DR. BABASAHEB AMBEDKAR MARATHWADA UNIVERSITY,
CHHATRAPATI SAMBHAJINAGAR.

CIRCULAR NO.SU/B.Sc./CBC&GS/103/2024

It is hereby inform to all concerned that, the syllabus prepared by the Board of Studies and recommended by the Dean, Faculty of Science & Technology, Academic Council at its meeting held on 08 April 2024 has accepted **the Syllabus of B.Sc. Non Conventional and Conventional Energy (Degree) Vth and VIth semester under the Faculty of Science & Technology as per Choice Based Credit Grading System** run at the Affiliated Colleges, Dr.Babasaheb Ambedkar Marathwada University as appended herewith.

This is effective from the Academic Year 2024-25 and onwards.

All concerned are requested to note the contents of this circular and bring the notice to the students, teachers and staff for their information and necessary action.

University Campus,
Aurangabad-431 004.
REF.NO.SU/2024/27135-42
Date:- 28.05.2024

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Deputy Registrar,
Academic Section

Copy forwarded with compliments to :-

1] **The Principal of all concerned Colleges,**
Dr. Babasaheb Ambedkar Marathwada University,
2] **The Director, University Network & Information Centre, UNIC, with a request to upload this Circular on University Website.**

Copy to :-

1] The Director, Board of Examinations & Evaluation, Dr.Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar.
2] The Section Officer,[B.Sc.Unit] Examination Branch, Dr.Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar.
3] The Programmer [Computer Unit-1] Examinations, Dr.Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar.
4] The Programmer [Computer Unit-2] Examinations, Dr.Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar.
5] The In-charge,[E-Suvidha Kendra], Rajarshi Shahu Maharaj Pariksha Bhavan, Dr.Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar.
6] The Public Relation Officer, Dr.Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar.
7] The Record Keeper, Dr.Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar.

Dr. Babasaheb Ambedkar Marathwada University,

Chhatrapati Sambhajinagar-431004 (M.S.), India

Undergraduate Bachelor Degree Program in Science and Technology

B. Sc.

(Non-Conventional and Conventional Energy)

Course Structure

and

Curriculum

(Outcome based Curriculum)

Choice Based Credit System

Effective from Academic Year: 2024-25

24/5/2024

Dr. Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar

Choice Based Credit System (CBCS) Curriculum

For

Faculty of Science and Technology

Course Structure and Scheme of Examination

B.Sc. Non-Conventional and Conventional Energy

Third Year Under graduate Degree Program

Semester V

	Course Code	Course Title	Total periods (Teaching periods/week)	Credits	Scheme of Examination			
					Max Marks	CIA	UA	Min Marks
Optional I (DSC-1A) Core Courses	NCCE-501-T	Solar Thermal Energy-I	45(3/week)	2	50	10	40	20
	NCCE-502-T	Modern Renewable Energy Sources	45(3/week)	2	50	10	40	20
	NCCE-509-P	Practical Based on NCCE-501-T	45(3/week)	1.5	50	10	40	20
	NCCE-510-P	Practical Based on NCCE-502-T	45(3/week)	1.5	50	10	40	20
Optional II (DSC-2A) Core Courses	NCCE-503-T	Atomic Physics and Molecular Physics	45(3/week)	2	50	10	40	20
	NCCE-504-T	Electrodynamics	45(3/week)	2	50	10	40	20
	NCCE-511-P	Practical Based on NCCE-503-T	45(3/week)	1.5	50	10	40	20
	NCCE-512-P	Practical Based on NCCE-504-T	45(3/week)	1.5	50	10	40	20
Optional III (DSC-3A) Core Courses	NCCE-505-T	Organic Chemistry	45(3/week)	2	50	10	40	20
	NCCE-506-T	Physical Chemistry	45(3/week)	2	50	10	40	20
	NCCE-513-P	Practical Based on NCCE-505-T	45(3/week)	1.5	50	10	40	20
	NCCE-514-P	Practical Based on NCCE-506-T	45(3/week)	1.5	50	10	40	20
Skill Enhancement Course	SEC - 515	Any one skill to be chosen out of two SEC – 1(A) Solar Power Plant Design Course SEC – 1(B) Renewable Energy	45(3/week)	2	50	10	40	20
			585	23	650	120	520	260

Total Credits for Semester V : 22.5 (Theory : 18 ; Laboratory : 4.5)

Semester VI

	Course Code	Course Title	Total periods (Teaching periods/week)	Credits	Scheme of Examination			
					Max Marks	CIA	UA	Min Marks
Optional I (DSC-1B) Core Courses	NCCE-601-T	Solar Thermal Energy-II	45(3/week)	2	50	10	40	20
	NCCE-602-T	Energy Storage System	45(3/week)	2	50	10	40	20
	NCCE-609-P	Practical Based on NCCE-601-T & NCCE-602-T	45(3/week)	1.5	50	10	40	20
	NCCE-609-P	Project Based on NCCE-601-T & NCCE-602-T	45(3/week)	1.5	50	10	40	20
Optional II (DSC-2B) Core Courses	NCCE-603-T	Quantum Mechanics	45(3/week)	2	50	10	40	20
	NCCE-604-T	Applied Physics	45(3/week)	2	50	10	40	. 20
	NCCE-610-P	Practical Based on NCCE-603-T	45(3/week)	1.5	50	10	40	20
	NCCE-611-P	Practical Based on NCCE-604	45(3/week)	1.5	50	10	40	20
Optional III (DSC-3B) Core Courses	NCCE-605-T	Analytical Chemistry	45(3/week)	2	50	10	40	20
	NCCE-606-T	Inorganic Chemistry	45(3/week)	2	50	10	40	20
	NCCE-611-P	Practical Based on NCCE-605-T	45(3/week)	1.5	50	10	40	20
	NCCE-611-P	Practical Based on NCCE-606-T	45(3/week)	1.5	50	10	40	20
Skill Enhancement Course	SEC - 615	Any one skill to be chosen out of two SEC – 1(C) Solar Power Plant Design Course SEC – 1(D) Fuel Chemistry	45(3/week)	2	50	10	40	20
			585	23	650	120	520	260

Total Credits for Semester VI : 22.5 (Theory : 18 ; Laboratory : 4.5

B.Sc. (Non-Conventional & Conventional Energy)

