

Appendix A

Common Abbreviations, Arrows, and Symbols










Abbreviations

Ac	acetyl, CH ₃ CO–
BBN	9-borabicyclo[3.3.1]nonane
BINAP	2,2'-bis(diphenylphosphino)-1,1'-binaphthyl
BOC	<i>tert</i> -butoxycarbonyl, (CH ₃) ₃ COCO–
bp	boiling point
Bu	butyl, CH ₃ CH ₂ CH ₂ CH ₂ –
CBS reagent	Corey–Bakshi–Shibata reagent
DBN	1,5-diazabicyclo[4.3.0]non-5-ene
DBU	1,8-diazabicyclo[5.4.0]undec-7-ene
DCC	dicyclohexylcarbodiimide
DET	diethyl tartrate
DIBAL-H	diisobutylaluminum hydride, [(CH ₃) ₂ CHCH ₂] ₂ AlH
DMF	dimethylformamide, HCON(CH ₃) ₂
DMSO	dimethyl sulfoxide, (CH ₃) ₂ S=O
<i>ee</i>	enantiomeric excess
Et	ethyl, CH ₃ CH ₂ –
FGI	functional group interconversion
HMPA	hexamethylphosphoramide, [(CH ₃) ₂ N] ₃ P=O
HOMO	highest occupied molecular orbital
IR	infrared
LAH	lithium aluminum hydride, LiAlH ₄
LDA	lithium diisopropylamide, LiN[CH(CH ₃) ₂] ₂
LUMO	lowest unoccupied molecular orbital
<i>m</i> -	meta
<i>m</i> CPBA	<i>m</i> -chloroperoxybenzoic acid
Me	methyl, CH ₃ –
MO	molecular orbital
mp	melting point
MS	mass spectrometry
MW	molecular weight
NBS	<i>N</i> -bromosuccinimide
NMO	<i>N</i> -methylmorpholine <i>N</i> -oxide
NMR	nuclear magnetic resonance
<i>o</i> -	ortho
<i>p</i> -	para
PCC	pyridinium chlorochromate
Ph	phenyl, C ₆ H ₅ –
ppm	parts per million
Pr	propyl, CH ₃ CH ₂ CH ₂ –
TBDMS	<i>tert</i> -butyldimethylsilyl
THF	tetrahydrofuran
TMS	tetramethylsilane, (CH ₃) ₄ Si
UV	ultraviolet

A-2 APPENDIX A Common Abbreviations, Arrows, and Symbols

Arrows

	reaction arrow
	equilibrium arrows
	double-headed arrow, used between resonance structures
	full-headed curved arrow, showing the movement of an electron pair
	half-headed curved arrow (fishhook), showing the movement of an electron
	retrosynthetic arrow
	no reaction

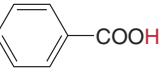
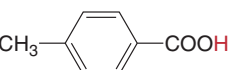
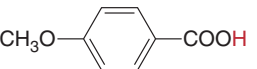
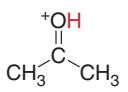
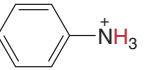
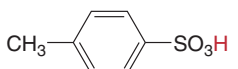
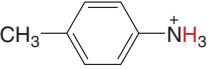
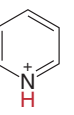

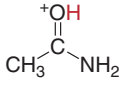
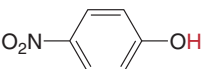
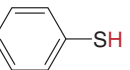

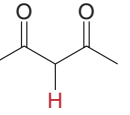
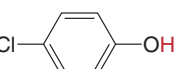
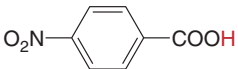
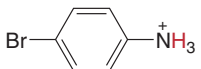
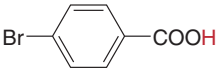
Symbols

$\overset{+}{\longrightarrow}$	dipole
$h\nu$	light
Δ	heat
δ^+	partial positive charge
δ^-	partial negative charge
λ	wavelength
ν	frequency
$\tilde{\nu}$	wavenumber
HA	Brønsted–Lowry acid
B:	Brønsted–Lowry base
$:\text{Nu}^-$	nucleophile
E^+	electrophile
X	halogen
\blacktriangleleft	bond oriented forward
\cdots	bond oriented behind
$---$	partial bond
$[\]^\ddagger$	transition state
[O]	oxidation
[H]	reduction

