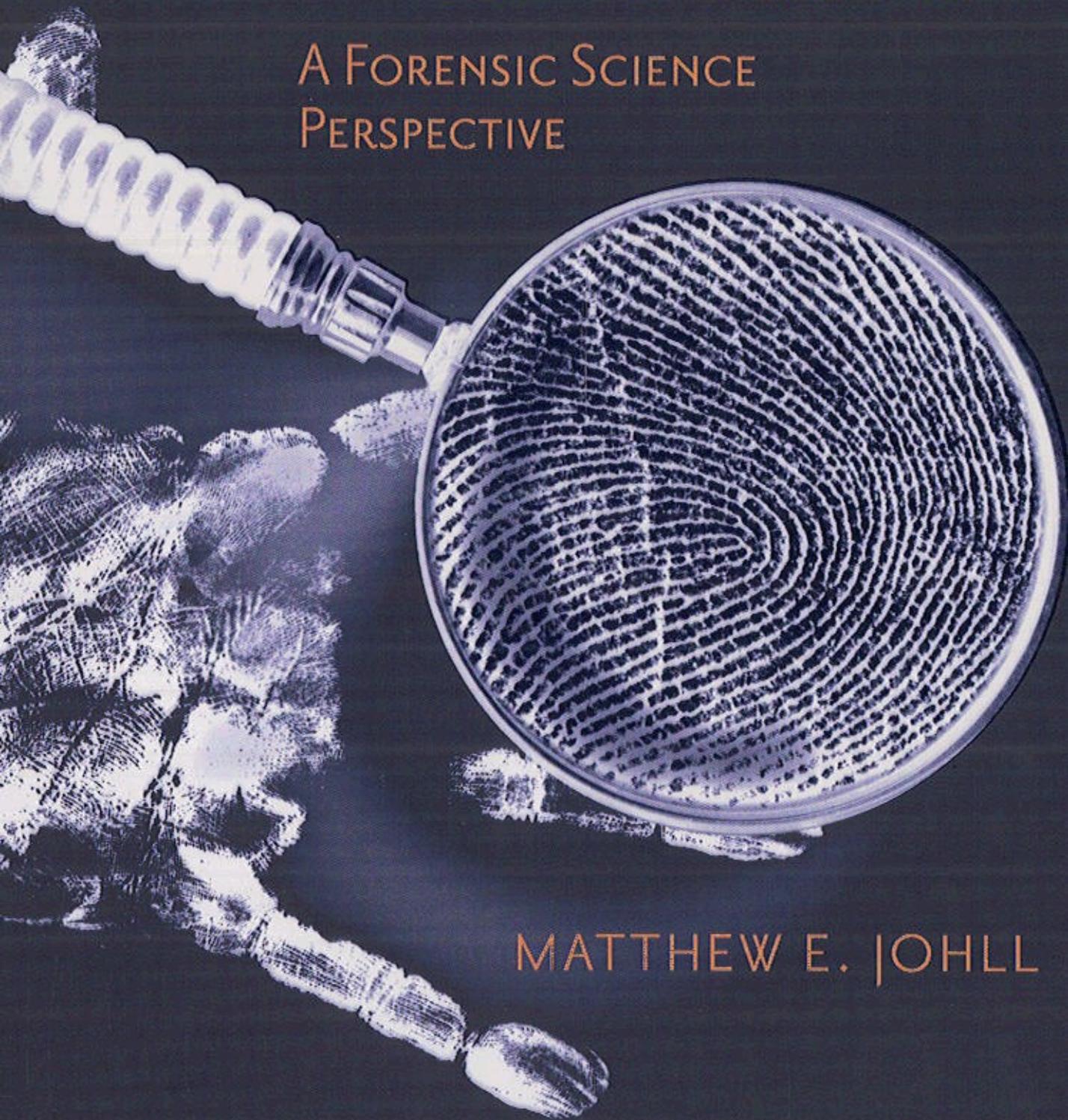


# INVESTIGATING CHEMISTRY

A FORENSIC SCIENCE  
PERSPECTIVE



MATTHEW E. JOHLL

# Contents

<b>Preface</b>	<b>ix</b>	<b>2.8</b> How to Analyze Evidence: Density Measurements	40
<hr/>		<b>2.9</b> Mathematics of Density Measurements	41
<b>CHAPTER 1 Introduction to Forensic Chemistry</b>	<b>2</b>	<b>2.10</b> How to Analyze Glass and Soil Evidence: Using Physical Properties	44
<b>Case Study: Whose Side Are They On?</b>	2	<b>2.11 Case Study Finale: Grave Evidence</b>	48
<b>1.1</b> Welcome	3	<hr/>	
<b>1.2</b> Chemistry, Crime, and the Global Society	4	<b>CHAPTER 3 Atomic Clues</b>	<b>56</b>
<b>1.3</b> Physical Evidence: Matter and Its Forms	5	<b>Case Study: To Burn or Not To Burn</b>	56
<b>1.4</b> The Periodic Table	11	<b>3.1</b> Origins of the Atomic Theory: Ancient Greek Philosophers	58
<b>Evidence Analysis: Thin-Layer Chromatography</b>	12	<b>3.2</b> Foundations of a Modern Atomic Theory: Gassendi, Lavoisier, and Proust	59
<b>1.5</b> Learning the Language of Chemistry	14	<b>3.3</b> Dalton's Atomic Theory	61
<b>1.6</b> The Most Important Skill of a Forensic Scientist: Observation	18	<b>3.4</b> Atomic Structure: Subatomic Particles	64
