

# Contents

<b>Preface</b>	xi
<b>Shining Light, Shedding Light</b> Roald Hoffmann	xiii
<b>Communicating Science via Demonstrations</b> Bassam Z. Shakhashiri	xxi
<b>Sources Containing Descriptions of Lecture Demonstrations</b>	xxvii
<b>Sources of Information on Hazards and Disposal</b>	xxxix
<b>Displaying Small Phenomena to a Large Audience</b>	xxxiii

## **12 COLOR, LIGHT, VISION, PERCEPTION 1**

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

Color	3
More Properties of Light	7
The Nature of Light	11
Electromagnetic Radiation	22
Interactions of Light and Matter	31
Vision	66
Perception	78
The Demonstrations	84

## **The Production of Light 85**

12.1 The Emission Spectrum from a Candle Flame	87
12.2 The Temperature Dependence of the Emission Spectrum from an Incandescent Lamp	93
12.3 Incandescence from the Combustion of Iron and of Zirconium	98
12.4 Chemical Reactions That Produce Light	102
12.5 Emission Spectra from Gas-Discharge Lamps	103
12.6 Colored Flames from Metal Ions	108
12.7 Light-Emitting Diodes: Voltage and Temperature Effects	111
12.8 Electrogenenerated Chemiluminescence	118
12.9 Chemiluminescence	123
12.10 Chemiluminescence from the Explosive Reaction of Nitrous Oxide and Carbon Disulfide	124

<b>Properties of Light</b>	<b>127</b>
12.11 The Conversion of Light Energy to Thermal Energy	129
12.12 Refraction and Diffraction: The Separation of White Light into Colors	131
12.13 Disappearing Glass: Index of Refraction	135
12.14 Disappearing Gel: Index of Refraction	141
12.15 Observing the Transmission Spectra of Dyes	146
12.16 Dichroism: Transmission versus Reflection	151
12.17 Iridescence from a Polymer Film	154
12.18 The Photoelectric Effect	156
12.19 The Tyndall Effect: Scattered Light Is Polarized	160
12.20 Rainbow Spiral in an Optically Active Solution	163
12.21 A Sugar Solution Between Polarizers	166
12.22 The Birefringence of Calcite	167
12.23 A Liquid Crystal Display through a Polarizer	171
12.24 Laser Light Is Polarized	175
<b>Perception and Vision</b>	<b>179</b>
12.25 Additive Color Mixing	181
12.26 Subtractive Primary Colors	189
12.27 The Perception of Brightness Is Relative	192
12.28 The Hermann-Grid Illusion	196
12.29 Finding the Blind Spot	201
12.30 The Land Effect	204
12.31 Saturation of the Retina: Afterimage	208
12.32 The Persistence of Vision	212
12.33 The Imprecision of Peripheral Vision	215
12.34 The Pulfrich Phenomenon: Perception of Motion	218
<b>Photemission: Fluorescence and Phosphorescence</b>	<b>221</b>
12.35 Photoluminescence	223
12.36 The Halide Quenching of Quinine Fluorescence	227
12.37 Differentiation of Fluorescence and Phosphorescence	232
12.38 Phosphorescence Excitation: Energy and Color Relationship	235
12.39 Quenching Phosphorescence with Light	238
12.40 Quenching Phosphorescence with Thermal Energy	241
12.41 The Fluorescence of Molecular Iodine Vapor	243
<b>Photochemistry</b>	<b>247</b>
12.42 The Reversible Photochemical Bleaching of Thionine	249
12.43 Photochromic Methylene Blue Solution	256
12.44 The Photochemical Reaction of Chlorine and Hydrogen	260
12.45 The Effects of Solvents on Spiropyran Photochromism and Equilibria	261
12.46 A Copper Oxide Photocell	274
12.47 The Photobleaching of Carotene	277

12.48 Making a Cyanotype	283
12.49 An Iron(III)-Oxalate Actinometer	287
12.50 The Photoreduction of Silver Halide	291
12.51 Photochemistry in Nitroprusside-Thiourea Solutions	293
12.52 Photochromism in Ultraviolet-Sensitive Beads	300
12.53 The Photodissociation of Bromine and the Bromination of Hydrocarbons	304
12.54 The Photochemical Formation and Reaction of Ozone	308
<b>Index to Volumes 1–5</b>	311
<b>Illustration Credits</b>	323

Color, light, vision, and perception are the topics of the fifth volume in the series of handbooks aimed at providing teachers of science at all educational levels with detailed instructions and background information for using chemical demonstrations in the classroom and in public presentations. This volume deals with sense of sight and consists of one large chapter with 54 demonstrations and 33 different procedures. The extensive introduction to this volume includes material aimed at reinforcing and expanding the background knowledge of the user. I believe firmly that whenever demonstrations are presented, the phenomena should be described and explained at a level suitable to the audience. A number of demonstrations included in this volume involve quite complex chemical concepts. The intricate details of electronic transitions in colorful (and all) chemical transformations are important, and I hope our explanations will enhance the teacher's ability to use the demonstrations effectively. Furthermore, I believe that by sharing fascinating aspects of the physiology of vision and of the psychology of perception, the teacher can succeed in triggering deeper interest in chemical biology, cognitive science, and neuroscience. I urge teachers in elementary and secondary schools, as well as teachers in colleges and universities, to use the material in the introduction to this volume, as well as in the demonstrations, to display intriguing chemical behavior and scientific concepts.

This volume is part of a continuing project whose purposes are to create, collect, develop, test, and publish demonstrations that will help teachers to connect chemistry with the sensations we receive via our senses of sight, hearing, smell, taste, and touch. Most classroom and public science demonstrations engage the brain through the eye and the ear, but very few involve olfaction, gustation, and touch. These latter topics are the subjects of forthcoming volumes.