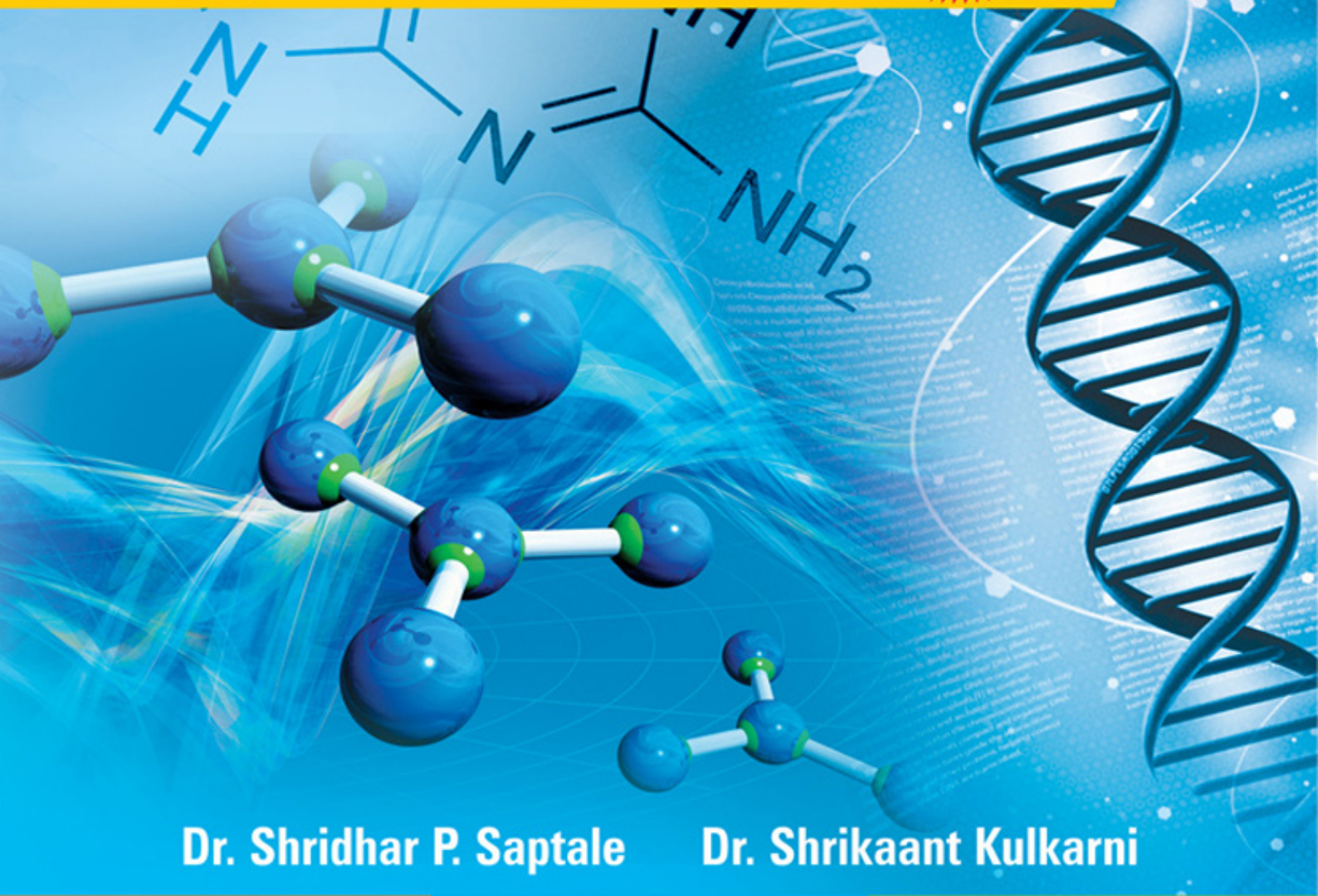
SPPU First Year Engineering (F.E.)

