

Demonstrations in Volume 1

1. THERMOCHEMISTRY

George L. Gilbert, Lloyd G. Williams, Bassam Z. Shakhshiri, Glen E. Dirreen, and Frederick H. Juergens

- 1.1 Evaporation as an Endothermic Process
- 1.2 Chemical Cold Pack
- 1.3 Endothermic Reactions of Hydrated Barium Hydroxide and Ammonium Salts
- 1.4 The Nonburning Towel
- 1.5 Heat of Neutralization
- 1.6 Heat of Dilution of Sulfuric Acid
- 1.7 Reaction of Calcium Oxide and Water (Slaking of Lime)
- 1.8 Heat of Solution of Lithium Chloride
- 1.9 Heat of Hydration of Copper(II) Sulfate
- 1.10 Reactions of Metals and Hydrochloric Acid
- 1.11 Crystallization from Supersaturated Solutions of Sodium Acetate
- 1.12 Crystallization of Sodium Thiosulfate
- 1.13 Supercooling of Thymol
- 1.14 Chemical Hot Pack
- 1.15 Burning of Magnesium
- 1.16 Combustion Under Water
- 1.17 Combustion of Cellulose Nitrate (Guncotton)
- 1.18 Combustion of Peroxyacetone
- 1.19 Reaction of Zinc and Iodine
- 1.20 Reaction of Zinc and a Mixture of Ammonium Nitrate and Ammonium Chloride
- 1.21 Reaction of Zinc and Sulfur
- 1.22 Reaction of Iron and Sulfur
- 1.23 Reaction of Sodium Peroxide and Sulfur
- 1.24 Reaction of Sodium Peroxide and Aluminum
- 1.25 Reaction of Sodium and Chlorine
- 1.26 Reaction of Antimony and Chlorine
- 1.27 Reaction of Iron and Chlorine
- 1.28 Reaction of Aluminum and Bromine
- 1.29 Reaction of White Phosphorus and Chlorine

- 1.30 Reaction of Red Phosphorus and Bromine
- 1.31 Spontaneous Combustion of White Phosphorus
- 1.32 Dehydration of Sugar by Sulfuric Acid
- 1.33 Reaction of Potassium Chlorate and Sugar
- 1.34 Decomposition of Ammonium Dichromate
- 1.35 Reaction of Potassium Permanganate and Glycerine
- 1.36 Thermite Reaction
- 1.37 Combustion of Magnesium in Carbon Dioxide
- 1.38 Pyrophoric Lead
- 1.39 Explosive Decomposition of Nitrogen Triiodide
- 1.40 Explosive Reactions of the Allotropes of Phosphorus and Potassium Chlorate
- 1.41 Explosions of Lycopodium and Other Powders
- 1.42 Explosive Reaction of Hydrogen and Oxygen
- 1.43 Combustion of Methane
- 1.44 Explosive Reaction of Nitric Oxide and Carbon Disulfide
- 1.45 Photochemical Reaction of Hydrogen and Chlorine

2. CHEMILUMINESCENCE

Rodney Schreiner, Mary Ellen Testen, Bassam Z. Shakhashiri, Glen E. Dirreen, and Lloyd G. Williams

- 2.1 Singlet Molecular Oxygen
- 2.2 Lightsticks
- 2.3 Sensitized Oxalyl Chloride Chemiluminescence
- 2.4 Oxidations of Luminol
- 2.5 Luminol Chemiluminescent Clock Reactions
- 2.6 Two-Color Chemiluminescent Clock Reaction
- 2.7 Hydrogen Peroxide Oxidation of Lucigenin
- 2.8 Air Oxidation of White Phosphorus
- 2.9 Air Oxidation of Tetrakis(dimethylamino)ethylene
- 2.10 Chemiluminescence of Tris(2,2'-bipyridyl)ruthenium(II) Ion
- 2.11 Explosive Reaction of Nitric Oxide and Carbon Disulfide

3. POLYMERS

Glen E. Dirreen and Bassam Z. Shakhashiri

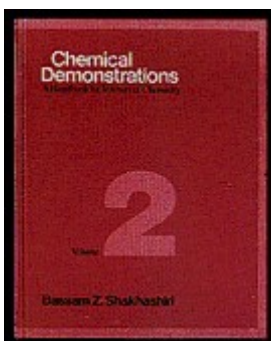
- 3.1 Nylon 6-10
- 3.2 Polyurethane Foam
- 3.3 Phenol-Formaldehyde Polymer
- 3.4 Resorcinol-Formaldehyde Polymer
- 3.5 Aniline Hydrochloride-Formaldehyde Polymer
- 3.6 Urea-Formaldehyde Polymer
- 3.7 Phenolphthalein-Terephthaloyl Chloride Polymer