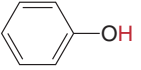
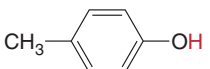

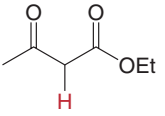
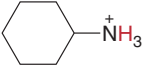
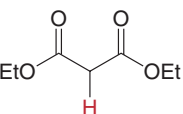
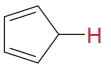
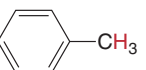
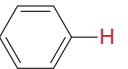

Appendix B

pK_a Values for Selected Compounds



Compound	pK _a	Compound	pK _a
HI	-10		4.2
HBr	-9		4.3
H ₂ SO ₄	-9		4.5
	-7.3		4.6
	-7	CH ₃ COOH	4.8
HCl	-7	(CH ₃) ₃ CCOOH	5.0
[(CH ₃) ₂ OH] ⁺	-3.8		5.1
[CH ₃ OH ₂] ⁺	-2.5		5.2
H ₃ O ⁺	-1.7		5.3
CH ₃ SO ₃ H	-1.2	H ₂ CO ₃	6.4
	0.0	H ₂ S	7.0
CF ₃ COOH	0.2		7.1
CCl ₃ COOH	0.64		7.8
	1.0		8.9
Cl ₂ CHCOOH	1.3	HC≡N	9.1
H ₃ PO ₄	2.1		9.4
FCH ₂ COOH	2.7	NH ₄ ⁺	9.4
ClCH ₂ COOH	2.8		
BrCH ₂ COOH	2.9		
ICH ₂ COOH	3.2		
HF	3.2		
	3.4		
HCOOH	3.8		
	3.9		
	4.0		

A-4 APPENDIX B pK_a Values for Selected Compounds

Compound	pK_a	Compound	pK_a
$H_3N^+CH_2COO^-$	9.8	CH_3OH	15.5
	10.0	H_2O	15.7
	10.2	CH_3CH_2OH	16.0
HCO_3^-	10.2	CH_3CONH_2	16
CH_3NO_2	10.2	CH_3CHO	17
	10.3	$(CH_3)_3COH$	18
CH_3CH_2SH	10.5	$(CH_3)_2C=O$	19.2
$[(CH_3)_3NH]^+$	10.6	$CH_3CO_2CH_2CH_3$	24.5
	10.7	$HC\equiv CH$	25
$[CH_3NH_3]^+$	10.7	$CH_3C\equiv N$	25
	10.7	$CHCl_3$	25
$[(CH_3)_2NH_2]^+$	10.7	$CH_3CON(CH_3)_2$	30
CF_3CH_2OH	12.4	H_2	35
	13.3	NH_3	38
	15	CH_3NH_2	40
			41
			43
		$CH_2=CHCH_3$	43
		$CH_2=CH_2$	44
			46
		CH_4	50
		CH_3CH_3	50

Appendix C

Bond Dissociation Energies for Some Common Bonds [A-B → A• + •B]

Bond	ΔH° kcal/mol	(kJ/mol)
H-Z bonds		
H-F	136	(569)
H-Cl	103	(431)
H-Br	88	(368)
H-I	71	(297)
H-OH	119	(498)
Z-Z bonds		
H-H	104	(435)
F-F	38	(159)
Cl-Cl	58	(242)
Br-Br	46	(192)
I-I	36	(151)
HO-OH	51	(213)
R-H bonds		
CH ₃ -H	104	(435)
CH ₃ CH ₂ -H	98	(410)
CH ₃ CH ₂ CH ₂ -H	98	(410)
(CH ₃) ₂ CH-H	95	(397)
(CH ₃) ₃ C-H	91	(381)
CH ₂ =CH-H	104	(435)
HC≡C-H	125	(523)
CH ₂ =CHCH ₂ -H	87	(364)
C ₆ H ₅ -H	110	(460)
C ₆ H ₅ CH ₂ -H	85	(356)
R-R bonds		
CH ₃ -CH ₃	88	(368)
CH ₃ -CH ₂ CH ₃	85	(356)
CH ₃ -CH=CH ₂	92	(385)
CH ₃ -C≡CH	117	(489)

