

ENVIRONMENTAL CHEMISTRY

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NEW AGE

ENVIRONMENTAL CHEMISTRY



ANIL KUMAR DE
ARNAB KUMAR DE

This book has been thoroughly revised and updated in its present Eleventh Multicolour Edition. Striking a neat balance between environmental chemistry and environmental chemical analysis, the book explains the various dimensions of environmental chemistry including latest concepts and developments in the subject with global and user-friendly approach.

Notable additions/features:

- A new chapter, The Characteristics of Industrial Waste Effluents (Chap 15)
- Impact of Covid 19 on Environment (Chap 18)

With all these inputs, this book will scale new heights of popularity in the academic community comprising BSc. and MSc. students of Chemistry and Biochemistry as well as teachers in the respective subjects. As before, scientists, engineers and researchers will find it a valuable reference source in their profession.



Dr. Anil Kumar De, analytical and environmental chemist of international fame, was Professor & Head of Department of Chemistry and Dean of Science Faculty of Visva Bharati University, Santiniketan, West Bengal. After brilliant academic career in Calcutta University, he was post-doctorate Fellow in Indiana University, USA and University of Michigan, USA. On his return, he joined Jadavpur University as Reader in Chemistry for eleven years and thereafter joined Visva Bharati University. He set up School of Research in Analytical and Environmental Chemistry opening up frontiers in research areas, with prolific contributions in research journals of national and international fame. He has published about 130 research papers in national and international journals and guided 24 students for PhD degree. He is recipient of several awards in recognition of his research contributions—Acharya P.C. Ray Gold Medal (1981), Umacharan Banerjee Gold Medal (1979) of Calcutta University, Cooper Memorial Medal and H.K. Sen Memorial Medal (Institute of Chemistry, India, 1996) and Lifetime Achievement Award (Indian Chemical Society, 2007).

He started as an author of Monograph: "Separation of Heavy Metals", Pergamon Press, Oxford (1961) and also "Solvent Extraction of Metals" Van Nostrand, London (1970) which shot him into international fame. Side by side, he wrote textbooks, which received warm reception by college and universities all over India. As on date, he is the author of 25 books notably textbook of Inorganic Chemistry, Environmental Chemistry and series of books on Environmental Studies for various universities.



Dr. Arnab Kumar De is an Associate Professor of Chemistry, Raja Peary Mohan College Uttarpara (under University of Calcutta), West Bengal. He obtained Ph.D from Visva Bharati University. His research areas are water and air pollution monitoring and wastewater treatment. Previously Dr. De was associated with CSIR-Indian Institute of Toxicology Research and Central Pulp and Paper Research Institute. Dr. De has published 35 research papers in international journals and 55 popular scientific articles in science magazines. He is co-author of several textbooks—Inorganic Chemistry and Analysis, Environmental Studies (New Age International Publishers).

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MRP: ₹ 450.00

ISBN: 978-93-89802-80-1



9 789389 802801

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ANIL KUMAR DE
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ENVIRONMENTAL CHEMISTRY

[For BSc. (Hons.), BTech. & MSc. Students]

ELEVENTH
Multi Colour
EDITION

ANIL KUMAR DE

Former Professor and Head
Department of Chemistry and Dean of Science Faculty
Visva Bharati University, Santiniketan
West Bengal

ARNAB KUMAR DE

Associate Professor of Chemistry
Raja Peary Mohan College, Uttarpara
West Bengal



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New Age International (P) Ltd., Publishers

Published by New Age International (P) Ltd., Publishers

First Edition: 1987

Eleventh Multi Colour Edition: 2024

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C-23-10-13816

Printed in India at A.P Offset, Delhi.
Typeset at In-house, Delhi.

NEW AGE INTERNATIONAL (P) LIMITED, PUBLISHERS

7/30 A, Daryaganj, New Delhi-110002

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(CIN: U74899DL1966PTC004618)

TO

My (Late) Parents

*who encouraged me to proceed along a path
"where tireless striving stretches
its arms towards perfection"*

PREFACE TO THE ELEVENTH EDITION

The warm reception to this book since its inception (1987) led to publication of ten editions in quick succession (10th edition in 2022). This new 11th edition is well-equipped to meet the challenging requirements for the students and the faculties of Indian Universities/IITs/NITs/Engineering Colleges.

A new chapter, the characteristics of industrial waste effluents (Chap.15) has been added in this edition to discuss the nature of pollutants of different types of industries. The chapter on the impact of Covid-19 on the environment (Chap. 18) was introduced in the last edition which is further enlarged by addition of more materials (Air Quality Index during the pandemic, disposal of plastic waste, PPE and hand sanitizers etc. into the environment). Minor additions have been made in some other chapters.

The author is thankful to Mr. Saumya Gupta, Managing Director, M/s New Age International Publishers, New Delhi for prompt publication of the new edition. Thanks are due to Mr. Aurab K. De and Ms. Godhuli De for their supports during the revision of this book.

Udichi
Kolkata-700054

Arnab K De

PREFACE TO THE FIRST EDITION

In the 1980s, writing a book on environmental chemistry does not need any justification. A wave of the environmental consciousness and concern swept across the developed countries in the 60s and the developing countries including India in the late 70s. Whereas environmental science and technology have been firmly rooted in university curricula in advanced countries since the 60s, we in India are lagging far behind. The Bhopal disaster of 1984, one of the worst environmental disaster in history, focussed very bluntly on the need for environmental education in India. This book, the first of its kind in India, is a modest attempt by the author, based on 15 years of experience in environmental research and education to meet the challenging requirements of teaching environmental chemistry in our Universities.

