KARNATAK UNIVERSITY, DHARWAD
ACADEMIC (S&T) SECTION

ಕರ್ನಾಟಕ ವಿಶ್ವವಿದ್ಯಾಲಯ, ಧಾರವಾಡ
ವಿದ್ಯಾಮಂಡಳ (ಎಸ್&ಟಿ) ವಿಭಾಗ

ಸ್ವಾತಂತ್ರ್ಯದ ಅಮೃತ ಮಹೋತ್ಸವ

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NAAC Accredited
'A' Grade 2014

website: kud.ac.in

No. KU/Aca(S&T)/JS/MGJ(Gen)/2024-25/436 Date: 11 NOV 2024

ಅಧಿಸೂಚನೆ

ವಿಷಯ: ರಾಷ್ಟ್ರೀಯ ಶಿಕ್ಷಣ ನೀತಿಯನುಸಾರ 2024–25ನೇ ಶೈಕ್ಷಣಿಕ ಸಾಲಿನಿಂದ ಎಲ್ಲ ಸ್ನಾತಕೋತ್ತರ ಪದವಿಗಳಿಗೆ / ಸ್ನಾತಕೋತ್ತರ ಡಿಪ್ಲೋಮಾಗಳಿಗೆ ಪಠ್ಯಕ್ರಮವನ್ನು ಪ್ರಕಟಣೆ ಕುರಿತು.

ಉಲ್ಲೇಖ: 1. ವಿದ್ಯಾವಿಷಯಕ ಪರಿಷತ್ ಸಭೆಯ ನಿರ್ಣಯ ಸಂಖ್ಯೆ: 2 ರಿಂದ 9, ದಿ: 08.11.2024.

2. ಮಾನ್ಯ ಕುಲಪತಿಗಳ ಅನುಮೋದನೆ ದಿನಾಂಕ: 11.11.2024.

ರಾಷ್ಟ್ರೀಯ ಶಿಕ್ಷಣ ನೀತಿಯನುಸಾರ 2024–25ನೇ ಶೈಕ್ಷಣಿಕ ಸಾಲಿನಿಂದ ಅನ್ವಯವಾಗುವಂತೆ, ಕರ್ನಾಟಕ ವಿಶ್ವವಿದ್ಯಾಲಯದ ಎಲ್ಲ ಸ್ನಾತಕೋತ್ತರ ಪದವಿಗಳಾದ M.A./ M.Sc / M.Com / MBA / M.Ed 1 ರಿಂದ 4ನೇ ಸೆಮೆಸ್ಟರ್‌ಗಳಿಗೆ ಮತ್ತು 1 & 2ನೇ ಸೆಮೆಸ್ಟರ್‌ಗಳ ಸ್ನಾತಕೋತ್ತರ ಡಿಪ್ಲೋಮಾಗಳಿಗೆ ವಿದ್ಯಾವಿಷಯಕ ಪರಿಷತ್ ಸಭೆಯ ಅನುಮೋದನೆಯೊಂದಿಗೆ ಈ ಕೆಳಗಿನಂತೆ ಪಠ್ಯಕ್ರಮಗಳನ್ನು ಅಳವಡಿಸಿಕೊಳ್ಳಲಾಗಿದೆ. ಕಾರಣ, ಸಂಬಂಧಪಟ್ಟ ಎಲ್ಲ ಸ್ನಾತಕೋತ್ತರ ವಿಭಾಗಗಳ ಅಧ್ಯಕ್ಷರು / ಸಂಯೋಜಕರು / ಆಡಳಿತಾಧಿಕಾರಿಗಳು / ಮಹಾವಿದ್ಯಾಲಯಗಳ ಪ್ರಾಚಾರ್ಯರುಗಳು / ಶಿಕ್ಷಕರು ಸದರಿ ಪಠ್ಯಕ್ರಮಗಳನ್ನು ಅನುಸರಿಸುವುದು ಮತ್ತು ಸದರಿ ಪಠ್ಯಕ್ರಮವನ್ನು ಕ.ವಿ.ವಿ. ಅಂತರ್ಜಾಲ www.kud.ac.in ದಲ್ಲಿ ಭಿತ್ತರಿಸಲಾಗಿದನ್ನು ಸಂಬಂಧಪಟ್ಟ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಸೂಚಿಸುವುದು.

Arts Faculty

Sl.No	Programmes	Sl.No	Programmes
1	Kannada	8	MVA in Applied Art
2	English	9	French
3	Folklore	10	Urdu
4	Linguistics	11	Persian
5	Hindi	12	Sanskrit
6	Marathi	13	MPA Music
7	MVA in Painting		

Faculty of Science & Technology

Sl.No	Programmes	Sl.No	Programmes
1	Geography	10	M.Sc (CS)
2	Chemistry	11	MCA
3	Statistics	12	Marine Biology
4	Applied Geology	13	Criminology & Forensic Science
5	Biochemistry	14	Mathematics
6	Biotechnology	15	Psychology
7	Microbiology	16	Applied Genetics
8	Zoology	17	Physics
9	Botany	18	Anthropology

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Faculty of Social Science

Sl.No	Programmes	Sl.No	Programmes
1	Political Science	8	Journalism m & Mass Commn.
2	Public Administration	9	M.Lib. Information Science
3	History & Archaeology	10	Philosophy
4	A.I.History & Epigraphy	11	Yoga Studies
5	Economics	12	MTTM
6	Sociology	13	Women's Studies
7	MSW		

Management Faculty

Sl.No	Programmes	Sl.No	Programmes
1	MBA	2	MBA (Evening)

Faculty of Commerce

Sl.No	Programmes	Sl.No	Programmes
1	M.Com	2	M.Com (CS)

Faculty of Education

Sl.No	Programmes	Sl.No	Programmes
1	M.Ed	2	M.P.Ed

OEC subject for PG

Sl.No	Programmes	Sl.No	Programmes
1	Russian	5	Veman Peetha
2	Kanaka Studies	6	Ambedkar Studies
3	Jainology	7	Chatrapati Shahu Maharaj Studies
4	Babu Jagajivan Ram	8	Vivekanand Studies

PG Diploma

Sl.No	Programmes	Sl.No	Programmes
1	PG Diploma in Chatrapati Shahu Maharaj Studies	2	P.G. Diploma in Women's Studies
3	P.G. Diploma in Entrepreneurial Finance		

ಕುಲಸಚಿವರು.

ಅಡಕ: ಮೇಲಿನಂತೆ

ಗೆ,

1. ಕ.ವಿ.ವಿ. ಸ್ನಾತಕೋತ್ತರ ಅಧ್ಯಕ್ಷರುಗಳಿಗೆ / ಸಂಯೋಜಕರುಗಳಿಗೆ / ಆಡಳಿತಾಧಿಕಾರಿಗಳಿಗೆ / ಮಹಾವಿದ್ಯಾಲಯಗಳ ಪ್ರಾಚಾರ್ಯರುಗಳಿಗೆ
2. ಎಲ್ಲ ನಿಖಾಯದ ಡೀನರು, ಕ.ವಿ.ವಿ. ಧಾರವಾಡ.

ಪ್ರತಿ:

1. ಕುಲಪತಿಗಳ ಆಪ್ತ ಕಾರ್ಯದರ್ಶಿಗಳು, ಕ.ವಿ.ವಿ. ಧಾರವಾಡ.
2. ಕುಲಸಚಿವರ ಆಪ್ತ ಕಾರ್ಯದರ್ಶಿಗಳು, ಕ.ವಿ.ವಿ. ಧಾರವಾಡ.
3. ಕುಲಸಚಿವರು (ಮೌಲ್ಯಮಾಪನ) ಆಪ್ತ ಕಾರ್ಯದರ್ಶಿಗಳು, ಕ.ವಿ.ವಿ. ಧಾರವಾಡ.
4. ಅಧೀಕ್ಷಕರು, ಪ್ರಶ್ನೆ ಪತ್ರಿಕೆ / ಗೌಪ್ಯ / ಜಿ.ಎ.ಡಿ. / ವಿದ್ಯಾಂಡಳ (ಪಿ.ಜಿ.ಪಿಎಚ್.ಡಿ) ವಿಭಾಗ/ ಸಿಸ್ಟಮ್ ಅನಾಲೆಸಿಸ್ಟ್ / ಸಂಬಂಧಿಸಿದ ಪದವಿಗಳ ವಿಭಾಗಗಳು, ಪರೀಕ್ಷಾ ವಿಭಾಗ, ಕ.ವಿ.ವಿ. ಧಾರವಾಡ.
5. ನಿರ್ದೇಶಕರು, ಕಾಲೇಜು ಅಭಿವೃದ್ಧಿ / ವಿದ್ಯಾರ್ಥಿ ಕಲ್ಯಾಣ ವಿಭಾಗ, ಕ.ವಿ.ವಿ. ಧಾರವಾಡ.
6. ನಿರ್ದೇಶಕರು, ಐ.ಟಿ. ವಿಭಾಗ, ಕ.ವಿ.ವಿ. ಧಾರವಾಡ ಇವರಿಗೆ ಕ.ವಿ.ವಿ. ಅಂತರ್ಜಾಲದಲ್ಲಿ ಪ್ರಕಟಿಸುವುದು.

KARNATAK UNIVERSITY, DHARWAD

NAAC Reaccredited with A Grade - 2022

M.Sc. Chemistry
(Analytical Chemistry)

As per NEP - 2020

With effect from 2024-25

Department of Chemistry

About the Department

The Department of Chemistry was one of the earliest Centers of post–graduate teaching and research under the Bombay University (1953). Later, the newly formed Karnatak University has trodden the path of more than five decades. Presently, the Department offers four semester Masters (M.Sc.) program in the three branches of Chemistry viz., Inorganic, Organic & Physical with a unique blend of high quality teaching and rigorous student training.

Infrastructure:

Department is housed in a 30,000 sq.ft. two storeyed building, offers an excellent environment for learning. This includes well-furnished classrooms, spacious laboratories, sophisticated instruments, departmental library, journal section and a computer laboratory. These are also supported by specially equipped research laboratories.

Faculty:

The Department has an experienced & dedicated group of faculty members with decades of teaching experience at various levels, who are equally competent in frontier areas of chemical research. This rich and vibrant intellectual pool will transform the budding and ambitious post–graduates into professional chemists, research scholars and inspiring teachers. Many of them have the financial support for research from agencies like DST, UGC, CSIR, AICTE etc.

Students Aid-in Programmes:

Financial aid to students: Every year 5 students get financial aid from the scholarships instituted in the names of former professors namely, Prof. S. Siddappa, Prof. N. S. Biradar and Prof. V. V. Badiger. On an average 10 students get government merit scholarships. In addition to departmental scholarships, private education trusts, namely, Jindal Pvt. Ltd., Mumbai and Dempo Pvt. Ltd., Goa also provide financial assistance to the students. Some research students also get University fellowships, every year.

Gold Medals/ Cash Prizes:

Gold medals are instituted in the names of Prof. S. Siddappa, Prof. V. V. Badiger, Prof. E. S. Jayadevappa, Prof. G. K. N. Reddy, Prof. A. R. Murthy, Prof. S. T. Nandibewoor and Prof. M. V. Kulkarni and Prof. B.V. Badami.

Centrally Aided Programmes:

The Department of Chemistry has been recognized for its potential research output and was selected for additional financial support by the University Grants Commission (UGC), New Delhi and Department of Science & Technology (DST), New Delhi. The details of these special distinctions achieved by the Department are as follows: SAP (DRS)-UGC: 1992–1997; SAP II

(DRS)–UGC:1998-2003; COSIST-UGC:1999-2004; FIST-DST:2001-2006; SAP III-UGC:2005-2010; FIST II-DST:2007-2012.

Facilities in the Department:

The Department has sophisticated instrumental facilities like UV–Visible–, Fluorescence–, FTIR– and NMR–spectrometers, Single Crystal X-ray diffraction instrument, Confocal microscope, Electrochemical analyzer, Potentiostat, Fuel cell work station, Polarimeter, Zeta sizer, Electrospinning machine, Water contact angle instrument, HPLC, CO_2 incubator, –40° to –80°C free dryer, Faraday balance and stopped flow accessory. Recently, the UGC–INFLIBNET through the University library has provided access to majority of the international journals and the University library has also provided access to the SciFinder^{TM} database of chemical and bibliographic information. The Department also houses its own departmental library and has procured a large number of text books under the centrally aided programmes which are useful to the post-graduate students, research students and staff and also has a separate periodical section which has chemical abstracts and many national and international journals up to the year 2000.

Special Features:

The Department has established its own employment cell and several national and multinational companies hold campus interviews for our post graduate and research students. It is a matter of pride to note that more than 50% of our students find their placement before completion of the course. The department is proud to have Karnatak University Alumni Association (R) to foster fellowship and to provide a forum to bring together members of KUCAA for their progress and development in chemical sciences.

Theory question paper format for NEP Semester Examinations:

i) Each theory paper has following pattern of questions:

Questions	Particulars	Questions
Q: 1 (Compulsory)	Eight sub questions carry two marks each (2 questions from each unit).	**16 Marks**
Q: 2 to Q: 7	Six questions from four units will be given. Each question carries 16 marks. Any four questions are to be answered. There may be mixing of questions from different units in question numbers 6 and 7.	**16 × 4 = 64 Marks**
	Total	**80 Marks**
	Internal Assessment (Conducted during each semester)	**20 Marks**
	Grand Total	**100 Marks**

Each theory paper (except Open Elective Course) has a corresponding Practical Paper.

ii) Scheme of Practical Examination in all the four semesters is as follows:

Sl. No.	Particulars	Marks
1.	Experiment	**35 Marks**
2.	Viva-voce and Journal	**05 Marks**
3.	Internal assessment*	**10 Marks**
4.	Total	**50 Marks**
Duration of Examination: 4 hours		

*Conducted during the semester. Practical Internal Assessment will be conducted out of 40 marks and will be reduced to out of 10 Marks.

Basis for Internal Assessment:

Internal assessment marks in theory papers shall be based on tests. The tests may be conducted 8 to 12 weeks after the start of a semester. Internal assessment marks in practicals shall be based on tests. The practical test may be conducted 10 weeks after the start of a semester.

The other general academic regulations will be same as laid by University.

GENERAL INSTRUCTIONS

I. CREDIT, WORKLOAD AND SYLLABUS EQUIVALENCE

1. One credit is equal to 1 hour theory teaching per week.
2. One credit is equal to 2 hour practical teaching per week.
3. One credit is equal to 15 hours theory syllabus per semester (1 Unit is equal to 15 Hours)
4. One credit is equal to 30 hours practical syllabus per semester (1 credit practical is equal to 2 hours/ week)

A. Workload for theory subjects

1. There shall be 16 hrs/week workload for Assistant Professor
2. There shall be 14 hrs/week workload for Associate Professor/ Professor/Senior Professor.
3. There shall be 2hrs/week workload relaxation for Guiding Ph.D. students

B. Workload for practical subjects

1. There shall be 20 hrs/week workload for Assistant Professor
2. There shall be 18 hrs/week workload for Associate Professor/ Professor/Senior Professor.
3. There shall be 2hrs/week workload relaxation for Guiding Ph.D. students

C. Workload for practical batches

1. A batch of 10-12 students shall have 1 teacher

D. Workload for Project

1. Students for projects / internship shall be preferably guided by permanent faculty for atleast10 students by sharing equally among the permanent faculty. If remained excess shall be allotted to other teacher's on roll on temporary basis.
2. If there are no permanent faculty, the students shall be distributed among the temporary teachers on roll.
3. There shall be maximum of 4 hrs/week workload for guiding the students for project work irrespective of number of students.

II. ALLOTMENT OF SPECIALIZATION: While allotting specialization in 3rd and 4th semester, minimum of 10 students shall have to select the specialization.

III. ATTENDANCE: 75% attendance is mandatory for every course (paper). No marks are reserved for attendance. If the candidates fail to fulfill 75% attendance in any one of the course (paper) in the given semester, such candidate is not eligible to appear for examination in all the papers and candidate has to get the readmission for such semester. However, up to 20% attendance may be condoned with the supportive documents for a student who represents University /State / National level sports, cultural and other events. Monthly attendance shall be displayed on notice board.

IV. CREDIT AND MARKS EQUIVALENCE

1. Generally, 20% weightage for Formative assessment and 80% weightage for Summative assessment.
2. Up to 2 credits equal to 50 marks (10 marks Formative assessment and 40 marks summative assessment).
3. 3-4 credits equal to 100 marks (20 marks Formative assessment and 80 marks summative assessment).
4. 5-6 credits equal to 150 marks (30 marks Formative assessment and 120 marks summative assessment).
5. Example for 100 marks out of which 20 marks for Formative assessment i.e., Formative Assessment shall be in two internal assessments i.e.: 10 marks I.A. for 8^{th} week and 10 marks for 14^{th}week of every semester.

V. Conduct of Examination

1. Formative assessment examination shall be conducted for 1hr. There shall not be any provision for improvement. A special Formative assessment examination shall be conducted for a student who represents University /State / National level sports, cultural and other events if a schedule is overlapping.

2. 80 marks summative theory examination shall be conducted for 3 hrs and 40 marks for 1.5 hrs.

3. 80/ 40 marks Formative / Summative Practical examination shall be conducted for 4 hrs.

4. There shall be a single examiner for both even and odd semesters' Formative Practical examination.

5. There shall be a single examiner for odd semester Summative Practical examination and two examiners for even semester Summative Practical examination; one from internal and other shall be external examiner.

VI. Assessment

1. **Theory papers:** There shall be a single valuation for odd semester theory papers preferably internal examiner and double valuation for even semesters; one from internal and other shall be external examiner.
2. **Project/Internship assessment**

A) **For 100 marks Project/Internship assessment (Wherever applicable)**

i. **Formative Assessment**: Project/Internship assessment carrying 20 marks out of 100 marks Candidate has to submit two Progress Reports; each carries 10 Marks. i.e. 10 x 2= 20 marks.

ii. **Summative Assessment**: Project/Internship assessment carrying 80 marks out of 100 marks

a. Project Report : 35
b. Presentation : 25
c. Viva-voce : 20

B) For150 marks **Project/Internship assessment (Wherever applicable)**

i. **Formative Assessment**: Project/Internship assessment carrying 30 marks out of 150 marks Candidate has to submit two Progress Reports; each carries 15 Marks. i.e. 15 x 2= 30 marks.

ii. **Summative Assessment:** Project/Internship assessment carrying 120 marks out of 150 marks

a. Project Report : 60
b. Presentation : 35
c. Viva-voce : 25

VII. Passing criteria:

1. There shall be no minimum passing marks for Formative assessment.
2. Candidate has to score minimum 40% in summative examination and fulfill 40% of the maximum marks including Formative assessment marks. For example: for 80 marks summative examination, candidate has to score minimum of 32

marks (40%) and should score cumulatively 40 marks including formative assessment in every course.

