Madhabdev University

(A State University Established under the Assam Act. No. XXXV of 2017)
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Skill Enhancement Course (SEC) Curriculum in Chemistry

| Under NEP 2020 |

1. Preface & Overview

The implementation of the National Education Policy (NEP) 2020 necessitates a paradigm shift in higher education, emphasizing skill enhancement, multidisciplinary learning, and employability. In alignment with these core objectives, the Department of Chemistry at Madhabdev University introduces a comprehensive suite of Skill Enhancement Courses (SEC) for the Undergraduate (UG) programme. Set to be implemented from the upcoming academic session, these courses are meticulously designed to bridge the crucial gap between theoretical knowledge and practical, real-world application.

Spanning across the initial semesters with progressive National Credit Framework (NCrF) levels (4.5 to 5.5), the curriculum offers immersive training in foundational and advanced chemistry skills. The courses are deliberately structured with a dominant emphasis on practical competency—allocating 60 hours to hands-on laboratory work and 15 hours to theoretical instruction per course. This structure ensures that students not only understand fundamental scientific principles but also acquire the dexterity, ethical grounding, and professional standards required in modern academic, research, industrial, and forensic environments.

2. Scope of the Programme

The scope of this SEC curriculum is broad, highly relevant to current industry demands, and encompasses three core domains:

- Laboratory Safety and Standard Operations (Semester I): Equips students with essential safety protocols, chemical management strategies (MSDS/SDS, GLP), and the fundamental handling of laboratory apparatus. This forms the bedrock for any student aspiring to work safely and efficiently in research, pharmaceuticals, or chemical manufacturing.
- Analytical Techniques and Quality Control (Semester II): Transitions into quantitative and qualitative analysis, focusing on volumetric, electroanalytical, and chromatographic techniques. This module opens direct career pathways into Quality Control (QC), Quality Assurance (QA), environmental testing, and analytical laboratories.
- Forensic Chemistry (Semester III): Applies chemical principles to investigative sciences, covering explosives, toxicology, and drug analysis. This specialized module introduces students to the

niche and highly sought-after field of criminology, law enforcement support, and forensic analysis.

3. Salient Features

- NEP 2020 Aligned & NCrF Integrated: Progressive complexity mapping to NCrF levels 4.5, 5.0, and 5.5, ensuring step-by-step skill acquisition.
- High Practical Weightage: A 4:1 ratio of practical to theory hours (60 hours Practical, 15 hours Theory) guarantees substantial hands-on experience.
- Industry-Ready Competencies: Intensive focus on Good Laboratory Practices (GLP), Standard Operating Procedures (SOPs), and the Global Harmonized System (GHS) makes students immediately employable.
- Comprehensive Assessment System: Evaluation is rigorously divided into continuous in-semester assessments and end-semester examinations, with significant weight assigned to laboratory performance, record-keeping, and case studies.
- Real-World Exposure & Case Studies: Inclusion of field visits (e.g., State Forensic Science Labs, Food and Drug Testing Labs) and real-world case study reporting connects classroom learning to societal applications.

Semester I

NCrF level	*4.5*
Title of the Course	Safety Measures and Standard Operation in Chemistry Laboratory
Course code	*CHES-101*
Paper credit	*03 (*(L 1 – T 0 - P 2)
Total Contact Hours	*Theory 15; Practical 60*
Distribution of Marks	*Theory 30 (Theory End semester 20+ In-semester 10)* *Practical 70 (Lab. performance 10, record book 5; attendance 5; exam 50)*

Course Objectives

After completing this course, students will be able to:

- Understand the importance of laboratory safety, identify various laboratory hazards, and recognize safety symbols, signage, and ethical practices required in a chemistry laboratory.
- Acquire knowledge of the classification, safe handling, storage, transportation, and disposal of chemicals
- Develop competency in the selection and proper use of personal protective equipment (PPE), emergency response procedures, first aid, fire safety etc
- Understand and implement Standard Operating Procedures (SOPs), Good Laboratory Practices (GLP)
- Gain hands-on training in laboratory safety practices, chemical management, laboratory apparatus, calibration techniques, purification methods, and standard laboratory operations
- Develop professional skills in laboratory management, documentation, scientific reporting, teamwork, and responsible conduct to enhance employability and research preparedness.

Course Outcomes (COs)

Upon successful completion of the course, students will be able to:

CO1: Explain laboratory safety principles, identify different types of laboratory hazards, interpret safety symbols, and demonstrate ethical laboratory behaviour.

CO2: Classify chemicals according to international safety standards, interpret MSDS/SDS information, and implement appropriate procedures for chemical handling, storage, transportation, and disposal.

