

Ninth Edition

Organic Chemistry

John McMurry

CORNELL UNIVERSITY



Australia • Brazil • Mexico • Singapore • United Kingdom • United States



BRIEF CONTENTS

1	Structure and Bonding	1
2	Polar Covalent Bonds; Acids and Bases	28
3	Organic Compounds: Alkanes and Their Stereochemistry	60
4	Organic Compounds: Cycloalkanes and Their Stereochemistry	89
5	Stereochemistry at Tetrahedral Centers	115
6	An Overview of Organic Reactions	149
	Practice Your Scientific Analysis and Reasoning I: The Chiral Drug Thalidomide	182
7	Alkenes: Structure and Reactivity	185
8	Alkenes: Reactions and Synthesis	220
9	Alkynes: An Introduction to Organic Synthesis	263
10	Organohalides	287
11	Reactions of Alkyl Halides: Nucleophilic Substitutions and Eliminations	309
	Practice Your Scientific Analysis and Reasoning II: From Mustard Gas to Alkylating Anticancer Drugs	351
12	Structure Determination: Mass Spectrometry and Infrared Spectroscopy	354
13	Structure Determination: Nuclear Magnetic Resonance Spectroscopy	386
14	Conjugated Compounds and Ultraviolet Spectroscopy	420
	Practice Your Scientific Analysis and Reasoning III: Photodynamic Therapy (PDT)	448
15	Benzene and Aromaticity	451
16	Chemistry of Benzene: Electrophilic Aromatic Substitution	478
17	Alcohols and Phenols	525
18	Ethers and Epoxides; Thiols and Sulfides	568
●	Preview of Carbonyl Chemistry	595
19	Aldehydes and Ketones: Nucleophilic Addition Reactions	604
	Practice Your Scientific Analysis and Reasoning IV: Selective Serotonin Reuptake Inhibitors (SSRIs)	649
20	Carboxylic Acids and Nitriles	653
21	Carboxylic Acid Derivatives: Nucleophilic Acyl Substitution Reactions	679
22	Carbonyl Alpha-Substitution Reactions	727

BRIEF CONTENTS

23	Carbonyl Condensation Reactions	753
	Practice Your Scientific Analysis and Reasoning V: Thymine in DNA	784
24	Amines and Heterocycles	787
25	Biomolecules: Carbohydrates	832
26	Biomolecules: Amino Acids, Peptides, and Proteins	870
27	Biomolecules: Lipids	907
	Practice Your Scientific Analysis and Reasoning VI: Melatonin and Serotonin	939
28	Biomolecules: Nucleic Acids	942
29	The Organic Chemistry of Metabolic Pathways	964
30	Orbitals and Organic Chemistry: Pericyclic Reactions	1013
	Practice Your Scientific Analysis and Reasoning VII: The Potent Antibiotic Traits of Endiandric Acid C	1034
31	Synthetic Polymers	1037
Appendix A:	Nomenclature of Polyfunctional Organic Compounds	A-1
Appendix B:	Acidity Constants for Some Organic Compounds	A-9
Appendix C:	Glossary	A-11
Appendix D:	Answers to In-Text Problems	A-31
Index		I-1

DETAILED CONTENTS

Structure and Bonding | 1



CHAPTER

1

1-1	Atomic Structure: The Nucleus	3
1-2	Atomic Structure: Orbitals	4
1-3	Atomic Structure: Electron Configurations	6
1-4	Development of Chemical Bonding Theory	7
1-5	Describing Chemical Bonds: Valence Bond Theory	10
1-6	sp^3 Hybrid Orbitals and the Structure of Methane	12
1-7	sp^3 Hybrid Orbitals and the Structure of Ethane	13
1-8	sp^2 Hybrid Orbitals and the Structure of Ethylene	14
1-9	sp Hybrid Orbitals and the Structure of Acetylene	17
1-10	Hybridization of Nitrogen, Oxygen, Phosphorus, and Sulfur	18
1-11	Describing Chemical Bonds: Molecular Orbital Theory	20
1-12	Drawing Chemical Structures	21
	SOMETHING EXTRA Organic Foods: Risk versus Benefit	25
	Summary	26
	Key words	26
	Working Problems	27
	Exercises	27a