VIII. DECLARATION OF RESULT

1. Candidate has to score 40% as above in all the courses to pass the semester end examination to declare pass.
2. **Percentage and Grading:** Result shall be declared in terms of SGPA and at the end of four semesters as CGPA. The calculation of CGPA is as under
3. If P is the percentage of marks secured (IA + semester end score) by the candidate in a course which is rounded off to the nearest integer, the grade point (GP) earned by the candidate in that course will be given as below.

Percentage (%)	Grade(GP)	Percentage (%)	Grade(GP)
40	4.0	71-75	7.5
41-45	4.5	76-80	8.0
46-50	5.0	81-85	8.5
51-55	5.5	86-90	9.0
56-60	6.0	91-95	9.5
61-65	6.5	96-100	10.0
66-70	7.0		

Grade point of less than 4 shall be considered as fail in the course, hence, GP=0 and for the absent candidate also GP=0

4. A student's level of competence shall be categorized by grade point (GP), Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA) of the programme.
5. **Semester Grade Point Average (SGPA):** The SGPA is a ratio of sum of the number of Credit Grade Points scored from all the courses (subject) of given semester to the total credits of such semester in which the candidate studied. (Credit Grade Points of each course = Credits x GP).
6. **Cumulative Grade Point Average (CGPA):** It is calculated as below for 4 semester programme.

   CGPA=$(Credit_1 \times SGPA_1) + (Credit_2 \times SGPA_2) + (Credit_3 \times SGPA_3) + (Credit_4 \times SGPA_4)$ / Total credits of programme (sum of credits of 4 semesters).

7. After studying and passing, all the credits prescribed for the programme the degree shall be awarded with CGPA score after rounding off to second decimal and class distinguishing as second class, first class, and distinction along with grade letter as under:

CGPA of the programme(Degree)	Class obtained	Grade Letter
9.5 to 10.00	Outstanding	A^{++}
7.00 to 9.49	Distinction	A^{+}
6.00 to 6.99	First Class	A
5.50 to 5.99	Second class	B^{+}
5.00 to 5.49		B
4.00 to 4.99	Pass	C
Less than 4.0	Fail/ Reappear	D

8. Each semester Grade Card shall have marks and SGPA and final Grade Card shall have semester wise marks obtained in all semesters, CGPA and % of cumulative marks obtained from all semesters.
9. There shall be Revaluation / Challenge valuations provisions as per the prevailing rules and regulations.
10. Marks obtained from the OEC shall not be considered for award of CASH PRIZE / RANK / GOLD MEDAL.

IX. MAXIMUM DURATION FOR COMPLETION OF THE PROGRAMME

A candidate admitted to any P.G. Programme shall complete it within a period, which is double the duration of the programme from the date of admission.

X. ANY OTHER TERMS AND CONDITIONS

Apart from the above, the prevailing rules and regulation are valid for any other matters which are not addressed in this regard

KARNATAK UNIVERSITY, DHARWAD
DEPARTMENT OF CHEMISTRY
M.Sc. DEGREE PROGRAMME IN CHEMISTRY (Analytical chemistry)
(With effect from 2024-25)

As per NEP - 2020
Course Structure and Scheme of Examination

FIRST SEMESTER

Semester	Type of Course	Theory / Practical	Course Code	Course Title	Credits	Instruction Hour /Week	Total Hours/Sem	Duration Of Exam	Marks		
									Formative	Summative	Total
I	DSC – 01	Theory	A1CHE001DT	Inorganic Chemistry - I	04	04	60	03	20	80	100
	DSC – 02	Theory	A1CHE002DT	Organic Chemistry - I	04	04	60	03	20	80	100
	DSC – 03	Theory	A1CHE003DT	Physical Chemistry **-** I	04	04	60	03	20	80	100
	DSC – 04	Theory	A1CHE004DT	Analytical Chemistry	04	04	60	03	20	80	100
	DSC – 05	Practical	A1CHE005DP	Lab Course in Inorganic Chemistry	02	04	60	04	10	40	50
	DSC – 06	Practical	A1CHE006DP	Lab Course in Organic Chemistry	02	04	60	04	10	40	50
	DSC – 07	Practical	A1CHE007DP	Lab Course in Physical Chemistry	02	04	60	04	10	40	50
	DSC – 08	Practical	A1CHE008DP	Lab Course in Analytical Chemistry	02	04	60	04	10	40	50
TOTAL									120	480	600

SECOND SEMESTER

Semester	Type of Course	Theory / Practical	Course Code	Course Title	Credits	Instruction Hour /Week	Total Hours/Sem	Duration Of Exam	Marks		
									Formative	Summative	Total
II	DSC – 09	Theory	A2CHE001DT	Inorganic Chemistry - I	04	04	60	03	20	80	100
	DSC – 10	Theory	A2CHE002DT	Organic Chemistry - I	04	04	60	03	20	80	100
	DSC – 11	Theory	A2CHE003DT	Physical Chemistry - I	04	04	60	03	20	80	100
	OEC - 01	Theory	A2CHE204AT	Applied Inorganic Chemistry	04	04	60	03	20	80	100
	DSC – 12	Practical	A2CHE005DP	Lab Course in Inorganic Chemistry	02	04	60	4	10	40	50
	DSC – 13	Practical	A2CHE006DP	Lab Course in Organic Chemistry	02	04	60	4	10	40	50
	DSC – 14	Practical	A2CHE007DP	Lab Course in Physical Chemistry	02	04	60	4	10	40	50
TOTAL									110	440	550

THIRD SEMESTER

Semester	Type of Course	Theory / Practical	Course Code	Course Title	Credits	Instruction Hour /Week	Total Hours/Sem	Duration Of Exam	Marks		
									Formative	Summative	Total
III	DSC – 15	Theory	A3CHE101DT	Instrumental Methods of Analysis	04	04	60	03	20	80	100
	DSC – 16	Theory	A3CHE102DT	Molecular Spectroscopy	04	04	60	03	20	80	100
	DSC – 17	Theory	A3CHE103DT	Selected Topics in Analytical Chemistry–I	04	04	60	03	20	80	100
	OEC – 02	Theory	A3CHE204BT A3CHE205CT	Applied Organic Chemistry OR Applied Physical Chemistry	02	04	60	04	10	40	50
	DSC – 18	Practical	A3CHE106DP	Lab Course in Analytical Chemistry	02	04	60	04	10	40	50
	DSC – 19	Practical	A3CHE107DP	Lab Course in Analytical Chemistry	02	04	60	04	10	40	50
	DSC – 20	Practical	A3CHE108DP	Lab Course in Analytical Chemistry	02	04	60	04	10	40	50
TOTAL									110	440	550

FOURTH SEMESTER

Semester	Type of Course	Theory / Practical	Course Code	Course Title	Credits	Instruction Hour /Week	Total Hours/Sem	Duration Of Exam	Marks		
									Formative	Summative	Total
IV	DSC – 21	Theory	A4CHE101DT	Pollution and Analysis	04	04	60	03	20	80	100
	DSC - 22	Theory	A4CHE102DT	Quality Control, Analysis of Food, Beverages and Pharmaceuticals	04	04	60	03	20	80	100
	DSC - 23	Theory	A4CHE103DT	Selected Topics in Analytical Chemistry-II	04	04	60	03	20	80	100
	DSC – 24	Practical	A4CHE104DP	Project Work	06	04	60	08	30	120	150
	DSC – 25	Practical	A4CHE105DP	Lab Course in Analytical Chemistry	02	04	60	04	10	40	50
	DSC – 26	Practical	A4CHE106DP	Lab Course in Analytical Chemistry	02	04	60	04	10	40	50
	DSC – 27	Practical	A4CHE107DP	Lab Course in Analytical Chemistry	02	04	60	04	10	40	50
TOTAL									120	480	600

***** Project Evaluation:
Dissertation – 60 Marks
Presentation and Viva-Voce – 60 Marks

KARNATAK UNIVERSITY, DHARWAD

DEPARTMENT OF CHEMISTRY

SYLLABUS FOR M.Sc. CHEMISTRY (with Specialization Analytical Chemistry)

NEP – 2020

(With effect from the Academic Year 2024-25)

Program Outcomes:

After the completion of this Program the student will

1. be able to appreciate the theory as well as practicals in such a way to foster their core competency and discovery learning.
2. Learnt to handle sophisticated equipments for the determination and characterization of chemical compounds.
3. have knowledge of the latest chemistry software to avoid the laborious work in research.
4. be sufficiently competent in the field to understand further discipline specific studies as well as to begin domine related employment.
5. will be able to design and carryout scientific experiments and accurately record and analyze the results of the experiments.
6. have global level research opportunities to pursue Ph.D. programme.
7. be able to explore new areas of research in both chemistry and allied fields such as Biochemistry, Material Chemistry, Pharmaceutical chemistry and chemical biology and related technology.
8. have enormous job opportunities at all levels of teaching, chemical, pharmaceutical, food products, life oriented material industries.
9. be moulded as a responsible citizen who will be aware of most basic domain-independent knowledge including critical thinking and communication.
10. prepare himself for national as well as international competitive examinations, especially UGC-CSIR-NET and UPSC civil service examinations.

FIRST SEMESTER

Program learning outcomes:

After completion of this program successfully,

1. Students understand the structures of ionic crystals, simple molecules and coordination compounds through different theories.
2. Students learn acid-base concepts and chemical reactions in non-aqueous, ionic liquids and supercritical fluids as media.
3. Students understand the elements of solid state chemistry, molecular solids, band theory, non-stoichiometric compounds and quantitative analyses skills will be developed.
4. Students will understand the structural information which helps them to predict the mechanism, stereochemical aspects of the molecule and structure reactivity.
5. Students can design and synthesize required molecules for the various pharmaceutical as well as material science applications.
6. Students will understand the various reactions by performing various experiments as well as reagents properties, functions and its MSDS.
7. Understand the mathematical aspects of quantum mechanics and their application.
8. Impart the students with different laws and concepts of thermodynamic.
9. Understand the theories of reaction kinetics, chain reaction and factors affecting reaction kinetics.
10. Students understand the theory behind ion-solvent and ion-ion interaction in solutions.
11. Imparting the importance of effect of temperature on chemical reaction.
12. Understand the heat of neutralization of acids and bases.
13. Understand the fundamentals of analytical chemistry with emphasis on validation parameters and statistical data treatment.
14. Learn different titrimetric methods of analysis.

M.Sc. Semester – I
Inorganic Chemistry (Theory)

Course Title: Inorganic Chemistry-I
Course Code: A1CHE001DT

Type of Course	Theory/ Practical	Credits	Instruction Hour per week	Total No. of Lectures / Hours / Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC - 01	**Theory**	**04**	**04**	**60 Hrs.**	**3 Hrs.**	**20**	**80**	**100**

Course outcomes (COs):

After completion of this course successfully,

1. Students will understand the structures of ionic solids, simple molecules/ions and transition metal complexes.
2. Students will understand the CFT and MOT bonding theories of metal complexes.
3. Students will be able to interpret the electronic spectra of coordination compounds.
4. Students will gain the knowledge of preparation, geometries of different coordination numbers and stability of complexes.
5. Students will appreciate various acid-base concepts and their applications in different fields besides the reactions in non-aqueous solvents.
6. Students will understand fundamentals of lattices, crystal systems, atomic packing, molecular solids and non-stoichiometric compounds.
7. Students will understand the chemistry of lanthanides, actinides and their applications.

Inorganic Chemistry - I : A1CHE001DT	**60 Hrs.**
UNIT I : Structures and energetics of Inorganic molecules	**15 Hrs.**
Chemical Periodicity: Review of periodic properties Structures and energetics of ionic crystals: Properties of ionic compounds, crystal lattices, closed packed structures, coordination number of an ion, radius ratio rule, structures of crystal lattices- NaCl, CsCl, ZnS, fluorite and rutile. Lattice enthalpies- Born Lande equation, Born-Haber cycle, Uses of Born-Haber type of calculations. Covalent character in ionic bonds, Fajan's rules, hydration energy and solubility of ionic solids. Structures and energetics of inorganic molecules: Resonance, hybridisation and energetics of hybridization.VSEPR theory- Deduction of molecular shapes. M.O. theory of homo and heteronuclear molecules and M.O. treatment for the molecules/ions (BF_3, H_2O, $NO_2^-$and CO_2). Walsh diagrams and Bent's rule.	
UNIT II: Coordination chemistry	**15 Hrs.**
Coordination numbers (2-10) and their geometries. Isomerism in metal complexes (structural and stereoisomerism). Crystal field theory of coordination compounds: octahedral, square planar, tetrahedral, trigonal bipyramidal and square pyramidal fields,	

measurement of crystal field splitting energy(10 Dq) and factors affecting it, CFSE, Spectrochemical series, Jahn-Teller effect. Structural evidences for ligand field splittings – hydration and lattice energies. Evidences for covalency in M-L bonding. MO theory of coordination compounds- MO energy level diagrams for octahedral and tetrahedral complexes with and without pi-bonding. Electronic spectra: Spectroscopic ground state term symbols for free metal ions (3d-series), Selection rules, electronic spectra of octahedral and tetrahedral complexes (3d series) based on Orgel diagrams. Calculation of spin-only magnetic moments of tetrahedral, square planar and octahedral complexes.	
UNIT III: Metal complexes, concepts of acids and bases, and non-aqueous solvents	**15 Hrs.**
Review of IUPAC nomenclature of coordination compounds. Preparation of coordination compounds-simple addition reactions, substitution reactions and oxidation-reduction reactions, Step-wise and overall formation constants, factors affecting stability of metal complexes, Thermodynamic aspects: the Irving-William series, chelate effect. Determination of stability constants of metal complexes by spectrophotometric methods. Concept of acids and bases: Modern Theories of acids and bases – Lewis acids and bases, Lux-Flood theory, Usanovich concept, solvent system, differentiating solvent and leveling effect of solvents. HSAB concept and its applications. Non-aqueous solvents: Classification of solvents, Properties of non-aqueous solvents. Reactions in non-aqueous media; liquid ammonia, anhydrous sulphuric acid, anhydrous HF, liquid sulphur dioxide. Reactions in molten salts. Super acids and super bases. Supercritical fluids: Properties of supercritical fluids and their uses as solvents. Supercritical fluids as media for inorganic chemistry.	
UNIT IV: Solid state chemistry	**15 Hrs.**
Space lattice and basic unit cells, Crystal systems and Bravais lattices, classification of space lattice by crystal systems and their structures, the relation between interatomic distance (d) and atomic radius(R) of cubic unit cells. The Atomic packing factor of BCC, FCC and primitive unit cell and their examples, atomic positions in cubic unit cells with origin at eight corners of the cube, directions in cubic unit cells, direction of indices in cubic unit cells, Miller indices for crystallographic planes in cubic unit cells. Volume, planar and linear density calculations of cubic unit cells. X-ray diffraction method. Molecular solids: Hydrogen bonding, metallic, covalent and ionic solids; structural classification of binary and tertiary compounds, Determination of simple structure- spinel and perosvskite structures. Band theory, conductors, semiconductors and insulators, energy bands, intrinsic and extrinsic semiconductors. Conductivity: electrons and holes, temperature dependence on conductivity, industrial applications of semiconductors. Non stoichiometric compounds: Perfect and imperfect crystals, intrinsic and extrinsic	

defects, point, line and plane defects. Vacancy, Schottky and Frenkel defects. Schottky and Frenkel defect formation, F- centres, non-stoichiometric defects.	

Recommended Books:

1. Inorganic Chemistry-Principles of Structure and Reactivity, 4th Ed. J. E. Huheey, E. A. Keiter, R. L. Keiter and O. K. Medhi. Pearson Education, 2009.
2. Shriver & Atkins' Inorganic Chemistry, 5th Ed. P. Atkins, Tina Overton, J. Rourke, Mark Weller and F. Armstrong. Oxford University Press, 2010.
3. Inorganic Chemistry, 5th Ed. Catherine E. Housecroft and A.G. Sharpe, Pearson Prentice Hall, 2018.
4. Concise Inorganic Chemistry-J. D. Lee, 5th Ed, New Age International, 1996.
5. Solid State Chemistry and its Applications- A. R. West, John-Wiley and sons, 2007.
6. Inorganic Chemistry- Gary L. Miessler and Donald A. Tarr, 3rd Ed, Pearson, 2016.
7. Fundamental Concepts of Inorganic Chemistry – A. K. Das, Vol. 3, 2nd Ed, CBS publishers, New Delhi, 2010.
8. Fundamental Concepts of Inorganic Chemistry, Vol. 4, A. K. Das and Mahua Das, CBS publishers, New Delhi, 2014.

Formative Assessment for Theory		
Sl. No	Assessment Occasion / type	Marks
01	Internal Assessment test 1	10
02	Internal Assessment test 2	10
	Total	20 Marks
Formative Assessment as per the guidelines		

M.Sc. Semester – I
Inorganic Chemistry (Practical)

Course Title: Lab Course in Inorganic Chemistry
Course Code: A1CHE005DP

Type of Course	Theory/ Practical	Credits	Instruction Hour per week	Total No. of Lectures / Hours / Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC - 05	**Practical**	**02**	**04**	**60 Hrs.**	**4 Hrs.**	**10**	**40**	**50**

Course outcomes:

After completion of this course successfully,

1. Students understand the determination of various analytes present in binary mixtures, different ore/alloy samples by volumetric and gravimetric methods.
2. Students understand the chemistry of redox, complexometric and indirect methods.

Lab Course in Inorganic Chemistry : A1CHE005DP	**60 Hrs.**
Experiments 1. Determination of iron in hematite ore using cerium (IV) solution (0.02M) as the titrant and gravimetric determination of insoluble residue. 2. Determination of calcium and magnesium carbonates in dolomite ore using EDTA titration and gravimetric analysis of insoluble residue. 3. Quantitative analysis of copper-nickel in alloy/mixture: i. Copper volumetrically using KIO_3 ii. Nickel gravimetrically using DMG 4. Determination of lead and tin in a mixture: Analysis of solder using EDTA. 5. Determination of Cr (III) and Fe (III) in a mixture: Kinetic masking. 6. Quantitative determination of iron (III) gravimetrically and calcium(II) volumetrically in a mixture. 7. Determination of iron (II) and nickel (II) in a mixture: i) Iron (II) volumetrically using $K_2Cr_2O_7$ solution ii) Nickel gravimetrically using DMG solution 8. Quantitative analysis of chloride and iodide in a mixture: i) Iodide volumetrically using KIO_3 ii) Total halide gravimetrically 9. Preparation of complexes: i) Tris (thiourea)copper(I) sulphate monohydrate ii) Mercury tetrathiocyanatocobaltate(II) 10. Demonstration: Colorimetric determination of Fe (II) using 1,10-phenanthroline.	

