

4th
Edition

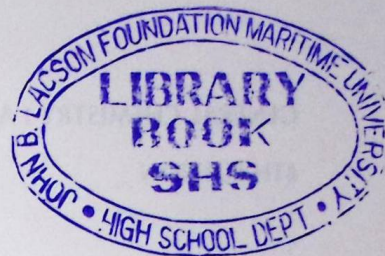
General Chemistry

1 and 2

INCLUDES

Access code to enrich learning experience with interactive e-lectures, quiz, videos and much more


3G E-LEARNING



General Chemistry 1 and 2

4th Edition



3G E-LEARNING

TABLE OF CONTENTS

Preface xv

SECTION 1 ATOMIC STRUCTURE 1

Scope 1

Overview 2

UNIT 1 MATTER AND ITS PROPERTIES 3

Introduction 4

Physical and Chemical Properties 4

Physical Properties and Changes 5

Physical Change 6

Chemical Properties and Changes 7

Extensive and Intensive Properties 8

Classification of Matter 9

Classifying Matter 10

Separation of Mixtures 14

States of Matter 15

Methods of Separating Mixtures into Their Component Substances 18

Conclusion 19

UNIT 2 MEASUREMENTS 25

Introduction 26

Accuracy and Precision 26

Difference between Accuracy and Precision 27

Significant Figures in Calculations 28

Rules of Significant Figures 29

Rules of Rounding Off Data 30

Use of Significant Figures in Addition and Subtraction 31

Use of Significant Figures in Multiplication and Division 31

Errors in Measurement System 32

Types of Errors in Measurement System 33

	Measurement Error Calculation	36
	Density Measurement	37
	Density and Graphical Analysis	39
	Conclusion	41
UNIT 3	ATOMS, MOLECULES, AND IONS	47
	Introduction	48
	History of Dalton's Atomic Theory	49
	Dalton's Atomic Theory	51
	Structure of Atoms	51
	Subatomic Particles (Protons, Electrons, Neutrons)	53
	Protons	54
	Electrons	54
	Neutrons	55
	MOLECULES AND IONS	55
	Molecules	56
	Ions	57
	Chemical Formulas and Naming Compounds	58
	Naming Compounds	60
	Conclusion	63
SECTION 2	CHEMICAL FORMULAS AND REACTIONS	69
	Scope	69
	Overview	70
UNIT 4	STOICHIOMETRY	71
	Introduction	72
	Atomic Mass	73
	Isotopes	73
	Atomic Weight	73
	Molecular Weight	73
	The Mole	74
	Avogadro's Number	74
	The Mole Concept	76
	One Interpretation: A Specific Number of Particles	76
	Percent Composition of Compounds	78
	Chemical Reaction Equations	82
	Chemical Reactions	84
	Reactions in Aqueous Solutions	85
	Precipitation Reactions	85
	Mass Relationships in Chemical Reactions	86

	Conclusion	87
SECTION 3	GASES: LAW AND THEORY	93
	Scope	93
	Overview	93
UNIT 5	GASES	95
	Introduction	96
	Pressure of a Gas	97
	Pressure	97
	The Gas Laws	100
	Boyle's Law	100
	Charles' Law	101
	Gay-Lussac's Law	104
	Avogadro's Hypothesis	105
	Ideal Gas Equation	107
	Dalton's Law of Partial Pressures and Gas Stoichiometry	108
	Explanation	108
	Derivation	109
	Gas Stoichiometry	111
	Kinetic Molecular Theory of Gases	112
	Temperature and KMT	113
	Pressure and KMT	114
	Conclusion	115
SECTION 4	ELECTRONIC STRUCTURE AND CHEMICAL BONDING	119
	Scope	119
	Overview	120
UNIT 6	ELECTRONIC STRUCTURE OF ATOMS AND PERIODICITY	121
	Introduction	122
	Concepts of Atomic Structure	125
	Quantum Mechanical Description of the Atom	133
	Development of Quantum Theory	134
	Schrodinger's Model of the Hydrogen Atom and Wave Functions	136
	Main Energy Levels, Sublevels and Orbitals	141
	Quantum Numbers and Electron Configuration	144
	The Electron Configuration and the Periodic Table	156
	Periodic Variation in Atomic Properties	158
	Variation in Covalent Radius	158
	Conclusion	167

