Chapter 1 Electrons and Chemical Bonds

1.1 Electron configuration of atom
1.2 Electron configuration of carbon atoms
1.3 Covalent bonds
1.4 Hybridized orbitals of carbon atoms
    (a) Structure of alkanes
        (1) sp^3 hybridization
        (2) Structure of methane
        (3) Structure of ethane
    (b) Structure of ethylene
        (1) sp^2 hybridization
        (2) Geometrical isomers
        (3) Conjugated system
    (c) Structure of benzene
    (d) Structure of acetylene
        (1) sp hybridization
        (2) Acetylene
1.5 Coordinate Bond
Problems
Answers

Chapter 2 Makeup of Organic Compounds

2.1 Structural unit of organic compounds
    (a) Hydrocarbons and functional groups
        (1) Linkage of carbon atoms
        (2) Groups, substituents, and functional groups
    (b) Classification of hydrocarbons
2.2 Functional groups
    (a) Important functional groups
    (b) Functional groups and electronegativity
    (c) Substituent effect; inductive effect
    (d) Resonance effect
    (e) Organometallic compounds
2.3 Nomenclature of organic compounds
    (a) Basic principle of nomenclature
    (b) Substitutive nomenclature
    (c) Radicofunctional nomenclature
    (d) Locant
        (1) Chain compounds
        (2) Cyclic compounds
Problems
Answers

Chapter 3 Acidity/Basicity and Structure

3.1 BrØnsted-Lowry theory
(a) Acid dissociation constant and acid dissociation exponent
(b)Acid dissociation constant and acid dissociation exponent
(c) Extension of the concept of acids and base
3. 2 Lewis's theory
(a) Outline of Lewis's theory
(b) Lewis's theory in organic chemistry
3.3 Acidity of carboxylic acids
(a) Carboxylic acids and alcohols
(b) Carboxylic acids and phenols
3.4 Substituent effects
(a) Inductive effect
(b) Resonance effect caused by substituents
(1) Resonance effect in nitrobenzene
(2) Resonance effect in nitrophenol
(3) Resonance effect in substituted benzoic acids
(4) Classification of substituents
3.5 Basicity of amines
(a) Basicity of alkylamines and arylamines
(b) Basicity of substituted aniline
Problems
Answers

Chapter 4 Mechanism and Rate of Reactions

4.1 Types of organic reactions
(a) Classification based on the relation between reactants and products
(1) Substitution reaction
(2) Addition reaction
(3) Elimination reaction
(4) Rearrangement reaction
(b) Classification by the mode of cleavage/formation of bonds
(c) Nucleophilic reactions and electrophilic reactions
(d) Mechanism of nucleophilic substitution
(1) Cleavage of the C-Br bond followed by the formation of the C-O bond.
(2) Simultaneous bond cleavage and bond formation
(3) Formation of the C-O bond followed by cleavage of the C-Br bond
(e) Reaction coordinate--energy diagram
(1) The path *via* a reaction intermediate
(2) The path *via* a transition state
4.2 Unimolecular reactions and bimolecular reactions
4.3 Reaction intermediates

(a) Carbon radical
(b) Carbocation
(c) Carbanion
4.4 Structure of reactants and reaction mechanism
(a) Nucleophilic substitution of primary alkyl halides
(b) Nucleophilic substitution of tertiary alkyl halides
(c) Does a nucleophilic substitution occur without fail at the carbon center substituted by electron withdrawing substituent?
(d) Radical substitution
Problems
Answers

Chapter 5 Alkanes and Cycloalkanes

5.1 Properties and nomenclature of alkanes
5.2 Structure of alkanes
(a) Structures of methane and ethane
(b) Conformational analysis
(1) Rotation about a single bond
(2) Newman projection
(c) Conformational analysis of ethane
(d) Conformational analysis of butane
5.3 Reactions of alkanes
(a) Combustion
(b) Radical reactions
5.4 Nomenclature of cycloalkanes
5.5 Structure of cycloalkanes
(a) Non-planar structure
(b) Conformational analysis of cyclohexane
(1) Inversion of cyclohexane
(2) Axial and equatorial bonds
(3) Newman projection of cyclohexane
(c) Conformational analysis of methylcyclohexane
(1) 1,3-diaxial interaction
(2) Butane-*gauche* interaction
5.6 Reactions of cycloalkanes
Problems
Answers