<b>1.7 Case Study Finale: Whose Side Are They On?</b>	19	<b>3.5</b> Nature's Detectives: Isotopes	67
<hr/>		<b>3.6</b> Atomic Mass: Isotopic Abundance and the Periodic Table	70
<b>CHAPTER 2 Evidence Collection and Preservation</b>	<b>24</b>	<b>3.7</b> Atomic Structure: Electrons and Emission Spectra	71
<b>Case Study: Grave Evidence</b>	24	<b>3.8</b> Mathematics of Light	73
<b>2.1</b> Preserving Evidence: Reactions, Properties, and Changes	25	<b>3.9</b> Atomic Structure: Electron Orbitals	76
<b>2.2</b> Critical Thinking and the Crime Scene: The Scientific Method	27	<b>3.10</b> Electron Configurations	78
<b>2.3</b> Physical Evidence Collection: Mass, Weight, and Units	30	<b>Evidence Analysis: Scanning Electron Microscopy</b>	83
<b>2.4</b> Mathematics of Unit Conversions	32	<b>3.11 Case Study Finale: To Burn or Not to Burn</b>	85
<b>2.5</b> Errors and Estimates in Laboratory Measurements: Significant Figures	33	<hr/>	
<b>2.6</b> Mathematics of Significant Figure Calculations	36	<b>CHAPTER 4 Chemical Evidence</b>	<b>92</b>
<b>2.7</b> Experimental Results: Accuracy and Precision	38	<b>Case Study: A Killer Headache</b>	92
		<b>4.1</b> Chemical Nature of Evidence: Regions of the Periodic Table	93