Recommended Books:

1. Fundamental of Analytical Chemistry, D. A. Skoog, D.M. West, Holler and Crouch 8th Ed, Saunders College Publishing, New York, 2005.
2. Analytical Chemistry, G.D. Christian, 5th Ed, John Wiley & Sons, Inc, India, 2001.
3. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R. C. Denney, J. D., 6th Ed, Pearson, 2009.
4. Practical Inorganic Chemistry– G. Pass and H. Sutcliff, Chapman and Hall Ltd, 1968.

Formative Assessment for Practical		
Sl. No	Assessment Occasion / type	Marks
01	Internal Assessment test 1	10
	Total	10 Marks
Formative Assessment as per the guidelines		

M.Sc. Semester – I
Organic Chemistry (Theory)

Course Title: Organic Chemistry-I
Course Code: A1CHE002DT

Type of Course	Theory/ Practical	Credits	Instruction Hour per week	Total No. of Lectures / Hours / Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC - 02	**Theory**	**04**	**04**	**60 Hrs.**	**3 Hrs.**	**20**	**80**	**100**

Course Outcomes

After completion of this course successfully, the student will be able to

1. Provide an insight into physical concepts of structure and bonding.
2. Understand the concepts related to the structure and reactivity.
3. Predict the reactivity based on physical concepts.
4. Understand the insights of aromaticity.
5. Have an idea about the basic stereochemistry and isomerism of organic molecules.

Organic Chemistry-I : A1CHE002DT	**60 Hrs.**
UNIT–I: Bonding in Organic Molecules	**15 Hrs.**
Localized chemical bonding: Hybridization index, bonding in cyclopropane, bond distances, bond angles, bond energies, bond polarity, dipole moment and calculation of heat of reactions. M.O. and V.B. methods (Huckel's MO Method, pictorial representation of MOs for organic molecules, Qualitative application of MO theory to reactivity). Delocalized chemical bonding: Conjugation, cross conjugation, steric inhibition of resonance, hyperconjugation, tautomerism, valence tautomerism. Bonding in fullerenes. **Bonding weaker than covalent:** Hydrogen bonding, EDA complexes, inclusion compounds, complexes of crown ethers, catenanes and rotaxanes. Supramolecular chemistry: Host-guest systems, crowns, cryptands, clathrates and inclusion complexes. Structure and reactivity: Brönsted-Lowry concept of organic acids, conjugate acids and bases, pH, pKa values. Electronic, steric, and solvent effects on their strengths. General and specific acid base catalysis, running scale of acidity. Lewis acids and bases. HSAB concept.	

UNIT–II: Organic Reaction Mechanisms	**15 Hrs.**
Classification of organic reactions: Meaning and importance of reaction mechanism. Methods of determination of reaction mechanisms. **Kinetic methods:** order and molecularity, mechanistic implications from rate laws. **Non–kinetic methods:** Product identification, cross over experiments, study of intermediates, isotopic labeling, kinetic isotope effects and stereochemical studies. **Nucleophilic substitutions (aliphatic):** Mechanisms of S_N2, S_N1 (rearrangements in S_N1 reactions) and S_Ni, $S_{RN}1$ pathways. Effects of structure, leaving groups and ambident nucleophiles. **Elimination Reactions:** E_2, E_1, E_1CB pathways. Stereochemistry, product proportions in dehydration of alcohols, alkyl halides (chiral and achiral), Hoffmann and Saytzeff rules. Substitution v/s elimination and pyrolytic eliminations.	
UNIT-III: Stereochemistry and Conformational Analysis	**15 Hrs.**
Elements of symmetry and chirality, optical isomerism, optical activity, specific rotation. molecules with one asymmetric center. Fischer, Wedge and 3D representations, DL and RS systems indicating configuration. Ring compounds, molecules with two chiral centers: Fischer, Saw–Horse, Newmann projections and their transformations. Enantiomers, diastereomers, epimers, racemization, resolution. Stereochemical correlation. Pseudo–asymmetric compounds. **Geometrical isomerism:** E–Z nomenclature, properties of geometrical isomers, configuration of geometrical isomers and *syn– & anti–* isomers. **Conformational analysis:** Conformational study of n–Butane, ethylene glycol, chlorohydrin, 1,2–dichloroethane, 2-aminoethanol, and Curtin–Hammett principle. Effect of Conformation on reactivity: Stereo electronic effects.	
UNIT–IV: Aromaticity	**15 Hrs.**
Aromaticity and Huckel's rule: HMO theory, energy level diagrams, möbius systems, benzenoid and non–benzenoid aromatic compounds. Tropones, tropolones, borazine and azulene. **Heterocyclic Systems:** Systems of the type pyrrole, pyridines, pyrilium cation, ferrocene. alternant and non-alternant hydrocarbons. Aromaticity of charged rings (3-8 membered), non aromatic, anti–aromatic and homo aromatic systems. **Physical methods to study aromaticity:** X-ray, UV and ^{1}H NMR methods. **Ring current as criteria for aromaticity:** Annulenes and heteroannulenes [10-18].	

Books Recommended:

1. Organic Chemistry - P. Y. Bruice, 8th Ed, Pearson Education Pvt. Ltd., New Delhi (2020).

2. Organic Chemistry - S. H. Pine, 5th Ed, McGraw-Hill, London (2006).
3. Mechanism and Structure in Organic Chemistry - E. S. Gould. Holt, Rinehart & Winston of Canada Ltd. (1969)
4. Organic Chemistry–R. T. Morrison and R.T. Boyd, Prentice Hall, New Delhi (2008).
5. Organic Chemistry–T. W. Graham Solomons, 4th Ed, John Wiley and Sons (1988).
6. Organic Chemistry–G. M. Loudon, 4th Edition, Oxford University Press, New York (2002).
7. Organic Chemistry Volume–I, II–I. L. Finar, 6th Ed, ELBS London (2004).
8. Organic Chemistry–F.A. Carey, 4th Edition, McGraw Hill (2000).
9. Advanced Organic Chemistry, Reactions, Mechanism and Structure - J. March, 7th Ed, Wiley Eastern Ltd. (2015).
10. Stereochemistry–Conformation and Mechanism - P. S. Kalsi, New Age International Pvt Ltd, New Delhi (2022).
11. Guidebook to Mechanism in Organic Chemistry - P. Sykes. 6th Ed, Orient Longman, London (2003).
12. Aromaticity – P. J. Garratt, McGraw Hill Book Company (1971).

Formative Assessment for Theory		
Sl. No	Assessment Occasion / type	Marks
01	Internal Assessment test 1	10
02	Internal Assessment test 2	10
	Total	20 Marks
Formative Assessment as per the guidelines		

M.Sc. Semester – I
Organic Chemistry (Practical)

Course Title: Lab Course in Organic Chemistry
Course Code: A1CHE006DP

Type of Course	Theory/ Practical	Credits	Instruction Hour per week	Total No. of Lectures / Hours / Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC – 06	**Practical**	**02**	**04**	**60 Hrs.**	**4 Hrs.**	**10**	**40**	**50**

Course outcomes (COs)

After completion of this course successfully, the students will be able to

1. Understand the methods preparation of various organic molecules involving aromatic electrophilic substitution reactions, oxidation of ketones, rearrangement reactions etc.
2. Various techniques of organic reactions such as room temperature and reflux reactions.
3. Purify the impure organic solids by crystallization.
4. Determine the melting point of pure organic solids.

Lab Course in Organic Chemistry : A1CHE006DP	**60 Hrs.**
Experiments **Preparation of the following organic compounds:** 1. Benzoic acid and benzyl alcohol from benzaldehyde (Cannizarro reaction). 2. Cyclohexanone from cyclohexanol. 3. Reduction of *p*-nitrobenzaldehyde to *p*-nitrobenzylalcohol. 4. 2,4-Dinitrophenol from chlorobezene. 5. Benzil from benzaldehyde. 6. *m*-Nitroaniline from nitrobenzene. 7. *m*-Nitro benzoic acid from ethyl benzoate. 8. Benzanilide from benzophenone (Beckmann rearrangement). 9. *p*–Bromoaniline from acetanilide. 10. *p-Nitroaniline* from acetanilide.	

Recommended Books:

1. Vogel's Textbook of Practical Organic Chemistry Revised–B. S. Furniss, A. J. Hannaford, P.W.G. Smith, A. R. Tatchell, 5th Ed, Addison Wesley Longman Limited, UK, 1997.
2. A Hand book of Organic Chemistry – by H. T. Clarke.
3. A Laboratory Manual of Organic Chemistry by B. B. Dey and M. V. Govindachari.

4. Lab Experiments in Organic Chemistry–by Arun Sethi, New Age International Ltd. New Delhi. 2010.

Formative Assessment for Practical		
Sl. No	Assessment Occasion / type	Marks
01	Internal Assessment test 1	10
	Total	10 Marks
Formative Assessment as per the guidelines		

M.Sc. Semester – I
PHYSICAL CHEMISTRY (Theory)

Course Title: PHYSICAL CHEMISTRY-I
Course Code: A1CHE003DT

Type of Course	Theory/ Practical	Credits	Instruction Hour per week	Total No. of Lectures / Hours / Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC – 03	**Theory**	**04**	**04**	**60 Hrs.**	**3 Hrs.**	**20**	**80**	**100**

Course Outcomes

The completion of this course will enable students to understand

1. The concepts and theoretical basis underlining Quantum Mechanics, Thermodynamics, Reaction kinetics and Electrochemistry which will create a base and facilitate students' comprehension of universal physics concepts at the chemistry interface.
2. This will help students to gain an insight to describes the ambiguous behavior of nature at the scale of sub-atomic particles and the solution to handle such behavior, universal principles of energy transfer, transformation, predicting the feasibility, spontaneity of chemical reactions, investigations on the influence of experimental conditions on the speed of a chemical reaction and the 28rinciples, dynamics and activities of electrochemical systems.
3. The students will also be introduced to the modern techniques developed for the practical applications of these concepts in various scientific and technological fields of relevance.

PHYSICAL CHEMISTRY-I (Theory): A1CHE003DT	**60 Hrs.**
UNIT–I: Quantum Mechanics – I	**15 Hrs.**
Review of Classical Mechanics, Newtonian, Lagrange's and Hamiltonian's equation of motion, Blackbody radiation, Photoelectric effect, de Broglie wave-particle duality hypothesis, uncertainty principle and its experimental evidence, Inadequacy of classical mechanics and development of quantum mechanics, Postulates of quantum mechanics, Schrodinger's, and Heisenberg's formulation of quantum mechanics. Need for operators, Linear and Hermitian operators, operator algebra, eigen value and eigen functions, commutation relations Dynamics of microscopic systems: Schrödinger wave equation, time-independent and time dependent Schrödinger wave equation, interpretation of wave function, properties of wave function, Solution of Schrödinger's equation for the particle in ID-, 2D- and 3D-boxes and applications, degeneracy, normalization and orthogonality of wave function,Superpositions and expectation values, Potential energy barrier, quantum mechanical tunneling and its experimental evidences.	

UNIT–II: Thermodynamics	**15 Hrs.**
Review of the basic thermodynamic concepts. Laws of thermodynamics. Standard states. Thermodynamic functions and their relationships: Gibbs-Helmholtz and Maxwell relations, Gibbs-Duhem equation, Van't Hoff equation. Criteria of spontaneity and equilibrium. Nernst equation and its application in relating electrode potential and thermodynamic quantities. Partial molar quantities. Thermodynamics of mixing. Chemical potential. Fugacity, activity and activity coefficients. Ideal and Non-ideal solutions, Deviations in Raoult's Law and Henry's Law, Chemical equilibria. Calculating $\Delta G_{reaction}$ and introducing equilibrium constant for mixture of ideal gases. Dependence of equilibrium constant on temperature and pressure.	
UNIT–III: Reaction Kinetics	**15 Hrs.**
A critical account of collision and transition state theories, Arrhenius and Eyring equations and their applications. Kinetics and mechanism: Steady state approximation and simple examples relating kinetics to mechanism, theories of unimolecular reactions: Hinshelwood and RRKM treatments, isomerization of methyl isocyanides. Chain Reactions: Chain reactions and examples, general aspects of chain reactions. Chain-length, chain transfer reactions, chain inhibition, kinetics of branching chain reactions and explosion limits.	
UNIT–IV: Electrochemistry – I	**15 Hrs.**
Introduction to electrochemistry, Ion solvent interaction: Structure of most common solvent water, size and dipole moment of water molecules in solution, Born model for calculating the free energy of ion-solvent interaction and its modifications.Ion- Ion interaction: nature of the electrolyte and the relevance of ion-ion interactions, the Debye Huckel theory of ion-ion interaction Ionics, The Debye-Hückel–Onsager theory for non-aqueous solutions, thesolvent effect on mobility at infinite dilution and on the concentration of free ions: Ion Association, effect of ion association on conductivity, Ion-Pair formation and columbicforces, Triple ions and Higher aggregates formed in nonaqueous solutions.	

Books Recommended

1. Introduction to Quantum Chemistry by A. K. Chandra, Ed. 3, Tata McGraw Hill, New Delhi, 1988.
2. Quantum Chemistry by R. K. Prasad, New Age International Publications, New Delhi, 1997.
3. Quantum Chemistry by Eyring, Walter and Kimball, John-Wiley, New York, 1961.
4. Physical Chemistry by G. M. Barrow, McGraw Hill, New York, 1996.
5. Fundamentals of Physical Chemistry by Maron and Lando, 1979.
6. Physical Chemistry by P. W. Atkins, ELBS, London, 1990 (Ed. 4).
7 The Elements of Physical chemistry, 2dn ed., Peter Atkins, W.H. Freeman and Company, New York, 1998.
8 Physical Chemistry, Hu Ying, Scientific International China, 2017.
9. Principles of Physical Chemistry, 4th ed., Samuel H. Maron, and Carl F. Prutton, Oxford and IBH, New Delhi, 1972.
10. Physical Chemistry by K. Vamulapalli, Prentice Hall of India Pvt. Ltd., New Delhi, 1997.
11. Physical Chemistry by Daniels and Alberty, Wiley, New York, 1961.
12. Physical Chemistry through Problems by S. K. Dogra and S. Dogra, Wiley Eastern, New Delhi, 1984.
13. A Text Book of Physical Chemistry by Samuel Glasstone, McMillan, London, 1943.
14. Atomic Structure and Chemical Bonding by Manas Chanda, Tata McGraw Hill Publishing Co., New Delhi, 2019.
15. Chemical Kinetics by K. J. Laidler, Tata McGraw Hill Publishing Co., New Delhi, 1965.
16. Kinetics and Reaction Mechanisms by Frost and Pearson, Wiley, New York, 1961.
17. An Introduction to Electrochemistry by S. Glasstone, Van Nostrand, London, 1942.
18. A Text book of Electrochemistry by G.F.A. Kortum and J.O.M. Bockris, *Elsevier*, New York, 1951.
19. Modern Electrochemistry by J.O.M. Bockris and A. K. N. Reddy Vol. I and Vol. II, Butterworth, London, 1970.

Formative Assessment for Theory		
Sl. No	Assessment Occasion / type	Marks
01	Internal Assessment test 1	10
02	Internal Assessment test 2	10
	Total	20 Marks
Formative Assessment as per the guidelines		

M.Sc. Semester – I
Physical Chemistry (Practical)

Course Title: Lab Course in Physical Chemistry
Course Code: A1CHE007DP

Type of Course	Theory/ Practical	Credits	Instruction Hour per week	Total No. of Lectures / Hours / Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC – 07	**Practical**	**02**	**04**	**60 Hrs.**	**4 Hrs.**	**10**	**40**	**50**

Course Outcomes

This practical course typically includes a variety of skills and knowledge areas like

At the end of the course student will be able to

1. Understand the practical aspects of reaction kinetics, thermochemistry, phase equilibria, viscosity measurements, determination of order of a reaction, various effects on reaction rates, various activation parameters and study mechanism, enthalpy and ionization energies, solubility, association and dissociation effects of solute between immiscible solvents and molecular parameters like radius of molecules.
2. Application of instrumentation techniques: practical skills in using instruments like conductometers, spectrophotometers, potentiometers, pH-meters and refractometers.

Lab Course in Physical Chemistry: A1CHE007DP	**60 Hrs.**
Experiments 1. General information and chemical mathematics: Calibration of glassware, concentration measures of solutions: concept of normality, molarity, molality and mole fraction, and preparation of standard solution. 2. Statistical treatment of experimental data: Errors, type of errors, accuracy and precision, mean deviation, standard deviation, significant figures, methods of average and least squares. **Non-Instrumental** 3. Chemical Kinetics: Determination of activation parameters for the acid hydrolysis of methyl acetate at two distinct temperatures. 4. Density of liquids: a. Determination of molar and partial molar volumes of given liquids (methanol, ethanol etc.) at room temperature b. Determination of apparent molal and partial molal volumes of given liquids (methanol, ethanol, acetone etc.) in dilute aqueous solutions.	

5. Phase equilibria: Studying the distribution of a given solute (benzoic acid, succinic acid etc.) between water and benzene and to determine the degree of association of benzoic acid in benzene.
6. Viscosity: Determination of radius of glycerol molecule by viscosity measurements relative to water.
7. Thermochemistry: Determination of the heat of neutralization of a strong acid (HCl, H_2SO_4 etc.) and a weak acid (acetic acid, formic acid etc.) and calculation of the heat of ionization of the weak acid.
8. Self-generated experiment.

Instrumental

9. Spectrophotometry:
   a. Verification of the Beer–Lambert law by obtaining the absorption curve of $KMnO_4$ solution on a colorimeter.
   b. To obtain the calibration curve for the Fe^{3+}-KCNS and Cu^{2+}-NH_3 system anddetermination of unknown concentration of Fe^{3+} and Cu^{2+} in a given solution.
10. Potentiometry: Determination of the dissociation constant of
    a. weak monobasic acid (Acetic acid, Formic acid etc.)
    b. weak dibasic acid (Oxalic acid, Succinic acid etc.)
11. Conductometry: Conductometric titrations of
    a. Weak acid with weak base, strong acid with weak base and weak acid with strong base.
    b. Mixture of strong and weak monobasic acidwith strong base and to estimate the composition and concentration of strong and weak acids
    c. Mixture of strong monobasic acidand weak dibasic acid (oxalic acid/succinic acid) with strong base and to estimate the composition and concentration of strong and weak acids.
12. Refractometry:
    a. Determination of the molar refraction of a solid substance by dissolving it in a solvent.
    b. Determination of the composition of an unknown mixture of two given liquids by refractive index measurements.

Books Recommended:

1. Practical Physical Chemistry by A. M. James and F. E. Prichard, Longmans, London, 1923.
2. Experiments in Physical Chemistry by Shoemaker and Garland, McGraw Hill, New York, 1964.
3. Experiments in Physical Chemistry by Daniels, Alberty and Willams, McGraw Hill, New York, 1970.
4. Experimental Physical Chemistry by W. G. Palmer, Cambridge University Press, London, 1946.
5. Advanced Physico-Chemical experiments by J. Rose, 1965.
6. Text Book of Physical Chemistry by S. Glasstone, McGraw Hill, London, 1969.
7. Text Book of Quantitative Chemical Analysis by A. I. Vogel, ELBS, Harlow, 1996.
8. Advanced Practical Physical Chemistry by J. B. Yadav, Goel Publishing House, 1999.
9. Experimental Physical Chemistry by V. D. Athawale and Parul Mathur, New Age International Publishers, 2001.
10. Advanced Physical Chemistry Experiments by Gurtu and Gurtu, Pragati Prakashan Education Publishers, 3rd Edition 2007.