CO3: Demonstrate the proper use of personal protective equipment (PPE), emergency safety equipment, fire extinguishers, first aid measures, spill management procedures, and emergency evacuation protocols.

CO4: Apply Standard Operating Procedures (SOPs) and Good Laboratory Practices (GLP) for routine laboratory operations, including the safe use and maintenance of laboratory instruments

CO5: Perform laboratory safety audits, prepare safety documents (MSDS, hazard labels, safety charts), identify laboratory risks, and recommend appropriate preventive and corrective measures.

CO6: Demonstrate proficiency in handling laboratory apparatus, calibration of glassware and instruments, purification techniques, heating, filtration, centrifugation, distillation, recrystallization, reagent preparation, and other essential laboratory operations following standard protocols.

CO7: Analyze laboratory observations, maintain accurate laboratory records, calculate experimental yields, and prepare technical reports in accordance with scientific and safety standards.

CO8: Demonstrate professional ethics, environmental responsibility, teamwork, effective communication, and safe laboratory practices expected in academic, research, and industrial laboratories.

Unit I: Introduction to Laboratory Safety — *4 hours*

- Importance of laboratory safety
- Types of laboratory hazards:
    - Chemical hazards
    - Physical hazards
    - Fire and explosion hazards
    - Electrical hazards
    - Biological hazards
- Laboratory safety symbols and signage's
- Safety rules and laboratory ethics

Unit II: Chemical Handling and Storage — *3 hours*

- Classification of chemicals
- Labelling and storage of chemicals
- Handling corrosive, flammable, toxic, and oxidizing chemicals
- Material Safety Data Sheet (MSDS/SDS)
- Safe transfer and transportation of chemicals

Unit III: Personal Protective Equipment and Emergency Measures *3 hours*

- Laboratory coat, gloves, goggles, masks
- Eye wash station and safety shower
- Fire extinguishers and their uses
- First aid measures in chemical accidents
- Spill management and emergency evacuation

Unit IV: Standard Operating Procedures (SOPs) *5 hours*

- SOP for common laboratory operations
- Handling glassware and heating equipment
- SOP for balances, pH meter, centrifuge, hot air oven, magnetic stirrer
- Laboratory housekeeping
- Good Laboratory Practices (GLP)

Unit V: Practical / Hands-on Training *60 hours*

Part A: Safety Measures

- Design an illustrative chart exhibiting creativity at transaction of Do's and Don'ts instructions for working in a chemistry laboratory.
- Carry out Classification and labelling of the given set of chemicals based upon Globally Harmonized System.
- Carry out detailed survey of the Chemical Abstract Service (CAS) Registry Number and identify the given set of CAS RN and explain the different sections of CAS RN.
- Carry out preparation of the indicative MSDS (Material Safety Data Sheet) of given set of chemicals as per Standard MSDS format.
- Design an illustrative chart exhibiting creativity at transaction of Common Safety Symbols along with its description. Associate appropriate safety symbol with each of the given set of chemicals.
- Draw and elucidate the National Fire Protection Association Hazard Labels.
- Identify and enlist the Incompatible Chemicals from a given set of chemicals available in the laboratory.
- Carry out investigations on Labelling and storage of Chemical in laboratory.
- On the basis of MSDS analysis, identify the required storage conditions for the given set of chemicals.
- Describe procedure for the storage, maintenance and handling of compressed gas cylinders.
- Explore guidelines for the Storage of shelf chemicals and reagents.
- Review common routes of chemical exposure to the human body.
- Carry out a detailed study of the Limits of Exposure of given Chemicals.
- Classify the Hazard based on storage, handling, and disposal of chemicals.
- Identification and describe handling protocols for Substances with Greater Hazardous Nature.
- Carry out detailed investigations on procedural protocols for safe Disposal of Chemicals.
- Carry out study on recommended Safety and Emergency Equipment essential for the safe practices in a Chemistry Laboratory.

- Study the guidelines in the Event of a Chemical Accident or Spill.
- Write detailed description on Fire Safety in the laboratory.
- Carry out investigations of the data regarding Institute Safety Policies: Safety Audits / Inspections.