- 3.8 Polybutadiene (Jumping Rubber)
- 3.9 Poly(methyl acrylate)
- 3.10 Poly(methyl methacrylate)
- 3.11 Polystyrene
- 3.12 Sulfur Polymer or Plastic Sulfur
- 3.13 Thiokol Rubber
- 3.14 Cuprammonium Rayon

4. COLOR AND EQUILIBRIA OF METAL ION PRECIPITATES AND COMPLEXES

Earle S. Scott, Bassam Z. Shakhashiri, Glen E. Dirreen, and Frederick H. Juergens

- 4.1 Iodo Complexes of Mercury(II): "The Orange Tornado"
- 4.2 Chloro and Thiocyanato Complexes of Cobalt(II)
- 4.3 Precipitates and Complexes of Lead(II)
- 4.4 Iodo and Silver(I) Complexes of Silver Iodide
- 4.5 Precipitates and Complexes of Nickel(II)
- 4.6 Precipitates and Complexes of Silver(I)
- 4.7 Bromo Complexes of Copper(II)
- 4.8 Precipitates and Complexes of Copper(II)
- 4.9 Reactions Between Antimony(III) and Chloride Ions
- 4.10 Reactions Between Carbon Dioxide and Limewater
- 4.11 Precipitates and Complexes of Iron(III)



Demonstrations in Volume 2

5. PHYSICAL BEHAVIOR OF GASES

**George M. Bodner, Rodney Schreiner, Thomas J. Greenbowe, Glen E. Dirreen,
and Bassam Z. Shakhshiri**

- 5.1 Collapsing Can
- 5.2 Mercury Barometers
- 5.3 Effect of Pressure on the Size of a Balloon
- 5.4 Boyle's Law
- 5.5 Boyle's Law and the Mass of a Textbook
- 5.6 Thermal Expansion of Gases
- 5.7 Charles's Law
- 5.8 Determination of Absolute Zero
- 5.9 Dependence of Pressure on the Amount of Gas
- 5.10 Dalton's Law of Partial Pressures
- 5.11 Avogadro's Hypothesis
- 5.12 Determination of the Molecular Mass of the Gas from a Butane Lighter
- 5.13 Determination of the Molecular Mass of a Volatile Liquid: The Dumas Method
- 5.14 Flow of Gases Through a Porous Cup
- 5.15 Ratio of Diffusion Coefficients: The Ammonium Chloride Ring
- 5.16 Molecular Collisions: The Diffusion of Bromine Vapor
- 5.17 Graham's Law of Diffusion
- 5.18 Graham's Law of Effusion
- 5.19 Liquid-Vapor Equilibrium
- 5.20 Solid-Vapor Equilibrium
- 5.21 Boiling Liquids at Reduced Pressure
- 5.22 Vapor Pressure
- 5.23 Relative Velocity of Sound Propagation: Musical Molecular Weights
- 5.24 Electrical Conductivity of Gases
- 5.25 Superheated Steam
- 5.26 Kinetic Molecular Theory Simulator

6. CHEMICAL BEHAVIOR OF GASES

Rodney Schreiner, Bassam Z. Shakhashiri, Glen E. Dirreen, and Lenard J. Magginnis

