



**Murdoch University**

# FUNDAMENTALS OF CHEMISTRY

**2nd Edition**

Compiled by  
**Dr Kate Rowen**

Reviewed by  
**Dr Leonie Hughes**  
**Dr LanChi Koenigsberger**  
**Dr Kate Rowen**

 **Pearson**

A PEARSON AUSTRALIA CUSTOM BOOK

# Fundamentals of Chemistry

Second Edition

Compiled by Dr Kate Rowen

Reviewed by Dr Leonie Hughes, Dr LanChi Koenigsberger and  
Dr Kate Rowen

This custom book is compiled for Murdoch University from:

## **INTRODUCTORY CHEMISTRY**

5TH EDITION

N. J. TRO

## **MODULE 12 ORGANIC COMPOUNDS**

WRITTEN BY KATE ROWEN FOR THIS CUSTOM EDITION

# TABLE OF CONTENTS

Preface.....	ix
<b>1 Matter.....</b>	<b>1</b>
1.1 What Is Matter? .....	1
1.2 Classifying Matter According to Its State: Solid, Liquid, and Gas.....	1
1.3 Classifying Matter According to Its Composition: Elements, Compounds, and Mixtures .....	4
1.4 Differences in Matter: Physical and Chemical Properties .....	7
1.5 Changes in Matter: Physical and Chemical Changes .....	9
MODULE IN REVIEW .....	12
KEY TERMS .....	14
EXERCISES.....	14
<b>2 Elements.....</b>	<b>19</b>
2.1 The Nuclear Theory of the Atom .....	19
2.2 Elements: Defined by Their Numbers of Protons.....	21
2.3 Isotopes: When the Number of Neutrons Varies.....	24
2.4 Atomic Mass: The Average Mass of an Element's Atoms .....	26
2.5 Ions: Losing and Gaining Electrons.....	29
2.6 Arrangements of Electrons Around the Nucleus .....	32
2.7 Looking for Patterns: The Periodic Law and the Periodic Table.....	38
2.8 Electron Configurations and the Periodic Table .....	43
2.9 The Explanatory Power of the Quantum-Mechanical Model.....	46
2.10 Periodic Trends: Atomic Size, Ionization Energy, and Metallic Character .....	48
MODULE IN REVIEW .....	54
KEY TERMS .....	59
EXERCISES.....	59
<b>3 Compounds .....</b>	<b>73</b>
3.1 Sugar and Salt .....	73
3.2 Compounds Display Constant Composition .....	74
3.3 Chemical Formulas: How to Represent Compounds .....	75
3.4 A Molecular View of Elements and Compounds .....	79
3.5 Writing Formulas for Ionic Compounds.....	82
3.6 Nomenclature: Naming Compounds.....	84
3.7 Naming Ionic Compounds .....	84
3.8 Naming Molecular Compounds .....	89
3.9 Naming Acids .....	90
3.10 Nomenclature Summary .....	92
3.11 Bonding Models and AIDS Drugs .....	94
3.12 Representing Valence Electrons with Dots .....	95
3.13 Lewis Structures of Ionic Compounds: Electrons Transferred .....	96
3.14 Covalent Lewis Structures: Electrons Shared.....	97
3.15 Writing Lewis Structures for Covalent Compounds.....	99
3.16 Resonance: Equivalent Lewis Structures for the Same Molecule.....	102
3.17 Predicting the Shapes of Molecules .....	103
3.18 Electronegativity and Polarity: Why Oil and Water Don't Mix .....	109
MODULE IN REVIEW .....	114
KEY TERMS .....	121
EXERCISES.....	121