A-6 APPENDIX C Bond Dissociation Energies for Some Common Bonds [A-B → A· + ·B]

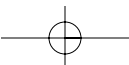
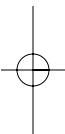
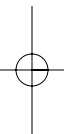
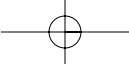
Bond	ΔH° kcal/mol	(kJ/mol)
R-X bonds		
CH ₃ -F	109	(456)
CH ₃ -Cl	84	(351)
CH ₃ -Br	70	(293)
CH ₃ -I	56	(234)
CH ₃ CH ₂ -F	107	(448)
CH ₃ CH ₂ -Cl	81	(339)
CH ₃ CH ₂ -Br	68	(285)
CH ₃ CH ₂ -I	53	(222)
(CH ₃) ₂ CH-F	106	(444)
(CH ₃) ₂ CH-Cl	80	(335)
(CH ₃) ₂ CH-Br	68	(285)
(CH ₃) ₂ CH-I	53	(222)
(CH ₃) ₃ C-F	106	(444)
(CH ₃) ₃ C-Cl	79	(331)
(CH ₃) ₃ C-Br	65	(272)
(CH ₃) ₃ C-I	50	(209)
R-OH bonds		
CH ₃ -OH	91	(381)
CH ₃ CH ₂ -OH	91	(381)
CH ₃ CH ₂ CH ₂ -OH	91	(381)
(CH ₃) ₂ CH-OH	91	(381)
(CH ₃) ₃ C-OH	91	(381)

Appendix D

Characteristic IR Absorption Frequencies



Bond	Functional group	Wavenumber (cm ⁻¹)	Comment
O-H	• ROH	3600–3200	broad, strong
	• RCOOH	3500–2500	very broad, strong
N-H	• RNH ₂	3500–3300	two peaks
	• R ₂ NH	3500–3300	one peak
	• RCONH ₂ , RCONHR	3400–3200	one or two peaks; N-H bending also observed at 1640 cm ⁻¹
C-H	• C _{sp} -H	3300	sharp, often strong
	• C _{sp} ² -H	3150–3000	medium
	• C _{sp} ³ -H	3000–2850	strong
	• C _{sp} ² -H of RCHO	2830–2700	one or two peaks
C≡C		2250	medium
C≡N		2250	medium
C=O			strong
	• RCOCl	1800	
	• (RCO) ₂ O	1800, 1760	two peaks
	• RCOOR	1745–1735	increasing $\bar{\nu}$ with decreasing ring size
	• RCHO	1730	
	• R ₂ CO	1715	increasing $\bar{\nu}$ with decreasing ring size
	• R ₂ CO, conjugated	1680	
	• RCOOH	1710	
	• RCONH ₂ , RCONHR, RCONR ₂	1680–1630	increasing $\bar{\nu}$ with decreasing ring size
	C=C	• Alkene	1650
• Arene		1600, 1500	medium
C=N		1650	medium



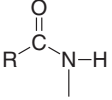
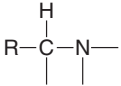
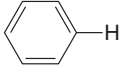
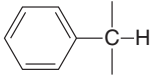
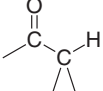
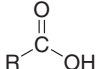
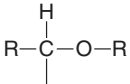
Appendix E

Characteristic ^1H NMR Absorptions



Compound type	Chemical shift (ppm)
Alcohol	
$\text{R}-\text{O}-\text{H}$	1-5
$\begin{array}{c} \text{H} \\ \\ \text{R}-\text{C}-\text{O}- \\ \end{array}$	3.4-4.0
Aldehyde	
$\begin{array}{c} \text{O} \\ \\ \text{R}-\text{C}-\text{H} \end{array}$	9-10
Alkane	
RCH_3	~0.9
R_2CH_2	~1.3
R_3CH	~1.7
Alkene	
$\begin{array}{c} \text{H} \\ \\ \text{C}=\text{C} \\ \end{array} \quad \text{sp}^2 \text{ C-H}$	4.5-6.0
$\begin{array}{c} \text{C} \\ \\ \text{C}=\text{C}-\text{C}-\text{H} \\ \end{array} \quad \text{allylic sp}^3 \text{ C-H}$	1.5-2.5
Alkyl halide	
$\begin{array}{c} \text{H} \\ \\ \text{R}-\text{C}-\text{F} \\ \end{array}$	4.0-4.5
$\begin{array}{c} \text{H} \\ \\ \text{R}-\text{C}-\text{Cl} \\ \end{array}$	3.0-4.0
$\begin{array}{c} \text{H} \\ \\ \text{R}-\text{C}-\text{Br} \\ \end{array}$	2.7-4.0
$\begin{array}{c} \text{H} \\ \\ \text{R}-\text{C}-\text{I} \\ \end{array}$	2.2-4.0

