## Contents

	Preface to the second edition	page xi
	Preface to the first edition	xii
1	Historical introduction	1
2	The continuous X-ray spectrum	7
2.1	Introduction	7
2.2	Energy distribution of the continuous spectrum	
	from thin targets	9
2.3	Angular distribution of the continuous spectrum	
	from thin targets	11
2.4	Energy distribution from electron-opaque targets	15
2.5	Angular distribution from electron-opaque	
	targets	21
2.6	Bremsstrahlung at higher energies	24
2.7	Theories of the continuous spectrum	26
	(a) Angular distribution	26
	(b) Energy distribution	33
	(c) Thick targets and the effect of scattering and	
	energy-loss	38
	(d) Semi-thick targets	40
	(e) Electron scattering effects	42
2.8	The efficiency of production of continuous X-	
	radiation	45
2.9	Polarization of the continuous radiation	48
2.10	Isochromats: the determination of $h/e$ , and the	
	structure near the high energy limit	54
2.11	Additional Bremsstrahlung processes	59

3	Characteristic X-rays	62
3.1	Energy levels and X-ray spectra from singly-	
	ionized atoms	62
3.2	The fluorescence yield and the Auger effect	74
3.3	Relative intensities of characteristic X-ray lines	78
3.4	Characteristic X-ray emission from thin targets	84
	(a) Cross-sections for inner-shell ionization	84
	(b) Experimental data obtained using thin	
	targets	86
3.5	The production of characteristic radiation from	
	thick targets	94
	(a) Integration of the cross-section	94
	(b) The indirect production in thick targets	95
	(c) Studies of the intensity of characteristic	
	radiation in practical situations	99
	(d) The variation of characteristic X-ray	
	production with depth, and the self-	440
	absorption effect	110
3.6	The ratio of characteristic to continuous	100
	radiation from thick targets	120
3.7	Satellites	124
3.8	Line width	130
4	Experimental techniques for the study of X-rays	136
4.1	Introduction	136
4.2	X-ray tubes and other generators	137
4.3	The detection and analysis of X-radiation	148
	(a) Introduction	148
	(b) Crystal spectrometers	149
	(c) Proportional counters	154
	(d) Scintillation counters	163
	(e) Solid-state detectors	167 170
4.4	X-ray attenuation – experimental aspects	170
4.5	Soft X-ray techniques	174
4.6	Study of secondary factors	178
	(a) Electron penetration	170
	(b) Electron backscattering and secondary	183
	emission (a) The fluorescence yield and the Auger effect	188
47	(c) The fluorescence yield and the Auger effect Polarization measurements	190
4.7	Radiation dosimetry	191
4.0	Nauiauvii uvsiiiivii v	1/1

ix

5	The absorption and scattering of X-rays	198
5.1	Absorption and scattering cross-sections	198
5.2	The photoelectric effect	200
5.3	The Compton effect	206
5.4	Pair production	213
5.5	Thomson and Rayleigh scattering	215
5.6	Nuclear Thomson scattering	225
5.7	Delbrück scattering	226
5.8	Nuclear resonant scattering	227
5.9	Attenuation coefficients in practical conditions	233
6	X-ray production by protons, α-particles and heavy	
	ions	241
6.1	Ionization cross-sections (experimental) for	Contact of
	protons and α-particles	241
6.2	Theoretical considerations	246
6.3	Relative intensities of lines in the $K$ and $L$	
	spectra	251
6.4	Bremsstrahlung production	258
6.5	X-ray production by heavy-ion bombardment	260
6.6	Proton-induced X-rays for elemental analysis	264
7	X-rays in radioactive decay	266
7.1	Introduction	266
7.2	X-rays produced by electron capture	268
7.3	X-rays following internal conversion	279
7.4	Inner Bremsstrahlung	284
7.5	External Bremsstrahlung in $\beta$ -decay	289
7.6	Externally produced characteristic radiation	
	using $\beta$ -emitters	296
7.7	Practical radioisotope sources of X-rays	300
7.8	X-rays in association with α-activity	302
8	Some additional fields of X-ray study	303
8.1	X-ray microscopy and microanalysis	303
8.2	Chemical influences in absorption and emission;	
	the isotope effect	316
	(a) Emission line-shifts	316
	(b) Absorption and isochromat structure	322
	(c) Electronic band structure	324
	(d) The isotope shift	326
8.3	Mesonic X-rays	327

## x Contents

8.4	Synchrotron radiation	332
8.5	Plasma physics and astrophysics	336
	(a) Introduction	336
	(b) X-rays in plasma physics	337
	(c) X-ray astronomy	338
	Appendices	344
1	Range energy relations, etc., for electrons	344
2	Experimentally determined mass attenuation	
	coefficients	353
3	Decay schemes of some radionuclides	364
4	Absorption edges and characteristic emission	
	energies in keV	378
5	K-shell fluorescence yields	382
	Bibliography	383
	Index	397