ENGINEERING CHEMISTRY

Common to all branches

- All important syllabus topics at your finger tips
- Important diagrams to remember
- Important questions & answers frequently asked in University Exam

Free MCQ's included



Dr. Shridhar P. Saptale Dr. Shrikaant Kulkarni

Gigatech Publishing House
Igniting Minds

Engineering Chemistry

Semester I
First Year Engineering Common to All Branches
As per the new revised syllabus of SSPU. w.e.f. academic year 2012-2013

Dr. Shridhar P Saptale

M.Sc. M.Phil. Ph.D.

Assistant Professor, FE Co-ordinator
Sinhgad Academy of Engineering,
Kondhwa, Pune - 48

Dr. Shrikaant Kulkarni

M.Sc., M.Phil, Ph.D. M.B.A. MA (ECO.)
MA (Pol.), PGDHE, D.I.P., D.P.Ed.

Asst. Prof. Chemistry, Vishwakarma
Institute of Technology, Pune

Gigatech Publishing House
Igniting Minds

Engineering Chemistry

First Year Engineering Common to All Branches

As per new revised syllabus of SPPUw.e.f. academic year 2012-2013

Dr. Shrikaant Kulkarni, Dr. Shridhar P. Saptale

First Edition:2017

Published By –

Gigatech Publishing House

631/32, Budhawar Peth,

Office No. 105, First Floor, Shan Bramha Complex, Pune – 411 002.

Phone No. 952 952 0952

ISBN NO. : 978-81-934-1404-0

Price : ₹ 250/–

Available at All Leading Book Stalls

Distributor :

PRADEEP BOOK DISTRIBUTORS

102/3, 1ST Floor, Shan Bramha Complex,
Pune. Telephone No. 020 – 24458333,
942 208 7031 / 844 699 5959

E-mail : pbd0909@gmail.com

Note: For any queries, doubts, suggestions & complaints regarding the subject, please feel free to contact on the below e-mail or phone number.We will be more than thankful for your feedback.

Ph: 952 952 0952 **E-mail : info.gigatech1@gmail.com**

Preface

This book 'Engineering Chemistry' is intended to be a textbook for students of first year engineering of Savitribai Phule Pune University. In most Sciences, one generation years down what another has built and what one has established another undoes. In Chemistry alone, each generation adds a new story to the old structure. Keeping this in mind, this book is written to have a better introduction of the Chemistry. This book is presented with simple but exact explanation of subject matter, application of each topic to real-life, engineering problems, large number of illustrative examples followed by well graded exercises. We hope that the students will not only learn some powerful Chemistry concept, but also will develop their ability to understand the concept and apply it properly to solve engineering problems. We feel that faculty members will also enjoy reading this book which is enriched with applications of each topic.

Acknowledgement

We express our sincere thanks to Hon. Prof. M. N. Navale, Founder-President STES, Hon. Dr. (Mrs.) Sunanda M. Navale, Founder- Secretary STES, Hon. Mr Rohit Navale, Vice president (HR), STES and Hon. Mrs. Rachana Navale – Ashtekar, Vice President (Admin), STES as they are constant source of inspiration to us right from the first day of our teaching carreer. We would also like to thank Principal SCOE, SKNCOE, NBNSOE, SAE, SITS, RMDSOE, SIT, SKNSITS for their co-operation and support. We would also thank our department colleagues for their suggestions and timely help.

Any suggestions for the improvement of this book will be sincerely acknowledged and incorporated in the next edition.

We are thankful to Mr. Harshal J Potadar and Rohit K Dongare from **Gigatech Publishing House (GPH)** for their continuous support and patience in preparing this book.

SYLLABUS

Unit - I : Water technology and Green Chemistry (08 Hrs.)

Water technology : Impurities in water. Hardness of water and its determination by EDTA method, Alkalinity of water and its determination. Numericals. III effects of hard water in boilers. Boiler feed water treatment : (1) Internal treatment : calgon, colloidal and phosphate conditioning, (2) External treatment : (a) Zeolite process and its numericals (b) Ion exchange method. Desalination of brackish water / Purification of water by Reverse osmosis and Electrodialysis.

Green Chemistry : Definition, goals of green chemistry. efficiency parameters, need of Green Chemistry Major uses traditional and green pathways of synthesis of adipic acid, polycarbonate, indigo dye

Unit - II : Electro analytical techniques (08 Hrs.)