A-10 APPENDIX E Characteristic ^1H NMR Absorptions

Compound type	Chemical shift (ppm)
Alkyne	
$\text{—C}\equiv\text{C—H}$	~2.5
Amide	
	7.5–8.5
Amine	
R—N—H	0.5–5.0
	2.3–3.0
Aromatic compound	
 sp^2 C–H	6.5–8
 benzylic sp^3 C–H	1.5–2.5
Carbonyl compound	
 sp^3 C–H on the α carbon	2.0–2.5
Carboxylic acid	
	10–12
Ether	
	3.4–4.0

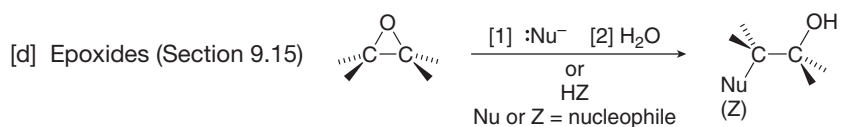
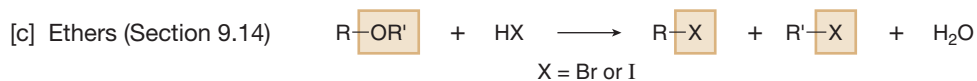
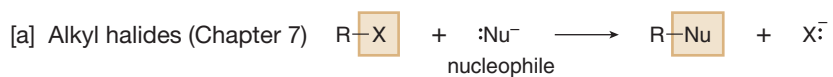
Appendix F

General Types of Organic Reactions



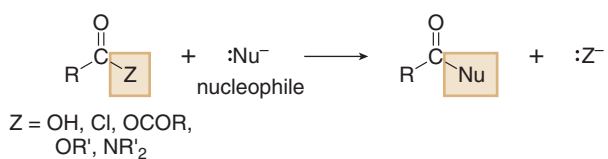
Substitution Reactions

[1] Nucleophilic substitution at an sp^3 hybridized carbon atom



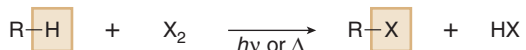
[2] Nucleophilic acyl substitution at an sp^2 hybridized carbon atom

Carboxylic acids and their derivatives (Chapter 22)



[3] Radical substitution at an sp^3 hybridized C–H bond

Alkanes (Section 13.3)



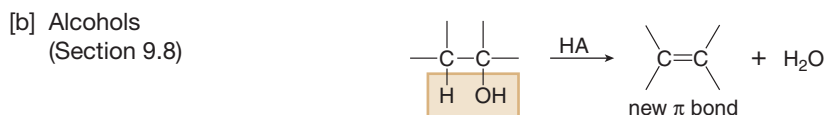
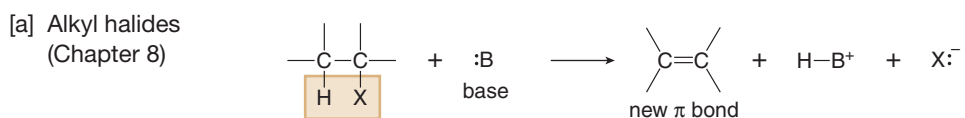
[4] Electrophilic aromatic substitution

Aromatic compounds (Chapter 18)



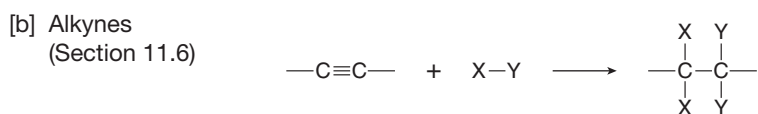
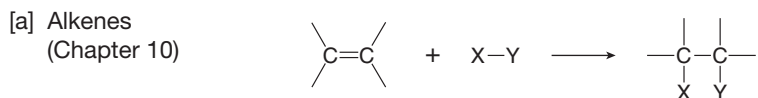
Elimination Reactions

