Preface

Overview

The power of X-ray crystallographic analysis was cited in Dorothy Crowfoot Hodgkin's 1964 Chemistry Nobel Prize Lecture:

"A great advantage of X-ray analysis as a method of chemical structure analysis is its power to show some totally unexpected and surprising structure with, at the same time, complete certainty."

From Linus Pauling's 1954 Nobel Prize for research on the chemical bond, to Dorothy Crowfoot Hodgkin's in 1964 for solving the structure of vitamin B_{12} and other biochemical substances, to Robert Lefkowitz and Brian Kobilka's in 2012 for solving the structure of G protein-coupled receptors, chemists of all persuasions have shared a common interest in the structure of molecules. It is this common interest in structure that has guided the shaping of this edition. Its most significant change is the relocation of chirality, previously a chapter 7 topic, to chapter 4 where it now is closer to the other fundamental structural concepts such as molecular shape, constitution, and conformation. A broader background in structure, acquired earlier in this new presentation, is designed to provide students the conceptual tools they need to understand and apply the relationship between the structures of organic compounds and their properties.

Mechanism

The text is organized according to functional groups--structural units within a molecule that are most closely identified with characteristic properties. Reaction mechanisms are emphasized early and often in an effort to develop the student's ability to see similarities in reactivity across the diverse range of functional groups encountered in organic

chemistry. Mechanisms are developed from observations; thus, reactions are normally presented first, followed by their mechanism.

In order to maintain consistency with what our students have already learned, this text presents multistep mechanisms in the same way as most general chemistry textbooks; that is, as a series of *elementary steps*. Additionally, we provide a brief comment about how each step contributes to the overall mechanism. Section 1.11 "Curved Arrows and Chemical Reactions" provides the student with an early introduction to the notational system employed in all of the mechanistic discussions in the text.

Numerous reaction mechanisms are accompanied by potential energy diagrams. Section 5.8 "Reaction of Alcohols with Hydrogen Halides: The S_N1 Mechanism" shows how the potential energy diagrams for three elementary steps are combined to give the diagram for the overall reaction.

Mechanism 4.1

Formation of *tert*-Butyl Chloride from *tert*-Butyl Alcohol and Hydrogen Chloride

THE OVERALL REACTION:

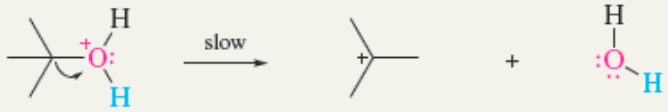
tert-Butyl alcohol Hydrogen chloride *tert*-Butyl chloride Water

THE MECHANISM:

Step 1: Protonation of *tert*-butyl alcohol to give an alkyloxonium ion:

