Preface

This book is a translation of a previous version published in French recently. Some errors have been corrected. There remain of course some typing errors and less obvious errors, which we ask the reader to forgive. This book brings together problems that are closely related to real issues in materials science. The book also presents succinct course reminders. It is intended for teachers and students of materials science. It can also be very useful for engineers, PhD students and researchers.

Diffusion and phase transformations in solids (precipitation of a new phase, ordering, growth of a thin film on a surface, oxidation of metals, etc.) constitute essential foundations in materials science. This body of knowledge is absolutely necessary for the design and optimization of materials and heat treatments leading to the desired properties whether they are structural materials (steels, Ni, Al, Cu, Ti based alloys…) or functional materials (semiconductors, quantum wells for optronics, and magnetic multilayers). Diffusive phase transformations are therefore essential in physical metallurgy. They are the foundations taught in particular in all the training courses of materials science in engineering schools and universities [1, 2].

After nearly 30 years of teaching in materials physics and designing exercises for tutorials and exam problems, the idea came to me to collect these exam subjects with detailed solutions. The problems proposed are often based on research problems with illustrations from electron microscopy or atom probe tomography observations, the flagship instrument designed in the Materials Physics Group in the 1990s. Links are frequently made with "everyday materials".

This book gathers a set of solved problems dealing with the thermodynamics of phase transformations, diffusion and solid-state transport phenomena in alloys and phase transformation kinetics. The book is organized into three main chapters. Each chapter begins with a course reminder that concisely gives the theoretical background necessary to solve the problems. There are of course many simplifications and omissions, which the reader will forgive. It is by no means an exhaustive course. Moreover, we have limited ourselves to binary alloys. To teach is to choose and

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therefore to exclude. Only the notions necessary to solve the problems of the book are introduced. The demonstrations of these reminders are sometimes not detailed. On the other hand, the steps of the calculations are most often given, which allow the reader to easily re-demonstrate the given expressions. The demonstration of some equations is also included in the problems. The book contains some bibliographical references of books or articles bringing a complementary addition.

The book gathers about thirty problems. They are often preceded by a preamble that sets the context by introducing the new concepts used. In a way, problems constitute a complement to course reminders. They are designed to guide the reader step by step and usually lead to the study of a real industrial problem (aeronautics, nuclear power plants, microelectronics...). The detailed solution is given at the end of each problem.

The problems of this book were inspired by other books, in particular those of Jean Philibert on diffusion, Yves Quéré on the physics of materials, Porter and Easteling on phase transformations, whom I wish to thank. This book was also inspired by exchanges with many colleagues, in particular Georges Martin, François Ducastelle, Alphonse Finel, Yann Lebouar, Annick Loiseau, Michel Guttmann, and many others who will forgive me for not being able to mention them all. My thanks also go to my former students and doctoral students who contributed directly or indirectly to this book. Thanks to Manon Bonvalet, Emmanuel Cadel, Fréderic Danoix, Bernard Deconihout, Fréderic De Geuser, Williams Lefebvre, Cristelle Pareige, Philippe Pareige, Thomas Philippe, Bertrand Radiguet, Xavier Sauvage and François Vurpillot for the enriching discussions we had and the vivid illustrations resulting from their research included in this book. This book owes a lot to Thomas Philippe, co-author of this book, who agreed to embark on the adventure by revisiting and enriching the problems and designing new ones.

Didier Blavette