



Contents

Preface xiii

1	Introduction to physical science	1
1-1	Studying the world around us	2
1-2	Describing and measuring things	5
	Questions and exercises	11

Part I. An overview of the physical Universe

2	Basic units of matter: atoms and molecules	15
2-1	The atomic concept	15
2-2	Chemical reactions	21
2-3	Oxidation and reduction	23
2-4	Respiration and chemical change	25
2-5	The conservation of mass	27
2-6	Avogadro's hypothesis and the concept of the mole	30
	Questions and exercises	36
3	Basic units of matter: electrons and nuclei	38
3-1	Electrons	38
3-2	The nuclear atom	41
3-3	The composition of nuclei	43
3-4	Isotopes	45
3-5	Radioactivity	46
3-6	Nuclear reactions	52
3-7	Elementary particles	53
	Questions and exercises	57

4	Light – A tool for exploring the Universe	59
4-1	Basic features of light and light sources	59
4-2	Lenses and optical instruments	66
4-3	Color and spectra	77
4-4	Light and vision	81
	Questions and exercises	87
5	The Earth and the Moon	90
5-1	Our planet in space	90
5-2	The astronomy of the Moon	94
5-3	The effect of the Moon on the Oceans	99
5-4	The structure of the Earth	102
5-5	The structure of the Moon	106
5-6	The ages of the Earth and the Moon	111
	Questions and exercises	114
6	The materials of the Earth's crust	116
6-1	Properties and composition of the Earth's crust	116
6-2	Minerals	120
6-3	Crystalline matter	124
6-4	Rocks	127
6-5	Igneous activity	130
6-6	Erosion	135
6-7	Sedimentation	142
	Questions and exercises	148
7	The Earth through geologic time	150
7-1	Diastrophism	150
7-2	Continental drift	162
7-3	The geologic eras	169
	Questions and exercises	173
8	The planets	174
8-1	Planetary motion	174
8-2	The terrestrial planets	179
8-3	The outer planets	184
8-4	Other members of the solar system	188
8-5	The origin of the solar system	192
	Questions and exercises	195

9	The Sun and the stars	197
9-1	The Sun	197
9-2	Stars	203
9-3	Galaxies	208
	Questions and exercises	213

Part II. A closer look at the physical world

10	Motion	217
10-1	Average speed	217
10-2	Graphical representation of speed	219
10-3	Acceleration	222
10-4	Accelerated motion	224
10-5	Free fall	226
10-6	Vectors	230
10-7	Motion in two dimensions	233
	Questions and exercises	238
11	Force and momentum	240
11-1	Force and inertia	240
11-2	Dynamics	243
11-3	Action and reaction	248
11-4	Linear momentum	250
11-5	Angular momentum	252
	Questions and exercises	257
12	The basic forces in Nature	259
12-1	Types of forces	259
12-2	Planetary motion	260
12-3	Universal gravitation	263
12-4	Space travel	268
12-5	The electrical force	274
12-6	The nuclear and weak forces	280
	Questions and exercises	281
13	Energy	284
13-1	Work and power	285
13-2	Kinetic and potential energy	288
13-3	Thermal energy	293
13-4	Chemical and biological energy	301
	Questions and exercises	305

14	Sources of energy	307
14-1	How much energy do we use?	307
14-2	Water power	310
14-3	Fossil fuels	312
14-4	Nuclear energy	316
14-5	Secondary energy sources	318
14-6	Energy and the environment	320
	Questions and exercises	331
15	Gas dynamics	332
15-1	The molecular properties of gases	332
15-2	Pressure	334
15-3	The gas laws	336
15-4	Kinetic theory	339
15-5	Changes of state	343
	Questions and exercises	347
16	Electricity	349
16-1	Electrons and current	349
16-2	Electric power	353
16-3	Electrical resistance	354
16-4	Electric circuits	360
	Questions and exercises	365
17	Electric and magnetic fields	367
17-1	The electric field	367
17-2	The electron charge and the electron volt	371
17-3	Magnetism and the Earth's magnetic field	374
17-4	The motion of charged particles in magnetic fields	381
17-5	Fields that vary with time	385
	Questions and exercises	389
18	Waves	391
18-1	Wave pulses on springs and strings	391
18-2	Traveling waves	394
18-3	Standing waves	397
18-4	Sound	400
18-5	Refraction, diffraction, and interference	404
18-6	Electromagnetic radiation	411
	Questions and exercises	421

19	The Earth's atmosphere	423
19-1	General features of the atmosphere	423
19-2	Winds	433
19-3	Weather	440
19-4	Atmospheric electricity	448
	Questions and exercises	450

Part III. The twentieth century view of matter and energy

20	Relativity	455
20-1	The basis of relativity	456
20-2	The velocity of light	457
20-3	Relativistic effects on time and length	462
20-4	Mass and energy	468
20-5	The general theory	470
	Questions and exercises	473
21	Electrons and photons	475
21-1	The photoelectric effect	475
21-2	The wave nature of particles	480
21-3	Quantum theory	484
	Questions and exercises	490
22	Atoms and radiation	492
22-1	The hydrogen atom	493
22-2	Quantum theory of the hydrogen atom	502
22-3	Complex atoms and the periodic table	505
22-4	Lasers	515
	Questions and exercises	520
23	Molecular structure	522
23-1	Ionic bonds between atoms	522
23-2	Covalent bonding	529
23-3	Hydrogen bonds	534
	Questions and exercises	538
24	Chemical systems	539
24-1	Solutions	539
24-2	Oxidation and reduction	542
24-3	Electrochemistry	547

24-4	Acids, bases, and salts	552
24-5	Chemical dynamics	559
	Questions and exercises	567
25	The chemistry of organic matter	569
25-1	Hydrocarbon compounds	571
25-2	Organic compounds related to the hydrocarbons	578
25-3	Benzene ring compounds	580
25-4	Food chemistry	583
25-5	Soaps and detergents	586
25-6	Proteins and the molecules of life	588
	Questions and answers	597
26	The materials of technology	598
26-1	Metals	598
26-2	Semiconductors	608
26-3	Superconductors	612
26-4	Plastics	615
	Questions and exercises	620
27	Nuclei and nuclear power	622
27-1	Nuclear masses	622
27-2	Nuclear reactions	624
27-3	Nuclear fission	626
27-4	Nuclear reactors	632
27-5	Nuclear fusion	640
	Questions and exercises	643
28	Applications of radiation	644
28-1	Radiation and radiation effects	644
28-2	Radiation techniques in various fields	649
28-3	Biological effects of radiation	656
28-4	Biological and medical uses of radiation	661
	Questions and exercises	664
29	The evolution of the stars and the Universe	666
29-1	The formation of stars	667
29-2	Stellar energy and the synthesis of elements	669
29-3	Stellar evolution	673

29-4	Strange objects in the sky	677
29-5	The expanding Universe	682
	Questions and exercises	686
	Answers to odd-numbered numerical exercises	689
	Glossary	691
	Index	709