

Chemistry

Part I

Textbook for Class XI



11082



एन सी ई आर टी
NCERT

राष्ट्रीय शैक्षिक अनुसंधान और प्रशिक्षण परिषद्
NATIONAL COUNCIL OF EDUCATIONAL RESEARCH AND TRAINING

ISBN 81-7450-494-X (Part I)
81-7450-535-0 (Part II)

First Edition

March 2006 Phalguna 1927

Reprinted

October 2006 Kartika 1928
November 2007 Kartika 1929
January 2009 Magha 1930
December 2009 Pausa 1931
November 2010 Kartika 1932
January 2012 Pausa 1933
November 2012 Kartika 1934
November 2013 Kartika 1935
December 2014 Pausa 1936
May 2016 Vaishakha 1938
January 2018 Magha 1939
December 2018 Agrahayana 1940

PD 400T BS

© National Council of Educational
Research and Training, 2006

₹ ???.00

Printed on 80 GSM paper with NCERT
watermark

Published at the Publication Division
by the Secretary, National Council of
Educational Research and Training, Sri
Aurobindo Marg, New Delhi 110 016 and printed
at Chandra Prabhu Offset Printing Works (P.)
Ltd., C-40, Sector-8, Noida - 201 301 (U.P.)

ALL RIGHTS RESERVED

- No part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise without the prior permission of the publisher.
- This book is sold subject to the condition that it shall not, by way of trade, be lent, re-sold, hired out or otherwise disposed of without the publisher's consent, in any form of binding or cover other than that in which it is published.
- The correct price of this publication is the price printed on this page. Any revised price indicated by a rubber stamp or by a sticker or by any other means is incorrect and should be unacceptable.

**OFFICES OF THE PUBLICATION
DIVISION, NCERT**

NCERT Campus
Sri Aurobindo Marg
New Delhi 110 016 Phone : 011-26562708

108, 100 Feet Road
Hosdakere Halli Extension
Banashankari III Stage
Bengaluru 560 085 Phone : 080-26725740

Navjivan Trust Building
P.O. Navjivan
Ahmedabad 380 014 Phone : 079-27541446

CWC Campus
Opp. Dhankal Bus Stop
Panihati
Kolkata 700 114 Phone : 033-25530454

CWC Complex
Maligaon
Guwahati 781 021 Phone : 0361-2674869

Publication Team

Head, Publication Division : M. Siraj Anwar
Chief Editor : Shveta Uppal
Chief Business Manager : Gautam Ganguly
Chief Production Officer : Arun Chitkara
Editor : Binoy Banerjee
Production Assistant : Mukesh Gaur

Cover

Shveta Rao

Illustrations

Nidhi Wadhwa
Anil Nayal

FOREWORD

The National Curriculum Framework (NCF), 2005 recommends that children's life at school must be linked to their life outside the school. This principle marks a departure from the legacy of bookish learning which continues to shape our system and causes a gap between the school, home and community. The syllabi and textbooks developed on the basis of NCF signify an attempt to implement this basic idea. They also attempt to discourage rote learning and the maintenance of sharp boundaries between different subject areas. We hope these measures will take us significantly further in the direction of a child-centred system of education outlined in the National Policy on Education (1986).

The success of this effort depends on the steps that school principals and teachers will take to encourage children to reflect on their own learning and to pursue imaginative activities and questions. We must recognise that, given space, time and freedom, children generate new knowledge by engaging with the information passed on to them by adults. Treating the prescribed textbook as the sole basis of examination is one of the key reasons why other resources and sites of learning are ignored. Inculcating creativity and initiative is possible if we perceive and treat children as participants in learning, not as receivers of a fixed body of knowledge.