<b>4</b>	<b>Measurement.....</b>	<b>139</b>
4.1	Scientific Notation: Writing Large and Small Numbers .....	139
4.2	Significant Figures: Writing Numbers to Reflect Precision .....	142
4.3	Significant Figures in Calculations .....	146
4.4	The Basic Units of Measurement.....	150
4.5	Problem Solving and Unit Conversion .....	153
4.6	Density .....	156
	MODULE IN REVIEW .....	160
	KEY TERMS .....	165
	EXERCISES.....	165
<b>5</b>	<b>Chemical Composition.....</b>	<b>173</b>
5.1	How Much Sodium? .....	173
5.2	Counting Atoms by the Gram .....	174
5.3	Counting Molecules by the Gram.....	179
5.4	Ratios of Atoms in Chemical Formulas.....	182
5.5	Mass Percent Composition .....	187
5.6	Calculating Empirical Formulas for Compounds .....	190
5.7	Calculating Molecular Formulas for Compounds .....	193
	MODULE IN REVIEW .....	195
	KEY TERMS .....	201
	EXERCISES.....	201
<b>6</b>	<b>States of Matter 1.....</b>	<b>211</b>
6.1	Kinetic Molecular Theory and Properties of Gases.....	211
6.2	Gas Pressure .....	213
6.3	Boyle's Law: Pressure and Volume.....	216
6.4	Temperature and the Kelvin Scale .....	221
6.5	Charles's Law: Volume and Temperature.....	224
6.6	The Combined Gas Law: Pressure, Volume, and Temperature.....	228
6.7	Avogadro's Law: Volume and Moles .....	230
6.8	The Ideal Gas Law: Pressure, Volume, Temperature, and Moles.....	232
6.9	Dalton's Law: Mixture of Gases .....	239
6.10	Interactions Between Molecules.....	242
6.11	Three States of Matter at the Molecular Level .....	242
6.12	Changes of State and Associated Energy Requirements .....	244
6.13	Types of Intermolecular Forces .....	250
	MODULE IN REVIEW .....	257
	KEY TERMS .....	265
	EXERCISES.....	265
<b>7</b>	<b>States of Matter 2.....</b>	<b>275</b>
7.1	Liquids, Surface Tension, and Viscosity.....	275
7.2	Remarkable Water .....	276
7.3	Types and Properties of Solids .....	279
7.4	Solutions .....	281
7.5	Solids in Aqueous Solution.....	282
7.6	Gases in Aqueous Solution .....	286
7.7	Specifying Solution Composition: Mass Percent.....	288
7.8	Specifying Solution Composition: Molarity.....	291
7.9	Solution Dilution .....	295
	MODULE IN REVIEW .....	298
	KEY TERMS .....	303
	EXERCISES.....	303

<b>8</b>	<b>Chemical Reactions 1</b>	<b>309</b>
8.1	Chemical Reactions	309
8.2	Evidence of a Chemical Reaction	310
8.3	The Chemical Equation	313
8.4	Conservation of Matter: Why Chemical Equations must be Balanced	315
8.5	How to Write Balanced Chemical Equations	316
8.6	Classifying Chemical Reactions	320
8.7	Precipitation Reactions	324
8.8	Acid-Base Reactions	332
8.9	Oxidation and Reduction	345
	MODULE IN REVIEW	357
	KEY TERMS	366
	EXERCISES	366
<b>9</b>	<b>Chemical Reactions 2</b>	<b>381</b>
9.1	Energy	381
9.2	Energy and Chemical and Physical Change	383
9.3	Enthalpy	384
9.4	Life: Controlled Disequilibrium	385
9.5	The Rate of a Chemical Reaction	386
9.6	The Idea of Dynamic Chemical Equilibrium	390
9.7	The Equilibrium Constant: A Measure of How Far a Reaction Goes	393
9.8	Heterogeneous Equilibria: The Equilibrium Expression for Reactions Involving a Solid or a Liquid	396
9.9	Disturbing a Reaction at Equilibrium: Le Châtelier's Principle	397
9.10	The Effect of a Concentration Change on Equilibrium	398
9.11	The Effect of a Volume Change on Equilibrium	400
9.12	The Effect of a Temperature Change on Equilibrium	403
9.13	The Path of a Reaction and the Effect of a Catalyst	406
	MODULE IN REVIEW	410
	KEY TERMS	413
	EXERCISES	413
<b>10</b>	<b>Chemical Quantities 1</b>	<b>421</b>
10.1	Climate Change: Too Much Carbon Dioxide	421
10.2	Making Pancakes: Relationships between Ingredients	422
10.3	Mole to Mole Calculations	424
10.4	Mass to Mass Calculations	426
10.5	Limiting Reactant, Theoretical Yield, and Percent Yield	431
	MODULE IN REVIEW	442
	KEY TERMS	446
	EXERCISES	446
<b>11</b>	<b>Chemical Quantities 2</b>	<b>457</b>
11.1	Gases in Chemical Reactions	457
11.2	Solution Stoichiometry	460
11.3	Acid-Base Titration: A Way to Quantify the Amount of Acid or Base in a Solution	462
11.4	Water: Acid and Base in One	466
11.5	The pH and pOH Scales: Ways to Express Acidity and Basicity	468
11.6	Buffers: Solutions That Resist pH Change	473
	MODULE IN REVIEW	477
	KEY TERMS	481
	EXERCISES	481