Introduction : Types of reference electrode (calomel electrode), indicator electrode (glass electrode), ion selective electrode, Half cell reaction and complete cell reaction.

Conductometry : Introduction, Kohlrausch's law, conductivity cell, measurement of conductance, Applications - Conductometric titrations, acid-base titrations, precipitation titrations.

pH-metry : Preparation of Buffers, standardization of pH meter, mixture of acids verses strong base titration, differential plots.

Potentiometry : Introduction, Potentiometric titrations - differential plots, Applications – redox titrations Fe/Ce titration.

UVNisible spectroscopy : Interaction of radiation with matter, Beer lambert's law. chromophore and auxochrome, types of electronic transitions. Instrumentation and principle -block diagram of single

and double beam spectrophotometer. Applications of uv-visible spectroscopy.

Unit – lll : Synthetic Organic Polymers (08 Hrs.)

Introduction, functionality of monomer, polymerization - free radical mechanism and step growth polymerization. Concept and significance of - Average molecular weight, crystallinity in polymers, Tm and Tg. Thermoplastic and Thermosetting polymers. Compounding of plastics. Techniques of polymerization, Preparation, properties and engineering applications of : Polyethylene (LDPE and HDPE) and Epoxy resin. Elastomers - natural rubber - processing and vulcanization by sulphur. Synthetic rubbers - SBR.

Specialty polymers : Engineering thermoplastics - Polycarbonate, Biodegradable polymers-Poly (hydroxybutarate- hydroxyvalanate), Conducting polymers - Polyacetyiene. Electroluminscent polymers - Polyphenylenevinylene, Liquid crystalline polymers - Polymer composites - Fibre reinforced plastic (FRP).

Unit - IV: Fuels and combustion (08 Hrs.)

Fossil Fuels : Definition, Calorific values, Determination- Bomb calorimeter, Boy's gas calorimeter, Numericals. Solid Fuel- Coal- Proximate and ultimate analysis. Numericals. Liquid fuels- Petroleum Composition and refining. Octane number of petrol, Cetane number of Diesel, Power alcohol, Biodiesel. Gaseous fuel- Composition, properties and applications of NG, CNG, LPG.

Combustion : Chemical reactions, calculations for air required. Numericals.

Fuel cells : Definition, Advantages and limitations, phosphoric acid fuel cell, polymer electrolyte membrane fuel cell.

Unit - V : Chemistry of Hydrogen and carbon (08 Hrs.)

Chemistry of Hydrogen : The element- isotopes- importance. Methods of preparation - (1) laboratory- from aqueous acid and alkali. (2) Industrial -steam reforming of methane and coke electrolysis of water. (3) From solar energy (water splitting). Storage- chemical (sodium alanates), physical (carbon materials), difficulties in storage and transportation. Compounds of hydrogen, methods of preparation and applications - (a) Molecular hydrides - hydrocarbons, silane, germane, ammonia. (b) Saline hydrides - LiH, NaH. Applications of Hydrogen, Hydrogen as a future fuel. Chemistry of Carbon : Position in periodic table, occurance, isotopes. Allotropes (crystalline and amorphous) - occurrence, structure based on bonding and applications in detail.

Unit - VI : Corrosion Science (08 Hrs.)

Introduction, Types of corrosion : Dry corrosion - mechanism, Pilling-bed worth rule. Wet corrosion-mechanism. Factors influencing corrosion - Nature of method , Nature of environment. Methods of corrosion control : Pourbaix diagram, Cathodic and anodic protection. Use of inhibitors, Protective coatings : surface preparation, (a) Metallic coatings : Types of coatings, methods of applications, (hot dipping, cladding, electroplating and cementation), Electro less coatings, Non-metallic coatings : chemical conversion coatings, powder coatings.

