# APPLIED CHEMISTRY

## (with Lab Manual)

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## FOREWORD

Engineering has played a very significant role in the progress and expansion of mankind and society for centuries. Engineering ideas that originated in the Indian subcontinent have had a thoughtful impact on the world.

All India Council for Technical Education (AICTE) had always been at the forefront of assisting Technical students in every possible manner since its inception in 1987. The goal of AICTE has been to promote quality Technical Education and thereby take the industry to a greater heights and ultimately turn our dear motherland India into a Modern Developed Nation. It will not be inept to mention here that Engineers are the backbone of the modern society - better the engineers, better the industry, and better the industry, better the country.

NEP 2020 envisages education in regional languages to all, thereby ensuring that each and every student becomes capable and competent enough and is in a position to contribute towards the national growth and development.

One of the spheres where AICTE had been relentlessly working from last few years was to provide high-quality moderately priced books of International standard prepared in various regional languages to all it's Engineering students. These books are not only prepared keeping in mind it's easy language, real life examples, rich contents and but also the industry needs in this everyday changing world. These books are as per AICTE Model Curriculum of Engineering & Technology – 2018.

Eminent Professors from all over India with great knowledge and experience have written these books for the benefit of academic fraternity. AICTE is confident that these books with their rich contents will help technical students master the subjects with greater ease and quality.

AICTE appreciates the hard work of the original authors, coordinators and the translators for their endeavour in making these Engineering subjects more lucid.

(**Anil D. Sahasrabudhe**)

# ACKNOWLEDGEMENT

The author(s) are grateful to AICTE for their meticulous planning and execution to publish the technical book for Diploma Engineering students.

We sincerely acknowledge the valuable contributions of the reviewer of the book Prof. Sunita Mukesh Patil, for making it students' friendly and giving a better shape in an artistic manner.

This book is an outcome of various suggestions of AICTE members, experts and authors who shared their opinion and thoughts to further develop the engineering education in our country.

It is also with great honour that we state that this book is aligned to the AICTE Model Curriculum and in line with the guidelines of National Education Policy (NEP) -2020. Towards promoting education in regional languages, this book is being translated in scheduled Indian regional languages.

Acknowledgements are due to the contributors and different workers in this field whose published books, review articles, papers, photographs, footnotes, references and other valuable information enriched us at the time of writing the book.

Finally, we like to express our sincere thanks to the publishing house, M/s. Khanna Book Publishing Company Private Limited, New Delhi, whose entire team was always ready to cooperate on all the aspects of publishing to make it a wonderful experience.

**Anju Rawlley**
**Devdatta Vinayakrao Saraf**

# PREFACE

Chemistry has been used for understanding and solving the intricacies of life. The advancement in chemistry is closely associated with the well being of all human beings and has made the life simpler and comfortable.

The textbook on "Applied Chemistry" has been developed as per AICTE model curriculum. This book is written, keeping in mind that basic concepts of chemistry should be comprehended in depth by budding diploma engineers, as these concepts may be applied in many of the engineering applications in industries and day to day life. The present text book is a sincere efforts in this direction.

Efforts have been made to make this book useful and interesting for learning, in self-learning mode. The structure of the textbook is comprehensive, wherein sixteen practical exercises are integral part of each theory units, from one to five.

Key feature of the book is that the text is presented in a very simple way with illustrations, examples, tables, flow charts, self-assessment questions with their solutions. Micro projects, points/issues for the creative inquisitiveness and curiosity, know more, video links, case study and summary points are integral part of different units to facilitate the students to develop the attitude of scientific inquiry, investigate the cause and effect relationship, systematic, scientific &logical thinking, ability to observe, analyse and interpret. All these abilities are essentially needed by diploma engineering passouts in the world of work.

Details of practicals listed in the curriculum of each unit are mentioned in a systematic format for ease of performance and implementation by students, laboratory personnel and teachers. Laboratory practical format is comprising of practical significance, relevant theory, stepwise procedure, safety precautions, sample probing questions for viva- voce etc. To meet the requirement of outcome based education (OBE) and outcome based assessment (OBA), criterion referenced testing (CRT) have been used as an integral part of assessment in each practical. For this, specific and measurable criteria of process and product assessment with their percentage weightage is included in each experiment. This would enable students, teachers and evaluators to know the criterion of performance and assessment of each experiment for attainment of out comes.