The book is divided into 10 chapters, in a logical sequence and it strikes a reasonable balance between Environmental Chemistry and Environmental Chemical Analysis, which are of practical use to practising environmental scientists and engineers. This textbook has been designed for M.Sc. students of Chemistry/Biochemistry in Indian Universities. It will also serve as a model manual on environmental monitoring (air/water pollution) for all concerned in the field.

The author places on record his grateful appreciation for permission to reproduce some figures, tables and text material from: Willard Grant Press, Boston (*Environmental Chemistry*, S.E. Manahan, 3rd Ed. 1979).

The author is thankful to Shri A. Machwe, Director, M/s New Age International (P) Ltd., New Delhi, for his keen interest and kind offer to publish this book. He also owes thanks to Professor N.S. Bose, Vice-Chancellor, Visva-Bharati for kind encouragement. Last but not the least, author is grateful to his wife and children for their sacrifice and support.

Shantiniketan 731 235
Birbhum, West Bengal

Anil K De

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Introduction

“Give up greed and enjoy the bounties of Nature.” — *Ishopanishad*

1.1 THE DAWN OF THE UNIVERSE AND OF TIME

According to cosmologists, the dawn of the Universe started with **Big Bang** some 13.7 billion years ago (1 billion = 1000 million = 100 crores). The entire matter of the Universe was condensed into a tiny cloud of gas and dust, of the size of a tennis ball, which after consecutive expansions and contractions exploded with terrific force and release of energy. This is the phenomenon of the **Big Bang**.

Very recently (2005), astronomers (NASA's Goddard Space Flight Centre, Greenland under the leadership of Alexander Kashlinsky) reported in *Nature* that using **Spitzer Space Telescope**, they could capture the primordial light from the first Stars, which were formed after the Big Bang. An infra-red camera on the Spitzer Space Telescope took images of the constellation *Draco* after masking out all stars and galaxies to reveal the background glow from the first Stars (**Population III**). The cosmologists estimate that the Big Bang was 13.7 billion years ago and after some 200 million years, the *Population III Stars* were formed from cosmic particles and dust. Scientists are of the opinion that these clusters were more than 100 times massive than the Sun and hot, bright and relatively short-lived, each lasting a few million years compared to billion of conventional stars. The objects vanished long ago but their light is still travelling across the universe.

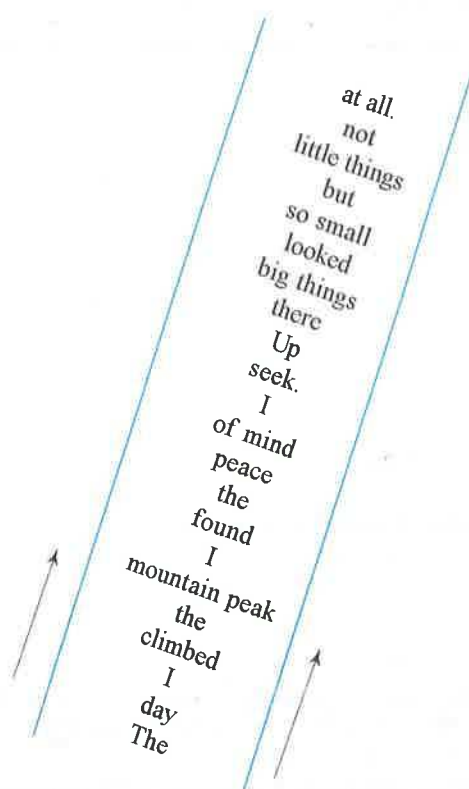


Fig. 1.1 The big bang

Figures 1.1, 1.2 and 1.3 illustrate the sequence of the dawn of the universe and time *i.e.*, sequence of the Big Bang events.

It may be noted that cosmology has been subjected to revised theories from time to time with advances in Space Telescopy and accordingly the age of the universe, which at present is estimated to be 13.7 billion years, was 6.5 billion years a few years back. This Edition logically uses the current estimate (13.7 billion years) replacing the last estimate (6.5 billion years).

*A. Kashlinsky *et al.* - *Nature* (2005): cited in *The Independent*, London – Steve Connor (Nov. 2005)



"There is enough on Earth for everybody's need, but not for everyone's greed."

[Mahatma Gandhi]

"Give up greed and enjoy the bounties of Nature."

[Ishopanishad—Ancient Vedic Text of India]

ENVIRONMENTAL CALENDAR

World Wetland Day	Feb. 2
World Forest Day	March 21
World Day for Water	March 22
World Meteorological Day	March 23
Earth Day	April 22
International Biodiversity Day	May 22
Anti-tobacco Day	May 31
World Environment Day	June 5
World Ocean Day	June 8
World Population Day	July 11
Ozone Week	Sept. 16–23
World Car-free Day	Sept. 22
Green Consumer Day	Sept. 23
World farm Animal's Day	Oct. 2
World Habitat Day	Oct. 3
World Animal Welfare Day	Oct. 4
Wildlife week	Oct. 1–7
World Conservation Day	Oct. 24
International Day for Natural Disaster Reduction	Oct. 13
International Day for Biological Diversity	Dec. 29

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