DEPARTMENT OF
CHEMISTRY

Curriculum and Syllabus for
Undergraduate Programmes
under Credit Semester System
(with effect from 2019 admissions)

St Berchmans College
Founded 1922
AUTONOMOUS | College with Potential for Excellence | Reaccredited by NAAC with A Grade
Affiliated to Mahatma Gandhi University, Kottayam, Kerala
Changanassery, Kottayam, Kerala, India-686101

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Department of Chemistry of St Berchmans College, with immense privilege under autonomous status, is presenting the undergraduate syllabus for an effective science education to the students. The curriculum being restructured by giving more importance to different aspects such as creativity, environmental impact due to the development of technology, current development in science and operational skill of various instruments. The academic skills imparted to the students during UG programme make them competent to meet the requirements of a developing country.

The programme is designed by incorporating various units in a systematic and more meaningful manner for the core as well as complementary courses.

The syllabi are prepared to give sound knowledge and understanding of Chemistry to a graduate student and will expose the students to various fields of science. The curriculum is designed after a thorough discussion with academic experts from diverse fields and by considering the existing BSc syllabi of other universities and model curriculum proposed by UGC in order to get continuity in the learning process from the new syllabi of NCERT, which will meet the demands of a science aspirant.

BOARD OF STUDIES

1.	Dr. P C Thomas (HoD & Chairman)	Associate Professor Department of Chemistry St Berchmans College, Changanassery
2.	Dr. Kuruvilla Joseph	Senior Professor & Dean Indian Institute of Space Science & Technology Thiruvananthapuram
3.	Dr. K. Girish Kumar	Professor & Head Department of Applied Chemistry Cochin University of Science and Technology
4.	Dr. Suneesh C. V.	Assistant Professor Department of Chemistry University of Kerala Thiruvananthapuram
5.	Dr. Anas S	Assistant Professor School of Chemical Sciences MG University Kottayam
6.	Mr. Siby Sebastian	Managing Director Sharkline Industries Industrial Estate Nagar Changanassery
7.	Dr. K C Philip	Associate Professor Department of Chemistry St Berchmans College, Changanassery
8.	Dr. Tomlal Jose E	Assistant Professor Department of Chemistry St Berchmans College, Changanassery
9.	Dr. Renjith Thomas	Assistant Professor Department of Chemistry St Berchmans College, Changanassery
10.	Mr. Aravind K	Assistant Professor Department of Chemistry St Berchmans College, Changanassery
11.	Dr. Bejoy Francis	Assistant Professor Department of Chemistry St Berchmans College, Changanassery
12.	Dr. Shijo K Cherian	Assistant Professor Department of Chemistry St Berchmans College, Changanassery
13.	Dr. Cyril Augustine V	Assistant Professor Department of Chemistry St Berchmans College, Changanassery
14.	Dr. Jinesh M Kuthanapillil	Assistant Professor Department of Chemistry St Berchmans College, Changanassery
15.	Mr. Subin Joseph	Assistant Professor Department of Chemistry St Berchmans College, Changanassery

16.	Lt. James Baben George	Assistant Professor Department of Chemistry St Berchmans College, Changanassery
17.	Dr. Benny Thomas	Assistant Professor Department of Chemistry St Berchmans College, Changanassery
18.	Dr. Sam John	Assistant Professor Department of Chemistry St Berchmans College, Changanassery
19.	Dr. Ajith James Jose	Assistant Professor Department of Chemistry St Berchmans College, Changanassery
20.	Dr. Renchu Scaria	Assistant Professor Department of Chemistry St Berchmans College, Changanassery
21.	Mrs. Sajini T	Assistant Professor Department of Chemistry St Berchmans College, Changanassery

Programme Objectives

To equip the students

- to understand the basic facts and concepts in Chemistry
- to develop the interest in the study of Chemistry
- to appreciate the achievements in Chemistry
- to familiarize with the emerging areas in Chemistry
- to develop skills in the proper handling of apparatus, instruments and chemicals
- to familiarize the industrial activities related to Chemistry

Programme Outcome

After the successful completion of the programme the learners shall

- develop the interest in the study of Chemistry
- appreciate the achievements in Chemistry
- familiarize with the emerging areas in Chemistry
- develop skills in the proper handling of apparatus, instruments and chemicals
- familiarize the industrial activities related to Chemistry

REGULATIONS FOR UNDERGRADUATE (UG) PROGRAMMES UNDER CREDIT SEMESTER SYSTEM (SB-CSS-UG) 2019

1. SHORT TITLE

1.1 These Regulations shall be called St. Berchmans College (Autonomous) Regulations (2019) governing undergraduate programmes under Credit Semester System.

1.2 These Regulations shall come into force with effect from the academic year 2019 - 20 onwards.

2. SCOPE

2.1 The regulation provided herein shall apply to all regular undergraduate programmes, BA/BSc/BCom/BCA, conducted by St. Berchmans College (Autonomous) with effect from the academic year 2019 - 20.

3. DEFINITIONS

3.1 'University' means Mahatma Gandhi University, Kottayam, Kerala.

3.2 'College' means St. Berchmans College (Autonomous).

3.3 There shall be an Academic Committee nominated by the Principal to look after the matters relating to the SB-CSS-UG system.

3.4 'Academic Council' means the Committee consisting of members as provided under section 107 of the University Act 2014, Government of Kerala.

3.5 'Parent Department' means the Department, which offers a particular undergraduate programme.

3.6 'Department Council' means the body of all teachers of a Department in the College.

3.7 'Faculty Mentor' is a teacher nominated by a Department Council to coordinate the continuous evaluation and other academic activities of the undergraduate programme undertaken in the Department.

3.8 'Programme' means a three year programme of study and examinations spread over six semesters, the successful completion of which would lead to the award of a degree.

3.9 'Duration of Programme' means the period of time required for the conduct of the programme. The duration of an undergraduate programme shall be six (6) semesters.

3.10 'Semester' means a term consisting of a minimum 90 working days, inclusive of tutorials, examination days and other academic activities within a period of six months.

3.11 'Course' means a portion of a subject to be taught and evaluated in a semester.

3.12 'Course Teacher' means the teacher who is taking classes on the course.

3.13 'Core Course' means a course in the subject of specialization within a degree programme. It includes a course on environmental studies and human rights.

3.14 'Complementary Course' means a course, which would enrich the study of core courses.

3.15 'Common Course I' means a course that comes under the category of courses for English.

3.16 'Common Course II' means additional language, which can be opted by a student, from among the languages offered by the College.

3.17 The Common Course I and II is compulsory for all students undergoing undergraduate programmes.

3.18 'Open Course' means a course offered by the departments other than the parent department outside the field specialization of the student, which can be opted by a student.

3.19 'Elective Course' means a course, which can be substituted, by equivalent course from the same subject.

3.20 'Vocational Course' means a course that enables the students to enhance their practical skills and ability to pursue a vocation in their subject of specialization.

3.21 'Audit Course' means a course opted by the students, in addition to the compulsory courses, in order to develop their skills and social responsibility.

3.22 'Extra Credit Course' means a course opted by the students, in addition to the compulsory courses, in order to gain additional credit that would boost the performance level and additional skills.

3.23 Extra credit and audit courses shall be completed by working outside the regular teaching hours.

3.24 There will be two categories of extra credit courses, mandatory and optional. If a candidate fails to complete the mandatory course, he/she shall complete the same within the tenure of the programme. The details of the extra credit and audit courses are given below:

Semester	Course	Type
I	Course on Basic Life Support System and Disaster Management	Compulsory, audit course, Grades shall be given
I to VI	Value Education	Compulsory, extra credit
	Virtual Lab experiments/MOOC	Optional, extra credit
II & III	Add on Course	Compulsory, extra credit, Grades shall be given
Summer vacation following semester II	50 hours (10 days) Social Awareness Programme	Compulsory, extra credit, Grades shall be given
IV	Internship/Skill Training	Compulsory, audit course, Grades shall be given
V	Finishing School	Compulsory, audit course

3.25 'On the Job Training' means a job training course given to the students to acquaint them with various industrial skills.

3.26 'Project' means a regular project work with stated credits on which the student conducts a project under the supervision of a teacher in the parent department/any appropriate research centre in order to submit a dissertation on the project work as specified.

3.27 'Dissertation' means a minor thesis to be submitted at the end of a research work carried out by each student on a specific area.

3.28 'Plagiarism' is the unreferenced use of other authors' material in dissertations and is a serious academic offence.

3.29 'Seminar' means a lecture expected to train the student in self-study, collection of relevant matter from books and internet resources, editing, document writing, typing and presentation.

3.30 'Improvement Examination' is an examination conducted to improve the performance of a student in the courses of a particular semester as per the exam manual.

3.31 'Supplementary Examination' is an examination conducted for students who fail in the courses of a particular semester as per the exam manual.

3.32 The minimum credits, required for completing an undergraduate programme is one hundred and twenty (120).

3.33 'Credit' (C) of a course is a measure of the weekly unit of work assigned for that course in a semester.

3.34 'Course Credit': One credit of the course is defined as a minimum of one (1) hour lecture/minimum of two (2) hours lab/field work per week for eighteen (18) weeks in a semester. The course will be considered as completed only by conducting the final examination.

3.35 'Grade' means a letter symbol (A, B, C etc.) which indicates the broad level of performance of a student in a course/semester/programme.

3.36 'Grade Point' (GP) is the numerical indicator of the percentage of marks awarded to a student in a course.

3.37 'Credit Point' (CP) of a course is the value obtained by multiplying the grade point (GP) by the credit (C) of the course.

3.38 'Semester Grade Point Average' (SGPA) of a semester is calculated by dividing total credit points obtained by the student in a semester by total credits of that semester and shall be rounded off to two decimal places.

3.39 'Cumulative Grade Point Average' (CGPA) is the value obtained by dividing the sum of credit points in all the courses obtained by the student for the entire programme by the total credits of the whole programme and shall be rounded off to two decimal places.

3.40 'Institution Average' is the value obtained by dividing the sum of the marks obtained by all students in a particular course by the number of students in the respective course.

3.41 'Weighted Average Score' means the score obtained by dividing sum of the products of marks secured and credit of each course by the total credits of that semester/programme and shall be rounded off to two decimal places.

3.42 'Grace Marks' means marks awarded to course/courses as per the choice of the student, in recognition of meritorious achievements of a student in NCC/NSS/sports/arts and cultural activities.

3.43 First, Second, Third, Fourth and Fifth position shall be awarded to students who come in the first five places based on the overall CGPA secured in the programme in the first chance itself.

4. PROGRAMME STRUCTURE

4.1. The programme shall include core courses, vocational courses, complementary courses, common courses, open course and elective courses. There shall be a project/dissertation to be undertaken by all students. The programme will also include assignments, seminars, practical, viva-voce, OJT, field visit, industry visit etc., if they are specified in the curriculum.

4.2. Total credits for a programme is one hundred and twenty (120). The credit distribution for various UG programmes is shown below.

Model I BA/BSc

i.	Programme duration	6 Semesters
ii.	Total credits required for successful completion of the programme	120
iii.	Minimum credits required from Core + Elective + Project + Complementary courses	79
iv.	Minimum credits required from Common courses	38
v.	Minimum credits required from Open course	3
vi.	Minimum attendance required	75%

4.3. **Project/Dissertation**

All students shall do a project/research work in the area of core course in the sixth semester. The project/ research work shall be done individually or as a group of maximum five (5) students. The projects/research work shall be identified during the fourth semester of the

programme with the help of the supervising teacher. The report of the project/research work shall be submitted to the department during sixth semester and shall be produced before the examiners appointed by the College. The project report/dissertation shall be subject to internal and external evaluation followed by a viva-voce/defence.

4.4. **Evaluations**

The evaluation of each course shall contain two parts.

i Internal or In-Semester Assessment (ISA)

ii External or End-Semester Assessment (ESA)

Both ISA and ESA shall be carried out using indirect grading. The ISA:ESA ratio shall be 1:4, for courses with or without practical. There shall be a maximum of eighty (80) marks for external evaluation and twenty (20) marks for internal evaluation.

4.5. **In-semester assessment**

The components of the internal or in-semester assessment and their marks are as below.

Common Courses

There are four components for ISA, which include attendance, assignment/seminar and in-semester examinations. All the components of the internal assessment are mandatory.

Component	Marks
Attendance	2
Assignment/Seminar	5
Class test	5
Model examination	8
Total	**20**

Marks for attendance

% of Attendance	Marks
Above 90	2
75 – 90	1

(Decimals shall be rounded off to the next higher whole number)

Courses other than common courses without practical

Component	Marks
Attendance	2
Viva	4
Assignment/Seminar	4
Class test	4
Model examination	6
Total	**20**

Marks for attendance

% of Attendance	Marks
Above 90	2
75 – 90	1

(Decimals shall be rounded off to the next higher whole number)

Courses other than common courses with practical

Component	Marks
Attendance	2
Viva	3
Assignment/Seminar	2
Class test	3
Model examination	5
Total	**15**

Marks for attendance

% of Attendance	Marks
Above 90	2
75 – 90	1

(Decimals shall be rounded off to the next higher whole number)

Internal assessment of practical courses

The internal assessment of practical courses shall be conducted either annually or in each semester. The components for internal assessment are given below.

Internal assessment of practical courses evaluated in each semester

Component	Marks
Attendance	1
Lab Test	2
Record*	2
Total	**5**

*Marks awarded for Record shall be related to number of experiments/practicals recorded.

Marks for attendance

% of Attendance	Marks
Above 75	1

(Decimals shall be rounded off to the next higher whole number)

Internal assessment of practical courses evaluated annually

Component	Marks
Attendance	2
Lab Test	4
Record*	4
Total	**10**

*Marks awarded for Record shall be related to number of experiments/practicals recorded.

Marks for attendance

% of Attendance	Marks
Above 90	2
75 – 90	1

(Decimals shall be rounded off to the next higher whole number)

4.6. **Assignments**

Assignments shall be submitted for every course in the first four semesters. At least one assignment for each course shall be submitted in each semester.

4.7. **Seminar**

A student shall present a seminar in the fifth and sixth semesters.

4.8. **In-semester examination**

Every student shall undergo at least two in-semester examinations as class test and model examination as internal component for every course.

4.9. To ensure transparency of the evaluation process, the ISA mark awarded to the students in each course in a semester shall be published on the notice board according to the schedule in the academic calendar published by the College. There shall not be any chance for improvement of ISA. The course teacher and the faculty mentor shall maintain the academic record of each student registered for the course which shall be forwarded to the office of the Controller of Examinations through the Head of the Department and a copy shall be kept in the office of the Head of the Department for at least two years for verification.

4.10. A student who has not secured minimum marks in internal examinations can redo the same before the end semester examination of the semester concerned.

4.11. **End-semester assessment**

The end-semester examination in theory and practical courses shall be conducted by the College.