Semester V

Course: B.Sc. (NCCE.) V Sem	Max. Marks:50
Paper Title: Solar Thermal Energy - 1	Paper No. : NCCE-501-T

Chapter	Details	No. of Lectures 45
	SOLAR THERMAL ENERGY CONVERSION – I	
1.	**BASICS IN SOLAR ENERGY SYSTEMS AND OVERVIEW OF THERMAL ENERGY.** 1.1 Different types of Renewable Energy Sources 1.2 Sun as a Source of Energy 1.3 Solar Radiation 1.4 Extra Terrestrial at Earth's Surface – Horizontal, Tilted Surface 1.5 Estimation of Radiation 1.6 Alternation of Solar Radiation by Atmosphere 1.7 Effect of Orientation of Receiving Surface 1.8 Devices for Thermal Collection and storage 1.9 Thermal applications	12
2.	**SOLAR RADIATION MEASUREMENT OF SOLAR RADIATION** 2.1 Solar Radiation Data 2.2 Empirical Equation for Predicating the Availability of Solar Radiation 2.2.1 Average Daily Global Radiation 2.2.2 Estimation Of Hourly Average, Daily Diffuse Solar Radiation 2.3 Computation of Radiation on Inclined Surface 2.4 Measurement of Solar Radiation 2.5.1 Pyranometer 2.5.2 Pyrheliometer 2.5.3 Sunshine Recorder 2.6 Spectral Measurement Spectral Distribution of Extraterrestrial Radiation	11
3.	**LIQUID FLAT-PLATE COLLECTORS (FPC)** 3.1 Definition 3.2 Characteristic Features of FPC 3.3 Performance Analysis 3.4 Transmissivity - Absorptivity Product 3.5 Overall Loss Coefficient and Heat Transfer Correlations 3.6 Collector Efficiency Factor 3.7 Effects of Various Parameters on Performance	10

	3.8 Advantages of Flat plate Collector 3.9 Alternatives to the Conventional Collector	
4.	**SOLAR AIR HEATERS & WATER HEATER** 4.1 Introduction 4.2 Performance Analysis of Solar Air Heater 4.3 Types of Air Heaters 4.3.1 Collector with Non-Porous Absorber 4.3.2 Collector with Porous Absorber 4.4 Testing Procedure of Solar Air Heater 4.5 Application of Solar Air Heater 4.6 Separate Collector and Storage type Solar Water Heater 4.6.1 Natural Circular Type System 4.6.2 Forced Circular OR Pumped Systems	12

TEXT BOOKS:

1. Non-Conventional Energy Sources, G.D. Rai, Khanna Publishers.
2. Non-Conventional Energy Resources, B.H. Khan, The McGraw-Hill Publications.
3. S.P. Sukhatme and J.K. Nayak, Solar Energy – Principles of thermal collection and storage; Tata McGraw-Hill, New Delhi
4. Solar Energy, Fundamentals and Applications, Garg, Prakash, Tata McGrawHill
5. Gilbert M. Masters, Renewable and efficient electric power systems, Prentice-Hall
6. C.S. Solanki, Solar Photovoltaics: Fundamental, technologies and applications,Prentice Hall of India, 2011.

REFERENCES:

1. Kreith F and Kreider J.F., 'Principles of Solar Engineering', McGraw HillBook Co.,
2. A. Rabl, Active Solar Collectors and Their Applications, Oxford UniversityPress, New York, 1985.
3. Gilbert M. Masters, Renewable and efficient electric power systems, Prentice
4. J.A. Duffie and W.A. Beckmann, Solar Engineering of Thermal Processes,John Wiley, London, 1991.
5. M.S. Sodha, N.K. Bansal, A. Kumar and M. A. S. Malik, Solar Passive Building: science and design, Pergamon Press, New York, 1986

Course: B.Sc. (NCCE.) V Sem	Max. Marks: 50
Paper Title: Modern Renewable Energy Sources	Paper No. : NCCE-502-T

Sr. No.	Details	No. of Lectures 45
	Modern Renewable Energy Sources	
1.	**GEOTHERMAL RESOURCES AND APPLICATIONS OF GEOTHERMAL ENERGY** 1.1 Introduction 1.2 Geothermal Resources 1.2.1 Hydrothermal Resources 1.2.2 Geothermal Resources 1.2.3 Magma rock Resources 1.2.4 Hot Dry resources of Petro-thermal System 1.3 Advantages & Disadvantages of geothermal energy 1.4 Application of geothermal energy	11
2.	**TIDAL ENERGY & WAVE ENERGY** 2.1 Introduction 2.2 Tidal range Power 2.3 Advantages & Limitations of Tidal Energy 2.4 Energy & Power in waves 2.5 Wave energy Conversion Devices 2.6 Tidal Steam power	12
3.	**HYDROGEN PRODUCTION** 3.1 Electrolysis 3.2 Thermo chemical Method 3.3 Fossil Fuel Method 3.4 Solar Energy Method 3.5 Some Thermo chemical Cyclic Processes	10
4.	**THERMO NUCLEAR FUSION ENERGY** 4.1 Introduction 4.2 Requirements for Nuclear Fusion 4.3 Plasma Coefficient	12

	4.4 Magnetic Coefficient Fusion 4.5 Inertial Coefficient Fusion 4.6 Advantages of Nuclear Fusion	

TEXT BOOKS:

1. Non-Conventional Energy Sources, **G.D. Rai, Khanna Publishers.**

2. Non-Conventional Energy Resources, **B.H. Khan, The McGraw-Hill Publications**

Reference Books:

1. Kreith F and Kreider J.F., 'Principles of Solar Engineering', McGraw Hill Book Co.,
2. A. Rabl, Active Solar Collectors and Their Applications, Oxford University Press, New York, 1985.
3. Gilbert M. Masters, Renewable and efficient electric power systems, Prentice
4. Solar Energy, Fundamentals and Applications, Garg, Prakash, Tata McGraw Hill
5. M.A.S. Malik, G.N. Tiwari, A. Kumar and M.S. Sodha, Solar Distillation. Pergamon Press, New York, 1982.