CONTENTS

1. Water Technology and Green Chemistry 1.1 – 1.41

1.1 Introduction
1.2 Impurities in water
1.2.1 Chemical Analysis of water
1.3 Hardness
1.3.1 Hardness is classified broadly into following two types
1.3.2 Units of hardness
1.4 EDTA method for hardness determination
1.4.1 Singnificance of hardness determination
1.4.2 Principle
1.4.3 Method
1.5 Alkalinity determination
1.6 III effects of using hard water in boilers
1.6.1 Scale and sludge formation
1.6.2 Boiler Corrosion
1.6.3 priming and foaming : Explain
1.6.4 Caustic Embrittlement
1.7 Water Treatments
1.7.1 Zeolite or permutit process.
1.7.2 demineralization or Deionization or lon-exchange process
1.8 Industrial waste water treatment methods :
1.8.1 Principle
1.8.2 Electrodialysis
1.9 Green Chemistry
1.9.1 Principle of green chemistry
1.9.2 Goals of green chemistry
1.9.3 major uses
1.9.4 Traditional and Green Pathways of synthesis of

2. Electro Analytical Techniques 2.1 – 2.43

2.1 Introduction to Analytical Techniques
2.2 Electro Analytical Techniques
2.3 Calomel Electrode
2.3.1 Construction
2.4 Indicator electrode
2.4.1 The Glass Electrode for pH Measurements
2.4.2 Construction
2.4.3 Membrane Indicator Electrodes or ion selective electrodes
2.5 Conductometry

2.5.1 Definition of terms
2.5.2 Factors affecting conductivity:
2.6 Conductivity cell
2.7 Kohlrausch's law
2.7.1 Statement
2.7. 2 Applications of the Kohlrausch's law
2.8 Conductometric Titrations
2.8.1 Some Typical Conductometric Titration Curves are:
2.8.2 Precipitation Titration :
2.9 Preparation of Buffers
2.9.1 Buffer Capacity :
2.9.2 Buffer Range
2.10 Potentiometry
2.10.1 Introduction
2.10.2 General Principle
2.11 Potentiometric measurement
2.12 Potentiometric Titrations
2.12.1 End-Point Detection with Potentiometric Titrations :
2.12.2 Redox titration
2.13 Spectroscopy
2.14 Nature of electromagnetic radiation
2.14.1 Characteristics of electromagnetic radiation:
2.14. 2 The Electromagnetic Spectrum
2.15 The UV-Visible Spectroscopy :
2.15.1 Principle :
2.15.2 The Ultraviolet Spectrum:
2.15.3 Types of electronic transitions :
2.16 Absorptions laws :
2.16.1 Lambert's law
2.16.2 Beer's law:
2.16.3 Limitations of the Beer-Lambert law
2.17 Important useful terms concerning UV spectroscopy :
2.18 Instrumentation for UV-Vis Spectroscopy :
2.18.1 Radiation source :
2.19 Monochromator :
2.19.1 Prism as a Monochromator:
2.19.2 Grating as a monochromator :
2.20 Cells or Cuvettes :
2.21 Concentration of solution :
2.22 Functioning of spectrophotometer :
2.23 Applications of UV spectroscopy :

3. Synthetic Organic Polymers. 3.1 – 3.34

3.1 Introduction
3.2 Polymer
3.2.1 Monomers
3.2.2 Functionality of Monomers
3.3 Degree of Polimerization.
3.3.1 Polimerization.
3.3.2 Free radical polymerization (Chain) Polimerization
3.3.3 Initiator
3.4 Concept and Significance of Average molecular weight of polymer
3.5 Crystallinity in Polymers
3.6 Glass transition temperature (Tg)
3.7 Thermoplastic and thermosetting polymers :
3.7.1 Thermosetting polymers
3.7.2 Compounding of plastics
3.8 Techniques of polymerization
3.9 Preparation, properties and applications of POLYETHYLENE
3.9.1 POLYETHYLENE (PE)
3.10 Epoxy Resin
3.10.1 Properties
3.10.2 Applications
3.11 Rubbers
3.11.1 History of Rubber : Elastomer : Natural Rubber
3.11.2 Reaction of poly isoprene(natural rubber)
3.11.3 Drawbacks of natural rubber
3.12 VULCANISATION OF RUBBER
3.12.1 Origin & Development of Vulcanization Process
3.12.2 Vulcanization Reaction
3.13 SYNTHETIC RUBBERS
3.13.1 Styrene-Butadience-Rubber(SBR)
3.13.2 Preparation
3.13.3 Properties of SBR
3.14 Specialty polymers
3.15 Biodegradable polymers
3.15.1 Conducting polymers
3.16 Liquid Crystal polymers (LCP)
3.17 Liquid Crystal Phase
3.17.1 Types of Liquid Crystals
3.18 Electroluminescent polymers
3.18.1 Mechanism
3.18.2 (PPV or polyphenylene vinylene)
3.18.3 Fibre reinforced plastic (FRP) as a polymer composite

