

Chemistry

Part I
Textbook for Class XII

© NCERT
not to be republished

© NCERT
not to be republished



Chemistry

Part I

Textbook for Class XII



12085



एन सी ई आर टी
NCERT

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

ISBN 81-7450-648-9

First Edition

January 2007

Pausa 1928

Reprinted

November 2007

Kartika 1929

December 2008

Pausa 1930

January 2010

Magha 1931

January 2011

Magha 1932

January 2012

Magha 1933

January 2013

Magha 1934

November 2013

Kartika 1935

December 2014

Pausa 1936

December 2015

Pausa 1937

February 2017

Magha 1938

February 2018

Magha 1939

January 2019

Magha 1940

PD 400T BS

© **National Council of Educational
Research and Training, 2007**

₹ ????.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 Prabhat Packaging Pvt. Ltd.,
C-63, Industrial Area, Site-A, Mathura - 281 001
Uttar Pradesh

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 (Incharge)	: Arun Chitkara
Assistant Editor	: R.N. Bhardwaj
Production Assistant	: Sunil Kumar

Cover and Layout
Nidhi Wadhwa


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 November 2006

Director
National Council of Educational
Research and Training

© NCERT
not to be republished

PREFACE

Chemistry has made a profound impact on the society. It is intimately linked to the well-being of human kind. The rate of advancements in chemistry is so high that curriculum developers continuously look for strategies to cope with these advancements. Also, the students have to be inspired to be the future leaders who would make fundamental contributions. The present textbook is a sincere effort in this direction.

The structure of the textbook, presented in two parts, comprises of sixteen Units. Although the titles of various Units indicate a sort of compartmentalisation into physical, inorganic and organic chemistry, readers will find that these sub-disciplines have been intermingled, at least to a certain extent, to have a unified approach to the subject. The approach of presentation of the subject matter discourages students from rote memorisation. The subject has in fact, been organised around the laws and principles of chemistry. As students master these laws and principles, they will soon get to the point where they can predict much of what will come.

Efforts have been directed towards making the subject stimulating and exciting by references to the historical developments and its usefulness to our lives, wherever appropriate. The text is well illustrated with examples from surrounding environment to facilitate grasping of the qualitative and quantitative aspects of the concept easily. Physical data are given in SI units throughout the book to make comparison of various properties easier. IUPAC system of nomenclature has been followed along with the common system. Structural formulae of chemical compounds showing functional/coordinating groups in different colours are drawn using electronic system. Each Unit has a good number of examples, as illustrations, with their solutions and some intext questions, the answers of some of which are given at the end of the Unit. The end of Unit exercises are designed to apply important principles and provoke thinking process to solve them. Answers of some of these exercises are given at the end of the book.

A variety of materials, e.g., biographical sketches of some scientists, additional information related to a particular topic, etc., is given in boxes with a deep yellow coloured bar. This boxed material with a 'deep yellow bar' is to bring additional life to the topic. However, it is non-evaluative. The structures of some of the more complex compounds incorporated in the book are for understanding their chemistry. As their reproduction would lead to memorisation, it is also a non-evaluative portion of the text.

The information part has been significantly reduced and, wherever possible, it has been substantiated with facts. However, it is necessary for students to

be aware of commercially important chemicals, their process of manufacture and sources of raw materials. This leads to descriptive material in the book. Attempts have been made to make descriptions of such compounds interesting by considering their structures and reactivity. Thermodynamics, kinetics and electrochemical aspects have been applied to chemical reactions which should be beneficial to students for understanding why a particular reaction happened and why a particular property is exhibited by the product. There is currently great awareness of environmental and energy issues which are directly related to chemistry. Such issues have been highlighted and dealt with at appropriate places in the book.

A team of experts constituted by the NCERT has developed the manuscript of the book. It gives me great pleasure to acknowledge the valuable contribution of all the members of this team. I also acknowledge the valuable and relentless contribution of the editors in bringing the book to the present shape. I also acknowledge with thanks the dedicated efforts and valuable contribution of Professor Brahm Parkash, who not only coordinated the entire programme but also actively involved in writing and editing of this book. Thanks are also due to the participating teachers and subject experts of the review workshop for their contribution, which has helped us to make the book learner friendly. Also, I thank the technical and administrative staff of the NCERT for their support in the entire process.

