

Table of Contents

- Preface to the Fourth Edition p. xv
- Preface to the First Edition p. xvii
- Symbols and Definitions p. xix
- 1 Introduction to Polymer Science p. 1
- 1.1 From Little Molecules to Big Molecules p. 2
- 1.2 Molecular Weight and Molecular Weight Distributions p. 4
- 1.3 Major Polymer Transitions p. 8
- 1.4 Polymer Synthesis and Structure p. 10
- 1.5 Cross-Linking, Plasticizers, and Fillers p. 18
- 1.6 The Macromolecular Hypothesis p. 19
- 1.7 Historical Development of Industrial Polymers p. 20
- 1.8 Molecular Engineering p. 21
- References p. 22
- General Reading p. 22
- Handbooks, Encyclopedias, and Dictionaries p. 24
- Web Sites p. 24
- Study Problems p. 25
- Appendix 1.1 Names for Polymers p. 26
- 2 Chain Structure and Configuration p. 29
- 2.1 Examples of Configurations and Conformations p. 30
- 2.2 Theory and Instruments p. 31
- 2.3 Stereochemistry of Repeating Units p. 36
- 2.4 Repeating Unit Isomerism p. 42
- 2.5 Common Types of Copolymers p. 45
- 2.6 NMR in Modern Research p. 47
- 2.7 Multicomponent Polymers p. 51
- 2.8 Conformational States in Polymers p. 55
- 2.9 Analysis of Polymers during Mechanical Strain p. 56
- 2.10 Photophysics of Polymers p. 58
- 2.11 Configuration and Conformation p. 63
- References p. 63
- General Reading p. 65
- Study Problems p. 65
- Appendix 2.1 Assorted Isomeric and Copolymer Macromolecules p. 67
- 3 Dilute Solution Thermodynamics, Molecular Weights, and Sizes p. 71
- 3.1 Introduction p. 71
- 3.2 The Solubility Parameter p. 73
- 3.3 Thermodynamics of Mixing p. 79
- 3.4 Molecular Weight Averages p. 85
- 3.5 Determination of the Number-Average Molecular Weight p. 87
- 3.6 Weight-Average Molecular Weights and Radii of Gyration p. 91
- 3.7 Molecular Weights of Polymers p. 103
- 3.8 Intrinsic Viscosity p. 110
- 3.9 Gel Permeation Chromatography p. 117

- References p. 136
- 3.10 Mass Spectrometry p. 130
- 3.11 Instrumentation for Molecular Weight Determination p. 134
- 3.12 Solution Thermodynamics and Molecular Weights p. 135
- General Reading p. 139
- Study Problems p. 140
- Appendix 3.1 Calibration and Application of Light-Scattering Instrumentation for the Case Where $P(\theta) \rightarrow 0$ p. 142
- 4 Concentrated Solutions, Phase Separation Behavior, and Diffusion p. 145
- 4.1 Phase Separation and Fractionation p. 145
- 4.2 Regions of the Polymer-Solvent Phase Diagram p. 150
- 4.3 Polymer-Polymer Phase Separation p. 153
- 4.4 Diffusion and Permeability in Polymers p. 172
- 4.5 Latexes and Suspensions p. 184
- 4.6 Multicomponent and Multiphase Materials p. 186
- References p. 186
- General Reading p. 190
- Study Problems p. 190
- Appendix 4.1 Scaling Law Theories and Applications p. 192
- 5 The Amorphous State p. 197
- 5.1 The Amorphous Polymer State p. 198
- 5.2 Experimental Evidence Regarding Amorphous Polymers p. 199
- 5.3 Conformation of the Polymer Chain p. 211
- 5.4 Macromolecular Dynamics p. 217
- 5.5 Concluding Remarks p. 227
- References p. 227
- General Reading p. 230
- Study Problems p. 230
- Appendix 5.1 History of the Random Coil Model for Polymer Chains p. 232
- Appendix 5.2 Calculations Using the Diffusion Coefficient p. 236
- Appendix 5.3 Nobel Prize Winners in Polymer Science and Engineering p. 237
- 6 The Crystalline State p. 239
- 6.1 General Considerations p. 239
- 6.2 Methods of Determining Crystal Structure p. 245
- 6.6 Kinetics of Crystallization p. 271
- 6.3 The Unit Cell of Crystalline Polymers p. 248
- 6.4 Structure of Crystalline Polymers p. 256
- 6.5 Crystallization from the Melt p. 260
- 6.7 The Reentry Problem in Lamellae p. 290
- 6.8 Thermodynamics of Fusion p. 299
- 6.9 Effect of Chemical Structure on the Melting Temperature p. 305
- 6.10 Fiber Formation and Structure p. 307
- 6.11 The Hierarchical Structure of Polymeric Materials p. 311
- 6.12 How Do You Know It's a Polymer? p. 312
- References p. 314
- General Reading p. 320