Polar Covalent Bonds; Acids and Bases | 28

©Kostyantyn
Ivanyshter/
Shutterstock.com



CHAPTER

2

2-1	Polar Covalent Bonds: Electronegativity	28
2-2	Polar Covalent Bonds: Dipole Moments	31
2-3	Formal Charges	33
2-4	Resonance	36
2-5	Rules for Resonance Forms	37
2-6	Drawing Resonance Forms	39
2-7	Acids and Bases: The Brønsted–Lowry Definition	42

2-8	Acid and Base Strength	44
2-9	Predicting Acid–Base Reactions from pK_a Values	46
2-10	Organic Acids and Organic Bases	47
2-11	Acids and Bases: The Lewis Definition	50
2-12	Noncovalent Interactions between Molecules	54
	SOMETHING EXTRA Alkaloids: From Cocaine to Dental Anesthetics	56
	Summary	58
	Key words	58
	Exercises	59

Organic Compounds: Alkanes and Their Stereochemistry | 60

©tractlephoto/
Shutterstock.com



CHAPTER 3

3-1	Functional Groups	60
3-2	Alkanes and Alkane Isomers	66
3-3	Alkyl Groups	70
3-4	Naming Alkanes	73
3-5	Properties of Alkanes	78
3-6	Conformations of Ethane	80
3-7	Conformations of Other Alkanes	82
	SOMETHING EXTRA Gasoline	86
	Summary	87
	Key words	87
	Exercises	88

Organic Compounds: Cycloalkanes and Their Stereochemistry | 89

Indiapicture/
Alamy



CHAPTER 4

4-1	Naming Cycloalkanes	90
4-2	Cis–Trans Isomerism in Cycloalkanes	92
4-3	Stability of Cycloalkanes: Ring Strain	95
4-4	Conformations of Cycloalkanes	97
4-5	Conformations of Cyclohexane	99
4-6	Axial and Equatorial Bonds in Cyclohexane	101

4-7	Conformations of Monosubstituted Cyclohexanes	104
4-8	Conformations of Disubstituted Cyclohexanes	107
4-9	Conformations of Polycyclic Molecules	110
	SOMETHING EXTRA Molecular Mechanics	113
	Summary	114
	Key words	114
	Exercises	114a

Stereochemistry at Tetrahedral Centers | 115

©Bart Brouwer/
Shutterstock.com



CHAPTER

5

5-1	Enantiomers and the Tetrahedral Carbon	116
5-2	The Reason for Handedness in Molecules: Chirality	117
5-3	Optical Activity	121
5-4	Pasteur's Discovery of Enantiomers	123
5-5	Sequence Rules for Specifying Configuration	124
5-6	Diastereomers	131
5-7	Meso Compounds	133
5-8	Racemic Mixtures and the Resolution of Enantiomers	135
5-9	A Review of Isomerism	138
5-10	Chirality at Nitrogen, Phosphorus, and Sulfur	140
5-11	Prochirality	141
5-12	Chirality in Nature and Chiral Environments	145
	SOMETHING EXTRA Chiral Drugs	147
	Summary	148
	Key words	148
	Exercises	148a

An Overview of Organic Reactions | 149

©Aspen Photo/
Shutterstock.com



CHAPTER

6

6-1	Kinds of Organic Reactions	149
6-2	How Organic Reactions Occur: Mechanisms	151
6-3	Radical Reactions	152
6-4	Polar Reactions	155
6-5	An Example of a Polar Reaction: Addition of HBr to Ethylene	159
6-6	Using Curved Arrows in Polar Reaction Mechanisms	162

