KRISHNA KANTA HANDIQUI STATE OPEN UNIVERSITY (KKHSOU)

PROGRAMME PROJECT REPORT

ON

MASTER OF SCIENCE IN CHEMISTRY

Two Year (Four Semester) Post Graduate Programme in UGC-CBCS Mode and in Accordance with NEP-2020 to be offered from 2026-27 Academic Session

Submitted to
UNIVERSITY GRANTS COMMISSION
NEW DELHI

Submitted by
K. K. HANDIQUI STATE OPEN UNIVERSITY
GUWAHATI, ASSAM

May 2026

Registrar
Krishna Kanta Handiqui
State Open University
Guwahati

CONTENTS

KRISHNA KANTA HANDIQUI STATE OPEN UNIVERSITY

PROGRAMME PROJECT REPORT

MASTER OF SCIENCE IN CHEMISTRY

1. OVERVIEW OF THE PROGRAMME

Master of Science in Chemistry (M.Sc. Chemistry) is a two year (four semester) postgraduate programme, proposed to be offered by Krishna Kanta Handiqui State Open University (KKHSOU) from July, 2026 academic session onward. The programme is offered in UGC-CBCS mode and the framework of the programme has been based on the National Credit Framework, September, 2022. And, the programme was designed in consonance with the NEP-2020incorporating its ideals and principles. KKHSOU has adopted various provisions of the curriculum and credit framework, multidisciplinary/interdisciplinary approach in curriculum design, and assessment and evaluation methods of UGC from time to time. This programme has been designed incorporating all these provisions. Further, the programme has been designed and proposed in accordance with the University Grants Commission (Open and Distance Learning Programmes and Online Programmes) Regulations, 2020.

The proposed programme consists of Core courses specific to the discipline (Discipline Specific Core, DSC) along with a range of Discipline-Specific Elective (DSE) courses that enable students to develop a deeper understanding of various branches of Chemistry and explore specialized areas of interest. In addition to the core and elective courses, Ability Enhancement Courses (AEC) and Value Added Courses (VAC) are offered to broaden the learners' academic exposure and skill sets. As the university organizes its academic programmes through a school system, it is expected that multidisciplinary and interdisciplinary courses under AEC and VAC will be effectively implemented with the support of faculty members from relevant disciplines. Furthermore, the University is registered with the Academic Bank of Credit (ABC), which allows learners to transfer and accumulate academic credits across institutions, thereby providing greater flexibility in course selection and learning pathways.

The Centre for Internal Quality Assurance (CIQA) of the University has organized several meetings and workshops to design and review academic programmes in the

context of Open and Distance Learning (ODL). Based on the inputs gathered during these consultations, the Committee on Courses of Studies (CCS), in collaboration with external subject experts from reputed Universities of the region, has developed and approved the programme structure and detailed syllabus. Subsequently, the syllabus and other relevant matter were approved in the 50th Meeting of the Academic Council held on 27th February, 2026.

This Programme Project Report (PPR) presents the Two-Year Postgraduate Programme of Master of Science (Chemistry) offered by the Discipline of Chemistry at the Hiranya Chandra Bhuyan School of Science and Technology of KKHSOU, which is the outcome of this academic planning and approval process of KKHSOU.

2. PROGRAMME MISSION AND OBJECTIVES

The overall mission of M.Sc. in Chemistry programme is to create a pool of human resources with professional competence in the field of Chemistry. To achieve this, the programme is designed with a mission to impart comprehensive knowledge and understanding of both fundamental and applied areas of Chemistry, incorporating both theoretical and practical foundation with interdisciplinary components. Specifically, the mission of the Master of Science (Chemistry) programme is to provide comprehensive and systematic knowledge of chemical sciences through flexible and learner-centred open and distance learningby providing accessible opportunities to enhance their academic qualifications. The programme aims to develop analytical thinking, experimental competence, and research aptitude among learners so that they can apply chemical principles to address scientific, industrial, environmental, and societal challenges. It also seeks to promote innovation, scientific inquiry and critical thinking.

With this mission, the programme is proposed with the following objectives.

- To develop a strong conceptual understanding of fundamental and advanced areas of chemistry such as Organic, Inorganic, Physical, Analytical, Industrial, Pharmaceutical and Materials Chemistry.
- To nurture scientific temperament and analytical thinking so that learners can critically analyse chemical phenomena and solve complex chemical problems.
- To provide learners with knowledge of modern experimental techniques, instrumentation, and laboratory skills required in chemical research and industry.

- To strengthen computational and data-analysis skills relevant to chemical research, modelling, and interpretation of experimental results.
- To encourage research aptitude and innovation by exposing learners to contemporary developments in chemical sciences.
- To enhance learners' ability to apply chemical knowledge in interdisciplinary areas such as environmental science, materials science, pharmaceuticals, and nanotechnology.
- To develop professional competence and ethical scientific practices required for careers in academia, research laboratories, chemical industries, and related sectors.
- To promote lifelong learning and the ability to adapt chemical knowledge to emerging scientific and technological advancements.

3. RELEVANCE OF THE PROGRAMME WITH KKHSOU'S MISSION AND GOALS

The M.Sc. in Chemistry programme is closely aligned with the vision and mission of the University and its motto **"*Education Beyond Barriers*".** Conforming to the mission of KKHSOU, the programme is prepared to achieve the following goals.

(a) To expand postgraduate education in Chemistry to a wide range of learners through a flexible, inclusive and learner-centric ODL framework.

(b) To create opportunities for learners from diverse socio-economic and geographical backgrounds, working professionals, and individuals who could not complete their higher education earlier.

(c) To equip learners with a strong conceptual understanding of both fundamental and applied areas of Chemistry to acquire multidisciplinary knowledge and skills in accordance with the societal needs.

(d) To ensure quality and excellence in higher education in Chemistry to prepare learners to contribute meaningfully to scientific advancement, technological development, and societal progress.

(e) To foster strong theoretical knowledge, analytical thinking, and experimental proficiency for contributing to the broader academic goals of KKHSOU in promoting excellence in education, research, and innovation.

4. NATURE OF PROSPECTIVE TARGET GROUP LEARNERS

The M.Sc. Chemistry programme is designed to prospective learners, who are **Graduates with B.Sc. Degree with Chemistry as one of the subjects at the undergraduate level**, who intend to pursue postgraduate studies in Chemistry. Prospective learners with the said qualification include the following target groups.

a) Working professionals like teachers, laboratory assistants, and professionals working in chemical or allied industries who wish to upgrade their qualifications and gain advanced knowledge in the field, who may not be able to attend regular classroom-based programmes due to professional or personal commitments.

b) Learners of any age who have been unable to secure admission through conventional system due to various adverse situations primarily stemming from social, financial, and demographic factors.

c) Learners who aspire to pursue careers in research and development, higher education, quality control, environmental monitoring, chemical industries, pharmaceutical companies, research laboratories, and allied scientific sectors.

d) Learners who are interested in developing advanced conceptual understanding, laboratory competencies, analytical abilities, and research aptitude in Chemistry, thereby preparing them for diverse professional opportunities and further academic pursuits such as doctoral research.

5. APPROPRIATENESS OF THE PROGRAMME TO BE CONDUCTED IN ODL MODE TO ACQUIRE SPECIFIC SKILL AND COMPETENCE

The M.Sc. in Chemistry programme is appropriate to be conducted in ODL mode, as it is developed to offer with a focus on conceptual understanding, analytical thinking and problem solving abilities in various fields of Chemistry. These aspects can be effectively delivered through meticulously designed and developed learner-friendly Self Learning Materials (SLM) and by the effective modes of curriculum delivery system of KKHSOU.

The programme is designed to follow a blended learning approach that includes printed SLMs, recorded video lectures, digital learning resources, assignments, and academic counselling sessions conducted at selected study centres with required credentials. In addition, the programme includes laboratory experiments, seminars, and project work. These practical components will be conducted through selected Learner Support Centres

of the University, where appropriate laboratory facilities and academic guidance will be provided to learners. To ensure this, the programme is proposed to offer initially from Learners Support Centres, chosen as per UGC (ODL Programmes and Online Programmes) Regulations, 2020, where M.Sc. in Chemistry has been offered at least for seven years. Overall, this M.Sc. in Chemistry programme is appropriate to be offered in ODL delivery mode.

6. INSTRUCTIONAL DESIGN AND TEACHING-LEARNING SCHEME

6.1 Curriculum Design

The M.Sc. in Chemistry programme has been designed in accordance to the standards of the UGC (Open and Distance Learning Programmes and Online Programmes) Regulations, 2020, while preparing the syllabus, UGC LOCF Curricular Framework, Academic Integrity Regulation 2018, UGCdefinitionsofDegreesJuly2014, syllabi of other Universities and recommendations of Madhava Menon Committee have been consulted. In consonance with the UGC's Guidelines for incorporating Indian Knowledge in Higher Education Curricula, 2023, on recommendation of National Education Policy 2020 (NEP 2020), the syllabus has been prepared incorporating relevant components of Chemical Science from Indian Knowledge System (IKS). With the help of experts in the subject from other reputed Universities in the region, viz., Gauhati University and Cotton University, Assam, the contents of the syllabus are updated.

6.2 Programme Structure

M.Sc. in Chemistry programme is of 2 Years (4 Semesters). A detailed outline of the program is given in ***Annexure I.*** The detailed course wise syllabus with credit distribution of the M.Sc. in Chemistry programme is given in ***Annexure II.***

6.3 Duration of the programme

The duration for completion of M.Sc. in Chemistry in accordance with the UGC (ODL and Online Programmes) Regulations, 2020 [vide clause 13(A)(2)].

Minimum duration : 2 years (4 semesters)

Maximum duration : 4 years

In case, a learner is not able to qualify a course in its first attempt, he/she has to qualify in the particular course within the next four attempts, subject to maximum duration of the study.

6.4 Definition of Credit Hours:

As per UGC (ODL and Online Programmes) Regulations, 2020, the University follows the system of assigning 30 hours of study hour per credit of a course. Thus, following this norm, a 4 credit course constitutes a total of 120 hours of study hours. Out of the total credit hours, a minimum of 10 percent, *i.e*., minimum12 hours of academic counselling per 4 credit course are offered to learners at their respective Study Centres. In addition, the University will provide Learning Management System (LMS) support based on the four-quadrant approach, which includes self-learning materials, video lectures, self-assessment activities, and discussion support for learners and also through centralized online counselling. Credit hours for laboratory work have also been determined as per the UGC Regulations, 2020.

6.5 Faculty and Support Staff Requirement

The Discipline of Chemistry of Hiranya Chandra Bhuyan School of Science and Technology of the University currently has three full time faculty members (one Professor and two Assistant Professors).

Hiranya Chandra Bhuyan School of Science and Technology			
Chemistry faculty at Discipline of Chemistry			
Sl. No.	Name	Designation	Qualification
1	Prof. Jyotirekha G. Handique	Professor	M.Sc.(Chemistry), Ph.D.(Chemistry)
2	Dr. Bedika Phukan	Assistant Professor	M.Sc.(Chemistry), Ph.D.(Chemistry)
3	Dr. Khairujjaman Laskar	Assistant Professor	M.Sc.(Chemistry), Ph.D.(Chemistry)

As the M.Sc. in Chemistry Programme has components of Ability Enhancement Courses (AEC) and Value Addition Courses (VAC), it requires interdisciplinary and multidisciplinary effort. Therefore, support of faculties from different schools of the University has been mobilized for design and delivery of the M.Sc. in Chemistry

Programme. A list of course coordinators against each core course of this M.Sc. in Chemistry programme is presented in ***Annexure V.***

Moreover, supports for required counselling to the learners will be provided through a network of well-qualified and experienced counsellors at their respective study centres. Besides the faculty, the University also has adequate number of other supporting staff to look after the learners' requirements of SLM preparation, delivery and distribution; timely conduct of examinations; providing IT enabled services; preparing digital and multimedia contents; addressing grievances and queries of the learners. The Regional Centre and the LSCs are also well equipped with required support staff starting from the Assistant Regional Director to the Centre Coordinators and counsellors to the secretarial staff.

6.6 Instructional Delivery Mechanism

The proposed programme has been prepared with special attention to include contents of both fundamental and contemporary fields of Chemistry in the syllabus. Special attention has been given to focus on conceptual, analytical and synthetic aspects while preparing the syllabus. As such, the primary instructional delivery mechanism of the programme is to make available to the learners the Self Learning Materials (SLMs) prepared including the said aspects in a comprehensive manner. For this, the Self Learning Materials (SLMs) have been prepared keeping in mind the requirements of instructional design. These SLMs are prepared and finalised by the internal faculty with the help of resource persons across the state. Besides the internal faculty members, Senior/Retired Professors/Associate Professors/Assistant Professors from different Universities/Colleges are engaged as SLM writers and Content Editors. The University provides print SLMs for all the semesters to all the learners, which are comprehensive in terms of the contents of the syllabus. The learners will also be given access to the e-SLMs simultaneously and the same in audio-visual formats. The SLMs are prepared systematically to make these easy to read and easy to understand with the following major components:

a) *Learning Objectives,* b) *Introduction, c) Contents, divided in units and sub-units,* d) *Check Your Progress,* e) *Answers to Check Your Progress,* f) *Activity/Activities* g) *Let us Know More* (additional important information related to the content is

provided), h) *Let Us Sum Up* i) *Further Reading* (for learners who are interested in advance knowledge of the content), j) *Model Questions.*

The University has its own LMS – e-bidya with the four quadrants i.e. video lectures, downloadable/printable reading materials, self-assessment tests and quizzes, and an online discussion forum for clarifying doubts and queries of the learners. The LMS of the University will be utilised to the optimum level for efficient instructional delivery of the proposed Programme.

6.7 Learner Support Services

M.Sc. in Chemistry programme will be supported by learner support system of KKHSOU. As an Open University, KKHSOU provides comprehensive and learner-centric support mechanisms to assist the learners throughout the entire period of study and beyond. It extends support to learners to access learning resources, interact with academic counsellors, and resolve academic or administrative issues in a seamless manner.

The learner support system for the programme includes institutional infrastructure, study centre networks, digital resources, academic counselling, and grievance redressal mechanisms. In addition, the programme will also incorporate discipline-specific support for learners, such as virtual laboratory demonstrations, computational tools, and guidance for research projects. The major components of learner support services are outlined below.

6.7.1 Academic Counselling Support: In ODL system of education, academic counselling is the essential component of the teaching–learning process. Academic guidance through multiple modes of interaction will be made available for the learners enrolled in the M.Sc. Chemistry programme. Counselling sessions will be organized periodically at designated study centres where qualified academic counsellors and subject experts provide academic counselling including guidance on assignments and projects. These sessions help learners understand the Self Learning Materials (SLMs) more effectively and strengthen their conceptual understanding and clearing any doubts in difficult topics. In addition to face-to-face sessions, the University faculty will also conduct online academic counselling through digital platforms from the City Study Centre located at the KKHSOU City Campus. These

sessions allow learners from different regions of the state to interact with faculty members and clarify their doubts without geographical constraints.

The KKHSOU City Campus at Guwahati organises training for coordinators, counsellors, and other functionaries. Responsibility for Admission, distribution of SLMs and examination also lies with City Campus. Online counselling for all learners of all study centres of all programmes are centrally organised from city campus. The City Campus has the provision of walk-in counselling for the learners in all working days.

6.7.2 Institutional Support Infrastructure: Regional Centres: KKHSOU has established institutional infrastructure to provide academic and administrative support to learners across the state. The University's City Campus located at Khanapara in Guwahati functions as a major centre for learner services. The campus facilitates interaction between learners and faculty members, provides walk-in academic guidance, and supports activities related to admission, examination, and distribution of study materials. In addition to the City Campus, the University operates regional centres that coordinate academic and administrative activities in different parts of Assam. These centres assist learners in accessing support services and coordinate the functioning of study centres within their jurisdiction. Regional centres are in places such as Jorhat, Bongaigaon, Lakhimpur, and Silchar, thereby expanding the reach of the University's learner support network. The Regional Centres also conduct orientation programmes, facilitate communication between the University and the study centres, and provide assistance regarding admission, academic schedules, and examinations.

6.7.3 Study Centre Network: Study centres are the backbone of an open and distance learning institution. On behalf of the University, the study centres serve as local support units across the state, to the various requirements of learners, viz. admissions-related information, delivering Self Learning Materials, conducting counselling sessions, distributing assignments and evaluating them, conducting term-end exams, etc. The study centres throughout the state handle these affairs on behalf of the University. Study Centres also organize orientation programmes and mentoring activities so that learners become familiar with the academic requirements of their

programme. There are at present 300+ study centres providing these support services to the learners.

6.7.4 Pre-enrolment Counselling: For prospective learners, the University provides pre-enrolment counselling for all the programmes through online and offline modes in cooperation with study centres. It provides all the basic information about the programmes. Moreover, programme specific pre-enrolment counselling is also organised. After admission, orientation or induction programmes are also organised for newly admitted learners to provide information regarding Open and Distance Learning system, structure of the programme, methods of using SLMs effectively, assignment submission procedures, examination patterns, and academic schedules.

6.7.5 Learner Helpdesk and Grievance Redressal System

- **Siksharthi Mitra:** A few employees of the University have been engaged as Siksharthi Mitra in order to provide necessary information, assistance and technical support to the aspiring learners during online admission process.
- **Learners' Charter:** The University has brought out a Learners' Charter which can be accessed at http://www.kkhsou.in/web_new/lcharter.php, pronouncing the basic rights and responsibilities of its learners. In the Induction Programmes at the Study Centres, the learners are sensitized about this Charter.
- **Handbook/SOP:** The University has brought out a Handbook for the Study Centres and a Standard Operating System (SOP) of Examination.
- **Face to face and Walk-in Counselling:** Learners in Master of Science (Chemistry) will receive face-to face counselling from study centres. The University also provides face-to-face counselling/walk-in counselling to learners at the specially maintained City Learner Support Centre located at the City Campus on Sundays or weekdays. Besides, the University faculty offers online counselling to all learners on a regular basis for various programmes. The routine is made available through the University's website and the links are shared through the mentoring groups.
- **Face-to-face and Online Grievance Redressal System:** Learners' queries are attended in the face-to face mode and digital mode as well in a continuous way, through telephone, SMS and emails. The University also has a single window grievance redressal cell for handling the grievances of the learners. It allows learners to submit complaints or queries through a dedicated digital portal. The system

automatically forwards the complaint to the concerned department for resolution. Once the issue is addressed, learners are informed through digital communication channels, viz., by SMS and email. This system ensures to maintain transparency, responsiveness and efficiency in addressing learners' concerns.

6.7.6 Support for Differently Abled Learners: In adherence to the principles of inclusive education, KKHSOU makes continuous efforts to ensure that learners with special needs e.g. with visual or other physical disabilities can access learning resources and academic support without difficulty and thus, extends necessary support services to learners. In this regard, the visually impaired learners are provided with free audio SLMs in CDs to overcome their difficulties of learning. The University has installed Braille printers for this category of special learners in the University SLM branch. Additional academic assistance through appropriate facilities and institutional support mechanisms is also made available through study centres and counselling services.

6.7.7 ICT Enabled Learner Support and Digital Academic Services: ICT support is a major component of any ODL system of education. Some of the ICT-based support systems provided by the University, which can be availed by the learners of M.Sc. Chemistry Programme are listed below:

- **Website:** The University has developed a full-fledged official website www.kkhsou.ac.infor learners and the general public. The website has a dedicated Learners' Corner that contains exhaustive information and links to useful resources which is accessible to the vast learner population. Furthermore, it also provides links for downloading e-SLMs, assignments, e-admits, e-mark-sheets etc. besides important notices and latest news. Additionally, the site offers a tailored search by Programmes and Study Centres. Also, most of the audio-visual learning resources are accessible online through YouTube videos (accessible athttps://www.youtube.com/user/kkhsou)
- **Learning Management System(e-Bidya):** KKHSOU has developed a Learning Management System (LMS) portal called e-Bidya using open source MOODLE which can be accessed. The site allows learners to access e-resources 24×7, regardless of where they are in relation to the particular programme they are enrolled in. It contains all four quadrants including video lectures and tutorials and the reading

materials. Learners can also interact with experts through the discussion forum. Learners can experience the benefits of online learning through their mobile devices as well. The proposed Programme will also be made available in e-Bidya with all resources for all learners enrolling in the Programme.

- **E-Mentoring Groups:** The University has introduced e-mentoring system, in which group of learners are guided by faculty mentors from the concerned discipline utilizing Telegram App/WhatsApp, to help learners to continue their studies with self-confidence, self-esteem, morale, and a feeling of identity. It also helps the learners to share personal difficulties and identify the obstacles they face due to the diverse needs and backgrounds. During this process, they are also guided to develop appropriate and suitable learning strategies for overcoming all these difficulties and problems as a team.

6.7.8 Online Counselling: The University's faculty conducts online counselling sessions through different online platform like Zoom, Google Meet, Cisco Webex and Facebook etc. in addition to regular counselling sessions in study centres. It provides direct interaction of learners with the regular faculty members of the University which creates a greater sense of inclusion and reduces feelings of isolation by offering personal care and guidance to all learners.

- **KKHSOU Mobile App:** The University has developed a mobile application "KKHSOU" that allows students to access the university website 24×7. The main purpose of this application is to provide the relevant information to all learners in an easily accessible manner. Using this application, learners can view the course information, fees structures based on their requirements. At the same time, they can directly call any study centre of KKHSOU. Learner can download assignments, old question papers and other important forms.
- **SMS Alert Facility:** The University has implemented an SMS alert system for learners which notify of University news, events, and learner-related information.
- **E-mail Support:** Learners can also write emails to any official/faculty members of the University. For this a general email ID: info@kkhsou.in has been created. Concerns raised through email to this email address are addressed by the University's relevant officials or faculty members. Apart from that, the email and

phone numbers of all faculty members are available on the website and Information Brochure. Any learners can write directly to them as well.

- **Social Media Based Learner Engagement:** KKHSOU has incorporated social media sites like Facebook pages, Whatsapp group, Twitter Account to its official website for sharing announcements, academic updates, and information about University events and for interaction with the learners, thereby creating a collaborative learning environment.

6.7.9 Learner Support Services from EMPC: The Electronic Media Production Centre (EMPC) serves as the media and digital learning support KKHSOU. It facilitates learner support through the production and dissemination of multimedia educational content, community radio broadcasting, and other ICT-enabled academic resources. These initiatives aim to enhance accessibility, promote interactive learning, and strengthen the overall learner support system of the University.

- **Multimedia Learning Materials:** EMPC produces a wide range of audio-visual educational content to support various academic programmes offered by the University, which are disseminated through the official KKHSOU YouTube channel and other digital platforms, enabling learners to access supplementary learning resources beyond the printed Self Learning Materials (SLMs). These include:

- Course-based educational video lectures
- Academic lectures and expert discussions for reference
- Demonstrations and concept-based learning modules

- **Community Radio Service**: EMPC also supports learner engagement through the University's Community Radio Station Jnan Taranga 90.0 FM, which broadcasts educational and interactive programmes for learners as well as the wider community. The following programmes are specifically designed to support the learners of the University:

i) **Siksha Barta:** A 30-minute interactive programme broadcast every Thursday at 10:00 AM. Through this programme, learners from different locations can directly interact with faculty members and University officials to clarify their academic queries and concerns.

ii) **Gyan Safura:** A 30-minute programme broadcast every Monday at 10:00 AM, featuring discussions on various educational topics contributed by faculty members of the University.

iii) **News Bulletin:** Broadcast daily at 10:50 AM and 2:30 PM, this programme provides updates on important academic announcements and key activities of KKHSOU.

iv) **Ekalavya:** Broadcast at 3:30 PM, this programme features educational episodes focusing on both the academic programmes offered by KKHSOU and other relevant educational topics.

v) **Academic Counselling through Radio:** A dedicated one-hour programme focusing on academic discussions based on the Self Learning Material (SLM) units of different courses. This programme is broadcast every Monday, Wednesday, and Friday from 3:30 PM to support learners in understanding their course contents more effectively.

vi) **Internet Radio Facility:** The Internet Radio facility enables the broadcast of radio programmes through online platforms, making them accessible to listeners from anywhere in the world. Through this facility, educational and awareness programmes of the Community Radio Station Jnan Taranga 90.0 FM can be accessed globally via the platform iRadioLive.com, thereby extending the reach of the University's academic and learner support services beyond geographical boundaries.

7. PROCEDURE FOR ADMISSION, CURRICULUM TRANSACTION ANDEVALUATION

7.1 Procedure for Admission

i. Eligibility criteria:

The eligibility requirements for admission to the **M.Sc. Chemistry** programme are outlined below:

a) Graduates with B.Sc. Degree having Chemistry as either in the major or minor discipline in his/her UG programme from any University recognized by UGC.

