

CONTENTS

CHAPTER 1	ATOMS AND MOLECULES	1
1-1	Introduction	1
Atomic Structure		
1-2	Bohr's Atomic Model	2
1-3	Quantum Mechanics	3
1-4	Quantum Numbers	4
1-5	Energy Levels for Hydrogen Atom	5
1-6	Electronic Configuration of Atoms	7
1-7	Periodic Classification of the Elements	9
Interatomic and Intermolecular Forces		
1-8	Binding Energy	11
1-9	Ionic Bonds	15
1-10	Covalent Bond	20
1-11	Electronegativity and the Bond Energy	22
1-12	Metallic Bond	26
1-13	Intermolecular Forces	27
	References	30
	Problems	30
CHAPTER 2	STRUCTURE OF SOLIDS	32
Crystal Structures		
2-1	Space Lattices	33
2-2	Crystallographic Planes and Directions	35
2-3	Methods of Determining the Crystal Structures	40

Typical Crystal Structures

2-4	Atomic Radii	43
2-5	Atomic Packing	44
2-6	Metallic Structures	48
2-7	Ionic Structures	50
2-8	Covalent Structures	52
2-9	Molecular Structures	54

Complex Structures

2-10	Polymorphism	56
2-11	Silica and Silicates	58
2-12	Feldspars and Zeolites	61
2-13	Chain and Layer Structures	62
2-14	Intercalation in Layer Compounds	64

Amorphous and Partly Crystalline Structures

2-15	Glasses	65
2-16	Nature of Organic Polymers	67
2-17	Structure of Polymer Chains	69
2-18	Amorphous Polymers	72
2-19	Crystallinity in Polymers	73
	References	76
	Problems	77

CHAPTER 3 PHASE TRANSFORMATIONS AND PHASE EQUILIBRIA

80

3-1	Stability of Phases and Equilibrium	81
-----	-------------------------------------	----

Phase Transitions

3-2	Liquid-Solid Transition	82
3-3	Glass Transition Temperature and Glass Formation	83
3-4	Solid Solutions	85
3-5	Intermetallic Compounds	87

Phase Equilibrium Diagrams

3-6	Phase Rule and Equilibrium	88
3-7	Cooling Curves	90
3-8	Solid Solutions Equilibrium Diagram	91
3-9	Nonequilibrium Cooling	94
3-10	Eutectic Systems	96

3-11	Equilibrium Diagrams with Intermediate Compounds	102
3-12	Layer-type Equilibrium Diagrams	103
	References	104
	Problems	104

CHAPTER 4 DEFECTS AND IMPERFECTIONS IN SOLIDS 108

Point Defects

4-1	Formation of Point Defects	109
4-2	Vacancies	110
4-3	Interstitials	112
4-4	Impurity Defects	113

Dislocations

4-5	Types of Dislocations	114
4-6	Dislocation Movement	117
4-7	Interaction of Dislocations	119
4-8	Dislocations in Polymer Crystals	120

Grain Boundaries or Planar Imperfections

4-9	Structure of Grain Boundaries	122
4-10	Properties (or Behavior) of Grain Boundaries	123
	References	124
	Problems	125

CHAPTER 5 RATE PROCESSES AND CRYSTALLIZATION 126

5-1	Kinetics of Phase Transformations	126
-----	---	-----

Diffusion

5-2	Mechanism of Diffusion in Solids	129
5-3	Steady-State Diffusion	130
5-4	Unsteady-State Diffusion	132
5-5	Kirkendall Effect	134
5-6	Temperature Effect on Diffusion	136