4. Fuel and Combustion 4.1 – 4.46

4.1 Introduction
- 4.1.1 Definitions of Fuels
- 4.1.2 Classification of Fuels

4.2 Characteristics of an ideal fuel

4.3 Calorific value
- 4.3.1 Experimental Determination of Calorific value

4.4 Bomb Calorimeter
- 4.4.1 Principle
- 4.4.2 Construction
- 4.4.3 Working
- 4.4.4. Calculation

4.5 Boy's gas Calorimeter
- 4.5.1 Principle
- 4.5.2 Construction
- 4.5.3 Working
- 4.5.4 Calculation

4.6 Solid fuels
- 4.6.1 Coal
- 4.6.2 Types of Coal
- 4.6.3 Proximate Analysis
- 4.6.4 Liquid fuels
- 4.6.5 Classification of petroleum
- 4.6.6 Origin of Petroleum
- 4.6.7 Mining of petroleum

4.7 Refining of crude oil

4.8 principal products

4.9 Chemical structure and knocking

4.10 Improvement of anti-knock characteristics of a fule

4.11 Cetane number or Cetanerating

4.12 Power Alcohol
- 4.12.1 Manufacture of power Alcohol
- 4.12.2 Advantages of alcohol blended fuel
- 4.12.3 Disadvantages of the alcohol blended petrol

4.13 Biodiesel
- 4.13.1 Preparation
- 4.13.2 Properties

4.14 Gaseous fuels
- 4.14.1 natural Gas
- 4.14.2 properties
- 4.14.3 Uses
- 4.14.4 Compressed Natural Gas (CNG)

4.14.5 Drawbacks
4.14.6 CNG compared to LNG
4.14.7 Liquefied natural gas (LNG)
4.15 Liquefied Petroleum Gas (LPG)
4.16 Combustion
4.17 Calculation of air
4.18 Fuel cell
4.18.1 Definition
4.18.2 General Construction
4.18.3 Types of fuel cells
4.18.4 Polymer electrolyte membrane fuel cell
4.18.5 Advantages
4.18.6 Limitation
4.18.7 Phosphoric acid fuel cell

5. Chemistry of Hydrogen And Carbon 5.1 – 5.26

5.1 Introduction
5.1.1 PROPERTIES OF HYDROGEN
5.1.2 ISOTOPES OF HYDROGEN
5.1.3 Applications of Isotopes
5.2 methods of Preparation of hydrogen
5.3 Difficulties in storage and transportation
5.3.1 Storage and transportation of H_2-
5.3.2 Physical Storage in the form carbon materials
5.4 Applications of Hydrogen
5.5 Compounds of Hydrogen
5.5.1 Saline hydrides
5.5.2 Lithium Hydride (LiH)
5.6 ISOTOPES OF CARBON
5.7 ALLOTROPES OF CARBON
5.7.1 Diamond
5.7.2 Graphite
5.7.3 FULLERENE
5.8 CARBON NANOTUBES

6. Corrosion 6.1 – 6.31

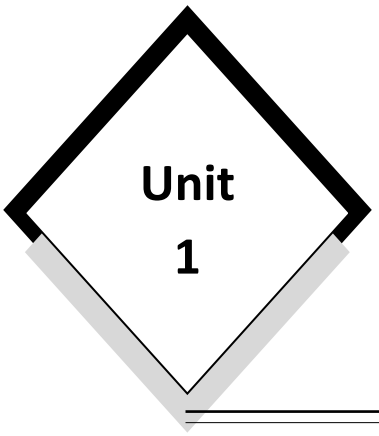
6.1 Definition
6.2 Causes of corrosion
6.3 types of corrosion
6.3.1 Dry or atmospheric
6.4 Mechanism
6.5 Pilling – Bedworth rule
6.6 Mechanism of wet or electrochemical corrosion
6.7 Galvanic series