Or

b) Any science graduates after successfully completing the third year of the Four Year Undergraduate Programme (FYUGP) having Chemistry as a subject in his/her UG programme from any University recognized by UGC.

ii. Online Admission: Admission to M.Sc. in Chemistry programme will be conducted entirely in online mode through the University-s Online Admission Portal. A prospective learner may take admission in one of the designated study centres as per his/her preference for the M.Sc. in Chemistry programme. During registration, the applicant must select the study centre after verifying the availability of subject. The learners have to register first in the portal providing their email and mobile number. After successful registration, the login credentials are provided to their registered email and mobile numbers. Learners can login to the admission portal using these credentials and then fill up the online application form and upload all required supporting documents and photograph. Upon completing all the requirements of application process they can make online payments of the requisite fee via net banking, credit/debit card, UPI or by using the QR code. Once the fee is paid, they can get their enrolment receipt with their enrolment number and get a print out of the application form for future reference. On completion of the admission process the learners receive a welcome email with all relevant information and links to various digital resources for instant access. After admission is done, a unique Registration / Enrolment Number is automatically generated which will have to be used for future communications with the University. Based on his/her choice, and operational conveniences, a learner shall be assigned to a particular study centre for availing of dedicated services and counselling/tutoring facilities. The newly admitted learners will receive the SLMs through a dedicated study centre and in certain cases SLMs may be sent to the learners' home address also. e-SLMs are also available in the University website. The University has a Credit Transfer Policy which is being revised to facilitate course exemption in order to promote dual degree.

iii. Refusal/Cancellation of Admission: At the time of admission the learners have to submit a declaration that all information and document provided by her/him at the time admission are, correct, true and valid. If, however, any false declaration is detected at any stage, the University has the authority to refuse, reject and/or cancel his/her admission, mark sheets, certificates etc. as the case may be.

iv. Continuous Admission: By paying the necessary fees, a learner can obtain admission to the next semester once a particular semester is completed. Admission to the subsequent semester is not determined by the results of the previous semester. One may take admission in the next semester even without appearing in the previous semester examination. The admission period should be continuous from the date of completion of the previous semester's exams until 60 days after the start date. Incomplete exams, including back papers, will be allowed to be taken up when announcements of examination results are made. Learners are advised to regularly visit the University's website (www.kkhsou.ac.in) and maintain regular contact with their allotted study centres.

v. Pursuing Two Academic Programmes Simultaneously: As per UGC guidelines dated April 2022 a learner can pursue two academic programmes simultaneously, one in full time physical mode and another in Open and Distance Learning (ODL)/Online mode; or up to two ODL/Online programmes.

vi. Fee Waiver for Differently Able Persons (DIVYANGJAN): The fee waiver will be applicable for differently able learners in all semesters of the programme where he/she has enrolled. Such learners must submit 'Form no. IV' issued by the Social Welfare Department or Disability and a copy of the Certificate issued by the Department of Empowerment of Persons with Disabilities (DEPwD), Ministry of Social Justice and Empowerment, Govt. of India. The forms/certificates of differently able learners which are verified by the Social Welfare Department, Govt. of Assam will be allowed the fee waiver for the eligible learners of this Programme also.

vii. Fee Structure: The fee structure of the M.Sc. in Chemistry programme would have a break-up across semesters of the programmes. The fee is inclusive of Course fee, SLM Fee, Examination fee, Centre fee, Mark-sheet fee, Lab Fee and Practical Exam Fee. Currently the fee charged for one semester of this M.Sc. in Chemistry programme is **Rs. 9830/-** with an additional fee of **Rs. 1200/- as Project Fee in 4th Semester.** (As approved in the Finance Committee Meeting, vide resolution No. Item No. FC/54/12/A.O.B/02: Fee Structure of New Courses).

7.2 Curriculum Transaction

i. Activity Planner: There will be an activity planner, which guides the overall academic activities in the M.Sc. in Chemistry programme. This will be released prior to the

University's admission schedule. The CIQA office as per UGC guidelines and the office of the Dean (Academic) would upload the Academic Plan and month wise Academic Calendar. This will enable learners to plan their studies and activities accordingly.

ii. Self-learning Materials (SLMs): SLMs are designed in such a way with the help of subject experts that learners can easily follow them (vide clause 6.6, viz., Instructional Delivery Mechanism of this PPR**)**.

iii. Multimedia Materials: Apart from printed SLM, the University provides audio-visual learning materials related to course content.

iv. Induction and Counselling Sessions: Induction sessions are conducted by University officials and faculty together. Counselling sessions are conducted by the Study Centres. Normally all counselling sessions are scheduled on Sunday. A face-to-face interaction between the learners and the counsellor takes place during the counselling session. This enables learners to clear their doubts with regard to the various courses provided to them. Apart from that, from time to time, online counselling sessions will be provided by the faculties of the University for this M.Sc. in Chemistry Programmes.

v. Web-based tools: The University also provide Web Enabled Academic Support Portal through e-Bidya, the Learning management system of KKHSOU available at https://www.lmskkhsou.in/web/ to access the course materials and other learning resources.

7.3 Assessment and Evaluation

The assessment and evaluation in the M.Sc. Chemistry programme is designed to ensure transparency, fairness, and academic rigor in measuring learners' performance as per the KKHSOU regulations. The evaluation framework follows the guidelines of the UGC (Open and Distance Learning Programmes and Online Programmes) Regulations, 2020 and the UGC Curriculum and Credit Framework. The system aims to assess the attainment of the programme learning outcomes as well as the specific course outcomes through continuous monitoring and final examinations.

The University adopts a two-component evaluation system, consisting of Formative Assessment (continuous evaluation) and Summative Assessment (end-semester examination**)**. This dual approach ensures that learners are assessed not only on their final examination performance but also on their continuous engagement with the course

content and academic activities. This pattern applies to both theoretical and practical courses unless otherwise specified. The evaluation framework also emphasizes research orientation and analytical thinking through seminars, presentations, and project/dissertation work.

The 33rd Academic Council of the University decided that Formative Assessment is to be given a weight of 30 percent while the Summative Assessment is to be assigned the remaining 70 percent of the weight. Further, 35th Academic Council has adopted the SGPA and CGPA system of evaluation as per the UGC's Curriculum and Credit Framework for UG Programme, 2022. As per the UGC's Curriculum and Credit Framework for UG Programme, 2022, the "Letter Grades" will be provided to the learner after due assessment and evaluation as given under:

Table: Letter Grades System of KKHSOU

Letter Grade	Grade Point
O(Outstanding)	10
A+ (Excellent)	9
A (Very Good)	8
B+ (Good)	7
B (Above Average)	6
C (Average)	5
P (Pass)	4

The Semester Grade Point Average (SGPA) will be computed from the grades as a measure of the learner's performance in a given semester. The SGPA will be based on the grades of the current term, while the Cumulative GPA (CGPA) will be based on the grades in all courses taken after joining the programme of study. Here SGPA is the ratio of the sum of the product of the number of credits with the grade points scored by a learner in all the courses taken by a learner and the sum of the number of credits of all the courses undergone by a learner, while the Cumulative Grade Point Average (CGPA) is also calculated in the same manner taking into account all the courses undergone by a learner over all the semesters of a programme. As recommended by the UGC, the SGPA and CGPA shall be rounded off to 2 decimal points and reported in the transcripts. Based on the above mentioned Letter grades, grade points and SGPA and CCPA, the transcript

for each semester and a consolidated transcript indicating the performance in all semesters will be provided to the learners.

7.3.1 Structure of Course Evaluation

The M.Sc. Chemistry programme is organized into four semesters, and each course generally carries 100 marks. The marks distribution is as follows:

- Formative Assessment (Internal Assessment) – 30 Marks
- Summative Assessment (End Semester Examination) – 70 Marks

7.3.2 Formative Assessment (Continuous Evaluation)

Formative assessment is designed to evaluate learners' progress throughout the semester. The purpose of continuous assessment is to encourage regular study, conceptual understanding, and academic participation. In the M.Sc. Chemistry programme, formative assessment carries 30 marks for each course and it will follow the general guidelines of the University that include a combination of various flexible modes of evaluation.

Self-Learning Materials contain 'Check Your Progress' exercises that enable learners to evaluate their understanding of the topics independently. Although these exercises are primarily for self-learning purposes, they help learners prepare for assignments and examinations.

Assignments constitute a significant component of formative assessment. Learners are required to submit handwritten assignments for each course to their respective study centres within the prescribed deadlines. The learners are communicated about the details of the assessment through the University website, official notifications, study centres, mentoring groups and social media. The concerned study centres conducts MCQ based test (online/offline) for the learners. However, if required, they may alternatively arrange for written test/ viva/quiz etc. and assess the learners for formative assessment.

The study centres also arrange Personal Contact Programmes (Online or Offline) and the learners are expected to attend the same, as per UGC Guidelines. Based on their level of participation and engagement they are given marks. Marks obtained through continuous evaluation as described above are uploaded by the coordinators of the study centre in the Home Assignment portal specifically created by the examination branch and contribute to the final grade of the course. Feedback and suggestions are provided to help learners improve their understanding of the subject.

7.3.3 Summative Assessment (End Semester Examination)

Summative assessment is conducted at the end of each semester to evaluate the learners' comprehensive understanding of the course content. The University conducts these examinations in pen-and-paper mode at designated examination centres or study centres. following a standard operating procedure (SOP) to maintain fairness and transparency. To ensure the integrity of the examination process, the University appoints Supervisory Officers, Examination Monitoring Officers, and examination inspection teams.

Question papers are prepared by subject experts and undergo moderation to ensure academic quality and standard. Answer scripts are evaluated by qualified examiners, including both internal and external faculty members. After the evaluation process is completed, results are declared following verification and scrutiny. Learners have the option to apply for re-scrutiny or re-evaluation within the stipulated time if they wish to review their results.

7.3.4 Evaluation of Practical Courses

Experimental training forms an essential component of the M.Sc. Chemistry programme. The laboratory courses— Chemistry Laboratory I, II and III—are designed to develop experimental skills, data analysis ability, and scientific reasoning. For laboratory courses, formative assessment (30%)will include performance of laboratory experiments and analysis (including timely submission of records), and continuous internal evaluation through assignments. The formative component also includes MCQ-based tests conducted periodically to assess conceptual clarity and theoretical understanding related to the experiments.

The formative evaluation of practical courses includes:

- performance during laboratory experiments
- maintenance and submission of laboratory records
- analysis and interpretation of experimental data
- viva-voce examination conducted during the practical examination
- periodic MCQ-based assessment to evaluate conceptual understanding

Summative assessment constituting 70% will be done by practical examination and viva-voce. Practical examinations will be conducted under the supervision of both internal and external examiners to ensure objectivity and fairness.

7.3.5 Seminar Evaluation

In the Semester II, learners are required to present a seminar on a selected topic related to Chemistry. The seminar will be evaluated for 100 marks and carries 4 credits. The seminar evaluation focuses on:

- Understanding of the selected topic
- Clarity of presentation
- Analytical interpretation of scientific concepts
- Ability to respond to questions and discussions

This activity helps learners develop scientific communication skills and encourages them to explore contemporary developments in Chemistry.

7.3.6 Project / Dissertation Evaluation

In the final semester, learners are required to undertake a research project, which carries 200 marks and 8 credits. The project work provides an opportunity for learners to apply theoretical knowledge and research skills in a specialized area of chemistry. Under the supervision of a qualified faculty member or approved guide, learners will identify a research problem, conduct literature review, collect and analyse data, perform experiments and analyse the experimental results, and prepare a detailed research report. The evaluation of the project includes:

- Assessment of the written research report
- Quality and originality of the research work
- Methodology and analysis of results
- Presentation of the dissertation report
- Viva-voce examination

The project report is expected to demonstrate the learner's ability to apply scientific reasoning and research methodology to real-world problems in chemistry.

7.3.7 Alignment with Learning Outcomes

The assessment and evaluation system of the M.Sc. Chemistry programme is designed to measure the attainment of programme outcomes as well as course outcomes. While preparing question papers, assignments, laboratory exercises, seminar topics, and project guidelines, due consideration is given to the intended learning objectives of the respective courses and the overall programme. This outcome-based evaluation approach ensures that the assessment process reflects the knowledge and competencies that learners are expected to acquire during the programme. It helps maintain academic quality and ensures that learners develop conceptual understanding of chemical

principles, analytical and problem-solving abilities, and experimental skills in laboratory work, and research aptitude through seminars and project work, which are essential for a postgraduate programme in Chemistry.

8. LABORATORY SUPPORT AND LIBRARY RESOURCES

8.1 Laboratory Support

Laboratory courses are an integral component of the M.Sc. in Chemistry programme. Importance has been given to the utility of the practical sessions with respect to development of problem-solving skills and industry-oriented applications. Laboratory classes are to be conducted at the Study Centre and provision for online laboratory counselling sessions will be there. For in-service learners, laboratory classes will be conducted on Sundays and holidays. The Learner Support Centres have been chosen for offering the M.Sc. in Chemistry program as per UGC Regulations for ODL and Online Programmes, 2020, [vide Part II, Clause 4 (B) (ii)] i.e. Learner Support Centres which are offering same programme under conventional mode at least for seven years have been chosen. It was also ensured that the chosen LSCs are having adequate laboratory facilities.

8.2 Library Resources

Library services for learners of KKHSOU are provided through physical facilities at recognized study centres and the Central Library located at the University's city campus. Reference books and learning materials are recommended by faculty members of the respective disciplines/schools as well as by the Self-Learning Material (SLM) contributors. The Central Library of KKHSOU maintains a substantial collection of relevant reference books and textbooks supporting the M.Sc. Chemistry Programme. As in March, 2026, the library houses approximately 20,000 print books along with 8 newspapers and 7 magazines and 2 print journals. In addition to print materials, the library provides access to a wide range of electronic resources, including e-journals, online databases, and gateway portals. Programme-specific journal subscriptions are communicated to learners as they become available.

The library is fully automated using an Integrated Library System (ILS) and is equipped with RFID (Radio-Frequency Identification) technology to enhance efficiency and accessibility. Learners can access library services at their convenience through the library webpage (http://library.kkhsou.in/). They can also utilize the Digital Library

(http://dlkkhsou.inflibnet.ac.in/), which serves as an online platform for collecting, preserving, and disseminating the University's academic and intellectual output to a global audience. Beyond physical access, the library offers an Online Public Access Catalogue (OPAC) (http://opac.kkhsou.ac.in/), enabling users to browse and search the library collection remotely.

The University has implemented an Open Educational Resources (OER) Policy, which governs the development and dissemination of learning materials in both physical and digital formats. Furthermore, KKHSOU has entered into a Content Partner Agreement with the National Digital Library of India (NDLI), facilitating access to a vast repository of national and international digital resources through a single-window platform (https://ndl.iitkgp.ac.in/).To further strengthen digital access, the University integrates resources from the Open Network for Open Science (ONOS), providing learners with access to a wide range of scholarly publications, research outputs, and open-access academic content.

The University also participates in Shodhganga, the national repository of theses and dissertations maintained by the INFLIBNET Centre, at UGC. Through this initiative, the theses produced by the University are archived and made available to scholars and researchers, thereby contributing to the broader dissemination of academic research.

Overall, the KKHSOU library system ensures comprehensive academic support by combining traditional resources with advanced digital services, thereby catering effectively to the diverse needs of learners enrolled in the M.Sc. Chemistry Programme.

9. COST ESTIMATE OF THE PROGRAMME AND THE PROVISIONS

The office of the Finance Officer of KKHSOU keeps all the records of finances regarding print of SLMs, honorarium paid to the members of the Committee on Courses, Content Writers, Content Editors, Language Editors, Translators, Proof Readers and also the expenditure related with organizing counsellors' workshops, meeting of the co-ordinators of the study centres etc. Moreover, the finance office also maintains records of purchase of computers, online space, books, journals etc. The accounts are maintained as per the laid down procedures of government. Regarding the cost of programme development, programme delivery, and programme maintenance, the finance office conducted an exercise based on historical costing method to arrive at indicative figures

of cost. The findings are presented below in respect of the M.Sc. in Chemistry Programme.

9.1 Programme Development Cost

a) SLM Development Cost Per Unit for Master Degree Programme is at present: Rs. 7600/- per Unit. A course normally has 14 Units. In Two Year PG Programme, there will be minimum 16 to 20 Courses. The discipline specific courses will be explicitly attributed to this programme. The rest can be apportioned depending on the learners' enrolment and number of units to be printed.

b) Printing Cost per Unit of SLM: The printing cost per unit is Rs. 69/-. However, this also depends on the print number as scale related advantage of cost is normally availed.

9.2 Programme Delivery Cost

The self-learning materials (SLMs) prepared for the M.Sc. in Chemistry program need to be delivered to various study centres located in remote areas. On average, the University delivers about 2.2 kg of study materials per learner, per semester. The cost of delivering2.2 kg of such materials is Rs. 60 per semester. Accordingly, depending upon the number of learners; the cost for the MSc in Chemistry programme will be provisioned by the University. The office of the Finance Officer has calculated the delivery cost of SLMs per learner at Rs. 132/-. Moreover, there will be proportionate expenditures on providing LMS based services for which a detailed exercise will be required.

9.3 Programme Maintenance Cost

The University has made financial provisions for organizing stakeholder meetings, counselling workshops, and other activities as per the Academic Plan and Academic Calendar approved by the Academic Council. These workshops and meetings will not only benefit learners of the M.Sc. in Chemistry program but also learners of other programs. The University will also bear the cost of organizing the meetings of the Syllabus Revision Committee and providing additional study materials if required to improve the quality of the program. Based on data from the University's finance department, the program maintenance cost is Rs. 1,750. This will be applicable for the MSc in Chemistry programme too.

The University is fully committed to offer a high quality MSc Programme in Chemistry as per provisions of the UGC ODL and Online Regulations, 2020.

Accordingly, the University will keep adequate financial provision for development, delivery, and maintenance of the MSc programme in Chemistry.

10. QUALITY ASSURANCE MECHANISM AND EXPECTED PROGRAMME AND COURSE OUTCOMES

10.1 Quality Assurance Mechanism

With regard to quality assurance of all the programmes of the University including the M.Sc. in Chemistry Programme, the University is involved in the following activities:

- The design and structure of the programme are decided upon after a series of discussions and deliberations with a team of subject experts, who are eminent professors from reputed Universities. Formed with due approval from the University authority, this Committee on Courses of Studies (CCS) is helped by the in-house faculties of the Discipline of Chemistry of Hiranya Chandra Bhuyan School of Science and Technology of the University in preparing the framework of the programme.
- The University has a SLM Policy which is followed in development of SLM. The writers of the contents for the SLMs and content editors involved, are mostly in-house faculties and academics from reputed HEIs maintaining the ratio laid by the UGC regulations. SLMs are distributed through a well laid down mechanism to all the learners. Moreover, eSLM has been made available. Overall, the University has its University-wide approaches for development of policies, Strategic Action Plan and their implementation, encompassing all the academic programmes including M.Sc. in Chemistry.
- CIQA takes care of the following among others to enhance the quality of the various facets of the University:
    - Counsellors' workshops
    - Stakeholders' meetings
    - SLM Audit
    - Feedback responses from the learners from various programmes
- In order to keep the programme on M.Sc. in Chemistry updated, the programme would be revised and necessary changes would be incorporated for the benefit of the learners, based on the inputs received from the mechanism as mentioned

above. Learners' and stakeholders' feedback is regularly collected and based on that; remedial measures and improvement mechanisms are worked out.

10.2 Expected Programme Outcomes

The Master of Science (M.Sc.) in Chemistry programme is designed to ensure that, upon successful completion, learners acquire advanced knowledge, professional competencies, and research capabilities in the discipline of Chemistry. In alignment with the principles of outcome-based education and the guidelines of the UGC, the expected Programme Outcomes (POs) are as follows:

PO1: Advanced Disciplinary Knowledge
Learners will be able to understand, explain, and apply advanced concepts and principles of Chemistry including Physical, Organic, Inorganic, and Analytical chemistry to solve complex chemical problems.

PO2: Analytical and Problem-Solving Ability
Learners will analyze, interpret, and solve theoretical and numerical problems using chemical principles, mathematical tools, and logical reasoning.

PO3: Experimental and Laboratory Competence
Learners will design, perform and analyze chemical experiments using standard laboratory techniques, instrumentation, and safety protocols along with proper error analysis.

PO4: Instrumentation and Computational Skills
Learners will apply modern analytical instruments (such as spectroscopy, chromatography, pH metry, electrochemical techniques etc) and computational tools for chemical analysis, modeling, and data interpretation.

PO5: Interdisciplinary Application and Industrial Relevance
Learners will relate chemical knowledge to interdisciplinary areas such as material science, environmental science, pharmaceuticals, and nanotechnology with awareness of industrial applications.

PO6: Research Aptitude and Scientific Inquiry
Learners will formulate research problems, design methodologies, conduct experiments, and critically evaluate results using scientific reasoning and literature support.

PO7: Scientific Communication Skills
Learners will communicate chemical concepts, experimental results, and research findings effectively in written and oral forms using appropriate scientific terminology.

PO8: Critical Thinking and Innovation
Learners will develop the ability to critically analyze scientific data, evaluate theories, and propose innovative solutions to chemical and real-world problems.

PO9: Environmental Awareness and Ethical Responsibility

Learners will understand environmental issues, practice green chemistry principles, and adhere to ethical standards, safety regulations and responsibility for scientific revival of Indian Knowledge Systems.

PO10: Academic Progress

Learners will acquire the academic preparedness, subject competence, and research aptitude required for doctoral research (Ph.D.), NET/JRF, other competitive examinations, higher studies, and advanced academic or professional engagement in Chemistry.

10.3 Learning Outcome based Curriculum Framework (LOCF) of M.Sc. in Chemistry Programme

The M.Sc. Chemistry programme is developed in accordance with the Learning Outcome-Based Curriculum Framework (LOCF) as recommended by the UGC, and is aligned with the provisions of the UGC (Open and Distance Learning Programmes and Online Programmes) Regulations, 2020. The framework ensures a learner-centric, outcome-oriented, and competency-based approach to curriculum design, delivery, and assessment.