Chapter 6 Alkenes and Alkynes

6.1 Properties and nomenclature of alkenes and alkynes
6.2 Structure of alkenes and alkynes

(a) Bond length and bond angle
(b) Geometrical isomers of alkenes
6.3 Reaction of alkenes
(a) Addition reaction of halogens and hydrogen halides
(1) Addition reaction of halogens
(2) Addition reaction of hydrogen halides
(3) Stereochemistry of addition reactions
(b) Orientation of the addition reaction
(1) Addition reaction to propene
(2) Markovnikov's rule
(3) Anti-Markovnikov's rule
(c) Other addition reactions
(1) Addition reaction of water
(2) Addition reaction of hydrogen (Reduction of alkenes)
(d) Conjugate addition
(e) Other reactions
(1) Oxidation of alkenes
(2) Hydroboration
(f) Diels-Alder reaction
(g) Addition polymerization
6.4 Property and nomenclature of alkynes
6.5 Reactions of alkynes
(a) Addition reactions of halogens and hydrogen halides
(b) Addition reactions of hydrogen
(c) Addition reactions of water
(d) Formation of acetylides
Problems
Answers

Chapter 7 Arenes

7.1 Properties and nomenclature of arenes
(a) Benzene and alkylbenzenes
(b) Condensed ring aromatic hydrocarbons
7.2 Structure of arenes.
(a) Structure of benzene, naphthalene, and biphenyl
(b) Aromaticity
(1) Aromaticity based on heat of reaction
(2) Hückel rule
(3) Nonbenzenoid aromatic compounds
7.3 Reactions of arenes
(a) Electrophilic aromatic substitution of benzene
(1) Halogenation
(2) Nitration

(3) Sulfonation
(4) Friedel-Crafts reaction (alkylation)
(5) Friedel-Crafts reaction (acylation)
(b) Nitration of substituted benzenes
(1) Nitration of toluene
(2) The role of methyl group: activation
(3) The role of methyl group: orientation
(4)Nitration of other arenes
(c) Other reactions
Problems
Answers

Chapter 8 Chirality

8.1 Stereochemistry of asymmetric carbon atom
(a) Asymmetric carbon atom
(1) Tetrahedral structure of a carbon atom
(2) Optical activity
(b) Chirality
8.2 Stereochemical nomenclature
(a) Steric configuration (configuration)
(b) (*R*)-(*S*) Nomenclature.
(1) Sequence rule
(2) Determination of configuration
(c) Fischer projection formula
8.3 Stereochemistry of sugars
(a) Glyceraldehyde
(b) Erythrose and threose
(c) Resolution
(d) Tartaric acid
(e) Glucose and its stereoisomers
(1) Configuration of glucose
(2) Mutarotation
8.4 Stereochemistry of addition reactions
Problems
Answers

Chapter 9 Alkyl Halides and Aryl Halides

9.1 Properties and nomenclature of organohalogen compounds
(a) Alkyl halides
(1) Types and names of alkyl halides
(2) Nomenclature of alkyl halides

(b) Aryl halide
(1) Types and names of aryl halides
(2) Nomenclature of aryl halides
9.2 Structure of organic halides
9.3 Reaction of alkyl halides
(a) Nucleophilic substitution reaction
(1) Williamson's ether synthesis
(2) Reaction with cyanides
(3) Esterification
(b) Stereochemistry of nucleophilic substitution reaction
(1) Stereochemistry of S_N1 reactions
(2) Stereochemistry of S_N2 reactions
(3) Example of inversion
(4) Simultaneous progress of S_N1 and S_N2.
(c) Elimination reaction
(1) Driving force of elimination reaction
(2) Unimolecular elimination (E1)
(3) Bimolecular elimination (E2)
(4) Orientation of elimination reaction
(5) Competition between substitution reaction and elimination reaction
(d) Stereochemistry of elimination reaction
9.4 Reactions of aryl halides
(a) Nucleophilic substitution
(b) Electrophilic substitution reaction
(1) Halogens as substituents
(2) Electronic effect and steric effect
(3) Grignard reagent
Problems
Answers