β Elimination at an sp^3 hybridized carbon atom

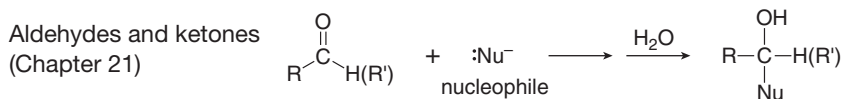


Addition Reactions

[1] Electrophilic addition to carbon-carbon multiple bonds



[2] Nucleophilic addition to carbon-oxygen multiple bonds



Appendix G

How to Synthesize Particular Functional Groups



Acetals

- ◆ Reaction of an aldehyde or ketone with two equivalents of an alcohol (21.14)

Acid chlorides

- ◆ Reaction of a carboxylic acid with thionyl chloride (22.10)

Alcohols

- ◆ Nucleophilic substitution of an alkyl halide with OH^- or H_2O (9.6)
- ◆ Hydration of an alkene (10.12)
- ◆ Hydroboration–oxidation of an alkene (10.16)
- ◆ Reduction of an epoxide with LiAlH_4 (12.6)
- ◆ Reduction of an aldehyde or ketone (20.4)
- ◆ Hydrogenation of an α,β -unsaturated carbonyl compound with $\text{H}_2 + \text{Pd-C}$ (20.4C)
- ◆ Enantioselective reduction of an aldehyde or ketone with the chiral CBS reagent (20.6)
- ◆ Reduction of an acid chloride with LiAlH_4 (20.7)
- ◆ Reduction of an ester with LiAlH_4 (20.7)
- ◆ Reduction of a carboxylic acid with LiAlH_4 (20.7)
- ◆ Reaction of an aldehyde or ketone with a Grignard or organolithium reagent (20.10)
- ◆ Reaction of an acid chloride with a Grignard or organolithium reagent (20.13)
- ◆ Reaction of an ester with a Grignard or organolithium reagent (20.13)
- ◆ Reaction of an organometallic reagent with an epoxide (20.14B)

Aldehydes

- ◆ Hydroboration–oxidation of a terminal alkyne (11.10)
- ◆ Oxidation of a 1° alcohol with PCC (12.12)
- ◆ Oxidative cleavage of an alkene with O_3 followed by Zn or $(\text{CH}_3)_2\text{S}$ (12.10)
- ◆ Reduction of an acid chloride with $\text{LiAlH}[\text{OC}(\text{CH}_3)_3]_3$ (20.7)
- ◆ Reduction of an ester with DIBAL-H (20.7)
- ◆ Hydrolysis of an acetal (21.14B)
- ◆ Hydrolysis of an imine or enamine (21.12)
- ◆ Reduction of a nitrile (22.18B)

Alkanes

- ◆ Catalytic hydrogenation of an alkene with $\text{H}_2 + \text{Pd-C}$ (12.3)
- ◆ Catalytic hydrogenation of an alkyne with two equivalents of $\text{H}_2 + \text{Pd-C}$ (12.5A)
- ◆ Reduction of an alkyl halide with LiAlH_4 (12.6)
- ◆ Reduction of a ketone to a methylene group (CH_2)—the Wolff–Kishner or Clemmensen reaction (18.14B)
- ◆ Protonation of an organometallic reagent with H_2O , ROH , or acid (20.9)

A-14 APPENDIX G How to Synthesize Particular Functional Groups**Alkenes**

- ◆ Dehydrohalogenation of an alkyl halide with base (8.3)
- ◆ Dehydration of an alcohol with acid (9.8)
- ◆ Dehydration of an alcohol using POCl_3 and pyridine (9.10)
- ◆ β Elimination of an alkyl tosylate with base (9.13)
- ◆ Catalytic hydrogenation of an alkyne with H_2 + Lindlar catalyst to form a cis alkene (12.5B)
- ◆ Dissolving metal reduction of an alkyne with Na, NH_3 to form a trans alkene (12.5C)
- ◆ Wittig reaction (21.10)
- ◆ Hofmann elimination of an amine (25.12)