Table: Course Objectives and LOCF of the M.Sc. in Chemistry

Sem	Name of Course	Type of Course	Course Objectives	Course Outcomes
I	Inorganic Chemistry-I	DSC 1	To provide learners a systematic understanding of structure, bonding, properties and reaction mechanisms of inorganic compounds	Learners will be able to explain and apply concepts of structure, bonding, properties, and reaction mechanisms to analyze inorganic compounds
	Organic Chemistry-I	DSC-2	To provide the learners the knowledge of i) principles of organic reaction mechanism, ii) reactivity and selectivity of organic reactions and iii) some selected organic transformations.	Learners will be able to: explain organic reaction mechanism and acquire working knowledge of some organic transformations; learn about the use of some important reaction intermediates for organic transformations.
	Physical Chemistry-I	DSC-3	To impart the knowledge and interpret thermodynamic behavior, predict equilibrium, evaluate reactions, and material properties using fundamental chemical	Learners will acquire a comprehensive understanding of thermodynamics, phase equilibria, polymers, surface chemistry, and catalysis, and apply these

			principles	principles to analyze chemical systems and processes
	Laboratory Course-IA	DSE-IA	Preparation and characterization of inorganic complexes. Study of reaction kinetics. Viscometric analysis. Spectrophotometric determination of concentration/composition	Learners will have hands-on experience on preparation and characterization of inorganic complexes, study of reaction kinetics, viscometric analysis and spectrophotometric determination of concentration/composition.
	Laboratory Course-IB	DSE-IB	Preparation and characterisation of inorganic complexes. Study of reaction kinetics. Viscometric analysis. Spectrophotometric determination of concentration/composition.	Learners will have hands-on experience on preparation and characterization of inorganic complexes, study of reaction kinetics, viscometric analysis and spectrophotometric determination of concentration/composition.
II	Inorganic Chemistry-II	DSC-4	To enable learners to understand bonding, structure, reactions, and catalysis in organometallic compounds and the principles and applications of symmetry and group theory in chemistry	Learners will be able to explain bonding and reactions in organometallic compounds and apply group theory concepts to molecular structure, bonding, and spectroscopy.
	Organic Chemistry-II	DSC-5	To provide students with fundamental knowledge on i) stereochemistry, and its effect on reactivity and reaction mechanism of organic compounds; ii) Oxidation and reductions in organic compounds	Learners will gain insight into the fundamentals of stereochemistry in organic reactions, and its implications in the reactivity and properties of organic compound. They will acquire knowledge on various oxidation and reduction reactions in organic synthesis.
	Physical Chemistry-II	DSC-6	To provide learners with a thorough understanding of the principles of chemical kinetics, electrochemistry	Learners will develop a comprehensive understanding of chemical kinetics, and

			and their applications to electrochemical processes and corrosion	electrochemistry; will be able to analyze reaction rates, mechanisms and apply electrochemical principles to interpret and solve chemical problems
	Laboratory Course-2A	DSE-2A	Quantitative estimation of organic compounds. Analytical and polarimetric study of chemical reaction, measurement of conductivity, pH-metric titration, determination of specific rotation by polarimetric measurement	Learners will have hands-on knowledge of the quantitative estimation of organic compounds. Analytical and polarimetric study of chemical reaction, measurement of conductivity, pH-metric titration, determination of specific rotation by polarimetric measurement.
	Laboratory Course-2B	DSE-2B	Quantitative estimation of organic compounds. Polarimetric measurement and conductometric titration, determination of i) ionization constant by conductance method, ii) hydrolysis constant pH measurements, and iii) specific rotation by polarimetric measurement	Learners will have hands-on knowledge of quantitative estimation of organic compounds. Polarimetric measurement and conductometric titration, determination of i) ionization constant by conductance method, ii) hydrolysis constant pH measurements, and iii) specific rotation by polarimetric measurement.
III	Spectroscopic Methods	DSC-7	To enable learners to acquire comprehensive understanding of the principles, instrumentation, and applications of different spectroscopic techniques for structural and analytical studies in chemistry	Learners will be able to analyse and apply various spectroscopic methods for the interpretation of molecular structure, bonding and chemical processes.
	Quantum Chemistry	DSC-8	To make the students familiar with the various aspects of basic quantum mechanics	Learners will develop a comprehensive understanding of foundations of quantum mechanics, evaluate molecular structures, wave

				functions, and can apply in critical thinking skills to solve problems related to molecular orbitals, quantum mechanics, and experimental analysis in chemistry
	Green Chemistry and Chemistry in Indian Knowledge System	DSC-9	To enable learners to understand the principles, strategies, and applications of green and sustainable chemistry for minimizing environmental impact, improving resource efficiency, and promoting safer chemical practices and to introduce to some aspects of Chemistry in Indian Knowledge System, in metallurgy, glassmaking and ancient nanotechnology and rich heritage of Indian system of medicine, involving medicinal plants and herbal formulations	Learners will be able to understand, analyse, apply, and evaluate the principles and practices of green and sustainable chemistry for environmentally benign and resource-efficient chemical products and processes. Learners will also understand and integrate traditional chemical knowledge from IKS with modern chemistry for interdisciplinary and sustainable applications.
	Laboratory Course-3A	DSE-3A	Inorganic estimation by complexometric titration. Preparation and purification organic compounds and their spectroscopic identification (UV and IR) and separation and identification of mixture of organic compounds by paper chromatography	Learners will have hands-on experience on i) inorganic estimation by complexo-metric titration, ii) preparation and purification organic compounds and their spectroscopic identification (UV and IR) and iii) separation and identification of mixture of organic compounds by paper chromatography
	Laboratory Course-3B	DSE-3B	Inorganic estimation by complexometric titration. Synthesis of green solvents and reagents. Two-step preparation of organic compounds. Separation and identification of	Learners will have hands-on experience on Inorganic estimation by complexo-metric titration. Synthesis of green solvents and reagents. Two-step preparation of organic

			mixture of organic compounds by thin layer chromatography	compounds. Separation and identification of mixture of organic compounds by thin layer chromatography
IV	Principles of Biochemistry	DSC-10	This course will provide the knowledge on the basic principles of biophysical, bioorganic and bioinorganic chemistry	Learners will be able to describe and interpret the chemical and physical processes of living organisms
	Analytical Chemistry	DSC-11	To impart fundamental knowledge of different types of errors and the working principles and applications of different analytical techniques	Learners will be able to understand various types of errors, working principles and applications of chromatographic methods, Electron Microscopy and Atomic Force Microscopy; powder and single crystal XRD techniques, Polarography, Thermal methods.
	Research Methodology	DSC-12	To impart knowledge on the basic approach to research process and to provide guidance for scientific data analysis and publication	Learners will gain knowledge about research process and the skill to analyze data in a scientific way
	Advanced Inorganic Chemistry	DSE-4A	To understand reaction mechanisms, bonding, and reactivity of inorganic compounds including coordination and organometallic systems. To introduce advanced inorganic topics such as cluster chemistry, supramolecular systems, metal–organic frameworks, and spectroscopic methods	Learners will be able to explain and analyse reaction mechanisms, bonding, and structural features of coordination, organometallic, and cluster compounds. They will be able to apply spectroscopic techniques and concepts of supramolecular chemistry and MOFs to understand modern inorganic materials and their applications
	Advanced Organic Chemistry	DSE-4B	To impart knowledge on different classes of pericyclic reactions, organic photochemical reaction and principles and applications of disconnection approach in	Students will be able to understand and apply the stereochemical and mechanistic principles governing pericyclic reactions, photochemical behaviour of carbonyl

			organic synthesis	compounds and alkenes, and the applications of disconnection approach in organic synthesis
	Advanced Physical Chemistry	DSE-4C	This course will provide the knowledge on the advanced electrochemistry, non-equilibrium and statistical thermodynamics	Learners will be able to describe and interpret the electrochemical processes, non-equilibrium and statistical thermodynamics along with their application in simple system.
	Natural Products and Heterocyclic Chemistry	DSE-4D	To provide knowledge on isolation, characterization and synthesis of various natural compounds of biological importance and heterocyclic compounds of biological and pharmaceutical importance	Learners will acquire 1) insight on isolation, characterization and synthesis of various natural compounds of biological importance and 2) knowledge on different heterocylic compounds.
	Solid State and Materials Chemistry	DSE-4E	Learners will be introduced to the interdisciplinary field of solid state and materials chemistry, the development of materials for various applications and characterization techniques	Learners will be able to examine/differentiate between different materials, and design/plan novel materials for applications and will know how to characterize them

10.4 Course Outcome-Programme Outcome (CO-PO) Mapping

In accordance with the principles of Outcome-Based Education (OBE), the Course Outcomes (COs) of each course in the M.Sc. Chemistry programme are systematically mapped with the Programme Outcomes (POs). This mapping ensures that the learning objectives of individual courses contribute effectively to the attainment of the overall programme outcomes.

The CO-PO mapping matrix presented below indicates the degree of correlation between course outcomes and programme outcomes using a three-point scale, where 3 represents high correlation, 2 represents moderate correlation, 1 represents low correlation and blank space represents no significant correlation. This structured alignment facilitates continuous evaluation, quality assurance, and attainment analysis of programme objectives.

Table: Mapping of Courses with Programme Outcomes of M.Sc. Chemistry Programme

Course Name	Course Title	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10
DSC-1	Inorganic Chemistry-I	3	2			2	2		2		2
DSC-2	Organic Chemistry-I	3	3			1	1		2		3
DSC-3	Physical Chemistry-I	3	3		1	1	1		2		3
DSE-1A	Laboratory Course-IA	2	2	3	3	1	2	2	2	2	2
DSE-1B	Laboratory Course-IB	2	2	3	3	1	2	2	2	2	2
DSC-4	Inorganic Chemistry-II	3	2		1	2	2		2		2
DSC-5	Organic Chemistry-II	3	3			1	2		2		3
DSC-6	Physical Chemistry-II	3	3		1	1	2		2		3
DSE-2A	Laboratory Course-2A	2	2	3	3	1	2	2	2	2	2
DSE-2B	Laboratory Course-2B	2	2	3	3	1	2	2	2	2	2
DSC-7	Spectroscopic Methods	3	3		3	1	1		2		3
DSC-8	Quantum Chemistry	3	3		1		2		2		3
DSC-9	Green Chemistry and Chemistry in Indian Knowledge System	3	2			3	1		2	3	2
DSE-3A	Laboratory Course-3A	2	2	3	3	1	2	1	2	2	2
DSE-3B	Laboratory Course-3B	2	2	3	3	1	2	1	2	2	2
DSC-10	Principles of Biochemistry	3	2			2	1		2		2
DSC-11	Analytical Chemistry	3	3	3	3	2	1		2	1	3
DSC-12	Research Methodology	2	3	3	3	1	3	3	3	3	3
DSE-4A	Advanced Inorganic Chemistry	3	2			2	2		2		3

DSE-4B	Advanced Organic Chemistry	3	3			1	2		2		3
DSE-4C	Advanced Physical Chemistry	3	3		1	1	2		2		3
DSE-4D	Natural Products Chemistry	3	2			1	2		2		3
DSE-4E	Solid State and Materials Chemistry	3	2		1	3	2		2	1	3

ANNEXURE I

Krishna Kanta Handiqui State Open University

CURRICULUM STRUCTURE OF MASTER OF SCIENCE IN CHEMISTRY

Table-1 Course Distribution of M.Sc. in Chemistry

Semester	DSC (4 credits each)	DSE (4 credits)	AEC (4 credits)	VAC (2 credits)	Dissertation/ Seminar	Semester wise credits
I	DSC-1, DSC-2, DSC-3	DSE-1	AEC-1	VAC-1		22
II	DSC-4, DSC-5, DSC-6	DSE-2		VAC-2	Seminar (4 credits)	22
III	DSC-7, DSC-8, DSC-9	DSE-3	AEC-2			20
IV	DSC-10, DSC-11, DSC-12	DSE-4			Project/ Dissertation (8 credits)	24
Total Credits	48	16	8	4	12	**88**

Table-2 Semester-wise Credit Distribution in M.Sc. in Chemistry

Semester	**DSC Courses**	**DSE Courses**	**AEC Courses**	**VAC Courses**	**Seminar /Project /Dissertation**	**Semester wise credits**
I	12	4	4	2		22
II	12	4		2	4 (Seminar)	22
III	12	4	4			20
IV	12	4			8 (Project)	24
Total Credits	**48**	**16**	**8**	**4**	**12**	**88**

Course Curriculum and Credit Distribution for

M.Sc. Chemistry Programme

Semester I			
Course	Course title	Credit	Marks
DSC-1	Inorganic Chemistry-I	4	100 (30F+70S)
DSC-2	Organic Chemistry-I	4	100 (30F+70S)
DSC-3	Physical Chemistry-I	4	100 (30F+70S)
DSE-1A or DSE-1B	Laboratory Course-IA or Laboratory Course-IB	4 4	100 (30F+70S)
AEC-1	Any Course from the Basket of AEC courses of KKHSOU	4	100 (30F+70S)
VAC-1	Any Course from the Basket of VAC courses of KKHSOU(in the basket one course on Indian Knowledge System (IKS) is available)	2	100 (30F+70S)
	Total	**22**	**600**

Note:DSC: Discipline Specific Core;
DSE: Discipline Specific Elective.
AEC: Ability Enhancement Course;
VAC: Value Added Course (To be adopted from related/allied disciplines)

F = Formative Assessment (i.e. Internal Assessment)
S = Summative Assessment (End Semester)
P = Practical

1 Credit = 30 hours of learning
4 credit = 30×4 = 120 hours of learning

Semester II			
Course	Course title	Credit	Marks
DSC-4	Inorganic Chemistry-II	4	100 (30F+70S)
DSC-5	Organic Chemistry-II	4	100 (30F+70S)
DSC-6	Physical Chemistry-II	4	100 (30F+70S)
DSE-2A or DSE-2B	Laboratory Course-2A or Laboratory Course-2B	4 4	100 (30F+70S)
VAC-2	Any Course from the Basket of VAC courses of KKHSOU	2	100 (30F+70S)
Seminar	Seminar	4	100
	Total	**22**	**600**

Semester III			
Course	Course title	Credit	Marks
DSC-7	Spectroscopic Methods	4	100 (30F+70S)
DSC-8	Quantum Chemistry	4	100 (30F+70S)
DSC-9	Green Chemistry and Chemistry in Indian Knowledge System	4	100 (30F+70S)
DSE-3A or DSE-3B	Laboratory Course-3A or Laboratory Course-3B	4 4	100 (30F+70S)
AEC-2	A course from the basket of AEC courses in KKHSOU ('Cyber Security' course is chosen as it is mandatory)	4	100 (30F+70S)
	Total	**20**	**500**

Semester IV			
Course	Course title	Credit	Marks
DSC-10	Principles of Biochemistry	4	100 (30F+70S)
DSC-11	Analytical Chemistry	4	100 (30F+70S)
DSC-12	Research Methodology	4	100 (30F+70S)
DSE-4*	*Any one course from the given choices as DSE-4A, DSE-4B, DSE-4C, DSE-4D and DSE-4E	4	100 (30F+70S)
Project	Research Project/Dissertation	8	200 [80F + 120S (Dissertation-90, Viva voce-30)]
	Total	**24**	**600**

*DSE-4 courses for choice
DSE-4A Advanced Inorganic Chemistry
DSE-4B Advanced Organic Chemistry
DSE-4C Advanced Physical Chemistry
DSE-4D Natural Products Chemistry
DSE-4E Solid State and Materials Chemistry

Total no. of courses: 20, 1 Seminar, 1 Project/Dissertation

DSC: 48 credits [Total courses: 12 (4 credits each)]
DSE: 16 credits [Total courses: 4 (Out of a set of 11 courses; 4 credits each)]
AEC: 08 credits [Total courses: 2 (4 credits each)]
VAC: 04 credits [Total courses: 2 (2 credits each)]
Seminar 1: 04 credits
Project/Dissertation 1: 08 credits

Total Credits: 88 credits Total Marks = 600+600+500+600 = 2300

ANNEXURE II

Detailed Course-wise Syllabus of M.Sc. in Chemistry Programme

Semester I

Course Type	**DSC-1**
Course Name	**Inorganic Chemistry-I**
Number of Credits	**4**
Total Marks	**100 (Formative: 30, Summative: 70)**

Objectives: To provide learners a systematic understanding of structure, bonding, properties and reaction mechanisms of inorganic compounds.

Course outcome: Learners will be able to explain and apply concepts of structure, bonding, properties, and reaction mechanisms to analyse inorganic compounds.

Unit 1 Valence Shell Electron Pair Repulsion (VSEPR) Theory

Structure of molecules containing bond pairs of electrons, bond pairs and lone pair(s) of electrons, structure and hybridization, Bent's rule, Bent bond, Non-bonded repulsion and structure.

Unit 2Bonding in Covalent Compounds

LCAO-MO methods in homo and heteronuclear diatomic molecules (O_2, N_2, CO, NO, HCl, HF), qualitative MO description of tri- and tetra-atomic molecules (CO_2, NO_2, NO_2^+, CO_3^{2-}).

Unit 3 Bonding in Coordination Compounds

Types of ligands: monodentate, bidentate, ambidentate, polydentate, and macrocyclic ligand; Werner's theory, Valence Bond Theory (VBT) of coordination compounds.

Unit 4 Crystal Field Theory

d-orbital splitting in octahedral, square planar, square pyramidal, trigonal bipyramidal and tetrahedral complexes; Crystal Field Stabilisation Energy (CFSE), CFSE for d^1 to d^{10} systems, pairing energy, low-spin and high-spin complexes, Spectrochemical and Nephelauxetic series, Ligand field theory of metal complexes, Jahn-Teller distortion.

Unit 5 Molecular Orbital Theory of Transition Metal complexes

Molecular orbital (MO) theory ofoctahedral $ML_6(O_h)$, tetrahedral $ML_4(T_d)$ and Square planar $ML_4(D_{4h})$ complexes and other geometries, transition metal complexes with σ and π bonding ligands.

Unit 6 Electronic Spectra of Transition Metal Complexes

Absorption of light, Beer-Lambert Law, Electronic states and terms for transition metals (atomic and molecular term symbols). Selection rules, Orgel diagram and Tanabe Sugano diagrams: Applications in transition metal electronic spectroscopy. d-d and charge transfer transitions, calculation of Dq, B and C parameters, nephelauxetic ratio.

Unit 7 Magnetic Properties of Transition Metal Complexes

Types of magnetic bodies (e.g., Diamagnetic, Paramagnetic, ferromagnetic and antiferromagnetic), antiferromagnetic coupling, Magnetic properties based on crystal field theory: spin only magnetic moments, quenching of orbital magnetic moment by CF, orbital contribution, effect of temperature on magnetic behaviour.

Unit 8 Acid-Base and Redox Chemistry

Hard and soft acid-base (HSAB) concept and its applications. Standard electrode potentials, pH dependence of electrode potentials. Redox stability of metal ions in water, oxidation by atmospheric oxygen. Applications of Latimer and Frost diagrams.

Unit 9 Lanthanides and Actinides

Electronic configuration, lanthanide contraction, separation of lanthanides.

Unit 10: Properties and Applications of Lanthanides and Actinides

Magnetic and spectral properties; stability of lanthanide and actinide complexes; lanthanide shift reagents; MRI contrast agents.

Unit 11Stability and Reactivity of Coordination Compounds

Lability and inertness, stability constant- formation constant of complexes, chelate effect, Thermodynamic and Kinetic stability; Factor affecting stability, Correlation of stability constant with thermodynamic factors –ΔG, ΔH and ΔS. Determination of stability constant – Jobs and Bjerrum's methods.

Unit 12 Ligand Substitution Reactions in Coordination Compounds

Substitution reactions in octahedral [Cr(III), Co(III)] and square planar [Rh(I), Pt(II) and Pd(II)] complexes, Rate of water replacement reaction.

Unit 13 Solvolysis, Hydrolysis and Trans Effect

Acid hydrolysis and base hydrolysis reaction, Trans effect and its importance, Theories of trans effect.

Unit 14 Electron Transfer Reactions

Inner sphere and outer sphere reactions in coordination compounds.

Recommended Books:

1. Basic Inorganic Chemistry by F.A. Cotton, G. Wilkinson, P.L. Gauss
2. Concise Inorganic Chemistry by J.D. Lee
3. Inorganic Chemistry by G.L. Meissler and D.A. Tarr
4. Inorganic Chemistry Principles of Structure and Reactivity by J. E. Huheey, E.A. Keiter, R.L. Keiter and O.K. Medhi
5. Principles of Inorganic Chemistry by B. R. Puri, L. K. Sharma and K. C. Kalia
6. Fundamental Concepts of Inorganic Chemistry by Ashim K. Das

Semester I

Course Type	**DSC-2**
Course Name	**Organic Chemistry-I**
Number of Credits	**4**
Total Marks	**100 (Formative: 30, Summative: 70)**

Objectives: To provide the learners the knowledge of i) principles of organic reaction mechanism, ii) reactivity and selectivity of organic reactions and iii) some selected organic transformations

Course outcome: Learners will be able to explain organic reaction mechanism and acquire working knowledge of some organic transformations. They will also learn about the use of some important reaction intermediates for organic transformations

Unit 1 Energy Profiles of Organic Reactions

Transition state vs. Reaction intermediate, Energy profile of multistep reaction, Significance of rate limiting step in multistep reactions, Catalysed and uncatalysed reactions,

Unit 2 Kinetic vs. Thermodynamic control of Organic reactions

Kinetically and Thermodynamically controlled Organic reactions, Hammond postulate, Curtin-Hammett Principle;

Unit 3 Methods of Studying Organic Reaction Mechanism;

Kinetic and non-kinetic methods of studying organic reaction mechanism; Isotope labelling studies and kinetic isotope effects, Cross-over experiment. Isotope labelling studies and kinetic isotope effects, Cross-over experiment.

Unit 4 Linear Free Energy Relationships (LFER):

Hammett equation - substituent and reaction constants; the Taft treatment of polar and steric effects in aliphatic compounds; Effects of conformation on reactivity: anomeric effect, stereoelectronic effects, neighbouring group participation.

Unit 5 Chemoselectivity, regioselectivity, stereoselectivity and stereospecificity

Definitions of chemoselectivity, regioselectivity, stereoselectivity and stereospecificity

Unit 6 Examples of Selectivity in Organic Reaction

Illustration of chemoselectivity, regioselectivity, stereoselectivity and stereospecificity in selected substitution, elimination and addition reactions.

Unit 7 Neighbouring Group Effects.

Definitions and examples of neighbouring group effect in selected reactions

Unit 8 Protection and Deprotection in Organic Synthesis

Protection and deprotection of selected functional groups such as aldehydes, ketone and –OH, NH_2.

Unit 9 Formation of C=C Bonds

Formation of C=C bondsby elimination reactions, syn elimination; Wittig and related reactions, McMurry reaction, Peterson olefination, Julia reaction and Tebbe olefination.

Unit 10 Use of Organosulphur Compounds for reversal of polarity (Corey-Seebach Umpolung).

Unit 11 Application of Enolates and Enamines,

Kinetic and thermodynamic enolates, lithium and boron enolates in aldol and Michael reactions, alkylation and acylation of enolates; Reactions involving carbanions: e.g. Henry reaction, Nef reaction, Baylis-Hillman reaction

Unit 12 Hydroboration and Trialkylsilyl Halides in Organic Synthesis.

Unit 13 Mitsunobu reaction, Wohl-Ziegler Allylic Bromination.

Study of the mechanism and synthetic utility.

Unit 14 Use of Organometallic Reagents in formation of carbon-carbon bonds

Organopalladium in C-C formation (Heck reaction, Stille, Suzuki, Sonogashira and Negishi Coupling).

Recommended Books:

1. Organic Chemistry – Paula Yurkanis Bruice, Pearson
2. Organic Chemistry, Vols I and II – I. L. Finar, ELBS.
3. Organic Chemistry – R. T. Morrison, R. N. Boyd and S. K. Bhattacharjee, Prentice Hall India Limited
4. Principles of Organic Synthesis, R. O. C. Norman and J. M. Coxon, ELBS
5. Modern Methods of Organic Synthesis – W Carruthers, Iain Coldham, Cambridge University Press
6. Applications of Redox and Reagents in Organic Chemistry, R. K. Kar, NCBA

Semester I

Course Type	**DSC-3**
Course Name	**Physical Chemistry-I**
Number of Credits	**4**
Total Marks	**100 (Formative: 30, Summative: 70)**

Objectives:

To impart the knowledge and interpret thermodynamic behaviour, predict equilibrium, evaluate reactions, and material properties using fundamental chemical principles.

Course Outcome:

Learners will acquire a comprehensive understanding of thermodynamics, phase equilibria, polymers, surface chemistry, and catalysis, and apply these principles to analyze chemical systems and processes.

Unit 1: Basic Concepts of Thermodynamics

System and surroundings, Thermodynamic state and thermodynamic equilibrium, State functions and path functions, Intensive and extensive state functions as Euler's homogeneous functions, Internal energy and enthalpy, Heat and work, Mathematical formulation of the first law, Concept of thermochemistry and Hess's

law, Statements of the second law, Concept and physical significance of entropy, Clausius inequality

Unit 2: Thermodynamic Functions, Spontaneity, Equilibrium and Maxwell Relations

Helmholtz and Gibbs free energy, Criteria of spontaneity and equilibrium, Gibbs–Helmholtz equation, Le Chatelier's principle and its applications, Maxwell's relations and their applications, Thermodynamic equations of state

Unit 3: Thermodynamics of Real Gases and Gas Mixtures

Deviations from ideal gas behaviour, Thermodynamics of real gases and gas mixtures, Partial molar properties, Fugacity and fugacity coefficient, Determination of fugacity

Unit 4: Thermodynamics of Non-Ideal Solutions and Electrolytes

Ideal and non-ideal solutions, Activity and activity coefficient, Different scales of activity and activity coefficient, Ionic activity coefficients, Applications to chemical equilibria.

Unit 5: Phase Equilibrium Concept and Three-Component Systems

Thermodynamic criteria of phase equilibrium, Gibbs phase rule, Reduced phase rule, Triangular phase diagrams, Water–acetic acid–chloroform system, Ammonium chloride–ammonium sulphate–water system, Applications of ternary systems

Unit 6: Basic Concepts of Non-Equilibrium Thermodynamics

Concept of internal entropy production in irreversible processes, Generalised forces and flows, Linear laws of non-equilibrium thermodynamics, Phenomenological equations, Statement of Onsager's reciprocal relation

Unit 7: Coupled Flows, Stationary States and Local Sustenance of Order

Coupled flows, Thermoelectric effects: Seebeck, Peltier and Thomson effects, Non-equilibrium stationary states, Statement of Prigogine's principle of minimum entropy production, Local sustenance of highly ordered living organisms in spite of continual entropy production

Unit 8: Introduction to Polymer Chemistry

Introduction about polymers, Concepts of monomers and repeat units, Degree of polymerisation, Concepts of linear, branched and network polymers with examples, Natural and synthetic polymers, Thermoplastic and thermosetting polymers, Classification as fibres, elastomers and plastics.

Unit 9: Average Molecular Weights of Polymers and their Determination

Polydispersity and average molecular weight concept, Polydispersity index, Number, weight and viscosity average molecular weights – numerical calculations, Determination of molecular weights: viscosity, osmotic pressure and light scattering methods, Size exclusion chromatography.

Unit 10: Average dimension of polymer chains in Solutions

Chain configuration of macromolecules in solutions, Root mean square end to end distance and radius of gyration, Random flight model and chain stiffness concept, Short range and long range effects, Average dimension of polymer chains, concept of theta solvent.