While every care has been taken to bring out this textbook error free. Nevertheless, there could inevitably be occasional errors. It would be our great pleasure to know from readers to make necessary modifications. Moreover, suggestions are welcome for the improvement of the book.

**Anju Rawlley**
**Devdatta Vinayakrao Saraf**

# OUTCOME BASED EDUCATION

Though, there are many challenges and issues in implementation and assessment of Outcome Based Education (OBE) and Outcome Based Curriculum (OBC), but the management and teachers need to ensure that the programme outcomes, as stated by NBA, for diploma engineering programme should be developed by the students, at the exit point of the diploma programme,through effective implementation and assessment of outcomes of different courses. The seven programme outcomes of the diploma engineering programme are as follows:

**PO1.** **Basic and Discipline Specific Knowledge:** Apply knowledge of basic mathematics, science and engineering fundamentals and engineering specialization to solve the engineering problems.

**PO2.** **Problem Analysis:** Identify and analyse well-defined engineering problems using codified standard methods.

**PO3.** **Design/ Development of Solutions:** Design solutions for well-defined technical problems and assist with the design of systems components or processes to meet specified needs.

**PO4.** **Engineering Tools, Experimentation and Testing:** Apply modern engineering tools and appropriate technique to conduct standard tests and measurements.

**PO5.** **Engineering Practices for Society, Sustainability and Environment:** Apply appropriate technology in context of society, sustainability, environment and ethical practices.

**PO6.** **Project Management:** Use engineering management principles individually, as a team member or a leader to manage projects and effectively communicate about well-defined engineering activities.

**PO7.** **Life-Long Learning:** Ability to analyse individual needs and engage in updating in the context of technological changes.

# COURSE OUTCOMES

After completion of the course the students will be able to:

CO-1: Solve various engineering problems applying the basic concepts of atomic structure, chemical bonding and solutions.

CO-2: Use relevant water treatment method to solve domestic and industrial problems.

CO-3: Solve the engineering problems using concepts of engineering materials and properties.

CO-4: Use relevant fuel and lubricants for domestic and industrial applications.

CO-5: Solve the engineering problems using concept of electrochemistry and corrosion.

| Course Outcomes | Expected Mapping with Programme Outcomes (1-Weak Correlation; 2-Medium correlation; 3-Strong Correlation) | | | | | | |
|---|---|---|---|---|---|---|---|
| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 |
| CO-1 | 3 | 2 | 1 | 1 | 2 | 1 | 1 |
| CO-2 | 3 | 3 | 2 | 3 | 2 | 3 | 2 |
| CO-3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 |
| CO-4 | 3 | 3 | 2 | 3 | 3 | 2 | 2 |
| CO-5 | 3 | 2 | 2 | 2 | 2 | 2 | 2 |

# ABBREVIATIONS AND SYMBOLS

## List of Abbreviations

| Abbreviations | Full form | Abbreviations | Full form |
|---|---|---|---|
| C.E. | Chemical Equivalent or Equivalent Weight | TAN | Total Acid Number |
| CO | Course Outcome | TEL | Tetra Ethyl Lead |
| EDTA | Ethylene Diamine Tetra Acetic acid | UO | Unit Outcome |
| HCV | Higher Calorific Value | VII | Viscosity Index Improvers |
| LCV | Lower Calorific Value | VM | Viscosity Modifiers |
| PO | Programme Outcome | Z or E.C.E. | Electrochemical Equivalent |
| RCC | Reinforced Cement Concrete | | |

# LIST OF SYMBOLS

| Symbols | Description |
|---|---|
| n | Principal Quantum Number |
| l | Angular Momentum or Azimuthal Quantum Number |
| m | Magnetic Quantum Number |
| $m_s$ | Spin Quantum Number |