Course: B.Sc. (NCCE.) V Sem	Max. Marks: 50
Paper Title: Atomic Physics and Molecular Physics	**Paper No. :** NCCE-503-T

Sr. No.	Details	No. of Lectures 45
	Atomic Physics and Molecular Physics	
1	**ATOMIC STRUCTURE** 1.1 Thomson atom model 1.2 Rutherford Experiment-Scattering of alpha particles and Rutherford model of the atom 1.3 Rutherford scattering of alpha particles 1.4 Bohr model of the atom 1.5 Bohr's theory of the hydrogen spectrum 1.6 Spectral series of the hydrogen atom 1.7 Energy levels of Hydrogen atom	10
2	**ATOM WITH ONE ELECTRON** 2.1 Introduction 2.2 Critical ionization and excitation potentials 2.3 Frank-Hertz Expt, Quantization of magnetic moment 2.4 Larmour precession (atomic dipole in a strong magnetic field B) 2.5 Factors leading to discovery of spin 2.6 Spin angular momentum, Space quantization 2.7 Gyromagnetic ratio 2.8 Spin orbit coupling	11
3	**VECTOR ATOM MODEL** 3.1 Introduction 3.2 Vector atom model 3.3 Quantum numbers associated with the vector atom model 3.4 Spin orbit interaction, 3.5 Fine structure of hydrogen atomic spectrum 3.6 Total magnetic moment and Lande's factor 3.7 Hyperfine structure of spectral lines 3.8 Pauli's Exclusion Principle 3.9 Selection rules 3.10 Intensity rules 3.11 Normal Zeeman effect 3.12 Anomalous Zeeman effect, Stark Effect	12
4	**MOLECULAR SPECTRA** 4.1 Diatomic molecule 4.2 Molecular spectra 4.3 Kinds of molecular spectra 4.4 Rotational spectra 4.5 Vibrational spectra 4.6 Vibration rotational spectra 4.7 Potential energy curve 4.8 Spectra of homonuclear diatomic molecule 4.9 Electronic spectra of di- and Poly atomic molecules 4.10 Raman effect 4.11 Characteristics of Raman lines	12

	4.12 Experimental arrangement on quantum theory 4.13 Intensity of Raman lines	

Text books:

1. Physics For Degree Students, As per UGC model Curriculum (For All Indian Universities) C.L. Arora, Dr. P.S. Hemne Chand & Company Ltd Ram Nagar, New Delhi-110055
2. Atomic and Nuclear Physics, N. Subrahmanyam, Brij Lal S. Chand & Company Ltd Ram Nagar, New Delhi-110055
3. Atomic and Nuclear Physics, N. Subrahmanyam, Brij Lal Revised by Jivan Seshan, Chand & Company Ltd Ram Nagar, New Delhi-110055
4. Introduction of Atomic Spectra, White
5. Fundamental of Molecular Spectroscopy- C.N. Banwell and E. M. McCash (McGraw Hill International Edition)
6. Atomic Physics- J.B. Rajam, S Chand, Chand & Company Ltd

Course: B.Sc. (NCCE.) V Sem	Max. Marks: 50
Paper Title: **ELECTRODYNAMICS**	Paper No. : NCCE-504-T

Sr. No.	Details	No. of Lectures 45
	ELECTRODYNAMICS	
1.	Mathematical background: Vector algebra Scalar and vectors, dot and cross products of vectors, scalar and vector triple product, physical significance of: (1) gradient of scalar, (2) divergence of vector, (3) curl of vector; vector identities, basics of line-surface-volume integrals, problems.	11
2.	Definition of electric charge and its unit, Coulomb's law (statement and proof), electric field, lines of force and its properties, intensity of electric field, electric flux and flux density, electric potential and its unit, potential due to point charge, Gauss law (statement and proof), applications of Gauss law: electric field around charged (1) straight conductor, (2) charged sphere, (3) Gaussian pillbox; differential form of Gauss law, curl of E, problems	12
3.	**Magnetostatics:** Magnetic lines of forces, magnetic field and intensity, magnetic induction and magnetic flux, Biot-Savart's law, magnetic induction due to straight current carrying current, concept of solenoid, Ampere's law, differential form of Ampere's law, application of Ampere's law-magnetic induction due to long solenoid, problems	10
4.	**Electrodynamics & Electromagnetic waves** Concept of electromagnetic induction, self-induction, mutual induction, Faraday's laws of electromagnetic induction, Lenz's law, equation of continuity, concept of displacement current, Maxwell's equations for electromagnetic waves (integral and differential form), problems. Generation of electromagnetic waves, characteristics of EM waves, equation of EM waves through conducting media, polarization-reflection-transmission of EM waves at the boundary of media, Poynting vector (only definition).	12

Reference Books:

1. Electrodynamics-Gupta, Kumar and Singh, Pragati Prakashan, Meerut,
2. Engineering Physics – Gaur and Gupta, Dhanpat Rai Publishing Co Pvt Ltd,
3. Physics for Degree Students – C.L. Arora, S. Chand & Company Pvt Ltd
4. Mechanics and Electrodynamics-Brijlal, Subrahmanyam &Jivan Seshan, S. Chand & Company Pvt Ltd.
5. Introduction to Electrodynamics-D.J. Griffith, Cambridge India

Course: B.Sc. (NCCE.) V Sem	Max. Marks:50
Paper Title: Organic Chemistry	**Paper No. :** NCCE-505-T

Sr. No.	Details	No. of Lectures 45
	Organic Chemistry	
1	**Nuclear Magnetic Resonance Spectroscopy** 1.1. Principal of spectroscopy 1.2. Instrumentation 1.3. Shielding and Deshielding 1.4. Chemical shift 1.5. Coupling constant 1.6. Areas of signals 1.7. Interpretation of PMR spectra of simple organic molecules- 1.7.1.1. Ethyl bromide and Ethanoiz acid. 1.7.1.2. Etanol and Touene 1.7.1.3. Acetaldehyde and Acetophenone 1.7.1.4. Dimethylketone and Nitropropane. 1.7.1.5. Ethyl acetate and Ethyl-amine	11
2	**Organometallic Compounds** 2.1 Definition with five examples of OMC 2.2 Organo magnesium compounds-synthesis and chemical reactions. 2.3 Organo zinc compounds-synthesis and chemical reactions. 2.4 Organo Lithium compounds-synthesis &chemical reactions.	10
3	**Organic Synthesis via Enolates** 3.1 Definition with examples of Enolates 3.2 Definition with examples of Active methylene compounds. 3.3 Ethyl Aceto Acetate- 3.3.1 Synthesis 3.3.2 Chemical Reaction w.r.t. synthesis of i)) mono carboxylic Acid ii) Di-carboxylic Acid iii) Alkylation iv) Acylation v) Unsaturated carboxylic Acid vi) Reaction with urea vii) Ketones 3.3.3 Acidic Properties 3.3.4 Keto enol Toutomerism 3.4 Di ethyl malonates-	12