Unit 11: Polymerisation Reactions

Chain and step polymerisation, introductory concepts of cationic, anionic and coordination chain polymerisation and ring-scission step polymerisation. Kinetics of free radical chain polymerisation, kinetics of step polymerisation and copolymerisation

Unit 12: Surface Chemistry and Surfactants

Nature of surfaces, Thermodynamics of adsorption processes, Physical and chemical adsorption, Adsorption isotherms: Langmuir and BET, Determination of surface area of adsorbents, Capillary condensation, Adsorption in micropores and hysteresis loop. Surfactants: definition and classification, Micelle formation and critical micelle concentration (CMC), Reverse micelles, solubilization and microemulsions

Unit 13: Chemisorption

Chemisorption on metals, semiconducting and insulating oxides, Electrical aspects of surface chemistry, Electrical double layer and zeta potential, Measurement of zeta potential and colloidal stability,

Unit 14: Mechanism of Heterogeneous Catalysis

Kinetics and mechanism of heterogeneous catalysis, Langmuir–Hinshelwood and Eley–Rideal models, Unimolecular and bimolecular surface reactions.

Recommended Books:

1. Physical Chemistry by P.W. Atkins
2. Physical Chemistry by I. N. Levine
3. Thermodynamics for Chemist by S. Glasstone
4. Chemical Thermodynamics – Classical, Statistical and Irreversible by J. Rajaram and J. C. Kuriacose
5. Physical Chemistry-B.R. Puri, L.R. Sharma, Madan S. Pathania
6. A Textbook of Physical Chemistry by K. L. Kapoor

Semester I

Course Type	**DSE-1A**
Course Name	**Laboratory Course-1A**
Number of Credits	4
Total Marks	100 (Formative: 30, Summative: 70)

Objectives: Preparation and characterisation of inorganic complexes. Study of reaction kinetics. Viscometric analysis. Spectrophotometric determination of concentration/composition.

Course outcome: After completion of the course learners will have hands-on experience on preparation and characterisation of inorganic complexes, study of reaction kinetics, viscometric analysis and spectrophotometric determination of concentration/composition.

A) Inorganic Synthesis

Group I Preparation and characterization (conductivity measurement, IR and UV–Visible spectroscopy) of the following complexes:

1. Potassium tris(oxalato)chromate(III), $K_3[Cr(C_2O_4)_3]$
2. Reinecke's salt, $[NH_4][Cr(NCS)_4(NH_3)_2]\cdot H_2O$
3. Tris(thiourea)copper(I) sulphate dihydrate, $[Cu(tu)_3]_2SO_4\cdot 2H_2O$
4. Potassium chromithiocyanate, $K_3[Cr(SCN)_6]$
5. Chloropentaamminecobalt(III) chloride, $[Co(NH_3)_5Cl]Cl_2$
6. Nitropentaamminecobalt(III) chloride, $[Co(NO_2)(NH_3)_5]Cl_2$

Group II

1. Synthesis and characterization (melting point, conductivity, IR, UV-vis etc.) of trans triglycinato Cu(II) monohydrate and estimate the percentage of 'Cu' in the synthesized compound.
2. Synthesis and characterization of Schiff-base ligands and their metal complexes.
3. Synthesis and characterization of magnetic nanoparticles by surfactant assisted method.
4. Synthesis and characterization of nanoparticles by sol-gel and co-precipitation methods.

B) Physical Chemistry Experiments

1. To determine the rate constant of hydrolysis of methyl acetate catalyzed by an acid and also theenergy of activation.
2. Determine the rate constant of inversion of cane sugar by analytical method.
3. Investigation of the reaction between H_2O_2 and HI (clock reaction). Determination of the energy of activation.
4. Determine the molar mass of a polymer by viscometric method.
5. Verify Beer's law and determine the unknown concentration of supplied solutions like$KMnO_4$ / $K_2Cr_2O_7$
6. Determine the composition of iron-salicylic acid complex spectrophotometrically by Job's

method.

Recommended Books

1. Gurdeep Raj, Advanced Practical Inorganic Chemistry
2. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, B. Sivasankar, Vogel's Textbook of Quantitative Chemical Analysis, 6th Edition, Pearson, 2009.
3. JB Yadav, Advanced Practical Physical Chemistry
4. K. K. Sharma & L. R. Sharma, Practical Physical Chemistry

or

Course Type	**DSE-1B**
Course Name	**Laboratory Course-1B**
Number of Credits	4
Total Marks	100 (Formative: 30, Summative: 70)

Objectives: Preparation and characterisation of inorganic complexes. Study of reaction kinetics. Viscometric analysis. Spectrophotometric determination of concentration/composition.

Course outcome: After completion of the course learners will have hands-on experience on preparation and characterisation of inorganic complexes, study of reaction kinetics, viscometric analysis and spectrophotometric determination of concentration/composition.

A) Inorganic Synthesis

Group I Preparation and characterization (viz. conductivity measurement, IR, UV-Vis) of the following complexes:

1. Sodium ferrioxalate, $Na_3[Fe(C_2O_4)_3]\ 9H_2O$
2. TetraamineCu(II)sulphate, $[Cu(NH_3)_4]SO_4.H_2O$
3. Hexa-amine Ni(II) chloride $[Ni(NH_3)_6]Cl_2$
4. Sodium Cobaltinitrite $Na_3[Co(NO_2)_6]$
5. Nitrito Pentamine Cobalt(III) chloride, $[Co(ONO)\ (NH_3)_5]Cl_2$
6. Hexamine Co(III) sulphatepentahydrate, $[Co(NH_3)_6]_2(SO_4)_3.5H_2O$

Group II

1. Synthesis and characterization (melting point, conductivity, IR, UV-vis etc.) of Ni-DMG complex and estimate the percentage of nickel in the synthesized compound.
2. Synthesis and characterization of Schiff-base ligands and their metal complexes.
3. Synthesis and characterization of metal and metal oxide nanoparticles by surfactant assisted methods.
4. Synthesis and characterization of nanoparticles by biogenic methods.

B) Physical Chemistry Experiments

1. To determine the rate constant of hydrolysis of ethyl acetate catalyzed by an acid and also the

energy of activation.

2. To study the kinetics of reaction between $K_2S_2O_8$ and KI.
   a) Determine the rate constant and order of the reaction
   b) Study the influence of ionic strength on the rate constant.
3. Study the kinetics of the reaction between iodine and acetone in acidic medium by half-life

period method and determine the order with respect to iodine and acetone.
4. To determine the radius of a molecule (glycerol) by viscosity measurements.
5. Determination of the composition of the binary mixture ($K_2Cr_2O_7$ and $KMnO_4$) by spectroscopic method (MLRA).
6. Determination of the indicator constant of methyl red.

Recommended Books

1. Gurdeep Raj, Advanced Practical Inorganic Chemistry
2. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, B. Sivasankar, Vogel's Textbook of Quantitative Chemical Analysis, 6th Edition, Pearson, 2009.
3. JB Yadav, Advanced Practical Physical Chemistry
4. K. K. Sharma & L. R. Sharma, Practical Physical Chemistry

Semester I

Course Type	**AEC-1**
Course Name	**Any Course from the Basket of AEC courses offered in KKHSOU**
Number of Credits	**4**
Total Marks	**100 (Formative: 30, Summative: 70)**

Semester I

Course Type	**VAC-1**
Course Name	**Any Course from the Basket of VAC courses offered in KKHSOU (The course on IKS may be chosen as per UGC Guideline on IKS)**
Number of Credits	**2**
Total Marks	**100 (Formative: 30, Summative: 70)**

Semester II

Course Type	**DSC-4**
Course Name	**Inorganic Chemistry-II**
Number of Credits	**4**
Total Marks	**100 (Formative: 30, Summative: 70)**

Objectives: To enable learners to understand bonding, structure, reactions, and catalysis in organometallic compounds and the principles and applications of symmetry and group theory in chemistry.

Course Outcomes: Learners will be able to explain bonding and reactions in organometallic compounds and apply group theory concepts to molecular structure, bonding, and spectroscopy.

Unit 1 Introduction to Organometalic Chemistry

Metal carbon bond formation, 18 electron rule in organometallic complexes, Counting Electrons in complexes, Isolobal analogy in organometallic compounds.

Unit 2 Metal Carbonyls

Synthesis, structure, bonding and reactivity of mono and polynuclear metal carbonyls. Substituted metal carbonyls. Vibrational spectra of metal carbonyls.

Unit 3 σ- and π-Bonded Organometallic Compounds

Synthesis and reactivity of metal alkyls, alkenes, alkynes, allyl and arene complexes; metal carbene, carbyne and carbide complexes

Unit 4 Metallocenes

Synthesis, structure and bonding in metallocenes; bent metallocenes.

Unit 5 Reactions of Organometallic Complexes-I

Substitution reactions in Carbonyl Compounds, Oxidative addition and reductive elimination, insertion and elimination

Unit 6Reactions of Organometallic Complexes-II

Catalysis by organometallic compounds: hydrogenation and hydroformylation; Monsanto process, Wacker process, alkene polymerization, olefin metathesis; Suzuki coupling reaction.

Unit 7 Symmetry Elements and Symmetry Operations

Symmetry elements, Symmetry Operations, Classes of symmetry operation, Matrices and matrix representation of symmetry operations,

Unit 8 Concept of Group Theory

Definition of Group, finite and infinite groups. Examples of groups using geometrical objects and symmetry operations.

Unit 9 Point Groups

Symmetry elements of groups. Point groups. Assignment of point groups to simple molecules.

Unit 10 Orthogonality Theorem

Reducible and irreducible representations, use of vectors and mathematical functions in group representation.

Unit 11 Character Table for Molecular Point Group

Construction of C_{2v} and C_{3v} Character table.

Unit 12 Direct Product Representation

Projection operator, symmetry-adapted linear combination (SALC) for C_{2v}, C_{3v}, D_{4h} and T_d point group molecules.

Unit 13 Chemical Application of Group Theory

Use of group theory in the construction of hybrid Orbitals (d^2sp and sp^3 hybrids).

Unit 14 Application of Group Theory in Molecular Vibration

Vibrational modes as bases for group representation, Determining symmetry types of normal modes of vibrations with selected examples, Selection rules for Fundamental Vibrational Transition (IR and Raman)

Recommended Books:

1. Inorganic Chemistry: Principles of structure and reactivity, 4th Edition; J.E. Huheey, E.A. Keiter, R.L. Keiter, O.K. Medhi.
2. Advanced Inorganic Chemistry, 6thEdition, F.A. Cotton, G. Wilkinson, C.A. Murillo and M. Bochmann.
3. Inorganic Chemistry, K.F. Purcell and J.C. Kotz.
4. Inorganic Chemistry by G.L. Meissler and D.A. Tarr
5. Chemical Applications of Group Theory by F. Albert Cotton
6. A Simple Approach to Group Theory in Chemistry by S. Swarnalakshmi, T. Saroja & R. M. Ezhilarasi
7. Symmetry Group Theory and Its Chemical Applications — D. Rama Sekhara Reddy & G. Ravi

Semester II

Course Type	**DSC-5**
Course Name	**Organic Chemistry-II**
Number of Credits	**4**
Total Marks	**100 (Formative: 30, Summative: 70)**

Objectives: To provide students with fundamental knowledge on i) stereochemistry, and its effect on reactivity and reaction mechanism of organic compounds; ii) Oxidation and reductions in organic compounds.

Course Outcomes: Learners will gain insight into the fundamentals of stereochemistry in organic reactions, and its implications in the reactivity and properties of organic compound. They will acquire knowledge on various oxidation and reduction reactions in organic synthesis.

Unit 1 Concept of prostereoisomerism and prochirality

Homotopic and heterotopic ligands and faces;

Unit 2 Optical purity

Optical purity and enantiomeric excess

Unit 3 Chirality in molecules devoid of chiral centers

Allenes, spirans and biphenyls.

Unit 4 Classification of stereoselective synthesis

Diastereoselective and enantioselective reactions; Stereo-differentiating approach

Unit 5 Nucleophilic addition to aldehydes and acyclic ketones

Cram and Felkin – Ahn model.

Unit 6 Enantioselective synthesis

Use of chiral reagent, chiral catalyst and chiral auxillary.

Unit 7 Resolution

Optical and kinetic resolution

Unit 8 Conformational analysis

Conformational analysis of disubstituted cyclohexanes, cyclohexene, cyclohexanone, 2-alkyl, 1,2 3-alkyl, and 4-alkyl ketone effects. A 1,3 and A strains.

Unit 9 Conformation of fused systems

Conformation of decalins and perhydrophenanthrenes.

Unit 10 Effects of conformation on reactivity and mechanism of basic organic reactions

Effects of conformation on reactivity and mechanism of basic organic reactions of 6-membered ring compounds.

Unit 11 Oxidation of carbon-carbon double bond:

Dihydroxylation by $KMnO_4$, OsO_4(including Sharpless asymmetric dihydroxylation), iodine and silver carboxylate (Woodward and Prevost condition) and peroxy acid. Allylic and benzylic oxidation of alkene: Use of SeO_2 and DDQ.

Unit 12 Oxidation of alcohols

Use of Cr(VI) based reagents (PCC, PDC), DMSO-based reagents (Swern, Pfitzner-Moffatt and Albright – Goldman), Tetrapropyl ammonium perruthenate (TPAP);

Unit 13 Oxidation of 1,2- diols.

Malaprade oxidation, oxidation by Pb-tetra acetate

Unit 14 Reduction by catalytic hydrogenation

Reduction by both heterogeneous (H_2/Pd-C, H_2/Pt_2O, Lindlar's and Rosendmund's reduction) and homogeneous (Wilkinson catalyst).

Unit 15 Reduction by hydride transfer reagents

Reduction by modified hydride transfer reagents e.g. Lithium trialkoxyaluminium hydrides, DIBAL, $NaCNBH_4$, SMEAH (Red Al); Superhydride and Selectrides; by 9-BBN, by Trialkylsilanes and Trialkylstannane, Meerwein Pondorff-Verley reduction.

Unit 16 Reduction by dissolving metal

Reduction by alkali metals in liquid ammonia, Birch reduction.

Recommended Books:

1. Stereochemistry of Organic Compounds – D. Nasipuri, Wiley Eastern
2. Stereochemistry of Carbon Compounds – Earnest E. Eliel, Tata McGraw Hill
3. Stereochemistry of Carbon Compounds – Subrata Sengupta, New Central Book agency, Kolkata
4. Stereochemistry and Mechanism through Solved Problems- P.S. Kalsi, New Age International Publishers
5. Principles of Organic Synthesis, R. O. C. Norman and J. M. Coxon, ELBS
6. Modern Methods of Organic Synthesis – W Carruthers, Iain Coldham, Cambridge University Press
7. Applications of Redox and Reagents in Organic Chemistry, R. K. Kar, NCBA

Semester II

Course Type	**DSC-6**
Course Name	**Physical Chemistry-II**
Number of Credits	**4**
Total Marks	**100 (Formative: 30, Summative: 70)**

Objectives: To provide learners with a thorough understanding of the principles of chemical kinetics, electrochemistry and their applications to electrochemical processes and corrosion.

Course Outcome: Learners will develop a comprehensive understanding of chemical kinetics, and electrochemistry. Learners will be able to analyze reaction rates, mechanisms and apply electrochemical principles to interpret and solve chemical problems.

Unit 1: Fundamentals of Chemical Kinetics

Rate of reaction and rate laws, Order and molecularity of reactions, Experimental methods of determining rate laws, Integrated rate equations, Temperature dependence of reaction rates, Arrhenius equation and energy of activation

Unit 2: Theories of Reaction Rates

Collision theory, Transition state theory (Activated complex theory), Structure of transition state, Eyring equation, Comparison of collision and transition state theories

Unit 3: Unimolecular Reactions

Lindemann theory and its limitations, Hinshelwood theory, Kassel theory, Rice–Ramsperger–Kassel (RRK) theory, Slater's theory, Pressure dependence of unimolecular reactions

Unit 4: Chain Reactions

Elementary steps in chain reactions, Straight-chain reactions: hydrogen–halogen reactions, Alkane pyrolysis, Branching-chain reactions: hydrogen–oxygen reaction, Explosion limits and criteria for explosions

Unit 5: Oscillatory Reactions and Chemical Chaos

Nature of oscillatory reactions, Chemical oscillations and feedback mechanisms, Belousov–Zhabotinsky reaction, Concept of chemical chaos, Temporal and spatial oscillations

Unit 6: Reactions in Solution

Factors affecting reaction rates in solution, Diffusion-controlled and activation-controlled reactions, Ion–ion and ion–dipole reactions, Influence of solvent polarity, Effect of ionic strength and pressure on reaction rates

Unit 7: Fast Reactions and Relaxation Kinetics

Need for fast reaction techniques, Flow methods, Temperature-jump and pressure-jump methods, Flash photolysis, NMR methods, Relaxation kinetics, Linearized rate equations, Relaxation time and determination of rate constants

Unit 8: Enzyme Catalysed Reactions

Characteristics of enzyme catalysis, Michaelis–Menten kinetics, Derivation and significance of Michaelis constant, Lineweaver–Burk and Eadie–Hofstee plots, Effect of temperature, pH and substrate concentration, Enzyme inhibition (competitive, non-competitive and uncompetitive), Acid–base catalysis and acidity functions

Unit 9: Basic Electrochemical Concepts

Introduction to electrochemistry, Electrochemical cells, Galvanic and electrolytic cells, Electrode potentials and Nernst equation, Thermodynamics of electrochemical cells, Measurement of electrode potentials

Unit 10: Electrode Kinetics and Dynamic Electrochemistry

Charge transfer reactions, Overpotential and polarization, Mass transport: migration, diffusion and convection, Diffusion layers, Limiting current

Unit 11: Ion–Solvent Interactions

Solvation and hydration of ions, Born model of ion–solvent interaction, Thermodynamic parameters of solvation, Ion–dipole interactions and their modifications, Ion–quadrupole and ion-induced dipole interactions

Unit 12: Ion Association in Electrolyte Solutions

Debye–Hückel theory (brief review), Bjerrum's hypothesis, Thermodynamics of ion-pair formation, Free ions and ion pairs, Relationship between Debye–Hückel and Bjerrum models

Unit 13: Electrified Interfaces and Electrical Double Layer

Polarizable and non-polarizable electrodes, Inner and outer potentials, Thermodynamics of electrified interfaces, Surface excess and its determination, Electrical double layer, Helmholtz, Gouy–Chapman and Stern models, Potential variation and capacitance of double layer

Unit 14: Corrosion and Its Prevention

Electrochemical theory of corrosion, Types of corrosion: dry, wet, galvanic, pitting, differential aeration, Factors affecting corrosion, Corrosion prevention method, Cathodic and anodic protection, Corrosion inhibitors

Recommended Books

1. Physical Chemistry by P.W. Atkins, Oxford University Press
2. Physical Chemistry-B.R. Puri, L.R. Sharma, Madan S. Pathania
3. Physical Chemistry-Levine
4. A Textbook of Physical Chemistry by K. L. Kapoor

Semester II

Course Type	**DSE-2A**
Course Name	**Laboratory Course-2A**
Number of Credits	**4**
Total Marks	**100 (Formative: 30, Summative: 70)**

Objectives: Quantitative estimation of organic compounds. Analytical and polarimetric study of chemical reaction, measurement of conductivity, pH-metric titration, determination of specific rotation by polarimetric measurement.

Course outcome: Learners will have hands-on knowledge of the quantitative estimation of organic compounds. Analytical and polarimetric study of chemical reaction, measurement of conductivity, pH-metric titration, determination of specific rotation by polarimetric measurement.

A) Organic Estimation

1. Estimation of glucose and sucrose in a mixture.
2. Estimation of acetone by iodoform method.
3. Estimation of hydroxyl by acetylation method
4. Estimation of and amino groups by acetylation method

B) Physical Chemistry experiments

1. To study hydrolysis of methyl acetate in presence of HCl and H_2SO_4 and hence determine the relative strength of the acids (use Guggenheim method) i) analytically. ii) polarimetrically.
2. Determination of the equivalent conductivity of acetic acid at infinite dilution by Kohlrausch's method.
3. Determine the strengths of HCl and CH_3COOH in a given mixture by pH-metric titration.
4. Determination of the specific rotation of sucrose and hence determine the unknown concentration of supplied solution by polarimetric measurements.
5. Determination of pH of a mixture of CH_3COOH and CH_3COONa, and hence determination of the dissociation constant of the acid.
6. Preparation of conducting polymers and study of their electrical conductivity.

Recommended Books

1. O.P. Agarwal, Advanced Practical Organic Chemistry
2. *Vogel's Textbook of Practical Organic Chemistry*
3. *Mann & Saunders, Practical Organic Chemistry*
4. JB Yadav, Advanced Practical Physical Chemistry
5. K. K. Sharma & L. R. Sharma, Practical Physical Chemistry

or

Course Type	**DSE-2B**
Course Name	**Laboratory Course-2B**
Number of Credits	4
Total Marks	100 (Formative: 30, Summative: 70)

Objectives: Quantitative estimation of organic compounds. Polarimetric measurement and conductometric titration, determination of i) ionization constant by conductance method, ii) hydrolysis constant pH measurements, and iii) specific rotation by polarimetric measurement.

Course outcome: Learners will have hands-on knowledge of quantitative estimation of organic compounds. Polarimetric measurement and conductometric titration, determination of i) ionization constant by conductance method, ii) hydrolysis constant pH measurements, and iii) specific rotation by polarimetric measurement.

A) Organic estimation

1. Estimation of glycine by formalin method
2. Estimation of halogen by fusion method
3. Estimation of hydroxyl by acetylation method
4. Estimation of and amino groups by acetylation method

B) Physical chemistry experiments

1. Determine the specific rotation of sucrose and hence determine the unknown concentration of supplied solution by polarimetric measurements.
2. Determine the strengths of the components of the following mixtures by conductometric titration a) Hydrochloric acid and acetic acid b) Sulphuric acid and copper sulphate
3. To determine the velocity constant of hydrolysis of ethyl acetate by NaOH.
4. Determine the ionization constant of acetic acid by conductivity method.
5. Determination of the relative strength of acetic acid and monochloro acetic acid by conductance measurement.
6. Determination of hydrolysis constant of aniline hydrochloride by pH measurements.
7. Establish the order reaction for $K_2C_2O_4 + 2HgCl_2 \rightarrow Hg_2Cl_2 + 2KCl + 2CO_2$ by the method of ratio variation.

Recommended Books

1. O.P. Agarwal, Advanced Practical Organic Chemistry
2. *Vogel's Textbook of Practical Organic Chemistry*
3. *Mann & Saunders, Practical Organic Chemistry*
4. JB Yadav, Advanced Practical Physical Chemistry
5. K. K. Sharma & L. R. Sharma, Practical Physical Chemistry

Semester II

Course Type	**VAC-2**
Course Name	**Any Course from the Basket of VAC courses**
Number of Credits	**2**
Total Marks	**100 (Formative: 30, Summative: 70)**

Semester II

Course Type	**Seminar**
Course Name	**Seminar**
Number of Credits	**4**
Total Marks	**100 (Formative: 30, Summative: 70)**

Guidelines is provided in Annexure III

Semester III

Course Type	**DSC-7**
Course Name	**Spectroscopic Methods**
Number of Credits	**4**
Total Marks	**100 (Formative: 30, Summative: 70)**

Objectives: To enable learners to acquire comprehensive understanding of the principles, instrumentation, and applications of different spectroscopic techniques for structural and analytical studies in chemistry.

Course Outcomes: Learners will be able to analyse and apply various spectroscopic methods for the interpretation of molecular structure, bonding and chemical processes.

Unit 1 Principles of Spectroscopy

Electromagnetic radiation (EMR), Interaction of EMR with matter, natural line width and line broadening; intensity of spectral transitions, Selection rules.

Unit 2 Rotational (microwave) spectroscopy

Classification of molecules according to their moments of inertia, rotational energy levels of HCl, Selection rule for Microwave spectra, intensity, effect of substitution in Microwave spectra. Stark effect, spectra of symmetric top and asymmetric top type molecules.

Unit 3 Vibrational Spectroscopy

Fundamental vibrational frequencies, Selection rules and vibrational energy for harmonic and anharmonic oscillators, vibration rotational spectra of diatomic molecules, Fundamental, overtone and combination bands, P, Q and R branches, hot bands, group frequencies, normal modes of vibrations, symmetry of vibrations.

Unit 4 Raman Spectroscopy

Selection rules, mutual exclusion principle, vibration rotation Raman spectra. Intensity of Raman lines.

Unit 5 Electronic spectroscopy

Electronic transitions and selection rules, Frank Condon principle and electronic spectra of polyatomic molecules, $\pi \rightarrow \pi^*$, $n \rightarrow \pi^*$ transitions and their selection rules.

Unit 6 Fluorescence and phosphorescence

Principles of fluorescence and phosphorescence; Jablonski diagram, solvent effects, absorption and intensity shifts

Unit 7 Calculation of absorption maxima by Woodward-Fieser Rules

Woodward–Fieser rules for conjugated dienes and polyenes, Effect of substituents, exocyclic double bonds, and ring residues, Calculation of absorption maxima for α,β-unsaturated carbonyl compounds.