<b>4.2</b>	Types of Compounds: Ionic Compounds	97		
<b>4.3</b>	Types of Compounds: Covalent Compounds	107		
<b>4.4</b>	Common Names and Diatomic Elements	110		
<b>4.5</b>	Basics of Chemical Reactions	112		
<b>4.6</b>	Balancing Chemical Equations	113		
<b>4.7</b>	Mathematics of Chemical Reactions: Mole Calculations	116		
<b>4.8</b>	Mathematics of Chemical Reactions: Stoichiometry Calculations	119		
<b>4.9</b>	Types of Reactions	120		
<b>4.10</b>	Mathematics of Chemical Reactions: Limiting Reactants and Theoretical Yields	123		
	<b>Evidence Analysis:</b> Spectrophotometry	124		
<b>4.11</b>	<b>Case Study Finale:</b> A Killer Headache	125		
<hr/>			<hr/>	
<b>CHAPTER 5</b>	<b>Properties of Solutions I: Aqueous Solutions</b>	<b>134</b>	<b>CHAPTER 6</b>	<b>Properties of Solutions II: Intermolecular Forces and Colligative Properties 168</b>
	<b>Case Study:</b> An Aquatic Apocalypse	134		<b>Case Study:</b> Something for the Pain
<b>5.1</b>	Aqueous Solutions	135	<b>6.1</b>	Intermolecular Forces and Surface Tension
<b>5.2</b>	The Process of Dissolution	136	<b>6.2</b>	Types of Intermolecular Forces
<b>5.3</b>	Rate of Dissolving Soluble Compounds	138	<b>6.3</b>	Mixed Intermolecular Forces
<b>5.4</b>	Solution Properties	140	<b>6.4</b>	Colligative Properties: Boiling Point of Solutions
<b>5.5</b>	Solubility and Solubility Rules	142	<b>6.5</b>	Mathematics of Boiling Point Elevation
<b>5.6</b>	Net Ionic Reactions	145	<b>6.6</b>	Colligative Properties: Freezing Point of Solutions
<b>5.7</b>	Mathematics of Solutions: Concentration Calculations	147	<b>6.7</b>	Mathematics of Freezing Point Depression
<b>5.8</b>	Acid Chemistry	150	<b>6.8</b>	Colligative Properties: Osmosis
<b>5.9</b>	Base Chemistry	152		<b>Evidence Analysis:</b> HPLC
<b>5.10</b>	The pH Scale and Buffers	153	<b>6.9</b>	<b>Case Study Finale:</b> Something for the Pain
<b>5.11</b>	Mathematics of Solutions: Calculating pH	156		
<b>5.12</b>	<b>Case Study Finale:</b> An Aquatic Apocalypse	158	<hr/>	
			<b>CHAPTER 7</b>	<b>Drug Chemistry 196</b>
				<b>Case Study:</b> The Experts Agreed
			<b>7.1</b>	Introduction to Organic Chemistry
			<b>7.2</b>	Alkanes
			<b>7.3</b>	Alkenes and Alkynes
			<b>7.4</b>	Branched Isomers
			<b>7.5</b>	Cyclic Compounds
			<b>7.6</b>	Ethers, Ketones, and Esters
			<b>7.7</b>	Amines
			<b>7.8</b>	Alcohols, Aldehydes, and Carboxylic Acids
			<b>7.9</b>	How to Extract Organic Compounds: Solubility and Acid-Base Properties
				<b>Evidence Analysis:</b> Infrared Spectroscopy
			<b>7.10</b>	<b>Case Study Finale:</b> The Experts Agreed

**CHAPTER 8 Chemistry of Addiction 236**

<b>Case Study:</b> Vigilante Jell-O	236
<b>8.1</b> Nature of Covalent Bonds	238
<b>8.2</b> Lewis Structures of Ionic Compounds	240
<b>8.3</b> Lewis Structures of Covalent Compounds	242
<b>8.4</b> Resonance Structures	245
<b>8.5</b> VSEPR Theory	247
<b>8.6</b> Polarity of Bonds and Molecules	251
<b>8.7</b> Molecular Geometry of Drugs	254
<b>8.8</b> Drug Receptors and Brain Chemistry	258
<b>Evidence Analysis:</b> Immunoassay Methods	260
<b>8.9 Case Study Finale:</b> Vigilante Jell-O	260

**CHAPTER 9 Arson Investigation 268**

<b>Case Study:</b> "False and Unreliable"	268
<b>9.1</b> The Chemistry of Fire	270
<b>9.2</b> Combustion Reactions	272
<b>9.3</b> Redox Reactions	276
<b>9.4</b> Thermochemistry of Fire	278
<b>9.5</b> Heat Capacity and Phase Changes	281
<b>9.6</b> Mathematics of Heat Capacity	285
<b>9.7</b> The First Law of Thermodynamics and Calorimetry	286
<b>9.8</b> Mathematics of Calorimetry	289
<b>9.9</b> Petroleum Refinement	290
<b>Evidence Analysis:</b> Gas Chromatography	292
<b>9.10 Case Study Finale:</b> "False and Unreliable"	292