Formative Assessment for Practical		
Sl. No	Assessment Occasion / type	Marks
01	Internal Assessment test 1	10
	Total	10 Marks
Formative Assessment as per the guidelines		

M.Sc. Semester – I
Analytical Chemistry (Theory)

Course Title: Analytical Chemistry -I
Course Code: A1CHE004DT

Type of Course	Theory/ Practical	Credits	Instruction Hour per week	Total No. of Lectures / Hours / Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC – 04	**Theory**	**04**	**04**	**60 Hrs.**	**3 Hrs.**	**20**	**80**	**100**

Course outcomes:

1. Students will have the knowledge to select an analytical method to achieve accuracy, precision and also have an understanding about statistical treatment of results.
2. Students will understand the basic principles of titrimetric analysis with emphasis on the understanding of complexometric, redox and precipitation titrations.
3. The students will learn the fundamentals of chromatography and classification of chromatographic techniques like column, TLC and HPLC besides methodologies and applications.
4. Students will get the knowledge about gas chromatography, ion exchange chromatography and solvent extraction.

Analytical Chemistry -I : A1CHE004DT	**60 Hrs.**
UNIT-I: Language of Analytical Chemistry, Data Treatment and Gravimetric Analysis	**15 Hrs.**
Language of analytical chemistry: Definition of analysis, determination, measurement, techniques and methods. Classification of analytical techniques. Selection of an analytical method: Accuracy, precision, sensitivity, selectivity, robustness and ruggedness. Figures of merit of analytical methods: Sensitivity, detection limit and linear dynamic range. Errors and Treatment of analytical Data: Limitations of analytical methods–Errors: determinate and indeterminate errors, minimization of errors. Significant figures. Statistical treatment of finite samples, mean, median, range, standard deviation, % RSD and variance. Student's t-test, analysis of variance (ANOVA) confidence interval of mean. Testing for significance and comparison of two means and two standard deviations. Comparison of an experimental mean and a true mean. Criteria for the rejection of an observation, Q-test. Standard/calibration graph/curve, the least squares methods, regression equation and correlation coefficient. Gravimetric analysis: Stages involved in gravimetric analysis. Mechanism of precipitation, factors influencing precipitation, co-precipitation, post-precipitation and organic reagents used in gravimetry (oxine, salicylaldoxime and cupferron). Numerical problems.	

UNIT-II: Volumetric Methods	**15 Hrs.**
Titrimetric Analysis: Principles of titrimetric analysis. Classification of reactions in titrimetry. Titrations based on acid-base reactions: Titration curves for strong acid and strong base, weak acid and strong base and weak base and strong acid titrations. Quantitative applications (alkalinity, acidity, ammonium salts, free carbon dioxide in water samples), selecting and standardizing a titrant. Complexometric titrations: Indicators for EDTA titrations, theory of common indicators, titration methods employing EDTA, direct, back and displacement titrations, indirect determinations, conditions for selectivity in EDTA titrations, titration of mixtures using masking and demasking agents. Redox Titrations: Balancing redox equations, calculation of the equilibrium constant of redox reactions, titration curves, theory of redox indicators, calculation of standard potentials, and determination of chemical oxygen demand (COD) and biological oxygen demand (BOD) in natural and waste waters. Precipitation titrations: Titration curves, titrants and standards, indicators for precipitation titrations involving silver nitrate, the Volhard, the Mohr's and the Fajan's methods. Numerical problems.	
UNIT-III: Separation Methods I	**15 Hrs.**
Fundamentals of chromatography: General description, definition, terms and parameters used in chromatography, classification of chromatographic methods, criteria for selection of stationary and mobile phase and nature of adsorbents. Column chromatography: Theories, plate theory, rate theory, band broadening-eddy diffusion, longitudinal diffusion and resistance to mass transfer, column efficiency, van Deemter's equation and its modern version, interrelationships, capacity factor, selectivity factor, column resolution, distribution constant and applications of conventional column chromatography, advantages and limitations. Affinity chromatography: Principle and applications. Thin layer chromatography (TLC): Definition, mechanism, efficiency of TLC plates, methodology, selection of stationary and mobile phases, development, spray reagents, identification and detection, reproducibility of R_f values, qualitative and quantitative analysis (organic and inorganic compounds). High performance liquid chromatography (HPLC): Instrumentation, methodology, isocratic and gradient elution, pumps, column packing, characteristics of liquid chromatographic detectors, UV and fluorescence detectors, advantages and applications. Stability indicating studies. Basics of preparative HPLC. Numerical problems.	
UNIT-IV: Separation methods-II	**15 Hrs.**
Gas chromatography (GC): Principle, instrumentation, columns, study of detectors, thermal conductivity, flame ionization and mass spectrometry, factors affecting separation, retention volume, retention time and applications.	

GCMS: Principle, instrumentation and applications. Ion exchange chromatography (IEC): Definition, principle, requirements for ion-exchange resin, types of ion-exchange resins, resin properties-ion-exchange capacity and its determination, resin selectivity and factors affecting the selectivity, applications of IEC in purification and recovery processes. Solvent extraction: Nernst partition law, efficiency and selectivity of extraction. Extraction systems: Extraction of covalent neutral molecules, extraction of uncharged metal chelates and synergic extraction, extraction of ion-association complexes-non chelated complexes and chelated complexes. Use of salting out agents. Methods of extraction: batch and continuous extractions. Applications (special emphasis on extraction of iron and copper). Numerical problems.	

Recommended Books:

1. Fundamental of Analytical Chemistry, D.A. Skoog, D. M. West, Holler and Crouch, 8th edition, Saunders College Publishing, New York, (2005).
2. Analytical Chemistry, G. D. Christian, 6th Ed, Wiley, India (2007).
3. Quantitative Analysis, R. A. Day and A. L. Underwood, 6th Ed, PHI Learning Pvt. Ltd. New Delhi, (2009).
4. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, 5th Ed, (1989)
5. J.D. Barnes and M.J.K. Thomas, 6th edition, Third Indian Reprint, Pearson Education Pvt. Ltd. (2007).
6. Analytical Chemistry Principles, John H. Kennedy, 2nd Ed, Saunders College (2018).

Formative Assessment for Theory		
Sl. No	Assessment Occasion / type	Marks
01	Internal Assessment test 1	10
02	Internal Assessment test 2	10
	Total	20 Marks
Formative Assessment as per the guidelines		

M.Sc. Semester – I
Analytical Chemistry (Practical)

Course Title: Lab Course in Analytical Chemistry
Course Code: A1CHE008DP

Type of Course	Theory/ Practical	Credits	Instruction Hour per week	Total No. of Lectures / Hours / Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC – 08	**Practical**	**02**	**04**	**60 Hrs.**	**4 Hrs.**	**10**	**40**	**50**

Course outcomes:

After the completion of the course,

1. Students get hands on experience in the use of various instruments to understand the instrumentation.
2. Students will gain the in-depth knowledge and skill in organic separations, purification and qualitative analysis.
3. Students will be able to understand the concepts of electrochemistry, Thermodynamics and surface chemistry.

Lab Course in Analytical Chemistry: A1CHE008DP	**60 Hrs.**
Experiments **I. Organic Chemistry Practical** **Quantitative analysis** 1. Titrimetric Estimation of amino acids. 2. Estimation of glucose by Bertrand's method. 3. Estimation of keto-group. 4. Iodine value of oil (Chloramine-T method) 5. Estimation of Nitro group by reduction using $SnCl_2$. **Qualitative Analysis** Separation of binary mixture of organic compounds using ether and identification of separated compounds by systematic qualitative organic analysis. Please Note: 1) Individual organic compounds are to be given after the candidate reports the nature of the mixture. 2) Ether insoluble acids and ether insoluble neutral organic compounds may be given. 3) Low boiling liquids and amino acids need not be given. The following mixtures may be given:	

1. Acid + Base 2. Acid + Neutral 3. Base + Neutral 4. Phenol + Acid 5. Base + Phenol **II. Physical Chemistry practicals** 1. Determination of molecular radius of glycerol molecule by viscosity method. 2. Determination of metal ions of ferric-thiocyanate and copper-ammonia complexes by spectrophotometrically. 3. Determination of relative strength of acids (HCl and H_2SO_4) by studying the hydrolysis of methyl actetate. 4. Determination of dissociation constants of weak monobasic acids potentiometrically by titrating against NaOH. 5. Comparison of strengths of chloroacetic acid and acetic acid using Conductometric method. 6. Determine the dissociation constant of acetic acid pH-metrically by titrating against NaOH.	

Recommended Books:

1. Practical Physical Chemistry by A. M. James and F. E. Prichard, Longmans, London (1974).
2. Experiments in Physical Chemistry by Shoemaker and Garland, McGraw Hill, New York (2011).
3. Experiments in Physical Chemistry by Daniels, Alberty and Willams, McGraw Hill, New York (2006).
4. Experimental Physical Chemistry by W. G. Palmer, Cambridge University Press, London (1949).
5. Advanced Physico-Chemical experiments by J. Rose. 6. Text Book of Physical Chemistry by S (1964).
6. Physical Chemistry, S. Glasstone, , McGraw Hill, London.
7. Text book of Quantitative Analysis by A. I. Vogel, ELBS, Harlow (2021).
8. Advanced Practical Physical Chemistry by J. B. Yadav, Goel Publishing House.
9. Experimental Physical Chemistry by V. D. Athawale and Parul Mathur, New Age International Publishers (2001).
10. Advanced Physical Chemistry Experiments by Gurtu and Gurtu, Pragati Prakashan Educational Publishers, 3rd Edition (2007).

Formative Assessment for Practical		
Sl. No	Assessment Occasion / type	Marks
01	Internal Assessment test 1	10
	Total	10 Marks
Formative Assessment as per the guidelines		

SECOND SEMESTER

Program learning outcomes:

After completion of the program, Students will

1. Learn basic chemistry of some selected group elements.
2. Understand the properties and structures of metal carbonyls, nitrosyls and clusters
3. learn the application of symmetry and group theory in molecules and spectroscopy
4. Have the skill for the qualitative analysis of various mixtures containing 5 radicals.
5. Have idea about the Reaction mechanism and its conditions helps to students for understanding the type of the reaction, major minor products formation, sterochemical changes in the products.
6. Understand carbohydrates and its biopolymers properties as well as synthesis, reactions and biological importance of heterocycles.
7. Understand and identify the functional groups by performing experiments and importance of the functional groups in various useful transformations as well as reagents properties, functions and its MSDS.
8. Have the basic knowledge of quantum mechanics and properties of hydrogen atoms in terms of wave function.
9. Gain the fundamental knowledge solution kinetics of fast reactions and also effect of solvent and ionic strength on the concentration of the reactions and also, electrochemistry of Metal-Water interaction.
10. Understand the fundamental concept in polymers and types of polymers, polymerization, classification, solubility, chemical reaction of polymers.
11. Study the effect of added salt, heat of solution of a solute, viscosity average molecular weight of a polymer, enthalpy of neutralization of weak acid.
12. Understand the importance of formal redox potential of ferrous-ferric system, limiting equivalent conductance of a weak electrolyte, Ostwald's dilution law and dissociation constant of a weak acid.

M.Sc. Semester – II
Inorganic Chemistry (Theory)

Course Title: Inorganic Chemistry-II
Course Code: A2CHE001DT

Type of Course	Theory/ Practical	Credits	Instruction Hour per week	Total No. of Lectures / Hours / Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC – 09	**Theory**	**04**	**04**	**60 Hrs.**	**3 Hrs.**	**20**	**80**	**100**

Course outcomes:

After the completion of the course,

1. Students will understand the chemistry of p-block elements, inorganic polymers, metal carbonyls, nitrosyls and clusters.
2. Students will understand preparation and chemistry of various binary compounds including hydrides, chlorides, oxides and oxoacids.
3. Students will understand the interhalogen compounds and noble gas compounds.
4. Students will understand the symmetry and group theory of various molecules and its applications.

Inorganic Chemistry-II : A2CHE001DT	**60 Hrs.**
UNIT I: Chemistry of non-transition elements	**15 Hrs.**
Alkali and alkaline earth metal complexes of crown ethers, cryptands and calixarenes and their biological importance. Hydrogen bonding and its influence on properties. Synthesis, properties, reactivity and structures of boron, carbon and silicon compounds: Trihalides of Al, Ga, In and Tl. Chalcogenides, Chemistry of higher boranes, classification, structures and M.O. description of bonding, framework electron counting, Wade's rules, chemistry of B_5H_9, $B_{10}H_{14}$ and $B_nH_n^{2-}$, metalloboranes,boron nitride, borazines, carboranes, metallocarboranes; silicate minerals, aluminosilicates, zeolites- preparation and applications, silicones, Allotropes of carbon (graphite, diamond, C_{60} fullerene, graphene, carbon nanotubes).	
UNIT II: Chemistry of main group elements	**15 Hrs.**
Preparation, reactivity and structures of nitrogen, phosphorous and sulphur compounds: Hydrides, oxides and oxo acids of Nitrogen, Phosphorous, Sulphur and halogens; phosphazines, phosphazene polymers, P-O and P-S cage compounds, Chain polyphosphates. Sulphur-nitrogen compounds: binary sulphur nitrides- S_4N_4, S_2N_2 and $(SN)_x$. Chemistry of halogens and Xenon: Interhalogens, psuedohalogens, polyhalogen cations, polyhalide	

anions, oxyhalogen species. Aqueous chemistry of group 17 elements. Xenon oxides, fluorides, chlorides, oxofluorides and oxochlorides. Compounds of Ar, Kr & Rn. Clathrates of noble gas compounds.	
UNIT III: Symmetry and group theory	**15 Hrs.**
Molecular symmetry, representation of symmetry operation as matrices. Definition of groups, set of symmetry operations of molecules satisfying the condition of point groups. Representation, basis of representation, reducible and irreducible representation. The great orthogonality theorem and its consequences, character tables. The direct product. Applications of group theory - Molecular vibrations, group theoretical selection rules for electronic transitions, for IR and Raman spectra, Hybridization.Molecular transforming properties of atomic orbitals.	
UNIT IV: Metal carbonyls, nitrosyls and clusters	**15 Hrs.**
Metal carbonyls– Binding modes of carbon monoxides, pi (π) acidity of CO, back bonding, Synergic effect, 18-electron rule, mononuclear carbonyls, low nuclear carbonyl clusters, high nuclear carbonyl clusters and calculation of number of M-M bonds. Prediction of nature of metal framework using polyhedral skeletal electron pair theory (PSEPT) in high nuclear clusters. Preparative methods, structure and bonding, IR spectroscopy of metal carbonyls, magnetic properties and reactions of metal carbonyls.Metal carbonylates and carbonyl halides – preparation and important reactions. Metal nitrosyls: Binding modes of NO, factors favoring linear and bent M-N-O linkage, synthesis of heteroleptic nitrosyl complexes, relative instability of homoleptic nitrosyl complexes and structural aspects of some nitrosyl complexes (Roussin's salts, nitroprusside and brown ring complexes). Bimetallic clusters: Quadruple bonding in dinuclear clusters containing halide, acetate, phosphine and mixed ligands and calculation of M-M bond order.	

Recommended Books:

1. Inorganic Chemistry-Principles of Structure and Reactivity, 4thEd - J. E. Huheey, E. A. Keiter, R. L. Keiter and O.K. Medhi. Pearson Education, 2009.
2. Inorganic Chemistry, 5th Edn. Catherine E. Housecroft and A.G. Sharpe, Pearson Prentice Hall, 2018.
3. Chemical Applications of Group Theory -F. A. Cotton, 2nd Ed. Wiley Eastern Ltd, 2005.
4. Symmetry and Spectroscopy of Molecules-K. Veera Reddy, New Age International, 2011.
5. Group Theory in Chemistry - M. S. Gopinathanan and V. Ramakrishnan, Vishal Publishing Co., 2007.
6. Organometallic Chemistry - A unified Approach, R.C. Mehrotra and A. Singh, 2nd Ed. New Age International, 2011.
7. Chemistry of the elements, N.N. Greenwood and A. Earnshaw, 2nd Ed., Butterworth & Heinemann publishers, 1997.

8. Basic Organometallic Chemistry – B D Gupta and A J Elias, 2nd Ed., Universities Press, 2013.
9. Inorganic Chemistry- Gary L. Miessler and Donald A. Tarr, 3rd Ed, Pearson, 2016.
10. Fundamental Concepts of Inorganic Chemistry – A. K. Das, Vol 2, 2nd Ed, CBS publishers, New Delhi, 2010.
11. Fundamental Concepts of Inorganic Chemistry – A. K. Das and Mahua Das, Vol 6, CBS publishers, New Delhi, 2014.
12. Cluster Chemistry- Guillermo Gonzalez-Moraga, Springer-Verlag Berlin Heidelberg, New York, 1993.
13. Multiple bonds between metal atoms – F. A. Cotton, C. A. Murillo and R. A. Walton, 3rd Edn, Springer Science and Business Media, Inc. 2005.

Formative Assessment for Theory		
Sl. No	Assessment Occasion / type	Marks
01	Internal Assessment test 1	10
02	Internal Assessment test 2	10
	Total	20 Marks
Formative Assessment as per the guidelines		

M.Sc. Semester – II

Inorganic Chemistry (Practical)

Course Title: Lab Course in Inorganic Chemistry

Course Code: A2CHE005DP

Type of Course	Theory/ Practical	Credits	Instruction Hour per week	Total No. of Lectures / Hours / Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC - 12	**Practical**	**02**	**04**	**60 Hrs.**	**4 Hrs.**	**10**	**40**	**50**

Course outcomes:

After the completion of the course,

1. Students will understand the principles involved in the semi-microanalysis of inorganic salt mixtures.
2. Students will understand the chemistry involved in each semi-micro test of acid and basic radicals.

Lab Course in Inorganic Chemistry : A2CHE005DP	**60 Hrs.**
Experiments 1. Semi-micro qualitative inorganic analysis of a mixture containing three cations (including one less common cation such as W, Mo, Ti, Zr, Ce, and Li) and two anions (one of them may or may not be interfering anion such as PO_4^{3-}, BO_3^{3-}, $C_2O_4^{2-}$, F^- and CH_3COO^-). 2. Demonstration experiment: Solvent extractionof iron using 8-hydroxyquinoline.	