These aims imply considerable change in school routines and mode of functioning. Flexibility in the daily time-table is as necessary as rigour in implementing the annual calendar so that the required number of teaching days are actually devoted to teaching. The methods used for teaching and evaluation will also determine how effective this textbook proves for making children's life at school a happy experience, rather than a source of stress or boredom. Syllabus designers have tried to address the problem of curricular burden by restructuring and reorienting knowledge at different stages with greater consideration for child psychology and the time available for teaching. The textbook attempts to enhance this endeavour by giving higher priority and space to opportunities for contemplation and wondering, discussion in small groups, and activities requiring hands-on experience.

The National Council of Educational Research and Training (NCERT) appreciates the hard work done by the textbook development committee responsible for this book. We wish to thank the Chairperson of the advisory group in science and mathematics, Professor J.V. Narlikar and the Chief Advisor for this book, Professor B. L. Khandelwal for guiding the work of this committee. Several teachers contributed to the development of this textbook; we are grateful to their principals for making this possible. We are indebted to the institutions and organisations which have generously permitted us to draw upon their resources, material and personnel. As an organisation committed to systemic reform and continuous improvement in the quality of its products, NCERT welcomes comments and suggestions which will enable us to undertake further revision and refinement.

New Delhi
20 December 2005

Director
National Council of Educational
Research and Training



Under My Scheme

Thus, I claim that I am not an enemy of Higher Education. But I am an enemy of Higher Education as it is given in this country. Under my scheme, there will be more and better libraries, more and better laboratories, more and better research institutes. Under it, we should have an army of chemists, engineers and other experts who will be real servants of the nation and answer the varied and growing requirements of people who are becoming increasingly conscious of their rights and wants. And all these experts will speak, not a foreign language, but the language of the people. The knowledge gained by them will be the common property of the people. There will be truly original work instead of mere imitation. And the cost will be evenly and justly distributed.

- Harijan : 9 July 1938

TEXTBOOK DEVELOPMENT COMMITTEE

CHAIRPERSON, ADVISORY GROUP FOR TEXTBOOKS IN SCIENCE AND MATHEMATICS

J.V. Narlikar, *Emeritus Professor*, Chairman, Advisory Committee, Inter University Centre for Astronomy and Astrophysics (IUCCA), Ganeshbhind, Pune University, Pune

CHIEF ADVISOR

B.L. Khandelwal, *Professor (Retd.)*, *Emeritus Scientist*, CSIR; *Emeritus Fellow*, AICTE and formerly *Chairman*, Department of Chemistry, Indian Institute of Technology, New Delhi

MEMBERS

A. S. Brar, *Professor*, Indian Institute of Technology, Delhi

Anjni Koul, *Lecturer*, DESM, NCERT, New Delhi

H.O. Gupta, *Professor*, DESM, NCERT, New Delhi

I.P. Aggarwal, *Professor*, Regional Institute of Education, Bhopal

Jaishree Sharma, *Professor*, DESM, NCERT, New Delhi

M. Chandra, *Professor*, DESM, NCERT, New Delhi

Poonam Sawhney, *PGT (Chemistry)*, Kendriya Vidyalaya, Vikas Puri, New Delhi

R.K. Parashar, *Lecturer*, DESM, NCERT, New Delhi

S.K. Dogra, *Professor*, Dr. B.R. Ambedkar Centre for Biomedical Research, University of Delhi, Delhi

S.K. Gupta, *Reader*, School of Studies in Chemistry, Jiwaji University, Gwalior

Sadhna Bhargava, *PGT (Chemistry)*, Sardar Patel Vidyalaya, Lodhi Estate, New Delhi

Shubha Keshwan, *Headmistress*, Demonstration School, Regional Institute of Education, Mysuru

Sukhvir Singh, *Reader*, DESM, NCERT, New Delhi

Sunita Malhotra, *Professor*, School of Sciences, IGNOU, Maidan Garhi, New Delhi

V.K. Verma, *Professor (Retd.)*, Institute of Technology, Banaras Hindu University, Varanasi

V.P. Gupta, *Reader*, Regional Institute of Education, Bhopal

MEMBER-COORDINATOR

Alka Mehrotra, *Reader*, DESM, NCERT, New Delhi

ACKNOWLEDGEMENTS

The National Council of Educational Research and Training acknowledges the valuable contributions of the individuals and organisations involved in the development of Chemistry textbook for Class XI. It also acknowledges that some useful material from the reprint editions (2005) of Chemistry textbooks has been utilised in the development of the present textbook.