tert-Butyl alcohol Hydrogen chloride *tert*-Butyloxonium ion Chloride ion

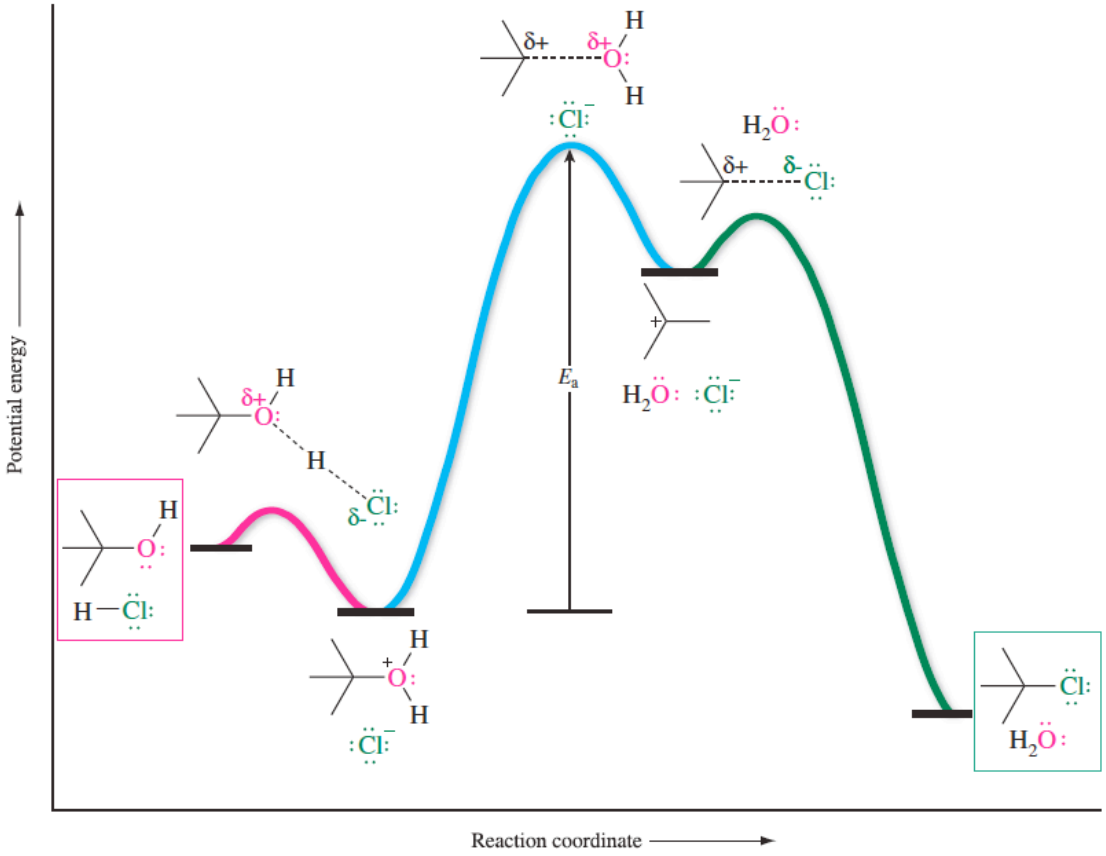
Step 2: Dissociation of *tert*-butyloxonium ion to give a carbocation:



tert-Butyloxonium ion *tert*-Butyl cation Water

Step 3: Capture of *tert*-butyl cation by chloride ion:

tert-Butyl cation Chloride ion *tert*-Butyl chloride



Enhanced Graphics

The teaching of organic chemistry has especially benefited as powerful modeling and graphics software has become routinely available. Computer-generated molecular models and electrostatic potential maps were integrated into the third edition of this text and their number has increased in succeeding editions. Also seeing increasing use are molecular orbital theory and the role of orbital interactions in chemical reactivity.

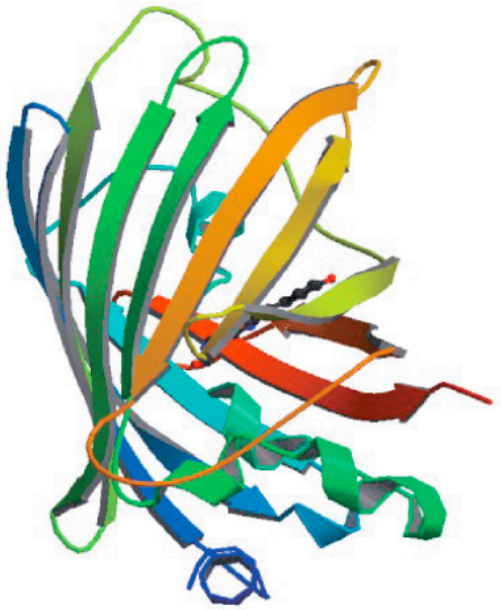
Coverage of Biochemical Topics

From its earliest editions four chapters have been included on biochemical topics and updated to cover topics of recent interest.