Alkyl halides

- ◆ Reaction of an alcohol with HX (9.11)
- ◆ Reaction of an alcohol with SOCl_2 or PBr_3 (9.12)
- ◆ Cleavage of an ether with HBr or HI (9.14)
- ◆ Hydrohalogenation of an alkene with HX (10.9)
- ◆ Halogenation of an alkene with X_2 (10.13)
- ◆ Hydrohalogenation of an alkyne with two equivalents of HX (11.7)
- ◆ Halogenation of an alkyne with two equivalents of X_2 (11.8)
- ◆ Radical halogenation of an alkane (13.3)
- ◆ Radical halogenation at an allylic carbon (13.10)
- ◆ Radical addition of HBr to an alkene (13.13)
- ◆ Electrophilic addition of HX to a 1,3-diene (16.10)
- ◆ Radical halogenation of an alkyl benzene (18.13)
- ◆ Halogenation α to a carbonyl group (23.7)

Alkynes

- ◆ Dehydrohalogenation of an alkyl dihalide with base (11.5)
- ◆ $\text{S}_{\text{N}}2$ reaction of an alkyl halide with an acetylide anion, $\text{C}\equiv\text{CR}^-$ (11.11)

Amides

- ◆ Reaction of an acid chloride with NH_3 or an amine (22.8)
- ◆ Reaction of an anhydride with NH_3 or an amine (22.9)
- ◆ Reaction of a carboxylic acid with NH_3 or an amine and DCC (22.10)
- ◆ Reaction of an ester with NH_3 or an amine (22.11)

Amines

- ◆ Reduction of a nitro group (18.14C)
- ◆ Reduction of an amide with LiAlH_4 (20.7B)
- ◆ Reduction of a nitrile (22.18B)
- ◆ $\text{S}_{\text{N}}2$ reaction using NH_3 or an amine (25.7A)
- ◆ Gabriel synthesis (25.7A)
- ◆ Reductive amination of an aldehyde or ketone (25.7C)

Amino acids

- ◆ $\text{S}_{\text{N}}2$ reaction of an α -halo carboxylic acid with excess NH_3 (28.2A)
- ◆ Alkylation of diethyl acetamidomalonate (28.2B)
- ◆ Strecker synthesis (28.2C)
- ◆ Enantioselective hydrogenation using a chiral catalyst (28.4)

Anhydrides

- ◆ Reaction of an acid chloride with a carboxylate anion (22.8)
- ◆ Dehydration of a dicarboxylic acid (22.10)

Aryl halides

- ◆ Halogenation of benzene with $X_2 + FeX_3$ (18.3)
- ◆ Reaction of a diazonium salt with CuCl, CuBr, HBF_4 , NaI, or KI (25.14A)

Carboxylic acids

- ◆ Oxidative cleavage of an alkyne with ozone (12.11)
- ◆ Oxidation of a 1° alcohol with CrO_3 (or a similar Cr^{6+} reagent), H_2O , H_2SO_4 (12.12B)
- ◆ Oxidation of an alkyl benzene with $KMnO_4$ (18.14A)
- ◆ Oxidation of an aldehyde (20.8)
- ◆ Reaction of a Grignard reagent with CO_2 (20.14A)
- ◆ Hydrolysis of a cyanohydrin (21.9)
- ◆ Hydrolysis of an acid chloride (22.8)
- ◆ Hydrolysis of an anhydride (22.9)
- ◆ Hydrolysis of an ester (22.11)
- ◆ Hydrolysis of an amide (22.13)
- ◆ Hydrolysis of a nitrile (22.18A)
- ◆ Malonic ester synthesis (23.9)

Cyanohydrins

- ◆ Addition of HCN to an aldehyde or ketone (21.9)

1,2-Diols

- ◆ Anti dihydroxylation of an alkene with a peroxyacid, followed by ring opening with ^-OH or H_2O (12.9A)
- ◆ Syn dihydroxylation of an alkene with $KMnO_4$ or OsO_4 (12.9B)

Enamines

- ◆ Reaction of an aldehyde or ketone with a 2° amine (21.12)

Epoxides

- ◆ Intramolecular S_N2 reaction of a halohydrin using base (9.6)
- ◆ Epoxidation of an alkene with mCPBA (12.8)
- ◆ Enantioselective epoxidation of an allylic alcohol with the Sharpless reagent (12.14)

