, oxidation of *para*-xylene is used to form terephthalic acid ($1,4\text{-}C_6H_4(CO_2H)_2$), which can be converted into the polyester PET. PET is used to make clothing and plastic bottles (Chapter 24 opening page, pp.1098–1099).