- Chapter 24 Carbohydrates
- Chapter 25 Lipids
- Chapter 26 Amino Acids, Peptides, and Proteins
- Chapter 27 Nucleosides, Nucleotides, and Nucleic Acids

Figure ~~25.16~~

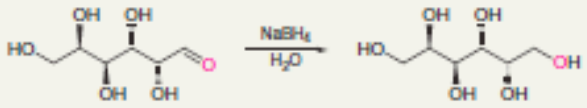
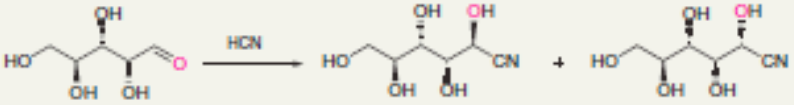
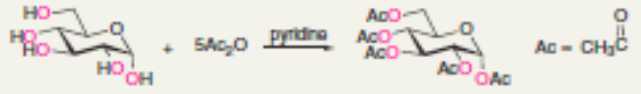
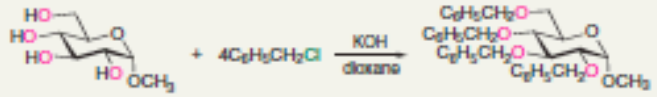
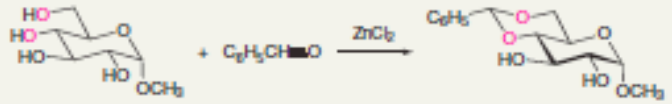
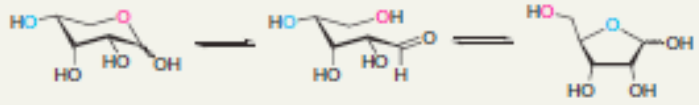
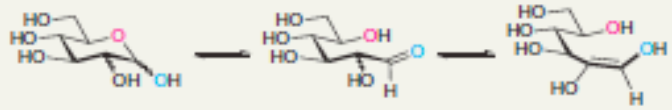
Barrel-shaped green fluorescent protein (GFP) has an outer β-sheet structure and an α helix in the inner region.



Generous and Effective Use of Tables

Annotated summary tables have been a staple of *Organic Chemistry* since the first edition. Some tables review reactions from earlier chapters, others the reactions or concepts of a current chapter. Still others walk the reader step-by-step through skill builders and concepts unique to organic chemistry. Well received by students and faculty alike, these summary tables remain one of the text's strengths.

TABLE 23.2 Familiar Reaction Types of Carbohydrates

Reaction and comments	Example
1. Reduction: Carbonyl groups in carbohydrates are reduced by the same methods used for aldehydes and ketones: reduction with sodium borohydride or lithium aluminum hydride or by catalytic hydrogenation.	 D-Galactose → D-Galactitol (90%)
2. Cyanohydrin formation: Reaction of an aldose with HCN gives a mixture of two diastereomeric cyanohydrins.	 L-Arabinose → L-Mannonitrile + L-Glucononitrile
3. Acylation: All available hydroxyl groups of carbohydrates are capable of undergoing acylation to form esters.	 α-D-Glucopyranose + Acetic anhydride → 1,2,3,4,6-Penta-*O*-acetyl-D-glucopyranose (88%)
4. Alkylation: Carbohydrate hydroxyl groups react with alkyl halides, especially methyl and benzyl halides, to give ethers.	 Methyl α-D-glucopyranoside + Benzyl chloride → Methyl 2,3,4,6-tetra-*O*-benzyl-α-D-glucopyranoside (95%)
5. Acetal formation: Carbohydrates can serve as the diol component in the formation of cyclic acetals on reaction with aldehydes and ketones in the presence of an acid catalyst. In the example shown, the catalyst is a Lewis acid.	 Methyl α-D-glucopyranoside + Benzaldehyde → Methyl 4,6-*O*-benzylidene-α-D-glucopyranoside (63%)
6. Pyranose-furanose isomerization: The furanose and pyranose forms of a carbohydrate are cyclic hemiacetals and equilibrate by way of their open-chain isomer.	 D-Ribopyranose (α and/or β) → D-Ribose → D-Ribofuranose (α and/or β)
7. Enolization: Enolization of the open-chain form of a carbohydrate gives an enediol. Carbohydrates that are epimeric at C-2 give the same enediol.	 D-Gluco- or D-mannopyranose (α and/or β) → D-Glucose or D-mannose → Enediol

There are three more examples in this Table, but perhaps this is sufficient to illustrate?