Esters

- ◆ S_N2 reaction of an alkyl halide with a carboxylate anion, $RCOO^-$ (7.19)
- ◆ Reaction of an acid chloride with an alcohol (22.8)
- ◆ Reaction of an anhydride with an alcohol (22.9)
- ◆ Fischer esterification of a carboxylic acid with an alcohol (22.10)

Ethers

- ◆ Williamson ether synthesis— S_N2 reaction of an alkyl halide with an alkoxide, ^-OR (9.6)
- ◆ Reaction of an alkyl tosylate with an alkoxide, ^-OR (9.13)
- ◆ Addition of an alcohol to an alkene in the presence of acid (10.12)

Halohydrins

- ◆ Reaction of an epoxide with HX (9.15)
- ◆ Addition of X and OH to an alkene (10.15)

Imine

- ◆ Reaction of an aldehyde or ketone with a 1° amine (21.11)

A-16 APPENDIX G How to Synthesize Particular Functional Groups**Ketones**

- ◆ Hydration of an alkyne with H_2O , H_2SO_4 , and HgSO_4 (11.9)
- ◆ Oxidative cleavage of an alkene with O_3 followed by Zn or $(\text{CH}_3)_2\text{S}$ (12.10)
- ◆ Oxidation of a 2° alcohol with any Cr^{6+} reagent (12.12)
- ◆ Friedel–Crafts acylation (18.5)
- ◆ Reaction of an acid chloride with an organocuprate reagent (20.13)
- ◆ Hydrolysis of an imine or enamine (21.12)
- ◆ Hydrolysis of an acetal (21.14B)
- ◆ Reaction of a nitrile with a Grignard or organolithium reagent (22.18C)
- ◆ Acetoacetic ester synthesis (23.10)

Nitriles

- ◆ $\text{S}_{\text{N}}2$ reaction of an alkyl halide with NaCN (7.19, 22.18)
- ◆ Reaction of an aryl diazonium salt with CuCN (25.14A)

Phenols

- ◆ Reaction of an aryl diazonium salt with H_2O (25.14A)

Appendix H

Reactions that Form Carbon–Carbon Bonds



Section	Reaction
11.11A	S_N2 reaction of an alkyl halide with an acetylide anion, $^-C\equiv CR$
11.11B	Opening of an epoxide ring with an acetylide anion, $^-C\equiv CR$
13.14	Radical polymerization of an alkene
16.12	Diels–Alder reaction
18.5	Friedel–Crafts alkylation
18.5	Friedel–Crafts acylation
20.10	Reaction of an aldehyde or ketone with a Grignard or organolithium reagent
20.13A	Reaction of an acid chloride with a Grignard or organolithium reagent
20.13A	Reaction of an ester with a Grignard or organolithium reagent
20.13B	Reaction of an acid chloride with an organocuprate reagent
20.14A	Reaction of a Grignard reagent with CO_2
20.14B	Reaction of an epoxide with an organometallic reagent
20.15	Reaction of an α,β -unsaturated carbonyl compound with an organocuprate reagent
21.9	Cyanohydrin formation
21.10	Wittig reaction to form an alkene
22.18	S_N2 reaction of an alkyl halide with NaCN
22.18C	Reaction of a nitrile with a Grignard or organolithium reagent
23.8	Direct enolate alkylation using LDA and an alkyl halide
23.9	Malonic ester synthesis to form an α -substituted carboxylic acid
23.10	Acetoacetic ester synthesis to form an α -substituted ketone
24.1	Aldol reaction to form a β -hydroxy carbonyl compound or an α,β -unsaturated carbonyl compound
24.2	Crossed aldol reaction
24.3	Directed aldol reaction
24.5	Claisen reaction to form a β -keto ester
24.6	Crossed Claisen reaction to form a β -dicarbonyl compound
24.7	Dieckmann reaction to form a five- or six-membered ring
24.8	Michael reaction to form a 1,5-dicarbonyl compound
24.9	Robinson annulation to form a 2-cyclohexenone
27.10B	Kiliani–Fischer synthesis of an aldose
28.2B	Alkylation of diethyl acetamidomalonate to form an amino acid
28.2C	Strecker synthesis of an amino acid

