

**STUDY GUIDE
SOLUTION MANUAL**

Third Edition

Organic Chemistry

Janice Gorzynski Smith



<http://create.mcgraw-hill.com>

Copyright 2011 by The McGraw-Hill Companies, Inc. All rights reserved. Printed in the United States of America. Except as permitted under the United States Copyright Act of 1976, no part of this publication may be reproduced or distributed in any form or by any means, or stored in a database or retrieval system, without prior written permission of the publisher.

This McGraw-Hill Create text may include materials submitted to McGraw-Hill for publication by the instructor of this course. The instructor is solely responsible for the editorial content of such materials. Instructors retain copyright of these additional materials.

ISBN-10: 1121180612 ISBN-13: 9781121180611

Contents

1. Structure and Bonding	1
2. Acids and Bases	33
3. Introduction to Organic Molecules and Functional Groups	57
4. Alkanes	75
5. Stereochemistry	111
6. Understanding Organic Reactions	139
7. Alkyl Halides and Nucleophilic Substitution	159
8. Alkyl Halides and Elimination Reactions	193
9. Alcohols, Ethers, and Epoxides	223
10. Alkenes	257
11. Alkynes	287
12. Oxidation and Reduction	309
13. Mass Spectrometry and Infrared Spectroscopy	337
14. Nuclear Magnetic Resonance Spectroscopy	351
15. Radical Reactions	373
16. Conjugation, Resonance, and Dienes	397
17. Benzene and Aromatic Compounds	421
18. Electrophilic and Aromatic Substitution	443
19. Carboxylic Acids and the Acidity of the O-H Bond	479
20. Introduction to Carbonyl Chemistry	501
21. Aldehydes and Ketones — Nucleophilic Addition	535
22. Carboxylic Acids and Their Derivatives — Nucleophilic Acyl Substitution	567
23. Substitution Reactions of Carbonyl Compounds at the α Carbon	603
24. Carbonyl Condensation Reactions	631
25. Amines	659
26. Carbon-Carbon Bonding-Forming Reactions in Organic Synthesis	693
27. Carbohydrates	715
28. Amino Acids and Proteins	751
29. Lipids	785
30. Synthetic Polymers	801