Part B: Chemistry Lab Standard Operations

- Carry out exploration on Holding, Handling and use of Common Laboratory Apparatus as per given list of laboratory apparatus (Appendix A).
- Carry out investigations of various types of apparatus in labs based on material they are made of such as Pyrex Glass (borosilicate Glass) Apparatus, Fused Silica Apparatus: Corning Vycor Glass, Porcelain apparatus, Plastic Apparatus, Metal Apparatus.
- Understanding the protocol of Cleaning and drying and polishing of Glassware apparatus.
- Identification of glassware and their uses in laboratory
- Carry out detailed investigations on Identification, diagrammatic representation, set up of Apparatus assemblies and details exploration on operational procedural protocols for glassware apparatus with Interchangeable ground glass joints: Typical Assemblies.
- Carry out calibration of Volumetric/Graduated Glassware Apparatus (burette, pipette etc) along with description on Temperature Standards and Calibration of thermometers.
- Carry out exploration and investigations of working protocol for various heating equipment in laboratory: Burners, Hot Plates, Electrical Heating Mantles, Electric Oven, Microwave Oven, Muffle Furnace, Infrared lamps, Crucible and Beaker Tongs and Emersion heaters.
- Carry out exploration and investigations of working protocol for various Stirring apparatus in laboratory: Stirring rods; Policeman, Boiling rods, Use of Mechanical agitation-Magnetic Stirrer and Mechanical Shaker.
- Carefully analyse the Glass, Cork and Rubber Stoppers and investigate their preparation and appropriate applications.
- Carry out detailed investigations of Heating and Cooling Bath, and determine their working ranges and working protocols
- Explore and differentiate between different forms of water for Laboratory Use: Distilled (Grade I to III), De-ionized and tap water, and carry out conductance measurement /other analytical investigations for the differentiation purpose.
- Differentiate among Various types of Filter Paper and explore their applications, filtering techniques
- Classification of reagents as AR/ GR grade.
- Care and Use of Analytical Balance: Mass and Weight, Two-Pan Balance and Electronic Balance
- Carry out Calibration of weighing balances and accuracy in measurement.
- Use of melting point apparatus. Experimental determination of the melting point and boiling points using various methods.
- Purify given organic solvents. Hand on training for working with typical assemblies of apparatus for distillation and refluxing.
- Assessment of Fire hazards attending the distillation of inflammable solvents.
- Purification of given solid organic compounds by crystallisation method.

- Recrystallization of given non-volatile organic solids and outline the Difficulties encountered in recrystallization process.
- Removal of traces of colouring matter and use of decolourising carbon.
- Carry out exploration and investigations of working and working protocol for Filtration Apparatus: Filtration with suction.
- Explore and imbibe knowledge about types of Vacuum Pump; Water and Oil Pump and their applications.
- Investigate Conventions for Drying of the recrystallized material.
- Differentiate between various types of centrifugation methods, principle, uses and application of centrifugation method.
- Calculation of yields for different chemical processes.
- Preparation of some useful reagent and storage procedure.

Instruction or Note

A minimum of 5 exercises from Part A and 10 exercises from Part B is required to be discussed/performed/investigate. Moreover, exercises related to MSDS, CASRN safety symbols identification is required to be performed mandatorily. Some experiments shall be performed by the students in presence of instructor/teacher.

References

- Skoog D.A., West D.M., Holler F.J., Stanley R.C., **Fundamentals of analytical chemistry**, 9th Edition, Cengage Learning.
- Mendham, J.; Denney, R.C.; Barnes, J.D.; Thomas, M.J.K. (2007), **Vogel's Quantitative Chemical Analysis**, 6th Edition, Prentice Hall.
- Furniss, B. S; Hannaford, A. J.; Smith, Peter W. G.; Tatchell, A. R; **Vogel's Text Book of Practical Organic Chemistry**, 5th Edition, Longman Scientific and Technical, Longman Group Ltd.
- Garland, C. W.; Nibler, J. W.; Shoemaker, D. P. (2003), **Experiments in Physical Chemistry**, 8th Edition, McGraw-Hill, New York.
- https://iupac.org/
- https://edu.rsc.org/resources/practical/experiments

Semester II

NCrF level	*5.0*
Title of the Course	**Basic Analytical Techniques**
Course code	*CHES-201*
Paper credit	*03 (*(L 1 – T 0 - P 2)
Total Contact Hours	*Theory 15; Practical 60*
Distribution of Marks	*Theory 30 (Theory End semester 20+ In-semester 10)* *Practical 70 (Lab. performance 10, record book 5; attendance 5; exam 50)*

Course Objectives

After successful completion of this course, students will be able to

- Understand the role of analytical chemistry in scientific research and industry.
- Prepare standard solutions accurately.
- Apply volumetric analytical techniques.
- Understand sampling and sample preparation.
- Record and interpret analytical data.
- Follow quality control and laboratory ethics.