The team of this textbook development programme hopes that the book stimulates its readers and makes them feel the excitement and fascination for this subject. Efforts have been made to bring out this book error-free. Nevertheless, it is recognised that in such a book of complexity, there could inevitably be occasional errors. It will always be a pleasure to hear about them from readers to take necessary steps to rectify them.

B.L. KHANDELWAL

TEXTBOOK DEVELOPMENT COMMITTEE

CHAIRMAN, ADVISORY GROUP FOR TEXTBOOKS IN SCIENCE AND MATHEMATICS

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

CHIEF ADVISOR

B.L. Khandelwal, *Professor, Director*, Disha Institute of Management and Technology, Raipur, Chhattisgarh. Formerly *Chairman*, Department of Chemistry, Indian Institute of Technology, New Delhi

MEMBERS

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

A.Q. Contractor, *Professor*, Department of Chemistry, Indian Institute of Technology, Powai, Mumbai

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

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

Brahm Parkash, *Professor*, DESM, NCERT, New Delhi

I.P. Agarwal, *Professor*, DESM, Regional Institute of Education, NCERT, Bhopal, M.P.

K.K. Arora, *Reader*, Department of Chemistry, Zakir Hussain College, University of Delhi, New Delhi

K.N. Upadhyaya, *Head (Retired)*, Department of Chemistry, Ramjas College, Delhi University, Delhi

Kavita Sharma, *Lecturer*, DEE, NCERT, New Delhi

M.P. Mahajan, *Professor*, Department of Chemistry, Guru Nanak Dev University, Amritsar, Punjab

M.L. Agarwal, *Principal (Retired)*, Kendriya Vidyalaya, Jaipur, Rajasthan

Puran Chand, *Professor, Joint Director (Retired)*, CIET, NCERT, New Delhi

R.A. Verma, *Vice Principal*, Shaheed Basant Kumar Biswas Sarvodaya Vidyalaya, Civil Lines, New Delhi

R.K. Verma, *Professor*, Department of Chemistry, Magadh University, Bihar

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

R.S. Sindhu, *Professor*, DESM, NCERT, New Delhi

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

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

Sarabjeet Sachdeva, *PGT*, (Chemistry), St. Columbas School, New Delhi

S. Badhwar, *Lecturer*, The Daly College, Indore, M.P.

V.N. Pathak, *Professor*, Department of Chemistry, University of Rajasthan, Jaipur, Rajasthan

Vijay Sarda, *Reader*, Department of Chemistry, Zakir Hussain College, University of Delhi, New Delhi

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

V.P. Gupta, *Professor*, DESM, Regional Institute of Education, NCERT, Bhopal, M.P.