- Study Problems p. 320
- 7 Polymers in the Liquid Crystalline State p. 325
- 7.1 Definition of a Liquid Crystal p. 325
- 7.2 Rod-Shaped Chemical Structures p. 326
- 7.3 Liquid Crystalline Mesophases p. 326
- 7.4 Liquid Crystal Classification p. 331
- 7.5 Thermodynamics and Phase Diagrams p. 338
- 7.6 Mesophase Identification in Thermotropic Polymers p. 341
- 7.7 Fiber Formation p. 342
- 7.8 Comparison of Major Polymer Types p. 344
- 7.9 Basic Requirements for Liquid Crystal Formation p. 345
- References p. 346
- General Reading p. 347
- Study Problems p. 348
- 8 Glass-Rubber Transition Behavior p. 349
- 8.1 Simple Mechanical Relationships p. 350
- 8.2 Five Regions of Viscoelastic Behavior p. 355
- 8.3 Methods of Measuring Transitions in Polymers p. 366
- 8.7 Effect of Molecular Weight on T_g p. 397
- 8.4 Other Transitions and Relaxations p. 375
- 8.5 Time and Frequency Effects on Relaxation Processes p. 377
- 8.6 Theories of the Glass Transition p. 381
- 8.8 Effect of Copolymerization on T_g p. 399
- 8.9 Effect of Crystallinity on T_g p. 404
- 8.10 Dependence of T_g on Chemical Structure p. 408
- 8.11 Effect of Pressure on T_g p. 410
- 8.12 Damping and Dynamic Mechanical Behavior p. 412
- 8.13 Definitions of Elastomers, Plastics, Adhesives, and Fibers p. 415
- References p. 415
- General Reading p. 420
- Study Problems p. 420
- Appendix 8.1 Molecular Motion near the Glass Transition p. 423
- 9 Cross-linked Polymers and Rubber Elasticity p. 427
- 9.1 Cross-links and Networks p. 427
- 9.2 Historical Development of Rubber p. 430
- 9.3 Rubber Network Structure p. 432
- 9.4 Rubber Elasticity Concepts p. 434
- 9.5 Thermodynamic Equation of State p. 437
- 9.6 Equation of State for Gases p. 439
- 9.7 Statistical Thermodynamics of Rubber Elasticity p. 442
- 9.8 The "Carnot Cycle" for Elastomers p. 450
- 9.9 Continuum Theories of Rubber Elasticity p. 453
- 9.10 Some Refinements to Rubber Elasticity p. 459
- 9.11 Internal Energy Effects p. 469
- 9.12 The Flory-Rehner Equation p. 472
- 9.13 Gelation Phenomena in Polymers p. 473