6-7	Describing a Reaction: Equilibria, Rates, and Energy Changes	165
6-8	Describing a Reaction: Bond Dissociation Energies	169
6-9	Describing a Reaction: Energy Diagrams and Transition States	171
6-10	Describing a Reaction: Intermediates	174
6-11	A Comparison Between Biological Reactions and Laboratory Reactions	177
	SOMETHING EXTRA Where Do Drugs Come From?	179
	Summary	181
	Key words	181
	Exercises	181a

Practice Your Scientific Analysis and Reasoning I

The Chiral Drug Thalidomide | 182

Alkenes: Structure and Reactivity | 185

©JIANHAO
GUAN/
Shutterstock.com



CHAPTER 7

7-1	Industrial Preparation and Use of Alkenes	186
7-2	Calculating Degree of Unsaturation	187
7-3	Naming Alkenes	189
7-4	Cis–Trans Isomerism in Alkenes	192
7-5	Alkene Stereochemistry and the <i>E,Z</i> Designation	194
7-6	Stability of Alkenes	198
7-7	Electrophilic Addition Reactions of Alkenes	201
7-8	Orientation of Electrophilic Additions: Markovnikov's Rule	205
7-9	Carbocation Structure and Stability	208
7-10	The Hammond Postulate	211
7-11	Evidence for the Mechanism of Electrophilic Additions: Carbocation Rearrangements	214
	SOMETHING EXTRA Bioprospecting: Hunting for Natural Products	217
	Summary	218
	Key words	218
	Exercises	219

Alkenes: Reactions and Synthesis | 220

Ed Darack/
Science Faction/
Getty Images



CHAPTER

8

8-1	Preparing Alkenes: A Preview of Elimination Reactions	221
8-2	Halogenation of Alkenes: Addition of X_2	222
8-3	Halohydrins from Alkenes: Addition of HOX	225
8-4	Hydration of Alkenes: Addition of H_2O by Oxymercuration	227
8-5	Hydration of Alkenes: Addition of H_2O by Hydroboration	230
8-6	Reduction of Alkenes: Hydrogenation	235
8-7	Oxidation of Alkenes: Epoxidation and Hydroxylation	239
8-8	Oxidation of Alkenes: Cleavage to Carbonyl Compounds	242
8-9	Addition of Carbenes to Alkenes: Cyclopropane Synthesis	245
8-10	Radical Additions to Alkenes: Chain-Growth Polymers	247
8-11	Biological Additions of Radicals to Alkenes	251
8-12	Reaction Stereochemistry: Addition of H_2O to an Achiral Alkene	252
8-13	Reaction Stereochemistry: Addition of H_2O to a Chiral Alkene	255
	SOMETHING EXTRA Terpenes: Naturally Occurring Alkenes	257
	Summary	259
	Key words	259
	Learning Reactions	260
	Summary of Reactions	260
	Exercises	262

Alkynes: An Introduction to Organic Synthesis | 263

©Igor Bulgarin/
Shutterstock.com



CHAPTER

9

9-1	Naming Alkynes	264
9-2	Preparation of Alkynes: Elimination Reactions of Dihalides	265
9-3	Reactions of Alkynes: Addition of HX and X_2	265
9-4	Hydration of Alkynes	268
9-5	Reduction of Alkynes	272
9-6	Oxidative Cleavage of Alkynes	275
9-7	Alkyne Acidity: Formation of Acetylide Anions	275
9-8	Alkylation of Acetylide Anions	277
9-9	An Introduction to Organic Synthesis	279
	SOMETHING EXTRA The Art of Organic Synthesis	283