The following academics contributed effectively in editing, reviewing, refining and finalisation of the manuscript of this book: G.T. Bhandage, *Professor*, RIE, Mysuru; N. Ram, *Professor*, IIT, New Delhi; Sanjeev Kumar, *Associate Professor*, School of Science, IGNOU, Maidan Garhi, New Delhi; Shampa Bhattacharya, *Associate Professor*, Hans Raj College, Delhi; Vijay Sarda, *Associate Professor (Retd.)*, Zakir Husain College, New Delhi; K.K. Arora, *Associate Professor*, Zakir Husain College, New Delhi; Shashi Saxena, *Associate Professor*, Hans Raj College, Delhi; Anuradha Sen, Apeejay School, Sheikh Sarai, New Delhi; C. Shrinivas, *PGT*, Kendriya Vidyalaya, Pushp Vihar, New Delhi; D.L. Bharti, *PGT*, Ramjas School, Sector IV, R.K. Puram, New Delhi; Ila Sharma, *PGT*, Delhi Public School, Dwarka, Sector-B, New Delhi; Raj Lakshmi Karthikeyan, *Head (Science)*, Mother's International School, Sri Aurobindo Marg, New Delhi; Sushma Kiran Setia, *Principal*, Sarvodaya Kanya Vidyalaya, Hari Nagar (CT), New Delhi; Nidhi Chaudray, *PGT*, CRPF Public School, Rohini, Delhi; and Veena Suri, *PGT*, Bluebells School, Kailash Colony, New Delhi. We are thankful to them.

We express our gratitude to R.S. Sindhu, *Professor (Retd.)*, DESM, NCERT, New Delhi, for editing and refining the content of the textbook right from the initial stage.

We are also grateful to Ruchi Verma, *Associate Professor*, DESM, NCERT, New Delhi; Pramila Tanwar, *Assistant Professor*, DESM, NCERT, New Delhi; R.B. Pareek, *Associate Professor*, RIE, Ajmer; and A.K. Arya, *Associate Professor*, RIE, Ajmer, for refining the content of the textbook.

Special thanks are due to M. Chandra, *Professor and Head (Retd.)*, DESM, NCERT for her support.

The Council also gratefully acknowledges the contributions of Surendra Kumar, Narender Verma and Ramesh Kumar, *DTP Operators*; Subhash Saluja, Ramendra Kumar Sharma and Abhimanyu Mohanty, *Proofreaders*; Bhavna Saxena, *Copy Editor*; and Deepak Kapoor, *In-charge*, Computer Station, in shaping this book. The contributions of the Publication Department, NCERT, New Delhi, in bringing out this book are also duly acknowledged.

CONTENTS

	Foreword	iii
Unit 1	Some Basic Concepts of Chemistry	1
	1.1 Importance of Chemistry	4
	1.2 Nature of Matter	4
	1.3 Properties of Matter and their Measurement	6
	1.4 Uncertainty in Measurement	10
	1.5 Laws of Chemical Combinations	14
	1.6 Dalton's Atomic Theory	16
	1.7 Atomic and Molecular Masses	16
	1.8 Mole Concept and Molar Masses	18
	1.9 Percentage Composition	18
	1.10 Stoichiometry and Stoichiometric Calculations	20
Unit 2	Structure of Atom	29
	2.1 Discovery of Sub-atomic Particles	30
	2.2 Atomic Models	32
	2.3 Developments Leading to the Bohr's Model of Atom	37
	2.4 Bohr's Model for Hydrogen Atom	46
	2.5 Towards Quantum Mechanical Model of the Atom	49
	2.6 Quantum Mechanical Model of Atom	53
Unit 3	Classification of Elements and Periodicity in Properties	74
	3.1 Why do we Need to Classify Elements ?	74
	3.2 Genesis of Periodic Classification	75
	3.3 Modern Periodic Law and the present form of the Periodic Table	79
	3.4 Nomenclature of Elements with Atomic Numbers > 100	79
	3.5 Electronic Configurations of Elements and the Periodic Table	82
	3.6 Electronic Configurations and Types of Elements: <i>s</i> -, <i>p</i> -, <i>d</i> -, <i>f</i> - Blocks	83
	3.7 Periodic Trends in Properties of Elements	86