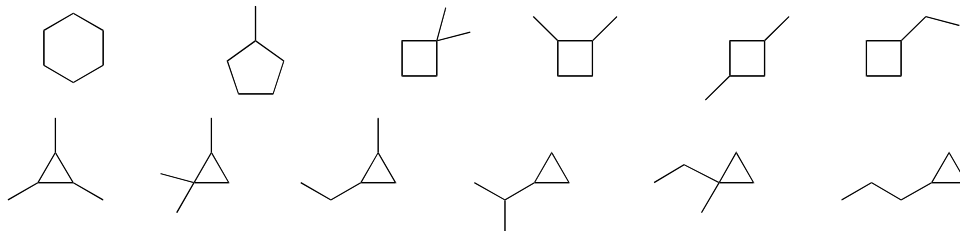
Credits

1. Structure and Bonding: *Chapter 1 from Study Guide/Solutions Manual to accompany Organic Chemistry, Third Edition by Smith* 1
2. Acids and Bases: *Chapter 2 from Study Guide/Solutions Manual to accompany Organic Chemistry, Third Edition by Smith* 33
3. Introduction to Organic Molecules and Functional Groups: *Chapter 3 from Study Guide/Solutions Manual to accompany Organic Chemistry, Third Edition by Smith* 57
4. Alkanes: *Chapter 4 from Study Guide/Solutions Manual to accompany Organic Chemistry, Third Edition by Smith* 75
5. Stereochemistry: *Chapter 5 from Study Guide/Solutions Manual to accompany Organic Chemistry, Third Edition by Smith* 111
6. Understanding Organic Reactions: *Chapter 6 from Study Guide/Solutions Manual to accompany Organic Chemistry, Third Edition by Smith* 139
7. Alkyl Halides and Nucleophilic Substitution: *Chapter 7 from Study Guide/Solutions Manual to accompany Organic Chemistry, Third Edition by Smith* 159
8. Alkyl Halides and Elimination Reactions: *Chapter 8 from Study Guide/Solutions Manual to accompany Organic Chemistry, Third Edition by Smith* 193
9. Alcohols, Ethers, and Epoxides: *Chapter 9 from Study Guide/Solutions Manual to accompany Organic Chemistry, Third Edition by Smith* 223
10. Alkenes: *Chapter 10 from Study Guide/Solutions Manual to accompany Organic Chemistry, Third Edition by Smith* 257
11. Alkynes: *Chapter 11 from Study Guide/Solutions Manual to accompany Organic Chemistry, Third Edition by Smith* 287
12. Oxidation and Reduction: *Chapter 12 from Study Guide/Solutions Manual to accompany Organic Chemistry, Third Edition by Smith* 309
13. Mass Spectrometry and Infrared Spectroscopy: *Chapter 13 from Study Guide/Solutions Manual to accompany Organic Chemistry, Third Edition by Smith* 337
14. Nuclear Magnetic Resonance Spectroscopy: *Chapter 14 from Study Guide/Solutions Manual to accompany Organic Chemistry, Third Edition by Smith* 351
15. Radical Reactions: *Chapter 15 from Study Guide/Solutions Manual to accompany Organic Chemistry, Third Edition by Smith* 373
16. Conjugation, Resonance, and Dienes: *Chapter 16 from Study Guide/Solutions Manual to accompany Organic Chemistry, Third Edition by Smith* 397
17. Benzene and Aromatic Compounds: *Chapter 17 from Study Guide/Solutions Manual to accompany Organic Chemistry, Third Edition by Smith* 421
18. Electrophilic and Aromatic Substitution: *Chapter 18 from Study Guide/Solutions Manual to accompany Organic Chemistry, Third Edition by Smith* 443
19. Carboxylic Acids and the Acidity of the O-H Bond: *Chapter 19 from Study Guide/Solutions Manual to accompany Organic Chemistry, Third Edition by Smith* 479