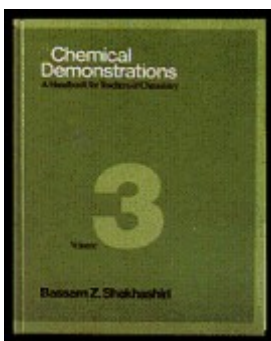
- 6.1 Preparation and Properties of Carbon Dioxide
- 6.2 Reactions of Carbon Dioxide in Aqueous Solution
- 6.3 Reaction Between Carbon Dioxide and Limewater
- 6.4 Carbon Dioxide Equilibria and Reaction Rates: Carbonic Anhydrase-catalyzed Hydration
- 6.5 Combustion of Magnesium in Carbon Dioxide
- 6.6 Preparation and Properties of Hydrogen
- 6.7 Explosiveness of Hydrogen
- 6.8 Preparation and Properties of Oxygen
- 6.9 Reaction of Oxygen with Dextrose: "The Blue-Bottle Experiment"
- 6.10 Preparation and Properties of Liquid Oxygen
- 6.11 Explosive Reaction of Hydrogen and Oxygen
- 6.12 Preparation and Properties of Nitrogen
- 6.13 Combustion of a Candle in Air
- 6.14 Combustion of Magnesium in Air
- 6.15 Preparation and Properties of Nitrogen(II) Oxide
- 6.16 Reaction Between Nitrogen(II) Oxide and Oxygen: Combining Volumes of Gases
- 6.17 Equilibrium Between Nitrogen Dioxide and Dinitrogen Tetroxide
- 6.18 Preparation and Properties of Sulfur Dioxide
- 6.19 Combining Volume of Oxygen with Sulfur
- 6.20 Preparation and Properties of Methane
- 6.21 Combustion of Methane
- 6.22 Preparation and Properties of Hydrogen Chloride
- 6.23 Preparation and Properties of Ammonia
- 6.24 Gas Solubility: The Fountain Effect
- 6.25 Reaction Between Ammonia and Hydrogen Chloride
- 6.26 Catalytic Oxidation of Ammonia
- 6.27 Vapor-Phase Oxidations
- 6.28 Preparation and Properties of Chlorine
- 6.29 Facilitated Transport of Carbon Dioxide Through a Soap Film

7. OSCILLATING CHEMICAL REACTIONS

Earle S. Scott, Rodney Schreiner, Lee R. Sharpe, Bassam Z. Shakhashiri, and Glen E. Dirreen

- 7.1 Briggs-Rauscher Reaction
- 7.2 Cerium-catalyzed Bromate-Malonic Acid Reaction (The Classic Belousov-Zhabotinsky Reaction)
- 7.3 Cerium-catalyzed Bromate-Methylmalonic Acid Reaction (A Modified Belousov-Zhabotinsky Reaction)

- 7.4 Cerium-catalyzed Bromate-Ethylacetoacetate Reaction (A Modified Belousov-Zhabotinsky Reaction)
- 7.5 Manganese-catalyzed Bromate-Ethylacetoacetate Reaction (A Modified Belousov-Zhabotinsky Reaction)
- 7.6 Manganese-catalyzed Bromate-Malonic Acid Reaction (A Modified Belousov-Zhabotinsky Reaction)
- 7.7 Manganese-catalyzed Bromate-2,4-Pentanedione Reaction (A Modified Belousov-Zhabotinsky Reaction)
- 7.8 Manganese-catalyzed Bromate-Citric Acid Reaction (A Modified Belousov-Zhabotinsky Reaction)
- 7.9 Photofluorescent Cerium-catalyzed Bromate-Malonic Acid Reaction (A Modified Belousov-Zhabotinsky Reaction)
- 7.10 Oxidation of Pyrogallol by Bromate
- 7.11 Oxidation of Tannic Acid by Bromate
- 7.12 Traveling Waves of Color
- 7.13 Nitrogen Gas Evolution Oscillator
- 7.14 Liesegang Rings



Demonstrations in Volume 3

8. ACIDS AND BASES

Rodney Schreiner, Bassam Z. Shakhashiri, David B. Shaw, Ronald I. Perkins, and Frederick H. Juergens