Unit 8 Nuclear Magnetic Resonance Spectroscopy

Basic principles, Chemical shift, Factors influencing chemical shifts and their interpretation; Shielding and de-shielding, ^{1}H NMR

Unit 9 Spin-spin coupling

Homo-nuclear coupling interactions, vicinal, germinal and long-range coupling, variation of coupling constant with dihedral angle, α(Karplus relationship)

Unit 10 ^{13}C NMR and Nuclear Overhauser effect (NOE)

Chemical shift ranges and sensitivity in ^{13}C NMR, proton-decoupled ^{13}C NMR, NOE

Unit 11 Advanced NMR Techniques

DEPT experiment, brief introduction to 2D NMR – COSY, NOESY and HETCOR, NMR in living systems-MRI

Unit 12 Electron Spin Resonance (ESR) Spectroscopy

Basic principles, g value and the hyperfine coupling parameter (A), origin of hyperfine interactions. Spin orbit coupling and significance of g-tensors, factors affecting g-tensors, structure elucidation of organic free radicals using ESR spectroscopy.

Unit 13 Mass Spectrometry

Basic principles and instrumentation. Ionization techniques in Mass Spectrometry (Electron ionization (EI), chemical ionization (CI), desorption ionization (FAB/MALDI), electrospray ionization (ESI)), analysis of mass spectra: base peak, molecular ion peak and isotope peak. McLafferty Rearrangement.

Unit 14 Mössbauer spectroscopy

Principles, doppler shift, recoil energy, isomer shift, quadrupole splitting, magnetic interactions. Applications: Mossbauer spectra of high and low-spin Fe and Sn compounds.

Recommended Books

1. C. N. Banwell and E. M. McCash, Fundamentals of Molecular Spectroscopy, 4th Ed., Tata McGraw Hill, New Delhi, 2000.
2. G.M. Barrow, Introduction to Molecular Spectroscopy, McGraw Hill.
3. Donald L. Pavia, Introduction to Spectroscopy, Cengage Learning India Private Limited
4. R. M. Silverstein and F. X. Webster, Spectroscopic Identification of Organic Compounds, 6th Ed., John Wiley & Sons, New York, 2003.
5. William Kemp, Organic Spectroscopy, Palgrave Macmillan.
6. Willium Kemp, Applications of Spectroscopy, English Language Book Society, 1987.
7. D. H. Williams and I. Fleming, Spectroscopic Methods in Organic Chemistry, 4th Ed., Tata McGraw-Hill Publishing Company, New Delhi, 1988.
8. R. S. Drago, Physical Methods in Chemistry; Saunders: Philadelphia, 1992.

Semester III

Course Type	**DSC-8**
Course Name	**Quantum Chemistry**
Number of Credits	**4**
Total Marks	**100 (Formative: 30, Summative: 70)**

Course Objectives: To make the students familiar with the various aspects of basic quantum mechanics

Course Outcomes: Learners will develop a comprehensive understanding of quantum mechanics foundations, evaluate molecular structures, wave functions, and can apply in critical thinking skills to solve problems related to molecular orbitals, quantum mechanics, and experimental analysis in chemistry.

Unit 1 Basic principles of Quantum Mechanics

Review of the basic principles of Quantum Mechanics, Black-body radiation, the photoelectric and Compton effects, atomic spectra, the duality of matter, review of vectors and vector spaces, Dirac bra-ket notation, Postualtes of quantum mechanics

Unit 2 Operators

Linear and Hermitian operators, commutation relation, related important theorems. Parity Operators, Permutation Operators, Ladder Operators

Unit 3 Model Systems

Free particle and particle in a box (One and three dimensional), degeneracy, particle in a ring, quantum mechanical tunnelling.

Unit 4 Simple Harmonic Oscillator

SHO-Schrodinger equation and its solution, Power series solution and Hermite polynomials

Unit 5 Angular Momentum

Two-particle rigid rotor- rotational energy levels of diatomic molecules, Hydrogen atom- Schrodinger equation, separation of relative coordinates, radial solution, probability and radial distribution function, angular solution,

Unit 6 Orbital degeneracy

Representation of orbitals, degeneracy, orbital and spin angular momentum.

Unit 7 Approximate methods

Variation theorem, Linear variation functions. Time independent Perturbation theory for non-degenerate systems (up to second order in energy); application of variation and perturbation method to particle in 1D, Simple Harmonic Oscillator

Unit 8 Application to the helium atom

Hamiltonian for a Multi-Electron Atom, Independent Particle Approximation, Variational Method for Ground State and Excited State, Time independent Perturbation Method for Ground State

Unit 9 Hellmann-Feynmann theorem

Definition and application

Unit 10 Antisymmetry Principle and Slater determinant

Slater Determinant for He and Li atom

Unit 11 Term symbol, spectroscopic states

Russell–Saunders coupling and jj coupling, Molecular Term Symbols and Electronic States

Unit 12 Born-Oppenheimer approximation

LCAO-MO and VB treatment of the Hydrogen molecule and Hydrogen molecule ion.

Unit 13Comparison of Molecular Orbital and Valence Bond Methods

Unit 14 Huckel molecular orbital theory:

Postulates, application to ethylene, butadiene, and benzene. Introduction to extended Huckel theory.

Recommended Books:

1. P. W. Atkins & R.S. Friedman, Molecular Quantum Mechanics, Oxford University Press, 1997
2. Ira N. Levine, Quantum Chemistry, Pearson Education, 2004
3. A.K. Chandra, Introduction to Quantum Chemistry, Tata McGraw Hill.
4. D. A. McQuarrie, Quantum Chemistry, Viva Books Pvt. Ltd., 2007
5. R. K. Prasad, Quantum Chemistry, New Age, 2010
6. P.W. Atkins, Physical Chemistry

Semester III

Course Type	**DSC-9**
Course Name	**Green Chemistry and Chemistry in Indian Knowledge System**
Number of Credits	**4**
Total Marks	**100 (Formative: 30, Summative: 70)**

Objectives: To enable learners to understand the principles, strategies, and applications of green chemistry for minimizing environmental impact, improving resource efficiency, and promoting safer chemical practices and to introduce to some aspects of Chemistry in Indian Knowledge System, in metallurgy, glassmaking and ancient nanotechnology and rich heritage of Indian system of medicine, involving medicinal plants and herbal formulations

Course outcomes: Learners will be able to understand, analyse, apply, and evaluate the principles and practices of green and sustainable chemistry for environmentally benign and resource-efficient chemical products and processes and will be familiar with the ancient practices of metallurgy, glassmaking and nanotechnology and Indian system of medicine, involving medicinal plants and herbal formulations.

Part-1 Green Chemistry

Unit 1 Introduction to Green Chemistry and Principles of Green Chemistry

What is Green Chemistry? Need for Green Chemistry. Goals of Green Chemistry. Limitations and obstacles in the pursuit of the goals of Green Chemistry; E-factor. Twelve principles of Green Chemistry with their explanations

Unit 2 Designing green synthesis and Atom Economy

Designing reactions by using the principles of Green Chemistry; Atom Economy: Calculation of atom economy for chemical transformations. Prevention of waste/by-products, Prevention/minimization of hazardous/ toxic products. Elementary idea of PASE Chemistry, Parallel synthesis.

Unit 3 Energy requirements for reactions Feedstock chemicals

Alternative sources of energy, use of microwaves and ultrasonic energy. Chemicals from biomass, Concept of platform molecules, Selection of starting materials; carbohydrates, CO_2 and vegetable oils as green starting materials. Conversion of biomass to value-added products.

Unit 5 Green staring materials, Green reagents and Green solvents

Green starting materials; Green reagents: Dimethyl carbonate (DMC) and Tetrabutylammoniumtribromide (TBATB), oxidation using hydrogen peroxide. Green solvents: Water, Ionic liquids, supercritical fluids (CO_2 and H_2O) and PEGs.

Unit 6 Green catalysis

Catalytic reagents in preference to stoichiometric reagents; solid acids catalysis-use of zeolite. Oxidation and Basic catalysts, Polymer supported catalysts-Poly styrene aluminium chloride, polymeric super acid catalysts, Polymer supported photosensitizers. Co-enzymes as catalysts.

Unit 7 Green techniques in chemical synthesis: Microwave assisted reactions

Microwave assisted reactions: Introduction, Instrumentation, Principle and applications. Microwave assisted reactions in water (oxidation of toluene to benzoic acid, oxidation of alcohols); microwave assisted reactions in organic solvents (Diels-Alder reaction and Decarboxylation); Microwave assisted solvent-free reactions (solid state reaction),

Unit 8 Sonochemistry

Sonochemistry, Instrumentation, Cavitation theory - Ultra sound assisted green synthesis and Applications: Grignard reaction, Ulmann coupling and Cannizaro reaction under sonication.

Unit 9 Examples of Green synthesis and Prevention of chemical accidents

Synthesis of Adipic acid, catechol, disodium iminodiacetate, paracetamol, ibuprofen by green chemistry methods. Designing greener processes to avoid chemical accidents, inherent safer design.

Part-II Chemistry in Indian Knowledge System

Unit 10 Chemistry in Pre-historic and Vedic period of India

Historical perspective in knowledge of Chemistry in India: Archaeological, historiogeographical and textual sources; Pre-Harappan Period and Indus Valley Civilization; Chemical practices in Vedic periods; Indian theories of matter and its properties and transformation, Concepts of acids, bases and indicators.

Unit 11 Classification of Inorganic Substances in IKS

Dhatus (metals), Upadhatus (secondary metals) Ratnas (precious stones), Uparasas (semi-metals/minerals) Lavana (salts), Shilas (ores, stones), Ksharas (alkalis) Early material taxonomy and terminology**;** Knowledge and use of metals, like gold, silver, copper, iron, tin, lead, zinc, mercury. Gems and minerals for therapeutic and ritual purposes.

Unit 12 Metallurgical Techniques of Ancient India

Smelting, roasting, and refining methods; Alloying practices (e.g., Panchaloha) Ancient furnaces, crucibles, bellows and metallurgical tools; Case studies: Iron pillar of Delhi, zinc distillation at Zawar, Wootz Steel.

Unit 13 Plant-derived Organic Compounds in Ayurveda and Rasashastra

Textual sources: Charaka Samhita, Sushruta Samhita, Bhaishajya Ratnavali, Rasa Ratnakara, Vrksayurveda; Classification of herbs and plants (Vanaspatika dravya); Active compounds from roots, leaves, flowers, barks, and resins; Organic molecules with therapeutic properties: curcumin (turmeric), piperine (black pepper), ascorbic acid (amla), alkaloids, glycosides. Polyherbal formulations and synergistic effects. Extraction and Processing Techniques: Methods of decoction (kashaya), infusion (phanta), distillation (arka), fermentation (asava, arishta); Use of organic solvents (ghee, oils, water, alcohol from natural fermentation); Techniques to isolate active constituents: filtration, drying, grinding, maceration

Unit 14 Chemistry in Agricultural and Artisanal Technologies

Traditional knowledge of use of natural fertilizers, manures, ash and plant extracts; Soil treatment with salts, alkalis, and minerals; Organic pest control and post-harvest preservation techniques; Role of fermentation and composting in traditional farming;

Dyeing, tanning, paper-making, and textile treatment using organic and inorganic chemicals, Traditional inks and natural pigments in manuscripts and murals, Varnishes, glues, and binding agents, Chemistry in sculpting and preservation of artworks.

Recommended Books

1. P. T. Anastas & J. K. Warner: Green Chemistry: Theory and Practice, Oxford University Press (1998).
2. B. Saikia and D. Sarma, A textbook on Green Chemistry, Kalyani Publications (2017).
3. P. C. Ray, History of Chemistry in Ancient and Medievel India; Incorporating Hindu Chemistry, Chowkhamba Krishnadas Academy, Varanasi, 2022 (1st edition, 1956)

Semester III

Course Type	**DSE-3A**
Course Name	**Laboratory Course-3A**
Number of Credits	**4**
Total Marks	**100 (Formative: 30, Summative: 70)**

Objectives: Inorganic estimation by complexometric titration. Preparation and purification organic compounds and their spectroscopic identification (UV and IR) and separation and identification of mixture of organic compounds by paper chromatography.

Course outcome: Learners will have hands-on experience on i) inorganic estimation by complexometric titration, ii) preparation and purification organic compounds and their spectroscopic identification (UV and IR) and iii) separation and identification of mixture of organic compounds by paper chromatography

A) Inorganic estimation

1. Estimation of Mg^{2+} and Ca^{2+} by complexometric titration method in different ores and from given solution with one / two components.
2. Estimation of alloys - Brass, Cu-Ni, etc.

B) Organic synthesis

Preparation and purification (by TLC) of the given organic compounds and their spectroscopic identification (UV and IR)

1. Benzilic acid from benzoin via benzyl (Benzilic acid rearrangement)
2. Benzanilide from benzophenone via oxime (Beckman rearrangement)
3. Indigo from anthranilic acid via phenylglycine-o-carboxylic acid and indoxyl
4. Sandmeyer reaction- (a) ortho-Chlorotoluene from ortho-toluidine (steam distillation of the product) (b) Acridone from anthranilic acid via o-chlorobenzoic acid and N phenylanthranilic acid
5. Sulphanilamide from acetanilide via p-acetamidobenzene-sulphonylchloride and p-acetamidobenzenesulphonamide
6. Pinacolone from benzophenone via pinacol (Pinacol-pinacolone rearrangement)
7. Cannizaro reaction of benzaldehyde (separation of benzyl alcohol and benzoic acid by solvent extraction)
8. Oxidation of p-nitrotoluene to p-nitrobenzoic acid
9. Reduction of benzophenone to benzhydrol iv) Phthalic anhydride to phthalimide

C) Separation and identification of organic compounds in a mixture by paper chromatography

Separation and identification of amino acids present in a mixture by paper chromatography.

Recommended Books

1. O.P. Agarwal, Advanced Practical Organic Chemistry
2. *Vogel's Textbook of Practical Organic Chemistry*
3. *Mann & Saunders, Practical Organic Chemistry*
4. Gurdeep Raj, Advanced Practical Inorganic Chemistry
5. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, B. Sivasankar, Vogel's Textbook of Quantitative Chemical Analysis, 6th Edition, Pearson, 2009.

or

Course Type	**DSE-3B**
Course Name	**Laboratory Course-3B**
Number of Credits	**4**
Total Marks	**100 (Formative: 30, Summative: 70)**

Objectives: Inorganic estimation by complexometric titration. Synthesis of green solvents and reagents. Two-step preparation of organic compounds. Separation and identification of mixture of organic compounds by thin layer chromatography.

Course outcome: Learners will have hands-on experience on Inorganic estimation by complexometric titration. Synthesis of green solvents and reagents. Two-step preparation of organic compounds. Separation and identification of mixture of organic compounds by thin layer chromatography.

A) Inorganic estimation

1. Estimation of Zn^{2+} and Cu^{2+} by complexometric titration method in different ores and from given solution with one / two components.
2. Estimation of alloys – Bronze, Cu-Ni, etc.

B) Organic synthesis

1. Synthesis of Deep Eutectic Solvents (DES) and its use.
2. Green synthesis of Coumarin derivative (clay catalyzed).
3. Benzoin condensation using Green catalysts (co-enzymes).
4. Organic two –step preparation
   i. p-nitrobenzene azo 2-naphthol (Para Red) from p-nitroaniline
   ii. Benzanilide from benzophenone
   iii. Dibenzyl from benzoin
5. Preparation of Green reagent: TetrabutylammoniumTribromide (TBATB) and its use
6. Preparation of Green solvent: Ionic liquid and its use.

C) Separation and identification of organic compounds present in a mixture by TLC.

Separation and identification of organic compounds present in a three components mixture by Thin Layer Chromatography.

Recommended Books

1. O.P. Agarwal, Advanced Practical Organic Chemistry
2. Vogel's Textbook of Practical Organic Chemistry
3. Mann & Saunders, Practical Organic Chemistry
4. Gurdeep Raj, Advanced Practical Inorganic Chemistry
5. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, B. Sivasankar, Vogel's Textbook of Quantitative Chemical Analysis, 6th Edition, Pearson, 2009.

Semester III

Course Type	**AEC-2**
Course Name	**Cyber Security***
Number of Credits	**4**
Total Marks	**100 (Formative: 30, Summative: 70)**

***this paper is mandatory and to be opted from the basket of AEC of KKHSOU**

Semester-IV

Course Type	**DSC-10**
Course Name	**Principles of Biochemistry**
Number of Credits	**4**
Total Marks	**100 (Formative: 30, Summative: 70)**

Objective: This course will provide the knowledge on the basic principles of biophysical, bioorganic and bioinorganic chemistry.

Course outcome: Learners will be able to describe and interpret the chemical and physical processes of living organisms.

Unit 1 Introduction

Prokaryotic and eukaryotic cells; structure of plant and animal cells; intracellular organelles and their functions; metabolic processes- catabolism and anabolism;

Unit 2 Cell nucleus

Constituents of cell nucleus structure of chromosomes, cell division- mitosis and meiosis; composition and functions biological membranes- lipids and lipoproteins.

Unit 2 Biophysical chemistry-part 1

Bioenergetics- standard free energy change in biochemical reactions, ATP hydrolysis, synthesis of ATP from ADP; biological redox reactions, electron transfer and redox potentials of biologically important half reactions, oxidative phosphorylation.

Unit 3 Biophysical chemistry-part I1

Thermodynamics of biopolymer solutions, Osmotic pressure; active transport of ions through cell membrane; muscle contraction; energy generation in living systems; transmission of nerve impulses.

Unit 4 Nucleic acid chemistry

Structure and functions of DNA and RNA, the double helical structure of DNA; stability of the double helix- thermal denaturation and renaturation of DNA double helix; chemical and enzymatic hydrolysis of nucleic acids;

Unit 5 Chemical basis of heredity

Genetic code, DNA replication, RNA transcription and translation of genetic information, Biosynthesis of proteins,

Unit 6 Carbohydrate metabolism-

Glycolysis, gluconeogenesis and Kreb‘s cycle.

Unit 7 Biochemistry of lipids

Biosynthesis of fatty acids, triglycerols, phospholipids, cholesterol and related steroids; prostaglandins.

Unit 8 Protein biochemistry

Protein structure- primary, secondary tertiary and quaternary structure of proteins, sequencing of amino acids in polypeptides.

Unit 9 Enzymes

Classification and catalytic behavior, Chemical nature of enzyme, Specificity of enzyme, mechanism of action, factors affecting enzyme activity, enzyme regulators and inhibitors, co-enzymes, co-factors, prosthetic groups: Mechanism of action of NAD^+, $NADP^+$, FMN, FAD.

Unit 10 Metal ions in biology

Role of metal ions in biology and their toxic effects; Iron management in biological systems – siderophores, ferritin and transferrin;

Unit 11 Dioxygen storage and transport

Structure of myoglobin and haemoglobin, cooperativity of O_2 binding in haemoglobin, Bohr effect and Hill coefficients;

Unit 12 Electron transfer proteins

Structure and functions of Electron transfer proteins - Fe-S proteins, cytocchromes and plastocyanines; Structure of nitrogenase and its role in di-nitrogen fixation;

Unit 14 Vitamin B_{12}

Structure and function of vitamin B_{12} and mechanism of 1,2-shift reaction;

Unit 15 Inorganic therapeutics

Chelate therapy, metal based drugs.

Recommended Books

1. D. L. Nelson, M. M. Cox, Lehninger Principles of Biochemistry; 5th edition, 2008 (W. H. Freeman &Co.).
2. R. H. Abeles, P. A. Frey, W. P. Jencks, Biochemistry, Jones and Bartlett Publishers, Boston, 1992.
3. D. Voet, J. G. Voet, C. W. Pratt, Fundamentals of Biochemistry: Life at the Molecular Level, 4th Edition, 2012.
4. I. Bertini, H. B. Gray, S. J. Lippard, J. S. Valentine, Bioinorganic Chemistry; Viva books Pvt. Ltd. 1998.
5. J. A. Cowan, Inorganic Biochemistry: An introduction, 2nd Edition, Wiley, 1997.

Semester-IV

Course Type	**DSC-11**
Course Name	**Analytical Chemistry**
Number of Credits	**4**
Total Marks	**100 (Formative: 30, Summative: 70)**

Objectives: To impart fundamental knowledge of different types of errors and the working principles and applications of different analytical techniques.

Course outcome: Learners will be able to understand various types of errors, working principles and applications of various chromatographic methods, Electron Microscopy and Atomic Force Microscopy; powder and single crystal XRD techniques, Polarography, Thermal methods.

Unit 1: Sampling and Data Analysis

Sampling of solid, liquid and gaseous samples, Accuracy and precision, Mean and standard deviation, Absolute and relative errors, Propagation of errors, Linear regression, Covariance and correlation coefficient

Unit 2 Chromatographic Methods

Introduction and Principles: Adsorption, partition, ion–exchange, size exclusion; Revered phase and Normal Phase Chromatography

Unit 3 Thin Layer Chromatography (TLC) and Column Chromatography

Principle and theory of TLC; Column chromatography: principle, types of adsorbents; packing of columns; applications in purification and separation

Unit 4 Gas Chromatography (GC)

Principles, Instrumentation and Applications., GC-MS.

Unit 5 High Performance Liquid Chromatography(HPLC)

Principles, Instrumentation and Applications. LC-MS.

Unit 6 Size Exclusion Chromatography

Principles; Instrumentation and Applications, Gel permeation chromatography (GPC)

Unit 7 HPTLC and Flash Chromatography

Working Principles and Applications of HPTLC and Flash Chromatography

Unit 8 Transmission Electron Microscopy (TEM)

Principles and Applications of Transmission Electron Microscopy

Unit 9 Scanning Electron Microscopy (SEM)

Principles and Applications Scanning Electron Microscopy

Unit 10 Atomic Force Microscopy (AFM)

Principles and Applications of Atomic Force Microscopy

Unit 11 X-Ray Diffraction (XRD)

Principles and applications of powder and single crystal XRD

Unit 12 Polarography and Cyclic Voltammetry

Polarography: Basic principles, instrumentation and applications of cyclic voltammetry

Unit 13 Thermal methods: Thermogravimetry

Principles and applications of Thermogravimetry (TG), Derivative thermogravimetry (DTG)

Unit 14 Differential thermal analysis (DTA) and Differential scanning calorimetry (DSC).

Principles and applications of Differential thermal analysis (DTA) and Differential scanning calorimetry (DSC)

Recommended Books:

1. Instrumental Methods of Chemical Analysis - H Kaur, Pragati Prakashan
2. Introduction to Instrumental analysis – R.D. Braun, McGraw Hill.

Semester-IV

Course Type	**DSC-12**
Course Name	**Research Methodology**
Number of Credits	**4**
Total Marks	**100 (Formative: 30, Summative: 70)**

Objectives: To impart knowledge on the basic approach to research process and to provide guidance for scientific data analysis and publication

Course Outcome: Learners will gain knowledge about research process and the skill to analyze data in a scientific way

Unit 1 Fundamentals of Research

Meaning, objective and motivation of research, types of research, research methods versus research methodology, Research process

Unit 2Identification of Research Problem and Hypothesis Formulation

Defining and selecting a research problem, formulation of research hypothesis—concept, types and testing.

Unit 3 Literature Survey

Purpose and importance of literature survey, different sources of literature survey including online databases, Literature search strategies.

Unit 4 Research Design

Concept and significance of research design, types of research designs-experimental, quasi-experimental and non-experimental designs, validity and reliability, limitations of research designs

Unit 5 Sampling Design

Concept of sampling, probability and non-probability sampling techniques, sample size determination, sampling errors and bias, applications of sampling in scientific research.

Unit 6 Methods of Data Collection

Primary and secondary data, experimental methods, observational and survey methods, laboratory data generation, ethical considerations in data collection

Unit 7: Statistical Methods for Research

Descriptive and Inferential statistical methods: Data classification and tabulation, graphical representation of data, measures of central tendency, sampling distributions, correlation and regression analysis, hypothesis testing, t-test, p-value and interpretation of statistical results.

Unit 8: Research Data Management

Data generation, documentation, storage, preservation, and sharing. Data quality control, reproducibility and transparency in research, data repositories, open-access data.

Unit 9 Error Analysis and Validation of Results

Types of errors, accuracy and precision, propagation of errors, calibration and standardization, reproducibility and repeatability, validation of experimental data.

Unit 10 Use of Computational and Digital Tools

Use of spreadsheets and statistical software (ChemDraw, Origin, ACD/NMR, Gaussian, MATLAB) for data analysis, graph plotting, molecular modeling, quantum chemical methods, density functional theory (DFT), data visualization of experimental results.

Unit 11 Research Metrics

Citation analysis, impact factor of journals, h-index and other author-level metrics, journal ranking systems

Unit 12 Scientific Writing and Research Communication

Structure of a research paper, writing abstracts, introductions, results and discussions, preparation of figures and tables, oral and poster presentations, conference participation.

Unit 13 Thesis Writing

Thesis Writing: Planning the thesis, Writing the thesis, Thesis structure, Writing up schedule, The Oral examination

Unit 14 Research Ethics

Ethics in general, Professional Ethics, Ethical issues that Arise from Computer Technology, General Moral Imperatives, More Specific Professional Responsibilities, plagiarism and research misconduct, use of plagiarism-detection tools, responsible authorship and collaboration.