Summary	284
Key words	284
Summary of Reactions	285
Exercises	286a

Organohalides | 287

Sebastián Crespo
Photography/
Getty Images



CHAPTER 10

10-1	Names and Structures of Alkyl Halides	288
10-2	Preparing Alkyl Halides from Alkanes: Radical Halogenation	290
10-3	Preparing Alkyl Halides from Alkenes: Allylic Bromination	292
10-4	Stability of the Allyl Radical: Resonance Revisited	294
10-5	Preparing Alkyl Halides from Alcohols	297
10-6	Reactions of Alkyl Halides: Grignard Reagents	298
10-7	Organometallic Coupling Reactions	300
10-8	Oxidation and Reduction in Organic Chemistry	303
	SOMETHING EXTRA Naturally Occurring Organohalides	305
	Summary	307
	Key words	307
	Summary of Reactions	307
	Exercises	308

Reactions of Alkyl Halides: Nucleophilic Substitutions and Eliminations | 309

Martin Harvey/
Getty Images



CHAPTER 11

11-1	The Discovery of Nucleophilic Substitution Reactions	310
11-2	The S_N2 Reaction	313
11-3	Characteristics of the S_N2 Reaction	316
11-4	The S_N1 Reaction	323
11-5	Characteristics of the S_N1 Reaction	327
11-6	Biological Substitution Reactions	333
11-7	Elimination Reactions: Zaitsev's Rule	335
11-8	The E2 Reaction and the Deuterium Isotope Effect	338
11-9	The E2 Reaction and Cyclohexane Conformation	341
11-10	The E1 and E1cB Reactions	343
11-11	Biological Elimination Reactions	345
11-12	A Summary of Reactivity: S_N1 , S_N2 , E1, E1cB, and E2	345

SOMETHING EXTRA Green Chemistry	347
Summary	349
Key words	349
Summary of Reactions	350
Exercises	350a

Practice Your Scientific Analysis and Reasoning II From Mustard Gas to Alkylating Anticancer Drugs | 351

Structure Determination: Mass Spectrometry and Infrared Spectroscopy | 354

MarkEri's photo/
Getty Images



CHAPTER 12

12-1	Mass Spectrometry of Small Molecules: Magnetic-Sector Instruments	355
12-2	Interpreting Mass Spectra	357
12-3	Mass Spectrometry of Some Common Functional Groups	362
12-4	Mass Spectrometry in Biological Chemistry: Time-of-Flight (TOF) Instruments	367
12-5	Spectroscopy and the Electromagnetic Spectrum	368
12-6	Infrared Spectroscopy	371
12-7	Interpreting Infrared Spectra	373
12-8	Infrared Spectra of Some Common Functional Groups	376
	SOMETHING EXTRA X-Ray Crystallography	384
	Summary	385
	Key words	385
	Exercises	385

Structure Determination: Nuclear Magnetic Resonance Spectroscopy | 386

©EM Kanuna/
Shutterstock.com




CHAPTER 13

13-1	Nuclear Magnetic Resonance Spectroscopy	386
13-2	The Nature of NMR Absorptions	389
13-3	The Chemical Shift	392
13-4	Chemical Shifts in ^1H NMR Spectroscopy	394
13-5	Integration of ^1H NMR Absorptions: Proton Counting	396

13-6	Spin–Spin Splitting in ^1H NMR Spectra	397
13-7	^1H NMR Spectroscopy and Proton Equivalence	402
13-8	More Complex Spin–Spin Splitting Patterns	404
13-9	Uses of ^1H NMR Spectroscopy	407
13-10	^{13}C NMR Spectroscopy: Signal Averaging and FT–NMR	408
13-11	Characteristics of ^{13}C NMR Spectroscopy	410
13-12	DEPT ^{13}C NMR Spectroscopy	413
13-13	Uses of ^{13}C NMR Spectroscopy	416
	SOMETHING EXTRA Magnetic Resonance Imaging (MRI)	417
	Summary	418
	Key words	418
	Exercises	419