EDITORIAL COMMITTEE

B.L. Khandelwal

Brahm Parkash

K.N. Upadhayaya

K.K. Arora

R.S. Sindhu

Vijay Sarda

MEMBER-COORDINATOR

Brahm Parkash, *Professor*, DESM, NCERT, New Delhi

ACKNOWLEDGEMENTS

The National Council of Educational Research and Training (NCERT) gratefully acknowledges the valuable contributions of the individuals and organisations involved in the development of Chemistry textbook for Class XII. The acknowledgements are also due to the following practicing teachers and subject experts for reviewing the draft manuscript and giving useful suggestions for its improvement in a workshop: Dr D.S. Rawat, Department of Chemistry, University of Delhi, Delhi; Dr Mahendra Nath, *Reader*, Chemistry Department, University of Delhi, Delhi; Dr Sulekh Chandra, *Reader*, Zakir Hussain College, New Delhi; Ms Ameeta K., *PGT (Chemistry)*, Vidyalaya No. 3, Patiala Cantt (Pb.); Dr G.T. Bhandge, *Professor and Head*, DESM, Regional Institute of Education, Mysore; Dr Neeti Mishra, *Senior Lecturer*, Department of Chemistry, Acharya Narendra Dev College, New Delhi; Dr. S.P.S. Mehta, Department of Chemistry, Kumaun University, Nainital (UA); Dr N.V.S. Naidu, *Assistant Professor (Chemistry)*, SVU College of Mathematics and Physical Sciences, S.V. University, Tirupati (A.P.); Dr A.C. Handa, Hindu College, Delhi University, Delhi; Dr A.K. Vashishtha, G.B.S.S.S. Jafrabad, Delhi; Dr Charanjit Kaur, *Head*, Department of Chemistry, Sri Sathya Sai College for Women, Bhopal, P.O. Habibganj; Ms Alka Sharma, *PGT (Chemistry)*, S.L.S. DAV Public School, Mausam Vihar, Delhi; Dr H.H. Tripathy, *Reader (Retired)*, Regional Institute of Education, Bhubaneswar; Shri C.B. Singh, *PGT (Chemistry)*, Kendriya Vidyalaya No. 2, Delhi Cantt, Delhi; Dr Neeti Mishra and Dr Sunita Hooda, Acharya Narendra Dev College, Delhi University, New Delhi.

The Council also thanks the Members of Editorial Committee for their unrelenting efforts in editing the manuscript and bringing it to the present shape.

The Council also acknowledges the contribution of Shri Vijay Singh, *Shri Narender Kr. Verma*, *DTP Operator*; Dr K.T. Chitralkha, *Copy Editor*; Shri Abhimanyu Mohanty, *Proof Reader*; Shri Deepak Kapoor, *Incharge*, Computer Station in shaping this book.

THE CONSTITUTION OF INDIA

PREAMBLE

WE, THE PEOPLE OF INDIA, having solemnly resolved to constitute India into a ¹**[SOVEREIGN SOCIALIST SECULAR DEMOCRATIC REPUBLIC]** and to secure to all its citizens :

JUSTICE, social, economic and political;

LIBERTY of thought, expression, belief, faith and worship;

EQUALITY of status and of opportunity; and to promote among them all

FRATERNITY assuring the dignity of the individual and the ²[unity and integrity of the Nation];

IN OUR CONSTITUENT ASSEMBLY this twenty-sixth day of November, 1949 do **HEREBY ADOPT, ENACT AND GIVE TO OURSELVES THIS CONSTITUTION.**

1. Subs. by the Constitution (Forty-second Amendment) Act, 1976, Sec.2, for "Sovereign Democratic Republic" (w.e.f. 3.1.1977)
2. Subs. by the Constitution (Forty-second Amendment) Act, 1976, Sec.2, for "Unity of the Nation" (w.e.f. 3.1.1977)

CONTENTS

FOREWORD	v
PREFACE	vii
Unit 1 The Solid State	1
1.1 General Characteristics of Solid State	2
1.2 Amorphous and Crystalline Solids	2
1.3 Classification of Crystalline Solids	4
1.4 Crystal Lattices and Unit Cells	7
1.5 Number of Atoms in a Unit Cell	12
1.6 Close Packed Structures	14
1.7 Packing Efficiency	20
1.8 Calculations Involving Unit Cell Dimensions	22
1.9 Imperfections in Solids	24
1.10 Electrical Properties	26
1.11 Magnetic Properties	29
Unit 2 Solutions	35
2.1 Types of Solutions	35
2.2 Expressing Concentration of Solutions	36
2.3 Solubility	39
2.4 Vapour Pressure of Liquid Solutions	43
2.5 Ideal and Non-ideal Solutions	47
2.6 Colligative Properties and Determination of Molar Mass	49
2.7 Abnormal Molar Masses	57
Unit 3 Electrochemistry	65
3.1 Electrochemical Cells	66
3.2 Galvanic Cells	67
3.3 Nernst Equation	70
3.4 Conductance of Electrolytic Solutions	75
3.5 Electrolytic Cells and Electrolysis	85
3.6 Batteries	88

