CHEMISTRY
in
Engineering and Technology
VOLUME I

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General and Physical Chemistry

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Madras

Tata McGraw-Hill Publishing Company Limited
NEW DELHI

Sponsoring Editor: RAJIV BERI
Editorial Assistant: USHA RAMAN
Production Assistant: B L DOGRA
Manuscript Lead: N V SESHAN

This book has been subsidized by the Government of India, through the National Book Trust, India, for the benefit of students

NBT Code: 45-68/1979

Rs 30.00

Published by Tata McGraw-Hill Publishing Company Limited
12/4 Asaf Ali Road, New Delhi 110002 and printed at
M/s Jagowal Printing Press, 7/15 Kirti Nagar Industrial Area,
New Delhi 110015 and M/s Maharani Printers, 1/29 Nicholson Road,
Kashmere Gate, Delhi-110 006

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McGraw-Hill Offices

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Foreword

Chemistry in Engineering and Technology by Dr J C Kuriacose and Dr J Rajaram is not just another book for students of engineering and technology. Each one of the 22 chapters bears testimony to the fact that this book has sought to fulfil the objective of making the student of engineering and technology realize that chemistry, like physics, is the real base of his profession and that therefore he must have a good understanding of chemistry before he can use it in his profession. Along with this objective, the authors have achieved another goal. An interested student majoring in chemistry will find in this book certain aspects of chemistry which are not ordinarily accessible, and certain sections of a few chapters in this book can even be used by the student working for a Master's degree in chemistry.

The authors have succeeded in maintaining a good balance between the theoretical and applied aspects of the subject. About a little less than three-fourths of the book is devoted to the fundamental aspects of chemistry and the rest to applied chemistry. Clear presentation, emphasis on fundamentals, inclusion of problems, examples to illustrate important phenomena, interpretation of the physical significance of theoretical concepts and a reasonably good coverage of applied chemistry are some of the features of this very well-written book. The fields of inorganic chemistry, physical chemistry, organic chemistry and applied chemistry have been dealt with sufficient detail so that the student of engineering and technology has all that he needs to understand the subject.

In my opinion, the chapters on thermodynamics, phase equilibria electrochemistry, chemical kinetics and catalysis, photochemistry, water and its treatment, fuels, explosives and role of fuels, pollution of the environment and its control, corrosion and its prevention, and high polymers are particularly well-written. These chapters provide a sound, solid foundation needed for the understanding of the principles of chemistry and for the application of chemistry in engineering and technology. The other chapters in the book provide the necessary background information in sufficient detail. Students and teachers of chemistry who wish to acquire a reasonably good

mastery of the principles of chemistry and apply them in the practice of engineering and technology, will find this book very useful.

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Preface

Many of the new products of the chemical industry find applications in fields of engineering. With each successive year, the role of chemistry and chemical products in every branch of engineering is expanding greatly. The strength of materials, the chemical composition of substances, their behaviour when subjected to different treatments and environments, and the laws of heat and dynamic energy enter in almost every activity of modern life.

Today the disadvantages of over specialization in science and technology are increasingly evident. For those who recognize this, there is no need to justify the inclusion of chemistry in the engineering curriculum and for those who do not recognize this, justification may serve little purpose.

The engineer is engaged in the practical application of physical, chemical and other scientific principles in large-scale construction or operation of one type or the other. In a general sense, technology deals with methods and processes for converting materials available in nature into items of consumption and tools of production. The emergence of materials science as a discipline is an acknowledgement of the need to interpret the behaviour of materials in terms of their structure and properties. Such an interpretation is possible only if one has a reasonable acquaintance with chemical principles. The engineer and technologist dealing with materials must have some training in chemistry, a certain minimum, to prepare them for their profession, and as much in more required to help them attain the success to which their ambition prompts them. An education intended to prepare an engineer or a technologist cannot be sound if one made abstraction of the sources and foundations that make engineering practice and technology possible.

During our several years of teaching chemistry to students of engineering, we have found that there is hardly any single book that presents all the topics in chemistry that are relevant to the instruction of a student of engineering. We have felt that the effort the teacher has to put in teaching chemistry to the student of engineering may be reduced to a considerable extent and the quality of teaching improved, if a proper textbook designed

to meet the needs of the students is available. This has motivated us to write this book.

This book is written not only to help the students during their formal education, but also later on when they continue their education as practising engineers. While it is recognized that all the material in this book will not be used by some teachers in the institutions of engineering education, it is hoped that all teachers will find the material they require treated adequately in this book.

The properties of engineering materials rather than processes for their manufacture has received greater attention, though when the manufacturing process itself is determined by the properties of the materials, both receive adequate emphasis. The depth and breadth of the presentation of these topics has been at a level adequate to make the student appreciate the place of chemistry in his overall training as an engineer, and later in the practice of his profession. This book is written for those whose major interest is in fields other than chemistry and so is not meant to be a textbook of chemistry for a student desirous of specializing in the subject. One will therefore find certain areas of chemistry completely omitted or only cursorily dealt with.

One may notice a difference in the level of presentation of the chemistry of engineering materials and general chemistry. It is our belief that an engineer would like to know more about the advances and latest developments concerning materials that he uses. This has prompted us to maintain a difference in the level of treatment. To the extent possible, latest information available in contemporary textbooks and scientific literature has been included, without engaging in an exhaustive treatment of the several branches of chemistry, which would be out of place in a book with the limited objective that this one has.