Conjugated Compounds and Ultraviolet Spectroscopy | 420

 <p>©iDenmark/Shutterstock.com</p> <p>CHAPTER 14</p>	14-1	Stability of Conjugated Dienes: Molecular Orbital Theory	421
	14-2	Electrophilic Additions to Conjugated Dienes: Allylic Carbocations	425
	14-3	Kinetic versus Thermodynamic Control of Reactions	428
	14-4	The Diels–Alder Cycloaddition Reaction	430
	14-5	Characteristics of the Diels–Alder Reaction	431
	14-6	Diene Polymers: Natural and Synthetic Rubbers	437
	14-7	Ultraviolet Spectroscopy	438
	14-8	Interpreting Ultraviolet Spectra: The Effect of Conjugation	441
	14-9	Conjugation, Color, and the Chemistry of Vision	442
		SOMETHING EXTRA Photolithography	444
	Summary	446	
	Key words	446	
	Summary of Reactions	447	
	Exercises	447a	

Practice Your Scientific Analysis and Reasoning III Photodynamic Therapy (PDT) | 448

Benzene and Aromaticity | 451

©Handmade
Pictures/
Shutterstock.com



CHAPTER 15

15-1	Naming Aromatic Compounds	452
15-2	Structure and Stability of Benzene	456
15-3	Aromaticity and the Hückel $4n + 2$ Rule	459
15-4	Aromatic Ions	461
15-5	Aromatic Heterocycles: Pyridine and Pyrrole	464
15-6	Polycyclic Aromatic Compounds	467
15-7	Spectroscopy of Aromatic Compounds	469
	SOMETHING EXTRA Aspirin, NSAIDs, and COX-2 Inhibitors	474
	Summary	476
	Key words	476
	Exercises	477

Chemistry of Benzene: Electrophilic Aromatic Substitution | 478

Niday Picture
Library / Alamy



CHAPTER 16

16-1	Electrophilic Aromatic Substitution Reactions: Bromination	479
16-2	Other Aromatic Substitutions	482
16-3	Alkylation and Acylation of Aromatic Rings: The Friedel–Crafts Reaction	488
16-4	Substituent Effects in Electrophilic Substitutions	493
16-5	Trisubstituted Benzenes: Additivity of Effects	503
16-6	Nucleophilic Aromatic Substitution	505
16-7	Benzyne	508
16-8	Oxidation of Aromatic Compounds	510
16-9	Reduction of Aromatic Compounds	513
16-10	Synthesis of Polysubstituted Benzenes	514
	SOMETHING EXTRA Combinatorial Chemistry	519
	Summary	521
	Key words	521
	Summary of Reactions	522
	Exercises	524

Alcohols and Phenols | 525

©JManuel
Murillo/
Shutterstock.com

CHAPTER 17

17-1	Naming Alcohols and Phenols	526
17-2	Properties of Alcohols and Phenols	528
17-3	Preparation of Alcohols: A Review	533
17-4	Alcohols from Carbonyl Compounds: Reduction	535
17-5	Alcohols from Carbonyl Compounds: Grignard Reaction	539
17-6	Reactions of Alcohols	543
17-7	Oxidation of Alcohols	550
17-8	Protection of Alcohols	553
17-9	Phenols and Their Uses	555
17-10	Reactions of Phenols	557
17-11	Spectroscopy of Alcohols and Phenols	559
	SOMETHING EXTRA Ethanol: Chemical, Drug, Poison	563
	Summary	564
	Key words	564
	Summary of Reactions	565
	Exercises	567

Ethers and Epoxides; Thiols and Sulfides | 568

©Heiko Kiara/
Shutterstock.com

CHAPTER 18

18-1	Names and Properties of Ethers	569
18-2	Preparing Ethers	570
18-3	Reactions of Ethers: Acidic Cleavage	573
18-4	Reactions of Ethers: Claisen Rearrangement	575
18-5	Cyclic Ethers: Epoxides	577
18-6	Reactions of Epoxides: Ring-Opening	578
18-7	Crown Ethers	583
18-8	Thiols and Sulfides	584
18-9	Spectroscopy of Ethers	588
	SOMETHING EXTRA Epoxy Resins and Adhesives	591
	Summary	592
	Key words	592
	Summary of Reactions	593
	Exercises	594a