## Units Used

| Abbreviations | Full form |
|---|---|
| B.Th.U/$ft^3$ | British Thermal Units Per Cubic Foot |
| B.Th.U./lb | British Thermal Units Per Pound |
| Cals/g | Calories Per Gram |
| C.H.U./lb | Centigrade Heat Unit Per Pound |
| $^0$Cl | $^0$Clark |
| $^0$Fr | $^0$French |
| K | Kelvin |
| K cals / kg | Kilocalories Per Kilogram |
| Kcal/$m^3$ | Kilocalories Per Cubic Meter |
| mg / L | Milligrams Per Litre |
| meq / L | Milliequivalent Per Litre |
| ppm | Parts Per Million |
| ppt | Precipitate |

# LIST OF FIGURES

## Unit 1

**Unit 2**



**Unit 3**

# LIST OF TABLES

## Unit 1



## Unit 2



## Unit 3

**Unit 4**



**Unit 5**

## Some Ionic Compounds (Electrovalent Compounds)

| Sr.No | Name | Formula | Ions present |
|---|---|---|---|
| 1. | Sodium Chloride | NaCl | $Na^+$ and $Cl^-$ |
| 2. | Potassium Chloride | KCl | $K^+$ and $Cl^-$ |
| 3. | Ammonium Chloride | $NH_4Cl$ | $NH_4^+$ and $Cl^-$ |
| 4. | Magnesium Chloride | $MgCl_2$ | $Mg^{2+}$ and $Cl^-$ |
| 5. | Calcium Chloride | $CaCl_2$ | $Ca^{2+}$ and $Cl^-$ |
| 6. | Sodium Oxide | $Na_2O$ | $Na^+$ and $O^{2-}$ |
| 7. | Magnesium Oxide | MgO | $Mg^{2+}$ and $O^{2-}$ |
| 8. | Calcium Oxide | CaO | $Ca^{++}$ and $O^{2-}$ |
| 9. | Aluminium Oxide | $Al_2O_3$ | $Al^{3+}$ and $O^{2-}$ |
| 10. | Sodium Hydroxide | NaOH | $Na^+$ and $OH^-$ |
| 11. | Copper Sulphate | $CuSO_4$ | $Cu^{2+}$ and $SO_4^{2-}$ |
| 12. | Calcium Nitrate | $Ca(NO_3)_2$ | $Ca^{2+}$ and $NO^{3-}$ |
| 13. | Aluminium Chloride | $AlCl_3$ | $Al^{3+}$ and $Cl^-$ |

## Some Covalent Compounds

| Sr. No. | Name | Formula | Present Atoms |
|---|---|---|---|
| 1. | Methane | $CH_4$ | C and H |
| 2. | Ethane | $C_2H_6$ | C and H |
| 3. | Ethylene | $C_2H_4$ | C and H |
| 4. | Ethyne (Acetylene) | $C_2H_2$ | C and H |
| 5. | Water | $H_2O$ | H and O |
| 6. | Ammonia | $NH_3$ | N and H |
| 7. | Ethyl Alcohol (Ethanol) | $C_2H_5OH$ | C, H and O |
| 8. | Hydrogen Chloride Gas | HCl | H and Cl |
| 9. | Hydrogen Sulphide Gas | $H_2S$ | H and S |
| 10. | Carbon Dioxide | $CO_2$ | C and O |
| 11. | Carbon Disulphide | $CS_2$ | C and S |
| 12. | Carbon Tetrachloride | $CCl_4$ | C and Cl |
| 13. | Glucose | $C_6H_{12}O_6$ | C, H and O |
| 14. | Cane Sugar | $C_{12}H_{22}O_{11}$ | C, H and O |
| 15. | Urea | $CO(NH_2)_2$ | C, O, N and H |
| 16. | Benzene | $C_6H_6$ | C and H |
| 17. | Hydrogen Gas | $H_2$ | H |
| 18. | Chlorine Gas | $Cl_2$ | Cl |
| 19. | Oxygen gas | $O_2$ | O |