**CHAPTER 10 Chemistry of Explosions 300**

<b>Case Study:</b> Tracing Explosives	300
---------------------------------------	-----

<b>10.1</b> Explosives	101	301
<b>10.2</b> Redox Chemistry of Explosives		303
<b>10.3</b> Kinetic-Molecular Theory of Gases		305
<b>10.4</b> Gas Laws		306
<b>10.5</b> Mathematics of the Gas Laws		314
<b>10.6</b> The Combined and Ideal Gas Laws		317
<b>10.7</b> Mathematics of the Combined and Ideal Gas Laws		319
<b>10.8</b> Detection of Explosives: Dalton's Law of Partial Pressures		321
<b>Evidence Analysis:</b> Mass Spectroscopy		322
<b>10.9 Case Study Finale:</b> Tracing Explosives		325

**CHAPTER 11 Estimating the Time of Death 334**

<b>Case Study:</b> Cold-Blooded Evidence		334
<b>11.1</b> Introduction to Chemical Kinetics		335
<b>11.2</b> Collision Theory		337
<b>11.3</b> Kinetics and Temperature		340
<b>11.4</b> Kinetics and Catalysts		343
<b>11.5</b> Zero-Order Reactions		346
<b>11.6</b> First-Order Reactions		348
<b>11.7</b> Half-Life		349
<b>11.8 Case Study Finale:</b> Cold-Blooded Evidence		351

**CHAPTER 12 Dirty Bombs and Nuclear Terrorism 356**

<b>Case Study:</b> Gangster Turned Terrorist?		356
<b>12.1</b> The Discovery of Natural Radioactivity		357
<b>12.2</b> Radiation Types and Hazards		359
<b>12.3</b> Balancing Nuclear Equations		362
<b>12.4</b> Half-Lives and Risk Assessment		364
<b>12.5</b> Medical Applications of Nuclear Isotopes		366

<b>12.6</b>	Nuclear Power Plants	368
<b>12.7</b>	Military Uses of Nuclear Isotopes	372
<b>12.8</b>	Nuclear Transmutations	374
	<b>Evidence Analysis:</b> Neutron Activation Analysis	376
<b>12.9</b>	<b>Case Study Finale:</b> Gangster Turned Terrorist?	378
<hr/> <b>CHAPTER 13 Poisons</b>		<b>384</b>
	<b>Case Study:</b> A Mother-in-Law's Justice	384
<b>13.1</b>	Introduction to Equilibrium	385
<b>13.2</b>	Dynamic Equilibrium	388
<b>13.3</b>	Values of the Equilibrium Constant	391
<b>13.4</b>	Le Chatelier's Principle	394
<b>13.5</b>	Solubility Equilibrium	398
<b>13.6</b>	<b>Case Study Finale:</b> A Mother-in- Law's Justice	399

<hr/> <b>CHAPTER 14 Identification of Victims: DNA Analysis</b>		<b>404</b>
	<b>Case Study:</b> Remembering 9-11	404
<b>14.1</b>	Lipids: Fats, Waxes, and Oils	405
<b>14.2</b>	Carbohydrates	409
<b>14.3</b>	Proteins	411
<b>14.4</b>	DNA Basics	416
<b>14.5</b>	DNA Analysis	419
<b>14.6</b>	Mitochondrial DNA	421
<b>14.7</b>	<b>Case Study Finale:</b> Remembering 9-11	422
<b>Appendix (Conversion Factors)</b>		<b>426</b>
<b>Answers to Odd-Numbered Questions and Problems</b>		<b>427</b>
<b>Combined Glossary/Index</b>		<b>440</b>