Preview of Carbonyl Chemistry | 595

I	Kinds of Carbonyl Compounds	595
II	Nature of the Carbonyl Group	597
III	General Reactions of Carbonyl Compounds	597
IV	Summary	603

Aldehydes and Ketones: Nucleophilic Addition Reactions | 604

©Lushtnikov/
Shutterstock.com



CHAPTER 19

19-1	Naming Aldehydes and Ketones	605
19-2	Preparing Aldehydes and Ketones	607
19-3	Oxidation of Aldehydes and Ketones	609
19-4	Nucleophilic Addition Reactions of Aldehydes and Ketones	610
19-5	Nucleophilic Addition of H ₂ O: Hydration	614
19-6	Nucleophilic Addition of HCN: Cyanohydrin Formation	616
19-7	Nucleophilic Addition of Hydride and Grignard Reagents: Alcohol Formation	617
19-8	Nucleophilic Addition of Amines: Imine and Enamine Formation	619
19-9	Nucleophilic Addition of Hydrazine: The Wolff–Kishner Reaction	624
19-10	Nucleophilic Addition of Alcohols: Acetal Formation	626
19-11	Nucleophilic Addition of Phosphorus Ylides: The Wittig Reaction	630
19-12	Biological Reductions	633
19-13	Conjugate Nucleophilic Addition to α,β -Unsaturated Aldehydes and Ketones	635
19-14	Spectroscopy of Aldehydes and Ketones	640
	SOMETHING EXTRA Enantioselective Synthesis	644
	Summary	646
	Key words	646
	Summary of Reactions	646
	Exercises	648a

Practice Your Scientific Analysis and Reasoning IV Selective Serotonin Reuptake Inhibitors (SSRIs) | 649

Carboxylic Acids and Nitriles | 653

©Marie C Fields/
Shutterstock.com

CHAPTER 20

20-1	Naming Carboxylic Acids and Nitriles	654
20-2	Structure and Properties of Carboxylic Acids	656
20-3	Biological Acids and the Henderson–Hasselbalch Equation	660
20-4	Substituent Effects on Acidity	661
20-5	Preparing Carboxylic Acids	664
20-6	Reactions of Carboxylic Acids: An Overview	667
20-7	Chemistry of Nitriles	668
20-8	Spectroscopy of Carboxylic Acids and Nitriles	672
	SOMETHING EXTRA Vitamin C	674
	Summary	676
	Key words	676
	Summary of Reactions	677
	Exercises	678

Carboxylic Acid Derivatives: Nucleophilic Acyl Substitution Reactions | 679

©Greg Epperson/
Shutterstock.com

CHAPTER 21

21-1	Naming Carboxylic Acid Derivatives	680
21-2	Nucleophilic Acyl Substitution Reactions	683
21-3	Reactions of Carboxylic Acids	688
21-4	Chemistry of Acid Halides	696
21-5	Chemistry of Acid Anhydrides	701
21-6	Chemistry of Esters	703
21-7	Chemistry of Amides	709
21-8	Chemistry of Thioesters and Acyl Phosphates: Biological Carboxylic Acid Derivatives	713
21-9	Polyamides and Polyesters: Step-Growth Polymers	715
21-10	Spectroscopy of Carboxylic Acid Derivatives	718
	SOMETHING EXTRA β -Lactam Antibiotics	721
	Summary	723
	Key words	723
	Summary of Reactions	723
	Exercises	726

Carbonyl Alpha-Substitution Reactions | 727

©justasc/
Shutterstock.com

CHAPTER 22

22-1	Keto–Enol Tautomerism	728
22-2	Reactivity of Enols: α -Substitution Reactions	730
22-3	Alpha Halogenation of Aldehydes and Ketones	731
22-4	Alpha Bromination of Carboxylic Acids	734
22-5	Acidity of Alpha Hydrogen Atoms: Enolate Ion Formation	735
22-6	Reactivity of Enolate Ions	738
22-7	Alkylation of Enolate Ions	739
	SOMETHING EXTRA Barbiturates	748
	Summary	750
	Key words	750
	Summary of Reactions	751
	Exercises	752