Problems

- Problem-solving strategies and skills are emphasized throughout. Understanding is progressively reinforced by problems that appear within topic sections.
- For many problems, sample solutions are given, including examples of handwritten solutions from the author.
- The text contains more than 1400 problems, many of which contain multiple parts. End-of-chapter problems are now organized so to conform to the primary topic areas of each chapter.

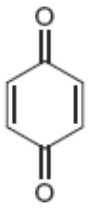
  What is needed here is an example that contains a group of eocps with a topic heading. This can be inserted later on.

Problem 10.19

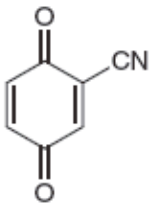
Dicarbonyl compounds such as quinones are reactive dienophiles.

(a) 1,4-Benzoquinone reacts with 2-chloro-1,3-butadiene to give a single product $C_{10}H_9ClO_2$ in 95% yield. Write a structural formula for this product.

(b) 2-Cyano-1,4-benzoquinone undergoes a Diels–Alder reaction with 1,3-butadiene to give a single product $C_{11}H_9NO_2$ in 84% yield. What is its structure?



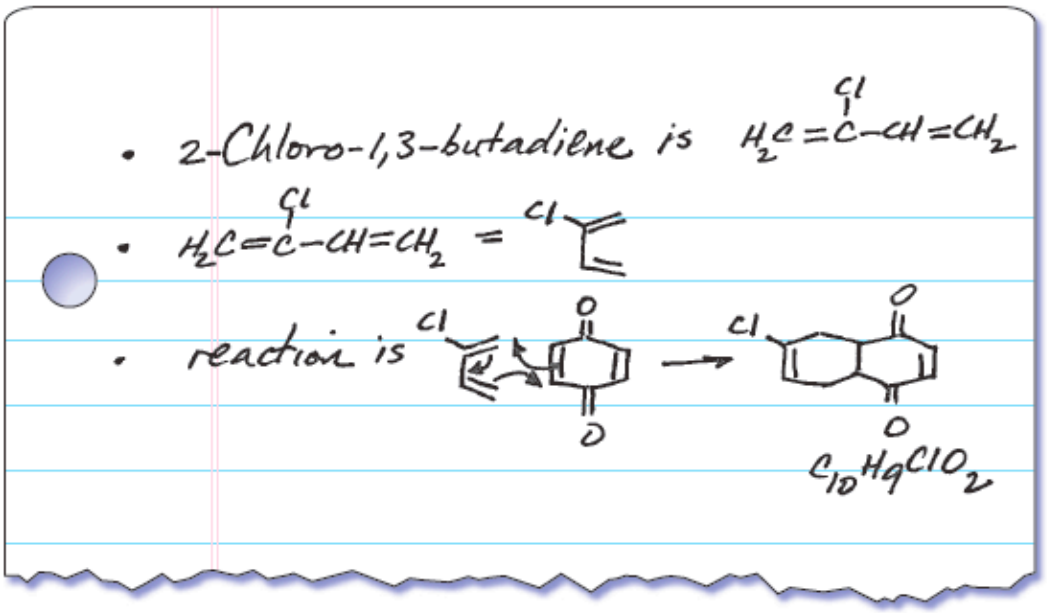
1,4-Benzoquinone



2-Cyano-1,4-benzoquinone

Sample Solution

(a)