	3.4.1 Synthesis of DEM 3.4.2 Chemical Reaction synthesis of i) mono carboxylic Acid ii) Di-carboxylic Acid iii) Alkylation iv) Acylation v) Unsaturated carboxylic Acid vi) Reaction with urea vii) Ketones 3.4.3 Acidic Properties 3.4.4 Keto enol Toutomerism	
4	**Synthesis Polymers Synthesis Dyes and Dugs** 4.1 Introduction 4.2 Classification based on nature of synthesis (without mechanism) with examples. (Addition and condensation polymers) 4.3 Properties, uses and synthesis of polyvinyl chloride, polyvinyl acetate, polystyrene, polyacrylonitrile, Nylon 6, Nylon 66. 4.4 Introduction to synthesis and natural rubber, properties, uses and synthesis of Bunn N., Neoprene and silicon rubber. 4.5 Introduction 4.6 Color and constitution (electronic concept) of dye, classification based on chemical constitution, synthesis of methyl orange, Congo red, malachite green, crystal violet, Alizarin and indigo dyes. 4.7 Synthetic Drugs, Definition, introduction, classification of drugs. 4.8 Properties of ideal drug. **4.9** synthesis of chloromycetien, paracetomol, phenacetien, sulphaguainidine	**12**

References:

1. Organic Chemistry By Morrison And Boyd
2. Organic Chemistry By Gurdeep Raj
3. Organic Chemistry By S. Chand
4. Organic Chemistry By Carry And Sunberg.
5. Organic Chemistry Of Drug Design And Drug Action, By Silverman

Course: B.Sc. (NCCE.) V Sem.	Max. Marks:50
Paper Title: Physical Chemistry	Paper No. : NCCE-506-T

Sr. No.	Details	No. of Lectures 45
	Physical Chemistry	
1	**Chemical Kinetics** 1.1. Rate of reaction ,The rate equation, rate constant 1.2. First order, second order reaction with example (derivation is not expected), Half -life period 1.3 Factors influencing the rate of reaction, Order of reaction, Molecularity 1.4 Effect of temperature on reaction rates 1.5 Concept of activation energy 1.6 Effect of catalyst on rate of reactions 1.7 Arrhenius equation 1.8 Lindemann theory of unimolecular reactions	12
2	**Phase equilibria and Phase rule** 2.1. Definitions of the terms, Phase, Component, Degree of freedom 2.2. One component system: water system. 2.3 Two Components System: Solid-Liquid Equilibria, Simple Eutectic 2.4 Pb-Ag. System Desilverisation of Lead, 2.5 Liquid-Liquid Mixture: Raoult's Law and Henry's Law. Ideal and Non-Ideal system. 2.8 Azeotropes: HCl-H2O and Ethanol-Water System 2.9 Partially Miscible Liquids: Phenol-Water, Trimethyl Amine-Water, Nicotine water System Lower and Upper consulate 2.10 Trimethyl Amine-Water, Nicotine water system, Lower and Upper Consulate Temperature, 2.11 Effect of Impurity on Consulate Temperature,	12
3	**Electrolytic Conductance** 3.1. Conductance. Specific Conductance and equivalent conductance 3.2. Measurement of equivalent conduction, variation of equivalent and specific conductance with dilution 3.3. Kohlrausch's law, numerical problems 3.4. Arrhenius Theory of Electrolyte Dissociation and its limitations 3.5 Weak and Strong Electrolytes 3.6. Ostwald's Dilution Law, its use and Limitations 3.7. Conductometric Titration: Types and its	10
4	**EMF of Galvanic Cell** 4.1. Galvanic cell, Types of reversible electrodes, 4.2. Hydrogen electrode Calomel electrode 4.3. Standard Electrode Potential , Nernst Equation 4.4. Derivation of Cell, E.M.F. and single Electrode potential 4.5. Sign Conventions, Electro-Chemical Series and its significance 4.6. Conventional Representation of Electrochemical Cells. E.M.F. of a cell and its measurement	11

	4.7 Calculation of Thermodynamic Quantities of Cell Reactions (G, H and K)	

References:

1. Peter Atkins and Julio de Paula, Atkin's Physical Chemistry, 7th Edn., Oxford University Press, 2002.
2. K.J. Laidler and J.H. Meiser, Physical Chemistry, 2nd Ed., CBS Publishers and Distributors, New Delhi, 1999.
3. Robert J. Silby and Robert A. Alberty, Physical Chemistry, 3rd Edn., John Wiley and Sons (Asia) Pte. Ltd, 2002.
4. Ira R. Levine, Physical Chemistry, 5th Edn., Tata McGraw-Hill New Delhi, 2002.
5. G.W. Castellan, Physical Chemistry, 3rd Edn., Narosa Publishing House, New Delhi, 1983.
6. S. Glasstone, Text Book of Physical Chemistry, 2nd Edn., McMillan and Co. Ltd., London, 1962
7. Thomas Engel and Philip Reid, Physical Chemistry, 3rd Edn., Pearson Education Limited 2013.
8. D.N. Bajpai, Advanced Physical Chemistry, S. Chand 1st Edn., 1992.
9. Bockris, John O'M., Reddy, Amulya K.N., Gamboa-Aldeco, Maria E., Modern Electrochemistry, 2A, Plenum Publishers, 1998.
10. Physical Chemistry by Gurtu and Gurtu
11. A Text book of Physical Chemistry by K L kapoor Vol 5 , 2nd Edn
12. Principles of physical Chemistry, Marrown and Prutton 5th edition
13. Essentials of Physical Chemistry, Arun Bahl, B. S Bahl, G. D.Tulli , S Chand and Co. Ltd , Edition 2012
14. Principles of Chemical Kinetics, 2nd Ed., James E. House, ELSEVIER, 2007.
15. Principles of Physical Chemistry Puri , Sharma ,Pathaniya
16. Advance Physical Chemistry Gurudeep Raj

B.Sc. Non-Conventional and Conventional Energy
Semester V
Skill Enhancement Course

