The Physical Properties of Liquid Metals

TAKAMICHI IIDA
Osaka University, Japan

and

RODERICK I. L. GUTHRIE
McGill University, Montreal, Canada

CLARENDON PRESS · OXFORD
1993

CONTENTS

PRINCIPAL SYMBOLS xi

ACKNOWLEDGEMENTS xvi

1. GENERAL PROPERTIES 1
   - 1.1. Introduction 1
   - 1.2. General properties of liquid metals 10

2. STRUCTURE 18
   - 2.1. Introduction 18
   - 2.2. Distribution functions 19
   - 2.3. The structure of pure liquid metals 27
   - 2.4. The structure of liquid alloys 32

3. DENSITY 47
   - 3.1. Introduction 47
   - 3.2. Methods of density measurement 47
   - 3.3. Estimation of density 58
   - 3.4. Atomic volume of liquid metals and alloys 67
   - 3.5. Experimental data for liquid metals and alloys 70

4. THERMODYNAMIC PROPERTIES 78
   - 4.1. Introduction 78
   - 4.2. Vapour pressure of pure liquid metals 78
   - 4.3. Heat capacity of pure liquid metals 85
   - 4.4. Velocity of sound in pure liquid metals 91

5. SURFACE TENSION 109
   - 5.1. Introduction 109
   - 5.2. Experimental measurements of surface tension 110
   - 5.3. Theoretical equations for surface tension 120
   - 5.4. Semi-empirical and empirical equations for surface tension 124
   - 5.5. Temperature coefficients of surface tension 131
   - 5.6. Experimental data for pure liquid metals 133
   - 5.7. Adsorption of solutes on liquid metal surfaces 135
   - 5.8. Equations for the surface tension of binary liquid mixtures 144

6. VISCOSITY 147
   - 6.1. Introduction 147
   - 6.2. Methods of viscosity measurement 148
   - 6.3. Viscosity determination by the oscillating-vessel method (an experimental investigation of working formulae) 156

6.4. Theoretical equations for viscosity 167
6.5. Semi-empirical (semi-theoretical) and empirical equations for viscosity 172
6.6. Experimental data for pure liquid metals 188
6.7. Viscosity of liquid alloys 189

7. DIFFUSION 199
7.1. Introduction 199
7.2. Experimental methods for measuring diffusivities 201
7.3. Theoretical expressions for self-diffusivity (dynamic theories of liquids) 206
7.4. Diffusion equations based on the hard-sphere theory 208
7.5. Equations based on particular models 209
7.6. Semi-empirical and empirical equations 211
7.7. Relationship between viscosity and diffusivity 213
7.8. Experimental data for self-diffusivity in pure liquid metals 216
7.9. Solute diffusion in liquid alloys 216

8. ELECTRICAL AND THERMAL CONDUCTIVITY 226
8.1. Introduction 226
8.2. Electrical conductivity (electrical resistivity) of liquid metals and alloys 227
8.3. Thermal conductivity of liquid metals and alloys 233
8.4. Relationship between electrical conductivity and thermal conductivity for liquid metals and alloys: the Wiedemann–Franz–Lorenz law 237

APPENDIX 1: Application of some expressions to molten salts 243

APPENDIX 2: The SI (Système Internationale) units, physical constants, and conversion factors 253

REFERENCES 255

SUBJECT INDEX 267

AUTHOR INDEX 283