UNIT 7

CHEMICAL BONDING IONIC BONDS

171

Introduction	172
Concept of Ionic Bonding	175
The Stability of Noble Gases	176
Forming Ions	177
Some Ion Formulas	178
Ionic Compounds	179
Formulas	180
Structure	181
Covalent Bonds	185
Organic Compounds	186
Examples of Organic Compounds:	186

UNIT 8

ORGANIC COMPOUNDS

191

Introduction	192
Carbon Atom	193
Physical Properties of the Carbon Atom	193
Atomic Structure	194
Isotopes	196
Uses of Carbon	196
Hydrocarbons	197
Bonding patterns in Hydrocarbons	197
Types of hydrocarbons	199
Reactivity of Hydrocarbons	200
Ethylene, C_2H_4	202
Ethylene adsorption on Pd	202
Ethylene and H_2 adsorption on Pd	203
Polymers	203
Properties of Polymers	203
Amorphous Solids (Polymers) Different Monomers	204
Types of polymers	204
Covalent Bonds	204
Biomolecules	205
Classes of Biomolecules	206
Carbohydrates	206
Lipids	207
Proteins	208
Nucleic Acids	208
Functions of Biomolecules	209
Structure of Biomolecules	209
Conclusion	210

UNIT 9	INTERMOLECULAR FORCES AND LIQUIDS AND SOLIDS	213
	Introduction	214
	Kinetic molecular model of liquids and solids	215
	Dipole-dipole forces	216
	Ion-dipole forces	218
	Dispersion forces	218
	Hydrogen bonds	220
	Surface Tension	221
	Viscosity	222
	Vapor pressure, boiling point	222
	Molar heat of vaporization	224
	Structure and Properties of Water	225
	Types and properties of solids	226
	Amorphous solids	227
	Types of Crystals – ionic, covalent, molecular, metallic	231
	Phase Changes - phase diagrams of water and carbon dioxide	233
	Phase Diagram of Water	234
	Phase Diagram of Carbon Dioxide	235
	Conclusion	236

UNIT 10	PHYSICAL PROPERTIES OF SOLUTIONS	243
	Introduction	244
	Fundamental Property of Solutions	244
	Classification of Solution	245
	Different Types of Solution	246
	Energy of Solution Formation	247
	Units of Concentration	247
	Solution Stoichiometry	251
	Chemical Reactions	253
	Limiting and Excess Reactants	254
	Theoretical and Actual Yields	255
	Factors affecting Solubility	255
	Solute-Solvent Interactions Affect Solubility	255
	Common-Ion Effect	256
	Temperature Affects Solubility	257
	Pressure Affects Solubility of Gases	258
	Colligative Properties of Solutions	259
	Colligative Properties of Nonelectrolyte Solutions	260
	Colligative Properties of Electrolytes	262
	Conclusion	263

UNIT 7**CHEMICAL BONDING IONIC BONDS****171**

Introduction	172
Concept of Ionic Bonding	175
The Stability of Noble Gases	176
Forming Ions	177
Some Ion Formulas	178
Ionic Compounds	179
Formulas	180
Structure	181
Covalent Bonds	185
Organic Compounds	186
Examples of Organic Compounds:	186

UNIT 8**ORGANIC COMPOUNDS****191**

Introduction	192
Carbon Atom	193
Physical Properties of the Carbon Atom	193
Atomic Structure	194
Isotopes	196
Uses of Carbon	196
Hydrocarbons	197
Bonding patterns in Hydrocarbons	197
Types of hydrocarbons	199
Reactivity of Hydrocarbons	200
Ethylene, C_2H_4	202
Ethylene adsorption on Pd	202
Ethylene and H_2 adsorption on Pd	203
Polymers	203
Properties of Polymers	203
Amorphous Solids (Polymers) Different Monomers	204
Types of polymers	204
Covalent Bonds	204
Biomolecules	205
Classes of Biomolecules	206
Carbohydrates	206
Lipids	207
Proteins	208
Nucleic Acids	208
Functions of Biomolecules	209
Structure of Biomolecules	209
Conclusion	210