- 9.14 Gels and Gelation p. 478
- 9.15 Effects of Strain on the Melting Temperature p. 479
- 9.16 Elastomers in Current Use p. 480
- 9.17 Summary of Rubber Elasticity Behavior p. 488
- References p. 489
- General Reading p. 494
- Study Problems p. 495
- Appendix 9.1 Gelatin as a Physically Cross-linked Elastomer p. 497
- Appendix 9.2 Elastic Behavior of a Rubber Band p. 501
- Appendix 9.3 Determination of the Cross-link Density of Rubber by Swelling to Equilibrium p. 503
- 10 Polymer Viscoelasticity and Rheology p. 507
- 10.4 Polymer Melt Viscosity p. 533
- 10.1 Stress Relaxation and Creep p. 507
- 10.2 Relaxation and Retardation Times p. 515
- 10.3 The Time-Temperature Superposition Principle p. 529
- 10.5 Polymer Rheology p. 538
- 10.6 Overview of Viscoelasticity and Rheology p. 547
- References p. 548
- General Reading p. 550
- Study Problems p. 550
- Appendix 10.1 Energy of Activation from Chemical Stress Relaxation Times p. 552
- Appendix 10.2 Viscoelasticity of Cheese p. 553
- 11 Mechanical Behavior of Polymers p. 557
- 11.1 An Energy Balance for Deformation and Fracture p. 557
- 11.2 Deformation and Fracture in Polymers p. 560
- 11.3 Crack Growth p. 585
- 11.4 Cyclic Deformations p. 588
- 11.5 Molecular Aspects of Fracture and Healing in Polymers p. 593
- 11.6 Friction and Wear in Polymers p. 601
- 11.7 Mechanical Behavior of Biomedical Polymers p. 603
- 11.8 Summary p. 606
- References p. 607
- General Reading p. 610
- 12.2 Thermodynamics of Surfaces and Interfaces p. 615
- Study Problems p. 611
- 12 Polymer Surfaces and Interfaces p. 613
- 12.1 Polymer Surfaces p. 614
- 12.3 Instrumental Methods of Characterization p. 619
- 12.4 Conformation of Polymer Chains in a Polymer Blend Interphase p. 644
- 12.5 The Dilute Solution-Solid Interface p. 646
- 12.6 Instrumental Methods for Analyzing Polymer Solution Interfaces p. 652
- 12.7 Theoretical Aspects of the Organization of Chains at Walls p. 659
- 12.8 Adhesion at Interfaces p. 667
- 12.9 Interfaces of Polymeric Biomaterials with Living Organisms p. 675
- 12.10 Overview of Polymer Surface and Interface Science p. 677

- References p. 679
- General Reading p. 683
- Study Problems p. 684
- Appendix 12.1 Estimation of Fractal Dimensions p. 686
- 13 Multicomponent Polymeric Materials p. 687
 - 13.1 Classification Schemes for Multicomponent Polymeric Materials p. 688
 - 13.2 Miscible and Immiscible Polymer Pairs p. 692
 - 13.3 The Glass Transition Behavior of Multicomponent Polymer Materials p. 693
 - 13.4 The Modulus of Multicomponent Polymeric Materials p. 698
 - 13.5 The Morphology of Multiphase Polymeric Materials p. 706
 - 13.6 Phase Diagrams in Polymer Blends (Broad Definition) p. 710
 - 13.7 Morphology of Composite Materials p. 721
 - 13.8 Nanotechnology-Based Materials p. 723
 - 13.9 Montmorillonite Clays p. 728
 - 13.10 Fracture Behavior of Multiphase Polymeric Materials p. 736
 - 13.11 Processing and Applications of Polymer Blends and Composites p. 741
 - References p. 748
 - General Reading p. 753
 - Study Problems p. 754
- 14 Modern Polymer Topics p. 757
 - 14.1 Polyolefins p. 757
 - 14.2 Thermoset Polymer Materials p. 762
 - 14.3 Polymer and Polymer Blend Aspects of Bread Doughs p. 765
 - 14.4 Natural Product Polymers p. 769
 - 14.5 Dendritic Polymers and Other Novel Polymeric Structures p. 773
 - 14.6 Polymers in Supercritical Fluids p. 779
 - 14.7 Electrical Behavior of Polymers p. 782
 - 14.8 Polymers for Nonlinear Optics p. 786
 - 14.9 Light-Emitting Polymers and Electroactive Materials p. 789
 - 14.10 Optical Tweezers in Biopolymer Research p. 794
 - 14.11 The 3-D Structure and Function of Biopolymers p. 795
 - 14.12 Fire Retardancy in Polymers p. 807
 - 14.13 Polymer Solution-Induced Drag Reduction p. 811
 - 14.14 Modern Engineering Plastics p. 814
 - 14.15 Major Advances in Polymer Science and Engineering p. 815
 - References p. 817
 - General Reading p. 822
 - Study Problems p. 823
- Index p. 827