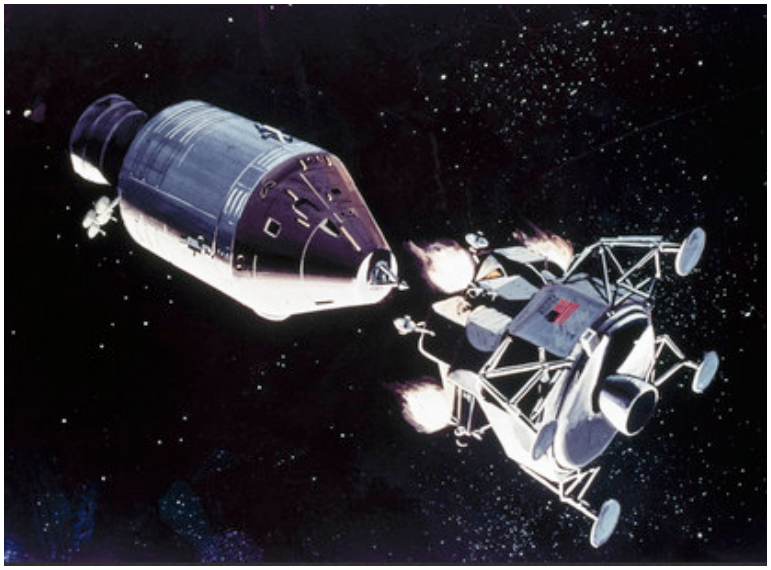


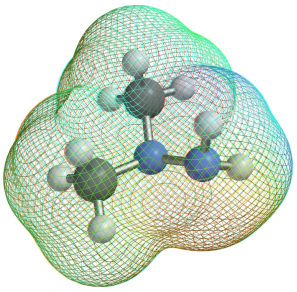
Pedagogy

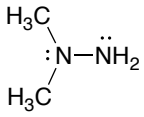
- A list of tables, mechanisms, boxes and Descriptive Passages and Interpretive Questions is included in the front matter as a quick reference to these important learning tools in each chapter.

- Each chapter begins with an opener that is meant to capture the reader's attention. Chemistry that is highlighted in the opener is relevant to chemistry that is included in the chapter.

Opener for Chapter 1



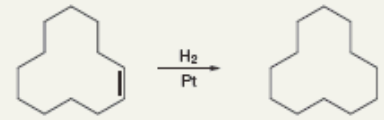
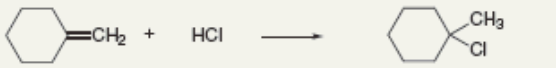
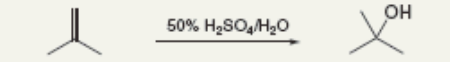
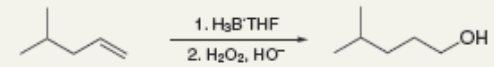




The Apollo lunar module is powered by a liquid fuel containing a mixture of substances, each with its own ignition characteristics and energy properties. One of the fuels is called UDMH which stands for "unsymmetrical dimethylhydrazine." Its chemical name is *N*,*N*-dimethylhydrazine.

- End-of-Chapter Summaries highlight and consolidate all of the important concepts and reactions within a chapter.