Carbonyl Condensation Reactions | 753

Picturebank /
Alamy

CHAPTER 23

23-1	Carbonyl Condensations: The Aldol Reaction	753
23-2	Carbonyl Condensations versus Alpha Substitutions	756
23-3	Dehydration of Aldol Products: Synthesis of Enones	757
23-4	Using Aldol Reactions in Synthesis	760
23-5	Mixed Aldol Reactions	761
23-6	Intramolecular Aldol Reactions	762
23-7	The Claisen Condensation Reaction	764
23-8	Mixed Claisen Condensations	766
23-9	Intramolecular Claisen Condensations: The Dieckmann Cyclization	768
23-10	Conjugate Carbonyl Additions: The Michael Reaction	770
23-11	Carbonyl Condensations with Enamines: The Stork Reaction	773
23-12	The Robinson Annulation Reaction	776
23-13	Some Biological Carbonyl Condensation Reactions	777
	SOMETHING EXTRA A Prologue to Metabolism	779
	Summary	781
	Key words	781
	Summary of Reactions	782
	Exercises	783

Practice Your Scientific Analysis and Reasoning V

Thymine in DNA | 784

Amines and Heterocycles | 787

©Mikadany/
Shutterstock.com



CHAPTER 24

24-1	Naming Amines	787
24-2	Structure and Properties of Amines	790
24-3	Basicity of Amines	792
24-4	Basicity of Arylamines	795
24-5	Biological Amines and the Henderson–Hasselbalch Equation	797
24-6	Synthesis of Amines	798
24-7	Reactions of Amines	806
24-8	Reactions of Arylamines	810
24-9	Heterocyclic Amines	816
24-10	Spectroscopy of Amines	823
	SOMETHING EXTRA Green Chemistry II: Ionic Liquids	826
	Summary	828
	Key words	828
	Summary of Reactions	830
	Exercises	831a

Biomolecules: Carbohydrates | 832

©Tischenko Irina/
Shutterstock.com



CHAPTER 25

25-1	Classification of Carbohydrates	833
25-2	Representing Carbohydrate Stereochemistry: Fischer Projections	834
25-3	D,L Sugars	838
25-4	Configurations of the Aldoses	840
25-5	Cyclic Structures of Monosaccharides: Anomers	844
25-6	Reactions of Monosaccharides	848
25-7	The Eight Essential Monosaccharides	856
25-8	Disaccharides	858
25-9	Polysaccharides and Their Synthesis	861
25-10	Some Other Important Carbohydrates	864
25-11	Cell-Surface Carbohydrates and Influenza Viruses	864
	SOMETHING EXTRA Sweetness	866

Summary	868
Key words	868
Summary of Reactions	869
Exercises	869

Biomolecules: Amino Acids, Peptides, and Proteins | 870

Stuart Cox/W&A
Images / Alamy



CHAPTER 26

26-1	Structures of Amino Acids	871
26-2	Amino Acids and the Henderson–Hasselbalch Equation: Isoelectric Points	876
26-3	Synthesis of Amino Acids	879
26-4	Peptides and Proteins	881
26-5	Amino Acid Analysis of Peptides	884
26-6	Peptide Sequencing: The Edman Degradation	885
26-7	Peptide Synthesis	888
26-8	Automated Peptide Synthesis: The Merrifield Solid-Phase Method	890
26-9	Protein Structure	893
26-10	Enzymes and Coenzymes	895
26-11	How Do Enzymes Work? Citrate Synthase	898
	SOMETHING EXTRA The Protein Data Bank	903
	Summary	904
	Key words	904
	Summary of Reactions	905
	Exercises	906a