## Some Common Salts Present in Water

| Sr.No | Name | Formula | Ions present |
|---|---|---|---|
| 1 | Calcium Carbonate | $CaCO_3$ | $Ca^{2+}$ and $CO_3^{2-}$ |
| 2 | Magnesium Carbonate | $MgCO_3$ | $Mg^{2+}$ and $CO_3^{2-}$ |
| 3 | Calcium Bicarbonate | $Ca(HCO_3)_2$ | $Ca^{2+}$ and $HCO_3^{-}$ |
| 4 | Magnesium Bicarbonate | $Mg(HCO_3)_2$ | $Mg^{2+}$ and $HCO_3^{-}$ |
| 5 | Calcium Chloride | $CaCl_2$ | $Ca^{2+}$ and $Cl^{-}$ |
| 6 | Magnesium Chloride | $MgCl_2$ | $Mg^{2+}$ and $Cl^{-}$ |
| 7 | Calcium sulphate | $CaSO_4$ | $Ca^{2+}$ and $SO_4^{2-}$ |
| 8 | Magnesium sulphate | $MgSO_4$ | $Mg^{2+}$ and $SO_4^{2-}$ |
| 9 | Ferrous Chloride | $FeCl_2$ | $Fe^{2+}$ and $Cl^{-}$ |
| 10 | Ferrous Sulphate | $FeSO_4$ | $Fe^{2+}$ and $SO_4^{2-}$ |
| 11 | Manganese Chloride | $MnCl_2$ | $Mn^{2+}$ and Cl- |
| 12 | Manganese Sulphate | $MnSO_4$ | $Mn^{2+}$ and $SO_4^{2-}$ |
| 13 | Calcium Silicate | $CaSiO_3$ | $Ca^{2+}$, $Si^{4+}$ and $O_2^{-}$ |
| 14 | Magnesium Silicate | $MgSiO_3$ | $Mg^{2+}$, $Si^{4+}$ and $O_2^{-}$ |
| 15 | Sodium Carbonate | $Na_2CO_3$ | $Na^{+}$ and $CO_3^{2-}$ |
| 16 | Sodium Sulphate | $Na_2SO_4$ | $Na^{+}$ and $SO_4^{2-}$ |
| 17 | Potassium Chloride | KCl | $K^{+}$ and $Cl^{-}$ |
| 18 | Potassium Carbonate | $K_2CO_3$ | $K^{+}$ and $CO_3^{2-}$ |
| 19 | Potassium Sulphate | $K_2SO_4$ | $K^{+}$ and $SO_4^{2-}$ |
| 20 | Calcium Hydrogen Phosphates | $CaHPO_4$ | $Ca^{2+}$, $HPO_4^{2-}$ |

# GUIDELINES FOR TEACHERS

To implement Outcome Based Education (OBE), knowledge level and skill set of the students should be enhanced. Teachers should take a major responsibility for the proper implementation of OBE. Some of the responsibilities (not limited to) for the teachers in OBE system may be as follows:

- Within reasonable constraint, they should manoeuvre time to the best advantage of all students.
- They should assess the students only upon certain defined criterion without considering any other potential ineligibility to discriminate them.
- They should try to grow the learning abilities of the students to a certain level before they leave the institute.
- They should try to ensure that all the students are equipped with the quality knowledge as well as competence after they finish their education.
- They should always encourage the students to develop their ultimate performance capabilities.
- They should facilitate and encourage group work and team work to consolidate newer approach.
- They should follow Blooms taxonomy in every part of the assessment.

## Bloom's Taxonomy

| Level | Teacher should Check | Student should be able to | Possible Mode of Assessment |
|---|---|---|---|
| **Creating** | Students ability to create | Design or Create | Mini project |
| **Evaluating** | Students ability to Justify | Argue or Defend | Assignment |
| **Analysing** | Students ability to distinguish | Differentiate or Distinguish | Project/Lab Methodology |
| **Applying** | Students ability to use information | Operate or Demonstrate | Technical Presentation/ Demonstration |
| **Understanding** | Students ability to explain the ideas | Explain or Classify | Presentation / Seminar |
| **Remembering** | Students ability to recall (or remember) | Define or Recall | Quiz |

# GUIDELINES FOR STUDENTS

Students should take equal responsibility for implementing the OBE. Some of the responsibilities (not limited to) for the students in OBE system are as follows :

- Students should be well aware of each UO before the start of a unit in each and every course.
- Students should be well aware of each CO before the start of the course.
- Students should be well aware of each PO before the start of the programme.
- Students should think critically and reasonably with proper reflection and action.
- Learning of the students should be connected and integrated with practical and real life consequences.
- Students should be well aware of their competency at every level of OBE.

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