Crystallization

5-7	Nucleation	139
5-8	Nucleation Rates	142
5-9	Crystal Growth	143

5-10	Single Crystals	147
5-11	Zone Refining	148
	References	151
	Problems	152
CHAPTER 6 SURFACES AND INTERFACIAL PHENOMENA		154
6-1	Surface Energy	154
6-2	Surface Structure	158
Interfacial Phenomena		
6-3	Liquid-Liquid Interaction	159
6-4	Liquid-Solid Interaction	161
Particulate Matter		
6-5	Particle Size versus Specific Surface Area	164
6-6	Packing of Particles	165
6-7	Powder Compacting and Sintering	169
Dispersive Systems		
6-8	Colloids	172
6-9	Gels and Pastes	175
6-10	Emulsions	176
6-11	Foams	179
Friction, Lubrication, and Wear		
6-12	Friction	182
6-13	Effect of the Surface Films	186
6-14	Mechanism of Lubrication	188
6-15	Wear	190
	References	191
	Problems	192
CHAPTER 7 MECHANICAL PROPERTIES		196
7-1	Stress and Strain	197
Elasticity		
7-2	Generalized Hooke's Law	200
7-3	Moduli of Elasticity	202
7-4	Deviations from Perfect Elastic Behavior	208

Plasticity and Flow

7-5	Plastic Deformation of a Single Crystal	212
7-6	Dislocations and Plastic Deformation	217
7-7	Energies of Dislocations	219
7-8	Dislocations and Strength	223
7-9	Strain Hardening	225
7-10	Recovery and Recrystallization	227
7-11	Stress-Strain Curves	230
7-12	Viscosity	234
7-13	Viscosity of Suspensions	239
7-14	Non-Newtonian Materials	241
7-15	Viscoelasticity	247
7-16	Creep	255

Strength and Fracture

7-17	Toughness and Resilience	261
7-18	Hardness	263
7-19	Mechanism of Fracture	265
7-20	Stress Concentrations	270
7-21	Ductile-Brittle Transition	271
7-22	Fatigue	274
7-23	Damping Characteristics of Materials	277
7-24	Working Stresses	280
	References	281
	Problems	282

CHAPTER 8 METALS

290

8-1	Solidification	290
8-2	Forming Processes	295
8-3	Cast versus Wrought Metals or Alloys	301
8-4	Special Methods	302
8-5	Powder Metallurgy	305

Ferrous Metals

8-6	Iron-Carbon Equilibrium Diagram	307
8-7	Time-Temperature Transformations	311
8-8	Continuous-Cooling Transformations	316
8-9	Heat Treatment of Carbon Steels	317
8-10	Cast Irons	321
8-11	Effect of Alloying Elements	321
8-12	Stainless and Heat-Resisting Steels	323

Nonferrous Metals

8-13	Precipitation Hardening	328
8-14	Copper and Copper Alloys	331
8-15	Nickel and Nickel Alloys	332
8-16	Aluminum, Magnesium, and Their Alloys	333
	References	334
	Problems	334

CHAPTER 9 CERAMICS AND RELATED MATERIALS 337

Clay Products

9-1	Plasticity of Clays	338
9-2	Drying	339
9-3	Firing	340
9-4	Porosity and Permeability	342

Refractories

9-5	Common Refractory Materials	345
9-6	Refractoriness versus the Ceramic Bond	349
9-7	High-Grade Refractories	351

Inorganic Cements

9-8	Portland Cement Composition	356
9-9	Setting and Hardening of Portland Cement	358
9-10	Aluminous Cements	361

Glasses

9-11	Types of Glasses	363
9-12	Glass Manufacture	364
9-13	Glass-Ceramics	368
	References	370
	Problems	370

CHAPTER 10 POLYMERS

373

Formation of Polymers

373

10-1	Addition Polymerization	374
10-2	Condensation Polymerization	375
10-3	Configuration of Polymer Chain	376
10-4	Molecular Weight Distribution	378

Linear Polymers

10-5	Degree of Crystallinity	383
10-6	Effect of Polar Groups	385
10-7	Transition Temperatures	387
10-8	Wood	390

Crosslinking in Polymers

10-9	Crosslinking Through Functional Groups	393
10-10	Crosslinking Through Addition Polymerization	396
10-11	Elastomers	398
10-12	Crosslinking by Free Radicals	402
10-13	Crosslinking Through Secondary Valences	403