Recommended Books:

1. Vogel's Text Book of Quantitative Chemical Analysis (5th Ed), G. H. Jeffrey, J. Bassette, J.Mendham and R. C.Denny, Longman, 1999.
2. Vogel's Qualitative Inorganic Analysis (7th Ed), G.Svehla, Longman, 2001.

Formative Assessment for Practical		
Sl. No	Assessment Occasion / type	Marks
01	Internal Assessment test 1	10
	Total	10 Marks
Formative Assessment as per the guidelines		

M.Sc. Semester – II
Organic Chemistry (Theory)

Course Title: Organic Chemistry-II
Course Code: A2CHE002DT

Type of Course	Theory/ Practical	Credits	Instruction Hour per week	Total No. of Lectures / Hours / Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC – 10	**Theory**	**04**	**04**	**60 Hrs.**	**3 Hrs.**	**20**	**80**	**100**

Course Outcomes (COs)

After completion of this course successfully, the student will be able to

1. Understand the insights of the reaction mechanism (Both aliphatic and aromatic).
2. Provide the insights on the factors responsible for prochirality and optical activity.
3. Write the stereochemical structures of the substituted cyclohexanes.
4. Appreciate the structures and properties of mono and disaccharides etc.
5. Understand systematic names and synthetic methods of the five member and benzfused heterocycles.

Organic Chemistry-I (Theory) : A2CHE002DT	**60 Hrs.**
UNIT-I: Reaction Mechanism	**15 Hrs.**
Aliphatic electrophilic substitutions: Bimolecular pathways. S_E2, S_E1 and S_Ei mechanisms. Reactions involving double bond shifts, α-halogenation of aldehydes, Ketones, aliphatic diazonium coupling, nitrosation at carbon bearing active hydrogen, mercury exchange reactions. **Aromatic electrophilic substitutions:** Mechanisms of aromatic, nitration, sulphonation, halogenation, isotope effects, energy profile diagrams. Kinetic and thermodynamic control, amination and sulphonation, Hammond's Postulate, o/p ratio, ipso–substitution, Vilsmeir Haack, Pechmann condensation, Fischer-Hepp rearrangement and Fries rearrangement. **Aromatic nucleophilic substitutions:** S_NAr, S_N1 and aryne pathways. Meisenheimer complexes, mechanism and synthetic applications of Vicarious Nucleophilic Substitution (VNS), Von-Richter, Goldberg, Bucherer, Shiemann reactions and Smiles rearrangement.	
UNIT-II: Advanced Stereochemistry	**15 Hrs.**
Prochirality: Homotopic, enantiotopic and diastereotopic atoms, groups and faces. **Stereochemical descriptors:** Application to reduction of carbonyl compounds, cyanohydrin formation, addition of water to alkenes. **Optical activity due to molecular dissymmetry:** Allenes, spiranes, biphenyls-	

atropisomerism, molecular crowding. Conformational analysis of cyclohexane, mono substituted and disubstituted (1,2, 1,3, 1,4) cyclohexanes, di– & tri–substituted cyclohexanones, *cis*- and *trans*–decalins. Chirality of cyclohexanes.	
UNIT–III: Carbohydrates	**15 Hrs.**
Monosaccharides: Conformational representation of monosaccharides and their transformations. Determination of configuration of the monosaccharides, mechanism of mutarotation–base catalyzed isomerisation of aldoses and ketoses. Epimerisation, anomeric effect, glycosides, ether and ester derivatives of carbohydrates. Amino sugars (β-D-glucosamine, galactosamine, N-acetylmuramic acid (NAMA), N-acetyl neuraminic acid (NANA) and deoxysugars. Oxidation and reduction reactions of carbohydrates. **Disaccharides:** Structure elucidation of maltose, lactose, sucrose, gentiobiose and meliobiose. **Trisaccharides:** Raffinose and melezitose. **Polysaccharides:** Structure and degradation of starch, cellulose and glycogen.	
UNIT–IV: Chemistry of heterocycles	**15 Hrs.**
Nomenclature of heterocyclic compounds: (i) Hantzhsch-Widmann (ii) Replacement Nomenclature. Structure, synthesis, reactivity and chemical reactions of indole, benzofuran, quinoline, isoquinoline, thiazole, imidazole, benzimidazole, coumarin, chromones, flavones and isoflavones.	

Recommended Books:

1. Advanced Organic Chemistry, Part A and B - F. A. Carey and R. J. Sundberg, 4th Ed, Plenum Publishers (2000).
2. Advanced Organic Chemistry, Reactions, Mechanism and Structure – J. March, 3rd Ed, Wiley Eastern Ltd. (2004).
3. Guide Book to Mechanism in Organic chemistry - Peter Sykes Oriant- Longman (1985).
4. Stereochemistry of Carbon Compounds–Eliel, Tata McGraw Hill, New Delhi (1976).
5. Stereochemistry of Organic Compounds, Principles and Applications – D. Nasipuri, Wiley Eastern Ltd (1992).
6. Organic Chemistry Vol-I, II, III–S. M. Mukherji, S. P. Singh and R. P. Kapoor, New Age International Ltd, New Delhi (2000).
7. Organic Chemistry Volume–I, II– I. L. Finar, 6th Ed, ELBS London (2004).
8. Chemistry of Carbohydrates–G. C. Percival.
9. Carbohydrates –Chemistry and Biochemistry –Pigman and Harton.
10. Heterocyclic Chemistry–T. L. Gilchrist, 3rd Edition, Pearson Education Delhi, (2005).
11. Heterocyclic Chemistry –J.A. Joule and G.F. Smith, 2nd Ed, Van Nostrand London (1978).

12. Heterocyclic Chemistry–R. K. Bansal, 3rd Ed, New Age Interantional, New Delhi, 2004.
13. https://profiles.uonbi.ac.ke/sderese/files/upc_213nomenclature_of_heterocyclic_compounds_0.pdf

Formative Assessment for Theory		
Sl. No	Assessment Occasion / type	Marks
01	Internal Assessment test 1	10
02	Internal Assessment test 2	10
	Total	20 Marks
Formative Assessment as per the guidelines		

M.Sc Semester – II
Organic Chemistry (Practical)

Course Title: Lab Course in Organic Chemistry
Course Code: A2CHE006DP

Type of Course	Theory/ Practical	Credits	Instruction Hour per week	Total No. of Lectures / Hours / Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC – 13	**Practical**	**02**	**04**	**60 Hrs.**	**4 Hrs.**	**10**	**40**	**50**

Course outcomes (COs)

After completion of this course successfully, the students will be able to….

1. Determine the amount of acid and ester/amides present in the mixture.
2. Determine the molecular weight.
3. Get hands on experience to synthesize the heterocyles.
4. Utilize the functional groups in the organic synthesis.

Lab Course in Organic Chemistry: A2CHE006DP	**60 Hrs.**
Experiments 1. Quantitative Estimation of the following Organic compounds: (i) Acid (ii) Acid + Amide (iii) Acid + Ester (iv) Molecular weight determination by base hydrochloride method (v) Phenol (Bromometric method). 2. Preparations of derivatives of heterocycles like coumarins, quinolines, benzimidazoles, benzoxazines, pyrazoles. 3. Preparations based on functional group reactions of organic compounds like aldehydes, ketones, esters, phenols etc. Note: Any two of the above experiments will be prescribed for the examination.	

Recommended Books:

1. Vogel's Textbook of Practical Organic Chemistry Revised–B. S. Furniss, A.J. Hannaford, P.W.G. Smith, A.R. Tatchell, 5th Edition, Addison Wesley Longman Limited, UK, 1997.
2. A Hand book of Organic Chemistry– H.T. Clarke.
3. A Laboratory Manual of Organic Chemistry–B. B. Dey and M. V. Govindachari.
4. Lab Experiments in Organic Chemistry - Arun Sethi, New Age International Ltd. New Delhi. 2006.
5. Experimental Organic Chemistry- L. M. Harwood, and C. J. Moody, Blackwell Scientific, London, 1989.
6. Practical Organic Chemistry - W. Kemp, McGraw Hill, London, 1967.

Formative Assessment for Practical		
Sl. No	Assessment Occasion / type	Marks
01	Internal Assessment test 1	10
	Total	10 Marks
Formative Assessment as per the guidelines		

M.Sc. Semester – II
PHYSICAL CHEMISTRY (Theory)

Course Title: PHYSICAL CHEMISTRY-II
Course Code: A2CHE003DT

Type of Course	Theory/ Practical	Credits	Instruction Hour per week	Total No. of Lectures / Hours / Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC – 11	**Theory**	**04**	**04**	**60 Hrs.**	**3 Hrs.**	**20**	**80**	**100**

Course outcomes

The completion of this course will enable students to understand

1. The interpretation of quantum systems and its application to simple molecular models, factors influencing the reaction dynamics in solutions and techniques to follow fast reactions, electrochemical models and electrochemistry occurring at interfaces and about polymers: their types, synthesis, stereochemistry, thermal and various other properties that can be fined tuned for practical application as per the needs.
2. Application of these theoretical concepts in various practical problems and gaps that still exists in different areas of science and technology.

PHYSICAL CHEMISTRY-II (Theory): A2CHE003DT	**60 Hrs.**
UNIT–I: Quantum Mechanics-II	**15 Hrs.**
Interpretation of quantum mechanics: Copenhagen interpretation and Bohr's interpretation, Quantum superimposition and Schrodinger's cat thought experiment. Rigid rotator, derivation of selection rules for transitions in rotating molecule, linear harmonic oscillator, Hermite polynomials. Equation for hydrogen atom and its solutions, separation of variables, the phi, theta and radial equations, the problems of spherical symmetry, the quantum numbers and their significance**.** Hydrogen-like atoms, properties of the H–atom wave functions. Electronic energy states of H–atom. Many electron systems and the self-consistent field method. Spectroscopic term symbols.	
UNIT–II: Solution Kinetics	**15 Hrs.**
Kinetics in Solution:Effect of solvent, pressure and ionic strength for ion–ion, ion–neutral molecule type reactions and cage effects. Potential energy surfaces, features and construction of potential energy surfaces, theoretical calculation of energy of activation Fast Reactions: Techniques for fast reactions, flow methods, stopped flow technique, relaxation methods, flash photolysis and pulse radiolysis.	

Kinetics of oscillation reactions and isokinetic temperature	
UNIT–III: Electrochemistry-II	**15 Hrs.**
Electrification of interface, the basis of electrodics, thermodynamics at electrified interfaces: electrocapilarity, Lippmann equation. Structure of electrified interface: theories of electrical double layer: Helmholtz–Perrin, Gouy–Chapman and Stern theories. Orientation of solvent at interface: Metal–water interactions, Three state water model, The enthalpy and entropy of adsorption. Mobile electrified interface: electrokinetic phenomena, streaming current, streaming potentials, zeta potential, Electrophoresis. Electrodics: Equilibrium and the exchange current density, out of equilibrium and over potentials, Tafel equation, Butler-volmer equation.	
UNIT–IV: Polymer Chemistry-I	**15 Hrs.**
Introduction and History of polymers, industrial scenario, monomers, types of monomers, functionality, polymerization and degree of polymerization. Initiators. Classification of polymers with examples - Based on the origin, composition, the method of preparation, thermal behavior, structure, magnitude of intermolecular forces. Plasticizers. Plasticizers in plastic industry – Introduction, types, basic properties, bioplasticizers and applications of plasticizers. Solubility, crystallization and Glass transition temperature of polymers, factors influencing the solubility, crystallization and glass transition temperature of polymers. Determination of glass transition temperature, significance of glass transition temperature. Reactions of vinyl polymers: Functional group reactions, ring-forming reactions and block & graft copolymer formation. Crosslinking reactions: peroxide crosslinking, sulphur vulcanization, radiation crosslinking, photo crosslinking, electron beam crosslinking and miscellaneous crosslinking reactions. Polymer degradation: Chemical, thermal and radiation degradations.Polymer molecular weight: Number average and weight average molecular weights, polydispersity and molecular weight distribution in polymers. Fibers: Silk, Cellulose acetate fibres, Polyester fibres, Nylon fibres, Rayon. Adhesives: Natural and synthetic adhesives. Ion exchange resin.	

Books Recommended

1. Atkins' Physical chemistry, Peter Atkins and Julio De Paula, Oxford University Press, Oxford, 2010 (9 and 10th ed.,).
2. Introduction to Quantum Chemistry by A. K. Chandra, Ed. 3, Tata McGraw Hill, New Delhi, 1988.
3. Quantum Chemistry by R. K. Prasad, New Age International Publications, New Delhi, 1997.
4. Quantum Chemistry by Eyring, Walter and Kimball, John-Wiley, New York, 1961.
5. Physical Chemistry by G. M. Barrow, McGraw Hill, New York, 1996.
6. Fundamentals of Physical Chemistry by Maron and Lando, 1974.

7. Physical Chemistry by P. W. Atkins, ELBS, London, 1990 (Ed. 4).
8. Physical Chemistry by K. Vamulapalli, Prentice Hall of India Pvt. Ltd., New Delhi, 1997.
9. Physical Chemistry by Daniels and Alberty, Wiley, New York, 1961.
10. Physical Chemistry through Problems by S. K. Dogra and S Dogra, Wiley Eastern, New Delhi, 1984.
11. A Text Book of Physical Chemistry by Samuel Glasstone, McMillan, London, 1943.
12. Atomic Structure and Chemical Bonding by ManasChanda, Tata McGraw Hill, Publishing Co., New Delhi, 2019.
13. Chemical Kinetics by K. J. Laidler, Tata McGraw Hill Publishing Co., New Delhi, 1965.
14. Kinetics and Reaction Mechanisms by Frost and Pearson, Wiley, New York, 1961.
15. Polymer Chemistry: An Introduction, Malcolm P. Stevens, Oxford University Press, 1999.
16. An Introduction to Electrochemistry by S. Glasstone, Van Nostrand, London, 1942.
17. A Text book of Electrochemistry by G.F.A. Kortum and J.O.M. Bockris, Elsevier, New York, 1951.
18. Modern Electrochemistry by J.O.M. Bockris and A.K.N. Reddy Vol. I and Vol. II, Butterworths, London, 1971.
19. Contemporary Polymer Chemistry, Harry R. Allcock and Frederick W. Lampe, Printice-Hall, 1981.
20. Principles of Polymer Chemistry, P. Bahadur and N. V. Shastri, Narosa Publisher, 2002
21. Polymer Chemistry: Properties and Applications, Andrew Peacock and Allison Calhoun, Hanser Publisher, 2006.
22. Text Book of Polymer Chemistry, Fred W. Billmeyer, Jr., Wiley Publisher, 1984.
23. Polymer Science, V. R. Gowariker, N. V. Viswanathan and Jayadev Sreedhar, New Age International Publisher, 2001.

Formative Assessment for Theory		
Sl. No	Assessment Occasion / type	Marks
01	Internal Assessment test 1	10
02	Internal Assessment test 2	10
	Total	20 Marks
Formative Assessment as per the guidelines		

M.Sc Semester – II
Physical Chemistry (Practical)

Course Title: Lab Course in Physical Chemistry
Course Code: A2CHE007DP

Type of Course	Theory/ Practical	Credits	Instruction Hour per week	Total No. of Lectures / Hours / Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC – 14	**Practical**	**02**	**04**	**60 Hrs.**	**4 Hrs.**	**10**	**40**	**50**

Course Outcomes

After completion of the practical's students will be able

1. comprehend the practical aspects of reaction kinetics, solubility, viscosity and cryoscopy techniques and apply theoretical knowledge of thermodynamics and chemical reactions to real world laboratory experiments like determining various effects on reactions, use of calorimeters for studying neutralization reactions, use of Beckman thermometer for determining the freezing point depression and its relation to molecular weight, determining various physical and chemical parameters of chemical compounds and their solutions like viscosity using Ostwald viscometer, heat evolved during solubility of a solute in solvent, partial molar volumes etc.
2. get insight into the experiments related to finding important physical properties and parameters such as the determination of stability constant of complex formation using spectrophotometer,redox potential using potentiometer, equivalent conductance using conductimetry and dissociation constants of weak acids using pH meters allow students to acquire practical proficiency with instruments. These skills help students develop a strong foundation in physicals chemistry, preparing them for advanced research or professional role in the field.

Lab Course in Physical Chemistry: A2CHE007DP	60 Hrs.

Experiments

Non-Instrumental

1. Chemical Kinetics: Study the effect of added salt on the persulphate oxidation of iodide ions.
2. Solubility: Determination of the heat of solution of a solute (oxalic acid, benzoic acid etc.) by solubility method
3. Viscosity: Determination of viscosity average molecular weight of a given polymer (polyvinyl alcohol, polyethylene glycol etc.) by viscosity measurements using Mark-Howink equation.
4. Thermochemistry: Determination of enthalpy of neutralization of weak acid (CH_3COOH) with a weak base (NH_4OH)
5. Cryoscopy: Determination of molecular weight of non-volatile substance (glucose, urea etc.) cryoscopically using water as the solvent.
6. Self-generated experiment.

Instrumental

7. Spectrophotometry: Investigation of the complex formation between Fe^{3+} and salicylic acid and find the formula, stability constant and free energy change of the reaction
8. Potentiometry: Determination of the formal redox potential of ferrous-ferric system by titrating with dichromate solution and estimation of amount of Fe2+/FeSO4 present in given solution
9. Conductometry:
    a. Determination of the limiting equivalent conductance of a weak electrolyte (acetic acid, formic acidetc) at infinite dilution following the Kohlrausch law.
    b. Verification of Ostwald's dilution law and determination of dissociation constant of the weak acid
10. pH-metry: Determination of dissociation constant of a weak acid (acetic acid, formic acid, etc.) pH metrically
11. Self-generated experiments

Recommended Books

1. Practical Physical Chemistry by A. M. James and F. E. Prichard, Longmans, London, 1974.
2. Experiments in Physical Chemistry by Shoemaker and Garland, McGraw Hill, New York, 1964.
3. Experiments in Physical Chemistry by Daniels, Alberty and Willams, McGraw Hill, New York, 1970.
4. Experimental Physical Chemistry by W. G. Palmer, Cambridge University Press, London, 1946.
5. Advanced Physico-Chemical experiments by J. Rose.
6. Text book of Quantitative Analysis by A. I. Vogel, ELBS, Harlow, 1978.
7. Advanced Practical Physical Chemistry by J. B. Yadav, Goel Publishing House, 1981.
8. Experimental Physical Chemistry by V. D. Athawale and Parul Mathur, New Age International Publishers, 2017.
9. Advanced Physical Chemistry Experiments by Gurtu and Gurtu, Pragati Prakashan Educational Publishers, 3rd Edition 2007.

Formative Assessment for Practical		
Sl. No	Assessment Occasion / type	Marks
01	Internal Assessment test 1	10
	Total	10 Marks
Formative Assessment as per the guidelines		

M.Sc. Semester – II
Applied Inorganic Chemistry (Elective)

Course Title: Applied Inorganic Chemistry (Elective)
Course Code: A2CHE204AT

Type of Course	Theory/ Practical	Credits	Instruction Hour per week	Total No. of Lectures / Hours / Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
OEC – 01	**Theory**	**04**	**04**	**60 Hrs.**	**3 Hrs.**	**20**	**80**	**100**

Program outcomes:

1. To understand the concepts of statistical data treatment, thermal methods of analysis and chromatographic methods.
2. To study about metallobiomolecules and their biological roles.