4.12. The end-semester examinations shall be conducted at the end of each semester. There shall be one end-semester examination of three (3) hours duration in each lecture based course.

4.13. The question paper shall be strictly on the basis of model question paper set by Board of Studies.

4.14. A question paper may contain short answer type/annotation, short essay type questions/problems and long essay type questions. Marks for each type of question can vary from programme to programme, but a general pattern may be followed by the Board of Studies.

4.15. End-semester Examination question pattern shall be as given below.

Courses without practical

Section	Total No. of Questions	Questions to be Answered	Marks	Total Marks for the Section
A	12	10	2	20
B	9	6	5	30
C	4	2	15	30
			Maximum	**80**

Courses with practical

Section	Total No. of Questions	Questions to be Answered	Marks	Total Marks for the Section
A	12	10	2	20
B	9	6	4	24
C	4	2	8	16
			Maximum	**60**

4.16. Photocopies of the answer scripts of the external examination shall be made available to the students for scrutiny as per the regulations in the examination manual.

4.17. Practical examination shall be conducted annually or in each semester. The duration and frequency of practical examination shall be decided by the respective Board of Studies.

4.18. Practical examination shall be conducted by one external examiner and one internal examiner.

4.19. The marks for end-semester theory and practical examinations are given below.

Course	Marks
Courses without practical	80
Course with practical	60
Practical (assessment in each semester)	20
Practical (odd and even semester combined)	40

4.20. The project report/dissertation shall be subject to internal and external evaluation followed by a viva-voce at the end of the programme. Internal Evaluation is to be done by the supervising teacher and external evaluation by an external evaluation board consisting of an examiner appointed by the Controller of Examinations and the Head of the Department or his nominee. A viva-voce/defence related to the project work shall be conducted by the external evaluation board and students have to attend the viva-voce/defence individually.

Components of Project Evaluation	Marks
Internal Evaluation	20
Dissertation (External)	50
Viva-Voce (External)	30
Total	**100**

4.21. If the student fails in project evaluation, he or she shall submit the project report/dissertation after modifying it on the basis of the recommendations of the examiners.

4.22. For all courses (theory and practical) an indirect grading system based on a seven (7) point scale according to the percentage of marks (ISA + ESA) is used to evaluate the performance of the student in that course. The percentage shall be rounded mathematically to the nearest whole number.

Percentage of Marks	Grade	Performance	Grade Point
95 and above	S	Outstanding	10
85 to below 95	A+	Excellent	9
75 to below 85	A	Very Good	8
65 to below 75	B+	Good	7
55 to below 65	B	Above Average	6
45 to below 55	C	Satisfactory	5
35 to below 45	D	Pass	4
Below 35	F	Failure	0

5. CREDIT POINT AND GRADE POINT AVERAGE

5.1. Credit Point

Credit Point (CP) of a course is calculated using the formula

CP = C × GP

where C is the credit and GP is the grade point.

5.2 Semester Grade Point Average

Semester Grade Point Average (SGPA) is calculated using the formula

SGPA = TCP/TCS

where TCP is the total credit point of all the courses in the semester and TCS is the total credits in the semester.

GPA shall be rounded off to two decimal places.

5.3 **Cumulative Grade Point Average**

Cumulative Grade Point Average (CGPA) is calculated using the formula

CGPA = TCP/TC

where TCP is the total credit point of all the courses in the whole programme and TC is the total credit in the whole programme

GPA shall be rounded off to two decimal places.

5.4 Grade **Point Average (GPA)** of different category of courses viz. Common Course I, Common Course II, Complementary Course I, Complementary Course II, Vocational Course, Core Course etc. are calculated using the formula

GPA = TCP/TC

where TCP is the Total Credit Point of a category of course and TC is the total credit of that category of course

Grades for the different courses, semesters, Semester Grade Point Average (SGPA) and grades for overall programme, Cumulative Grade Point Average (CGPA) are given based on the corresponding Grade Point Average (GPA) as shown below:

GPA	Grade	Performance
9.5 and above	S	Outstanding
8.5 to below 9.5	A+	Excellent
7.5 to below 8.5	A	Very Good
6.5 to below 7.5	B+	Good
5.5 to below 6.5	B	Above Average
4.5 to below 5.5	C	Satisfactory
3.5 to below 4.5	D	Pass
Below 3.5	F	Failure

5.5 A separate minimum of 30% marks each for internal and external (for both theory and practical) and aggregate minimum of 35% are required for a pass in a course.

5.6 For a pass in a programme, a separate minimum of grade 'D' is required for all the individual courses.

5.7 If a candidate secures F Grade for any one of the courses offered in a semester/programme, only F grade will be awarded for that semester/programme until the student improves this to D grade or above within the permitted period.

5.8 Candidate who secures D grade and above will be eligible for higher studies.

6 SUPPLEMENTARY/IMPROVEMENT EXAMINATION

6.1 There will be supplementary examinations and chance for improvement. Only one chance will be given for improving the marks of a course.

6.2 There shall not be any improvement examination for practical examinations and examinations of the final year.

7 ATTENDANCE

7.4 The minimum requirement of aggregate attendance during a semester for appearing the end semester examination shall be 75%. Condonation of shortage of attendance to a maximum of ten (10) days in a semester subject to a maximum of two times during the whole period of undergraduate programme may be granted by the College. This condonation shall not be counted for internal assessment.

7.5 Benefit of attendance may be granted to students representing the College, University, State or Nation in Sports, NCC, NSS or Cultural or any other officially sponsored activities such as

College union/University union activities etc., on production of participation/attendance certificates, within one week from competent authorities, for the actual number of days participated, subject to a maximum of ten (10) days in a semester, on the specific recommendations of the Faculty Mentor and Head of the Department.

7.6 A student who does not satisfy the requirements of attendance shall not be permitted to appear for the end-semester examinations.

7.7 Those students who are not eligible even with condonation of shortage of attendance shall repeat the course along with the next batch after obtaining readmission.

8 BOARD OF STUDIES AND COURSES

8.4 The Board of Studies concerned shall design all the courses offered in the UG programme. The Board shall design and introduce new courses, modify or re-design existing courses and replace any existing courses with new/modified courses to facilitate better exposure and training for the students.

8.5 The syllabus of a programme shall contain programme objectives and programme outcome.

8.6 The syllabus of a course shall contain the title of the course, course objectives, course outcome, contact hours, the number of credits, reference materials and model questions.

8.7 Each course shall have an alpha numeric code which includes abbreviation of the course in two letters, the semester number, course code and the serial number of the course.

8.8 Every programme conducted under Credit Semester System shall be monitored by the Academic Council.

9 REGISTRATION

9.4 A student who registers his/her name for the external examination for a semester will be eligible for promotion to the next semester.

9.5 A student who has completed the entire curriculum requirement, but could not register for the semester examination can register notionally, for getting eligibility for promotion to the next semester.

9.6 A student may be permitted to complete the programme, on valid reasons, within a period of twelve (12) continuous semesters from the date of commencement of the first semester of the programme.

9.7 The minimum strength of students for open courses is 15 and the maximum is 75 per batch.

9.8 Each student shall register for the open courses in the prescribed registration form in consultation with the faculty mentor during fourth semester. Faculty mentor shall permit registration on the basis of the preferences of the student and availability of seats.

10 ADMISSION

10.4 The admission to all UG programmes shall be as per the rules and regulations of the College/University.

10.5 The eligibility criteria for admission shall be as announced by the College/University from time to time.

10.6 Separate rank lists shall be drawn up for seats under reservation quota as per the existing rules.

10.7 There shall be an academic and examination calendar prepared by the College for the conduct of the programmes.

11 MARK CUM GRADE CARD

11.1 The College under its seal shall issue to the students, a Mark cum Grade Card on completion of each semester, which shall contain the following information.

i. Name of the Student

ii. Register Number
iii. Photo of the student
iv. Degree
v. Programme
vi. Semester and Name of the Examination
vii. Month and Year of Examination
viii. Stream
ix. Course Code, Title and Credits of each course opted in the semester
x. Marks for ISA, ESA, Total Marks (ISA + ESA), Maximum Marks, Letter Grade, Grade Point (GP), Credit Point (CP) and Institution Average in each course opted in the semester
xi. Total Credits, Marks Awarded, Credit Point, SGPA and Letter Grade in the semester
xii. Weighted Average Score
xiii. Result
xiv. Credits/Grade of Extra Credit and Audit Courses

11.2 The final Mark cum Grade Card issued at the end of the final semester shall contain the details of all courses taken during the entire programme including those taken over and above the prescribed minimum credits for obtaining the degree. The final Mark Cum Grade Card shall show the CGPA and the overall letter grade of a student for the entire programme.

11.3 A separate grade card shall be issued at the end of the final semester showing the extra credit and audit courses attended by the student, grade and credits acquired.

12 AWARD OF DEGREE

The successful completion of all courses other than extra credit and audit courses with 'D' grade shall be the minimum requirement for the award of the degree.

13 MONITORING COMMITTEE

There shall be a Monitoring Committee constituted by the Principal to monitor the internal evaluation conducted by the College. The Course Teacher, Faculty Mentor, and the College Coordinator shall keep all the records of the continuous evaluation, for at least a period of two years, for verification.

14 GRIEVANCE REDRESS MECHANISM

14.1 In order to address the grievance of students regarding ISA, a two-level grievance redress mechanism is envisaged.

14.2 A student can approach the upper level only if grievance is not addressed at the lower level.

14.3 Department level: The Principal shall form a Grievance Redress Committee in each Department comprising of course teacher and one senior teacher as members and the Head of the Department as Chairman. The Committee shall address all grievances relating to the internal assessment of the students.

14.4 College level: There shall be a College level Grievance Redress Committee comprising of Faculty Mentor, two senior teachers and two staff council members (one shall be an elected member) and the Principal as Chairman. The Committee shall address all grievances relating to the internal assessment of the students.

15. TRANSITORY PROVISION

Notwithstanding anything contained in these regulations, the Principal shall, for a period of three years from the date of coming into force of these regulations, have the power to provide

by order that these regulations shall be applied to any programme with such modifications as may be necessary.

REGULATIONS FOR ADD ON COURSES FOR UNDERGRADUATE PROGRAMMES

1. DEFINITIONS

1.1 'Add On Course General Coordinator' is a senior teacher nominated by the Principal to coordinate and monitor the Add On courses conducted by various departments.

1.2 'Add On Course Coordinator' is a teacher nominated by a Department Council to coordinate the evaluation and other academic activities of the Add On Course undertaken in the Department.

2. COURSE STRUCTURE

2.1 Add On Course shall be completed outside the regular teaching hours of the undergraduate programmes and shall be completed within the first four semesters of the programme.

2.2 The credit will be awarded only if the student get D grade (35% marks) and above.

2.3 A student can earn any number of extra credits according to his/her choice.

2.4 The minimum credits for an Add On Course shall be two (2).

3. EVALUATIONS

The evaluation of each course shall be done internally and contain two parts.

i. Continuous evaluation
ii. Final evaluation

Both continuous evaluation and final evaluation shall be carried out using indirect grading. The marks for continuous evaluation is twenty (20) and that of final evaluation is eighty (80).

Continuous evaluation

The components of the continuous evaluation and their marks are as below.

For all courses without practical

There are two components for continuous evaluation, which include attendance and assignment. All the components of the continuous evaluation are mandatory.

Components	Marks
Attendance	10
Assignment	10
Total	**20**

Marks for attendance

% of Attendance	Marks
90 and above	10
85 - 89	8
80 – 84	6
76 – 79	4
75	2

(Decimals shall be rounded mathematically to the nearest whole number)

For all courses with practical

The components for continuous evaluation of courses with practical are given below.

Components	Marks
Attendance	10
Lab involvement	10
Total	**20**

Marks for attendance

% of Attendance	Marks
90 and above	10
85 - 89	8
80 – 84	6
76 – 79	4
75	2

(Decimals shall be rounded mathematically to the nearest whole number)

Assignments

At least one assignment shall be submitted for each course.

4. FINAL EVALUATION

The final evaluation of theory and practical courses shall be conducted by the College/Department. It can be eighty marks written examination or eighty marks project/practical examination or eighty marks written and project/practical examination combined, as decided by the Board of Studies.

4.1 The question paper shall be strictly on the basis of model question paper set by Board of Studies.

4.2 A question paper may contain objective type, short answer type/annotation, short essay type questions/problems and long essay type questions.

4.3 The duration of written examination shall be decided by the respective Board of Studies and the duration of the practical examination shall be decided by the concerned course coordinator.

4.4 Practical examination shall be conducted by one internal examiner.

4.5 For all courses (theory and practical) an indirect grading system based on a seven (7) point scale according to the percentage of marks (ISA + ESA) is used to evaluate the performance of the student in that course. The percentage shall be rounded mathematically to the nearest whole number.

Percentage of Marks	Grade	Performance
95 and above	S	Outstanding
85 to below 95	A+	Excellent
75 to below 85	A	Very Good
65 to below 75	B+	Good
55 to below 65	B	Above Average
45 to below 55	C	Satisfactory
35 to below 45	D	Pass
Below 35	F	Failure

4.6 A separate minimum of 30% marks each for internal and external (for both theory and practical) and aggregate minimum of 35% are required for a pass in a course.

5. ATTENDANCE

The minimum requirement of aggregate attendance for appearing the final evaluation shall be 75%.

6. BOARD OF STUDIES AND COURSES

6.1 The Board of Studies concerned shall design the Add On Course offered by the department. The Board shall design and introduce new Add On Course, modify or redesign existing Add On

Course and replace any existing Add On course with new/modified Add On course to facilitate better exposure and training for the students.

6.2 The syllabus of an Add On course shall also include the title of the course, contact hours, the number of credits, reference materials and question paper pattern.

6.3 Each course shall have an alpha numeric code which includes programme code, abbreviation of the course in two letters, course code and serial number of the course

6.4 The Add On courses conducted under Credit Semester System shall be monitored by the Academic Council.

6.5 For redressing the complaints in connection with the conduct of Add On course, students shall approach the Grievance Redress Committee functioning in the college.

REGULATIONS FOR CERTIFICATE COURSE IN VALUE EDUCATION FOR UNDERGRADUATE PROGRAMMES

Value Education is a compulsory extra credit course for all the students admitted to the undergraduate programmes.

i. **Duration**

The duration of the course shall be three academic years (six semesters) spanning 60 hrs. There shall be minimum 20 hours in an academic year.

ii. **Evaluation**

The evaluation of each course shall contain two parts.

i. Continuous evaluation
ii. Final evaluation

There shall be a maximum of forty (40) marks for external assessment and ten (10) marks for internal assessment.

Continuous Evaluation

Assignment

The students are supposed to submit at least one assignment in every year and five (5) marks will be given for a submitted assignment

Attendance

The minimum requirement of aggregate attendance during a semester for appearing the end final examination shall be 75%.

Marks for attendance

Maximum of five (5) marks will be given for attendance as follows.