Biomolecules: Lipids | 907

©Cuson/
Shutterstock.com




CHAPTER 27

27-1	Waxes, Fats, and Oils	908
27-2	Soap	911
27-3	Phospholipids	913
27-4	Prostaglandins and Other Eicosanoids	915
27-5	Terpenoids	917
27-6	Steroids	926
27-7	Biosynthesis of Steroids	930

SOMETHING EXTRA	Saturated Fats, Cholesterol, and Heart Disease	937
	Summary	938
	Key words	938
	Exercises	938a

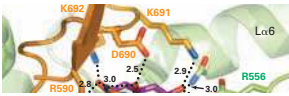
Practice Your Scientific Analysis and Reasoning VI Melatonin and Serotonin | 939

Biomolecules: Nucleic Acids | 942

Chung Sung-Jun/ Getty Images		28-1	Nucleotides and Nucleic Acids	942
		28-2	Base Pairing in DNA: The Watson–Crick Model	945
		28-3	Replication of DNA	947
		28-4	Transcription of DNA	949
		28-5	Translation of RNA: Protein Biosynthesis	951
		28-6	DNA Sequencing	954
		28-7	DNA Synthesis	956
		28-8	The Polymerase Chain Reaction	959
		SOMETHING EXTRA	DNA Fingerprinting	961
		Summary	962	
		Key words	962	
		Exercises	963	

CHAPTER 28

The Organic Chemistry of Metabolic Pathways | 964

	29-1	An Overview of Metabolism and Biochemical Energy	964
	29-2	Catabolism of Triacylglycerols: The Fate of Glycerol	968
	29-3	Catabolism of Triacylglycerols: β -Oxidation	972
	29-4	Biosynthesis of Fatty Acids	977
	29-5	Catabolism of Carbohydrates: Glycolysis	982
	29-6	Conversion of Pyruvate to Acetyl CoA	990
	29-7	The Citric Acid Cycle	993
	29-8	Carbohydrate Biosynthesis: Gluconeogenesis	998
	29-9	Catabolism of Proteins: Deamination	1005

CHAPTER 29

29-10	Some Conclusions about Biological Chemistry	1009
	SOMETHING EXTRA Statin Drugs	1010
	Summary	1011
	Key words	1011
	Exercises	1012

Orbitals and Organic Chemistry: Pericyclic Reactions | 1013

©Krylova Ksenia/
Shutterstock.com

CHAPTER 30

30-1	Molecular Orbitals of Conjugated Pi Systems	1013
30-2	Electrocyclic Reactions	1016
30-3	Stereochemistry of Thermal Electrocyclic Reactions	1018
30-4	Photochemical Electrocyclic Reactions	1020
30-5	Cycloaddition Reactions	1021
30-6	Stereochemistry of Cycloadditions	1023
30-7	Sigmatropic Rearrangements	1025
30-8	Some Examples of Sigmatropic Rearrangements	1027
30-9	A Summary of Rules for Pericyclic Reactions	1030
	SOMETHING EXTRA Vitamin D, the Sunshine Vitamin	1031
	Summary	1032
	Key words	1032
	Exercises	1033

Practice Your Scientific Analysis and Reasoning VII The Potent Antibiotic Traits of Endiandric Acid C | 1034

Synthetic Polymers | 1037

Tim Robbins/
Mint Images/
Getty Images

CHAPTER 31

31-1	Chain-Growth Polymers	1037
31-2	Stereochemistry of Polymerization: Ziegler–Natta Catalysts	1040
31-3	Copolymers	1041
31-4	Step-Growth Polymers	1043
31-5	Olefin Metathesis Polymerization	1046
31-6	Polymer Structure and Physical Properties	1048

SOMETHING EXTRA	Biodegradable Polymers	1052
	Summary	1053
	Key words	1053
	Exercises	1054
APPENDIX A:	Nomenclature of Polyfunctional Organic Compounds	A-1
APPENDIX B:	Acidity Constants for Some Organic Compounds	A-9
APPENDIX C:	Glossary	A-11
APPENDIX D:	Answers to In-Text Problems	A-31
INDEX		I-1