Recommended Books:

1.C. R. Kothari and Gaurav Garg, Research Methodology Methods and techniques, New Age International

Semester-IV

DSE-4 courses for choice
DSE-4A Advanced Inorganic Chemistry
DSE-4B Advanced Organic Chemistry
DSE-4C Advanced Physical Chemistry
DSE-4D Natural Products and Heterocyclic Chemistry
DSE-4E Solid State and Materials Chemistry

Discipline Specific Elective (DSE) Courses
(Any one course to be chosen)

Course Type	**DSE-4A**
Course Name	**Advanced Inorganic Chemistry**
Number of Credits	**4**
Total Marks	**100 (Formative: 30, Summative: 70)**

Objectives: To understand reaction mechanisms, bonding, and reactivity of inorganic compounds including coordination and organometallic systems. To introduce advanced inorganic topics such as cluster chemistry, supramolecular systems, metal–organic frameworks, and spectroscopic methods.

Course Outcome: Learners will be able to explain and analyse reaction mechanisms, bonding, and structural features of coordination, organometallic, and cluster compounds. They will be able to apply spectroscopic techniques and concepts of supramolecular chemistry and MOFs to understand modern inorganic materials and their applications.

Unit 1 Electron transfer reaction in Coordination Compounds

Rearrangement of Precursor complex and electron transfer; Nature of bridging ligand; 2-electron transfer; Synthesis of coordination compounds using redox reaction**;** Complementary and non-complementary reaction; Oscillating reactions; Template effect and macrocyclic ligands

Unit 2 Isomerization and Rearrangement Reactions in Coordination Compounds

Isomerization and racemization of tris- chelate complexes, Molecular rearrangement in four-coordinated and six-coordinated complex.

Unit 3 Reactions Involving Gain or Loss of Ligands in Organometallic Compounds

Ligand dissociation and substitution: CO dissociation, dissociation of phosphine, Reactions Involving Gain or Loss of Ligands, Oxidative Addition and C–H Bond Activation, Reductive Elimination and Pd-Catalyzed Cross-Coupling, Sigma Bond Metathesis.

Unit 4 Reactions Involving Modification of Ligands in Organometallic Compounds

Insertion Reactions: Carbonyl Insertion (Alkyl Migration), Examples of 1,2 Insertions, Hydride Elimination

Unit 5 Organometallic Compounds Having Extended π-Systems

Structure and bonding in organometallic compounds with linear π systems and cyclic π systems; bonding between metal atoms and organic π systems (π-ethylene, π-allyl systems, cyclopentadienyl (Cp) complexes); fullerenes as ligands; introduction to carbon wires: polyyne and polyene bridges.

Unit 6 Photochemical Reactions of Coordination Compounds

Basic photochemical processes, photosubstitution reactions, photoredox reactions, ligand photoreactions, photoreactions and solar energy conversion

Unit 7 Metal-Metal Bond

Metal-metal bond formation in organometallic compounds, multiple metal-metal bonds (quadruple bonding in $[Re_2Cl_8]^{2-}$)

Unit 8 Boranes and Carboranes

Styx notation, Wade‘s rules, Synthesis and electron count in polyhedral boranes.

Unit 9 Metalloboranes and Metallocarboranes

Classification,structure, bonding and synthesis in metalloboranes and metallocarboranes

Unit 10 Supramolecular Chemistry

Definition and examples of Supramolecules, Self-assembly and membranes, Concepts of host guest chemistry, Molecular receptors: Cryptands, Valinomycine, Spherands, Molecular recognition

Unit 11 Metal Organic Frameworks (MOFs)

Introduction, Properties and stability, Synthesis (Solvothermal and Hydro thermal methods, Microwave and Mechanochemical synthesis), Characterisation of MOFs by different analytical methods,

Unit 12 Application of MOFs

In gas storage and separation, catalysis, sensors and drug delivery, environmental applications (adsorption of pollutants)

Unit 13 Application of NMR Spectroscopy to Inorganic Compounds

Applications of ^{31}P and ^{19}F NMR spectroscopy incoordination compounds, NMR spectra of diamagnetic and paramagnetic inorganic compounds; paramagnetic shifts

Unit 14 Application of ESR Spectroscopy to Inorganic Compounds

Electron Spin Resonance (ESR spectroscopy): hyperfine splitting in metal complexes, zero field splitting, application of ESR in transition metal coordination complexes (e.g., d^1, d^3 and d^9).

Recommended Books:

1. Inorganic Chemistry: Principles of structure and reactivity, 4th Edition; J.E. Huheey, E.A. Keiter, R.L. Keiter, O.K. Medhi
2. Advanced Inorganic Chemistry, 6th Edition, F.A. Cotton, G. Wilkinson, C.A. Murillo and M. Bochmann.
3. Inorganic Chemistry, K.F. Purcell and J.C. Kotz.
4. Basic Organometallic Chemistry, concept, Synthesis and applications, B. D. Gupta and A. J. Elias; Universities Press, 2010
5. Organometallic Chemistry of Transition Metals, R. H. Crabtree; John Wiley & Sons, 2001
6. Coordination Polymers and Metal Organic Frameworks: Properties, Types, and Applications, Ortiz, scar L., 2011

Semester-IV

Course Type	**DSE-4B**
Course Name	**Advanced Organic Chemistry**
Number of Credits	**4**
Total Marks	**100 (Formative: 30, Summative: 70)**

Objectives: To impart knowledge on different classes of pericyclic reactions, organic photochemical reaction and principles and applications of disconnection approach in organic synthesis.

Course outcomes: Students will be able to understand and apply the stereochemical and mechanistic principles governing pericyclic reactions, photochemical behaviour of carbonyl compounds and alkenes, and the applications of disconnection approach in organic synthesis.

.

Unit 1 Introduction to Pericyclic Reactions

Classification of pericyclic reactions. Molecular orbital symmetry, FMO of conjugated polyenes,

Unit 2 Stereochemistry of electrocyclic reactions

Conrotatory and disrotatory process, FMO Approach, Woodward-Hoffmann principle of conservation of orbital symmetry, allowed and forbidden reactions,

Unit 3Orbital symmetry correlation diagram

Correlation diagrams of Electrocyclic reactions

Unit 4 Cycloaddition reactions:

[2+2], [4+2], [6+2] cycloadditions, Stereoselectivity and regioselectivity of the reactions: FMO Approach, Selection Rules, Diels-Alder reaction

Unit 5 1,3-dipolar cycloadditions and Cheletropic reactions Ene reactions

Introduction and examples of 1,3-dipolar cycloaddition reactions. Cheletropic reactions. Ene reactions of 1,7-dienes, carbonyl enophiles, simple problems

Unit 6 Sigmatropic rearrangement

[m+n] sigmatropic shifts of hydrogen and carbon, selection rules for Sigmatropic rearrangement- FMO approach,Cope and Claisen rearrangement

Unit 7 Application of PMO method to pericyclic reactions

Application of PMO method for explanation of electrocyclic reaction, cycloadditon reaction and Sigmatropic reaction

Unit 8 Photochemistry of organic compounds

Principles of photochemistry, Electronic excitation and fate of excited molecules, Jablonski diagram, photosensitization, quenching, quantum and quantum efficiency, Types of photochemical reactions

Unit 9 Photochemistry of alkene

Photostereomutation of cis-trans isomers, optical pumping, photochemistry of conjugated dienes – cycloaddition and dimerisation of butadiene, Photochemistry of vision.

Unit 10 Photochemistry of carbonyl compounds

Photochemical reactions of saturated acyclic carbonyl compounds: Norrish type I and type II processes, photoreduction of saturated aryl, alkyl and unsaturated ketones, Paterno-Buchi reaction,

Unit 11 Photorearrangements

di-π-methane rearrangement and rearrangement of cyclohexadienes,

Unit 12 Reaction of singlet oxygen

Reactions of singlet oxygen and photooxidation.

Unit 13 Concept of retrosynthesis

General principles: Synthons, Synthetic equivalents and Functional Group Interconversion. General strategies for a logical disconnection. Disconnection of aromatic compounds

Unit 14 Acceptor and donor synthons,

Definition of acceptor and donor synthons with examples. Umpolung: Concept of polarity and use of un-natural donor and acceptor.

Unit 15 Retrosynthesis of Alcohols

Disconnection of alcohols showing the path to Grignard approaches and hydride transfer approaches for synthesis of alcohols.

Unit 16 One group and two group C-C disconnections

Retrosynthsis of 1,2-, 1,3-, 1,4-, 1,5- and 1,6- difunctional (O,O and N,O in a difunctional relation) compounds

Recommended Books:

1. Frontier Orbitals and Organic Chemical Reaction – Ian Flaming, John Wiley
2. Photochemistry and Pericyclic Reactions: J Singh and J Singh, New Age International Publishers
3. Advanced Organic Chemistry Part A and B - Carey and Sundberg
4. Organic Photochemistry – J.M. Coxton and B. Halton, Cambridge University Press.
5. Introductory Photochemistry – A. Cox and T.J. Kemp, McGraw Hill
6. Elements of organic photochemistry – Dwaine O. Cown and Ronald L. Driske, Plenum Press, New York and London

7. Fundamentals of Photochemistry – K.K. Rohatgi-Mukherji, Wiley Eastern
8. Modern Methods of Organic Synthesis – W Carruthers, Iain Coldham, Cambridge University Press

Semester IV

Course Type	**DSE-4C**
Course Name	**Advanced Physical Chemistry**
Number of Credits	**4**
Total Marks	**100 (Formative: 30, Summative: 70)**

Objective: This course will provide the knowledge on the advanced electrochemistry, non-equilibrium and statistical thermodynamics

Course outcome: Learners will be able to describe and interpret the electrochemical processes, non-equilibrium and statistical thermodynamics along with their application in simple system.

Unit 1 Introduction to electrochemistry

Nernst equation, electrode kinetics, dynamic electrochemistry, the Butler-Volmer and Tafel equations. Overpotentials. Kinetically and mass transport controlled electrochemical processes. Mass transport by migration, convection and diffusion,

Unit 2 Conductivity

Solid state electrochemistry. Ion conducting and electronically conducting polymers, The electrochemical double layer.

Unit 3 Electrochemical methods

Potentiostatic and galvanostatic electrochemical methods including voltammetry chronoamperometry, coulometry, cyclic voltammetry.

Unit 4 Thermodynamics of Electrocapillary phenomenon

Surface excess, relevance of outer and surface potential to double layer (DL) studies, surface and inner potential difference. Capacity potential relations in electrode-electrolyte interface, Contact adsorption-its influence on capacity of interface, Capacitance hump.

Unit 5 Electrocatalysis

Definitions, Electrocatalytic potential, effect of electric field on electrocatalysis, Nanostructured and surface modified electrodes.

Unit 6 Electrochemical Cells.

Introduction to batteries, fuel cells and electrochemical solar cells. Electrochemical processes of particular relevance to energy conversion.

Unit 7 Introduction to non-equilibrium thermodynamics

Difference between equilibrium and non-equilibrium thermodynamics, Criteria of non-equilibrium thermodynamics; Assumptions of non-equilibrium thermodynamics, uncompensated heat and its relation to other thermodynamic functions, Fluxes and forces- relation between these two quantities,

Unit 8 Entropy in heat transfer

Entropy production in heat transfer, mass transfer in flow of current, in mixing of gases, and in chemical reaction.

Unit 9 The Phenomenological equations

The linear laws, The Onsagar relation, microscopic reversibility and Onsager reciprocity. Coupled reaction.

Unit 10 Thermoelectric effects

Seebeck, Peltier and Thompson effect.

Unit 11 Probability and most probable distribution

Distinguishable and indistinguishable particles, Concept of ensembles, partition functions and distributions, microcanonical, canonical and grand canonical ensembles, Boltzmann distribution, Elementary idea of Fermi-Dirac and Bose-Einstein distributions.

Unit 12 Ideal gases

Canonical partition function in terms of molecular partition function of non-interacting particles, Translational, rotational and vibrational partition functions.

Unit 13 Thermodynamic quantities

Absolute values of thermodynamic quantities (U,H,S,A) for ideal monoatomic and diatomic gases, heat capacity (C_v, C_p) of an ideal gas of linear and Non-linear molecules, chemical equilibrium.

Unit 14 Mono atomic Crystals

Einstein and Debye models. T^3 dependence of heat capacity of solids at low temperatures. Numerical calculations of thermodynamic quantities for monoatomic, diatomic and polyatomic molecules.

Recommended Books:

1. Advanced Physical Chemistry – J.N. Gurta & H. Snehi, Pragati Prakashan
2. Physical Chemistry Vols. I, II, III and IV – K.L. Kapoor, MacMillan (India) Ltd., New Delhi.
3. Physical Chemistry, G.W. Castellan, Narosa Publishing House, New Delhi.
4. Physical Chemistry – B.R. Puri, L.R. Sharma, Madan S. Pathania, Shobanlal Nagin, S. Chand & Co.
5. Physical Chemistry- P.W. Atkins, Oxford University Press.

Semester IV

Course Type	**DSE-4D**
Course Name	**Natural Products and Heterocyclic Chemistry**
Number of Credits	**4**
Total Marks	**100 (Formative: 30, Summative: 70)**

Objectives:

To provide knowledge on isolation, characterization and synthesis of various natural compounds of biological importance and heterocyclic compounds of biological and pharmaceutical importance

Course outcome: Learners will acquire 1) insight on isolation, characterization and synthesis of various natural compounds of biological importance and 2) knowledge on different heterocylic compounds.

Unit 1 Alkaloids

Occurrence, classification, general methods of isolation, test for detection.

Unit 2Structure elucidation of alkaloids

General principles of structure elucidation of alkaloids by physical and chemical methods.

Unit 3 Structure determination of alkaloid

Structure determination of Atropine and Morphine

Unit 4Terpenoids

Occurrence and classification, isoprene rule, general methods of isolation. Biogenetic pathway of mono- and sesquiterpenes.

Unit 5 Structure elucidation of terpenoids

General Principles of structure elucidation of terpenoids by physical and chemical methods.

Unit 6 Structure determination of a few representative terpenoids

Structure determination of the following. Acyclic monoterpenoid – Linalool. Monocyclic monoterpenoid - Menthol, Bicyclic monoterpenoid: Camphor.

Unit 7 Carbohydrates

Structure, reaction and conformation of disaccharides – sucrose, maltose and lactose.

Unit 8Polysaccharides

Starch and cellulose.

Unit 9Peptides and Proteins

Structure determination and synthesis of small peptides (di-, tri- and tetra-).

Unit 10 Proteins

Classification of proteins. Primary, secondary and tertiary structure of proteins. Solid phase synthesis of peptides.

Unit 11 Introduction to Heterocyclic Chemistry

Principles of heterocyclic synthesis involving cyclization and cyclo addition reaction.

Unit 12 Synthesis and properties of three membered heterocycles

Synthesis and properties of three membered heterocycles containing two heteroatoms viz., N, O and S (aziridine, oxirane, thiirane)

Unit 13 Synthesis and properties four membered heterocycles

Synthesis and properties of three membered heterocycles containing two heteroatoms viz., N, O and S (azetidine, oxetane, thietane]

Unit 14 Synthesis and properties of five membered heterocycles

Synthesis and properties of five membered heterocycles containing two heteroatoms (pyrazole, isoxazole, isothiazole, imidazole, oxazole and thiazole).

Unit 15 Click Chemistry

Elementary idea of Click Chemistry and a few examples of click chemistry in synthesis of heterocycles

Recommended Books

1. Organic Chemistry of Natural Products, Vol I and II, Gurdeep Chatwal, Himalaya Publishing House, Bombay.
2. Chemistry of Organic Natural Products, Vol I and II, O.P. Agarwal, Goel Publishing House, Meerut.
3. Organic Chemistry, Vol- II, I.L. Finar
4. Heterocyclic Chemistry: Synthesis, Reactions and Mechanisms – Raj K. Bansal, Wiley Eastern.
5. Heterocyclic Chemistry – T.L. Gilchrist, Longman Scientific and Technical/Pitman Publ. Ltd.
6. Disconnection Approach in Organic Synthesis – S. Warren, Wiley
7. Organic Reaction Mechanism, Christine Willis and martin Willis, Oxford chemistry Primers (No. 74)
8. Designing Organic Synthesis – S. Warren, Wiley, Chichester
9. The Logic of Organic Synthesis – E.J. Corey and Xue Min Chen, Wiley, New York

Semester-IV

Course Type	**DSE-4E**
Course Name	**Solid State and Materials Chemistry**
Number of Credits	4
Total Marks	100 (Formative: 30, Summative: 70)

Objective: Learners will be introduced to the interdisciplinary field of solid state and materials chemistry, the development of materials for various applications and characterisation techniques

Course outcome: Learners will be able to examine/differentiate between different materials, and design/plan novel materials for applications and will know how to characterise different materials

Unit 1: Introduction to Materials Chemistry

Scope and importance of materials chemistry, Classification of materials: Metals, Ceramics, Polymers and Composites, Structure–property–application relationship, Overview of traditional vs advanced materials

Unit 2: Advanced and Functional Materials

Smart materials: shape memory alloys, piezoelectric and magnetostrictive materials, Carbon-based materials: graphene, carbon nanotubes, fullerenes; Semiconductor materials: bulk and nanostructured semiconductors; Materials for the future: energy, electronics, and sustainability, Light-emitting materials: LED and OLED; Introduction to superconducting materials

Unit 3: Fundamentals of Solid State Chemistry

Nature of solids: crystalline vs amorphous solids, Crystal lattices and unit cells, Symmetry elements and crystal systems, Bravais lattices

Unit 4: Bonding and Electronic Structure in Solids

Types of bonding in solids: ionic, covalent, metallic, van der Waals, Free electron theory, Band theory of solids, Conductors, semiconductors, and insulators, Concept of Fermi level

Unit 5: Crystal Defects and Non-stoichiometry

Point defects: Schottky and Frenkel defects, Line and surface defects (brief introduction), Color centers, Non-stoichiometric compounds, Defects and their influence on material properties

Unit 6: Phase Diagrams and Phase Transitions

One-component and binary phase diagrams (qualitative treatment), Lever rule (introductory), Solid–solid and solid–liquid phase equilibria, Phase transitions: first-order and second-order, Order–disorder transitions

Unit 7: Synthesis of Solid Materials – Conventional Methods

High-temperature ceramic methods, Precursor-based synthesis, Sol–gel method and its modifications, Advantages and limitations of different methods

Unit 8: Advanced Solid-State and Thin-Film Synthesis

Hydrothermal and solvothermal methods, Chemical vapour deposition (CVD), Intercalation and de-intercalation methods, Brief introduction to thin-film fabrication techniques

Unit 9: Crystal Growth and Materials Processing

Importance of crystal growth, Crystal growth techniques: basic concepts, Bulk vs thin-film crystal growth, Materials processing and scalability considerations

Unit 10: Nanomaterials and Nanofabrication

Introduction to nanomaterials, Top-down and bottom-up approaches, Solution-based synthesis of nanoparticles, Other nanomaterial synthesis routes (overview), Size, shape, and surface effects

Unit 11: Physics and Chemistry of Nanoscale Materials

Physics of nanoscale systems, Quantum confinement effect, Electronic, optical, and magnetic behavior at nanoscale, Comparison of bulk vs nanomaterials

Unit 12: Properties of Solids and Materials

Chemical properties, Mechanical properties, Thermal properties, Electrical properties, Magnetic and optical properties, Materials for sensors and energy applications

Unit 13: Characterization Techniques for Solid Materials

Spectroscopic techniques: UV–Visible, Fluorescence, FTIR, NMR; Thermal analysis: TGA, DSC; Structural and morphological tools: Powder X-ray diffraction (PXRD), SEM and TEM, AFM and scanning probe microscopy; Surface and particle analysis: XPS, Particle size analyzer, Zeta potential; Brief introduction to electron beam lithography and electroanalytical methods

Unit 14: Organic Solid State Chemistry and Materials Design

Organic semiconductors, Liquid crystals, Organic energy materials, Organic smart materials, Materials design principles, Economic, environmental, and societal considerations, Sustainable and green materials chemistry

Recommended Books

1. P. Atkins, T. Overton, J. Rourke, M. Weller, F. Armstrong, Shriver & Atkins' Inorganic Chemistry, 5th Ed., OUP 2010.
2. B. Fahlman, Materials Chemistry, 2nd Ed., Springer, 2011
3. L. Smart, E. Moore, Solid State Chemistry: An Introduction, 4thEd. CRC Press 2012.
4. A. R. West, Solid State Chemistry and its Applications, Wiley Student Edition, John Wiley & Sons, 2007.
5. R. Balasubramaniam, Callister's Materials Science and Engineering, 2nd Edition, Wiley, 2014.

Annexure III

Guidelines for Seminar Paper Presentation

The seminar presentation is an important academic component designed to:

- Enhance scientific understanding of a chosen topic in Chemistry
- Develop research orientation and analytical thinking
- Improve scientific communication and presentation skills
- Encourage exploration of recent advancements in Chemistry

General guidelines for presenting seminar paper by learners are:

1. Topic Selection

The topic must be relevant to Chemistry (e.g., Organic, Inorganic, Physical, Analytical, Materials, Environmental Chemistry, *etc*.); preferably focus on the topics such as recent developments or emerging trends in Chemistry, interdisciplinary areas, application-oriented research *etc*.

Topic must be approved by the supervisor/teacher before preparation.

3. Preparation of Seminar Paper

The seminar paper should be well-organized and include:

a. Structure

1. Title Page
2. Abstract
3. Introduction
4. Literature Review
5. Core Content / Discussion
6. Analytical Interpretation
7. Conclusion
8. References (preferably recent journal articles)

b. Key Requirements

- Use authentic and updated sources (journals, books, review articles)
- Maintain scientific accuracy and clarity
- Include figures, diagrams, and reaction mechanisms where necessary
- Follow a standard referencing style (APA/ACS preferred)

4. Presentation Guidelines

- For presentation, slides should include Minimal text and clear diagrams, graphs, illustrations *etc*.
- Duration: Maximum 10-15 minutes' presentation +~5minutes' discussion
- Maintain:
    - Logical flow of content
    - Clear articulation and pace
    - Proper use of scientific terminology

Annexure IV

Guidelines for Project Work

Project Guidelines of M.Sc. in Chemistry Programme:

The project work is an integral part of the M.Sc. Chemistry programme and is designed to provide students with comprehensive practical exposure to research methodology, advanced experimental techniques, and scientific writing skills. It enables students to apply the theoretical knowledge gained during the course to real research problems, thereby developing critical thinking, analytical ability, and problem-solving skills. Through the project, students gain hands-on experience in laboratory work, data collection, analysis, and interpretation of results using appropriate scientific methods. It also familiarizes them with the use of modern instruments, safety practices, and ethical considerations in research. In addition, the project helps students to develop the ability to review scientific literature, present their findings systematically, and communicate results effectively in the form of a well-structured report, thereby preparing them for higher studies, research, or professional careers in Chemistry and related fields.

The guidelines for the project are as follows:

1. Objectives of the Project

- To develop research aptitude among students.
- To provide hands-on experience in theoretical and experimental chemistry.
- To enhance analytical thinking and problem-solving skills.
- To train students towards new innovations.
- To train students in scientific outlook, documentation and presentation of work done.

2. Selection of Topic

- The project topic should be chosen from any major branch of Chemistry such as Physical, Organic, Inorganic, or Analytical Chemistry, and must be scientifically relevant and aligned with contemporary areas like sustainable chemistry, pharmaceuticals, industrial, environmental, or materials chemistry.
- The topic should address a specific research problem, be feasible within available resources, and may involve experimental or theoretical work. Indicative areas that include reaction kinetics, synthesis, coordination chemistry, spectrophotometric analysis, and polymer studies.
- The topic must be approved by the concerned supervisor/department.
- It should be feasible within the available time and laboratory facilities.

3. Supervision

- Each student will carry out the project under the guidance of a faculty member/supervisor.
- The supervisor will guide in planning, execution, and report preparation.

4. Duration

- The project work is to be carried out during the M.Sc.4thSemester.
- Students must adhere to the timeline provided by the institution.

5. Project Work

The project may involve:

- Experimental laboratory work which includes Synthetic/Medicinal/Analytical etc. studies.
- Theoretical/Computational study.
- Students must maintain a proper laboratory record or project diary.

6. Project Report Format

The project report should be neatly typed and organized as follows:

1. Title Page
2. Certificate
3. Acknowledgement
4. Abstract
5. Introduction
6. Literature Review
7. Objectives
8. Materials and Methods / Experimental
9. Results and Discussion
10. Conclusion
11. References / Bibliography.

7. Submission

- The project report must be submitted before the deadline set by KKHSOU.
- It should be duly signed by the supervisor and the authorized signatory.

8. Evaluation

The project will be evaluated based on:

- Quality of work
- Understanding of the subject
- Presentation of results
- Viva-voce examination

9. Viva Voce

- Students must present their project work before an external/internal examiner.
- They should be prepared to answer questions related to their project.