TABLE 6.3 Addition Reactions of Alkenes

Reaction (section) and Comments	General Equation and Specific Example
Catalytic hydrogenation (Sections 6.1–6.2) Alkenes react with hydrogen in the presence of a platinum, palladium, rhodium, or nickel catalyst to form the corresponding alkane. Both hydrogens add to the same face of the double bond (syn addition). Heats of hydrogenation can be used to compare the relative stability of various double-bond types.	$R_2C{=}CR_2 + H_2 \xrightarrow{Pt,\ Pd,\ Rh,\ or\ Ni} R_2CHCHR_2$ Alkene — Hydrogen — Alkane  cis-Cyclododecene — Cyclododecane (100%)
Addition of hydrogen halides (Sections 6.4–6.5) A proton and a halogen add to the double bond of an alkene to yield an alkyl halide. Addition proceeds in accordance with Markovnikov's rule: hydrogen adds to the carbon that has the greater number of hydrogens, halide to the carbon that has the fewer hydrogens. The regioselectivity is controlled by the relative stability of the two possible carbocation intermediates. Because the reaction involves carbocations, rearrangement is possible.	$RCH{=}CR'_2 + HX \longrightarrow RCH_2{-}\underset{\displaystyle X}{\underset{|}{C}}R'_2$ Alkene — Hydrogen halide — Alkyl halide  Methylene-cyclohexane — Hydrogen chloride — 1-Chloro-1-methylcyclohexane (75–80%)
Acid-catalyzed hydration (Section 6.6) Addition of water to the double bond of an alkene takes place according to Markovnikov's rule in aqueous acid. A carbocation is an intermediate and is captured by a molecule of water acting as a nucleophile. Rearrangements are possible.	$RCH{=}CR'_2 + H_2O \xrightarrow{H^+} RCH_2{-}\underset{\displaystyle OH}{\underset{|}{C}}R'_2$ Alkene — Water — Alcohol  2-Methylpropene — *tert*-Butyl alcohol (55–58%)
Hydroboration-oxidation (Sections 6.8–6.9) This two-step sequence converts alkenes to alcohols with a regioselectivity opposite to Markovnikovs's rule. Addition of H and OH is stereospecific and syn. The reaction involves electrophilic addition of a boron hydride to the double bond, followed by oxidation of the intermediate organoborane with hydrogen peroxides. Carbocations are not intermediates and rearrangements do not occur.	$RCH{=}CR'_2 \xrightarrow[2.\ H_2O_2,\ HO^-]{1.\ B_2H_6,\ diglyme} RCH(OH){-}CHR'_2$ Alkene — Alcohol  4-Methyl-1-pentene — 4-Methyl-1-pentanol (80%)
Addition of Halogens (Section 6.10) Reactions with Br_2 or Cl_2 are the most common and yield vicinal dihalides except when the reaction is carried out in water. In water, the product is a vicinal halohydrin. The reactions involve a cyclic halonium ion intermediate and are stereospecific (anti addition). Halohydrin formation is regiospecific; the halogen bonds to the carbon of C—C that has the greater number of hydrogens.	$R_2C{=}CR'_2 + X_2 \longrightarrow R_2C(X){-}CR'_2(X)$ Alkene — Halogen — Vicinal dihalide $RCH{=}CR'_2 + X_2 + H_2O \longrightarrow RCH(X){-}CR'_2(OH) + HX$ Alkene — Halogen — Water — Vicinal halohydrin — Hydrogen halide

Audience

Organic Chemistry is designed to meet the needs of the "mainstream," two-semester undergraduate organic chemistry course. From the beginning and with each new edition, we have remained grounded in some fundamental notions. These include important issues concerning the intended audience. Is the topic appropriate for them with respect to their interests, aspirations, and experience? Just as important is the need to present an accurate picture of the present state of organic chemistry. How do we know what we know? What makes organic chemistry worth knowing? Where are we now? Where are we headed?

Descriptive Passages and Interpretive Problems

Many organic chemistry students later take standardized pre-professional examinations composed of problems derived from a descriptive passage, this text includes comparable passages and problems to familiarize students with this testing style.

Thus, *every* chapter concludes with a self-contained *Descriptive Passage and Interpretive Problems* unit that complements the chapter's content while emulating the "MCAT style." These 28 passages—listed on page 000--are accompanied by more than 100 total multiple-choice problems.

The passages focus on a wide range of topics—from structure, synthesis, mechanism, and natural products. They provide instructors with numerous opportunities to customize their own organic chemistry course while giving students practice in combining new information with what they have already learned.