- 8.1 Colorful Acid-Base Indicators
- 8.2 Rainbow Colors with Mixed Acid-Base Indicators
- 8.3 Invisible Painting
- 8.4 Acid-Base Indicators Extracted from Plants
- 8.5 Classical Properties of Acids and Bases
- 8.6 Food Is Usually Acidic, Cleaners Are Usually Basic
- 8.7 Differing Properties of Four Common Acids
- 8.8 Etching Glass with Hydrogen Fluoride
- 8.9 "Coin-Operated Red, White, and Blue Demonstration": Fountain Effect with Nitric Acid and Copper
- 8.10 Fountain Effect with Ammonia, Hydrogen Chloride, and Indicators
- 8.11 Fizzing and Foaming: Reactions of Acids with Carbonates
- 8.12 Sealed-Bag Reactions with Acids and Bases
- 8.13 Hydrolysis: Acidic and Basic Properties of Salts
- 8.14 Acidic and Basic Properties of Oxides
- 8.15 Colors, Bubbles, and Fog: Acidic Properties of Carbon Dioxide in Aqueous Solutions
- 8.16 Acidic Properties of Nitrogen(IV) Oxide
- 8.16 Acidic Properties of Combustion Products of Sulfur, Nitrogen, and Chlorinated Polymers
- 8.18 Acid-Neutralizing Capacity of Lake Beds
- 8.19 Amphoteric Properties of the Hydroxides of Aluminum, Zinc, Chromium, and Lead
- 8.20 Differences Between Acid Strength and Concentration
- 8.21 Conductivity and Extent of Dissociation of Acids in Aqueous Solution
- 8.22 Effects of Ion-Exchange Resins on pH and Solution Conductivity
- 8.23 End Point of an Acid-Base Titration Determined by Electrical Conductivity
- 8.24 Effect of Acetate Ion on the Acidity of Acetic Acid: Common Ion Effect
- 8.25 Effect of Molecular Structure on the Strength of Organic Acids and Bases in Aqueous Solutions
- 8.26 Determination of Neutralizing Capacity of Antacids
- 8.27 Instrumental Recording of a Titration Curve
- 8.28 Buffering Action and Capacity

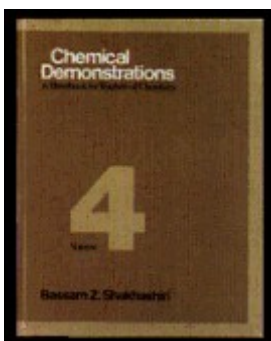
- 8.29 Buffering Action of Alka-Seltzer
- 8.30 Effect of pH on Protein Solubility
- 8.31 Lewis Acid-Base Properties of Aluminum Chloride and Hydrogen Chloride
- 8.32 Reaction Between Ammonia and Hydrogen Chloride

9. LIQUIDS, SOLUTIONS, AND COLLOIDS

Worth E. Vaughan, Rodney Schreiner, Bassam Z. Shakhshiri, and David B. Shaw

- 9.1 Volume Changes upon Mixing
- 9.2 Density and Miscibility of Liquids
- 9.3 The Dependence of Volume on Temperature: Coefficients of Thermal Expansion
- 9.4 Boiling Water in a Paper Cup: Heat Capacity of Water
- 9.5 Vapor Pressure of Pure Liquids and Solutions
- 9.6 Evaporation as an Endothermic Process
- 9.7 Liquid-Vapor Equilibrium
- 9.8 Boiling Liquids at Reduced Pressure
- 9.9 Vapor Pressure of a Solution (A Corridor Display)
- 9.10 Separating Liquids: Fractional Distillation
- 9.11 Failing to Separate Liquids: Azeotropy
- 9.12 Salting Out: Making Liquids Immiscible
- 9.13 Effect of Temperature on the Solubility of Manganese(II) Sulfate Hydrates
- 9.14 Chemical Cold Pack: Dissolution as an Endothermic Process
- 9.15 Heat of Solution of Lithium Chloride
- 9.16 Heat of Hydration of Copper(II) Sulfate
- 9.17 Volume Increase upon Neutralization
- 9.18 Effect of Temperature and Pressure on the Solubility of Gases in Liquids
- 9.19 Osmosis Through the Membrane of an Egg
- 9.20 Osmotic Pressure of a Sugar Solution
- 9.21 Getting Colder: Freezing-Point Depression
- 9.22 Getting Hotter: Boiling-Point Elevation by Nonvolatile Solutes
- 9.23 At the Water's Edge: Surface Spreading and Surface Tension
- 9.24 Will a Tissue Hold Water? Interfacial Tension
- 9.25 The Shape of Drops: Surface and Gravitational Work
- 9.26 The Ice Bomb: Expansion of Water as It Freezes
- 9.27 Flow of Liquids Through Pipes: Liquid Viscosities
- 9.28 Molecules in Slow Motion: Diffusion in Liquids
- 9.29 Facilitated Transport of Carbon Dioxide Through a Soap Film
- 9.30 Equilibration of Liquid Density via Diffusion
- 9.31 Electrical Conductivity of Liquids
- 9.32 Moving Liquids with Electricity: Dielectric Properties of Liquids
- 9.33 The Tubeless Siphon
- 9.34 Rod Climbing by a Polymer Solution
- 9.35 Snappy Liquid: Elastic Properties of a Soap Solution

