Contents

3.3

Fick's first law of diffusion

PA	RT I: THE BASIC THEORY		
80	201		E.
1.	Electrostatic fields and voltage		3
1.1	Ziertiirij, iiigiirtiirii alie olologj		3
1.2	The sources of electrical forces		4
1.3	The electric field		5
1.4	Representation of electric fields		8
1.5	Gauss's law		9
1.6	Voltage		18
Top	pics covered in Chapter 1		23
Imp	ortant equations of Chapter 1		24
Pro	DICHIS		25
			1000
2.	How conductors shape an electric field		29
2.1	Electrical conductors		29
2.2	The electric field within a conductor		30
2.3	The electric field surrounding a conductor		33
2.4	The electrical capacitor		37
2.5	The animal cell plasma membrane as a capaci	tor to be be to be be to be	39
2.6	The capacitance of a single conductor	The cell plasmanuscrimates	40
2.7	The spherical capacitor		41
Top	pics covered in Chapter 2		43
Imp	portant equations of Chapter 2		43
Pro	blems		44
3.			46
3.1	Ohm's law of conductivity		46
3.2	Ionic diffusion		48

51

viii Contents

53
55
56
57
59
61
61
66
68
72
74
76
77
78
79
81
81
82
84
86
88
91
92
93
94
95
96
100
100
104
106
107
108

6.6 The differences between the electrostatic and magnetostatic potential	als 112
Topics covered in Chapter 6	115
Important equations of Chapter 6	
Problems 01 resignation in Lease	voo eo 117
7. The generation of magnetic fields	119
7.1 The magnetic field around a straight current-carrying wire	119
7.2 The long solenoid	121
7.3 The Biot–Savart Law	123
7.4 The single coil and the Helmholtz pair of coils	125
7.5 Practical coils for the generation of laboratory magnetic fields	127
Topics covered in Chapter 7	128
Important equations of Chapter 7	129
Problems Problems and the branch and applications and the short of the problems	130
8. Magnetic polarization of material whom had the substitution of material who substitution of material who	
re ionization of residues	
8.1 Magnetic material	132
8.2 Modification of Ampère's law by induced magnetic moments	133
8.3 Properties of the vector $H_{\tilde{x}}$	
8.4 Boundary conditions for <i>B</i> and <i>H</i>	139
Topics covered in Chapter 8	140
Important equations of Chapter 8	141
Problems Proble	142
9. Induced electric and magnetic fields	
9.1 Faraday's law of induction	1/15
9.2 An application of Faraday's law	147
9.3 The screening of induced electric fields in biological tissue	149
The state of the s	150
The second of the second secon	153
Topics covered in Chapter 9	
Important equations of Chapter 9	154
Problems Problems and Charles	155
10. The motion of a charged particle in electric and magnetic fields and relativity	158
10.1 The Lorentz force	158
10.2 The motion of a free charged particle in a static magnetic field	159

x Contents

10.3	The Larmor theorem	161
10.4	Diamagnetism	164
10.5	Special relativity and magnetism	166
Topic	es covered in Chapter 10	168
Impo	rtant equations of Chapter 10	169
Probl	ems ems	170
PA	RT II: APPLICATIONS	
11.	Ions in aqueous solution and the ionization of acids and bases	175
11.1	Ions in aqueous solution	175
11.2	The dissociation of the water molecule and pH	178
11.3	Ionizable residues	179
11.4	The effects of electric fields on the ionization of acid and	
	basic residues	181
11.5	The effects of the electrical polarizability of the enviornment	
	on the ionization of residues	182
Refer	rences	185
12.	The Debye Layer	186
12.1	The basic electrostatics	186
12.2	The electric field and voltage at the surface for a given surface	
	charge density	188
12.3	The variation of voltage with distance from the surface	191
12.4	The variation of ionic concentration with distance from the	
	charged surface	194
12.5	How reliable is the simple theory of the Debye layer?	195
Refe	rences	196
13.	The behaviour of ions in narrow pores	197
13.1	Ion channels in biology	197
13.2	The electrostatic self-energy of an ion in a narrow	
	water-filled pore	198
13.3	Enhanced electrostatic interaction within narrow	
	water-filled pores	201
13.4	Interactions between ions and ionizable residues in the pore wall	204
13.5	The possible ordering of the water structure within narrow pores	205
Refer	rences	207

14.	Possible mechanisms for a magnetic animal compass	208
14.1	The magnetic field of the Earth	208
14.2	The animal compass	210
14.3	Magnetic induction	211
14.4	The magnetite compass	215
14.5	The free radical magnetic field detector	218
Refer	rences	222
15.	An electrostatic model of a proton/ion or an ion/ion coport	
	or counterport	223
15.1	The ionic coport and counterport	223
15.2	A simple mechanical model of a counterport	224
15.3	An electrostatic analogue of the mechanical model	
	for a proton/ion counterport	225
15.4	Kinetics of the model	227
15.5	A Monte Carlo computer simulation	229
Refer	rences	234
16.	An introduction to the semi-classical theory of pulsed	
10.	nuclear magnetic resonance	235
16.1	Classical angular momentum and the Larmor theorem	235
16.2	The rotating frame	237
16.3	Application of a small-amplitude rotating magnetic field and	
	magnetic resonance	239
16.4	The detection of nuclear magnetic resonance, the 90° pulse and	
	the free precession signal	241
16.5	The 180° pulse and the spin echo	244
16.6	Nuclear magnetic resonance as a structural technique	
	on a molecular scale	246
16.7	Nuclear magnetic resonance as a structural technique	
	on a macroscopic scale	248
Refer	rences	250
App	endix 1: Mathematics	251
A1.1	Cartesian and polar coordinates	251
A1.2		253
A1.3		255
A1.4	Vector products	257

xii Contents

A1.5	Vector calculus	258
A1.6	Integrals	259
A1.7	Geometrical vector theorems	262
Appe	endix 2: The Boltzmann distribution, entropy and detailed balance	263
A2.1	Disorder and the number of available states	263
A2.2	The Boltzmann distribution	265
A2.3	Entropy	266
A2.4	Detailed balance	266
A2.5	An entropic force	268
Appe	endix 3: An introduction to thermodynamics and the chemical potential	270
A3.1	The first law	270
A3.2	The second law	272
A3.3	The Gibbs function	272
A3.4	Uses of the chemical potential	274
A3.5	The tension in an 'entropic chain'	277
Appe	endix 4: Hints for the solution of and numerical answers to the problems	279
Index	The Lieu Calleman and the share the control of the	284