% of Attendance	Marks
90 and above	5
85-89	4
80-84	3
76-79	2
75	1

(Decimals shall be rounded off to the next higher whole number)

Final evaluation

The final examination shall be conducted by the course coordinator. The final assessment examination shall be conducted at the end of every year. There shall be an annual written examination of one and a half hours (1½) duration. The question paper shall be strictly on the basis of model question paper set by Expert Committee. A question paper consists of short answer type, short essay type and long essay type questions.

A separate minimum of 30% marks each for internal and external assessment (continuous and final evaluation) and aggregate minimum of 35% are required for a pass in a course.

iii. **Grading**

The total marks of the course shall be one hundred and fifty (150). The grading of the course is as follows:

Percentage of Marks	Grade	Performance
95 and above	S	Outstanding
85 to below 95	A+	Excellent
75 to below 85	A	Very Good
65 to below 75	B+	Good
55 to below 65	B	Above Average
45 to below 55	C	Satisfactory
35 to below 45	D	Pass
Below 35	F	Failure

iv. **Award of certificate**

The course is envisaged with three levels in three academic years. There shall be examination in every year. If a student does not acquire minimum marks he/she can continue with further levels. But he/ she shall be eligible to get certificate only after completing all the levels successfully. The certificate will be issued after completing all the levels with minimum grade D for the pass. On successful completion of the course, grade card shall be issued to the students indicating the grade. The college issues the certificate on value education to all the undergraduate students who successfully complete the course. The course shall be completed during the tenure of the programme.

REGULATIONS FOR COURSE ON BASIC LIFE SUPPORT SYSTEM AND DISASTER MANAGEMENT (BLS & DM)

i. The course on BLS & DM shall be conducted by a nodal centre created in the college.
ii. The nodal centre shall include at least one teacher from each department. A teacher shall be nominated as the Director of BLS & DM.
iii. The team of teachers under BLS & DM shall function as the trainers for BLS & DM.
iv. The team of teachers under BLS & DM shall be given intensive training on Basic Life Support System and Disaster Management and the team shall be equipped with adequate numbers of mannequins and kits for imparting the training to students.
v. Each student shall undergo five (5) hours of hands on training in BLS & DM organised by the Centre for BLS & DM.
vi. The training sessions shall be organised on weekends/holidays/vacation during the first semester of the programme.
vii. After the completion of the training, the skills acquired shall be evaluated using an online test and grades shall be awarded.
viii. Nodal centre for BLS & DM shall conduct online test and publish the results.
ix. The grading of the course is as follows:

Percentage of Marks	Grade	Performance
95 and above	S	Outstanding
85 to below 95	A+	Excellent
75 to below 85	A	Very Good
65 to below 75	B+	Good
55 to below 65	B	Above Average
45 to below 55	C	Satisfactory
35 to below 45	D	Pass
Below 35	F	Failure

x. Students who could not complete the requirements of the BLS & DM training shall appear for the same along with the next batch. There shall be two redo opportunity.
xi. For redressing the complaints in connection with the conduct of BLS & DM students shall approach the Grievance Redress Committee functioning in the college.

REGULATIONS FOR SOCIAL AWARENESS PROGRAMME (SAP)

i. Social Awareness Programme shall be conducted by a nodal centre created in the college.

ii. The nodal centre shall include at least one teacher from each department. A teacher shall be nominated as the Director of the SAP.

iii. The centre shall identify the areas where the students can serve the society through the SAP.

iv. During the first semester itself, the centre for SAP shall organise programmes to sensitize the students about the significance and relevance of SAP and publish a list of different areas where they can work as volunteers. Students shall register their preferences (three) with the centre for SAP. The centre shall allot students to various areas based on their preference. For the preparation of the allotment list, the marks obtained in the higher secondary examination shall also be used as a criterion. Centre for SAP shall take the help of the Head of the concerned department and the mentor(s) of the concerned batch at the time of finalization of the allotment list.

v. Students shall carry out the voluntary work allotted to them after the regular class hours/weekends/holidays falling in the second semester or the summer vacation following the second semester.

vi. Evaluation of the SAP activity shall be based on the hours of work put in by a student. A minimum of 50 hours of social work (corresponding to 50 marks) is required for the successful completion of SAP. Every additional work beyond the minimum 50 hours shall fetch five (5) marks per hour. Maximum marks shall be 100. Students who donate blood during the second semester shall be given 10 marks upon the production of the certificate from the medical officer. However, Marks earned through blood donation shall not be counted for a pass in the programme. Mark for blood donation shall be awarded only once during the SAP.

vii. Upon completion of SAP, the marks earned and the grades awarded shall be published by the Director of SAP. The grading is as follows:

Percentage of Marks	Grade	Performance
95 and above	S	Outstanding
85 to below 95	A+	Excellent
75 to below 85	A	Very Good
65 to below 75	B+	Good
55 to below 65	B	Above Average
45 to below 55	C	Satisfactory
35 to below 45	D	Pass
Below 35	F	Failure

viii. Two credits shall be awarded to students who complete the requirements of SAP.

ix. Students who could not complete the requirements of the SAP shall appear for the same with the next batch. There shall be two redo opportunity.

x. For redressing the complaints regarding allotment, harassment at the place of work, and the marks and grades awarded students shall approach the Grievance Redress Committee functioning in the college.

xi. Director of SAP has the right to exclude students who are physically handicapped from SAP.

REGULATIONS FOR INTERNSHIP/SKILL TRAINING PROGRAMME

i. Every UG student shall undergo an internship for a minimum period of five days (25 hours) at a centre identified by the concerned department. In the case of disciplines where internship opportunities are scanty (eg. Mathematics) special skill training programmes with duration of five days (25 hours) shall be organised.

ii. Each department shall identify a teacher in charge for internship/skill training programme.

iii. The department shall select institutions for internship/organising skill training programme.

iv. Internship/skill training programme shall be carried out preferably during the summer vacation following the fourth semester or during the Christmas vacation falling in the fourth semester or holidays falling in the semester.

v. At the end of the stipulated period of internship each student shall produce an internship completion cum attendance certificate and an illustrated report of the training he/she has underwent, duly certified by the tutor and Head of the institution where the internship has been undertaken.

vi. Students undergoing skill training programme shall submit a training completion cum attendance certificate and a report of the training he/she has underwent, duly certified by the trainer, teacher co-ordinator of the programme from the concerned department and the head of the department concerned.

vii. Upon receipt of the internship completion cum attendance certificate and illustrated report of the training or a training completion cum attendance certificate and a report of the training, the teacher in charge of internship/skill training programme shall prepare a list of students who have completed the internship/skill training programme and a list of students who failed to complete the programme. Head of the department shall verify the lists and forward the lists to the Controller of Examinations.

viii. Students who could not complete the requirements of the internship/skill training programme shall appear for the same with the next batch. There shall be only one redo opportunity.

REGULATIONS FOR FINISHING SCHOOL

i. The training to help students develop their soft skills and interview skills, 'the finishing school', shall be coordinated by a nodal centre.

ii. The nodal centre shall include at least one teacher from each department. A teacher shall be nominated as the Director of the nodal centre.

iii. The training shall impart soft skills comprising of language skills, personal presentation and grooming, resume preparation, group discussion techniques, and interview skills among the undergraduate students.

iv. This course shall be conducted during the fifth semester for all the undergraduate students.

v. There will be a total of 20 contact hours which shall be handled by a team of professional members/faculty. In addition, a one-day outbound training session by a team of professional trainers that touches on the aspects of creativity, problem solving and team building shall also be organized.

vi. The students shall be assessed and grades shall be awarded based on the components as shown below.

Component	Marks
Attendance	5
Class Test	10
Assignments	10
Group discussion	10
Interview	15
Total	**50**

vii. The grading of the course is as follows:

Percentage of Marks	Grade	Performance
95 and above	S	Outstanding
85 to below 95	A+	Excellent
75 to below 85	A	Very Good
65 to below 75	B+	Good
55 to below 65	B	Above Average
45 to below 55	C	Satisfactory
35 to below 45	D	Pass
Below 35	F	Failure

viii. For redressing the complaints in connection with the conduct of finishing school students shall approach the Grievance Redress Committee.

VIRTUAL LAB EXPERIMENTS/MOOC

i. There shall be a Nodal officer and a team of teachers to coordinate the logistics for conducting Virtual Lab experiments and MOOC courses and to authenticate the claims of the students regarding the successful completion of the Virtual Lab experiments and or MOOC courses.
ii. Students who are desirous to do Virtual Lab experiments and or MOOC courses shall register with the Nodal officer at the beginning of the experiment session/MOOC course. Students also shall submit proof of successful completion of the same to the Nodal officer.
iii. Upon receipt of valid proof, the nodal officer shall recommend, to the Controller of Examinations, the award of extra credits. In the case of Virtual Lab experiments, 36 hours of virtual experimentation shall equal one credit and in the case of MOOC courses 18 hours of course work shall equal one credit.
iv. College shall arrange infrastructure for taking up Virtual Lab experiments and/or MOOC courses.

Model Mark cum Grade Card

St Berchmans College
Founded 1922
AUTONOMOUS | College with Potential for Excellence | Reaccredited by NAAC with A Grade
Affiliated to Mahatma Gandhi University, Kottayam, Kerala
Changanassery, Kottayam, Kerala, India-686101

MARK CUM GRADE CARD

Date:

Name of the Candidate :

Permanent Register Number (PRN) :

Degree :

Programme :

Stream :

Name of Examination :

Photo

Course Code	Course Title	Credits (C)	Marks						Grade Awarded (G)	Grade Point (GP)	Credit Point (CP)	Institution Average	Result
			ISA		ESA		Total						
			Awarded	Maximum	Awarded	Maximum	Awarded	Maximum					
	Common Course I												
	Common Course II												
	Core Course												
	Complementary Course												
	Complementary Course												
	Total												
	Weighted Average Score												
	Semester Result												
	SGPA												
	End of Statement												

Entered by:

Verified by:

Controller of Examinations **Principal**

St Berchmans College
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AUTONOMOUS College with Potential for Excellence | Reaccredited by NAAC with A Grade
Affiliated to Mahatma Gandhi University, Kottayam, Kerala
Changanassery, Kottayam, Kerala, India - 686101, Tel: 91-481-2420025, 9961231314
E-mail: sbc@sbcollege.org Web: www.sbcollege.ac.in

CONSOLIDATED MARK CUM GRADE CARD

Photo

Name of the Candidate :

Permanent Register Number (PRN) :

Degree :

Programme :

Stream :

Date :

Course Code	Course Title	Credits (C)	Marks						Grade Awarded (G)	Grade Point (GP)	Credit Point (CP)	Institution Average	Result
			ISA		ESA		Total						
			Awarded	Maximum	Awarded	Maximum	Awarded	Maximum					
SEMESTER I													
	Common Course I **Common Course II** **Core Course** **Complementary Course** **Complementary Course**												

SEMESTER II													
	Common Course I **Common Course II** **Core Course** **Complementary Course** **Complementary Course**												
SEMESTER III													
	Common Course I **Common Course II** **Core Course** **Complementary Course** **Complementary Course**												
SEMESTER IV													
	Common Course I **Common Course II** **Core Course** **Complementary Course** **Complementary Course**												
SEMESTER V													
	Core Course **Open Course**												
SEMESTER VI													
	Core Course **Project**												

SEMESTER RESULTS

Semester	Marks Awarded	Maximum Marks	Credits	SGPA	Grade	Month & Year of Passing	Result
I II III IV V VI							

PROGRAMME PART RESULTS

Programme Part	Marks Awarded	Maximum Marks	Credits	CGPA	Grade
Common Course I: Common Course II: Core Course: Complementary Course: Complementary Course: Open Course:					
Total					

FINAL RESULT

CUMULATIVE GRADE POINT AVERAGE (CGPA) =

GRADE =

*** Separate grade card is issued for Audit and Extra Credit courses.**
**** Grace Mark awarded.**

Entered by:

Verified by:

Controller of Examinations **Principal**

Reverse side of the Mark cum Grade Card (COMMON FOR ALL SEMESTERS)

Description of the Evaluation Process

Grade and Grade Point

The evaluation of each course comprises of internal and external components in the ratio 1:4 for all Courses. Grades and Grade Points are given on a seven (7) point scale based on the percentage of Total Marks (ISA + ESA) as given in Table 1. Decimals are corrected to the nearest whole number.

Credit Point and Grade Point Average

Credit Point (CP) of a course is calculated using the formula

CP = C × GP

where C is the Credit and GP is the Grade Point

Grade Point Average of a Semester (SGPA) or Cumulative Grade Point Average (CGPA) for a Programme is calculated using the formula

SGPA or CGPA = TCP/TC

where TCP is the Total Credit Point for the semester/programme and TC is the Total Credit for the semester/programme

GPA shall be rounded off to two decimal places.

The percentage of marks is calculated using the formula;

$$\%\ \text{Marks} = \left(\frac{\text{total marks obtained}}{\text{maximum marks}}\right) \times 100$$

Percentage of Marks	Grade	Performance	Grade Point
95 and above	S	Outstanding	10
85 to below 95	A+	Excellent	9
75 to below 85	A	Very Good	8
65 to below 75	B+	Good	7
55 to below 65	B	Above Average	6
45 to below 55	C	Satisfactory	5
35 to below 45	D	Pass	4
Below 35	F	Failure	0

Table 1

Grades for the different Semesters and overall Programme are given based on the corresponding GPA, as shown in Table 2.

GPA	Grade	Performance
9.5 and above	S	Outstanding
8.5 to below 9.5	A+	Excellent
7.5 to below 8.5	A	Very Good
6.5 to below 7.5	B+	Good
5.5 to below 6.5	B	Above Average
4.5 to below 5.5	C	Satisfactory
3.5 to below 4.5	D	Pass
Below 3.5	F	Failure

Table 2

Weighted Average Score (WAS) is the score obtained by dividing sum of the products of marks secured and credit of each course by the total credits of that semester/programme and shall be rounded off to two decimal places.

Note: Course title followed by (P) stands for practical course. A separate minimum of 30% marks each for internal and external assessments (for both theory and practical) and an aggregate minimum of 35% marks is required for a pass in each course. For a pass in a programme, a separate minimum of Grade D for all the individual courses and an overall Grade D or above are mandatory. If a candidate secures Grade F for any one of the courses offered in a Semester/Programme, only Grade F will be awarded for that Semester/Programme until the candidate improves this to Grade D or above within the permitted period.