Course outcomes:

1. Students will be able to subject the results to statistical analysis.
2. Students will understand the chemistry of thermal methods and inorganic polymers and their applications.
3. Students will realize the importance of essential elements and proteins and their functions.
4. Students will understand the principle, instrumentation and applications of gas chromatography.

Applied Inorganic Chemistry (Elective): A2CHE204AT	**60 Hrs.**
UNIT–I: Data analysis	**15 Hrs.**
Types of errors, accuracy and precision, methods of minimization of systematic errors, mean and standard deviation, distribution of random errors, reliability of results, comparison of results-Student t-test, F-test and chi–square test, significant figures, confidence intervals, method of least squares, calibration curve and standard addition method.	
UNIT–II: Thermal methods of analysis and inorganic polymers	**15 Hrs.**
Thermal methods of analysis: Thermobalance, factors influencing thermogravimetric results, differntial thermal analysis: Instrumentation for differential thermal analysis (DTA) and differential scanning calorimetry (DSC). Applications of TG, DTA and DSC. Inorganic Polymers:Silicones, polyphosphazenes, synthesis, structure and applications.	
UNIT–III: Bioinorganic Chemistry	**15 Hrs.**
Metal ions in biological systems, deficiency of trace metal ions (Fe, Zn, Cu and Mn), metal ions and chelating agents in medicine: Treatment of toxicity due to	

inorganics (chelation therapy) and metal complexes as therapeutic agents. Proteins and their functions: Heme proteins, oxygen uptake proteins-hemoglobin and myoglobin.	
UNIT–IV: Chromatography	
Gas chromatography**:** Principles, instrumentation, stationary phases and types of carrier gases used in GC. Methods of sample injection, types of detectors, programmed temperature GC, plate and plate height theory in GC. Applications of GC and use of GC-MS in detection of samples.	

Recommended Books:

1. Vogel's Texbook of Quantitative Analysis. 6th Edition–J. Mendham, R. C. Denney, J. D. Branes and MJK Thomas, Pearson Education, 2007.
2. Contemporary polymer Chemistry, 3rd Ed, H. R. Allcock, F. W. Campe and J. E. Mark, Publisher: Pearson Education.
3. Inorganic Chemistry, 4th Ed, J. E Huheey, R. L. Keiter and A. L. Keiter, Addison Wesley, 2000.
4. Inorganic Chemistry of Biological Processes, 2nd Ed. –M. N. Hughes, Wiley, 1988.
5. Bioinorganic Chemistry – I. Bertini. H. B. Gray, S. J. Lippard and J. S. Valentine, Viva Books, 1998.
6. Bioinorganic Chemistry - A.K. Das, Books and Allied (P) Ltd, 2007.
7. Principles of Instrumental Analysis-Skoog, Holler and Nieman, Harcourt Afca, 2001.
8. Vogel's Text Book of Quantitative Inorganic Analysis., 4th Edn. J. Bessett, R. C. Denney, G. H. Jeffery and J. Mendham, Longman Green and Company Ltd.
9. Quantitative Chemical Analysis, 6th Ed-D. C. Harris, W. H. Freeman and Company, New York, 2003.

Formative Assessment for Theory		
Sl. No	Assessment Occasion / type	Marks
01	Internal Assessment test 1	10
02	Internal Assessment test 2	10
	Total	20 Marks
Formative Assessment as per the guidelines		

THIRD SEMESTER

Program learning outcomes

After completion of the course,

1. Students will understand the theory, principles, instrumentation, applications of various instrumental and separation methods.
2. Students will learn the theory and applications of electronic, IR and Raman spectroscopy.
3. Students will understand the principles and applications of NMR, NQR, mass, photoelectron and Mössbauer spectroscopy.
4. Students will learn about features of sensors and automated methods of analysis
5. Students will understand about computational chemistry and structural and functional roles of inorganic elements in biological systems.
6. Students will understand the principles of quantitative determination of metal ions by Spectrophotometry.
7. Students will learn the analysis of food and water samples besides the use of cation-exchanger.
8. Students will understand the principles and methods of chromatographic, conductometric and potentiometric analysis.
9. Students will learn the analysis of pharmaceutical formulations besides the interpretation of spectral data.
10. Students will understand the principles of quantitative determination by potentiometry, conductometry and pH metry.
11. Students will learn the analysis of water samples.

M.Sc Semester – III
Analytical Chemistry (Theory)

Course Title: Instrumental Methods of Analysis

Course Code: A3CHE101DT

Type of Course	Theory/ Practical	Credits	Instruction Hour per week	Total No. of Lectures / Hours / Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC - 15	**Theory**	**04**	**04**	**60 Hrs.**	**3 Hrs.**	**20**	**80**	**100**

Course outcomes:

1. Students will learn the principles and applications of different optical spectroscopic methods.
2. Students will understand the theory, instrumentation and applications of electroanalytical methods
3. Students will learn about different types and applications of thermal methods for characterization of inorganic and organic compounds, materials and polymers.
4. Students will learn the analysis of various samples by different instrumental methods.

Instrumental Methods of Analysis: A3CHE101DT	**60 Hrs.**
UNIT-I: Optical Methods	**15 Hrs.**
Atomic absorption spectrometry: Theory, instrumentation (double beam AAS), different types ofnebulizers, non flame techniques, electrothermal vapouriser, cold vapor AAS determination of mercury, interferences, differences between AAS and flame photometry and analytical applications ofAAS. Standard addition method and internal addition method. Emission Spectroscopy: Inductively coupled plasma optical emission spectrometry-theory, instrumentation and applications. Comparison between AAS, FES and ICP-AES. Molecular Luminescence Spectroscopy: Theoretical basis for fluorescence and phosphorescence, instrumentation, factors affecting fluorescence, its applications in quantitative analysis and in the study of biomolecules. X-rayfluorescence analysis: theory, instrumentation and applications. Numerical problems.	
UNIT-II: Analytical methods-I	**15 Hrs.**
Coulometric methods of analysis: General discussion, coulometry at controlled potential, apparatus and general technique, applications, Coulometric titrations Amperometric, Coulometric: Principles, apparatus, comparison of Coulometric titrations with conventional titrations, automatic Coulometric titrations and applications.	

Amperometry: Principle, titrations, advantages and limitations and applications. Ion selective electrodes: Glass ion selective electrodes, crystalline solid state ion selective electrodes, liquid-based ion selective electrodes and gas sensing electrodes. Supercritical fluid chromatography (SFC): Properties of supercritical fluids, instrumentation and operating variables, comparison of SFC with other types of chromatography and applications. Numerical problems.	
UNIT-III: Analytical methods-II	**15 Hrs.**
Polarography: Theory of classical polarography, polarograms, polarographic currents. Half wave potential, oxygen interference, advantages and limitations. pulse polarography and applications of polarography. **Spectrophotometry:** Principle, instrumentation and applications-spectrophotometric determination of metal ions (copper and nickel) and pharmaceutical drugs (aspirin and paracetamol). **Electrophoresis:** Theory and classification, factors influencing the mobility-macromolecular size and charge, interaction with supporting electrolyte and pH. Factors affecting electrophoretic phenomena-electrolysis, electroosmosis, temperature and supporting media. Instrumentation. **Methodology:** Preparation of gels-staining and destaining. Capillary electrophoresis methods: Capillary zone electrophoresis and capillary gel electrophoresis. Size exclusion chromatography: Principle, instrumentation and applications. Light-scattering methods: Nephelometry and turbidometry: Principle, instrumentation and applications. **Powder XRD:** Principle, instrumentation and applications. Numerical problems.	
UNIT-IV: Analytical methods-III	**15 Hrs.**
Thermogravimetric analysis (TGA): Types of thermogravimetric analysis, principles, factors affecting the results, heating rate, furnace, instrument control/data handling. Instrumentation and applications (Inorganic compounds, Polymers and pharmaceuticals). Differential scanning calorimetry (DSC): Basic principle, differences between DTA and DSC. Instrumentation, power compensated DSC, heat flux DSC and applications. (Inorganic compounds, Polymers and pharmaceuticals). **Voltammetry:** Fundamentals of voltammetry. Cyclic voltammetry: Principles and applications. Stripping analysis: Stripping voltammetry, basic principles, electrodes used for stripping analysis, apparatus for stripping analysis, applications and determination of lead in water by voltammetry. Electron microscopic techniques:Scanning electron microscopy (SEM), Transmission electron microscopy (TEM) and Atomic force microscopy (AFM): Principle, instrumentation and applications. Numerical problems.	

Recommended Books:

1. Instrumental Analysis, D. A. Skoog, F. J. Holler and S. R. Crouch, Cengage Learning (2007).
2. Fundamental of Analytical Chemistry, D. A. Skoog, D.M. West, Holler and Crouch, 8thEd, Saunders College Publishing, New York (2005).
3. Analytical Chemistry, G.D. Christian, 6th edition, Wiley-India (2007).
4. Quantitative Analysis, R.A. Day and A.L. Underwood, 6th Ed, PHI Learning Pvt. Ltd. New Delhi (2009).
5. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J. D. Barnes and M.J.K. Thomas, 6th edition, Third Indian Reprint, Pearson Education Pvt. Ltd. (2007).
6. Analytical Chemistry Principles, John H. Kennedy, 2nd edition, Saunders College Publishing, California (1990).
7. Instrumental Methods of Analysis by H.H. Willard, L.L. Merritt and J.A. Dean, 7thEd, CBS Publishers, New Delhi, (1988).
8. Scanning electron microscopy and x-ray microanalysis Goldstein, Dale E. Newbury , Joseph R. Michael , Nicholas W.M. Ritchie , John Henry J. Scott , David C. Joy, Springer (2018).
9. Micro structural Characterization of Materials D. Brandon and W.D. Kaplan, Wiley (2008).

Formative Assessment for Theory		
Sl. No	Assessment Occasion / type	Marks
01	Internal Assessment test 1	10
02	Internal Assessment test 2	10
	Total	20 Marks
Formative Assessment as per the guidelines		

M.Sc Semester – III

Analytical Chemistry (Practical)

Course Title: Lab course in Analytical Chemistry

Course Code: A3CHE106DP

Type of Course	Theory/ Practical	Credits	Instruction Hour per week	Total No. of Lectures / Hours / Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC – 18	**Practical**	**02**	**04**	**60 Hrs.**	**4 Hrs.**	**10**	**40**	**50**

Course outcomes:

1. Students get hands on experience in the use of spectrophotometer/colorimeter
2. Students will gain the in-depth knowledge and skill in quantitative determination of transition metal ions, food and biological samples besides the separation and determination of cations.

Lab course in Analytical Chemistry: A3CHE106DP	**60 Hrs.**
Experiments 1. Nephelometric/turbidimetric determination of sulphate/phosphate in ground water samples. 2. Determination of calcium in milk powder using EDTA. 3. Separation and determination of chloride in $[Co(NH_3)_5Cl]Cl_2$ using cation exchanger. 4. Cation exchange chromatographic separation of cadmium and zinc and their estimation by EDTA titration. 5. Analysis of a mixture of iron (II) and iron (III) by EDTA titration using pH control. 6. Determination of Fe (II) using 1,10-phenanthroline by spectrophotometry. 7. Colorimetric determination of Ti (IV) using H_2O_2. 8. Solvent extraction of Fe (III) using 8-hydroxyquinoline. 9. Determination of calcium in egg shell/teeth samples. **Recommended Books:** 1. A text Book of Quantitative Inorganic Analysis–A.I Vogel (1979). 2. Vogel's Text Book of Quantitative inorganic Analysis, Basset, Denney, Jeffery & Mendham (2019). 3. Colorimetric Determination of Traces of Metals–E. B. Sandell (1959). 4. Analytical Chemistry–G.D Christian, 4th Ed, Wiley, (1986).	

Formative Assessment for Practical		
Sl. No	Assessment Occasion / type	Marks
01	Internal Assessment test 1	10
	Total	10 Marks
Formative Assessment as per the guidelines		

M.Sc Semester – III
Analytical Chemistry (Theory)

Course Title: Molecular Spectroscopy
Course Code: A3CHE102DT

Type of Course	Theory/ Practical	Credits	Instruction Hour per week	Total No. of Lectures / Hours / Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC – 16	**Theory**	**04**	**04**	**60 Hrs.**	**3 Hrs.**	**20**	**80**	**100**

Course outcomes:

1. Students will learn the electric and magnetic properties of radiation, molecules and bulk matter and solve the problems related to these properties.
2. Students will understand the principles, instrumentation and applications of spectroscopic techniques such as IR, Raman, NMR, UV and MS spectroscopic techniques.
3. Students will understand various fragmentation patterns of organic and inorganic molecules.
4. Students will be able to solve structural problems using multi-spectroscopic data.

Molecular Spectroscopy: A3CHE102DT	**60 Hrs.**
UNIT-I: Basic concepts, Electronic Spectroscopy and Mass Spectrometry	**15 Hrs.**
Properties of electromagnetic radiation. Wave property: Interference and diffraction. Particle property: Photoelectric effect. Regions of the electromagnetic spectrum, energies corresponding to various kinds of radiation. Interaction of electromagnetic radiation with matter (absorption, emission, transmission, reflection, dispersion, polarisation and scattering). General application. Electronic spectroscopy: Molecular electronic absorption spectroscopy (UV-Visible), electronic spectra of diatomic molecules, electronic transitions, selection rules, assignment of transition, band intersities, substituent and solvent effect and change transfer transitions. Application to organic and inorganic molecules. Mass Spectrometry: Instrumentation: EI, CI, DI and ESI. Mass analysis. Fragmentation: Principles, odd electron ($OE^{\cdot+}$) and even electron (EE^{+}) ions, molecular ion and base peak, nitrogen rule, metastable ions. Isotope effects in chloro and bromo compounds. Fragmentation of inorganic and organic compounds. Problems.	

UNIT-II: Vibrational Spectroscopy	**15 Hrs.**
Vibrational spectroscopy: Infrared spectroscopy: Vibrational energy levels, infrared spectra of diatomic and polyatomic molecules, normal modes of vibration, force constant, selection rules, anhormonicity, the vibration-rotation spectroscopy. Infrared spectra of simple molecules and coordination compounds, changes in infrared spectra of donor molecules upon coordination (N,N-dimethylacetamide, urea, DMSO, acetate, ammine and thiocyanato complexes), mono and multinuclear carbonyl and nitrosyls. Hydrogen bonding. Instrumentation including FTIR. Raman spectroscopy: Theory, relation with IR spectroscopy, resonance Raman stimulated hyper and inverse Raman effects. Experimental techniques, structure determination from IR and Raman spectra. Problems.	
UNIT-III: Magnetic Resonance spectroscopy	**15 Hrs.**
Nuclear magnetic resonance spectroscopy: Magnetic properties of nuclei, population of energy levels, the Larmor precession, relaxation processes, chemical shift, shielding mechanism, spin-spin interactions, rules governing the interpretation of first order spectra, effect of chemical exchange on spectra. Analysis of complex NMR spectra, ^{1}H-NMR spectra of organic molecules and complex metal ligands. Spin-systems: First order and second order patterns. Long range coupling: Spin decoupling, CIDNP and NOE. NMR shift reagents. NMR studies of nuclei other than proton, ^{13}C-NMR (including heteronuclear coupling with other nuclei viz., ^{19}F and ^{31}P), ^{19}F, ^{31}P, ^{11}B, ^{15}N. Spectra of paramagnetic complexes, contact shift, double resonance technique. Instrumentation including FT-NMR. Composite problems.	
UNIT-IV: Electron Paramagnetic Resonance and Mössbauer Spectroscopy	**15 Hrs.**
Electron Paramagnetic Resonance (EPR) Spectroscopy: Basic principles, selection rules, intensity, width, position of spectral line, multiplet structure of EPR spectra, hyperfine interaction, spin-orbit coupling, zero field splitting and Kramer's degeneracy, rules for interpreting spectra, factors affecting the magnitude of values. Instrumentation. Applications to the study of free radicals, coordination compounds, biological studies and rate of electron exchange reactions. Mössbauer Spectroscopy: Introduction, principles, conditions for Mössbauer spectroscopy, parameters from Mossbauer spectra, isomer shifts, electric quadrupole interaction, magnetic interactions, Mossbauer spectrometer. Applications in structure determination of $Fe_3(CO)_{12}$, Prussian blue, oxyhemerythrin, hexacyanoferrates, nitropruside, tin halides. Problems.	

Books Recommended:

1. Fundamentals of Molecular Spectroscopy - C. N. Banwell (1972).
2. Physical Methods in Chemistry - R. S. Drago, Saunder College (1992).
3. Structural Methods in Inorganic Chemistry - E. A. Ebsworth, D. W. H. Ranbin and S.Cradock, ELBS (1991).
4. Infrared Spectra of Inorganic and Coordination Compounds - K. Nakamoto 6th edition (2008).
5. Infrared Spectroscopy - C.N.R. Rao, *ACS- Journal of Chemical Education*, (1965).
6. Electron Absorption Spectroscopy and Selected Techniques - D. N. Satyanarayana, University Press India Ltd. Hyderabad.
7. Introduction to Spectroscopy – D. L. Pavia, G. M. Lampman and G. S. Kriz, Thomson Learning, Singapore (2001)
8. Spectroscopic Identification of organic compounds – R. M. Silverstein and F. X. Webster, 6th Edition, Wiley and Sons, India Ltd. (2006).
9. Interpretation of Mass Spectroscopy–McLafferty(2006).
10. Organic Spectroscopy-3rd Ed.-W.Kemp (Pagrave Publishers, New York), 1991.

Formative Assessment for Theory		
Sl. No	Assessment Occasion / type	Marks
01	Internal Assessment test 1	10
02	Internal Assessment test 2	10
	Total	20 Marks
Formative Assessment as per the guidelines		

M.Sc Semester – III

Analytical Chemistry (Practical)

Course Title: Lab course in Analytical Chemistry

Course Code: A3CHE107DP

Type of Course	Theory/ Practical	Credits	Instruction Hour per week	Total No. of Lectures / Hours / Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC – 19	**Practical**	**02**	**04**	**60 Hrs.**	**4 Hrs.**	**10**	**40**	**50**

Course outcomes:

1. Students will understand the chromatographic, conductometric and potentiometric methods of analysis of inorganic and organic compounds
2. Students will gain the knowledge in the interpretation of spectral data and acquire skill for the analysis of pharmaceutical samples

Lab course in Analytical Chemistry: A3CHE107DP	**60 Hrs.**
Experiments 1. Chromatography: (i) Paper chromatography: Qualitative separation of amino acids in a given mixture. (ii) Thin Layer chromatography: Qualitative separation of amino acids in a given mixture. (iii) Column chromatography: Separation of plant pigments. 2. Conductometric titrations: (i) Sodium acetate with HCl (ii) NH_4Cl with NaOH (iii) HCl, CH_3COOH and $CuSO_4$ 3. Determination of iron in razor-blade by potentiometric & visual titration using sodium vanadate. 4. Assay of iron in pharmaceutical preparation by visual & potentiometric titration by $Ce(SO_4)_2$ 5. Determination of aluminium and magnesium in antacids by EDTA titration. 6. Determination of saccharin in tablets by precipitation titration. 7. Interpretation of spectral data.	