UNIT 9	INTERMOLECULAR FORCES AND LIQUIDS AND SOLIDS	213
	Introduction	214
	Kinetic molecular model of liquids and solids	215
	Dipole-dipole forces	216
	Ion-dipole forces	218
	Dispersion forces	218
	Hydrogen bonds	220
	Surface Tension	221
	Viscosity	222
	Vapor pressure, boiling point	222
	Molar heat of vaporization	224
	Structure and Properties of Water	225
	Types and properties of solids	226
	Amorphous solids	227
	Types of Crystals – ionic, covalent, molecular, metallic	231
	Phase Changes - phase diagrams of water and carbon dioxide	233
	Phase Diagram of Water	234
	Phase Diagram of Carbon Dioxide	235
	Conclusion	236

UNIT 10	PHYSICAL PROPERTIES OF SOLUTIONS	243
	Introduction	244
	Fundamental Property of Solutions	244
	Classification of Solution	245
	Different Types of Solution	246
	Energy of Solution Formation	247
	Units of Concentration	247
	Solution Stoichiometry	251
	Chemical Reactions	253
	Limiting and Excess Reactants	254
	Theoretical and Actual Yields	255
	Factors affecting Solubility	255
	Solute-Solvent Interactions Affect Solubility	255
	Common-Ion Effect	256
	Temperature Affects Solubility	257
	Pressure Affects Solubility of Gases	258
	Colligative Properties of Solutions	259
	Colligative Properties of Nonelectrolyte Solutions	260
	Colligative Properties of Electrolytes	262
	Conclusion	263

SECTION 5	THERMOCHEMISTRY	267
	Scope	267
	Overview	268
UNIT 11	THERMOCHEMISTRY FUNDAMENTAL	269
	Introduction	270
	Energy Changes in Chemical Reactions	271
	First Law of Thermodynamics	273
	Enthalpy of Chemical Reactions	274
	Enthalpy Change in Reactions	274
	Thermochemical Equations	275
	Calorimetry	276
	Introduction of Different Calorimeter	277
	Standard Enthalpy of Formation and Reaction Hess' Law	280
	Hess' law and Thermochemical Calculations	282
UNIT 12	CHEMICAL KINETICS	289
	Introduction	290
	The Rate of a Reaction	292
	Factors that Influence Reaction Rate	293
	Surface Area	293
	The Rate Law and Its Components	296
	Differential and Integral Rate Laws	298
	Experimental Determination of Rate Law	299
	Order of Reactions	301
	Determining Reaction Rate	304
	Collision Theory	305
	The Effect of Temperature on the Rate Constant and the Rate	306
	The Effect of Temperature on Collision Energy	309
	Catalysis	311
	Catalysts Provide Alternative Reaction Pathways	311
	Conclusion	315
UNIT 13	CHEMICAL THERMODYNAMICS	323
	Introduction	324
	Spontaneous Processes	325
	Reversible and Irreversible Processes	326
	Entropy	328
	Statistical Definition of Entropy	328
	Thermodynamic Definition of Entropy	330
	The Second Law as Energy Dispersion	331

The Second Law of Thermodynamics	332
Uses of Second Law	333
Classical Statements of Second Law	334
Derivation and Explanation	335
Gibbs free energy and Chemical Equilibrium	336
Chemical Equilibrium	341