PROGRAMME STRUCTURE

Semester I

Sl. No.	Course Title	Hours/ Week	Credit	Marks
1	Common Course I	5	4	100
2	Common Course I	4	3	100
3	Common Course II	4	4	100
4	Core Course	2	2	75
5	Core Course Practical	2	Evaluation in Semester II	
6	Complementary Course: Mathematics	4	3	100
7	Complementary Course: Physics	2	2	75
8	Complementary Course Practical: Physics	2	Evaluation in Semester II	
	Total	**25**	**18**	**550**

Semester II

Sl. No.	Course Title	Hours/ Week	Credit	Marks
1	Common Course I	5	4	100
2	Common Course I	4	3	100
3	Common Course II	4	4	100
4	Core Course	2	2	75
5	Core Course Practical	2	2	50
6	Complementary Course: Mathematics	4	3	100
7	Complementary Course: Physics	2	2	75
8	Complementary Course Practical: Physics	2	2	50
	Total	**25**	**22**	**650**

Semester III

Sl. No.	Course Title	Hours/ Week	Credit	Marks
1	Common Course I	5	4	100
3	Common Course II	5	4	100
4	Core Course	3	3	75
5	Core Course Practical	2	Evaluation in Semester IV	
6	Complementary Course: Mathematics	5	4	100
7	Complementary Course: Physics	3	3	75
8	Complementary Course Practical: Physics	2	Evaluation in Semester IV	
	Total	**25**	**18**	**450**

Semester IV

Sl. No.	Course Title	Hours/ Week	Credit	Marks
1	Common Course I	5	4	100
2	Common Course II	5	4	100
3	Core Course	3	3	75
4	Core Course Practical	2	2	50
5	Complementary Course: Mathematics	5	4	100
6	Complementary Course: Physics	3	3	75
7	Complementary Course Practical: Physics	2	2	50
	Total	**25**	**22**	**550**

Semester V

Sl. No.	Course Title	Hours/ Week	Credit	Marks
1	Core Course	3	3	75
2	Core Course	4	3	75
3	Core Course	3	3	75
4	Core Course	2	2	75
5	Open Course	3	3	100
6	Core Course Practical	3	Evaluation in Semester VI	
7	Core Course Practical	2		
8	Core Course Practical	3		
9	Core Course Practical	2		
	Total	**25**	**14**	**400**

Semester VI

Sl. No.	Course Title	Hours/ Week	Credit	Marks
1	Core Course	3	3	75
2	Core Course	3	3	75
3	Core Course	3	3	75
4	Core Course	3	3	75
5	Elective Course	3	3	100
6	Core Course Practical	3	3	50
7	Core Course Practical	2	2	50
8	Core Course Practical	3	3	50
9	Core Course Practical	2	2	50
10	Project/Paper Review/Industry Visit Report	-	1	100
	Total	**25**	**26**	**700**
	Grand Total		**120**	**3300**

OUTLINE OF CORE COURSES

Course Code	Course Title	Hours /Week	Total Hours	Credit	ISA	ESA	Total
Semester I							
BBCH101	Quantum Mechanics and Chemical Bonding	2	36	2	15	60	75
	Qualitative Inorganic Analysis (P)	2	36	-	-	-	-
Semester II							
BBCH202	States of Matter and Symmetry	2	36	2	15	60	75
BBCH2P01	Qualitative Inorganic Analysis (P)	2	36	2	10	40	50
Semester III							
BBCH303	Conceptual Organic Chemistry	3	54	3	15	60	75
	Qualitative Organic Analysis (P)	2	36	-	-	-	-
Semester IV							
BBCH404	Organic Chemistry of Aromatics, Heterocycles, Phenols and Carbonyls	3	54	3	15	60	75
BCH4P02	Qualitative Organic Analysis (P)	2	36	2	10	40	50
Semester V							
BBCH505	Chemistry of Main Group Elements	3	54	3	15	60	75
BBCH506	Environmental Science and Human Rights	4	72	3	15	60	75
BBCH507	Organic Chemistry of Acids, Nitrogen Compounds and Biomolecules	3	54	3	15	60	75
BBCH508	Basic Physical Chemistry	2	36	2	15	60	75
	Organic Chemistry Practical – II (P)	3	54	-	-	-	-
	Physical Chemistry Practical (P)	2	36	-	-	-	-
	Gravimetric Analysis (P)	3	54	-	-	-	-
	Volumetric Analysis (P)	2	36	-	-	-	-
Semester VI							
BBCH609	Inorganic Chemistry of *d* and *f* Block Elements	3	54	3	15	60	75
BBCH610	Advanced Organic Chemistry	3	54	3	15	60	75
BBCH611	Advanced Physical Chemistry	3	54	3	15	60	75
BBCH612	Electrochemistry and Surface Chemistry	3	54	3	15	60	75
	Elective Course	3	54	3	20	80	100
BBCH6P03	Organic Chemistry Practical – II (P)	3	54	3	10	40	50
BBCH6P04	Physical Chemistry Practical (P)	2	36	2	10	40	50
BBCH6P05	Gravimetric Analysis (P)	3	54	3	10	40	50
BBCH6P06	Volumetric Analysis (P)	2	36	2	10	40	50
BBCH6PJ	Project/Paper Review/Industry Visit Report	-	-	1	20	80	100

ELECTIVE COURSES

Course Code	Course Title
BBCH6E01	Materials Chemistry
BBCH6E02	Polymer Chemistry

COMPLEMENTARY COURSES

Course Code	Course Title	Hours /Week	Total Hours	Credit	ISA	ESA	Total
Semester I							
BDCH101	Basic Analytical and Material Chemistry *(Common to Physical Sciences and Life Sciences)*	2	36	2	15	60	75
	Volumetric Analysis (P) *(Common to Physical Sciences and Life Sciences)*	2	36	-	-	-	-
Semester II							
BDCH202	Basic Organic Chemistry *(Common to Physical Sciences and Life Sciences)*	2	36	2	15	60	75
BDCH2P01	Volumetric Analysis (P) *(Common to Physical Sciences and Life Sciences)*	2	36	2	10	40	50
Semester III							
BDCP303	Advanced Physical Chemistry - I *(For students who have opted Physical Sciences)*	3	54	3	15	60	75
BDCB303	Advanced Inorganic and Organic Chemistry *(For students who have opted Life Sciences)*	3	54	3	15	60	75
	Physical Chemistry Practical (P) *(For students who have opted Physical Sciences)*	2	36	-	-	-	-
	Organic Chemistry Practical (P) *(For students who have opted Life Sciences)*	2	36	-	-	-	-
Semester IV							
BDCP404	Advanced Physical Chemistry - II *(For students who have opted Physical Sciences)*	3	54	3	15	60	75
BDCB404	Advanced Bio-inorganic and Bio-organic Chemistry *(For students who have opted Life sciences)*	3	54	3	15	60	75
BDCP4P02	Physical Chemistry Practical (P) *(For students who have opted Physical Sciences)*	2	36	2	10	40	50
BDCB4P02	Organic Chemistry Practical (P) *(For students who have opted Life Sciences)*	2	36	2	10	40	50

OPEN COURSE

Course Code	Course Title	Hours /Week	Total Hours	Credit	ISA	ESA	Total
BOCH501	Chemistry in Everyday Life	3	54	3	20	80	100

ADD ON COURSES

Course Code	Course Title	Total Hours	Credit	CE	FE	Total
BCHEX01	Instrumental Methods of Analysis for Biologists, Chemists and Physicists	36	2	20	80	100
BCHEX02	Chemistry and Technology of Rubber and Plastics Processing	36	2	20	80	100

SEMESTER I

BBCH101: QUANTUM MECHANICS AND CHEMICAL BONDING

Credit: 2 **Total Hours: 36**

Objectives

The major objectives of this course are to:

- connect the historical development of quantum mechanics with previous knowledge
- learn the basic properties of quantum world
- understand the idea of wave function
- give an insight into postulates of quantum mechanics and operators
- study the periodicity in atomic properties

Outcome

The course shall make the students to:

- learn the aspects of aspects of quantum mechanics
- to explain the various atom models
- solve Schrodinger equation
- describe how the shapes of molecules and polyatomic ions are determined
- use the valence-shell electron-pair repulsion (VSEPR) theory to predict the parent structure, approximate bond angles, and molecular shape of a molecule or polyatomic ions
- understand the various theories of metallic bonding
- explain various atomic properties and their applications

Module 1: Basic Quantum Chemistry and Atomic Structure (18 hours)

Bohr atom model (derivation), explanation of spectrum of hydrogen and hydrogen like systems, limitations of Bohr theory, Sommerfield's extension to Bohr theory.

Dual Nature of electron - evidences for particle and wave nature - photoelectric effect, Davisson and Germer experiment, Heisenberg's Uncertainty Principle, Compton Effect, Planck's Quantum theory of radiation.

Wave Mechanics - Schrodinger's equation (justification required), time dependent Schrodinger's equation (justification not needed), operators in quantum mechanics. Postulates of quantum mechanics, orthogonality and normalization, Hermitian operators,

Hamiltonian operator, operator formalism of Schrodinger's equation, Born interpretation of the wave function, particle in one dimensional box.

One dimensional harmonic oscillator and rigid rotor (qualitative idea only, detailed derivations not expected), Hydrogen atom, radial and angular probability distribution curves. Shapes of s, p, d and f orbitals (basic idea).

Quantum numbers - principal, azimuthal, magnetic, and spin, Stern-Gerlac experiment.

Textbooks

1. P. W. Atkins, *Physical Chemistry*, 4th & 5th Edns., **1993**.
2. P. W. Atkins , J. de Paula, *Atkin's Physical Chemistry*, 7thEdn., Oxford University Press, **2006**
3. R. K. Prasad, *Quantum Chemistry*, Wiley Eastern Ltd., **2006.**

Reference

1. D.A. Mc Quarrie, J. D. Simon, *Physical Chemistry - A Molecular Approach*, Viva Books Pvt. Ltd. **2004**
2. Ira N. Levine, *Physical Chemistry*, 6thEdn., Mc Graw Hill, **2009**
3. Ira N. Levine, *Quantum Chemistry*, 7thEdn., Prentice Hall, **2013**

Module 2: Chemical Bonding **(9 hours)**

Ionic bond – Lattice energy of ionic compounds, Born-Lande equation (derivation not expected), Born-Haber cycle and its applications, lattice energy, solubility, polarisation of ions – Fajan's rules.

Covalent bond - polarity of covalent bond, percentage of ionic character, dipole moment and molecular structure, co-ordinate bond, VSEPR theory, hybridisation – sp, sp^2, sp^3, sp^3d and sp^3d^2 hybridisations, structure of H_2O, NH_3, XeF_2, XeF_4, SF_4, ClF_3, IF_7, I_3^-, SO_4^{2-}. Valence bond theory (VB) and its limitations, VB of hydrogen atom (derivation not expected). Molecular orbital theory (MOT), linear combination of atomic orbitals (LCAO), bonding, nonbonding and antibonding molecular orbitals. Applications of MO theory to explain the stability of homo and heterodiatomic molecules (N_2, O_2, CO and NO), bond strength and bond energy.

Metallic Bond - Free electron, valence bond and band theories (basic ideas only, derivations not expected).

Textbooks

1. B. R. Puri, L. R. Sharma, K. C. Kalia, *Principles of Inorganic Chemistry*, Vikas Publishing Co., Jalandhar, **2013**
2. M. Chanda, *Atomic Structure and Chemical Bonding*, Tata Mc Graw Hill, **2007.**
3. J. D. Lee, *Concise Inorganic Chemistry*, 5thEdn., Chapman & Hall, **2009.**

Reference

1. J. E. Huheey, E. A. Keiter, R. L. Keiter, *Inorganic Chemistry: Principles of Structure and Reactivity*, 4thEdn., Pearson Education, New York, **2006**
2. D. F. Shriver, P. W. Atkins, *Inorganic Chemistry*, 3rdEdn., Oxford University Press, New Delhi, **2004**

Module 3: Periodic Classification **(9 hours)**

Modern periodic law - Long form of periodic table, periodicity in properties - atomic, ionic, covalent radii (octahedral and tetrahedral), ionization enthalpy, successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy, electron affinity, electronegativity. Pauling's, Mulliken's and Allred - Rochow's scales of electronegativity. Variation of electronegativity with bond order, partial charge, hybridisation and group electronegativity. Effective nuclear change – screening effect – Slater's rules.

Textbooks

1. B. R. Puri, L. R. Sharma, K. C. Kalia, *Principles of Inorganic Chemistry*, Vikas Publishing Co., Jalandhar, **2013**
2. R. Gopal, *Inorganic Chemistry for Undergraduates*, Universities Press, India Pvt. Ltd., **2009**.
3. P. L. Soni, *Text book of Inorganic Chemistry*, S. Chand and Sons, **2006**

Reference

1. F. A. Cotton, G. Wilkinson, *Advanced Inorganic Chemistry*, 6thEdn., Wiley Interscience, **1999.**
2. J. D. Lee, *Concise Inorganic Chemistry*, 5thEdn., Chapman & Hall, **2009**

SEMESTER II

BBCH202: STATES OF MATTER AND SYMMETRY

Credit: 2 **Total Hours: 36**

Objectives

The major objectives of this course are

- understanding the basics of solid state chemistry
- learning the fundamentals of group theory
- studying the properties of liquid state
- assessing the behaviour of ideal and real gases

Outcome

At the end of the course, the learners shall be able to:

- outline the structure, properties and defects in different types of solids
- explain the theory of real gases
- find out the symmetry elements and point group of small molecules
- know the theories/models and properties of liquid state

Module 1: Solid State **(14 hours)**

Solid State: Types of solids- crystalline, amorphous, polycrystalline solids, nature of the solid state, External features of a crystal- faces, forms, edges, interfacial angles- their relationships, zone, and zone axis. Elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; law of constancy of interfacial angles, Hauy's law of rational indices, Law of constancy of symmetry,

Weiss's indices, Miller indices- calculation of inter planar distance between different planes of simple, bcc and fcc system, X - ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Interpretation of XRD pattern of NaCl, KCl and CsCl.

Detailed study of simple cubic, bcc and fcc structures. Packing efficiency, density of unit cells. Voids (Td, Oh and cubic), radius ratio. Close packing of spheres - types and coordination numbers. Structure of common ionic compounds like NaCl, ZnS, CsCl, CaF_2, Na_2O, spinels and inverse spinels.

Electrical properties of crystals: superconductivity, pyro electricity, piezoelectricity. Magnetic properties: ferro, ferri and anti-ferro magnetism, Curie temperature.

Defects in crystals: Schottky, Frenkel, Metal excess, Metal deficiency, thermal defects.

Glasses and liquid crystals: nematic, smetic and cholesteric - thermographic behaviour.

Textbooks

1. B. R Puri, L. R Sharma, M. S. Pathania, *Principles of Physical Chemistry*, Vishal Publishing Company, Jalandhar, **2018.**
2. K. L. Kapoor, Physical Chemistry, Vol. I, II, III & IV, Mac Millan (India) Ltd., **2000.**

Reference

1. P. Atkins, J. de Paula, *Atkin's Physical Chemistry*, 11th Edn., Oxford University Press, 2**018**
2. I. N. Levine, *Physical Chemistry*, 6thEdn., Mc Graw Hill, **2009.**
3. K. J. Laidler, J. H. Meiser, *Physical Chemistry*, 2nd Edn., **2002.**

Module 2: Liquid State and Gaseous State (18 hours)

Qualitative treatment of the structure of the liquid state- or: physical properties of liquid radial distribution functions, Theories/Models of liquid state – Cybotactic Group Model, Kinetic Molecular model, Hole theory and Eyring's vacancy theory and Random packing model.

Vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity, explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases. Qualitative discussion of structure of water.

Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation, collision frequency, collision diameter, mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of σ from η, variation of viscosity with temperature and pressure. Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, principle of equipartition of energy, degrees of freedom and molecular basis of heat capacities.

Behaviour of real gases: Deviations from ideal gas behaviour, compressibility factor Z, and its variation with pressure for different gases. Causes of deviation from ideal

behaviour, van der Waals equation of state, its derivation and application in explaining real gas behaviour, mention of other equations of state (Berthelot, Dietrich); virial equation of state; van der Waals equation expressed in virial form and calculation of Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states.

Textbooks

1. B.R. Puri, L. R Sharma, M. S. Pathania, *Principles of Physical Chemistry*, Vishal Publishing Company, Jalandhar, **2018.**
2. K. L. Kapoor, *Physical Chemistry*, *Vol. I, II, III & IV*, Macmillan (India) Ltd., **2000.**

Reference

1. P. Atkins, J. Paula, *Atkin's Physical Chemistry*, 11thEdn., Oxford University Press, **2018.**
2. I. N. Levine, *Physical Chemistry*, 6thEdn., Mc Graw Hill, **2009.**
3. K. J. Laidler, J. H. Meiser, *Physical Chemistry*, 2nd Edn., **1995.**
4. G. K. Vemulapalli, *Physical Chemistry*, Prentice Hall of India Pvt. Ltd., **1997.**
5. D. N. Bajpai, *Advanced Physical Chemistry*, S Chand & Company Pvt Ltd., **2013.**

Module 3: Group Theory **(4 hours)**

Group theory: molecular symmetry and symmetry groups - symmetry elements and operations. Symmetry planes, inversion centre, proper/improper axes and rotations. Molecular symmetry and optical isomerism, symmetry point groups, classification of molecular point groups. (Students must be trained to find point group of common molecules)

Textbooks

1. B. R Puri, L. R Sharma and M. S. Pathania, *Principles of Physical Chemistry*, Vishal Publishing Company, Jalandhar, **2018.**
2. K. L. Kapoor, *Physical Chemistry*, *Vol. I, II, III & IV*, Macmillan (India) Ltd., **2000.**

Reference

1. M. Tinkham, *Group theory and quantum mechanics*, Dover Books on Chemistry, **2003.**
2. C. N. Banwell, E. M. McCash, *Fundamentals of Molecular Spectroscopy*, 4th Edn., Tata Mc Graw Hill, **2017.**

PRACTICAL

SEMESTER I AND II

BBCH2P01: QUALITATIVE INORGANIC ANALYSIS

Credit: 2 **Total Hours: 72**

Systematic qualitative analysis of mixtures containing two cations and two anions from the following with one interfering radical by semi-micro method only. Identification and confirmation tests (with chemistry) and spot tests expected.

Ag^{+}, $Hg^{2+,}$ $Pb^{2+,}$ Cu^{2+}, Bi^{2+}, Cd^{2+}, As^{3+}, Sn^{2+}, Sb^{3+}, Fe^{2+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+}, Mg^{2+}, Li^{+}, Na^{+}, K^{+}, NH_4^{+}, $CO_3^{2-,}$ S_2^{2-}, SO_4^{2-}, NO_3^{-}, F^{-}, Cl^{-}, Br^{-}, BO_2^{-} $C_2O_4^{2-}$, $C_4H_4O_6^{2-}$, CH_3COO^{-}, PO_4^{3-}, AsO_3^{3-}, AsO_4^{3-} and CrO_4^{2-}

Interfering anions: F^{-}, BO_2^{-}, $C_2O_4^{2-}$, $C_4H_4O_6^{2-}$, PO_4^{3-}, AsO_3^{3-}, AsO_4^{3-}, and CrO_4^{2-}

(Minimum of eight mixtures (with interfering anions) to be analysed)

Reference

1. A. O. Thomas, *Practical Chemistry*, 7th Edn., Scientific Book Centre, Kannur, **1999.**
2. G. Svehla, *Vogel's Qualitative Inorganic Analysis*, 7th Edn., Pearson Education, New Delhi, **2006.**
3. V. V. Ramanujam, *Inorganic Semi Micro Qualitative Analysis*, 3rdEdn., The National Publishing Company, Chennai, **1974.**

SEMESTER III

BBCH303: CONCEPTUAL ORGANIC CHEMISTRY

Credit: 3 **Total Hours: 54**

Objectives

The course shall enable the student to:

- understand the basics of electronic displacement effect and reaction intermediates
- learn the fundamentals of stereoisomerism and geometrical isomerism
- know the preparation and properties of alkanes and haloalkanes

Outcome

After the successful completion of the course, the learners shall be able to:

- predict the structure and stability of various reaction intermediates
- draw the optical and geometric of various organic compounds
- outline the preparation and reactions of alkanes and haloalkanes

Module I: Electronic Effects and Mechanism **(9 hours)**

Isomerism and IUPAC nomenclature of organic compounds. (Self Study)

Dipole moment; Organic acids and bases-pKa, pKb- concept of conjugate base; Homolytic and heterolytic fission with suitable examples. Curly arrow rules; Electrophiles and nucleophiles; nucleophilicity and basicity.

Electronic displacement effects: Inductive, electromeric and mesomeric effects, resonance, hyperconjugation and their applications. Steric effect. Tautomersim.

Reaction intermediates: Types, hybridization, structure, shape and their relative stability of aliphatic and aromatic carbocations - non classical carbocations (examples only), carbanions, free radicals, carbenes and nitrenes.

Textbooks

1. K. S. Tewari, N. K. Vishnoi, *A Textbook of Organic Chemistry*, 4th Edn., Vikas Publishing House, **2017.**
2. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, 3rd Edn.,Vishal Publishing Company, **2017.**

Reference

1. S. M. Mukherji, S. P. Singh, *Reaction Mechanism in Organic Chemistry*, Macmillan, **1984.**

2. J. Clayden, N. Greeves, S. Warren, *Organic Chemistry*, 2nd Edn., Oxford University Press, **2012.**
3. R. T. Morrison, R. N. Boyd, *Organic Chemistry*, 6th Edn., Prentice Hall, **2004.**

Module 2: Stereochemistry and Conformational Analysis (**9 hours**)

Stereoisomerism: Optical Isomerism: optical activity, specific rotation, chirality/asymmetry, enantiomers, molecules with two or more chiral-centres, diastereoisomers, meso structures, racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations. Asymmetric synthesis: Asymmetric induction (basic idea only). Optical activity of systems without stereocentres- allenes and biphenyl

Geometrical isomerism: cis – trans- and syn - anti isomerism E/Z notations with C.I.P rules. Fischer projection, Newman and Sawhorse projection formulae and their interconversions.

Conformational analysis of alicyclic and cyclic compounds: ethane, propane, butane, cycloalkanes, Bayer's strain theory. Different conformers of cyclohexane and mono and di substituted cycloalkanes.

Textbooks

1. P. S. Kalsi, *Stereochemistry: Conformation and Mechanism*, 9th Edn. New Age International, New Delhi, **2019.**
2. L. Finar, *Organic Chemistry*, Vols. 1 & 2, 5th Edn., Pearson Education, 2005

Reference

1. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, 3rd Edn.,Vishal Publishing Company, **2017.**
2. J. Clayden, N. Greeves, S. Warren, *Organic Chemistry*, 2nd Edn., Oxford University Press, **2012.**
3. R. T. Morrison, R. N. Boyd, *Organic Chemistry*, 6th Edn., Prentice Hall, **2004.**

Module 3: Alkanes and Haloalkanes **(18 hours)**

Alkanes: preparation of alkanes - Wurtz reaction, reduction or hydrogenation of alkenes, Corey- House method. Reactions: mechanism of halogenation, free radical substitution, sulphonation, nitration, oxidation, cracking and aromatisation. Chemistry of petroleum, knocking and anti knocking agents, Octane number and cetane number. Synthetic petrol- Fischer Tropsch and Bergius process.

Cycloalkanes: preparation using Wurtz reaction, Dieckmann's ring closure and reduction of aromatic hydrocarbons. Reactions: mechanism of substitution and ring opening reactions.

Alkyl halides: nomenclature and classes of alkyl halides, methods of formation- from alcohols, halogenation, Darzens process, Hunsdicker, Finkelstien reactions etc., chemical reaction, vinyl halides, allyl iodide.

Mechanisms of nucleophilic substitution reactions of alkyl halides, S_N2 and $S_N1$with energy profile diagrams. Effect of solvent, substrate, nucleophile, nucleofuge, neighbouring group participation. Relative reactivity of alkyl halides vs. allyl, vinyl and aryl halides.

Nuclear and side chain aromatic halogen compounds- distinguishing tests. Synthesis and uses of DDT and BHC. Polyhalogen compounds: chloroform, iodoform, and carbon tetrachloride - preparation, reactions and uses, Freons.

Textbooks

1. K. S. Tewari, N.K. Vishnoi, *A Textbook of Organic Chemistry*, 4th Edn.,Vikas Publishing House, **2017**
2. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, 3rd Edn., Vishal Publishing Company, **2017**

Reference

1. P. Sykes, *A Guide to Mechanism in Organic Chemistry*, 6th Edn., Pearson Education, **2004**
2. P. S. Kalsi, *Organic Reactions and Their Mechanisms*, 8th Edn., New Age International, **2014**
1. J. March, *Advanced Organic Chemistry*, 6th Edn., John Wiley & Sons, **2007**
2. J. Clayden, N. Greeves, S. Warren, *Organic Chemistry*, 2nd Edn., Oxford University Press, **2012**
3. R. T. Morrison, R. N. Boyd, *Organic Chemistry*, 6th Edn., Prentice Hall, **2004**

Module 4: Alkenes and alkynes **(12 hours)**

Alkenes: general methods of preparation, dehydrogenation, preparation by elimination, dehydrohalogenation, dehydration, Regioselectivity using Hoffmann and Saytzeff rules, cis and trans eliminations. E1, E2, E1CB, Saytzeff and Hofmann elimination. Elimination versus substitution.

Reactions of alkenes: Addition of halogens, hydrogen halides, water, sulphuric acid-electrophilic and free radical addition-Markonikov's rule, additions involving carbocation

rearrangement, free radical additions-peroxide effect, Wagner – Meervin rearrangement, oxy mercuration - demercuration, hydroboration, ozonolysis, cis and trans additions with examples. Syn hydroxylation and epoxidation (mechanism not needed), Simmons-Smith reaction.

Dienes: stability of dienes (conjugated, isolated and cumulative dienes). General methods of preparation, mechanism of dehydrohalogenation. Reaction mechanism of 1,2 - and 1,4 - additions.

Alkynes: preparation- ascending the series. Reactions: acidity of alkynes- reaction with Tollens reagent and Fehlings solution, formation of acetylides, mechanism of addition of water, hydrogen halides and halogens–oxidation, ozonolysis and hydroboration/oxidation Reduction (cis and trans).

Textbooks

1. K. S. Tewari, N.K. Vishnoi, *A Textbook of Organic Chemistry*, 4thEdn., Vikas Publishing House, **2017**
2. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, 3rdEdn., Vishal Publishing Company, **2017**

Reference

1. V. K. Ahluwalia, *Green Chemistry: Environmentally Benign Reactions*, 2ndEdn., Ane Books India, **2013**
2. P. Sykes, *A Guide to Mechanism in Organic Chemistry*, 6th Edn., Pearson Education, **2004**
3. P. S. Kalsi, *Organic Reactions and Their Mechanisms*, 8th Edn., New Age International, **2014**
4. J. March, *Advanced Organic Chemistry*, 6th Edn., John Wiley & Sons, **2007**
5. J. Clayden, N. Greeves, S. Warren, *Organic Chemistry*, 2nd Edn., Oxford University Press, **2012**
6. R. T. Morrison, R. N. Boyd, *Organic Chemistry*, 6th Edn., Prentice Hall, **2004**

Module 5: Alcohols **(6 hours)**

Aliphatic alcohols: Primary, secondary and tertiary alcohols- preparation of alcohols by hydroboration, oxidation ($KMnO_4$, PCC, Cu), reduction of carbonyl compounds, epoxidation, and Grignard synthesis. Reactions with reference to C-OH bond cleavage and O-H bond cleavage, iodoform test, S_Ni reactions.

Primary, secondary and tertiary alcohols- tests to distinguish them (Lucas test & dichromate test). Conversion of primary to secondary, secondary to tertiary, primary to tertiary alcohols, ascending and descending in alcohol series.

Dihydric and trihydric alcohols: reactions with lead tetra acetate and periodic acid, Uses of glycol and glycerol. Pinacol-pinacolone rearrangement. Alcoholic beverages- manufacture of ethanol from molasses and starch, power alcohol, methylated and denatured alcohol.

Textbooks

1. K. S. Tewari, N.K. Vishnoi, *A Textbook of Organic Chemistry*, 4thEdn., Vikas Publishing House, **2017**
2. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, 3rdEdn., Vishal Publishing Company, **2017**

Reference

1. V. K. Ahluwalia, *Green Chemistry: Environmentally Benign Reactions*, 2ndEdn., Ane Books India, **2013**
2. J. March, *Advanced Organic Chemistry*, 6*th* Edn., John Wiley & Sons, **2007**
3. J. Clayden, N. Greeves, S. Warren, *Organic Chemistry*, 2nd Edn., Oxford University Press, **2012**
4. R. T. Morrison, R. N. Boyd, *Organic Chemistry*, 6th Edn., Prentice Hall, **2004**

SEMESTER IV

BBCH404: ORGANIC CHEMISTRY OF AROMATICS, HETEROCYCLES, PHENOLS AND CARBONYLS

Credit: 3 **Total Hours: 54**

Objectives

The major objectives of this course are

- understanding the concept of resonance
- learning the reactions of ethers and alcohols
- Studying the reactions of carbonyl and active methylene compounds
- understanding the chemistry of natural products and heterocyclic compounds

Outcome

At the end of the course, the learners shall be able to:

- explain the resonance structure of aromatic compounds
- outline the preparation and reactions of ethers and carbonyl compounds
- discuss the reactions of carbonyl compounds
- describe the preparation and properties of heterocyclic compounds

Module I: Aromatic compounds and Aromaticity (18 hours)

Concept of resonance: resonance energy, heat of hydrogenation and heat of combustion of benzene, orbital picture of benzene. Steric inhibition of resonance.