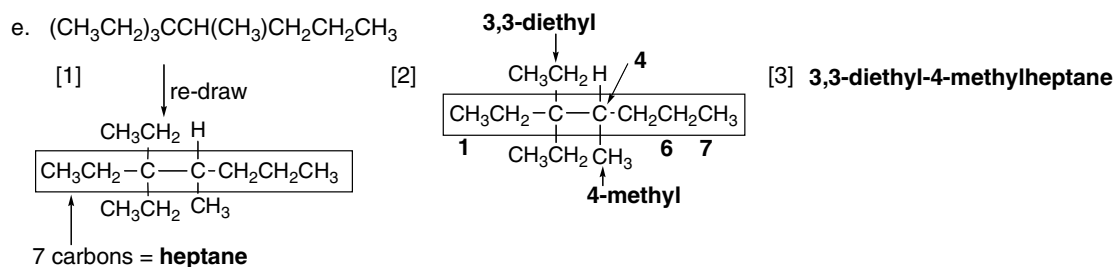
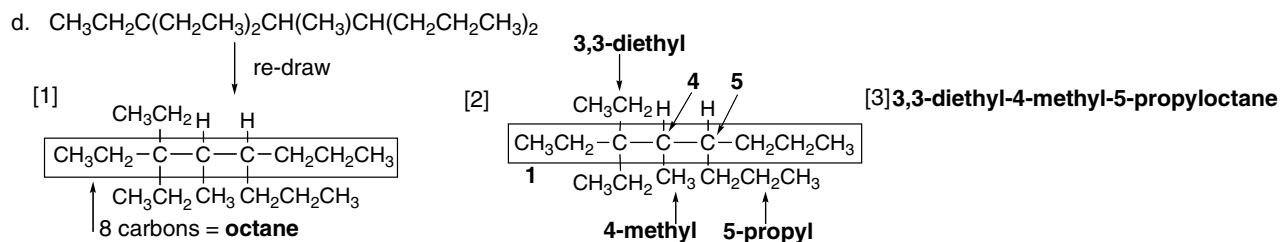
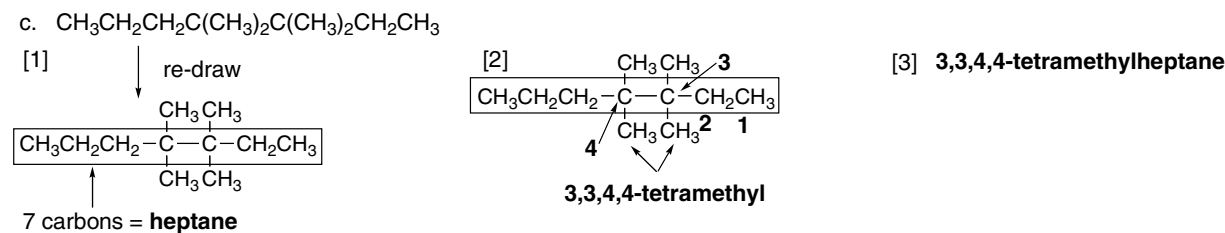
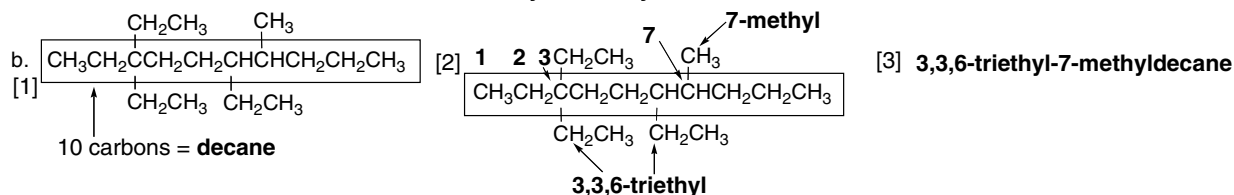
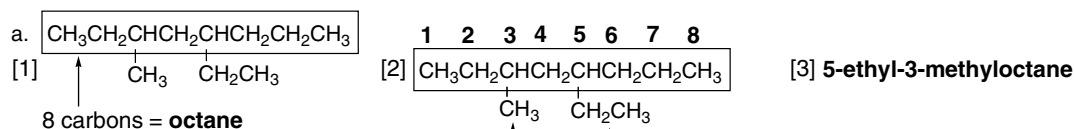
20. Introduction to Carbonyl Chemistry: *Chapter 20 from Study Guide/Solutions Manual to accompany Organic Chemistry, Third Edition by Smith* 501
21. Aldehydes and Ketones — Nucleophilic Addition: *Chapter 21 from Study Guide/Solutions Manual to accompany Organic Chemistry, Third Edition by Smith* 535
22. Carboxylic Acids and Their Derivatives — Nucleophilic Acyl Substitution: *Chapter 22 from Study Guide/Solutions Manual to accompany Organic Chemistry, Third Edition by Smith* 567
23. Substitution Reactions of Carbonyl Compounds at the α Carbon: *Chapter 23 from Study Guide/Solutions Manual to accompany Organic Chemistry, Third Edition by Smith* 603
24. Carbonyl Condensation Reactions: *Chapter 24 from Study Guide/Solutions Manual to accompany Organic Chemistry, Third Edition by Smith* 631
25. Amines: *Chapter 25 from Study Guide/Solutions Manual to accompany Organic Chemistry, Third Edition by Smith* 659
26. Carbon-Carbon Bonding-Forming Reactions in Organic Synthesis: *Chapter 26 from Study Guide/Solutions Manual to accompany Organic Chemistry, Third Edition by Smith* 693
27. Carbohydrates: *Chapter 27 from Study Guide/Solutions Manual to accompany Organic Chemistry, Third Edition by Smith* 715
28. Amino Acids and Proteins: *Chapter 28 from Study Guide/Solutions Manual to accompany Organic Chemistry, Third Edition by Smith* 751
29. Lipids: *Chapter 29 from Study Guide/Solutions Manual to accompany Organic Chemistry, Third Edition by Smith* 785
30. Synthetic Polymers: *Chapter 30 from Study Guide/Solutions Manual to accompany Organic Chemistry, Third Edition by Smith* 801