10. General Instructions

- Plagiarism must be strictly avoided.
- Proper referencing style should be learnt and followed.
- Data should be accurate and clearly presented using tables, graphs, and figures for better representation and understanding.

ANNEXURE V

List of Assigned Faculty (Course-wise) for M.Sc. in Chemistry

Discipline of Chemistry, Hiranya Chandra Bhuyan School of Science and Technology

Programme Co-ordinator: **Prof. Jyotirekha G. Handique**

Sem	Title of Courses	Faculty/Course Coordinator
I	Inorganic Chemistry-I	Dr. Bedika Phukan
	Organic Chemistry-I	Prof. Jyotirekha G. Handique
	Physical Chemistry-I	Dr. Khairujjaman Laskar
	Laboratory Course-IA	Dr. Bedika Phukan and Dr. Khairujjaman Laskar
	Laboratory Course-IB	Dr. Bedika Phukan and Dr. Khairujjaman Laskar
II	Inorganic Chemistry-II	Dr. Bedika Phukan
	Organic Chemistry-II	Prof. Jyotirekha G. Handique
	Physical Chemistry-II	Dr. Khairujjaman Laskar
	Laboratory Course-IIA	Prof. Jyotirekha G. Handique and Dr. Khairujjaman Laskar
	Laboratory Course-IIB	Prof. Jyotirekha G. Handique and Dr. Khairujjaman Laskar
III	Spectroscopic Methods	Dr. Bedika Phukan and Dr. Khairujjaman Laskar
	Quantum Chemistry	Dr. Bedika Phukan and Dr. Khairujjaman Laskar
	Green Chemistry and Chemistry in Indian Knowledge System	Prof. Jyotirekha G. Handique
	Laboratory Course-IIIA	Prof. Jyotirekha G. Handique and Dr. Bedika Phukan
	Laboratory Course-IIB	Prof. Jyotirekha G. Handique and Dr. Bedika Phukan
IV	Principles of Biochemistry	Prof. Jyotirekha G. Handique
	Analytical Chemistry	Dr. Bedika Phukan and Dr. Khairujjaman Laskar
	Research Methodology	Dr. Bedika Phukan and Dr. Khairujjaman Laskar
	Advanced Inorganic Chemistry	Dr. Bedika Phukan and Dr. Khairujjaman Laskar

	Advanced Organic Chemistry	Prof. Jyotirekha G. Handique
	Advanced Physical Chemistry	Dr. Bedika Phukan and Dr. Khairujjaman Laskar
	Natural Products Chemistry	Prof. Jyotirekha G. Handique
	Solid State and Materials Chemistry	Dr. Bedika Phukan and Dr. Khairujjaman Laskar

ANNEXURE VI

Common Basket of Ability Enhancement Courses (AECs) and Value Added Courses (VACs) for PG Programmes

Semester	Course Type	Name of the Course
I	**AEC** (any one course)	101 Essential Assamese *(Open to all except those from Assamese)*
		102 English for Media Studies
		103 Writing for Media
		104 Social Entrepreneurship and Project Management
		105 Renewable Energy
	VAC (any one course)	101 Introduction to Ethics *(Open to all except those from Philosophy)*
		102 Essentials of Indian Constitution *(Open to all except those from Political Science)*
		103 Indian Traditional Knowledge System (IKS) **(ভাৰতীয় পৰম্পৰাগত জ্ঞানকোষ)**
		104 English Communication Skills
		105 Traditional Media
II	**VAC** (any one course)	201 Advertisement Strategy
		202 Life Skills
III	**AEC**	**301 Cyber Security**

AEC -101
Essential Assamese

Course Objective

- To introduce learners with the nuances of Assamese grammar
- Illustrate useful contents related to vocabulary, narrative writing and professional writings

Course Outcomes

- The learners will develop their art of speaking and writing
- The learners will be able to demonstrate their professional skill in media houses and other professional houses

Syllabus

অধ্যায় ১: বর্ণ আৰু আখৰ
বর্ণ বা আখৰ, ধ্বনি, বর্ণ বা আখৰ আৰু ধ্বনিৰ সম্পর্ক, অসমীয়া স্বৰ আৰু ব্যঞ্জন ধ্বনি, অসমীয়া ভাষাৰ আখৰ, চন্দ্রবিন্দুৰ ব্যৱহাৰ, ণত্ববিধি আৰু ষত্ববিধি

অধ্যায় ২: বাক্যসজ্জা
অসমীয়া ভাষাৰ বাক্যৰীতি : উদ্দেশ্য আৰু বিধেয়, বাক্যৰ শ্রেণীবিভাজন, বাচ্য, উক্তি, বাক্যত পদৰ ক্রম

অধ্যায় ৩: প্রত্যয় আৰু বিভক্তি
প্রত্যয় : কৃৎ প্রত্যয়, তদ্ধিৎ প্রত্যয়, নিদির্ষ্টতাবাচক প্রত্যয়, বিভক্তি : নাম বিভক্তি বা কাৰক বিভক্তি, ক্রিয়া বিভক্তি, বিভক্তি আৰু প্রত্যয়ৰ পার্থক্য, উপসর্গ,

অধ্যায় ৪: কাৰক, লিঙ্গ আৰু বচন
কাৰকৰ সংজ্ঞা, কাৰকৰ ভাগ, লিংগৰ সংজ্ঞা, লিংগৰ ভাগ, লিংগবিচাৰৰ নিয়ম, বচনৰ সংজ্ঞা, বচনৰ ভাগ

অধ্যায় ৫: সন্ধিআৰুসমাস
স্বৰসন্ধি, ব্যঞ্জনসন্ধি, দ্বন্দ্ব সমাস, দ্বিগু সমাস, বহুব্রীহি সমাস, কর্মধাৰয় সমাস, তৎপুৰুষ সমাস, অব্যয়ী ভাব সমাস

অধ্যায় ৬: জতুৱা ঠাঁচ আৰু ভাৱ সম্প্রসাৰণ
জতুৱা ঠাঁচ আৰু খণ্ডবাক্য, ভাব সম্প্রসাৰণ, সাৰাংশ লিখন

অধ্যায় ৭: ৰচনা লিখাৰ সাধাৰণ প্রণালী
ৰচনা কি, ৰচনা লিখাৰ নীতি, ৰচনাৰ শ্রেণীবিভাগ

অধ্যায় ৮: লিখনি নির্মাণ
যতিচিন, লিখনি সুসঙ্গত গঠন; অনুচ্ছেদ নির্মাণ; অনুচ্ছেদ লেখন প্রক্রিয়া; প্রবন্ধ/ ৰচনা নির্মাণ; আপোনাৰ লেখনীৰ সম্পাদনা

অধ্যায় ৯: **বিশেষ প্ৰৱন্ধ লিখাৰ কৌশল**
বিশেষ প্ৰৱন্ধৰ অর্থ, বিশেষ প্ৰবন্ধৰ বিভিন্ন প্ৰকাৰ- সাক্ষাৎকাৰভিত্তিক প্ৰবন্ধ, তথ্যভিত্তিক প্ৰৱন্ধ, বিশেষ ব্যক্তিক কেন্দ্ৰ কৰি লিখা প্ৰবন্ধ, ফিচাৰেটচ্, সংবাদভিত্তিক প্ৰৱন্ধ আৰু মানৱীয় আগ্ৰহ বৃদ্ধিকাৰী প্ৰবন্ধ, বিশেষ প্ৰবন্ধ নির্মাণ কৌশল

অধ্যায় ১০: **বৃত্তান্ত ইয়াৰ বিভিন্ন ৰূপ**
বৃত্তান্ত কি; বৃত্তান্ত কথন, কথক, বৃত্তান্তৰ ধৰন, বৃত্তান্তৰ দৃষ্টিভংগী, শ্ৰোতা নাইবা সম্বোধিত ব্যক্তি; কথনৰ প্ৰকাৰ; কথনৰ উপাদান; বৃত্তান্তৰ বর্ণনা উপযুক্ততা আৰু বিশ্বাসযোগ্যতা; ৰৈখিক আৰু অ-ৰৈখিক বৃত্তান্তৰ গাঁথনি; বৃত্তান্তৰ অনুচ্ছেদ; প্ৰবন্ধ ৰচনাত বৃত্তান্ত

অধ্যায় ১১: **ভাষা দক্ষতা**
শব্দকোষ-শব্দৰ বাছনি; একাধিক অর্থ থকা শব্দ; সমার্থক আৰু বিপৰীত শব্দ, বাক্য গাঁথনি, কিছুমান সাধাৰণ ভুল

অধ্যায় ১২: **সংবাদ মাধ্যমৰ বাবে লিখাৰ উৎস**
উৎসৰ প্ৰকাৰ; সংবাদ উৎসৰ বিকাশ; নীতিগত দিশ আৰু আৰোপিত বৈশিষ্ট্য

অধ্যায় ১৩: **সমীক্ষা লেখন**
গ্ৰন্থ সমীক্ষাৰ কলা; চলচ্চিত্ৰ সমীক্ষাৰ কলা; নাট্য সমীক্ষাৰ কলা; সংগীত সমীক্ষাৰ কলা

অধ্যায় ১৪: **বিজ্ঞাপন**
বিজ্ঞাপন কি; বিজ্ঞাপনৰ প্ৰধান ধাৰণাসমূহ; কপি ৰাইটিং; ৰেডিঅ' কপি; টেলিভিছন কপি

Reading List

Goswami, Upendranath (1997); *Axamiya Bhasar Byakoron*; Guwahati: Moni-Manik Prakash

Goswami, Golokchandra (1996); *Axamiya Borno prokash*; Guwahati: Bina Library

Bora Satyanath (1998); *Bohol Byakoron*; Guwahati

Anker. S (1998); Real Writing, Boston: Bedford Books

Misra. P. S. (2009); *An Introduction to Stylistics: Theory and Practice*, New Delhi: Orient Black Swan

Puri, Manohar (2006); *Art of Editing*, Pragun Publications, New Delhi

AEC - 102
English for Media Studies

UNIT 1: INTERVIEWING AND NOTE TAKING
Definition of Interview, preparing for interview, conducting the interview, text of interview, language for audio-visual interview, note taking

UNIT 2: EDITORIAL WRITING
Defining Editorial, Introduction to the editorial page, writing the editorial, rules for Editorial writing, writing the Feature, Writing the Article, writing the middle, Letters to the Editor

UNIT 3: ART OF COLUMN WRITING
Types of columns, distinguishing characteristics of an op-ed, steps to be followed while writing a column

UNIT 4: ELEMENTS OF GOOD WRITING
Characteristics- precision, clarity in writing, use of simple sentences, grammar and punctuation, avoiding clichés, pacing, use of transitions

UNIT 5: PREPARING COPY
Copy editing- use of quotes, paraphrases, attribution, writing the lead, grammatical mistakes- confusion in the use of 'who' and 'whom', possessive pronouns, use of active voice, copy reading symbols

UNIT 6: MASTERING THE LANGUAGE OF EDITING
Importance on vocabulary, sentence construction, participles, pronouns, verbs, nouns, foreign words, prepositions, paragraphs, selection of right words

UNIT 7: REVIEW WRITING
Book review- fiction, adverse criticism, non-fiction, the collection, poetry, drama, Steps to be followed while doing a book review, drama review, Film review

UNIT 8: NEWS WRITING
Language and style of Indian Media, Language and style for print and cyber media, Language and style for Radio, Language and style for Television

UNIT 9: HEADLINE WRITING
Meaning of headline, Types of headline, Functions of a headline, Factors to be kept in mind while writing headlines, Headline writing skills- use of verbs, use of Articles and Voices, Use of Decks, The Five Ws, use of Short Synonyms, Abbreviations, Punctuation, Line Balance, Guidelines for Headline Writing

UNIT 10: WRITING FOR ADVERTISING COPY
Introduction, Key concepts in Advertising, Copywriting, Radio copy, Television copy

UNIT11: WRITING AND REWRITING FOR PUBLIC RELATIONS
Preparing news releases- Announcement releases, Backgrounders, Position Papers, Tip Sheets, Rewriting News Releases, Writing newsletter stories

UNIT 12: GRAMMAR AND USAGE
Sequence of Tenses, Voice, Narration, Punctuation, Vocabulary

UNIT 13: COMMON ERRORS IN THE USE OF ENGLISH LANGUAGE
Errors of Concord, Errors of Construction, Errors of Order, Errors in Prepositions, Errors in Conjunctions

UNIT 14: REPORTING PUBLIC SPEECH
Reporting public speeches- background information, covering the speech, using a prepared text, writing the speech story for print

UNIT 15: STYLE AND THE STYLEBOOK
Need of a stylebook, -consistency, preference and tradition, Guidelines of different stylebooks, Mechanical rules

AEC -103
Writing for Media

Unit 1: THE STRUCTURE OF WRITING
The cohesive structure of writing, The Structure of Paragraphs, The Writing Process of Paragraphs, The Structure of Essays/Articles, Editing your writing

Unit 2: WRITING FEATURE STORIES
Meaning of a feature story, Types of feature stories – Interview features, Information features, Personality features, Featurettes, News features and human interest features, Feature story construction

Unit 3: FORMS OF NARRATION
What is Narrative, Narration, Narrator, Narrative Mode and Narrative Point of View, Varieties of Narration, Elements of Narration, Reportability and Credibility of a Narrative, Linear and Non-linear Narrative Structure, The Narrative Paragraph, Narration in an Essay

Unit 4: LANGUAGE SKILLS
Vocabulary: Making choices, Words having multiple meaning, Synonyms and Antonyms, Sentence Structure, Some Common Errors

Unit 5: SOURCES OF WRITING FOR THE MEDIA
Types of sources, Developing news sources, Ethics and Attribution

Unit 6: REVIEW WRITING
Techniques of book review, Techniques of film review, Techniques of play review, Techniques of musical review

Unit 7: COPYWRITING FOR ADVERTISEMENTS
Introduction: What is advertising? Key concepts of advertising, Copywriting, Radio copy, Television copy

UNIT8: WRITING FOR COLUMN, SCIENCE AND PRESS RELEASE
Column writing, Science write- up, Press Release

UNIT 9: EDITING
Meaning of Editing, Language Editing, Writing and Editing Photo Caption, Language for explaining graphs, charts, maps; Proof Reading

UNIT 10: WRITING FOR RADIO
Language and style of radio, Writing for radio news, structure of a radio news bulletin, Radio features and current affairs programmes

UNIT 11: WRITING FOR TELEVISION
Characteristics of broadcast news, Broadcast Lead, Preparing a Broadcast Copy

UNIT12: SCRIPTWRITING FOR FILMS
Format, component and styles, Shooting script and storyboarding, Steps to follow while writing a script

UNIT13: ART OF WRITING PLAYS
Types of Play, Formats of performance, Structure of a Play, Steps to write a Play

UNIT 14: WRITING CAPTIONS FOR PHOTOJOURNALISM
Concept of photojournalism, Basics of photojournalism, Qualities of a photojournalist, Basic parts of a caption, Writing and editing captions

UNIT15: COPY AND PROOF EDITING
Principles of copy editing, The Language of copy writing, Print media requirements, Radio and television copyediting

AEC -104
Social Entrepreneurship and Project Management [Credits: 3+1]

Course Objectives
The Course aims at enabling the learner

- To be able to define the field of social entrepreneurship and key traits of social entrepreneurs
- To be able to describe and apply key theories and concepts the field of social entrepreneurship
- To understand the key elements and functions of project management

Course Outcomes
This course will enable the learners

- To understand social entrepreneurship and livelihood means for sustainable development. This course focuses on optimum utilization of available resources.

Syllabus

UNIT 1: ENTREPRENEURSHIP
Meaning of Entrepreneur; Characteristics of an Entrepreneur; Emergence of Entrepreneurial Class; Role of Entrepreneurs in Economic Growth; Meaning, concept of Entrepreneurship; entrepreneurial leadership and Motivation

UNIT 2: THEORIES OF ENTREPRENEURSHIP
Economic Theory; Sociological Theory; Dynamic Entrepreneurship Innovation Theory; Leibenstein's X- efficiency Theory; Theory of Profit

UNIT 3: SOCIAL ENTREPRENEURSHIP
Meaning, Concepts, Importance of Innovation in the social development sector; Entrepreneurship Development Programmes- Meaning and Importance; Institutions providing Entrepreneurship Development Programmes in India; Banking and Microfinance

UNIT 4: SOCIAL ENTREPRENEURSHIP IN NORTHEAST INDIA
Social Sector Perspectives and Interventions; Role of Entrepreneurship Development Programmes in Context of North- East Region; Local Economy and Training Indigenous Entrepreneurs

UNIT 5: SOCIAL ENTREPRENEURSHIP AND LIVELIHOODS
Joint ventures in social entrepreneurship, public private joint ventures, partnerships for power, solidarity and benefit sharing, ownership rights within joint ventures, addressing dilemmas of corporate and international joint ventures for livelihoods

UNIT 6: SOCIAL SECURITY AND LIVELIHOODS
Strategies through Networking and Partnerships, Livelihood Policy, Livelihood security through five-year plans MGNREGA- understanding from socio-political, cultural perspectives, impact, People's participation and democratic governance

UNIT 7: PROJECT MANAGEMENT AND SOCIAL ENTREPRENEURSHIP

Meaning of Project management; Social Entrepreneurship as an emerging concept in corporate India and skills in Project Management, Government bodies and Voluntary Sector, Social Entrepreneurship Models

UNIT 8: PROJECT LIFE CYCLE
Phases: Conception/Formation Stage; Definition/Build-up Phase; Acquisition/Production Phase; Operation Phase; Divestment/Termination Phase

UNIT 9: PROJECT ASSESSMENT
Assessment tools for social mapping, budget analysis, monitoring and evaluation of pro-people policies and projects supported by public and private funds, Diversity Mapping within organizations and groups; outreach of programme implementation process, Ecological debts, Environment and Social Costing; Financial Analysis

UNIT 10: LEADERSHIP AND RESOURCE PLANNING IN PROJECT MANAGEMENT
Leadership styles, processes, motivation, strategies, leadership roles in sustaining projects, leadership and communication, leadership in vulnerable sectors, people's leadership and ethics, Forward backward linkages between resource groups, fund raising, fund allocations, resource mobilization plans

UNIT 11: VALUE-CO CREATION
Synergy between products, people and process, innovations for market and for social capital creation, valuing abilities within disabilities, social inclusion with exclusive rights of marginalized categories, Quality driven initiatives and alternative development models

UNIT 12: NETWORKING
Tools of social resource mapping and utilization process, Livelihood networks based on ecosystems, Solidarity networks, Community networks, Outcome mapping through networks, power and networking, role of communication in networking.

Practicum: Social Entrepreneurship and Livelihood Initiatives/ Projects, Case Studies (1 credit)

Readings List

Khanka. S. S. (2013). *Entrepreneurial Development*; S. Chand & Co. Ltd., Ram Nagar, New Delhi.

Donald F. Kuratko, (2014). *Entrepreneurship – Theory, Process and Practice*, 9thEdition, Cengage Learning.

Abyad, Abdulrazak (2018), Project Management, Motivation Theories and Process Management, *Middle East Journal of Business*, Oct. 2018, Vol. 13, Issue. 4

PetarJovanović, Ivana Berić, (2018), Analyses of the available Project Management Methodologies, *Journal of Sustainable Business and Management Solutions in Emerging Economies*, 2018/23(3)

AEC-105

Renewable Energy (Credit:4; Marks:100)

COURSE OBJECTIVES:

The main objectives of the course are-

- to provide the fundamental concepts and types of renewable energy sources.
- to analyse the technical and economic aspects of various renewable sources
- to explore energy storage methods and grid integration techniques for renewable energy.
- to evaluate the environmental impacts and sustainability of renewable energy technologies.
- to give an idea about policies, incentives, and challenges in renewable energy adoption globally.

COURSE OUTCOMES:

The learners will be able to-

- Summarize the fundamental characteristics of various renewable energy sources and the technologies employed for their effective utilization.
- Demonstrate the technologies for energy conversion using different renewable energy resources.
- Analyze the advantages and limitations of various renewable energy sources.
- Interprete global and Indian government policies and programs aimed at promoting the adoption and expansion of renewable energy capacity.

UNIT 1: CONVENTIONAL SOURCES OF ENERGY

Overview of Conventional Energy Sources; Types of Conventional Sources: Fossil Fuels, (Limitations, Formation, and Extraction of Conventional Energy Sources), Nuclear Energy; Global and National (India-Focused) Distribution of Reserves; Strategic Importance of Conventional Energy Resources; Uses and Applications: Environmental Impacts.

UNIT 2: RENEWABLE SOURCES OF ENERGY

Introduction of Renewable Energy; Need of Renewable Energy: Energy Scenario: Global and Indian Context; Classification of Energy Sources: Renewable Vs Non-Renewable; Energy Security and Sustainability.

UNIT 3: SOLAR ENERGY

Introduction to Solar Energy: Importance, Solar Radiation and Measurement; Solar Radiation Geometry; Solar Thermal System, Classification of Solar Thermal Collectors: Non-Concentrating and Concentrating Collectors; Flat Plate Collector; Concept of Solar Thermal for Power Generation and Process Heating; Solar Thermal Application- Solar Distillation,

Solar Cooker, Solar Cooling, Solar Green Houses.

UNIT 4: SOLAR PHOTOVOLTAIC SYSTEM

Introduction to Photovoltaic (PV): Characteristics; Different Solar Cell Technologies; PV System Components; PV Models: Equivalent Circuits; PV System Applications: Off-Grid and Grid-Connected PV Systems; Rooftop PV System; Operation and Maintenance of Solar Power Plants; Sun Tracking Systems.

UNIT 5: WIND ENERGY

Introduction to Wind Energy; Characteristics of Wind and Wind Power (Betz limit for maximum power coefficient); Wind Turbines: Types, Components; Aerodynamics of Wind Turbine: Aerofoil, Lift and Drag Characteristics; Grid Integration of Wind Turbines: Power Electronic Interfaces, Grid Interconnection Topologies; Challenges of Wind Energy Technology.

UNIT 6: HYDRO ENERGY

Hydropower Resources; Fundamental of Hydro Energy Estimation; Components of A Hydropower System: Dams and Reservoirs, Intake Structures and Penstocks; Hydropower Technologies: Small, Medium, and Large Hydro Systems, Pumped Storage and Micro-Hydro; Hydro Turbines: Pumped Hydro Energy; Environmental Impact of Hydropower Applications.

UNIT 7: BIOENERGY

Introduction to Bioenergy: Biomass and Biofuels; Potential of Bioenergy; Sources of Bioenergy; Bioenergy Fuels: Characteristics and Applications; Environmental and Economic Aspect of Bioenergy.

UNIT 8: OCEAN ENERGY

Ocean Energy Potential; Wave Energy Devices; Ocean Thermal Energy Conversion (OTEC) and Applications; Introduction to Osmotic Power.

UNIT 9: TIDAL ENERGY

Energy from Wave, Wave Energy Devices, Introduction to Tidal Energy; Tide Energy Technologies,

UNIT 10: GEOTHERMAL ENERGY

Geothermal Resources; Potential of Geothermal energy; Geothermal Technologies and Applications.

UNIT 11: ENERGY STORAGE DEVICES AND HYBRID RENEWABLE ENERGY SOURCES

Battery: Types, Specifications, Charging and Discharging Characteristics; Definition and classifications of hybrid systems: Standalone, Grid-tied, Microgrid-based Hybrids; Role of

Storage in Hybridization, Hybrid systems for EV charging.

UNIT 12: ENERGY ECONOMICS AND AUDITING

Economics of Energy Savings Schemes: Costs, Interest, Depreciation; Investment in Energy Saving Projects: Rate of Return, Payback, Discounted Cash Flow Methods; Case Studies: Energy Production and Conversion, Energy Audit of Electrical, Mechanical, and Thermal Equipment, Energy Audit of Residential Sector, Industrial Sector, and Commercial Sectors; Lifecycle Assessment of Energy Systems; Socio-Economic Aspects of Energy Transition.

UNIT 13: RENEWABLE ENERGY POLICIES

National and International Renewable Energy Policies; Policy Implementation for Rural Electrification, Smart Cities etc. KUSUM, PM Surya Ghar: Muft Bijli Yojana, Green Energy Corridors (GEC).

UNIT 14: RENEWABLE ENERGY AND ENVIRONMENT

Environmental Effects of Energy Production and Utilization; Energy and Climate Change: Greenhouse Gas Emissions and Global Warming; Climate Change Mitigation and Adaptation; International Agreements and Policies on Climate Change; International Protocols; Carbon Pricing and Emission Trading Systems.

UNIT 15: FUTURE TRENDS

Role of AI/ML in Hybrid Renewable Optimization; Brief Idea of Smart Charging Systems: V2V, V2G, V2X Systems.