Concept of aromaticity: aromaticity, antiaromaticity and non aromaticity (definition), Huckel's rule: application to benzenoid; benzene, naphthalene and non-benzenoid compounds; cyclopropenyl cation, cyclopentadienyl anion and tropylium cation, homoaromaticity.

Benzene: structure, electrophilic substitution reactions with mechanism: halogenation, nitration, sulphonation, Friedel-Craft's alkylation and acylation.

Orientation of aromatic substitution: ortho, para and meta directing groups. Ring activating and deactivating groups with examples. Orientation of -OH, amino, methoxy, methyl, carboxy, nitro, nitrile, carbonyl and sulfonic acid groups and halogens.

Aromatic nucleophilic substitutions: The addition - elimination and the elimination - addition mechanisms of nucleophilic aromatic substitution reactions. Side chain oxidation.

Polynuclear aromatic hydrocarbons: Structure and aromaticity of naphthalene and anthracene Reactivity of naphthalene towards electrophilic substitution, nitration and sulphonation. Preparation and reactions of naphthalene, naphthyl amine, anthracene, phenanthrene.

Textbooks

1. A. Bahl, B.S. Bahl, *Advanced Organic Chemistry*, 1st Multicolour Edition, S. Chand & Company, New Delhi, **2010**
2. S.C. Sharma, M.K. Jain, *Modern Organic Chemistry*, Vishal Publishing Company, New Delhi, **2014**

Reference

1. K. S. Tewari, N.K. Vishnoi, *A Textbook of Organic Chemistry*, 4thEdn., Vikas Publishing House, **2017**
2. J. March, *Advanced Organic Chemistry*, 6th Edn., John Wiley & Sons, **2007**
3. J. Clayden, N. Greeves, S. Warren, *Organic Chemistry*, 7th Edn., Oxford University Press, **2012**
4. R. T. Morrison, R. N. Boyd, *Organic Chemistry*, 6th Edn., Prentice Hall, **2004**

Module 2: Ethers and Phenols **(9 hours)**

Ethers and epoxides: nomenclature and classification. Preparation by Williamson's synthesis and alkoxymercuration - demercuration methods. Reactions: cleavage by acids. Preparation and reactions of epoxides. Preparation and reactions of thiols and thioethers. Crown ethers (introduction).

Phenols: nomenclature, physical properties, hydrogen bonding. Preparation: Industrial source, preparation from diazonium salts and sulphonic acids.

Reactions (with mechanism): acidity, ether formation, ester formation, mechanism of ring substitution, nitration, sulphonation, halogenation, Friedel Craft's reaction, nitrosation, coupling reactions, Kolbe's reaction and Riemer-Tiemann reaction. Dienone-phenol rearrangement. Preparation and uses of nitrophenols, picric acid- charge transfer complex formation, catechol, resorcinol, quinol and naphthols.

Textbooks

1. A. Bahl, B.S. Bahl, *Advanced Organic Chemistry*, 1st Multicolour Edition, S. Chand & Company, New Delhi, **2010**
2. S.C. Sharma, M.K. Jain, *Modern Organic Chemistry*, Vishal Publishing Company, New Delhi, **2014**

Reference

1. K. S. Tewari, N.K. Vishnoi, *A Textbook of Organic Chemistry*, 4th Edn., Vikas Publishing House, **2017**
2. I.L. Finar, *Organic Chemistry* Vol. 1 & II, 5th Edition, Pearson Education, New Delhi, **2013**
3. V. K. Ahluwalia, *Green Chemistry: Environmentally Benign Reactions*, 2nd Edn., Ane Books India, **2013**
4. P. Sykes, *A guide to mechanism in Organic Chemistry*, 6th Edn., Pearson Education, **2004**
5. R. T. Morrison, R. N. Boyd, *Organic Chemistry*, 6th Edn., Prentice Hall, **2004**

Module 3: Carbonyl and Active Methylene Compounds (9 hours)

Aldehydes and ketones: nomenclature and classification. Preparation of aldehydes and ketones- preparation from alcohols (chromic acid, Collins reagent, Oppeneaur oxidation, catalytic dehydrogenation, Rossenmunds reduction, Reactivity of carbonyl groups, acidity of alpha hydrogen.

Reactions: mechanism of enolization reactions, nucleophilic addition, oxidation and reduction reactions, addition reactions with Grignard reagents, cyanide, and bisulphate, preparation of derivatives of ammonia and alcohols.

Mechanism of aldol, Perkin, Knoevenagel reactions and benzoin condensation, Claisen, Wittig reaction, Cannizarro, Beckmann, benzyl - benzilic acid rearrangement and Reformatsky reactions, Baeyer-Villiger oxidation. Mechanism of reductions with $NaBH_4$, $LiAlH_4$. Tests to distinguish between aldehydes and ketones.

Active methylene compounds: keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate, cyanoacetic ester and ethyl acetoacetate.

Textbooks

1. A. Bahl, B.S. Bahl, *Advanced Organic Chemistry*, 1st Multicolour Edition, S. Chand & Company, New Delhi, **2010**
2. S.C. Sharma, M.K. Jain, *Modern Organic Chemistry*, Vishal Publishing Company, New Delhi, **2014**

Reference

1. K. S. Tewari, N.K. Vishnoi, *A Textbook of Organic Chemistry*, 4thEdn., Vikas Publishing House, **2017**

2. V. K. Ahluwalia, *Green Chemistry: Environmentally Benign Reactions*, 2nd Edn., Ane Books India, **2013**
3. P. Sykes, *A guide to mechanism in Organic Chemistry*, 6th Edn., Pearson Education, **2004**
4. J. March, *Advanced Organic Chemistry*, 6th Edn., John Wiley & Sons, **2007**
5. J. Clayden, N. Greeves, S. Warren, *Organic Chemistry*, 7th Edn., Oxford University Press, **2012**

Module 4: Heterocyclic Compounds and Natural Products (18 hours)

Classification, structure and aromaticity of five-membered and six-membered rings containing one heteroatom. Preparation, properties and reactions (mechanism of electrophilic and nucleophilic substitutions, oxidation-reduction reactions) of: - Five membered ring compounds: Furan, Thiophene, Pyrrole (Paal-Knorr synthesis) and Indole (Fischer's indole synthesis). Six membered rings: Pyridine (Hantzsch synthesis), Quinoline (Skraup synthesis and Friedlander's synthesis) and Isoquinoline (Bischler-Napieralski reaction). Basicity of heterocyclic compounds in comparison with aliphatic and aromatic amines.

Alkaloids: occurrence, extraction of alkaloids from plants and general properties. Structural elucidation and physical properties of Coniine, Piperine and Nicotine.

Terpenoids: classification, occurrence, isolation and general properties. Isoprene and special isoprene rules. Structural elucidation and physical properties of Citral and Geraniol. Importance of Menthol, α-Pinene, Camphor and Natural rubber.

Textbooks

1. O.P. Agarwal, *Chemistry of Organic Natural Products* Vol. I, 40th Edition, Krishna Prakashan Media Pvt. Ltd., Meerut, **2010**
2. I.L. Finar, *Organic Chemistry* Vol. 1 & II, 5th Edn, Pearson Education, New Delhi, **2013**

Reference

1. R. K. Bansal, *Heterocyclic Chemistry*, 5th Edn, New Age International Publishers, New Delhi, **2017**
2. G. R. Chatwal, *Organic Chemistry of Natural Products*, Volume 1, Himalaya Publishing House, **2010**

PRACTICAL

SEMESTER III AND IV

BBCH4P02: QUALITATIVE ORGANIC ANALYSIS

Credit: 2 **Total Hours: 72**

1. Tests for elements: nitrogen, halogens and sulphur
2. Tests for unsaturation
3. Tests for aromatic character
4. Study of the reactions of the following functional groups: alcohol, aldehyde, ketone, carboxylic acid, 1,2-dicarboxylic acid, ester, primary, secondary and tertiary amines
5. Systematic analysis of the following organic compounds containing one functional group and characterization with a derivative- alcohol, aldehyde, ketone, carboxylic acid, dicarboxylic acid (aliphatic and aromatic), ester, primary and secondary amines halogen in nucleus and side chain, carbohydrates, diamides (urea and thiourea), amides, anilides, nitro compounds, primary, secondary and tertiary amines.
6. Preparation of solid derivative by modification of functional groups as possible
7. Melting and boiling points of the substance given for the analysis

Systematic Analysis using preliminary, identification and confirmatory tests and derivative preparation with chemical equations for all positive tests expected.
(Minimum ten compounds to be analysed)

Reference

1. A. O. Thomas, *Practical Chemistry*, 7th Edn., Scientific Book Centre, Kannur, **1999**
2. Brian S. Furniss, Antony J. Hannaford, Peter W. G. Smith, Austin R. Tatchell *Vogel's Textbook of Practical Organic Chemistry*, 5thEdn., Longman Scientific & Technical, **1989**
3. F. G. Mann, B. C. Saunders, *Practical Organic Chemistry*, 4thEdn., Pearson Education, **2009**
4. V. K. Ahluwalia, S. Dhingra, *Comprehensive Practical Organic Chemistry: Qualitative Analysis, Universities Press*, **2000**

SEMESTER V

BBCH505: CHEMISTRY OF MAIN GROUP ELEMENTS

Credit: 3 **Total Hours: 54**

Objectives

The objectives of this course are to:

- understand the chemistry of s and block elements
- learn the fundamentals and applications of nuclear chemistry
- know the separation, preparation and properties of noble gas compounds
- understand the fundamentals of various analytical techniques

Outcome

The course shall make the students to:

- describe the properties of s and p block elements
- explain the structure and preparation methods of noble gas compounds
- outline the applications of nuclear chemistry
- discuss the theory of solvent extraction and chromatography

Module 1: Characteristic and Distinctive Properties of s, and p Block Elements

(18 hours)

Chemistry of s - block elements: inert pair effect, relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Allotropy and catenation.

Hydrogen: hydrides - classification and chemistry. Heavy water: manufacture and properties.

Alkali metals: Li, Na, K, Rb and Cs - occurrence, comparative study of elements, oxides, halides, hydroxides and carbonates. Exceptional property of lithium.

Alkaline earth metals: Be, Mg, Ca, Sr and Ba - occurrence and comparative study of the elements, oxides, hydroxides, halides, sulphates and carbonates. Hydrides and their classification: ionic, covalent and interstitial. Basic beryllium acetate and nitrate. Exceptional property of Beryllium.

p - Block elements: comparative study of the p-block elements - groups 13 - 18 with special reference to electronic configuration, structure of elements and trends in atomic and

ionic radii, ionization potential, electron affinity, electronegativity and oxidation states, inert pair effect.

Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses; boric acid and borates, boron nitrides, borohydrides (diborane), borazene, carboranes, silanes, oxides and oxoacids of nitrogen, phosphorus and chlorine. Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens.

Textbooks

1. B. R. Puri, L. R. Sharma and K. C. Kalia, *Principles of Inorganic Chemistry*, Vikas Publishing Co., Jalandhar, **2013**
2. R. Gopal, *Inorganic Chemistry for Undergraduates*, Universities press, India Pvt. Ltd., **2009**

Reference

1. J. E. Huheey, E. A. Keiter, R. L. Keiter, *Inorganic Chemistry: Principles of Structure and Reactivity*, 4th Edn. Pearson Education, **2006**
2. J. D. Lee, *Concise Inorganic Chemistry*, 5th Edn, Chapman & Hall, **2002**
3. D. F. Shriver, P. W. Atkins, *Inorganic Chemistry*, 3rd Edn., Oxford University Press, New Delhi, **2004**
4. F. A. Cotton, G. Wilkinson, *Advanced Inorganic Chemistry*, 6th Edn., Wiley Interscience, **1999**

Module 2: Nuclear Chemistry **(12 hours)**

The nucleus: subatomic particles, structure of the nucleus-shell model, liquid drop model (basic idea); forces in the nucleus, mesons; stability of nucleus - n/p ratio, binding energy; radioactive elements. Mass defect: energy produced during common nuclear reactions. Radiochemistry: natural and induced radioactivity; radioactive decay α-decay, β-decay, γ-decay, neutron emission, positron emission, electron capture, unit of radioactivity (Curie); half-life period; Geiger-Nuttal rule, radioactive displacement law, radioactive series. Nuclear reactions: types of nuclear reactions, spallation, nuclear fission-theory of nuclear fission; chain reaction, critical mass; nuclear reactors - fast breeder reactors, fuels used in nuclear reactors, separation of isotopes, moderators, coolants; nuclear fusion. Atom bomb, neutron bomb and hydrogen bomb (principles).

Applications: energy tapping, radio carbon dating, neutron activation analysis, isotopic labelling studies, nuclear medicine.

Textbooks

1. H. J. Arnicker, *Essentials of Nuclear Chemistry*, 4th Edn., New Age International Publishers, **2011**
2. B. R. Puri, L. R. Sharma, K. C. Kalia, *Principles of Inorganic Chemistry*, Vikas Publishing Co., Jalandhar, **2013**

Reference

1. R. Gopalan, *Elements of Nuclear Chemistry*, Vikas Publishing House, **1999**
2. S. Glasstone, *Sourcebook on Atomic Energy*, 3rd Edn., Krieger Publishing Company, **1979**

Module 3: Noble Gases **(6 hours)**

Occurrence and uses, rationalization of inertness of noble gases, clathrates, preparation and properties of XeF_2, XeF_4, and XeF_6; nature of bonding in noble gas compounds (valence bond treatment and MO treatment for XeF_2). Molecular shapes of noble gas compounds – fluorides and oxy fluorides. (VSEPR theory). Separation of noble gases and uses.

Textbooks

1. B. R. Puri, L. R. Sharma, K. C. Kalia, *Principles of Inorganic Chemistry*, Vikas Publishing Co., Jalandhar, **2013**
2. R. Gopal, *Inorganic Chemistry for Undergraduates*, Universities press, India Pvt. Ltd., **2009**

Reference

1. J. D. Lee, *Concise Inorganic Chemistry*, 5th Edn., Chapman & Hall, **2002**
2. F. A. Cotton, G. Wilkinson, *Advanced Inorganic Chemistry*, 6th Edn., Wiley Interscience, **1999**

Module 4: Analytical Chemistry **(15 hours)**

Evaluation of analytical data: sampling, evaluation of analytical data, significant figures, errors, accuracy and precision, methods of their expression, normal law of distribution, determinate and indeterminate errors, statistical test of data; F, Q, and t test, rejection of data, and confidence intervals.

Solvent extraction: classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter current extractions. Qualitative and quantitative aspects of

solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and non-aqueous media.

Chromatography: Classification and principle and efficiency of the technique. Mechanism of separation: adsorption, partition and ion exchange. Development of chromatograms: frontal, elution and displacement methods. Qualitative and quantitative aspects of chromatographic methods of analysis: LC, GLC, GPC, TLC and HPLC.