Course Outcomes (COs)

At the end of the course, the student will be able to

CO1: Explain the importance of analytical chemistry

CO2: Prepare standard solutions and perform basic calculations

CO3: Conduct acid-base, redox and complexometric titrations

CO4: Collect, preserve and prepare samples for analysis

CO5: Maintain laboratory records and interpret analytical results

Unit I: Introduction to Analytical Chemistry *3 hours*

Scope and importance of analytical chemistry, Types of analysis: Qualitative and Quantitative, Analytical process, Accuracy and precision, Errors in chemical analysis, Significant figures, Laboratory ethics

Unit II: Reagents and Solution Preparation *2 hours*

Laboratory reagents, Purity grades of chemicals, Standard and secondary standard substances, Preparation of different solutions (molar, normal, percentage (w/v, v/v), ppm), standardization of solutions

Unit III: Basic Analytical Techniques *5 hours*

Basics of sample preparation, preservation and storage, standards and guidelines for sample handling, good storage practices
Gravimetric methods, volumetric methods (Acid-base titration, Redox titration, Complexometric titration, Iodometric titration), electroanalytical methods (pHmetry, Conductometry, spectroscopic methods (colorimetry, Flame Photometer), chromatographic techniques (Paper and Thin Layer Chromatography)

Unit 4: Quality checking *5 hours*

Overview, productivity concept, statistical analysis of laboratory data, measurements, calibrations, validation, reference standards and materials, requirements of a calibration lab, fundamentals of advanced QC approaches, Trouble shooting in QC, documentation, audit/ process related query, Quality certifications, Government regulations in industries

Laboratory Exercises ***60 hours***

Part A: Laboratory Skills and Volumetric Analysis

- Preparation of various normal and molar solutions
- Preparation of buffer solution
- Standardization of HCl using sodium carbonate.
- Estimation of acetic acid in vinegar.
- Standardization of sodium hydroxide using oxalic acid
- Determination of total hardness of water using EDTA.
- Estimation of ferrous ion using potassium dichromate.
- Estimation of available chlorine in bleaching powder.

Part B: Instrumental Demonstration

- Measurement of pH using pH meter.
- Determination of pH, acidity, and alkalinity of water samples collected from different water body/supply sources like river water, supply water, Groundwater, water samples collected from water sewage treatment plants in nearby areas
- Measurement of conductivity of water
- Determination of pH of different types of aerated drinks and fruit juices.
- Determination of absorbance using UV-Visible spectrophotometer/colorimeter
- Spectrophotometric determination of Iron in vitamin / dietary tablets / different solutions of iron
- Spectrophotometric determination of cadmium and chromium in the given water sample
- Spectrophotometric identification and determination of caffeine and benzoic acid in soft drink
- Estimation of macro-nutrients: Potassium, calcium and magnesium in soil samples by flame photometry
- Estimation of sodium or potassium using flame photometer (demonstration)
- Preparation of TLC plates and separation of amino acids
- Paper chromatographic separation (*ascending and circular both*) of the mixture of metal ion (Ni^{2+} and Co^{2+}) and (Cu^{2+} and Cd^{2+})

Part C: Sample Collection

- Preparation of sample for laboratory analysis.
- Collection and preservation of water sample.
- Collection of soil sample and measurement of pH and conductivity.

Suggested exercise: Visit some industries to study the validation of simple procedures.

Suggested reading

- Skoog D.A., West D.M., Holler, F.J., Crouch S.R., Fundamentals of Analytical Chemistry, 9th Edition, Cengage learning.
- Quality control chemist participant manual prepared by LSSSDC in collaboration with NSDC India.

Semester II

NCrF level	*5.5*
Title of the Course	**Chemistry in Forensic Science**
Course code	*CHES-301*
Paper credit	*03 (*(L 1 – T 0 - P 2)
Total Contact Hours	*Theory 15; Practical 60*
Distribution of Marks	*Theory 30 (Theory End semester 30 + In-semester 20)* *Practical 70 (Lab. performance 10, record book 5; attendance 5; case studies 20, exam 30)*

Course Objectives

- To provide a basic understanding of Forensic Science
- To comprehend the role of chemistry in Forensic Science

Course outcomes

At the end of the course, the student will be able to

CO1: Know the history and development of Forensic Science as well as recent advances in the field in context of India.

CO2: Familiarize with the recent scope of the Forensic Chemistry.