Chapter 4–20

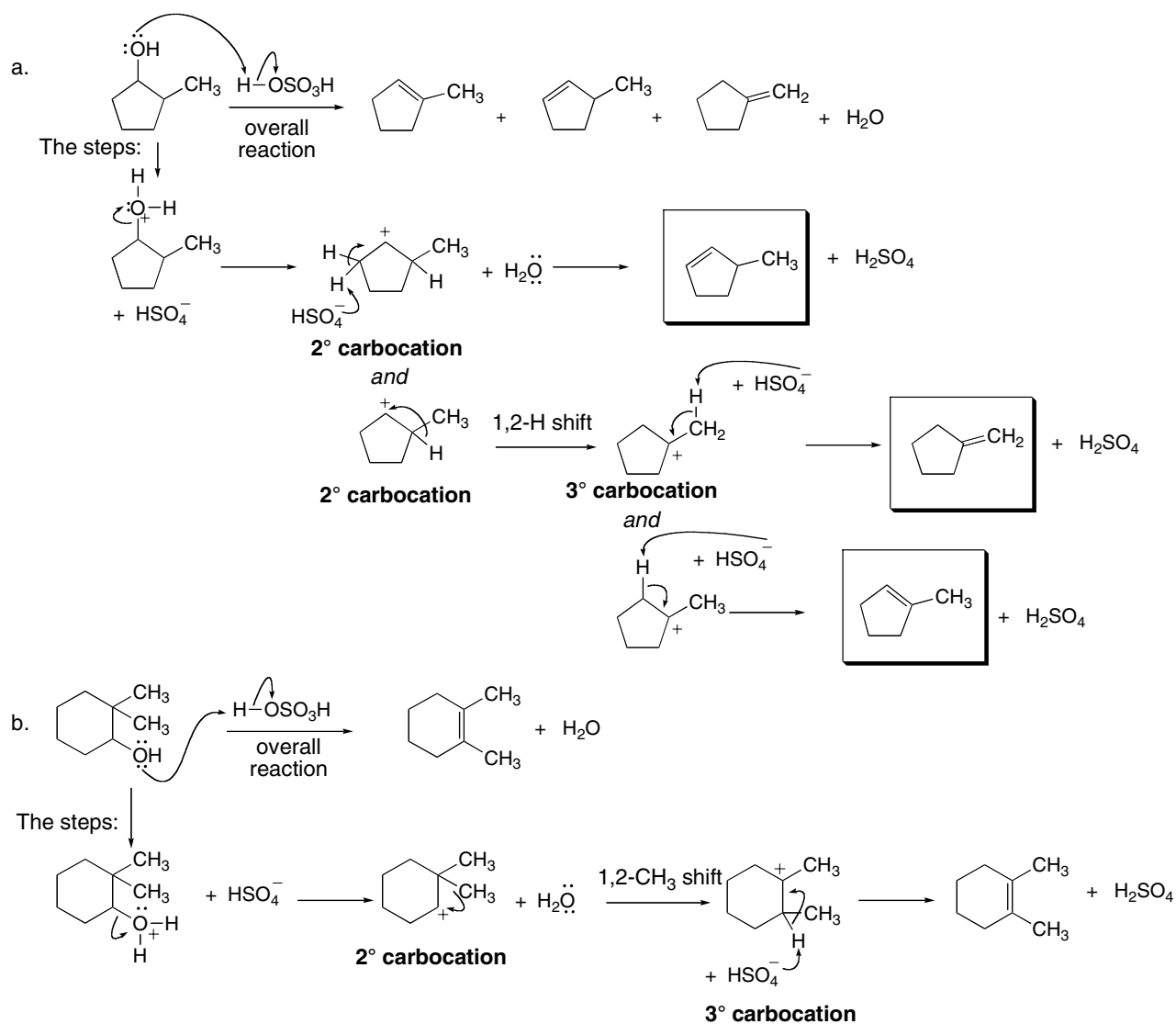
c. Twelve constitutional isomers of molecular formula C_6H_{12} containing one ring:



4.40 Use the steps in Answers 4.10 and 4.14 to name the alkanes.

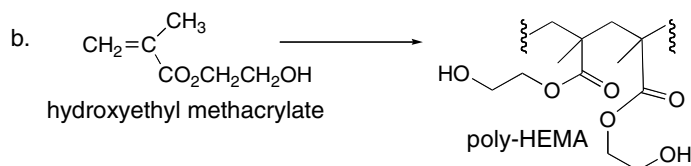
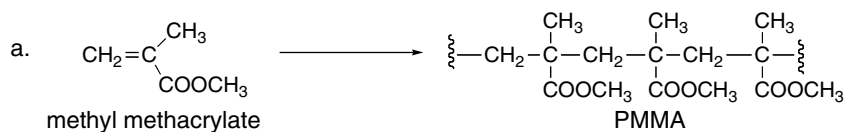