Textbooks

1. D. A. Skoog, F. J. Holler, S. R. Crouch, *Principles of Instrumental Analysis*, 6th Edition, Thomson Asia Pvt. Ltd., London, **2006**
2. G. R. Chatwal, S. K. Anand, *Instrumental Methods Of Chemical Analysis*, Himalaya Publishing House, **2011**
3. S. K. Anand, G. R. Chatwal, *Instrumental Methods Of Chemical Analysis*, Himalaya Publishing House, **2014**

Reference

1. G. Svehla, *Vogel's Qualitative Inorganic Analysis*, 7th Edn., Pearson Education, New Delhi, **2006**
2. G. D Christian, *Analytical Chemistry*, 6th Edn., New York, John Wiley, **2004**
3. S. M. Khopkar, *Basic Concepts of Analytical Chemistry*, New Age, International Publisher, **2009**

Module 5: Non-aqueous Solvents **(3 hours)**

Non-aqueous solvents: physical properties of a solvent for functioning as an effective reaction medium. Types of solvents and their general characteristics. Reactions in liquid ammonia and liquid sulphur dioxide.

Textbooks

1. B. R. Puri, L. R. Sharma, K. C. Kalia, *Principles of Inorganic Chemistry*, Vikas Publishing Co., Jalandhar, **2013**
2. P. L. Soni, *Text Book of Inorganic Chemistry*, S. Chand and Sons, **2007**

Reference

1. J. E. Huheey, E. A. Keiter, R. L. Keiter, *Inorganic Chemistry: Principles of Structure and Reactivity*, 4thEdn. Pearson Education, **2006**
2. J. D. Lee, *Concise Inorganic Chemistry*, 5thEdn, Chapman & Hall, **2002**

BBCH506: ENVIRONMENTAL SCIENCE AND HUMAN RIGHTS

Credit: 3 **Total Hours: 72**

Objectives

The major objectives are

- acquainting the students with recent environmental issues
- understanding the basic human rights of an individual
- knowing the toxic effects of heavy metals and various other pollutants
- understanding micro and macronutrients necessary for plant growth
- Giving an idea about energy conservation and different energy sources
- acquainting the students with various air, water and soil parameters

Outcome

After the successful completion of the course, the learners shall be able to:

- describe the status of current environmental issues
- explain the basic rights of an individual living in a society
- outline the preventive measures for pollutants
- justify the ambient soil conditions for the growth of crops
- conserve energy and explore new renewable energy sources
- control pollution in air, water and soil

Module 1: Environmental Issues **(18 hours)**

Pollution: air pollution, water pollution, ocean pollution, soil pollution, noise pollution – sources and effects. Solid waste management: types, 3R's. causes, effects and control measures of urban and industrial waste- biodegradable and non-degradable

Global and local environmental issues :global warming and climate change (use case studies to illustrate the points);ozone depletion; greenhouse effect; acid rain; carbon trading, carbon credit; carbon sequestration; IPCC/UNFCC; nuclear accidents and nuclear holocaust, sand mining; wetland reclamation; landscape changes; deforestation; soil erosion. flood and drought, desertification, overexploitation, threats to fresh water resources of Kerala; tourism and its impact on environment.

Disaster management: introduction to hazards; hazards classification; natural and anthropogenic, disaster management- earthquakes; cyclone; tsunami; floods; landslides; droughts carbon trading- replace by carbon emission trading.

Textbooks

1. A. K. De, *Environmental Chemistry*, New Age International, 7th Edn., **2007**
2. A. Gopinath, Chandradasan, *Environmental Chemistry*, Vishal Publishing Co. Jalandhar, **2017**

Reference

1. G. W. van Loon, S. J. Duffy, *Environmental Chemistry A Global Perspective*, Oxford University Press, New York, **2008**
2. N. Singh, A. K. Thakur, *Climatic Change and Environmental Issues*, The Energy and Resource Institute, New Delhi, **2016**

Module 2: Human Rights (18 hours)

National and International Perspectives: Definitions of Human Right, Relevance of Human Rights in India-Social Aspects-Economic Aspects-Political Aspects, Human Rights International Norms, UDHR-Civil and political rights-Economic, social and cultural rights-Rights against torture, Discrimination and forced labour-Rights of the child, Human Rights and duties in India- Preamble to the Indian constitution-Human Rights and Duties in Indian constitution.

Deprivation of Human Rights-The core issues: Poverty-Overpopulation-Illiteracy-Unsustainable Development, Disadvantageous Groups (Women, Children, SC/ST, Homeless and slum dwellers, physically and mentally handicapped, refugees and internally displaced persons.

Redressal Mechanisms against Human Rights Violation: Judiciary - Government systems for Redressal - NHRC and other Statutory Commissions-Media advocacy-Creation of Human Rights Literacy and Awareness.

Textbooks

1. J. K. Das, *Human Rights and Practice*, PHI Learning Private Limited, Delhi, **2016**
2. H. O. Agarwal, *Human Rights*, 16th Edn., Central Law Publications, **2016**

Reference

1. N. Chiranjivi, *Human Rights in India: Historical, Social and Political Perspectives*, Oxford University Press, **2002**

Module 3: Chemical Toxicology (9 hours)

Toxicity effects, Routes of toxicants to human body, toxic chemicals in the environment, impact of toxic chemicals on enzymes, biochemical effects of As, Cd, Pb, Hg, CO, NO_x, O_3, CN, pesticides and carcinogenic substances.

Textbooks

1. A. Gopinath, Chandradasan, *Environmental Chemistry*, Vishal Publishing Co. Jalandhar, **2017**

Reference

1. R. P. Cote, P. G. Wells, *Controlling Chemical Hazards: Fundamentals of the Management of Toxic Chemicals*, Springer, **2012**

Module 4: Lithosphere (6 hours)

Weathering of rocks- physical, chemical and biological processes. Factors controlling the formation of soil; soil profile and classification of soil. Composition of soil-organic and inorganic components in soil. Micro- and macro- nutrients, nitrogen pathways and NPK in soil. Acid base and ion exchange reactions in soil.

Textbooks

1. A. Gopinath, Chandradasan, *Environmental Chemistry*, Vishal Publishing Co. Jalandhar, **2017**

Reference

1. G. M. Tyler, *Living in the Environment: Principles, Connections, and Solutions*, Thomson Brooks/Cole, **2005**

Module 5: Energy and Environment (9 hours)

Energy resources: Growing energy needs, primary and secondary energy resources, conventional and non- conventional energy sources, geothermal energy, renewable and non renewable energy sources – hydroelectric power, hydrogen energy and nuclear energy, Photovoltaics, Solar Heating, Wind Energy, Tidal Power, use of alternate energy sources - Energy from Wastes, Biogas Plants in India and its use, Biomass and Biofuels, Conservation of Energy.

Textbooks

1. V. K. Ahluwalia, *Environmental Chemistry*, 2ndEdn., Ane Books Pvt. Ltd., New Delhi, **2013**
2. A. Gopinath, Chandradasan, *Environmental Chemistry*, Vishal Publishing Co. Jalandhar, **2017**

Reference

1. R. K. Khitoliya, *Environmental Pollution – Management and Control for Sustainable Development*, S. Chand Publishing, **2012**

2. C. Beggs, *Energy Management: Supply and Conservation*, Butterworth-Heinemann, **2002**

Module 6: Environmental Analysis and Pollution Control (12 hours)

Environmental Sampling: Spatial and temporal variability, Types of samples: water sampling-surface and groundwater sampling, soil sampling, Sample preparation techniques - extraction of organic analytes from liquid samples, Preservation techniques of the samples.

Sampling and Analysis of Air Samples: CO, H_2S, SO_2, Solid Particulate Matter (SPM) and hydrocarbons in air sample. Air Pollution Control Devices, Control of CO, SO_x, NO_x , Particulate matter and Hydrocarbons.

Sampling and Analysis of Water: Estimation of some physico chemical parameters of water quality such as pH, salinity, conductivity, total solids, total dissolved solids, total suspended solids, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand and hardness. Basic principles involved in the analysis of faecal indicator bacteria –test for coliforms – fecal coliforms – E.coli.

Sampling and Analysis of Soil: pH, cation exchange capacity, total nitrogen, phosphorous and potassium.

Textbooks

1. B. B. Kebbekus, S. Mitra, Environmental Chemical Analysis, Chapman and Hall, **1998**
2. A. Gopinath, Chandradasan, *Environmental Chemistry*, Vishal Publishing Co. Jalandhar, **2017**

Reference

1. R. B. Baird, *Standard Methods for the Examination of Water and Wastewater*, 23rd Edn., American Water Works Association, **2017**
2. A. K. De, *Environmental Chemistry*, New Age International, 7th Edn., **2007**
3. D. D. Mishra, S. S. Dara, *A Textbook of Environmental Chemistry and Pollution Control*, S. Chand Publishing, **1993**
4. P. Singh, *Environmental Pollution and Management*, Chugh Publications, **1985**
5. R. Gopalan, A. Anand, R. W. Sugumar, *A Laboratory Manual for Environmental Chemistry*, I.K. International Publishing House Pvt. Ltd., **2009**
6. R. A. Malviya, *Environmental Pollution and its Control Under International Law*, Chugh Publications, **1987**

BBCH507: ORGANIC CHEMISTRY OF ACIDS, NITROGEN COMPOUNDS AND BIOMOLECULES

Credit: 3 **Total Hours: 54**

Objectives

The objectives of this course are

- learning the nomenclature, preparation and properties of acids and its derivatives
- studying preparation and properties of nitrogen compounds
- understanding the classification of amino acids and structure of proteins
- studying the biological importance of compounds such as fats and oils, enzymes etc

Outcome

After the successful completion of the course, the learners shall be able to:

- describe the preparation and general reactions of acids and its derivatives.
- outline the classification of amino acids and structure of proteins
- introduce the preparation and reactions of nitrogen compounds
- describe the preparation of fats and oils, enzymes and proteins

Module 1: Carboxylic Acids and Derivatives **(18 hours)**

Nomenclature and classification of aliphatic and aromatic carboxylic acids, preparation and reactions. Acidity (effect of substituents on acidity) and salt formation. Ascent and descent in the homologous series.

Reactions: Mechanism of reduction, substitution in alkyl or aryl group. Preparation and properties of dicarboxylic acids such as oxalic, malonic, succinic, glutaric, adipic, pimelic and phthalic acids and unsaturated carboxylic acids such as acrylic, crotonic acids. Preparation of Maleic and Fumaric acids, lactic acid, malic acid, citric acid and tartaric acid. Madelic acid, cinnamic acid and phenyl acetic acid- preparation

Reactions: Action of heat on hydroxy and amino acids, and saturated dicarboxylic acids, stereospecific addition to maleic and fumaric acids. HVZ reaction, Coumarins.

Preparation and general reactions of acid chlorides, acid anhydrides, amides and esters, acid and alkaline hydrolysis of esters, trans-esterification. Claisen condensation, Dieckmann and Reformatsky reactions, Hofmann-bromamide degradation. Order of reactivity of functional group derivatives. Waxes.

Benzene sulphonic acids: preparation, reactions and uses. Benzene sulphonyl chlorides: o- and p- toluene benzene sulphonyl chlorides - uses.

Textbooks

1. K. S. Tewari, N.K. Vishnoi, *Organic Chemistry*, 4th Edn., Vikas Publishing House, **2017**
2. R. T. Morrison, R. N. Boyd, *Organic Chemistry*, 6th Edn., Prentice Hall, **2004**
3. G. Brahmachari, *Organic Name Reactions*, Narosa Publishing House New Delhi, **2007**

Reference

1. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, 3rdEdn., Vishal Publishing Company, **2017**
2. S. M. Mukherji, S. P. Singh, *Reaction Mechanism in Organic Chemistry*, Macmillan, **1984**
3. A. Bahl, B. S. Bahl, *Advanced Organic Chemistry*, S. Chand Publishers, **2010**

Module 2: Nitrogen compounds (10 hours)

Preparation and important reactions of nitro compounds, nitriles and isonitriles. Preparation of nitroalkanes and nitroarenes. Chemical reactions of nitroalkanes. Reduction in acidic, neutral and alkaline media. Diazomethane and diazoacetic ester: Preparation, structure and synthetic applications. Arndt- Eisterdt synthesis and Wolf rearrangement (mechanism).

Amines: Effect of substituent and solvent on basicity, preparation of amines, Gabriel phthalimide synthesis, carbylamine reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction, Separation of 1°, 2° and 3° amines with Hinsberg reagent and Hofmann method. Diazonium Salts: preparation and their synthetic applications- Sandmayer, Gatterman and Gomberg reactions (with mechanism). Hofmann, Curtius, Lossen rearrangements (with mechanism).

Urea and thiourea: preparation and reactions. Semicarbazide and basicity of guanines. Cyanides and isocyanides- preparation and reactions

Textbooks

1. K. S. Tewari, N. K. Vishnoi, Organic Chemistry, 4th Edn., Vikas Publishing House, **2017**
2. R. T. Morrison, R. N. Boyd, Organic Chemistry, 6th Edn., Prentice Hall, **2004**

Reference

1. M. K. Jain, S. C. Sharma, Modern Organic Chemistry, 3rd Edn., Vishal Publishing Company, **2017**

2. S. M. Mukherji, S. P. Singh, *Reaction Mechanism in Organic Chemistry*, Macmillan, **1984**
3. A. Bahl, B. S. Bahl, *Advanced Organic Chemistry*, S. Chand Publishers, **2010**

Module 3: Amino Acids, Proteins and Nucleic Acids (8 hours)

Amino acids, Peptides and their classification: α-Amino Acids - Synthesis-phthalimide synthesis, Strecker synthesis, solution phase peptide synthesis. Zwitter ions, pKa values, isoelectric point and electrophoresis. Structure of proteins: primary, secondary and tertiary structures of proteins: α-helix and β- pleated sheets, denaturation of proteins.

Components of nucleic acids, nucleosides and nucleotides. Structure and reactions of adenine, guanine, cytosine, uracil and thymine. Structure of polynucleotides - Watson and Crick model of DNA, structure of RNA.

Textbooks

1. I. L. Finar, *Organic Chemistry*, Vols. 1 & 2, 5th Edn., Pearson Education, **2005**
2. V. K. Ahluwalia, *Green Chemistry: Environmentally Benign Reactions*, 2nd Edn., Ane Books India, **2013**

Reference

1. J. March, *Advanced Organic Chemistry*, 6th Edn., John Wiley & Sons, **2007**
2. J. Clayden, N. Greeves, S. Warren, *Organic Chemistry*, 7th Edn., Oxford University Press, **2012**
3. R. T. Morrison, R. N. Boyd, *Organic Chemistry*, 6th Edn., Prentice Hall, **2004**

Module 4: Carbohydrates (10 hours)

Monosaccharides: Open chair and cyclic structures, Haworth projections and conformational structures. Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, interconversions of aldoses and ketoses; Kiliani - Fischer synthesis and Ruff degradation (ascent and descent in number of C atoms). Epimerisation, osazone formation, Disaccharides: reactions, structure of sucrose, lactose and maltose, ring structure. Polysaccharides: starch and cellulose-elementary idea only. Applications of starch and cellulose. Natural and artificial sweetners (introduction), Cyclodextrins (uses only- structure not required).