6.8 actors influencing corrosion
6.8.1 Nature of the corroding environment
6.9 Pourbaix Diagram
6.10 Methods of corrosion control
6.10.1 Cathodic protection
6.102 ANODIC PROTECTION
6.10.3 use of linhobitors
6.10.4 Anodic Inhibotors
6.10.5 Cathodic Inhibitors
6.10.6 Vapour Phase inhibitors
6.107 protective coatings
6.11 Surface peaparation
6.12 Metallic Coating
6.12.1 types of metallic coatings
6.12.2 Methods of applications of metallic
6.13 ELECTROLESS PLATIN
6.13.1 Principle
6.13.2 electroless nickel plating
6.13.3 preparation of plating bath
6.14 Non metallic coatings-
6.15 Powder Coating

QUESTIONS PAPERS DEC-2012 TO MAY-2015 1-9

MCQ 1-78

♦♦♦



Water Technology and Green Chemistry

: Syllabus :

Water Technology : Impurities in water. Hardness of water and its determination by EDTA method. Alkalinity of water and its determination, Numericals. It effects of hard water in boilers. Boiler feed water treatment 1) Internal treatment- calgon, coliodial and phosphate condition, 2) External treatment- a) Zeolite process & its numerical b) On exchange method. Desalination of brackish water/Purification of water by Reverse osmosis and Electrodialysis.

Green Chemistry : Definition, goals of green chemistry, efficiency parameters, need of Green Chemistry Major uses traditional and green pathways of synthesis of adipic acid, polycarbonate, indigo dye.

Part A.Water Technology

1.1 Introduction

Water is life and although it is precious still it is most misused compound available on the earth. Earth is called as a blue planet because $3/4^{th}$ of earth's surface was found to be covered with water. Over the years however it has been most misused and overused for domestic, industrial and agricultural purposes. The situation is alarming as a fallout of it. There has been a scarcity of water in many parts of the country. Had it been used judiciously and sustainably it would not have been the same precarious situation we are facing today. It is not only surface water but also underground water table too has gone down substantially. The masses have

realized of late the conservation of every drop of water and sustainable use of it. The initiatives like drip irrigation and sprinklers etc. in agriculture, cultivation of crops and industrial processes and household activities consuming less water have been gaining momentum.

Engineers need to develop tools, techniques, and evolve at practices which will not only conserve water but also foster sustainable use of it which will not compromise with the needs of the future generations.

1.2 Impurities in water:

Water based on the source is found to be contaminated with different types and extent of impurities. The type of impurities present in water collected from different sources are as shown below in the block diagram 1. Different impurities based on their nature impart different properties and require further different methods for their removal to make water safe for one or the other purposes.

Following are the few important types of impurities found in different sources of water.

1) **Dissolved gases :** Raindrops during their downward journey absorb gases like O_2, N_2, CO_2 etc. with the later makes water acidic. E.g. Still water like lake water contains more CO_2 due to biological oxidation of organic matter. Deep well water sometimes possess rotten egg smell due to dissolved H_2S. Well water located in oil and gas areas contains dissolved methane. These dissolved gases can be removed by methods like mechanical deaeration, suitably adjusting the temperature accompanied by through agitation etc.

2) **Suspended matter :** Presence of suspended matter imparts turbidity to water. E.g. clay, sand particles as inorganic and decaying vegetable and animal matter as organic impurities. Surface waters contain more suspensoids than underground water as in later case soil acts as a filter medium. It can be removed using techniques like filtration, sedimentation or sedimentation with coagulation.