- 9.36 Fog: An Aerosol of Condensed Water Vapor
- 9.37 Clean Air with the Cottrell Precipitator
- 9.38 A Collection of Foams: Some Suds for Drinking and Some for Washing
- 9.39 Solid Foams
- 9.40 Oil-Water Emulsions
- 9.41 Color of the Sunset: The Tyndall Effect
- 9.42 An Ancient Colloid: India Ink
- 9.43 Canned Heat: Alcohol Gels
- 9.44 "Slime": Gelation of Poly(vinyl alcohol) with Borax
- 9.45 Shake It and Move It: Thixotropy and Dilatancy
- 9.46 Staying Dry: Phase Transitions of a Poly(acrylamide) Gel
- 9.47 Growing Colorful Crystals in Gels
- 9.48 Liesegang Rings: Spatial Oscillation in Precipitate Formation
- 9.49 Colorful Stalagmites: The Silicate Garden
- 9.50 Colors and Shapes of Soap Films and Bubbles
- 9.51 Rotating Rainbows: A Solution in Polarized Light
- 9.52 Floating and Sinking: Osmosis Through a Copper Hexacyanoferrate(II) Membrane



Demonstrations in Volume 4

10. CLOCK REACTIONS

Rodney Schreiner, Bassam Z. Shakhshiri, Earle S. Scott, Jerry A. Bell, and Mary Ellen Testen

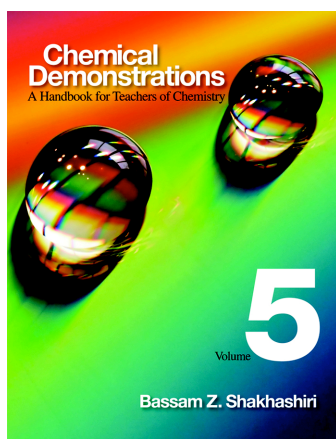
- 10.1 The Landolt Iodine Clock: Oxidation of Bisulfite by Iodate
- 10.2 Color Variations of the Landolt Reaction
- 10.3 Old Nassau Orange and Black: The Landolt Reaction with Mercury Indicator
- 10.4 Hydrogen Peroxide Iodine Clock: Oxidation of Potassium Iodide by Hydrogen Peroxide
- 10.5 Thiosulfate-Counteracted Oxidation of Iodide by Peroxydisulfate
- 10.6 Oxidation of Iodide by Iron(III)
- 10.7 Hydrolysis of 2-Chloro-2-Methylpropane
- 10.8 Aldehyde-Acetone Condensation
- 10.9 Formaldehyde-Sulfite Complex Formation
- 10.10 Luminol Chemiluminescent Clock Reactions
- 10.11 Two-Color Chemiluminescent Clock Reaction
- 10.12 Disproportionation of Acidified Sodium Thiosulfate
- 10.13 Precipitation of Arsenic(III) Sulfide
- 10.14 Bromate Oxidation of Manganese
- 10.15 Periodate-Thiosulfate Reaction

11. ELECTROCHEMISTRY: BATTERIES, ELECTROLYTIC CELLS, AND PLATING

Rodney Schreiner, Bassam Z. Shakhshiri, Ronald I. Perkins, Earle S. Scott, and Larry E. Judge

- 11.1 Magnetic Field from a Conducting Solution
- 11.2 An Activity Series: Zinc, Copper, and Silver Half Cells
- 11.3 The "Standard" Orange Electrode
- 11.4 Constructing a Dry Cell
- 11.5 The Lead Storage Battery
- 11.6 A Gravity Cell
- 11.7 Electricity from a Fuel Cell