UNIT 14

CHEMICAL EQUILIBRIUM

345

Concept of Equilibrium	347
Static and Dynamic Equilibrium	348
Reversible and Irreversible Reactions	349
Characteristics of Equilibrium State	351
Equilibrium in Physical Processes; Phase Equilibrium	352
Solid – Vapour Equilibrium	353
Solid – Liquid Equilibrium	354
Solute – Solution Equilibria	355
Phase and Phase Equilibrium	355
Equilibrium in Homogeneous and Heterogeneous Systems	356
Homogeneous and Heterogeneous Systems	356
Homogeneous and Heterogeneous Equilibrium Systems	356
Homogeneous Chemical Equilibrium System	357
Heterogeneous Chemical Equilibrium Systems	357
Quantitative Aspect of Equilibrium State	358
Law of Equilibrium and Concentration Equilibrium Constant	358
Pressure Equilibrium Constant K_p	359
Relation between K_p and K_c	359
Homogeneous Equilibria	361
Heterogeneous Equilibrium	362
Characteristics of Equilibrium Constant	363
Equilibrium Constant and Chemical Equation	363
Units of Equilibrium Constant	364
Significance of the Magnitude of K	365
Calculation of Equilibrium Constants	366
Factors Affecting Equilibrium State	367
Le Chatelier Principles	367
Change in Concentration	368
Change in Pressure	368
Change of Temperature	369
Applications of Le Chatelier's Principle	370
Conclusion	372

UNIT 15	ACID-BASE EQUILIBRIA AND SALT EQUILIBRIA	375
	Introduction	376
	Bronsted Acids and Bases	377
	Difference between Acids and Bases	379
	The Acid-Base Properties of Water	379
	pH- a Measure of Acidity	382
	pH is the Measure of Solution Acidity	383
	pH of Aqueous Solutions	383
	Strength of Acids and Bases	384
	Strong Acids	385
	Strong Bases	385
	Demonstration of Acid and Base Conductivity:	386
	Conductivity Principle:	386
	Bond Strength:	387
	Bond Strength Principle:	387
	Weak Acids/Weak Bases and Ionization Constants	387
	Ionization of Week Acids	388
	The pH and pK_a of Weak acid	389
	Ionization Constants	389
	Relationship between the Ionization Constants of Acids and their Conjugate Bases	391
	The Common Ion Effect	392
	Buffer Solutions	394
	Calculations involving buffer solutions	395
	Solubility Equilibria	399
	Solubility: the dissolution of salts in water	399
UNIT 16	ELECTROCHEMISTRY	405
	Basic Concepts of Oxidation and Reduction	406
	Oxidation Reactions	407
	Reduction Reactions	407
	Redox Reactions	407
	Spontaneous Redox Reaction	408
	Electrochemical Cells	408
	Structure of a Galvanic Cell	409
	Electrolyte and Electrodes	412
	Representation of an Electrochemical Cell	412
	Electrochemical Standard Reduction Potentials	413
	Standard Reduction Potentials	413
	Electrode Potential	414
	Standard Electrode Potentials	415
	Standard Hydrogen Electrode	416
	Electrode Potential at Non-Standard Conditions	417

Application of Electrochemistry in Biochemistry	418
pH Electrodes	419
pO ₂ (Clark) Electrode	421
Biosensors	422
Electrochemical Detectors	424
Detection principle	425
Corrosion Electrochemistry	425
What is Corrosion Electrochemistry?	426
Electrochemical Reactions	426
The Daniell Cell and Electrochemical Corrosion	427
The Anodic Method and Corrosion	428
Faraday's Law and Corrosion Electrochemistry	429
The Cathodic Method	430
Oxygen Reduction	431
Surface Area Impact	432

UNIT 17

SPECTROSCOPY: MOLECULAR ROTATIONS AND VIBRATIONS

439

Introduction	440
Rotational Spectroscopy	442
The Rotational Energy Levels of Molecules	442
The Populations of Rotational States	447
Rotational Transitions: Microwave Spectroscopy	452
Line widths	455
Rotational Raman Spectra	458
Vibrational Spectroscopy	460
Diatomic Molecules	461
Anharmonicity	467
Vibration–Rotation Spectroscopy	472

UNIT 18

CHEMICAL LAW

481

Introduction	482
Hess's Law: Definition, Formula And Examples	483
Chemical Reactions	483
Hess's Law Definition	484
How to Measure Enthalpy Change Using Hess's Law	485
Fick's Laws Of Diffusion	489
Fick's First Law	489
Fick's Second Law	490
Application of Fick's law	492
Grotthuss–Draper Law	493
Electron Excitation	493