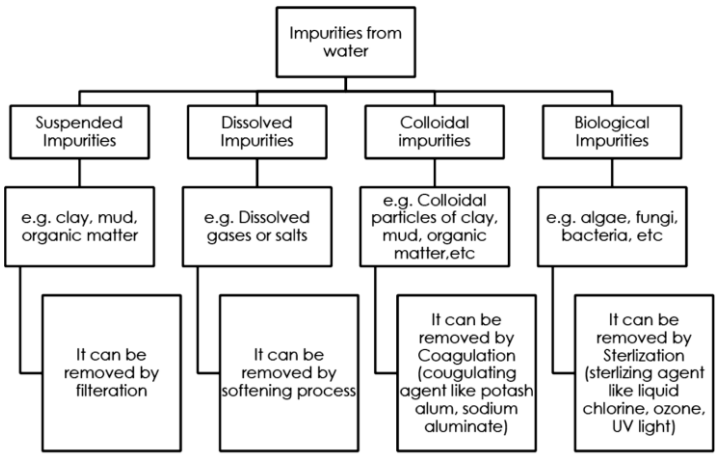


Fig.1.1 Types of impurities and the methods of their removal

3) **Biological impurities :** They impart colour, odour, turbidity to water. E.g. algae, fungi, microorganisms in the form bacteria and germs. These microbes may be pathogenic (disease causing or harmful) or nonpathogenic (harmless). The removal of biological impurities is done by filtration, oxidation, disinfection or sterilization types of techniques.

4) **Inorganic or dissolved mineral salts impurities :** Presence of salts impart hardness or softness to water depending upon kind of salts. Normally sulphates, chloride, nitrates of Na, K impart softness while carbonates, bicarbonates, chlorides, sulphates, nitrates of Ca, Mg etc. impart hardness to water. Underground water has more inorganic salts than surface water as in the former case water during its downward journey through the earth absorb salts present in the rocks. The hardness can be removed by softening methods like lime-soda, Zeolite, demineralization process.

1.2.1 Chemical Analysis of water :

Water is analyzed for checking its suitability for either domestic or industrial consumption. Chemical Analysis involves qualitative (what is it?) and quantitative (How much is it?) analysis of water. It refers to identification of impurities and their concentration level determination. The chemical analysis is aimed at testing the water for its hardness, chloride contents, alkalinity, sulphates, silica, Chemical Oxygen Demand (C.O.D.) and Biochemical Oxygen Demand (B.O.D.) etc.

1.3 Hardness :

Hardness in water is attributed to the presence of inorganic impurities or mineral salts like biocarbonates, carbonates, chlorides, sulphates, and nitrates of Calcium, Magnesium, Iron, Manganese, Strontium etc. Hard water is tested domestically by treating it with soap solution for its lather or foam forming capacity.

A soluble Soap is either Sodium or Potassium salt of higher fatty acids like Oleic, Linoleic, Linolenic, stearic etc. which reacts with hardness producing salts in water to form insoluble soap of Calcium or Magnesium in the form of white, curdy, adherent ppt rather than forming lather or foam. A chemical reaction involved is as follows :

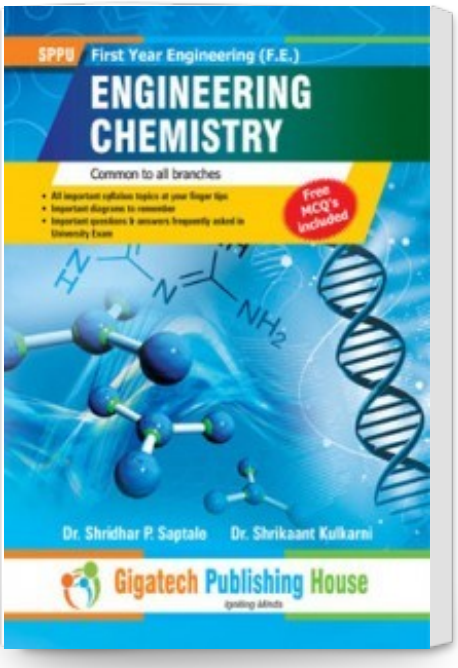
$$2C_{17}H_{35}COONa + Ca(HCO_3)_2 = (C_{17}H_{35}COO)_2Ca \downarrow + 2NaHCO_3$$

Soluble Sodium soap (Sodium Stearate) — Insoluble Calcium soap (Calcium Stearate)

As long as all hardness producing salts won't react with soap leading to formation of insoluble Calcium or Magnesium soap till then there is no lather or foam formation.

Hardness is therefore defined as soap consuming capacity of water.

Engineering Chemistry (Common to all branches)



Publisher : Gigatech Publishing House

ISBN : 9788193414040

Author : Dr. Shridhar P Saptale, Dr. Shrikaant Kulkarni