Recommended Books:

1. A text Book of Quantitative Inorganic Analysis– A. I. Vogel (1979).
2. Vogel's Text Book of Quantitative inorganic Analysis, Basset, Denney, Jeffery & Mendham (2019).
3. Colorimetric Determination of Traces of Metals– E. B. Sandell (1959).
4. Analytical Chemistry– G.D Christian, 4th Ed,, Wiley, (1986).

Formative Assessment for Practical		
Sl. No	Assessment Occasion / type	Marks
01	Internal Assessment test 1	10
	Total	10 Marks
Formative Assessment as per the guidelines		

M.Sc Semester – III

Analytical Chemistry (Theory)

Course Title: Selected Topics in Analytical Chemistry-I

Course Code: A3CHE103DT

Type of Course	Theory/ Practical	Credits	Instruction Hour per week	Total No. of Lectures / Hours / Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC – 17	**Theory**	**04**	**04**	**60 Hrs.**	**3 Hrs.**	**20**	**80**	**100**

Course outcomes:

1. Students will learn the fabrication and applications of sensors
2. Students will be able to study the structures and biological roles of various metallo enzymes, metallo-proteins and metal complexes
3. Students will be able to understand the important life processes like dioxygen transportation, photosynthesis and nitrogen fixation
4. Students will learn the features of computational chemistry and acquire skills to write the programs for various concepts

Selected Topics in Analytical Chemistry-I: A3CHE103DT	**60 Hrs.**
UNIT-I: Sensors	**15 Hrs.**
Sensors: Membrane electrodes, classification and properties, principle, membrane potential, sensors types: Crystalline, liquid membrane and enzyme electrodes, gas sensors, Preparation and analytical applications of voltammetric sensors, optical sensors, pH sensors, fluorescence based sensors and thermal sensors. Biosensors: Introduction to biosensors, characteristics of an ideal biosensor. Basic electrochemical principles and measurement system. Enzyme based electrochemical biosensors: Theory and applications of glucose, urea and alcohol biosensors. Transducer technology, enzyme based calorimetry, enzyme reactors with HPLC. Enzyme based micro electrodes. Analytical and biological applications of sensors.	
UNIT-II: Bioinorganic Chemistry	**15 Hrs.**
Bioinorganic chemistry: Metal ions in biological systems, essential and trace metals, Transport and storage of dioxygen, haemoglobin, myoglobin, hemerythrin and hemocyanins. Electron transfer proteins: Cytochromes, iron-sulphur proteins. Metalloproteins as enzymes: Carboxy peptidase, carbonic anhydrase, catalases, peroxidases, cytochrome P450, superoxide dismutase, copper oxidases, vitamin B_{12} coenzyme, chlorophyll and its role in photosynthesis, photosystems-I & II, nitrogen fixation. Metal complexes in medicine.	

UNIT-III: Automated methods of analysis	**15 Hrs.**
Automated methods of analysis: Overview, advantages and disadvantages of automated analyses, types of automatic systems, flow injection analysis, instrumentation, sample and reagent transport systems, sample injectors and detectors, separations in FIA. Dialysis and gas diffusion, principles of FIA, dispersion, applications: Spectrophotometric determination (phosphate & chloride), catalyzed reaction, stopped flow methods, flow injection titrations, microfluidics, discrete automatic systems, robotics, discrete clinical analyzers and automatic organic elemental analyzers.	
UNIT-IV: Computational Chemistry	**15 Hrs.**
Computer languages, packages: Linear regression, X-Y plot, operational packages, MS word and MS Excel. Programming equations in chemistry *viz*. Raoult's law, Henderson-Hasselbalch equation, van't Hoff equation into C program by use of artificial intelligence. Introduction to computational chemistry and computational methods, *abinitio*, semi empirical, molecular mechanics, density functional theory (DFT), molecular dynamics. Computational calculation of electronic and thermal energies of naphthalene and azulene using Gaussian software. Features and applications of Chemdraw. Search engines.	

Recommended Books:

1. Biosensor-Theory & Applications, Donald G. Burek, (Technomic Publication, Lancaster)1993,
2. Biosensors, ISHA Books, Delhi, Ed: Rajmohan Joshi, (2006).
3. Bioinorganic Chemistry - Asim K. Das, Books and Allied (P)Ltd,(2007).
4. PrinciplesofBioinorganicChemistry-S.J.LippardandJ.M.Berg,PanimaPublishingCorporation (1994).
5. Inorganic Chemistry –Principles of Structure and Reactivity, 4th Ed- J. E. Huheey, E. A. Keiter, R. L. Keiter and O. K. Medhi. Pearson Education (2009).
6. Instrumental Analysis, D. A.S koog, F. J. Holler and Stanley R. Crouch, Cengage Learning (2007).
7. Instrumental Methods of Analysis by H.H. Willard, L. L. Merritt and J. A. Dean, 7th Edition, CBS Publishers, New Delhi, (1988).
8. C Programming for Scientists and Engineers with Applications" by Rama N. Reddy and Carol A. Ziegler (2009).
9. Essentials of Computational Chemistry: Theories and Models" by Christopher J. Cramer (2004).

10. Naphthalene and Azulene I: Semimicro Bomb Calorimetry and Quantum Mechanical Calculations, *J. Chem. Educ*. 75, 10, 1341, (1998).

Formative Assessment for Theory		
Sl. No	Assessment Occasion / type	Marks
01	Internal Assessment test 1	10
02	Internal Assessment test 2	10
	Total	20 Marks
Formative Assessment as per the guidelines		

M.Sc Semester – III
Analytical Chemistry (Practical)

Course Title: Lab Course in Analytical Chemistry
Course Code: A3CHE108DP

Type of Course	Theory/ Practical	Credits	Instruction Hour per week	Total No. of Lectures / Hours / Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC – 20	**Practical**	**02**	**04**	**60 Hrs.**	**4 Hrs.**	**10**	**40**	**50**

Course outcomes:

1. Students will understand the applications of potentiometry, conductometry and pH metry in the analysis of different samples/mixtures
2. Students will gain the knowledge and skill in the analysis of waste water samples

Lab Course in Analytical Chemistry: A3CHE108DP	**60 Hrs.**
Experiments 1. Polarimetry: Determination of specific rotation of (i) cane Sugar solution (ii) cane sugar cane by inversion method (iii) cane sugar solution in presence of other sugar solution. 2. Potentiometric Titrations: (i) analysis of mixture of halides (ii) determination of iron using potassium dichromate. 3. Conductometric Titrations: (i) analysis of halides, (ii) determination of sulphates. 4. pH Metric titrations: (i) Determination of strength of acids (ii) determination of strength of commercial phosphoric acid (H_3PO_4) by pH titration (iii) determination of soda ash in washing soda. 5. Spectrophotometric analysis: Analysis of waste water for (i) phosphate by molybdenum blue method (ii) ammonia-nitrogen by Nessler's method.	

Recommended Books:

1. A text Book of Quantitative Inorganic Analysis - A. I. Vogel (1979).
2. Vogel's Text Book of Quantitative inorganic Analysis, Basset, Denney, Jeffery & Mendham (2019).
3. Colorimetric Determination of Traces of Metals - E.B. Sandell (1959).
4. Analytical Chemistry - G.D Christian, 4th Ed, Wiley, (1986).

M.Sc Semester – III
Applied Organic Chemistry (ELECTIVE)

Course Title: Applied Organic Chemistry (ELECTIVE)
Course Code: A3CHE204BT

Type of Course	Theory/ Practical	Credits	Instruction Hour per week	Total No. of Lectures / Hours / Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
OEC - 02	**Theory**	**04**	**04**	**60 Hrs.**	**3 Hrs.**	**20**	**80**	**100**

Course outcomes (COs)

After completion of this course successfully, the students will be able to…

1) understand the fundamental properties such as orientation and optical activity of the organic molecules.
2) predict the physical and chemical methods reaction mechanism and learn about few mechanisms of organic reactions.
3) understand the heterocycles structural feature and synthesis and its reactions as well as biological and material science importance.
4) learn about functional groups importance in organic synthesis and its internal transformations.

Applied Organic Chemistry (ELECTIVE) : A3CHE204BT	**60 Hrs.**
UNIT–I: Molecular Parameters, Isomerism and Prochirality	**15 Hrs.**
Molecular Parameters: bond lengths, bond angles, bond energies, bond polarity and dipole moment. Geometrical and optical isomerism: E/Z, R/S nomenclature, Fischer, Sawhorse, Newmann projections. Enantiomers, diastereomers and epimers, Prochirality: Homotopic, enantiotopic, diastereotopic groups & faces and their reactivity.	
UNIT–II: Organic Reactions	**15 Hrs.**
Classification of organic reactions, Methods of identification, kinetic, non–kinetic methods, isotopic labeling techniques, intermediates, cross over products and product proportions in different types of reactions. Named Reactions: Classification, aldol, Dieckmann, Claisen–Schmidt and similar carbanion addition reactions.	

UNIT–III: Chemistry of Heterocycles	**15 Hrs.**
Structure, synthesis, reactivity of the following heterocycles and their biologically important derivatives: (i) indole (ii) thiazole (iii) pyrimidine (iv) quinoline (v) furan (vi) thiophene and (vii) pyrrole.	
UNIT–IV: Functional group Transformations	**15 Hrs.**
Multi step organic functional group interconversions involving substitution, addition, eliminations, oxidation, reduction, etherification, hydrolysis and diazocoupling reactions.	

Recommended Books:

1. Organic Chemistry – P.Y. Bruice, Pearson Education Pvt. Ltd., New Delhi (2002).
2. Organic Chemistry–S. H. Pine, McGraw-Hill, London (1987).
3. Organic Chemistry–R.T. Morrison and R.T. Boyd, Prentice Hall New Delhi (1994).
4. Organic Chemistry–T.W. Graham Solomons, 4th Ed, John Wiley and Sons, (1988).
5. Organic Chemistry volume I, II-I. L. Finar, 6th Ed, ELBS London (2004).
6. Organic Chemistry–F.A. Carey, 4th Ed, McGraw Hill, (2000).
7. Advanced Organic Chemistry, Reactions, Mechanism and Structure–J. March, 4th Ed, Wiley Eastern Ltd (2004).
8. Stereochemistry–Conformation and Mechanism P. S. Kalsi, Wiley- Eastern Ltd, New Delhi (1992).
9. Heterocyclic Chemistry–T. L. Gilchrist, Butterworths (London), 1985.
10. Heterocyclic Chemistry – J. A. Joule and G. F. Smith, 2nd Ed, Van Nostrand (London), 1978.

Formative Assessment for Theory		
Sl. No	Assessment Occasion / type	Marks
01	Internal Assessment test 1	10
02	Internal Assessment test 2	10
	Total	20 Marks
Formative Assessment as per the guidelines		

M.Sc. Semester – III

Applied Physical Chemistry (ELECTIVE)

Course Title: Applied Physical Chemistry (ELECTIVE)

Course Code: A3CHE205CT

Type of Course	Theory/ Practical	Credits	Instruction Hour per week	Total No. of Lectures / Hours / Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
OEC – 02	**Theory**	**04**	**04**	**60 Hrs.**	**3 Hrs.**	**20**	**80**	**100**

Course outcomes

After completion of this course the students will be able to

1. understand and apply the principles of thermodynamics in daily life situations.

2. predict possible mechanisms of various reactions

3. understand the various concepts of electrochemistry of electrolytes.

4. appreciate the applications of polymers in day-to-day situations.

Applied Physical Chemistry (ELECTIVE): A3CHE205CT	**60 Hrs.**
UNIT-I: Reaction Kinetics	**15 Hrs.**
A critical account of collision and transition state theories. **Kinetics and Mechanism**: Steady state approximation and simple examples relating kinetics to mechanism. Theories of unimolecualr reactions: RRKM theory. Isomerisation of methyl isocyanide. General features of fast reactions, study of fast reactions by flow method, relaxation method, Flash photolysis and the nuclear magnetic resonance method.	
UNIT-II: Thermodynamics	**15 Hrs.**
Thermodynamic criteria for spontaneous chemical changes. Standard free energies and their determination. Relation between free energy change and equilibrium constant. The pressure dependence of free energy of non-ideal gases; fugacity. Standard state for non-ideal gas. Equilibrium constants in non-ideal systems. Temperature dependence of free energy and equilibrium constants.	
UNIT-III: Electrochemistry	**15 Hrs.**
Electrical double layer: Lippman equation, theories of electrical double layer-Helmholtz-Perrin, Gouy-Chapman and Stern theories. Effect of ions on zeta potential. Activity of ions in solution: ion-solvent interactions, ion-ion interactions and free energy of ions in solution. Born model and modifications, solvation number and their determination. triple ion formation and conductance minima.	

UNIT-IV: Introduction to Polymers	15 Hrs.
Basic Concepts: Monomers, repeat units, polymers and degree of polymerization. General classification of polymers, homopolymers, copolymers, terpolymers, additon polymers and condensation polymers with examples, tacticity, comparison between thermoplastics and thermosetting polymers. **Methods of Polymer Fabrications:** Fabrication of polymer films: solution casting, melt pressing, melt extrusion and bubble blown. Fabrication of shaped polymer objects: compression molding, injection molding, reaction injection molding, blow molding extrusion molding and calendaring. Spinning industrial polymers: solution spinning and melt spinning. Preparation, properties and commercial importance: Vinyl polymers: polyethylene, polypropylene, polystyrene, polymethylmethacralate, polyvinyl chloride, polytetrafluoroethylene. Polyesters: poly (ethylene terephthalate). Polyamides: aramides (Kevlar and Nomex). Polyimides. Polysulphone. Polyurethanes. Polyureas. **Natural polymers:** polyisoprenes, chitosan,	

Books Recommended:

1. Physical Chemistry-G. M. Barrow, McGraw Hill, 1996.
2. Physical Chemistry-R.A. Alberty, Wiley Eastern Ltd, 1961.
3. Elements of Physical Chemistry-P. W. Atkins, Oxford, 2009.
4. Physical Chemistry - P.W. Atkins, ELBS, 1990.
5. Modern Electrochemistry Vol.I and II-J.O.M, Bokris and A.K.N.Reddy, Plenum, 2006.
6. An Introduction to Electrochemistry-S.Glasstone, Van Norstrand, 1942.
7. A Text Book of Electrochemistry-G.F.A.Kortum and J.O.M. Bokris, Elsevier, 1951.
8. Electrolyte Solutions-R.A.Robinson and R. H. Stokes, Acedemic Press, 1959.
9. Chemical Kinetics-K.J.Laidler, Pearson Education 2004
10. Kinetics and mechanism of chemical transformations-J.Rajaraman and J. Kuriacose, McMillan.
11. Theory of rate processes-S. Glasstone, K. J. Laidler and H.Eyring, McGraw-Hill, 1941.
12. Thoeries of chemical reaction rates-K.J.Laidler, MacGraw-Hill, 1969.
13. Fast Reactionss-D.N. Hague, Wiley-Interscience, New York, 1971.
14. Techniques of Oraganic Chemistry- Weissberger(ed.), Interscience, 1963, Vol.VIII
15. Kinetics of Chemical Changes in Solution-E.S.Amis, McMillan, 1948
16. The Foundations of Chemical Kinetics-S.W. Benson, McGraw-Hill, 1960.
17. Polymer Chemistry An Introduction, Malcolm P. Stevens, Oxford University Press, 1999.
18. Contemporary Polymer Chemistry, Harry R. Allcock and Frederick W. Lampe, Printice-Hall, 1981.
19. Principles of Polymer Chemistry, P. Bahadur and N. V. Shastri, Narosa Publisher, 2002
20. Polymer Chemistry Properties and Applications, Andrew Peacock and Allison Calhoun, Hanser Publisher, 2006.
21. Text Book of Polymer Chemistry, Fred W. Billmeyer, Jr., Wiley Publisher, 1984.
22. Polymer Science, V.R. Gowariker, N. V. Viswanathan and Jayadev Sreedhar, New Age International Publisher, 2001

23. Principles of Polymer Chemistry, A. Ravve, Plenum Press, New York, 1998.

Formative Assessment for Theory		
Sl. No	Assessment Occasion / type	Marks
01	Internal Assessment test 1	10
02	Internal Assessment test 2	10
	Total	20 Marks
Formative Assessment as per the guidelines		

FOURTH SEMESTER

Program learning outcomes:

After completion of the program students will

1. Learn about air pollution and water pollution and their analysis.
2. Understand about soil pollution, noise and radiation pollution and their measurement.
3. Understand the features of quality control.
4. Understand about analysis of food, beverages and pharmaceutical samples.
5. Understand the importance and methods of analysis of biomedical samples, ores, minerals and fertilizers.
6. Understand the analysis of refineries, ores and alloys.
7. Understand the methodologies of analysis of water samples by volumetric/instrumental methods.
8. Develop skills related to the analysis of food and pharmaceutical samples by instrumental/volumetric methods.
9. Acquire the skills related to the use of instruments.
10. Develop skills related to the analysis of ores, alloys, fertilizers and cement by different methods.
11. Acquire the skills related to the analysis of body fluids.