Chapter 9–22

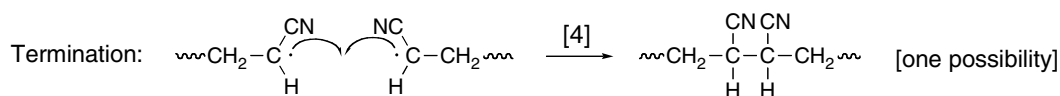
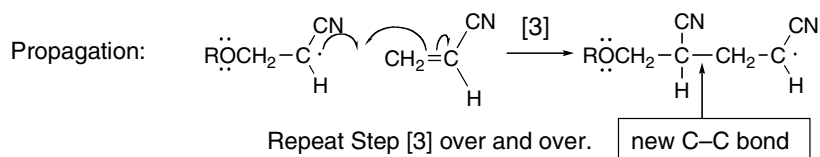
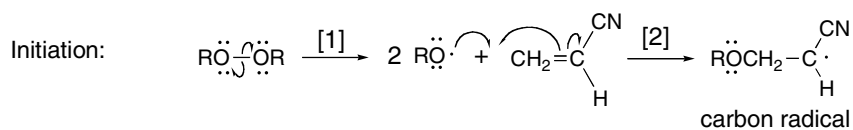
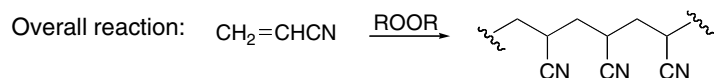


Chapter 15–22

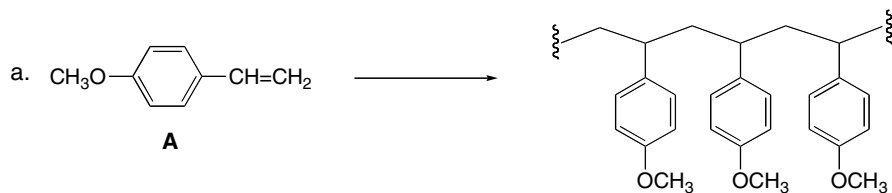
15.73



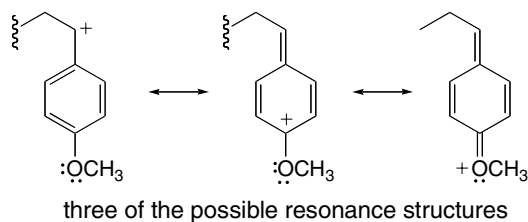
15.74



15.75



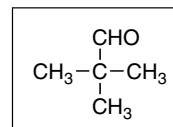
b. The OCH_3 group stabilizes an intermediate carbocation by resonance. This makes **A** react faster than styrene in cationic polymerization.



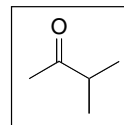
Chapter 21–30

21.84

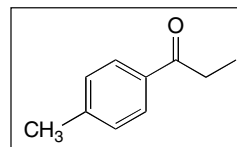
- A. Molecular formula $C_5H_{10}O$ \longrightarrow 1 degree of unsaturation
 IR absorptions at 1728, 2791, 2700 cm^{-1} \longrightarrow C=O, CHO
 NMR data: singlet at 1.08 (9 H) \longrightarrow 3 CH_3 groups
 singlet at 9.48 (1 H) ppm \longrightarrow CHO



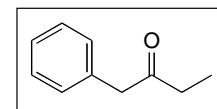
- B. Molecular formula $C_5H_{10}O$ \longrightarrow 1 degree of unsaturation
 IR absorption at 1718 cm^{-1} \longrightarrow C=O
 NMR data: doublet at 1.10 (6 H) \longrightarrow 2 CH_3 's adjacent to H
 singlet at 2.14 (3 H) \longrightarrow CH_3
 septet at 2.58 (1 H) ppm \longrightarrow CH adjacent to 2 CH_3 's



- C. Molecular formula $C_{10}H_{12}O$ \longrightarrow 5 degrees of unsaturation (4 due to a benzene ring)
 IR absorption at 1686 cm^{-1} \longrightarrow C=O
 NMR data: triplet at 1.21 (3 H) \longrightarrow CH_3 adjacent to 2 H's
 singlet at 2.39 (3 H) \longrightarrow CH_3
 quartet at 2.95 (2 H) \longrightarrow CH_2 adjacent to 3 H's
 doublet at 7.24 (2 H) \longrightarrow 2 H's on benzene ring
 doublet at 7.85 (2 H) ppm \longrightarrow 2 H's on benzene ring

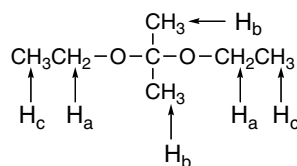


- D. Molecular formula $C_{10}H_{12}O$ \longrightarrow 5 degrees of unsaturation (4 due to a benzene ring)
 IR absorption at 1719 cm^{-1} \longrightarrow C=O
 NMR data: triplet at 1.02 (3 H) \longrightarrow CH_3 adjacent 2 H's
 quartet at 2.45 (2 H) \longrightarrow 2 H's adjacent to 3 H's
 singlet at 3.67 (2 H) \longrightarrow CH_2
 multiplet at 7.06–7.48 (5 H) ppm \longrightarrow a monosubstituted benzene ring