Note :
Any one skill enhancement course to be chosen out of two either
'SEC-1(A): Solar Power Plant Design Course I,' Or
'SEC-1(B): Environmental studies ,'

Course: B.Sc. (NCCE.) V Sem.	Max. Marks:50
Paper Title: SEC-1(A) Solar Power Plant Design Course	**Paper No. : NCCE-515 (A)-T**

Sr. No.	Details	No. of Lectures 45
	Physical Chemistry	
1	**Types of Solar Power Plant** Grid Connected solar Power Plant Grid interactive solar power plant Net Metering Solar Power Plant Off-Grid / Hybrid solar power plant Schemes of solar power plant	11
2	**Selection of site and shadow analysis** PV module structure interrow spacing calculation Pitch analysis, Selection of PV module tilt angle Near shading object calculation Site survey and plant assessment Type of solar radiation Irradiance assessment and comparison Solar Radiation Data Sun path Diagram Defining the Position of the Sun Solar Altitude Geometric Effects Tilting Solar Modules Magnetic North & True North	12
3	**Selection of PV module technology** Introduction Crystalline technology Thin film technology Bi-facial technology Comparison between PV module technology Comparison between solar power plant energy out put	10
4	**Selection of PV module (cells and BOM) and sizing** Types Crystalline module cells Manufacturing process of PV cells Comparison between mono crystalline Selection of PV cells Selection of front and rear sheet Selection of PV module glass Selection of EVA sheet , Bus bar and frame Characteristics of a Solar Cell Power Characteristics of a Solar Cell Fill factor and Equivalent Solar cell Circuit STC and NOCT	12

Reference books:

1. "Solar Electricity Handbook: A Simple, Practical Guide to Solar Energy – Designing and Installing Photovoltaic Solar Electric Systems" by Michael Boxwell:

2. "Photovoltaic Design and Installation For Dummies" by Ryan Mayfield:

3. "Solar PV Engineering and Installation: Preparation for the NABCEP PV Installation Professional Certification" by Sean White:

Course: B.Sc. (NCCE.) V Sem.	Max. Marks:50
Paper Title: SEC-1(B) Environmental Studies	Paper No. : NCCE-515(B)-T

Sr. No.	Details	No. of Lectures 45
	ENVIRONMENTAL STUDIES	
1	**The Environment:** The Atmosphere, Hydrosphere, Lithosphere, Biosphere, Ecology, Ecosystem, Biogeochemical Cycle (Carbon Cycle, Nitrogen Cycle), Environment Pollution: Air Pollution, Water Pollution, Soil Pollution, Radiation Pollution.	11
2	**Population Ecology:** Individuals, Species, Pollution, Community, Control Methods of Population, Urbanization and its effects on Society, Communicable Diseases and its Transmission, Non-Communicable Diseases.	12
3	**Environmental Movements in India:** Grass root Environmental movements in India, Role of women, Environmental Movements in Odisha, State Pollution Control Board, Central Pollution Control Board.	10
4	**Natural Resources:** Conservation of Natural Resources, Management and Conservation of Wildlife, Soil Erosion and Conservation, Environmental Laws: Water Act, 1974, Air Act, 1981, The Wildlife (Protection) Act, 1972, Environment Protection, 1986, Natural Disasters and their Management.	12

Books Recommended

1. Dash MC and Mishrs PC, Man and Environment, McMillan, London.

2. Mishra PC and Das MC, Environment and Society, McMillan, London.

3. Odeem EP, Fundamentals of Ecology, Natraj Publication.

4. Mishra DD, Fundamental Concept in Environmental Studies, S.Chand, New Delhi.

5. Asthana DK and Asthana Meera, A Testbook of Environmental Studies, S. Chand, New Delhi. 6. Bharucah Erach, Textbook for Environmental Studies, Universities Press India Pvt. Ltd., Hyderabad.

B.Sc.

(Non-Conventional & Conventional Energy)

Semester VI

Course: B.Sc.(NCCE.) V Sem	**Max. Marks:** 50
Paper Title: Solar Thermal Energy - II	**Paper No. :** NCCE-601-T

Chapter	Details	No. of Lectures 45
	SOLAR THERMAL ENERGY CONVERSION - II	
1.	**CONCENTRATING COLLECTORS** 1.1 Introduction 1.2 Flat-plate Collectors with Plane Reflectors 1.3 Tracking lodes & Analysis of Cylindrical Parabolic Collector 1.4 Compound Parabolic Collector (CPC) 1.5 Paraboloid Dish Collector 1.6 Central Receiver Collector	11
2.	**OTHER SOLAR THERMAL DEVICES** 2.1 Solar still basin & multiple effect 2.2 Solar Cookers 2.2.1 Box Type 2.2.2 Paraboloid Dish 2.2.3 Scheffler Type 2.3 Solar Dryers : Cabinet Type Dryer & Indirect Driers 2.4 Solar Ponds & its Analysis	12
3.	**OTHER APPLICATIONS OF SOLAR ENERGY** 3.1 Solar Distillation 3.2 Solar Pumping 3.3 Solar Cooking 3.4 Solar Cooling & Refrigeration	10
4.	**THERMAL ENERGY STORAGE & APPLICATIONS** 4.1 Introduction 4.2 Sensible Heat Storage 4.3 Latent Heat Storage 4.4 Thermo Chemical Storage 4.5 Thermal energy storage : various methods and applications 4.6 Solar ponds : thermal applications 4.7 Thermal Power Conversion 4.8 Solar Cooling and Heating 4.9 Solar Desalination, Drying, Solar Pumping	12

TEXT BOOKS:

1. Non-Conventional Energy Sources, G.D. Rai, Khanna Publishers.
2. Non-Conventional Energy Resources, B.H. Khan, The McGraw-Hill Publications.
3. S.P. Sukhatme and J.K. Nayak, Solar Energy – Priniciples of thermal collection and storage; Tata McGraw-Hill, New Delhi
4. Solar Energy, Fundamentals and Applications, Garg, Prakash, Tata McGraw Hill
5. J.A. Duffie and W.A. Beckmann, Solar Engineering of Thermal Processes, John Wiley, London, 1991.
6. M.S. Sodha, N.K. Bansal, A. Kumar and M. A. S. Malik, Solar Passive Building: science and design, Pergamon Press, New York,
7. Gilbert M. Masters, Renewable and efficient electric power systems, Prentice-Hall
8. C.S. Solanki, Solar Photovoltaics: Fundamental, technologies and applications, Prentice Hall of India, 2011.

