Contents

Part I Principles of Biophysical Inquiry

1 Philosophy and Practice of Biophysical Study 3
1.1 Questions 3
1.2 Thought Assignment 3
1.3 Answers 4

2 Overview of the Biological System Under Study – Descriptive Models 9
2.1 Thought exercises 9

3 Physical Thoughts, Biological Systems – The Application of Modeling Principles to Understanding Biological Systems 11
3.1 Questions 11
3.2 Thought Exercise 12
3.3 Thought Exercise 12
3.4 Answers 12

4 Probability and Statistics 15
4.1 Questions 15
4.2 Answers 16

Part II Foundations

5 Physical Principles: Energy – The Prime Observable 25
5.1 Questions 25
5.2 Answers 26

6 Biophysical Forces in Molecular Systems 29
6.1 Questions 29
6.2 Answers 31

7 An Introduction to Quantum Mechanics 35
7.1 Questions 35
7.2 Answers 36

8 Chemical Principles 39
8.1 Questions 39
8.2 Answers 40

9 Measuring the Energy of a System: Energetics and the First Law of Thermodynamics 43
9.1 Questions 43
9.2 Answers 45

10 Entropy and the Second Law of Thermodynamics 49
10.1 Questions 49
10.2 Answers 51

11 Which Way Did That System Go? The Gibbs Free Energy 53
11.1 Questions 53
11.2 Answers 54

12 The Thermodynamics of Phase Equilibria 57
12.1 Questions 57
12.2 Answers 58

Part III Building a Model of Biomolecular Structure

13 Water: A Unique Structure, a Unique Solvent 63
13.1 Thought Exercises 63

14 Ion-Solvent Interactions 65
14.1 Questions 65
14.2 Thought Exercise 65
14.3 Thought Exercise 65
14.4 Answers 66

15 Ion-Ion Interactions 67
15.1 Questions 67
15.2 Answers 68

16 Lipids in Aqueous Solution 71
16.1 Questions 71
16.2 Thought Exercise 71
16.3 Answers 72

17 Macromolecules in Solution 73
17.1 Questions 73
17.2 Answers 73

18 Molecular Modeling – Mapping Biochemical State Space 75
18.1 Questions 75
18.2 Answers 76

19 The Electrified Interphase 81
19.1 Questions 81
19.2 Answers 82

Part IV Function and Action Biological State Space

20 Transport and Kinetics: Processes Not at Equilibrium 87
20.1 Questions 87
20.2 Answers 87

21 Flow in a Chemical Potential Field: Diffusion 89
21.1 Questions 89
21.2 Answers 89

22 Flow in an Electrical Field: Conduction 91
22.1 Questions 91
22.2 Answers 92

23 Forces Across Membranes 95
23.1 Questions 95
23.2 Answers 95

24 Kinetics – Chemical Kinetics 97
24.1 Questions 97
24.2 Thought Review 99
24.3 Answers 99

25 Bioelectrochemistry – Charge Transfer in Biological Systems . . . 103
25.1 Questions 103
25.2 Answers 104

Part V Methods for the Measuring Structure and Function

26 Separation and Characterization of Biomolecules Based on Macroscopic Properties 109
26.1 Questions 109
26.2 Answers 112

27 Determining Structure by Molecular Interactions with Photons: Electronic Spectroscopy 115
27.1 Questions 115
27.2 Answers 116

28 Determining Structure by Molecular Interactions with Photons: Scattering Phenomena 121
28.1 Questions 121
28.2 Thought Exercise 122
28.3 Answers 122

29 Analysis of Structure – Microscopy 129
29.1 Questions 129
29.2 Answers 130

Part VI Physical Constants

30 Physical Constants 137
30.1 Conversions 137

Index 139