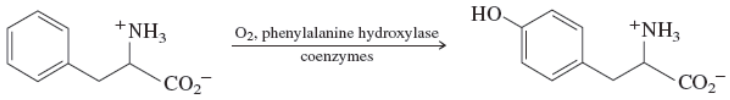
Descriptive Passage and Interpretive Problems 16

Epoxide Rearrangements and the NIH Shift

This passage is about two seemingly unrelated aspects of epoxides:

1. epoxide rearrangements
2. arene oxides

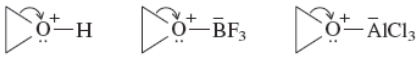
These two topics merge in an important biological transformation in which neither the reactant nor the product is an epoxide—the conversion of the amino acid phenylalanine to tyrosine.



Phenylalanine Tyrosine

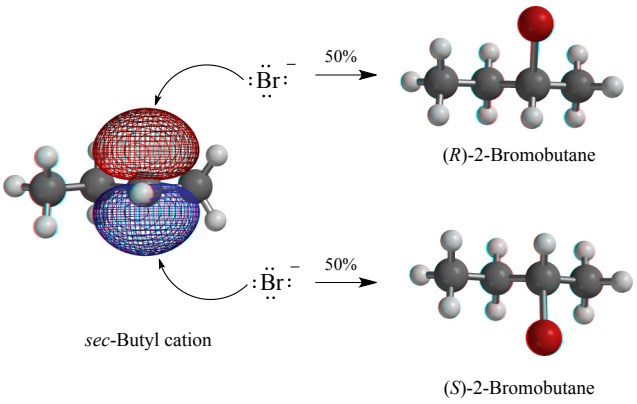
Epoxide rearrangements

In some epoxide ring-opening reactions C—O bond cleavage is accompanied by the development of enough carbocation character at carbon ($^{\delta+}$C---O) to allow rearrangement to occur. These reactions are typically promoted by protonation of the epoxide oxygen or by its coordination to Lewis acids such as boron trifluoride (BF_3) and aluminum chloride ($AlCl_3$).



What's New

- Chirality has been moved from its place as Chapter 7 previous editions to Chapter 4 here and required major changes and required major changes in the chapters on nucleophilic substitution and alkenes as well. For example, electrophilic additions to alkenes are not revisited to cover their stereochemical aspects. These additions now appear in the appropriate alkene chapter along with their mechanism and stereochemical details. An example is the addition of HB to 1-butene.



Spiraling through topics is reduced with the earlier placement of chirality and chapter reorganization, allowing some topics to be explained in greater detail. Stereoelectronic effects in E2 eliminations, for example, are now presented as another example of a stereospecific process.

- Nucleophilic substitution, previously Chapters 4 and 8, is now covered in back-to-back in Chapters 5 and 6. This change makes for a tighter presentation in the early part of the book where mechanisms are first introduced.
- A new chapter on the chemistry of free radicals has been added. This change improves topic flow in the first chapter on nucleophilic substitution and allows a more unified approach to free radical chemistry. ~~which previously was distributed across several chapters in the textbook.~~
- A new Descriptive Passage with Interpretive Problems "Free-Radical Reduction of Alkyl Halides" has been added to the new chapter on free radicals.
- The revising of **structural drawings** to bond-line format begun in previous editions continues. These drawings not only reflect common usage in organic chemistry as it is practiced and taught, but also foster a closer connection between

what the student reads in the text, what the instructor presents in ~~the~~ class, what is used throughout the electronic resources in Connect and SmartBook, and what appears on examinations.

- ❖ All end-of-chapter problems are now grouped according to topic. This should allow students to identify and focus more readily on specific areas where they need more practice.
- ❖ Several new chapter openers have been created for this edition.

Course Management Software

The Classroom Performance System's (CPS) eInstruction

Test Bank

Solutions Manual

Student Resources

Solutions Manual

McGraw-Hill Connect Chemistry

Schaum's Outline of Organic Chemistry

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List of 10e reviewers