REFERENCES:

1. Kreith F and Kreider J.F., 'Principles of Solar Engineering', McGraw Hill Book Co.,
2. A. Rabl, Active Solar Collectors and Their Applications, Oxford University Press, New York, 1985.
3. Gilbert M. Masters, Renewable and efficient electric power systems, Prentice-Hall
4. M.A.S. Malik, G.N. Tiwari, A. Kumar and M.S. Sodha, Solar Distillation. Pergamon Press, New York, 1982.

Course: B.Sc. (NCCE.) VI Sem	**Max. Marks:**50
Paper Title: ENERGY STORAGE SYSTEM	**Paper No. :** NCCE-602-T

Sr. No.	Details	No. of Lectures 45
	ENERGY STORAGE SYSTEM	
1	**ENERGY STORAGE** 1.1Need of energy storage 1.2 Different modes of Energy Storage 1.2.1Size and Duration of Energy Storage 1.2.2 Storage in Reversible Chemical Reactions 1.2.3 Electrical and magnetic energy storage 1.2.4 Chemical energy storage 1.2.5 Hydrogen for energy storage 1.2.6 Solar Ponds for energy storage	10
2	**ELECTROCHEMICAL & ELECTROMAGNETIC STORAGE SYSTEM** 2.1 Introduction 2.2 Definitions of fundamental Quantities 2.3 Lead acid Batteries 2.4 Nickel Cadmium Batteries, Advanced Batteries 2.5 Batteries Fundamental Characteristics 2.6 Factors Affecting Battery Performance 2.6.1 Battery Voltage Level 2.6.2 Battery Discharge Current	11
3	**FUEL CELL** 3.1 Introduction 3.2 Fuel cell types 3.3 Conversion Efficiency of Fuel Cell 3.4 Characteristics and advantages/disadvantages of Fuel Cell 3.5Classification of Fuel Cell 3.6 Applications of Fuel Cell 3.7 Work output and EMF of Fuel Cell	12

4	**LATENT HEAT THERMAL ENERGY STORAGE PHASE** 4.1 Change materials (PCMs) : Selection criteria of PCMs 4.2 Solar thermal LHTES systems 4.2.1 Energy conservation through LHTES systems 4.2.2 LHTES systems in refrigeration and air conditioning systems 4.3 Distribution of Energy 4.3.1 Gas Pipeline 4.3.2 Electricity Transmission 4.4 Solar Energy Storage 4.5 Energy Storage via Hydrogen 4.6 Reversible Chemical Reactions 4.7 Waste Heat Utilization	12

TEXT BOOKS:

1. Non-Conventional Energy Sources, G.D. Rai, Khanna Publishers.
2. Non-Conventional Energy Resources, B.H. Khan, The McGraw-Hill Publications.

REFERENCES:

1. Kreith F and Kreider J.F., 'Principles of Solar Engineering', McGraw Hill Book Co.,
2. A. Rabl, Active Solar Collectors and Their Applications, Oxford University Press, New York, 1985.
3. Gilbert M. Masters, Renewable and efficient electric power systems, Prentice-Hall
4. M.A.S. Malik, G.N. Tiwari, A. Kumar and M.S. Sodha, Solar Distillation. Pergamon Press, New York, 1982.

Course: B.Sc.(NCCE.) VI Sem	**Max. Marks:** 50
Paper Title: Quantum Mechanics	**Paper No. :** NCCE-603-T

Chapter	Details	No. of Lectures 45
	Quantum Mechanics	
1.	**Origin of Quantum Mechanics** Failure of Classical mechanics, Black body Radiation-Distribution of energy in black body spectrum, Plank's Quantum theory-(Plank's Quantum postulates, linear momentum of photon in terms of wave vector), Plank's radiation law-Wien's law and Rayleigh's law, Photo electric effect, Experimental arrangement,, Laws of photo electric emission, Einstein's equation: Quantum theory of photoelectric effect, Bohr's theory of hydrogen atom- Quantum concept, quantisation of energy, Ritz Combination Principle, Compton effect, Compton shift	12
2.	**Wave Particle duality** Matter waves-De Broglie hypothesis, de-Broglie's wavelength in terms of energy and temperature, de-Broglie Wave velocity and Particle velocity, Relation between Particle Velocity and Wave velocity, Group velocity, Relation between group velocity and phase velocity, G. P. Thomson's Experiment, Heisenberg uncertainty principle, Applications of uncertainty principle-Binding energy of an electron in an atom, Nonexistence of electrons in nucleus, The Zero Point Energy. Uncertainty in Frequency of radiation emitted by an atom, Minimum energy of Harmonic oscillator using uncertainty principle	12
3.	**The Schrodinger equation** Physical interpretation of wave function, Schrodinger time dependent equation, Schrodinger time independent equation. (Steady state equation), Schrodinger's wave equation in momentum representation, Born's interpretation, Requirements of wave function, Probability current density, equation of continuity and its physical significance, Definition of an operator in Quantum mechanics. - Eigen function and Eigen values, Expectation value – Ehrenfest's theorem	10

4.	**Applications of Schrodinger Steady state equation** Free particle in infinitely deep potential well (one - dimension), Particle in three dimension rigid box, Parity, Parity of one dimensional harmonic oscillator wave function, Step potential, Potential barrier. (Qualitative discussion). Barrier penetration and tunnelling effect, Harmonic oscillator (one-dimension), correspondence principle.	**11**

References:

1. Physics for degree student – C.L. Arora, P.S. Hemne (Ist edition S. Chand Publication).

2. Perspective of Modern Physics – Arthur Beiser.

3. Introduction to Quantum Mechanics. - By D. Griffiths Published by Prentice Hall.

4. Quantum Mechanics. - By Ghatak and Lokanathan Published by Mc. Millan.

5. Advance Quantum Mechanics: Satya Prakash, Kedarnath Ran Nath, Meerut

6. Quantum Mechanics: Powell and Crasemann, Addison-Wesley Pub. Co.

7. Introduction to Quantum Mechanics: D. Griffiths Published by Prentice

8. Advance Quantum Mechanics: Satya Prakash, Kedarnath Ran Nath, Meerut

9. Quantum Mechanics: Chatwal and Anand. Himalaya Publication. Co.

Course: B.Sc.(NCCE.) VI Sem	**Max. Marks:**50
Paper Title: Applied Physics	**Paper No. :** NCCE-604-T