CO3: Learn about various explosive materials, drugs and narcotics as well as chemical poisons involved in various criminal activities

Unit I: Introduction to Forensic Science *7 hours*

Definitions and concepts in forensic science; Historical aspects of forensic science in India and abroad; Basic principles of forensic science; Scope of forensic science; Functions of forensic science; Importance of Forensic Science; Functions of Forensic Science; Code of conduct for forensic scientists

History of Forensic Chemistry; Role of chemistry in Forensic Science, Need of in Forensic Chemistry Education and Qualifications of forensic scientists

Unit II: Forensic Chemistry *8 hours*

Explosives: Classification of explosives, Blasting agents. Examples of some explosives and their structure & characteristics, TNT, PETN RDX, tetrazine, DDNP, picric acid, HMX, NG, dynamite, ammonium nitrate, black powder, smokeless powder, Systematic Procedure for the examination of Explosive Evidence; Explosion process; Blast waves; Bomb scene management

Drugs & Narcotics : Definition of narcotics, drugs and psychotropic substances. Broad classification – Narcotics, stimulants, depressants and hallucinogens, General characteristics and common example of each classification, Natural, synthetic and semi-synthetic narcotics, drugs and psychotropic substances,

Poisons: Classification of poisons. Physico-chemical characteristics and mode of action of poisons, Accidental, suicidal and homicidal poisonings, Collection and preservation of viscera, blood and urine for various poison cases, Identification of biocides and metal salts in body fluids, Metabolism and excretion of poisons, Application of immunoassays in forensic work, Animal poisons, Snake venom. Mode of action, Carbon monoxide poisoning, Vegetable poisons, Poisonous seeds, fruits, roots and mushrooms,

Unit III Practical *60 hours*

(Students should perform any two experiments and a case study report on explosion/poison/ drugs/ accidental, suicidal and homicidal poisonings)

A) ***Crime Scene Documentation***

- Mock crime scene observation, photography and documentation.
- Collection, packaging and labelling of forensic samples maintaining chain of custody.

B) ***Explosive Analysis***

- Preliminary colour tests for common explosive residues.
- Determination of nitrate, chlorate and perchlorate ions.
- Detection of sulphur and charcoal residues in black powder.
- Identification of ammonium nitrate fertilizers used as explosive precursors.
- Demonstration of explosive residue sampling from surfaces.

C) ***Forensic Toxicology***

- Detection of common metallic poisons (As, Hg, Pb, Cu) by classical qualitative tests.
- Screening of organophosphorus pesticide residues.
- Extraction of poisons from simulated biological samples.
- Determination of blood alcohol concentration (demonstration/simulation).
- Presumptive tests for carbon monoxide poisoning.

D) ***Drug Analysis***

- TLC separation of mixed narcotic samples.
- UV-visible spectrophotometric analysis of selected drugs.
- Demonstration of GC-MS/HPLC/FTIR applications using laboratory data or instrument demonstration.
- Identification of counterfeit pharmaceutical tablets.

E) ***Chromatographic Techniques***

- Paper chromatography of ink and dye samples.
- Comparison of TLC and paper chromatography in forensic analysis.
- Calculation of Rf values and interpretation.

F) ***Microscopic Examination***

- Identification of plant fragments used as poisons.

- Microscopic examination of unknown powders.
- Identification of crystals formed in common poison tests.

G) Evidence Preservation

- Packaging and preservation of biological samples.
- Preservation of viscera according to forensic guidelines.
- Preparation of laboratory chain-of-custody documentation.

H) Instrumental Demonstration

- Demonstration of FTIR in explosive identification.
- Demonstration of GC-MS in drug analysis.
- Demonstration of UV-Visible spectroscopy in toxicological analysis.
- Demonstration of Raman spectroscopy for explosive detection.

I) Case Studies

- Preparation of forensic toxicology report from a simulated poisoning case.
- Preparation of explosive examination report.
- Interpretation of forensic laboratory reports.
- Study of famous forensic chemistry case studies.

J) Field Exposure

- Visit to State Forensic Science Laboratory.
- Visit to Narcotics Control Bureau/Police Forensic Unit (where feasible).
- Visit to Food and Drug Testing Laboratory.
- Visit to Explosives or Industrial Safety Laboratory (where permitted).

Suggested Readings

- S. K. Bharadwaj and P. Borthakur, *Chemistry in Forensic Science*, 1st edition, Bandhab Publication
- S.H. James and J.J. Nordby, *Forensic Science: An Introduction to Scientific and Investigative Techniques*, 2nd Edition, CRC Press, Boca Raton (2005).
- W.G. Eckert and R.K. Wright in *Introduction to Forensic Sciences*, 2nd Edition, W.G. Eckert (ED.), CRC Press, Boca Raton (1997).
- S. Ballou, M. Houck, J.A. Siegel, C.A. Crouse, J.J. Lentini and S. Palenik in *Forensic Science*, D.H. Ubelaker (Ed.), Wiley-Blackwell, Chichester (2013).
- F.G. Hofmann, *A Handbook on Drug and Alcohol Abuse*, 2nd Edition, Oxford University Press, New York (1983).