M.Sc Semester – IV
Analytical Chemistry (Theory)

Course Title: Pollution and Analysis
Course Code: A4CHE101DT

Type of Course	Theory/ Practical	Credits	Instruction Hour per week	Total No. of Lectures / Hours / Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC – 21	**Theory**	**04**	**04**	**60 Hrs.**	**3 Hrs.**	**20**	**80**	**100**

Course outcomes:

1. Students will understand about different types of soil samples and measurement of soil pollution.
2. Students will learn about sources of water pollution and measurement of water pollution.
3. Students will learn about the causes of air pollution and measurement of air pollution.
4. Students will acquire knowledge on noise and radiation pollution and their measurement

Pollution and Analysis : A4CHE101DT	**60 Hrs.**
UNIT-I: Soil pollution and Analysis	**15 Hrs.**
Soil pollution: Acidification, salinisation, sodification, agrochemical pollution, urban and industrial pollution, effects of soil pollution and solutions for soil pollution. Soil composition and classification of soil. Macro and micro nutrients in soil and its function. Soil analysis: Sampling. Preparation of laboratory sample, measurement/ determination of moisture, pH and conductivity, acidic and alkaline soil. Analysis of major constituents: Organic matter, nitrogen, sulphur, sodium, manganese, phosphorous, magnesium, potassium and calcium. Determination of silica and lime. **Analysis of trace elements**: Copper, molybdenum, zinc and boron. Numerical problems	
UNIT-II: Air Pollution and Analysis	
Air pollutants: Classification and properties of air pollutants, emission sources, major emissions from global sources. Behaviors and fate of air pollutants, wet precipitation, dry deposition, interaction at the earth's surface, chemical reactions in the atmosphere, photochemical smog, effects of air pollution on human health, vegetation and materials. Acid rain. Air pollution sampling and measurement: Ambient air sampling, collection of gaseous and particulate air pollutants. Analysis of air pollutants: SO_2- ambient air measurements, stack gas measurement chemiluminescent techniques, CO-NDIR, amperometric, FID & catalytic oxidation methods, Coulometric & chemiluminescent	

methods. Hydrocarbon measurement: Total and individual hydrocarbons by chromatographic methods, particulates optical & mass measurement methods. Environmental segments. Green house effect and its consequences. Numerical problems	
UNIT-III: Water Pollution and Analysis	
Sources of water pollution, classification of water pollutants: Organic, inorganic, sediment, thermal and radioactive materials, effects and solutions. **Analysis of water parameters**: Hardness, carbonate, bicarbonate, chloride, sulphate, fluoride, sodium, potassium, iron, chromium, manganese, chlorine demand, dissolved oxygen, biochemical oxygen demand and chemical oxygen demand and TOC. Heavy metal pollution. Biochemical effects of heavy metals (Hg, As, Pb, Cd). Pesticides as water pollutants and analysis of pesticides pollution. Numerical problems.	
UNIT-IV: Noise and Radiation Pollution and analysis	
Noise pollution: Concept of sound, noise and hearing problems, measurement of noise, sources of noise, effects of noise pollution. Regulation and control rules 2000 for noise pollution. **Radiation Pollution:** Sources, effects, protection from radiation pollution, disposal of radioactive waste. **Analysis of radionuclides**: Isotope dilution technique, Neutron activation analysis and radiometric titrations. Radiometry method for α, β, γ radiation, isotopic enrichment, application of mass spectrometry (Basics, TIMS, ICP-MS, AMS methods). Numerical problems.	

Recommended Books:

1. Environmental Chemistry, S.E. Manahan, CRC Press/ Lewis Publishers, (1994).
2. Environmental Chemistry with Green Chemistry, A. K. Das, Books and Allied (P) Ltd,(2012).
3. Environmental Chemistry, A.K. Dey, New Age International, (P) Ltd, Publishers, New Delhi (2006).
4. Environmental Chemistry, B.K. Sharma, Goel Publishing House (1981).
5. Environmental Science and Technology, S.E. Manahan, Lewis Publishers, New York (1997).
6. Environmental pollution analysis, S. M. Khopkar, New Age International Pvt. Ltd. Publishers, New Delhi (1995).
7. Chemistry and Analysis of Radionuclides, Laboratory techniques and methodology, Prof. Jukka Lehto and Dr. Xiaolin Hou, Wiley-VCH verlag Gmbh and Co.KGaA, John Wiley & Sons (2011).

Formative Assessment for Theory		
Sl. No	Assessment Occasion / type	Marks
01	Internal Assessment test 1	10
02	Internal Assessment test 2	10
	Total	20 Marks
Formative Assessment as per the guidelines		

M.Sc Semester – IV
Analytical Chemistry (Practical)

Course Title: Lab course in Analytical Chemistry
Course Code: A4CHE105DP

Type of Course	Theory/ Practical	Credits	Instruction Hour per week	Total No. of Lectures / Hours / Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC – 25	**Practical**	**02**	**04**	**60 Hrs.**	**4 Hrs.**	**10**	**40**	**50**

Course outcomes:

1. Students will understand the chemistry involved in the analysis of various parameters of water samples.
2. Students will gain the knowledge about analysis of soil samples.

Lab course in Analytical Chemistry: A4CHE105DP	**60 Hrs.**
Experiments 1. Analysis of water for alkalinity and acidity by pH metric method. 2. Determination of strength of commercial phosphoric acid by pH titration. 3. Determination of ammonia in house hold cleaners by conductometric titrations. 4. Determination of sodium and potassium in soil by flame photometry. 5. Determination of phosphate in domestic waste water by spectrophotometry. 6. Determination of DO, BOD and COD of a waste water sample by titrimetry 7. Determination of fluoride by spectrophotometric method 8. Soil analysis. 9. Determination of nitrite in a water sample by titrimetry.	

Recommended Books:

1. A text Book of Quantitative Inorganic Analysis– A.I Vogel (1979).
2. Vogel's Text Book of Quantitative inorganic Analysis, Basset, Denney, Jeffery & Mendham (2019).
3. Colorimetric Determination of Traces of Metals– E.B Sandell (1959).
4. Analytical Chemistry– G.D Christian, 4th edition, Wiley, (1986).

Formative Assessment for Practical		
Sl. No	Assessment Occasion / type	Marks
01	Internal Assessment test 1	10
	Total	10 Marks
Formative Assessment as per the guidelines		

M.Sc Semester – IV
Analytical Chemistry (Theory)

Course Title: Quality Control, Analysis of Food, Beverages and Pharmaceuticals

Course Code: A4CHE102DT

Type of Course	Theory/ Practical	Credits	Instruction Hour per week	Total No. of Lectures / Hours / Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC – 22	**Theory**	**04**	**04**	**60 Hrs.**	**3 Hrs.**	**20**	**80**	**100**

Course outcomes:

1. Students will realize the importance of quality control.
2. Students will acquire knowledge about the analysis of beverages, food preservatives and adulterants.
3. Students will learn about different class of drugs and their assay by instrumental/volumetric methods.
4. Students will acquire knowledge on the analysis of dairy products and edible oils and their adulterants.

Quality Control, Analysis of Food, Beverages and Pharmaceuticals : A4CHE102DT	**60 Hrs.**
UNIT-I: Quality Control	**15 Hrs.**
An introduction to quality control and quality assurance: Basic concepts, quality assurance, aspects of specification and tolerance, quality acceptance, sampling, reliability, cost aspects of quality decisions. Importance of quality control: Drugs and pharmaceuticals. Sources of impurities in pharmaceutical chemicals. Quality control in raw materials, production (in process), finished product. Current Good Manufacturing Practices (CGMPs) and ICH guidelines. Current trends in quality control, ISO-9000 and ISO-14000 series. Laws related to quality control. Case studies of quality control in various industries such as plastics and polymers, fertilizers, agrochemicals, petrochemicals and pharmaceuticals. Numerical problems.	
UNIT-II: Analysis of Beverages, Food Preservatives and Adulterants	**15 Hrs.**
Soft drinks, alcoholic drinks, tea, coffee and fruit juices. Analysis of Caffeine in coffee and tannin in tea, detection of chicory in coffee, chloral hydrate in toddy. Estimation of methyl alcohol in alcoholic beverages, poisonous materials derived from containers. Food preservatives like sodium benzoate, sodium propionate, sodium sulphate, potassium metabisulphate (qualitative and quantitative analysis). Food Adulterants: Artificial sweeteners like saccharin and dulcin, coal tar dyes and	

non-permitted colors and trace metals, detection and estimation. Numerical problems.	
UNIT-III: Drugs and Pharmaceutical Analysis	
Antibiotics: Classification, structure elucidation, stereochemistry and reaction mechanism of ciprofloxacin, tetracycline and chloramphenicol. Analysis of common drugs: Analgesics: Aspirin and paracetamol. Antihelmentics: Mebendazole. **Antiallergies:** Chlorapheneramine malleate, cetirizine. Anti-inflammatory agents: Oxyphenbutazone, diclofenac. Antimalerials: Chloroquine. Antituberculosists: Isoniazid (INH) **Narcotics:** Nicotine, morphine. **Sedatives:** Diazepam. Vitamins: A, B_1, B_2, B_6, C, B_{12}& folic acid. Numerical problems.	
UNIT-IV: Analysis of dairy products and edible oils	
Chemistry, principles and analysis of liquids (edible): (i) general composition of edible oils, qualitative tests to purity, rancidity of fats and oil, estimation of rancidity, hydrogenated fat, tests for common edible oils like groundnut oil & mustard oil. Tests for adulterants like argemoss oil & mineral oils and (ii) analytical principles in the analysis of dairy products composition of milk and milk products, alcohol test, dye reduction. Methylene blue and resazurin tests. Tests to distinguish between butter and margarine, phosphate tests for efficacy of pasteurization. Analysis of fat content. Estimation of added water in milk. Test for adulterants (sugar, urea, salt) and preservatives (hydrogen peroxide, hypochlorites, formaldehyde, boric acid and borates). Numerical problems.	

Recommended Books:

1. Analysis of Foods, H. E. Cox (1938).
2. Chemical Analysis of Foods, H. E. Cox (2017).
3. Foods: Facts and Principles; N. Shakuntala Many and S. Swamy, 4th Ed., New Age International (1998).
4. Pharmaceutical analysis: Ed. By T. Higuchi and E. B. Hanssen, Wiley New York (1961).
5. Quantitative analysis of drugs: D. C. Garratt, Chappman and Hall, New York, 3rd Ed, (2012).
6. Drugs and Pharmaceutical sciences Series; Marcel Dekkar, Vol. II, INC. New York (2000).

Formative Assessment for Theory		
Sl. No	Assessment Occasion / type	Marks
01	Internal Assessment test 1	10
02	Internal Assessment test 2	10
	Total	20 Marks
Formative Assessment as per the guidelines		

M.Sc Semester – IV
Analytical Chemistry (Practical)

Course Title: Lab course in Analytical Chemistry
Course Code: A4CHE106DP

Type of Course	Theory/ Practical	Credits	Instruction Hour per week	Total No. of Lectures / Hours / Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC – 26	**Practical**	**02**	**04**	**60 Hrs.**	**4 Hrs.**	**10**	**40**	**50**

Course outcomes:

1. Students will be able to develop skills for the analysis of different class of drugs and food samples
2. Students will learn the chemistry of analysis of variety of samples

Lab course in Analytical Chemistry : A4CHE106DP	**60 Hrs.**
Experiments 1. Analysis of medicines: APC tablet, paracetomol, sulpha drugs by potentiometry/spectrophotometry/titrimetry. 2. Assay of aspirin / caffeiene / phenacetin by spectrophoptmetry. 3. Determination of vitamin A in vanaspathi by UV spectrophotometry. 4. Isolation of casein and lactose from milk 5. Food analysis: Determination of iron in mustard seeds and sugar, phosphorus in peas, ascorbic acid in tomato, benzoic acid in food products. 6. Determination of iodine value of an oil sample. 7. Determination of saponification value of an oil sample. 8. Analysis of iodine in table salt.	

Recommended Books:

1. A text Book of Quantitative Inorganic Analysis– A. I. Vogel (1979).
2. Vogel's Text Book of Quantitative inorganic Analysis, Basset, Denney, Jeffery & Mendham (2019).
3. Colorimetric Determination of Traces of Metals– E. B. Sandell (1959).
4. Analytical Chemistry - G. D. Christian, 4th Ed, Wiley, (1986).

Formative Assessment for Practical		
Sl. No	Assessment Occasion / type	Marks
01	Internal Assessment test 1	10
	Total	10 Marks
Formative Assessment as per the guidelines		

M.Sc Semester – IV
Analytical Chemistry (Theory)

Course Title: Selected Topics in Analytical Chemistry-III
Course Code: A4CHE103DT

Type of Course	Theory/ Practical	Credits	Instruction Hour per week	Total No. of Lectures / Hours / Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC – 23	**Theory**	**04**	**04**	**60 Hrs.**	**3 Hrs.**	**20**	**80**	**100**

Course outcomes:

1. Students will realize the importance of analysis of biomedical samples for diagnosis of diseases.
2. Students will acquire knowledge about the chemistry involved in the analysis of variety of ores, minerals and fertilizers.
3. Students will learn about analytical methods for the determination of metal ions in different ores and minerals besides the analysis of fertilizers.
4. Students will acquire knowledge on methods of oil refineries.

Selected Topics in Analytical Chemistry-III : A4CHE103DT	**60 Hrs.**
UNIT-I: Analysis of Biomedical samples	
Composition of body fluids and detection of abnormal levels of certain constituents leading to diagnosis of disease. Sample collection and preservation of physiological fluids, analytical methods for the constituents of physiological fluids (blood, serum, urine).Blood-determination of glucose, cholesterol, urea, hemoglobin and bilirubin. Urine: Urea, uric acid, creatinine, calcium phosphate, sodium, potassium and chloride. Biological significance, analysis and assay of enzymes (pepsin, monoaminoxide, tyrosinase) and hormones (progesterone, oxytocin, insulin). Chemical, instrumental and biological assays to be discussed wherever necessary. Determination of poisonous materials such as lead, mercury and arsenic in biological materials. Numerical problems.	
UNIT-II: Analysis of Ores, Minerals and Fertilizers	
Composition, properties and analysis of minerals and ores: Heamatite, pyrolusite, dolomite, bauxite, limestone, illmenite, gypsum and galena. **Fertilizer analysis:** Types, analysis of nitrogenous fertilizers, organic nitrogenous, phosphatic and potassic fertilizers. **Pesticide and insecticide analysis**: introduction, classification and analysis of DDT, gammexane, endosulphon, zinaf, ziram, malathian, thiram, thiometon, simazine & chloridane. Numerical problems.	

UNIT-III: Metals, Alloys and Cement Analysis	
Steel, Cu-Ni alloy, solder, bronze. brass, aluminum alloy, molybdenum, chromium, titanium and vanadium. **Analysis of structural materials**: Cement and glass. **Analysis of refractory materials**: Fireclay, fluorspar. Analysis of cement. Solid fuels-ultimate and proximate analysis, caloric values, grading of coal. Liquid fuels- flash point, aniline point, carbon residues. Gaseous fuels- Producer gas and water gas. Numerical problems.	
UNIT-IV: Analytical procedures in refineries	
Types of crude oil (sweet and sour), composition of crude oil, causes for corrosion in refinery (sulfidic & naphthenic acid), crude oil refining, fractional distillation (atmospheric and vacuum distillation). Purification processes (Merox, alkylation, reformulation, hydrotreating, cracking etc.). Products of refinery (naphtha, gasoline, diesel, furnace oil, lube oil etc.), residues of refining processes (sulfur, pet coke). Specifications of gasoline, jet fuel and diesel in India and abroad. Paraffins, iso-paraffins, olefins, naphthenes, aromatics. **Analytical techniques used in crude oil and products evaluation**: True boiling point distillation, spectroscopic evaluation (NIR & FTIR), density, viscosity, cloud point, pourpoint, PIONA analysis in gasoline, simulated distillation, GC-MS, HPLC, cetane number and octane number. Numerical problems.	

Recommended Books:

1. Technical methods of analysis: R.C. Griggin (2015)
2. Analytical Chemistry: Principles;J.H.Kennedy,2nd Ed., Saunders (1990)
3. Principles of Instrumental methods of analysis: Skoog, Holler and Nieman, 5th Ed., Saunders (1998)
4. Quantitative analysis: Day and Underwood, Prentice Hall (1998).
5. Fundamentals of petroleum refining: M.A. Fahim, T.A. Alsahhaf and Amal Elkilani,ElsevierScience,ISBN;978□0□444□52785□1
6. Analytical methods in petroleum upstream applications. Etd., by Cesar Ovalles, Carl E. Rechsteiner Jr., CRC Press, Taylor and Francis Group (2015)
7. Industrial Chemistry: B.K. Sharma, Goel Publishing House
8. Quantitative analysis, An instrumental approach: Srivastava and Jain, S. Chand (1997)
9. Biochemistry: The chemical reactions of living cells. D.E. Metzler, Academic Press (1995).

10. Enzymes Chemistry: Impact and application Edn. Collin J. Suckling, Academic Press (1990).

Formative Assessment for Theory		
Sl. No	Assessment Occasion / type	Marks
01	Internal Assessment test 1	10
02	Internal Assessment test 2	10
	Total	20 Marks
Formative Assessment as per the guidelines		

M.Sc Semester – IV
Analytical Chemistry (Practical)

Course Title: Lab course in Analytical Chemistry
Course Code: A4CHE007DP

Type of Course	Theory/ Practical	Credits	Instruction Hour per week	Total No. of Lectures / Hours / Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC – 27	**Practical**	**02**	**04**	**60 Hrs.**	**4 Hrs.**	**10**	**40**	**50**

Course outcomes:

1. Students will be able to develop skills for the analysis of ores, alloys, fertilizers and cement by different methods
2. Students will learn the analysis of body fluids such as cholesterol, glucose in blood besides uric acid and creatinine in urine samples

Lab course in Analytical Chemistry: A4CHE007DP	**60 Hrs.**
Experiments 1. Analysis of fertilizers: Urea, superphosphates 2. Analysis of pyrolusite ore 3. Analysis of alloys: solder, copper-nickel and bronze 4. Analysis of cement 5. Determination of aluminum and magnesium in a mixture 6. Analysis of Stainless steel-Ni gravimetrically using DMG, Fe volumetrically using Ce (IV) and Cr (VI) volumetrically by persulphate oxidation, 7. Analysis of body fluids: Determination of cholesterol, glucose in blood; uric acid, creatinine in urine.	

Recommended Books:

1. A text Book of Quantitative Inorganic Analysis– A.I Vogel (1979).
2. Vogel's Text Book of Quantitative inorganic Analysis, Basset, Denney, Jeffery & Mendham (2019).
3. Colorimetric Determination of Traces of Metals– E.B. Sandell (1959).
4. Analytical Chemistry– G.D Christian, 4th edition, Wiley, (1986)

Formative Assessment for Practical		
Sl. No	Assessment Occasion / type	Marks
01	Internal Assessment test 1	10
	Total	10 Marks
Formative Assessment as per the guidelines		

M.Sc. Semester – IV
Analytical Chemistry (Project Work)

Course Title: Project Work
Course Code: A4CHE004DP

Type of Course	Theory/ Practical	Credits	Instruction Hour per week	Total No. of Lectures / Hours / Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC – 24	**Practical**	**06**	**04**	**60 Hrs.**	**8 Hrs.**	**30**	**120**	**150**

Course Outcomes (COs)

After completion of this course successfully, the students will be able to……

1. identify the research problem.
2. carry out literature search on a research topic.
3. design new experiments to address research problems.
4. conduct experiments in a scientific way.
5. analyze and interpret the results.
6. write the research articles.

The project work may include in–plant training in industries/short term work in the Department/other educational institutions/R&D organizations/data mining/review of current literature/theoretical methods/computer applications. Experimental work may involve studies on synthesis/measurements/study of properties/characterization by physical methods/activities for reported/unreported research or any suitable combination thereof. In case of the students who would work outside the campus, the supervising staff member may visit to the work place at least once during the period and may be eligible for TA-DA as per the University rules.