Chapter 10 Alcohols, Phenols, and Ethers

10.1 Properties and nomenclature
(a) Alcohol
(1) Properties and types of alcohol
(2) Nomenclature of alcohol
(b) Phenols
(1) Properties and types of phenols
(2) Nomenclature of phenols
(3) Acidity of phenols
(4) Acidity of substituted phenols
(c) Ethers
(1) Structure and property of ethers
(2) Nomenclature of ethers

10.2 Structure and reactions of alcohols
(a) Structure of alcohols
(b) Polarity of alcohols
(c) Nucleophilic substitution reaction
(d) Acid-catalyzed nucleophilic substitution reaction
(e) Elimination reaction
(f) Oxidation reaction
10.3 Reaction of phenols
(a) Electrophilic substitution reaction
(b) Reaction of hydroxy group
10.4 Reaction of ethers
(a) Nucleophilic substitution reaction
(b) Reaction of epoxides
Problems
Answers

Chapter 11 Carbonyl Compounds

11.1 Types and nomenclature of carbonyl compounds
(a) Types of carbonyl compounds
(b) Nomenclature of carbonyl compounds
(1) Nomenclature of aldehydes
(2) Nomenclature of ketones
11.2 The structure of carbonyl compounds
(a) sp^2 hybridized oxygen atom
(b) Polarization of the carbonyl group
11.3 Oxidation and reduction
(a) Oxidation
(b) Reduction
11.4 Nucleophilic addition
(a) Driving force of nucleophilic addition
(b) Addition of water
(c) Addition of alcohol
(d) Addition of sodium hydrogen sulfite
(e) Addition of nitrogen compounds
(f) Addition of cyanide ion
(g) Addition of metal hydrides
11.5 Grignard reaction
(a) Preparation of Grignard reagent
(b) Grignard reaction
11.6 Wittig reaction
(a) Preparation of Wittig reagent
(b) Reaction between carbonyl compounds and Wittig reagents
11.7 Conjugate addition

(a) α, β-Unsaturated carbonyl compound
(b) Mechanism of conjugate addition
(c) Addition of hydrogen chloride
(d) Michael addition
11.8 Aldol condensation
(a) Reactivity of α-carbon atom of carbonyl group
(b) Enolate ion
(c) Aldol condensation
(d) Mixed aldol condensation
Problems
Answers

Chapter 12 Carboxylic Acids and Derivatives

12.1 Types and nomenclature of carboxylic acids
(a) Types of carboxylic acids
(b) Names of carboxylic acids
12.2 Types and nomenclature of carboxylic acid derivatives
(a) Types of carboxylic acid derivative
(b) Nomenclature of carboxylic acid derivatives
(1) Names of acyl group
(2) Names of acyl halides
(3) Names of acyl anhydride
(4) Names of salts of carboxylic acids
(5) Names of esters
(6) Names of amides
12.3 Structure of carboxylic acid their derivatives
(a) Structure of carboxylic acids and their dimerization
(b) Comparison between the reaction of carboxylic acids and that of carbonyl compounds
(c) Comparison among the reactivity of carboxylic acid derivatives
12.4 Reaction of carboxylic acids and their derivatives
(a) Acidity of carboxylic acids
(b) Oxidation and reduction
(1) Oxidation
(2) Reduction
(c) Grignard reaction
(d) Interconversion among carboxylic acids and their derivatives
(1) Conversion from acid halides
(2) Conversion from acid anhydride
(3) Conversion from carboxylic acids and esters
(4) Conversion from amides
(e) Esterification and hydrolysis of esters
(1) Acid-catalyzed condition
(2) Base-catalyzed condition
(f) Reactions of α-carbon

(1) Claisen condensation
(2) Mixed Claisen condensation
(3) Active methylene compounds
(4) Malonic ester synthesis
(5) Acetoacetic ester synthesis
Problems
Answers