We have assumed that the reader has an elementary knowledge of general chemistry. In the treatment of the various topics we have sought to maintain a rapport with the potential user, be he a teacher, a student or any other seeker of facts and orientations relating to the topics dealt with. We have attempted wherever possible to augment the understanding of the material presented within each chapter by introducing relevant problems right on the trails of the theoretical treatment.

In writing this book we have become indebted to several people who have written on the various topics we have selected. The help and encouragement we have received from our colleagues in the Department of Chemistry is gratefully acknowledged. We particularly wish to acknowledge the help we have received from our research scholars at various stages in the preparation of this book. Professor T J Varkey of the Karnataka Regional Engineering College, Suratkal, and Professor Sp. Shanmuganathan, Principal, Pachaiyappa's College, Madras, have been constant sources of encouragement. While acknowledging our gratitude to them, we record our particular thanks to Professor Sp Shanmuganathan for kindly writing

the Foreword to this book. Among the several others we must thank, we wish to make special mention of Shri G Lakshmikanthan, Shri K Buchi Babu, Shri S Arumugam, Shri M M Thomas and Shri K Gangadharan, without whose patient help and cooperation this book could not have been made ready for the publishers. Our gratitude is also due to the authorities of the Indian Institute of Techology, Madras, for permitting and encouraging this venture.

One of us (J.R.) is thankful to the authorities of the Indian Institute of Technology, Madras, for granting him sabbatical leave for one year, which enabled him to collect the necessary material for writing this book.

We will be very grateful to all those who will have the opportunity to examine this book, if they would point out any mistakes that might have remained undetected in spite of our best efforts and above all, if they could give us their suggestions for improvement.

J C KURIACOSE
J RAJARAM

Acknowledgements

Figures 6.30 and 6.32 taken from Glasstone, S and D Lewis: *Elements of Physical Chemistry*, Macmillan with permission of D Van Nostrand Company, Inc USA.

List of Symbols

A Area, Work function, Absorbance Mass number, A constant
A_s Surface area
a A constant, Activity, van der Waals constant
$a_\pm$ Mean ionic activity
a_0 Bohr radius
B A constant
b Breadth, van der Waals constant, A constant
C Mixing coefficient, conductance, A constant
C Coulomb
$\bar{C}$ Molar heat capacity
c Number of components, Concentration, Velocity of light, Velocity
[ ] Concentration in mol/litre
D Rate of diffusion, Dielectric constant, Optical density, Dissociation energy
D Debye
d Thickness distance, Deuteron
E Potential, Equivalent weight
E Energy, Einstein, Potential gradient, Electromotive force (EMF)
e^- Electron
e Electronic charge
F Formality of a solution
$\mathcal{F}$ Faraday (96500 C)
F Force
f Fugacity, Number of degrees of freedom
G Free energy
g Degeneracy, Acceleration due to gravity
g Gram
(g) gas
H Enthalpy
h Height, Planck's constant
I Intensity, Ionic strength, Moment of inertia
i Current, van't Hoff factor
J Joules
K Compressibility factor, Extinction coefficient, Equilibrium constant, A constant
k Rate constant, Boltzmann constant
L Latent heat per mole
L Avogadro number
(l) Liquid phase

l Length, Latent heat per gram
l litre
l Azimuthal quantum number
M Molecular weight
M Isotopic mass, molarity
m Mass, Molality, Magnetic quantum number
N Number of atoms (molecules), Normality, Normalizing constant
n Principal quantum number
n Number of moles, Neutron, Number
P Pressure
p Number of phases, Probability factor
p Partial pressure, Proton momentum
Q, q Heat absorbed, Partition function
Q Reaction quotient
R Rydberg constant, Resistance, Molar gas constant
(Re) Reynolds number
r Number of restrictions, Radius
r Radius vector
S Solubility in mole/lit, Entropy, Screening constant
(s) Solid phase
s Second
s Spin quantum number
T Temperature in K
t Temperature in deg, Celsius, Time
U Potential energy, internal energy
u Rate of fall, Speed (velocity) of anion, Mobility of anion, Velocity component along x-axis, Velocity
V Volt
V Volume
$\bar{V}$ Molar volume
Vi Ionization potential
(v) Vapour phase
v Rate, Velocity, Velocity component along y-axis
W Work function
w Weight, work, velocity component along z-axis
X A constant
$\bar{X}$ Partial molar property
x Amount of substance, Mole fraction x-axis, Distance along x-axis, Electronegativity
Y A constant
y Mole fraction of a substance in the vapour phase y-axis
Z Collision number, Atomic number
z Ionic charge, z-axis
α Mixing Coefficient, Coefficient of expansion, Alpha particle, Degree of dissociation
β Beta particle, Mixing coefficient, A constant
γ Gamma radiation (rays), Surface tension, Activity (fugacity) coefficient, Ratio of specific heats
ε Efficiency of an engine, Energy
Z Zeta potential
η Viscosity
η_d Dynamic viscosity
η_k Kinematic viscosity
θ Angle, Temperature, Fraction of surface covered, Reduced temperature
K Specific conductance

Λ Equivalent conductance
λ Ionic conductance, Wavelength
λ_d Decay constant
μ Chemical potential
μ_r Reduced mass
μ_d Dipole moment
μ_m Magnetic moment
μ_{JT} Joule-Thomson coefficient
ν Frequency, Neutrino
$\bar{\nu}$ Antineutrino, Wave number
π Reduced pressure, Osmotic pressure
ρ Density
ρ_r Radius ratio
ρ_s Specific resistance
σ Collision diameter
ϕ Reduced volume (ratio of volumes), Quantum yield, Ionic potential, Angle, Fluidity
ψ Wave function
ω Over voltage

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