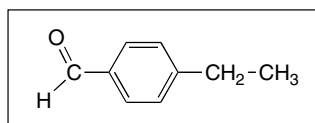
21.85

- $C_7H_{16}O_2$: 0 degrees of unsaturation
 IR: 3000 cm^{-1} : C–H bonds
 NMR data (ppm):
 H_a : quartet at 3.5 (4 H), split by 3 H's
 H_b : singlet at 1.4 (6 H)
 H_c : triplet at 1.2 (6 H), split by 2 H's

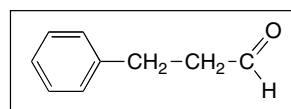


21.86

- A. Molecular formula $C_9H_{10}O$
 5 degrees of unsaturation
 IR absorption at 1700 cm^{-1} \longrightarrow C=O
 IR absorption at $\sim 2700\text{ cm}^{-1}$ \longrightarrow CH of RCHO
 NMR data (ppm):
 triplet at 1.2 (2 H's adjacent)
 quartet at 2.7 (3 H's adjacent)
 doublet at 7.3 (2 H's on benzene)
 doublet at 7.7 (2 H's on benzene)
 singlet at 9.9 (CHO)



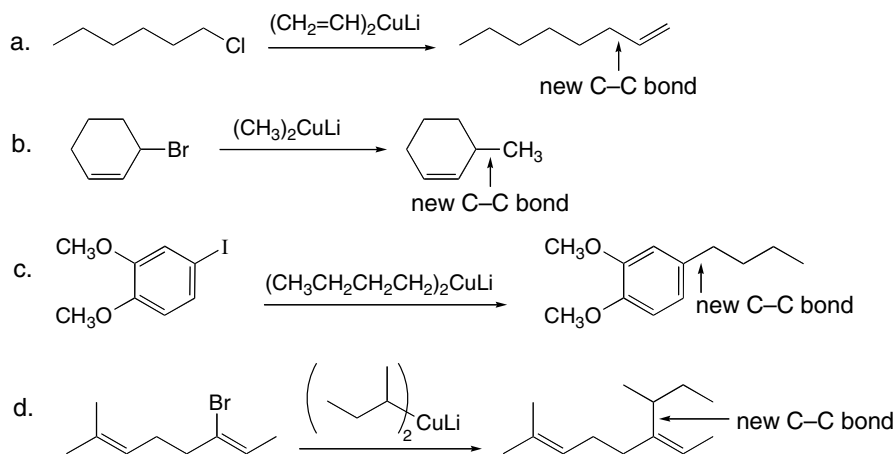
- B. Molecular formula $C_9H_{10}O$
 5 degrees of unsaturation
 IR absorption at 1720 cm^{-1} \longrightarrow C=O
 IR absorption at $\sim 2700\text{ cm}^{-1}$ \longrightarrow CH of RCHO
 NMR data (ppm):
 2 triplets at 2.85 and 2.95 (suggests $-CH_2CH_2-$)
 multiplet at 7.2 (benzene H's)
 signal at 9.8 (CHO)



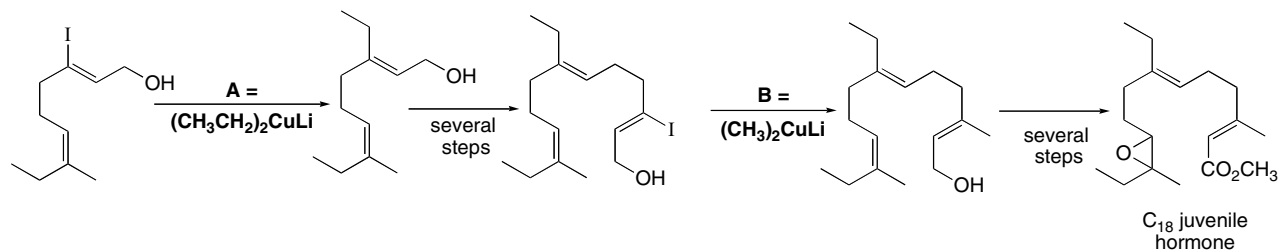
Chapter 26–2

Chapter 26: Answers to Problems

26.1 A new C–C bond is formed in each coupling reaction.



26.2



26.3