Sr. No.	Details	No. of lectures 45
1	**Superconductivity** 1.1 The Josephson Effect 1.2 Theory of DC Josephson Effect 1.3 Theory of AC Josephson Effect 1.4 Flux Quantization 1.5 High - T_c Superconductivity 1.6 Applications 1.7 London Equation 1.8 Energy Gap 1.9 Microwave and Infrared Absorptions	11
2	**Astrophysics** 2.1 Introduction 2.2 Classification of Stars-The Harvard Classification System 2.3 Hertzsprung - Russel Diagram 2.4 Luminosity of a Star 2.5 Stellar Evolution 2.6 White Dwarfs 2.7 Electrons in White Dwarf star 2.8 Chandrasekhar Limit 2.9 Neutron Stars 2.10 Black Holes 2.11 Supernova Explosion	12
3	**Nanotechnology** 3.1 Introduction 3.2 Nano particles 3.3 Metal Nano clusters 3.4 Semiconducting Nano particles 3.5 Rare Gas and Molecular Clusters 3.6 Carbon Clusters 3.7 Carbon Nano tubes 3.8 Applications of Carbon Nano tubes 3.9 Quantum Nanostructures 3.10 Preparation of Quantum Nanostructures 3.11 Size and Dimensionality Effects 3.12 Applications of Quantum Nanostructures	12
4	**Photoelectric effect** 4.1 Introduction 4.2 Lenard's Method to Determine e/m for Photoelectrons 4.3 Richardson and Compton Experiment 4.4 Experimental Investigations on the Photoelectric Effect 4.5 Einstein's Photoelectric Equation 4.6 Photoelectric Cells	10

Reference Books:

1. Modern Physics - R. Murgeshan, Kiruthiga Shivprasath, S. Chand Publication, 17th Edition 2014.
2. Modern Physics - J. B. Rajam
3. Astrophysics: Stars and Galaxies - K. D. Abhyankar, Universities Press.

Course: B.Sc. (NCCE.) VI Sem	**Max. Marks:50**
Paper Title: Analytical Chemistry	**Paper No. :** NCCE-605-T

Sr. No.	**Details**	**No. of Lectures 45**
	Analytical Chemistry	
1	**Chromatography** 1.1 Definition and 1.2 Classification of chromatography 1.3.Paper and Thin Layer Chromatography 1.4.Method of Development (Ascending, Descending Chromatography) 1.5. Locating Technique (UV-light / Chemicals) 1.6. R f value 1.7.Comparison between paper and TLC 1.8.Applications of Chromatography	**12**
2	**Basic Separation Techniques: Distillations** 2.1 Introduction 2.2 Basic concept of Separation techniques. 2.3.Distillation: 2.3.1. Simple distillation, 2.3.2. Fractional distillation, 2.3.3. Vacuum and 2.3.4. Steam distillation, 2.3.5. Theory of operation of distillation methods, 2.3.6. Some practical considerations. 2.3.7. Applications of distillation methods.	**10**
3	**Basic Separation Techniques: Extractions** 3.1. Extractions: 3.1.1 Solvent and 3.1.2. Solid phase extractions, 3.2. Application of extraction methods, 3.3. Extraction of metals, 3.4. Molecular species, 3.5. Ion-pair extraction, 3.6. Accelerated and microwave assisted extraction, 3.7. Solid phase extraction.	**11**
4	**Mole Concept and Concentration Units:** 4.1. Mole Concept, 4.2. Molecular weight, 4.3. Formula weight, and 4.4. Equivalent weight.	**12**

	4.5. Concentration units: 4.5.1. Molarity, 4.5.2. Formality, 4.5.3. Normality, 4.5.4. Molality, 4.5.5. Mole fraction, 4.5.6. Percent by weight, 4.5.7. Percent by volume, 4.5.8. Parts per thousand, 4.5.9. Parts per million, 4.5.10 Parts per billion, 4.6. pH, 4.7. pOH,	

References:

1. Instrumental methods of Chemical Analysis: GR Chatwal and SK Anand.
2. Fundamental of Analytical Chemistry : Skoog and West Hollar
3. Analytical Chemistry : GD Christian
4. Analytical chemistry: an introduction: D. A. Skoog, D. M. West and F. J. Holler, Saunders the College publishers, 6 edition.
5. An introduction to analytical chemistry, S. A. Iqbal, M. Satake, Y. Mido and M. S. Shethi.
6. College analytical chemistry: Joshi, Baliga and Shetty, Himalaya Publishing house.
7. Qualitative analysis: Day and Underwood.
8. Qualitative inorganic analysis: A. I. Vogel.
9. Principles of analytical chemistry: Pandit and Soman.
10. Analytical chemistry, G. D. Christian, J. Wiley eastern press Ltd.
11. Analytical chemistry: Alka Gupta.
12. Basic concepts of analytical chemistry: S. M. Khopkar.
13. Advanced pratical organic chemistry: Vishnoi.
14. Qualitative analysis: A laboratory manual: Day and Underwood.
15. Fundamentals of analytical chemistry: D. A. Skoog, D.M. West and H. J. Holler, 7 edition.
16. Analytical chemistry principles: J. H. Kennedy, W. B. S. Saunders pub. Ltd.
17. Analytical chemistry: Principles and Techniques: L. G. Hargis, Prentice Hall.
18. Principles in semi-micro qualitative analysis: G. R. Chatwal edited by M. Arora.
19. A text book of experimental and calculation in engineering chemistry: S. S. Dara.
20. Modern analytical chemistry: W. F. Pickering, Marcel Decker INC. New York.
21. Introduction to chromatography: Srivastava and Srivastava.
22. University Practical Chemistry by PC Kamboj, Vishal Publishing Company, Jalandhar.
23. Practical Chemistry (for B.Sc.I, II & III Year Students of All Indian Universities) Dr.O.P.