<b>12 Organic Compounds.....</b>	<b>489</b>
12.1 Organic Compounds and Carbon Atoms .....	489
12.2 Representing Organic Compounds .....	492
12.3 Hydrocarbons .....	496
12.4 Alkanes and Cycloalkanes .....	498
12.5 Alkenes .....	516
12.6 Aromatic Hydrocarbons .....	525
12.7 Organic Compounds with Halogen Atoms.....	528
12.8 Functional Groups.....	534
12.9 Alcohols .....	538
12.10 Ethers .....	548
12.11 Aldehydes and Ketones .....	551
12.12 Carboxylic Acids .....	558
12.13 Oxidation of Alcohols .....	563
12.14 Esters .....	568
12.15 Amines .....	574
12.16 Amides.....	582
12.17 Polymers .....	584
12.18 Amino Acids .....	593
12.19 Proteins .....	597
12.20 Fats.....	604
EXERCISES.....	611
Appendix: Mathematics Review.....	A-1
Glossary .....	G-1
Index .....	I-1

# PREFACE

This custom textbook has been specially prepared for students studying Fundamentals of Chemistry at Murdoch University. All the content you need for the unit is in this book, every Module is relevant. In developing this textbook we have applied our extensive involvement in teaching this level of chemistry. Collectively we have over four decades of experience and a thorough understanding of your learning needs.

Modules 1 – 11 were sourced from an American book, *Introductory Chemistry* by Tro, but we have adapted them extensively to the way this level of chemistry is taught in Australia. Textbooks for this kind of chemistry unit typically use a particular style of problem solving, but in our lectures we show what we believe to be better methods using equations and other types of reasoning. The demonstration of different problem solving approaches between lectures and the textbook naturally causes confusion for students who may already be anxious about studying chemistry for the first time. We have adapted the sourcebook material for Modules 1 – 11 so the textbook and lectures show the same problem solving techniques.

Fundamentals of Chemistry also provides an introduction to the diverse and amazing world of organic compounds, which is covered in Module 12. Despite our best efforts, we have never been able to source textbook material that succinctly covers the curriculum topics for this module to the depth required. Students would have to rely on lecture material and other disparate resources that we brought together to support learning about organic compounds. We decided the only thing to do was to write Module 12 specifically for this book. Now all the content you need for Fundamentals of Chemistry is in one tailored source.

The source textbook is American, so there are many references to everyday life in America and less commonly used units of measurement. Therefore we have endeavoured to ensure that most of the units of measurement referred to in the book are the metric units that are used in Australia and the international scientific community.

We want your first experience with chemistry to be a positive one, where you will learn much about the world around you in addition to the basic chemistry you need to support your further study. This is what has motivated us to work towards providing you with the best textbook possible for Fundamentals of Chemistry.

Dr Kate Rowen, Dr Leonie Hughes, Dr LanChi Koenigsberger.