General Properties

10-14	Chemical Resistance	403
10-15	High-Temperature Resistance and Thermal Stability	405

Polymer Processing

10-16	Compounding	407
10-17	Forming Operations	411
10-18	Molecular Orientation and Morphology	414
10-19	Annealing	415
	References	417
	Problems	418

CHAPTER 11 ELECTRONIC PROPERTIES

421

11-1	Electronic Energy Levels in Solids	421
11-2	Conductivity	426
11-3	Superconductivity	430

Semiconductivity

11-4	Intrinsic Semiconductivity	433
11-5	Impurity or Extrinsic Semiconductors	435
11-6	Compound Semiconductors	441
11-7	pn Junctions	444
11-8	Junction Transistors	445
11-9	Microelectronics	446

Dielectric Properties

11-10	Polarization and Dielectric Constant	447
11-11	Mechanism of Polarization	450
11-12	Polarizability in Condensed State	453
11-13	Electrostriction, Piezoelectricity, and Ferroelectricity	456
11-14	Insulating Materials	458

Radiation Interaction

11-15	Characteristic of Electromagnetic Radiation	461
11-16	Optical Properties	463
11-17	Photoconductivity	465
11-18	Luminescence	466
11-19	Lasers	466
11-20	Radiation Damage	471
	References	473
	Problems	474

CHAPTER 12 MAGNETIC PROPERTIES

476

12-1	Basic Concepts	476
12-2	Magnetization Curve and Hysteresis	478
12-3	Domain Theory	482
12-4	Magnetic Materials	483
	References	488
	Problems	488

CHAPTER 13 THERMAL PROPERTIES

490

13-1	Formation of Oxide Films on Metals	491
13-2	Mechanism of Growth of the Film	492
13-3	The Growth Laws	495
13-4	Heat Capacity	497
13-5	Thermal Expansion	499
13-6	Thermal Conductivity	501
13-7	Thermal Radiation	506
13-8	Thermal Protection	509
13-9	Thermal Stresses	511
13-10	Thermal Shock Resistance	513
13-11	Preventing or Minimizing Thermal Shock	514
	References	516
	Problems	517

Joining Processes

14-1	Welding Methods	520
14-2	Factors Affecting the Weld Quality	523
14-3	Brazing and Soldering	524
14-4	Welding of Plastics	525
14-5	Adhesives	525

Concrete

14-6	Design of Concrete Mixes	529
14-7	Characteristics of Concrete	532
14-8	Reinforced Concrete	532
14-9	Prestressed Concrete	534

Modern Composite Materials

14-10	Dispersion-Strengthened Composites	535
14-11	Particulate-Strengthened Systems	536
14-12	Fiber-Reinforced Composites	537
14-13	Discontinuous Fibers	541
14-14	Factors in Composites Preparation	544
14-15	Characteristics of Fibers	545
	References	548
	Problems	549

15-1	Electrode Potentials	552
15-2	Electrochemical Series	558
15-3	Origin of Potential Differences	559
15-4	Basic Mechanisms of Corrosion	561
15-5	Galvanic Corrosion	567
15-6	Polarization Phenomena	569
15-7	Passivity	576
15-8	Microbiological Corrosion	578
15-9	Stress Corrosion	581
15-10	Erosion-Corrosion	585

Corrosion Control and Prevention

15-11	Protection by Design	587
15-12	Inhibitors	588
15-13	Increasing Corrosion Resistance of Metals and Alloys	590

15-14	Cathodic Protection	591
15-15	Anodic Protection	596
15-16	Protective Materials	597
	References	600
	Problems	601

APPENDIX

Table A1	Selected Characteristics of Elements	606
Table A2	Comparative Properties of Selected Nonferrous Metals and Alloys	611
Table A3	Comparative Properties of Selected Ferrous Metals and Alloys	612
Table A4	Structures and Properties of Thermoplastics	614
Table A5	Structures and Properties of Rubbers	618

INDEX

621–633