Unit 4	Chemical Bonding and Molecular Structure	100
4.1	Kössel-Lewis Approach to Chemical Bonding	101
4.2	Ionic or Electrovalent Bond	106
4.3	Bond Parameters	107
4.4	The Valence Shell Electron Pair Repulsion (VSEPR) Theory	112
4.5	Valence Bond Theory	117
4.6	Hybridisation	120
4.7	Molecular Orbital Theory	125
4.8	Bonding in Some Homonuclear Diatomic Molecules	129
4.9	Hydrogen Bonding	131
Unit 5	States of Matter	136
5.1	Intermolecular Forces	137
5.2	Thermal Energy	139
5.3	Intermolecular Forces vs Thermal Interactions	139
5.4	The Gaseous State	139
5.5	The Gas Laws	140
5.6	Ideal Gas Equation	145
5.7	Kinetic Energy and Molecular Speeds	147
5.8	Kinetic Molecular Theory of Gases	149
5.9	Behaviour of Real Gases: Deviation from Ideal Gas Behaviour	150
5.10	Liquefaction of Gases	152
5.11	Liquid State	154
Unit 6	Thermodynamics	160
6.1	Thermodynamic Terms	161
6.2	Applications	164
6.3	Measurement of ΔU and ΔH : Calorimetry	169
6.4	Enthalpy Change, $\Delta_r H$ of a Reaction – Reaction Enthalpy	171
6.5	Enthalpies for Different Types of Reactions	176
6.6	Spontaneity	181
6.7	Gibbs Energy Change and Equilibrium	186

Unit 7	Equilibrium	192
7.1	Equilibrium in Physical Processes	193
7.2	Equilibrium in Chemical Processes – Dynamic Equilibrium	196
7.3	Law of Chemical Equilibrium and Equilibrium Constant	198
7.4	Homogeneous Equilibria	201
7.5	Heterogeneous Equilibria	203
7.6	Applications of Equilibrium Constants	205
7.7	Relationship between Equilibrium Constant K , Reaction Quotient Q and Gibbs Energy G	208
7.8	Factors Affecting Equilibria	208
7.9	Ionic Equilibrium in Solution	212
7.10	Acids, Bases and Salts	213
7.11	Ionization of Acids and Bases	216
7.12	Buffer Solutions	226
7.13	Solubility Equilibria of Sparingly Soluble Salts	228
	Appendices	239
	Answer to some Selected Questions	253
	Index	259

Our National Anthem

*Jana-gana-mana adhinayaka, jaya he
Bharata-bhagya-vidhata.
Punjab-Sindh-Gujarat-Maratha
Dravida-Utkala-Banga
Vindhya-Himachala-Yamuna-Ganga
Uchchhala-jaladhi-taranga.
Tava shubha name jage,
Tava shubha asisa mage,
Gahe tava jaya gatha.
Jana-gana-mangala-dayaka jaya he
Bharata-bhagya-vidhata.
Jaya he, jaya he, jaya he,
Jaya jaya jaya, jaya he!*

Our National Anthem, composed originally in Bangla by Rabindranath Tagore, was adopted in its Hindi version by the Constituent Assembly as the national anthem of India on 24 January 1950.