Photoexcitation	494
Law Of Definite Composition	495
Law of Definite Proportions Definition	495
Law of Definition Proportions Example	496
History of the Law of Definite Composition or Proportions	496
Exceptions to the Law of Definite Proportions	497
Applications of the Law of Definite Composition or Proportions	497
Law Of Multiple Proportions: Definition And Examples	497
Law of Multiple Proportions Definition	499
Law of Multiple Proportions Examples	500
The Law of Definite Proportions vs. the Law of Multiple Proportions	503

UNIT 19 CARBOXYLIC ACID AND ACID DERIVATIVES 509

Introduction	510
Structure Of Carboxylic Acid and Acid Derivatives	511
Structures of Carboxylic Acid Derivatives	512
Substitution by Addition-Elimination	512
Nomenclature Of Carboxylic Acids And Carboxylic Acid Derivatives	517
Naming Carboxyl Groups Added to a Ring	518
Naming Carboxylates	519
Naming Carboxylic Acids which Contain other Functional Groups	519
Naming Dicarboxylic Acids	520
Properties Of Carboxylic Acids	521
Acidity	521
Solubility	522
Boiling point	523
Physical Properties of Carboxylic Acids	523
Chemical Properties of Carboxylic Acids	524
Biologically Important Carboxylic Acid And Their Derivatives	524
Fatty Acids	525
Tartaric Acid	526
Oxalic Acid	527
Lactic Acid	528

INDEX 535

INDEX

A

Absolute value 27, 28
Accuracy 26, 27, 28
Acid catalyzed formation 515
Acidic solution 384
Activation Energy 307
Acyl chlorides 514, 515, 517
Addition-elimination mechanism 513
Aluminum atom 177
Amorphous solid 240
Aqueous acid-base equilibria 376
Aromatic hydrocarbon 198, 199
Atmospheric pressure 98, 116
Atomic Mass 73
Atomic mass unit 51, 52, 54
Atomic number 52, 54, 60, 62
Atomic theory 51
Atomic Weight 73, 91
Aufbau principle 131, 160
Avogadro's Hypothesis 105
Avogadro's number 74, 75, 76, 77, 91

B

Balanced chemical reaction 270
Barometer 98
barometric pressure 98, 99
Biomolecules 205, 206, 209, 211
Bohr model 53, 66

boiling point 259, 260, 261
Boiling point 213, 237
Boyle's Law 100, 101
Bronsted-Lowry acid 377, 378
Brønsted-Lowry theory 378
Buffer solution 395, 403

C

Calorimetry 287, 288
Carbohydrates 192, 206, 209, 211
Carbon atom 48, 52
Carbon-chlorine bond 513
Carbon dioxide 186
Carbon monoxide (CO) 499, 504
Carbonyl carbon 511, 512, 513, 514, 515, 516
Carbonyl group 512, 513, 523, 524
Carboxylic acid 510, 512, 523
Carboxylic acid and alcohol 516, 519
Carboxylic acid derivatives 509, 510, 515
Catalysts 295, 296, 311, 312
Charge-forming equilibria 376
Charles' Law 101
Chemical amount 76
Chemical Bonding 119, 132
Chemical bonds 48, 52
Chemical change 7
Chemical equation 72, 78
Chemical equilibrium 346, 373
Chemical formula 56, 57, 58, 59, 66

Chemical kinetics 297
 Chemical properties 7
 chemical reaction 292, 293, 296, 297, 307
 Chemical reactivity 200
 Chemical reactor 70
 Chemical systems 348
 Chlorine anions 179
 Colligative properties 243, 244, 259, 260, 262, 263, 264
 Collision 115
 Collision energy 309
 Collision frequency 309
 Collision theory 289, 305
 Concentrations 247, 249
 Conductivity 489
 Conservation of mass 482, 497
 Covalent bonding 172, 185, 186

D

Dalton's law 482
 Dalton's Law of Partial Pressures 108
 diatomic molecule 461, 462, 463, 464, 466, 467, 468, 473
 Diffusion 481, 489, 490, 491, 492, 506
 Dipole forces 240
 Direct redox reaction 407
 dissociation energy 467, 469, 470