- 11.8 A Zinc-Acid Cell
- 11.9 A Zinc-iodine Cell
- 11.10 A Copper-Magnesium Cell
- 11.11 A Concentration Cell
- 11.12 A Potentiometric Silver Series
- 11.13 Migration of Copper(II) and Dichromate Ions
- 11.14 Electrolysis of Water: Color Changes and Exploding Bubbles
- 11.15 Electrochemical Production of an Explosive Gas Mixture
- 11.16 Electrolytic Cells in Series: A Red, White, and Blue Electrolysis
- 11.17 Electrolysis of Potassium Iodide Solution
- 11.18 Electrolysis of Sodium Chloride Solution: The Disappearing Indicator
- 11.19 Coulometers: Measuring Charge by Electrolysis
- 11.20 A Chemical Rectifier: Converting AC to DC
- 11.21 Growing Metallic Crystals: Electrolysis of Metal Salts
- 11.22 Electrolysis of Copper(II) Bromide Solution
- 11.23 Copper Leaves: Electroplating with Copper
- 11.24 Forming a CoPPER Mirror
- 11.25 Nickel Plating: Shiny Nickel Leaves
- 11.26 Chromium Plating
- 11.27 Silver Plating
- 11.28 Formation of a Silver Mirror
- 11.29 Galvanizing: Zinc Plating
- 11.30 Electrodeposition of Metallic Sodium Through Glass
- 11.31 Anodization of Aluminum
- 11.32 The Mercury Beating Heart
- 11.33 Copper to Silver to Gold



Demonstrations in Volume 5

12. Color, Light, Vision, Perception

Rodney Schreiner, Jerry A. Bell, and Bassam Z. Shakhashiri

The Production of Light

- 12.1 The Emission Spectrum from a Candle Flame
- 12.2 The Temperature Dependence of the Emission Spectrum from an Incandescent Lamp
- 12.3 Incandescence from the Combustion of Iron and of Zirconium
- 12.4 Chemical Reactions That Produce Light
- 12.5 Emission Spectra from Gas-Discharge Lamps
- 12.6 Colored Flames from Metal Ions
- 12.7 Light-Emitting Diodes: Voltage and Temperature Effects
- 12.8 Electrogenated Chemiluminescence
- 12.9 Chemiluminescence
- 12.10 Chemiluminescence from the Explosive Reaction of Nitrous Oxide and Carbon Disulfide

Properties of Light

- 12.11 The Conversion of Light Energy to Thermal Energy
- 12.12 Refraction and Diffraction: The Separation of White Light into Colors
- 12.13 Disappearing Glass: Index of Refraction
- 12.14 Disappearing Gel: Index of Refraction
- 12.15 Observing the Transmission Spectra of Dyes
- 12.16 Dichroism: Transmission versus Reflection
- 12.17 Iridescence from a Polymer Film
- 12.18 The Photoelectric Effect
- 12.19 The Tyndall Effect: Scattered Light Is Polarized
- 12.20 Rainbow Spiral in an Optically Active Solution
- 12.21 A Sugar Solution Between Polarizers
- 12.22 The Birefringence of Calcite
- 12.23 A Liquid Crystal Display through a Polarizer
- 12.24 Laser Light Is Polarized

Perception and Vision

- 12.25 Additive Color Mixing
- 12.26 Subtractive Primary Colors
- 12.27 The Perception of Brightness Is Relative
- 12.28 The Hermann-Grid Illusion
- 12.29 Finding the Blind Spot
- 12.30 The Land Effect
- 12.31 Saturation of the Retina: Afterimage
- 12.32 The Persistence of Vision
- 12.33 The Imprecision of Peripheral Vision
- 12.34 The Pulfrich Phenomenon: Perception of Motion

Photoemission: Fluorescence and Phosphorescence

- 12.35 Photoluminescence
- 12.36 The Halide Quenching of Quinine Fluorescence
- 12.37 Differentiation of Fluorescence and Phosphorescence
- 12.38 Phosphorescence Excitation: Energy and Color Relationship
- 12.39 Quenching Phosphorescence with Light
- 12.40 Quenching Phosphorescence with Thermal Energy
- 12.41 The Fluorescence of Molecular Iodine Vapor

Photochemistry

- 12.42 The Reversible Photochemical Bleaching of Thionine
- 12.43 Photochromic Methylene Blue Solution
- 12.44 The Photochemical Reaction of Chlorine and Hydrogen
- 12.45 The Effects of Solvents on Spiropyran Photochromism and Equilibria
- 12.46 A Copper Oxide Photocell
- 12.47 The Photobleaching of Carotene
- 12.48 Making a Cyanotype
- 12.49 An Iron(III)-Oxalate Actinometer
- 12.50 The Photoreduction of Silver Halide
- 12.51 Photochemistry in Nitroprusside-Thiourea Solutions
- 12.52 Photochromism in Ultraviolet-Sensitive Beads
- 12.53 The Photodissociation of Bromine and the Bromination of Hydrocarbons
- 12.54 The Photochemical Formation and Reaction of Ozone