References:

- Renewable energy resources: Tiwari and Ghosal, Narosa publication.
- Non-conventional energy sources - G.D Rai - Khanna Publishers, New Delhi
- Solar Photovoltaics: Fundamental, Technologies and Applications. C. S. Solanki, PHI Learning
- Renewable Energy Sources: Twidell & Weir, CRC Press.
- Solar Energy/ S.P. Sukhatme, Tata McGraw Hill.
- Renewable Energy Technologies: Ramesh & Kumar, Narosa publication.
- Solar energy - M P Agarwal - S Chand and Co. Ltd.
- Non-Conventional Energy Systems: K M. Mittal, A H Wheeler Publishing Co Ltd.
- Solar Energy: Resource Assessment Handbook, Dr. P Jayakumar, 2009
- Biomass Energy, Oxford & IBH Publication Co.
- Principles of Solar Engineering – Yogi Goswami – CRC Press

****

AEC - 301
Cyber Security

Unit 1: CYBER SECURITY: Navigating Cyberspace
Cyber security increasing threat landscape, Cyber security terminologies- Cyberspace, attack, attack vector, attack surface, threat, risk, vulnerability, exploit, exploitation, hacker., Non-state actors, Cyber terrorism

Unit 2: Cybersecurity: National Infrastructure
Protection of end user machine, Critical IT and National Critical Infrastructure, Cyber warfare, Case Studies.

Unit 3: CYBER CRIMES 1
Cybercrimes targeting Computer systems and Mobiles- data diddling attacks, spyware, logic bombs, DoS, DDoS, APTs, virus, Trojans, ransomware, data breach.

Unit 4: CYBER CRIMES 2
Online scams and frauds email scams, Phishing, Vishing, Smishing, Online job fraud, Online sextortion, Debit/ credit card fraud, Online payment fraud.

Unit 5: CYBER CRIMES 3
Cyberbullying, website defacement, Cyber-squatting, Pharming, Cyber espionage, Cryptojacking, Darknet- illegal trades, drug trafficking, human trafficking.

Unit 6: SOCIAL MEDIA SCAMS & FRAUDS
Social Media Scams & Frauds- impersonation, identity theft, job scams, misinformation, fake News cyber crime against persons - cyber grooming, child pornography, cyber stalking.

UNIT 7: SOCIAL ENGINEERING ATTACKS
Social Engineering attacks, Cyber Police stations, Crime reporting procedure, Case studies.

UNIT 8: CYBER CRIME AND LEGAL LANDSCAPE 1
Cybercrime and legal landscape around the world, IT Act,2000 and its amendments. Limitations of IT Act, 2000.

UNIT 9: CYBER CRIME AND LEGAL LANDSCAPE 2
Cybercrime and punishments, Cyber Laws and Legal and ethical aspects related to new technologies- AI/ML, IoT, Blockchain, Darknet and Social media.

UNIT 10: CYBER LAWS AND CASE STUDIES
Cyber Laws of other countries, Case Studies.

Unit 11: DATA PRIVACY AND DATA SECURITY 1
Defining data, meta-data, big data, non-personal data. Data protection, Data privacy and data security, Personal Data Protection Bill and its compliance, Data protection principles, Big data security issues and challenges

UNIT 12: DATA PRIVACY AND DATA SECURITY 2

Data protection regulations of other countries- General Data Protection Regulations (GDPR),2016 Personal Information Protection and Electronic Documents Act (PIPEDA)., Social media- data privacy and security issues.

Unit 13: CYBER SECURITY MANAGEMENT

Cyber security Plan- cyber security policy, cyber crises management plan., Business continuity, Risk assessment

Unit 14: CYBER SECURITY COMPLIANCE AND GOVERNANCE

Types of security controls and their goals, Cyber security audit and compliance, National cyber security policy and strategy.

VAC 101
Introduction to Ethics

UNIT 1: NATURE AND SCOPE OF ETHICS
Definition of Ethics, Nature of Ethics, Scope of Ethics

UNIT 2: THE CONCEPT OF MORALITY
Definition of Morality, The Nature of Morality, Different Moral Concepts, Moral theory

UNIT 3: FACT AND VALUE
What is fact, What is value, Classification of values, Distinction between fact and value

UNIT 4: MORAL CONCEPTS
Good, Right, Duty, Virtue, Good, Right, Duty, Virtue

UNIT 5: FREEDOM AND DETERMINISM
Determinism: Its Meaning, Arguments in Support of Determinism, What is Freedom or Free Will, Arguments In Support of Free Will, Brief Note On Predestination, Fatalism and Scientific Determinism, The Case Of Freedom and Determinism

UNIT 6: PURUSARTHA
Artha, Kama, Dharma, Moksa, Four Basic Sciences

UNIT 7: THEORIES OF PUNISHMENT NOTION OF CRIME AND PUNISHMENT
Theories of Punishment, Deterrent Theory, Reformative Theory, Retributive Theory, Capital Punishment

Reading list

S.P. Sharma: *Nature and Scope of Ethics*
Ravi, I: *Foundations of Indian Ethics*
J.N. Sinha: *A Manual of Ethics*
J.N. Mohanty: *Classical Indian Philosophy*
I.C. Sharma: *Ethical Philosophies of India*
J.N. Mohanty: *Explorations in Philosophy*
P. Benn: Ethics: *Fundamentals of Philosophy*

VAC 102
Essentials of Indian Constitution

UNIT 1: MAKING OF THE INDIAN CONSTITUTION
Formation of the Constituent Assembly, Drafting Committee, Adoption of the Constitution of India

UNIT 2: PHILOSOPHY AND IDEALS OF THE INDIAN CONSTITUTION
Philosophy and Ideals of the Indian Constitution: The Preamble of the Constitution of India; Sources of the Indian Constitution

UNIT 3: FEATURES OF THE INDIAN CONSTITUTION
Salient Features of the Indian Constitution

UNIT 4: FUNDAMENTAL RIGHTS AND FUNDAMENTAL DUTIES
Meaning, Historical Background, Nature, Importance, Categories of Fundamental Rights, Limitations of Fundamental Rights; Fundamental Duties: Background, Types and Significance of Fundamental Duties

UNIT 5: DIRECTIVE PRINCIPLES OF STATE POLICY
Meaning, Nature and Classification of Directive Principles of State Policy; Difference between Fundamental Rights and Directive Principles of State Policy

UNIT 6: GOVERNMENT AT THE UNION AND STATE LEVELS
Government at the Union level: The President of India, The Vice-President of India, The Union Council of Ministers, The Prime Minister; Government at the State level: The Governor, The State Council of Ministers and the Chief Minister

UNIT 7: THE PARLIAMENT OF INDIA AND THE STATE LEGISLATURE
Composition of the Parliament of India: The President, The Rajya Sabha, The Lok Sabha; Powers and Functions of the Parliament; Relation between the two Houses of the Parliament; Legislative Procedure: Procedure for a Money Bill; The State Legislature: The Legislative Assembly or Vidhan Sabha, The Legislative Council or Vidhan Parishad

UNIT 8: JUDICIARY IN INDIA
Supreme Court and High Courts; The Supreme Court; The High Court: Subordinate Courts; Judicial Review, Judicial Activism and Independence of the Judiciary in India: Judicial Review, Judicial Activism, Independence of the Judiciary in India

Reading List

Basu, D. D. (2009). Introduction to the Constitution of India. New Delhi: Prentice Hall of India.

Brass, Paul R. (1997). The Politics of India Since Independence. New Delhi: Cambridge University Press.

Chander, Prakash (2000). Indian Government and Politics. New Delhi: Cosmos Bookhive Pvt. Ltd.

Dev, B.J and Lahiri, D.K. (1985). Assam Muslims- Politics and Cohesion. Delhi: Mittal Publication.

Ghai, K. K. (2007). Indian Government and Politics. New Delhi: Kalyani Publishers.
Kapur, Anup Chand &Misra, K. K. (2006). Select Constitutions. New Delhi: S. Chand and Company.
Kothari, Rajni. (2009). Politics in India. New Delhi: Orient Black Swan Private Limited.
Palanithurai, G. (2000). Grass-root Democracy in Indian Society. New Delhi: Concept Publishing Company.
Pylee, M. V. (2006). Constitutional Government in India. New Delhi: S. Chand and Company.
Singh Sisodia, Yatindra (2005). Functioning of Panchayati Raj System. Jaipur: Rawat Publication.
Jayal, Niraja Gopal; Mehta Pratap, Bhanu (eds) (2010). Oxford Companion to Politics in India. New Delhi. Oxford University Press.

VAC 103
Indian Traditional Knowledge System
(ভাৰতীয় পৰম্পৰাগত জ্ঞানকোষ)*

Course Objectives

- To illustrate selective contents from the rich grove of Indian classical literature as well as other fields of pragmatic study
- To develop understanding of rich Indian heritage through the selective texts among the learners

Course Outcomes

- The learners will be able to identify a rich cultural past and connect it with the present India
- The learners will be able to organize themselves and gain benefit in their vocational pursuit

Syllabus

অধ্যায় ১: যোগদর্শনৰপৰিচয়
দর্শনৰ সংজ্ঞা, দার্শনিক পৰিভাষাত যোগৰ মূল্যায়ন, যোগৰ সংজ্ঞা আৰু অর্থবিচাৰ, যোগৰ উৎপত্তি, যোগসাহিত্য, যোগপণ্ডিতসকল, যোগৰ শ্রেণীবিভাজন, যোগদর্শনৰ মূলসিদ্ধান্তসমূহ, যোগৰ লক্ষ্য আৰু উদ্দেশ্য

অধ্যায় ২: আয়ুর্বেদআৰুবাস্তুশাস্ত্র
আয়ুর্বেদ বা চিকিৎসাশাস্ত্র, আয়ুর্বেদশাস্ত্রৰ উদ্দেশ্য আৰু ভাগ, আয়ুর্বেদ শাস্ত্রৰ উৎস, বিভিন্ন আয়ুর্বেদশাস্ত্রৰ উল্লেখ, বাস্তুশাস্ত্রপৰিচয়, বাস্তুশাস্ত্রৰ উৎস, বিভিন্ন বাস্তুশাস্ত্রৰ উল্লেখ, শব্দার্থ তালিকা

অধ্যায় ৩: বেদান্ত দর্শনৰপৰিচয়
বেদান্তৰউৎপত্তিআৰুক্রমবিকাশ, অদ্বৈতবেদান্তদর্শনৰবিভিন্নবিষয়বস্তুৰচমুআভাস, জ্ঞানতত্ত্ব, ব্রহ্মতত্ত্ব, জগততত্ত্ব, মায়াতত্ত্ব, ঈশ্বৰতত্ত্ব, জীৱতত্ত্ব, মোক্ষতত্ত্ব

অধ্যায় ৪: অলংকাৰ শাস্ত্রৰ সম্প্রদায়সমূহ
কাব্যশাস্ত্রৰ আৰম্ভণি আৰু বিকাশ, অলংকাৰ শাস্ত্রৰ বিভিন্ন সম্প্রদায়

অধ্যায় ৫: কৌটিল্যৰ অর্থশাস্ত্রঃ পৰিচয়
অর্থশাস্ত্রৰ ৰচয়িতা, অর্থশাস্ত্রৰ বিষয়বস্তু, অর্থশাস্ত্রৰ নামকৰণৰ তাৎপর্য, ভাৰতীয় পৰম্পৰাত অর্থশাস্ত্রৰ গুৰুত্ব

অধ্যায় ৬: চৰক সংহিতাঃ সাধাৰণ আলোচনা
আয়ুর্বেদঃ আয়ুর্বেদৰ অৱতৰণ, চৰক সংহিতাৰ পৰম্পৰা, চৰক সংহিতাৰ অধ্যায়বিভাগ, চৰক সংহিতাৰ অধ্যায়সমূহৰ নামকৰণ, চৰকসংহিতা টীকাকাৰ

অধ্যায়৭: অসমত ৰচিত হোৱা সংস্কৃতকাব্য

ধর্মশাস্ত্র অথবা স্মৃতিশাস্ত্রঃ তন্ত্রসাহিত্য, পুৰাণসাহিত্য, নাটক, ব্যাকৰণ, কাব্যঃ শ্রীকৃষ্ণলীলামৃত্‌ম্‌, সতীজয়মতী, শ্লোকমালা, পতাকান্নায়, প্রকামকামৰূপম্‌, অবিনাশি, কবিকৌতূহলম্‌, প্রশস্তিমূলককাব্য, ব্যঞ্জনা প্রপঞ্চসমীক্ষা, অনূদিত কাব্য

*(Arrangements are being made to translate this course into English)

Reading List

Bahadur.K.P. The Wisdom of Yoga; New Delhi; Sterling Publishers Pvt. Ltd.

Kane, P.V. (1994);History of Indian Poetics; Delhi: Motilal Banarasidas

Goswami, Haramohan Deb (1992); Sanskrit Sahityar Buranji; Guwahati: Bookland

Goswami, (Dr) Dilip Kumar (2018); Essentials of Ayurveda; Jorhat: Eastern Readers Publication

VAC 104
English Communication Skills

UNIT 1: WHAT IS COMMUNICATION?
Defining Communication, Significance and Process of Communication, Communication Network, Communication Media or Methods, Barriers to Communication, Effective Communication

UNIT 2: COMMUNICATION SKILLS
What is Communication? Types of Communication, Written Communication, Spoken Communication, Non-Verbal Communication, Essentials of Written Communication, Essentials of Oral Communication

UNIT 3: ISSUES ON ORAL COMMUNICATION I
Skills Involved in Oral Communication, Listening and Speaking Skills, Reading and Writing Skills, The Process of Speech, Non-verbal Communication

UNIT 4: ISSUES ON ORAL COMMUNICATION II
Conversation as a speech event, Turn-Taking, The Language of Conversation, Phrasal Verbs

UNIT 5: TELEPHONE SKILLS
Understanding Telephone Communication, Handling Calls, Making Requests, Request to Do Things, Giving Instructions

UNIT 6: INTERVIEW SKILLS
The Art of Interviewing, Examples of Interviews—Job Interviews, Media Interviews

UNIT 7: PUBLIC SPEAKING
The art of Public Speaking, Techniques of Persuasive Speech, Techniques of Informative Speech

UNIT 8: DIALOGUES IN CONTEXTS
Importance of Dialogues in Social Interactions, Some Dialogues of Contexts—At the Post Office, At the Doctor's, buying a Shirt, At the Market, In the Library, At the Railway Station, At the Tea Stall, An Interview, At the Book Seller's, At the Garage, Hiring a Taxi, At the Restaurant, At the Bank, At the Hotel

VAC 105
Traditional Media

UNIT1: TRADITIONAL FOLK MEDIA
Traditional folk media- An introduction, Nature of traditional folk media, communication through traditional folk media, traditional media as a part of socio-cultural and ritual communication

UNIT 2: FEATURES OF TRADITIONAL FOLK MEDIA
Traditional media as a mass medium, features and characteristics of traditional folk media- its advantages and disadvantages, storytelling as the core of traditional media

UNIT 3: TRADITIONAL MEDIA IN INDIA
History and growth of traditional media in India- A brief overview of some of the traditional folk media forms of India; Applications of traditional media for development purposes

UNIT 4: TECHNOLOGICAL IMPLICATIONS ON TRADITIONAL FOLK MEDIA
Impact of electronic media on traditional media; Mass communication media vis-à-vis Folk Culture; Success stories of the use of traditional media as a catalyst of social change and development

UNIT 5: TRADITIONAL MEDIA FOR DEVELOPMENT COMMUNICATION
Development Communication and Traditional Media – Development Communication, Traditional media as development media; How to use traditional folk media for development communication

UNIT 6: TRADITIONAL FOLK MEDIA AND INDIAN CULTURE
Features of Folk Tradition- features of folk tradition, role of traditional media, Media for Communicating Social Ethos- traditional media and social ethos, modern mass media and social ethos, Folk media as a platform for disseminating information about Indian culture

Unit 7: RELEVANCE OF TRADITIONAL FOLK MEDIA
Traditional folk forms in rural India- folk theatre, folk songs, narrative forms, religious discourse, puppet show, Impact on rural development, Uses in different fields

VAC 201
Advertisement Strategy

UNIT1: ADVERTISING – BASIC CONCEPT
Concept of advertising; objectives & scope; social and ethical implications of advertising; types of advertising

UNIT 2: INTEGRATED MARKETING COMMUNICATION AND ADVERTISING
Importance of business communication; advertising as a communication process; AIDA model and its purpose; advertising as an element of marketing mix

UNIT 3: DEVELOPING EFFECTIVE PROMOTION
Identifying the target audience; determining the promotional objectives; designing the promotion and selecting the channel; establishing the promotional budget and implementing promotional strategy

UNIT4: MANAGING ADVERTISEMENTS -I
Developing and managing advertising program, setting advertising objectives, DAGMAR, Deciding on advertising budget

UNIT 5: MANAGING ADVERTISEMENTS -II
Developing the advertising message, role of music and humour in advertising, factors considered while developing the advertising copy, creativity in advertising

UNIT 6: MEDIA STRATEGIES
Media planning and objectives, deciding on media, different types of media and their advantages and disadvantages, choosing among major media types, media schedule decisions, space and time buying

UNIT 7: EVALUATING ADVERTISING EFFECTIVENESS
Deciding on reach, frequency and impact; copy testing, advertising recognition and recall tests, Issues in assessing impact of advertising, measuring the performance of an advertising agency.

VAC - 202
Life Skills

Course Objectives
The objectives of the course are to:

- Enhance the ability of developing self-knowledge and self-awareness by overcoming all fears and insecurities
- Increase emotional competency and emotional intelligence at the place of study/work
- Provide the opportunity for realizing self-potential through practical examples
- Develop interpersonal skills and adopt good leadership behaviour for self-empowerment and the empowerment of others

Course Outcomes
After successfully completing the course, learners will be able to

- Gain Self-competency and Confidence
- Gain Emotional Competency
- Gain Intellectual Competency
- Gain an Edge through Professional Competency
- Aim for a High Sense of Social Competency
- Imbibe the attributes of an Integral Human Being

Syllabus

UNIT 1: LISTENING AND SPEAKING
Techniques of Effective Listening and speaking, Listening and Comprehension, Probing Questions, Barriers to Listening, Pronunciation, Enunciation, Vocabulary, Fluency, Common Errors

UNIT 2: READING, WRITING AND DIFFERENT MODES OF WRITING
Techniques of Effective Reading, Gathering Ideas and Information from a Given Text, Evaluating and Interpreting the Text; Avoiding Ambiguity, Vagueness, Unwanted Generalizations, and Oversimplification of Issues; Being structured and sequenced; Using Different Modes of Writing like E-mails, Proposal, Recording the Proceedings of Meetings

UNIT 3: DIGITAL LITERACY AND SOCIAL MEDIA, DIGITAL ETHICS AND CYBER SECURITY
Basic Computer Skills on MS Office Suite, MS Excel, MS Word, MS PowerPoint; Basic Virtual Platforms like Zoom, Google Meet, Cisco Webex, MS Teams; Cyber Security and Threats, Vulnerabilities of Cyber Attacks; Digital Ethics, Digital Etiquette and Digital Life Skills

UNIT 4: NONVERBAL COMMUNICATION
Meaning of Nonverbal Communication; Advantages of Using Nonverbal Communication, Modes of Nonverbal Communication like Eye Contact and Facial Expression, Hand Gestures; Do's and Don'ts in NVC

UNIT 5: GROUP DISCUSSION SKILLS AND INTERVIEW SKILLS
Meaning and Methods of Group Discussion; Procedure of Group Discussion; Group Discussion — Common Errors; Meaning and types of interviews; Dress code, background research; Do's and Don'ts; Situation, task, action, and response (STAR concept) for facing an interview; Interview procedure; Important questions generally asked at a job interview; common errors that candidates generally make at an interview

UNIT 6: EXPLORING CAREER OPPORTUNITIES, RÉSUMÉ SKILLS

Knowing yourself — Personal characteristics; Knowledge about the world of work, requirements of jobs, including self-employment; Sources of career information; Preparing for a career based on potential and availability of opportunities; Introduction of résumé and its importance; Difference between a CV, résumé and biodata; Essential components of a good résumé; Common errors while preparing a résumé

UNIT 7: COGNITIVE AND NON-COGNITIVE SKILLS, PRESENTATION SKILLS, AND LISTENING AS A TEAM SKILL

Cognitive Skills: Meaning and Types of Cognitive Skills, Strategies to Develop Cognitive Skills like Critical Thinking Skills, Problem-solving skill; Non-cognitive Skills: Meaning and Types of Non-cognitive Skills; Strategies to Develop Non-cognitive Skills like Empathy, Creativity, Teamwork; Types of Presentations; Knowing the Purpose; Knowing the Audience; Opening and Closing a Presentation; Using Presentation Tools; Handling Questions; Ways to Improve Presentation Skills over Time

UNIT 8: TRUST AND COLLABORATION, BRAINSTORMING, SOCIAL AND CULTURAL ETIQUETTES, INTERNAL COMMUNICATION

Importance of Trust in Creating a Collaborative Team; Spirit of Teamwork; Understanding Fear of Being Judged and Strategies to Overcome Fear; Advantages of Effective Listening; Listening as a Team Member and Team Leader; Brainstorming as a Technique to Promote Idea Generation; Need for Etiquette; Aspects of Social and Cultural/Corporate Etiquette in Promoting Teamwork; Use of Various Channels for Transmitting Information to Team Members

UNIT 9: LEADERSHIP SKILLS, INNOVATIVE LEADERSHIP AND DESIGN THINKING

Understanding Leadership and its Importance; Traits and Models of Leadership; Key characteristics of an effective leader; Leadership styles; Basic Leadership Skills like Motivation, Teamwork, Negotiation, Networking; Concept of emotional and social intelligence; Design thinking and its key elements; Learning through Biographies - Drawing insights on how leaders sail through difficult situations

UNIT 10: MANAGERIAL SKILLS

Basic managerial skills like planning for effective management, organizing teams, recruiting and retaining talent, delegation of tasks, coordinating, managing conflict; Self-management skills like understanding self-concept, developing self-awareness, self-examination, self-reflection and introspection, self-regulation, managing personal finance; Aspects of budgeting like setting personal goals, estimating likely expenses and managing saving, investment and spending

UNIT 11: ENTREPRENEURIAL SKILLS, ETHICS AND INTEGRITY

Basics of entrepreneurship- meaning of Entrepreneurship, classification and types of entrepreneurships, traits and competencies of entrepreneur; creating business plan - problem identification and idea generation, idea validation, pitch making; ethics and conduct - importance of ethics, personal and professional moral codes of conduct, creating a harmonious life

UNIT 12: LOVE AND COMPASSION, TRUTH, NON-VIOLENCE

Forms of love; love, compassion, empathy, sympathy and non-violence, narratives and anecdotes from history and literature including local folklore on gains and losses in practising love; Truth-truth as value, truth as fact- narratives and anecdotes from history and literature including local folklore on gains and losses in practicing truth; Non-violence – Ahimsa, individuals and

organizations that are known for their commitment to non-violence; Narratives and anecdotes about non-violence from history and literature, including local folklore on gains and losses in practicing non-violence

UNIT 13: PEACE, SERVICE, RENUNCIATION

Peace- its need, relation with harmony, and balance; Narratives and anecdotes about peace from history and literature, including local folklore on gains and losses in practicing peace; Service and its forms; Narratives and anecdotes dealing with instances of service from history and literature, including local folklore on gains and losses in practicing service; Renunciation and sacrifice; self-restrain and ways of overcoming greed; narratives and anecdotes from history and literature, including local folklore on gains and losses in practicing renunciation and sacrifice

UNIT 14: CONSTITUTIONAL VALUES, JUSTICE AND HUMAN RIGHTS, RIGHTEOUSNESS

Righteousness, dharma and propriety; Fundamental Values like Justice, Liberty, Equality, Fraternity, Human Dignity; Fundamental Rights and Fundamental Duties as stated in Indian Constitution

Reading List

Sen, Madhuchanda. 2010. An Introduction to Critical Thinking. Delhi: Pearson.

Silvia, P. J. 2007. How to Read a lot, Washington DC: American Psychological Association

EH McCrath, 1999; Basic Managerial Skills for All; Prentice Hall of India

Ashokan, M. S. 2015. Karmayogi: A Biography of E. Sreedharan. London, UK: Penguin

Chandra, P. 2017. Financial Management: Theory & Practice. 9th edition. New York: McGraw Hill Education

Leading with Cultural Intelligence: The New Secret to Success, New York: American Management Association

McCormack, M.H. 1986. What They Don't Teach You at Harvard Business School: Notes from A Street-Smart Executive. New York: Bentham

Sinek, S. 2009. Start with Why: How Great Leaders Inspire Everyone to Take Action. London: Penguin

Basham, A.L. 1954. First edition. The Wonder That Was India. London: Picador Press.

Ghosh, Shantikumar. 2004. Universal Values. Kolkata: The Ramakrishna Mission.

Ghosh, Sri Aurobindo. 1998. The Foundations of Indian Culture. Pondicherry: Sri Aurobindo Ashram.

Joshi, Kireet. 1997 Education for Character Development, Delhi: Dharma Hinduja Centre of India Studies

****