E

Electrical energy 324
 Electrical excitation (EE) 494
 Electrified tungsten filament 176
 Electrochemical cell 408, 409, 412
 electromagnetic field 452, 453
 Electronegative chlorine atom 174
 Electrophilic carbon 513
 Endothermic reaction 270, 287
 Energy 82, 91
 Energy orbital 123, 152
 Enthalpy 287, 324
 Environmental error 34
 Environmental process 346
 Equilibrium 482

Exothermic reaction 287

F

First law of thermodynamics 325, 333
 First-Order Reactions 302
 Fixed volume 94, 96
 Formic acid 512
 Free energy 323, 324, 343

G

gas laws 95, 100, 116
 Gas molecules 94, 115
 Gas phase chemical equilibria 376
 Gas stoichiometry 72, 91, 111, 112
 Gay-Lussac 104, 116
 Gay-Lussac's Law 104
 Gibbs' Energy 483
 Glycolipids 207
 Glycosidic bond 206
 Gravity 96, 98, 99
 Gross error 33

H

harmonic oscillator 461, 463, 467, 468, 469, 471
 Heat energy 270
 Helium 48, 54
 Hess's Law 483, 484, 485
 Heterogeneous Catalysis 312
 heteronuclear 462, 463, 464, 465
 homogeneous 11, 12, 244, 245, 247
 Homogeneous Catalysis 312
 Homogeneous mixture 4, 11, 12, 244
 Homogeneous system 373
 homogenous 27
 Hydrocarbon chain 207
 Hydrocarbons 197, 198, 199, 200, 210, 211
 Hydrogen atoms 48, 59
 Hydrogen source 192
 hydrolysis 306, 310
 Hydronium ions 377
 Hydroxyl acids 510



I

Ideal Gas Equation 107
 Ideal gases 112
 Immune system 192, 209
 Infinite number 32
 Infrared (IR) 460
 Intensive properties 5, 8, 9
 Intermolecular forces 214, 236, 240
 Internal energy 325, 326, 336, 337
 Interrelation 324
 Intrinsic tendency 376
 Ion-dipole forces 214, 240
 Ionic bond 175
 Ionic solid 172
 Ion-pair formation 376
 Isotopes 73
 Isotopic substitution 455, 461, 470

K

Kerosene oil 197
 Kinetic 290
 kinetic energy 97, 107, 108, 113
 Kinetic Molecular Theory of Gases (KMT) 112
 Kinetics 482

L

Law of conservation 72, 87
 Law of Partial Pressures 108, 110, 116
 Le Châtelier's principle 263
 Lewis diagrams 173
 limiting reactant 252, 254, 255
 linear molecule 442, 451, 454, 455, 459
 Liquid state 215
 LNG' (liquified natural gas) 197
 London dispersion forces 237
 Lower density 12

M

Macroscopic level 290
 Macroscopic measurement 214
 Magnetic resonance imaging (MRI) 440
 Mathematical method 324
 Matter 3, 10, 15

Maxwell-Boltzmann Distribution 308
 Measurement 26, 32, 33, 36, 37, 44, 45
 measurement errors 33
 measurement methods 26
 Methane 270, 271
 microwave 442, 455, 458, 479
 molality 251, 260, 261
 Molar concentration 403
 molarity 251, 261
 Molecular composition 460
 Molecular Weight 73, 89, 91
 Molecule 237
 Mole fraction 244, 263
 Mole Ratio 110
 Momentum conservation 492
 Multiplication 31

N

Naming Compound 58
 natural components 14
 Neutral oxygen atom 514
 Neutrons 52, 53, 54, 55
 Nitrogen 193, 194, 206
 Noble gases 172, 176, 189
 Non-ideal-gas thermodynamic behavior 214
 Non-metallic elements 204
 Non-numerical measurement 26
 Nuclear chemistry 482
 Nucleic acid 193, 206, 208
 Nucleophilic addition 513
 Nucleus 51, 52, 53, 54, 55, 122, 125, 127, 128, 129,
 134, 136, 141, 143, 144, 145, 150, 153, 156, 158, 160,
 161, 162, 165, 166, 167

O

Oleic acid 511
 Order of Reactions 301
 Organic chemistry 180, 186
 Organic compounds 186
 Oxygen atom 48

P

para-hydrogen 449