

CONTENTS

1. STRUCTURE OF MATTER	9
1.1 Particles and force interactions	9
1.2 Energy	11
1.3 Quantum effects.	13
1.3.1 Quantum numbers.	15
1.4 Hydrogen atom	18
1.4.1 Spectrum of the hydrogen atom	20
1.5 Electron structure of heavy atoms	20
1.6 Excitation and ionisation of atoms	22
1.6.1 Binding energy of electrons in an atom.	23
1.7 Principle of mass spectroscopy	24
1.8 Atomic nuclei	26
1.8.1 Binding energy of a nucleus	27
1.8.2 Magnetic properties of nuclei	28
1.9 Forces acting between atoms.	29
1.9.1 Ionic bonds	29
1.9.2 Covalent bonds	30
1.10 Physical basis of nuclear magnetic resonance tomography	32
2. MOLECULAR BIOPHYSICS	41
2.1 Molecular Bonds and Forces	41
2.2 Phases of matter.	43
2.2.1 Gaseous phase	44
2.2.2 Liquid phase	49
2.2.3 Solids	49
2.2.4 Plasma	50
2.3 Change of phases.	50
2.3.1 Phase diagram	50
2.3.2 Gibbs law of phases.	51
2.4 Classification of dispersion system	52
2.4.1 Analytical dispersions	53
2.4.2 Colloidal dispersions	54
2.5 Water	60
2.6 Transport phenomena	63
2.6.1 Basic laws of fluids	63
2.6.2 Law of Laplace	64
2.6.3 Viscosity	66
2.6.4 The Hagen-Poiseuille law	68
2.6.5 Stokes law	69
2.6.6 Diffusion	70

2.7	Colligative properties of solutions	71
2.7.1	Raoult laws	72
2.7.2	Osmotic pressure	73
2.8	Phase border phenomena	75
2.8.1	Surface tension	75
2.8.2	Adsorption	76
3.	THERMODYNAMICS	77
3.1	Thermodynamic system	77
3.2	Work and heat	79
3.4	Heat transport	81
3.5	Functions of state	82
3.5.1	Internal energy	83
3.5.2	Enthalpy	84
3.5.3	Entropy	85
3.5.4	Free energy	87
3.5.5	Free enthalpy	87
3.6	Chemical potential	88
3.7	Reaction heat	88
3.8	Thermodynamics of biological system	89
3.9	Transformation and accumulation of energy in biological system	91
3.10	Measurement of temperature	92
3.10.1	Liquid thermometers	92
3.10.2	Medical thermometer	93
3.10.3	Calorimetric thermometer	93
3.10.4	Thermocouple	93
3.10.5	Electrical resistance thermometer	93
3.10.6	Thermistor	94
3.10.7	Thermography	94
3.10.8	A bimetallic strip	94
3.11	Calorimetry	94
3.12	Thermal losses	95
3.13	The laws of thermodynamics	96
4.	BIOPHYSICS OF ELECTRIC PHENOMENA	98
4.1	Introduction	98
4.1.1	Coulomb law and permittivity	98
4.1.2	Electric potential, potentials of phase boundary-lines	100
4.1.3	Donnan equilibrium	103
4.2	Electric phenomena in alive organism	103
4.2.1	Resting membrane potential of nerve cell	104
4.2.2	Action potential of nerve fibre	106
4.2.3	Action potential in heart cell	110
4.2.4	Electrocardiogram (ECG)	111
4.2.5	Heart's electrical sequence and interpretation of electrocardiogram	113
4.2.6	Electroencephalograph (EEG) and Electromyograph (EMG)	115
4.3	Electric field, electric current and voltage	115
4.3.1	Conduction of electric current in organism	115
4.3.2	Effect of electric current on organism	118
4.3.3	Conductometry	120
4.4	Oscilloscope	122
5.	ACOUSTICS AND PHYSICAL PRINCIPLES OF HEARING	123
5.1	Introduction	123
5.1.1	Basic quantities	124

5.1.2	The Doppler effect	127
5.1.3	Weber-Fechner's law	129
5.1.4	Complex tones	131
5.2	The principles of hearing	133
5.3	Ultrasound	135
5.3.1	Piezoelectric effect	135
5.3.2	Ultrasound imaging	136
5.3.3	Effect of ultrasound on tissue	141
5.4	Shock waves	141
6.	OPTICS	143
6.1	Propagation of light	143
6.2	Ray optics	145
6.3	Dispersion of light	149
6.4	Light scattering	149
6.4.1	Rayleigh scattering	150
6.4.2	Raman scattering	150
6.5	Absorption of light	151
6.6	Polarisation of light	152
6.6.1	Polarimetry	154
6.7	Quantum optics	155
6.8	Wave optics	155
6.8.1	Interference of light	155
6.8.2	Diffraction of light	157
6.9	Lenses	158
6.9.1	Compound microscope	160
6.10	Laser	162
6.11	Optics of the human eye	164
6.11.1	Eye defects	166
6.11.2	Biophysics of vision	167
7.	X-RAY PHYSICS AND MEDICAL APPLICATION	169
7.1	General features of X-rays	169
7.1.1	Production of braking radiation (bremsstrahlung)	170
7.1.2	Production of characteristic X-rays	172
7.1.3	The attenuation of X-radiation	172
7.1.4	X-ray contrast	174
7.2	Use of X-rays for diagnostic purposes	177
7.2.1	X-ray imaging methods	179
7.2.2	Computed tomography	180
7.2.3	Risks of X-ray radiation	184
7.3	Therapeutic application of X-rays	185
8.	RADIOACTIVITY AND IONISING RADIATION	187
8.1	Natural and artificial radioactivity	187
8.1.1	Basic law of radioactive decay	188
8.1.2	Radioactive equilibrium	190
8.1.3	Radioactive series	192
8.1.4	Types of radioactive decay	193
8.2	Ionising radiation and its sources	196
8.2.1	Positively charged particles	196
8.2.2	Linear accelerators	196
8.2.3	Circular accelerators	197
8.2.4	Negatively charged particles – electrons	198
8.2.5	Neutrons	199

8.2.6	Radionuclide sources of neutrons	199
8.2.7	γ -radiation	199
8.2.8	Cosmic rays	200
8.3	Interaction of radiation with matter	200
8.3.1	Interaction of α -particles	201
8.3.2	Interaction of β -radiation	201
8.3.3	Interaction of γ -radiation	203
8.3.4	Neutron interactions	207
8.4	Detection of ionising radiation	208
8.4.1	Ionisation chambers	209
8.4.2	Geiger-Müller counter	210
8.4.3	Scintillation counter	212
8.4.4	Semiconductor-based detector	213
8.4.5	Integral and selective detection of γ -radiation	214
8.5	Basic quantities in radiation dosimetry	215
8.5.1	Personal dosimeters	216
8.6	Use of nuclear medicine in therapy	217
8.7	Use of nuclear medicine in diagnostics	217
8.7.1	Radionuclides	218
8.7.2	Scintigraphy (planar gamma radiography)	218
8.7.3	Single photon emission computerised tomography	220
8.7.4	Positron emission tomography	221