3.7	Fuel Cells	90
3.8	Corrosion	91
Unit 4	Chemical Kinetics	95
4.1	Rate of a Chemical Reaction	96
4.2	Factors Influencing Rate of a Reaction	100
4.3	Integrated Rate Equations	105
4.4	Temperature Dependence of the Rate of a Reaction	112
4.5	Collision Theory of Chemical Reactions	116
Unit 5	Surface Chemistry	123
5.1	Adsorption	124
5.2	Catalysis	129
5.3	Colloids	136
5.4	Classification of Colloids	136
5.5	Emulsions	145
5.6	Colloids Around Us	145
Unit 6	General Principles and Processes of Isolation of Elements	149
6.1	Occurrence of Metals	152
6.2	Concentration of Ores	153
6.3	Extraction of Crude Metal from Concentrated Ore	155
6.4	Thermodynamic Principles of Metallurgy	156
6.5	Electrochemical Principles of Metallurgy	162
6.6	Oxidation Reduction	163
6.7	Refining	164
6.8	Uses of Aluminium, Copper, Zinc and Iron	166
Unit 7	The p-Block Elements	170
7.1	Group 15 Elements	170
7.2	Dinitrogen	174
7.3	Ammonia	175
7.4	Oxides of Nitrogen	177
7.5	Nitric Acid	179
7.6	Phosphorus – Allotropic Forms	180
7.7	Phosphine	181
7.8	Phosphorus Halides	182
7.9	Oxoacids of Phosphorus	184

7.10	Group 16 Elements	185
7.11	Dioxygen	189
7.12	Simple Oxides	190
7.13	Ozone	191
7.14	Sulphur – Allotropic Forms	192
7.15	Sulphur Dioxide	193
7.16	Oxoacids of Sulphur	194
7.17	Sulphuric Acid	195
7.18	Group 17 Elements	197
7.19	Chlorine	202
7.20	Hydrogen Chloride	204
7.21	Oxoacids of Halogens	205
7.22	Interhalogen Compounds	206
7.23	Group 18 Elements	208
Unit 8	The <i>d</i>- and <i>f</i>-Block Elements	215
8.1	Position in the Periodic Table	216
8.2	Electronic Configurations of the <i>d</i> -Block Elements	216
8.3	General Properties of the Transition Elements (<i>d</i> -Block)	218
8.4	Some Important Compounds of Transition Elements	231
8.5	The Lanthanoids	234
8.6	The Actinoids	237
8.7	Some Applications of <i>d</i> - and <i>f</i> -Block Elements	239
Unit 9	Coordination Compounds	244
9.1	Werner's Theory of Coordination Compounds	244
9.2	Definitions of Some Important Terms Pertaining to Coordination Compounds	247
9.3	Nomenclature of Coordination Compounds	248
9.4	Isomerism in Coordination Compounds	251
9.5	Bonding in Coordination Compounds	254
9.6	Bonding in Metal Carbonyls	261
9.7	Importance and Applications of Coordination Compounds	262
Appendices		268
Answers to Some Questions in Exercises		281
Index		285

Constitution of India

Part IV A (Article 51 A)

Fundamental Duties

It shall be the duty of every citizen of India —

- (a) to abide by the Constitution and respect its ideals and institutions, the National Flag and the National Anthem;
- (b) to cherish and follow the noble ideals which inspired our national struggle for freedom;
- (c) to uphold and protect the sovereignty, unity and integrity of India;
- (d) to defend the country and render national service when called upon to do so;
- (e) to promote harmony and the spirit of common brotherhood amongst all the people of India transcending religious, linguistic and regional or sectional diversities; to renounce practices derogatory to the dignity of women;
- (f) to value and preserve the rich heritage of our composite culture;
- (g) to protect and improve the natural environment including forests, lakes, rivers, wildlife and to have compassion for living creatures;
- (h) to develop the scientific temper, humanism and the spirit of inquiry and reform;
- (i) to safeguard public property and to abjure violence;
- (j) to strive towards excellence in all spheres of individual and collective activity so that the nation constantly rises to higher levels of endeavour and achievement;
- * (k) who is a parent or guardian, to provide opportunities for education to his child or, as the case may be, ward between the age of six and fourteen years.

Note: The Article 51A containing Fundamental Duties was inserted by the Constitution (42nd Amendment) Act, 1976 (with effect from 3 January 1977).

* (k) was inserted by the Constitution (86th Amendment) Act, 2002 (with effect from 1 April 2010).