Course: B.Sc. (NCCE.) VI Sem.	**Max. Marks:50**
Paper Title: Inorganic Chemistry	**Paper No. :** NCCE-606-T

Sr. No.	**Details**	**No. of Lectures 45**
	Inorganic Chemistry	
1	**Chemistry of Elements of First Transition Series** 1.1. General characteristic features of d-block elements. 1.2. Properties of the elements of the first transition series: 1.2.1. Ionic Size, 1.2.2. Atomic Size, 1.2.3. Metallic properties, 1.2.4. Ionization potential, 1.2.5.magnetic properties, 1.2.6. Oxidation State.	**12**
2	**Chemistry of Elements of Second and Third Transition Series** 2.1. General characteristic, 2.2. Comparative study with their 3d analogues in respect of 2.2.1. Ionic radii, 2.2.2. Oxidation State, 2..2.3. Magnetic behaviour, 2.2.4. Spectral properties.	**10**
3	**Chemistry of Lanthanide and actinides Elements** 3.1. Occurrence, 3.2. Electronic Configuration, 3.3. Oxidation States, 3.4. Ionic Radii, 3.5. Isolation of Lanthanides , 3.6. Lanthanide contraction and its consequences, 3.7. Chemistry of separation of Np, Pu and Am from U.	**12**

4	**Co-ordination Compounds** 4.1. Werner's Co-ordination Theory and its experimental verification, 4.2. Effective atomic Number concept, 4.3. Chelates, 4.4. Nomenclature of co-ordination compounds, 4.5. Isomerism in co-ordination compounds, 4.6. Valence bond theory of transition metal complexes.	11

References:

1. Textbook of Inorganic Chemistry- P.L.Soni
2. Modern Inorganic Chemistry- R.C.Agrawal
3. Modern Inorganic Chemistry- R.L.Madan
4. Advanced Inorganic Chemistry- Satya Prakash
5. Principles of Inorganic Chemistry- Puri,Sharma,Kalia
6. Concise Inorganic Chemistry- J.D.Lee
7. Selected Topics in Inorganic Chemistry- Madan, Malik,Tuli
8. Advanced Inorganic Chemistry- Gurudeep Raj
9. Advanced Inorganic Chemistry- Cotton, Wilkinson
10. Chemistry for Degree students- B.Sc. I, II, III- R.L.Madan

B.Sc. Non-Conventional and Conventional Energy
Semester VI
Skill Enhancement Course

Note :
Any one skill enhancement course to be chosen out of two either
'SEC-1(C): Solar Power Plant Design Course II,' Or
'SEC-1(D): Fuel Chemistry,'

Course: B.Sc. (NCCE.) VI Sem.	Max. Marks:50
Paper Title: SEC-1(C) Solar Power Plant Design Course II	Paper No. : NCCE-615 (C)-T

Sr. No.	Details	No. of Lectures 45
	Solar Power Plant Design Course II	
1	**Inverters Selection and Sizing (Grid Connection and Off Grid)** • Types of solar inverter • Selection of string /central / off grid inverter • Selection of power conditioning unit (PCU) • Sizing of solar inverter for roof top and grid connected projects • Selection and sizing of string inverter • Selection and sizing of central inverter • AC/DC overloading calculation and losses • Protection requirement of solar inverter • Passive and active protection • Anti- islanding protection • Mounting arrangement of string inverter • IEC/IEEE /Grid Compliance of inverters • Grid-Connected Inverters vs. Stand-Alone Inverters • Inverter Communication and remote monitoring • Inverter Products For Use In India	11
2	**Connection of PV Module (Series and Parallel Circuit)** Series Circuits Parallel Circuits Combining Series & Parallel Circuits PV module string connection Matching The PV Array To The Voltage Specifications of An Inverter Matching the PV Array to the Inverter's Current Rating Matching the PV Array to the Inverter's Power Rating Summary of Calculations for Matching Array and Inverter	12
3	**Preparation of single line diagram and plant array layout.** Preparation of rooftop solar power (single line diagram) SLD Preparation of Net Metering solar power (single line diagram) SLD Preparation utility scale solar power (Ground mounted) SLD Rooftop solar power plant layout Ground mounted solar power plant layout DC SLD /AC SLD Protection SLD Earthing Layout/ AC /DC cabling Layout DC Block sizing layout Overall Array Plant Layout	10

4	**Solar Power Plant String Combiner Box/ ACDB/ MDB/Metering cubical** Selection and sizing of SCB/SMB Selection of Isolator/ fuse Selection of Monitoring of SCB/SMB Mounting arrangement of SCB/SMB ACDB Switchgear sizing Types of energy meter and selection	12

Reference books:

1. "Solar Electricity Handbook: A Simple, Practical Guide to Solar Energy – Designing and Installing Photovoltaic Solar Electric Systems" by Michael Boxwell:

2. "Photovoltaic Design and Installation for Dummies" by Ryan Mayfield:

3. "Solar PV Engineering and Installation: Preparation for the NABCEP PV Installation Professional Certification" by Sean White:

Course: B.Sc. (NCCE.) VI Sem.	Max. Marks:50
Paper Title: SEC-1(D) Fuel Chemistry	Paper No. : NCCE-615 (D)-T

Sr. No.	Details	No. of Lectures 45
	Fuel Chemistry	
1	**Coal**: Uses of coal (fuel and nonfuel) in various industries, its composition, carbonization of coal.	11
2	**Coal gas**, producer gas and water gas—composition and uses. Fractionation of coal tar, uses of coal tar bases chemicals, requisites of a good metallurgical coke, Coal gasification (Hydro gasification and Catalytic gasification), Coal liquefaction and Solvent Refining.	12
3	**Petroleum and Petrochemical Industry**: Composition of crude petroleum, Refining and different types of petroleum products and their applications. Fractional Distillation (Principle and process), Cracking (Thermal and catalytic cracking), Reforming Petroleum and non-petroleum fuels (LPG, CNG, LNG, bio-gas, fuels derived from biomass), fuel from waste, synthetic fuels (gaseous and liquids), clean fuels.	10
4	**Petrochemicals:** Vinyl acetate, Propylene oxide, Isoprene, Butadiene, Toluene and its derivatives Xylene. Lubricants: Classification of lubricants, lubricating oils (conducting and non-conducting) Solid and semisolid lubricants, synthetic lubricants. Properties of lubricants (viscosity index, cloud point, pore point) and their determination.	12

Reference Books:

1. Stocchi, E. Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK (1990).
2. Jain, P.C. & Jain, M. Engineering Chemistry Dhanpat Rai & Sons, Delhi. 75
3. Sharma, B.K. & Gaur, H. Industrial Chemistry, Goel Publishing House, Meerut (1996).

24/5/2024