Textbooks

1. I. L. Finar, *Organic Chemistry*, Vols. 1 & 2, 5th Edn., Pearson Education, **2005**

2. V. K. Ahluwalia, *Green Chemistry: Environmentally Benign Reactions*, 2nd Edn., Ane Books India, **2013**

Reference

1. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, 3rd Edn., Vishal Publishing Company, **2017**
2. S. M. Mukherji, S. P. Singh, *Reaction Mechanism in Organic Chemistry*, Macmillan, **1984**
3. A. Bahl, S. Bahl, *Advanced Organic Chemistry*, S. Chand Publishers, **2010**

Module 5: Biologically Important Compounds (8 hours)

Introduction to oils and fats; common fatty acids present in oils and fats, hydrogenation of fats and oils, saponification value, acid value, iodine number. Reversion and rancidity.

Enzymes: Classification, mechanism of enzyme action, enzyme inhibition. Uses of common enzymes. Enzyme inhibitors.

Steroids: structure and function of cholesterol. Diels hydrocarbon. Elementary ideas of HDL, LDL and Vitamin D.

Vitamins: classification, uses and deficiency diseases.

Textbooks

1. I. L. Finar, *Organic Chemistry*, Vols. 1 & 2, 5th Edn., Pearson Education, **2005**
2. V. K. Ahluwalia, *Green Chemistry: Environmentally Benign Reactions*, 2nd Edn., Ane Books India, **2013**

Reference

1. J. Clayden, N. Greeves, S. Warren, *Organic Chemistry*, 7th Edn., Oxford University Press, **2012**
2. R. T. Morrison, R. N. Boyd, *Organic Chemistry*, 6th Edn.,Prentice Hall, **2004**
3. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, 3rd Edn., Vishal Publishing Company, **2017**

BBCH508: BASIC PHYSICAL CHEMISTRY

Credit: 2 **Total Hours: 36**

Objectives

The major objectives are to:

- study various laws of thermodynamics
- understand the fundamentals of chemical equilibrium
- study basics of spectroscopy
- know theory of interaction of light and matter
- analyse the rotational and vibrational energy levels of molecules

Outcome

After the successful the course, the learners shall be able to:

- analyse the laws of thermodynamics
- demonstrate the application of chemical equilibrium
- explain the interaction of various components of EM radiation with matter
- calculate the rotational and vibrational energy levels, internuclear distance etc

Module 1: Thermodynamics and Chemical Equilibrium (18 hours)

First law: concept of work, heat, internal energy, enthalpy, statement of first law. Heat capacity, relationship between heat capacities, calculations of q, w, U and H for reversible, irreversible and free expansion of ideal gases under isothermal and adiabatic conditions. Comparison of isothermal and adiabatic expansions.

Joule-Thomson effect: inversion temperature, Joule-Thomson coefficient for an ideal gas.

Zeroth law of thermodynamics: statement.

Cyclic process, Carnot cycle, Carnot's theorem, efficiency of heat engine.

Second law of thermodynamics, concept of entropy, entropy change for reversible and irreversible processes, entropy change accompanying changes of phase, entropy change of an ideal gas with change in pressure, volume and temperature, entropy change in isothermal, isobaric and isochoric process.

Enthalpy of reactions, standard enthalpy of reaction, standard enthalpy of combustion, standard enthalpy of neutralisation, standard enthalpy of formation.

Kirchhoff equations, (integrated Kirchhoff equation), flame temperature, explosion temperature

Applications of Hess's law and bond energy

Gibbs and Helmholtz free energy, variation of free energy change with temperature and pressure, Maxwell relations (equations only), criteria for reversible and irreversible process (equations only), Gibbs-Helmholtz equation.

Partial molar properties, chemical potential, Gibbs-Duhem equation, chemical potential of a mixture of ideal gases in terms of partial pressure, molar concentration and mol fraction, Clausius - Clapeyron equation.

Third law of thermodynamics (statement only)

Chemical Equilibrium - Standard free energy change, Standard free energy of formation of compounds, law of mass action, equilibrium constant, derivation of law of chemical equilibrium, derivation of relations between K_p, K_c and K_x, pressure dependence of equilibrium constants, derivation of van't Hoff equation.

Textbooks

1. B. R. Puri, L. R. Sharma, M. S. Pathania, *Principles of Physical Chemistry*, Vishal Publishing Company, Jalandhar, **2010**
2. K. L. Kapoor, *Physical Chemistry*, Vol. I, II, III & IV, Mac Millan (India) Ltd., **2000**

Reference

1. P. Atkins, J. de Paula, *Atkin's Physical Chemistry*, 7th Edn., Oxford University Press, **2006**
2. F. A. Alberty, R. J. Silby, *Physical Chemistry*, 3rd Edn., John Wiley & Sons, **2004**
3. J. Rajaram, J. C. Kuriakose, *Thermodynamics*, Shoban Lal Nagin Chand & Co., **1986**
4. G. K. Vemulapalli, *Physical Chemistry*, Prentice Hall of India Pvt. Ltd., **1997**

Module 2: Spectroscopy **(18 hours)**

Interaction of electromagnetic radiation with molecules and various types of spectra; Factors affecting width and intensity, Born- Oppenheimer approximation.

Rotation spectroscopy: classification of molecules, selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution, basic instrumentation

Vibrational spectroscopy: classical equation of vibration, computation of force constant, SHO of diatomic molecules, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, Fermi resonance, skeletal vibrations, finger print region, group frequencies, degrees of freedom for polyatomic molecules, modes of vibration, Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches.

Raman spectroscopy: classical and quantum theories, qualitative treatment of rotational Raman effect, vibrational Raman spectra, Stokes and anti-Stokes lines, rule of mutual exclusion.

Textbooks

1. N. Banwell, E.M. McCash, *Fundamentals of Molecular Spectroscopy*, 5thEdn., Tata McGraw Hill, **2017.**
2. G. Aruldhas, *Molecular Structure and Spectroscopy*, Prentice Hall of India, **2008**
3. P. S. Sindhu, *Fundamentals of Molecular Spectroscopy*, New Age International, **2011**

Reference

1. D. N. Sathyanarayan, *Handbook of Molecular Spectroscopy*, IK International Publishing, **2015**
2. H. S. Randhawa, *Modern Molecular Spectroscopy*, Macmillan India Ltd., **2009**

SEMESTR VI

BBCH609: INORGANIC CHEMISTRYOF d AND f BLOCK ELEMENTS

Credit: 3 **Total Hours: 54**

Objectives

The major objectives of the course are to:

- understand the general features of transition metals, lanthanides and actinides
- learn the chemistry of coordination compounds
- analyse the classification of metal carbonyls and various application of organometallic compound
- familiarise with inorganic clusters

Outcome

After the successful completion of the course, the learners shall able to:

- explain oxidation states in transition metals, lanthanides and actinides
- find out the crystal field splitting pattern in coordination compounds
- describe the structure and bonding in selected organometallic compounds
- assign structure to metal carbonyls based on the electron counting scheme

Module 1: d and f Block Elements **(18 hours)**

Transition Metals: general group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer and Pourbaix diagrams). Difference between first, second and third transition series.

Chemistry of Ti, V, Cr, Mn, Fe and Co in various oxidation states (extractive metallurgy not expected)

Lanthanides and actinides: comparative study of lanthanide elements with respect to electronic configuration, atomic and ionic radii, oxidation state and complex formation, colour, spectral and magnetic properties. Lanthanide contraction. Occurrence and principles of separation of lanthanides.

General features and chemistry of actinides. Trans-uranium elements. Genesis of elements and extension of periodic table. Szilard - Chalmers' separation process, processing of spent fuel, extraction of U^{233} and Pu^{239}.

Textbooks

1. B. R. Puri, L. R. Sharma, K. C. Kalia, *Principles of Inorganic Chemistry*, Vikas Publishing Co., Jalandhar, **2013**
2. R. Gopal, *Inorganic Chemistry for Undergraduates*, Universities Press, India Pvt. Ltd., **2009**
3. P. L. Soni, *Text Book of Inorganic Chemistry*, S. Chand and Sons, **2007**

Reference

1. J. E. Huheey, E. A. Keiter, R. L. Keiter, *Inorganic Chemistry: Principles of Structure and Reactivity*, 4thEdn. Pearson Education, **2006**
2. J. D. Lee, *Concise Inorganic Chemistry*, 5thEdn., Chapman & Hall, **2002**
3. D. F. Shriver, P. W. Atkins, *Inorganic Chemistry*, 3rdEdn., Oxford University Press, New Delhi, **2004**
4. F. A. Cotton, G. Wilkinson, *Advanced Inorganic Chemistry*, 1st - 6thEdns., Wiley Interscience, **1962, 1966, 1972, 1980, 1988, 1999**

Module 2: Coordination Chemistry **(18 hours)**

Werner's theory, electronic interpretation of co-ordination compounds, EAN rule, types of ligands, nomenclature, isomerism, stability of complexes, factors influencing stability, application of coordination compounds in qualitative and quantitative analysis.

VBT, CFT and MOT, merits and demerits, CFT – crystal field splitting in tetrahedral, square planar and octahedral complexes, factors affecting crystal field splitting, CFSE of complexes, consequences of crystal field splitting, tetragonal distortions from octahedral geometry. Jahn-Teller Effect. Qualitative aspect of ligand field and MO theory. Spectrochemical series. Explanation of geometry, magnetism and colour on the basis of the above theories. Origin of colour in coordination complexes, d-d transition, charge transfer transition (MLCT, LMCT). Reactivity of metal complexes: labile and inert complexes, ligand substitution reactions, substitution reactions of square planar complexes – trans effect.

Textbooks

1. B. R. Puri, L. R. Sharma, K. C. Kalia, *Principles of Inorganic Chemistry*, Vikas Publishing Co., Jalandhar, **2013**
2. R. Gopal, *Inorganic Chemistry for Undergraduates*, Universities Press, India Pvt. Ltd., **2009**

Reference

1. J. E. Huheey, E. A. Keiter, R. L. Keiter, *Inorganic Chemistry: Principles of Structure and Reactivity*, 4thEdn. Pearson Education, **2006**

2. J. D. Lee, *Concise Inorganic Chemistry*, 5thEdn, Chapman & Hall, **2002**
3. D. F. Shriver, P. W. Atkins, *Inorganic Chemistry*, 3rdEdn., Oxford University Press, New Delhi, **2004**
4. F. A. Cotton, G. Wilkinson, *Advanced Inorganic Chemistry*, 6thEdn., Wiley Interscience, **1999**

Module 3: Organometallic Compounds (12 hours)

Definition, classification based on the nature of metal-carbon bond. 18 electron rule, hapticity. Metal carbonyls: mononuclear and polynuclear carbonyls (give examples of Fe, Co, Ni) bonding in metal carbonyls, preparation of carbonyls of Fe and Ni. Ferrocene: preparation, properties, structure and bonding (only qualitative treatment). Applications of organometallic compounds: Ziegler-Natta catalyst, Wilkinson catalyst (mechanism not expected).

Textbooks

1. B. R. Puri, L. R. Sharma, K. C. Kalia, *Principles of Inorganic Chemistry*, Vikas Publishing Co., Jalandhar, **2013**
2. R. Gopal, *Inorganic Chemistry for Undergraduates*, Universities Press, India Pvt. Ltd., **2009**

Reference

1. J. E. Huheey, E. A. Keiter, R. L. Keiter, *Inorganic Chemistry: Principles of Structure and Reactivity*, 4thEdn. Pearson Education, **2006**
2. D. F. Shriver, P. W. Atkins, *Inorganic Chemistry*, 3rd Edn., Oxford University Press, New Delhi, **2004**
3. F. A. Cotton, G. Wilkinson, *Advanced Inorganic Chemistry*, 6th Edn., Wiley Interscience, **1999**

Module 4: Inorganic Clusters (6 hours)

Clusters: Metal clusters - carbonyl and halide clusters, low nuclearity carbonyl clusters and high nuclearity carbonyl clusters, electron counting schemes for $Rh_6(CO)_{16}$ and $[Os_6(CO)_{18}]^{2-}$, metal only clusters (Zintl ions). Quadruple bond - structure of $Re_2Cl_8^{2-}$.

Textbooks

7.1 B. R. Puri, L. R. Sharma, K. C. Kalia, *Principles of Inorganic Chemistry*, Vikas Publishing Co., Jalandhar, **2013**

7.2 R. Gopal, *Inorganic Chemistry for Undergraduates*, Universities Press, India Pvt. Ltd., **2009**

Reference

1. J. E. Huheey, E. A. Keiter, R. L. Keiter, *Inorganic Chemistry: Principles of Structure and Reactivity*, 4thEdn. Pearson Education, **2006**
2. J. D. Lee, *Concise Inorganic Chemistry*, 5thEdn, Chapman & Hall, **2002**
3. D. F. Shriver, P. W. Atkins, *Inorganic Chemistry*, 3rdEdn., Oxford University Press, New Delhi, **2004**
4. F. A. Cotton, G. Wilkinson, *Advanced Inorganic Chemistry*, 6th Edn., Wiley Interscience, **1999**

BBCH610: ADVANCED ORGANIC CHEMISTRY

Credit: 3 **Total Hours: 54**

Objectives

The major objective are

- understanding the fundamentals of organic spectroscopy
- familiarizing with properties and applications of polymers
- learning the chemistry of dyes
- giving an insight into the action of drugs and medicines
- Studying pericyclic reactions

Outcome

After the successful completion of the course the learners shall be able to:

- assess the IR and UV –Vis spectrum of organic molecules
- explain the mechanism of polymerization
- describe the preparation and application of dyes
- classify various drugs based on their structure
- illustrate pericyclic reactions

Module 1: Organic Spectroscopy **(18 hours)**

General principles, introduction to absorption and emission spectroscopy.

UV-Visible Spectroscopy: types of electronic transitions, effect of conjugation, concept of chromophore and auxochrome, bathochromic, hypsochromic, hyperchromic and hypochromic shifts. Woodward rules for calculation of $\lambda_{max}$for th: α,β unsaturated carbonyl compounds and conjugated dienes - alicyclic, homoannular and heteroannular and extended conjugated systems (aldehydes, ketones and dienes).

IR Spectroscopy: Factors influencing vibrational frequencies-inductive effect, hydrogen bonding, conjugation, resonance and ring size. Fingerprint region and its significance, application in functional group analysis. Interpretation of IR spectra of simple organic molecules such alcohols, phenols, amines, ethers, aldehydes, ketones, carboxylic acids, esters and amides etc.

NMR Spectroscopy: Proton NMR- Chemical shift values and factors influencing it; shielding and deshielding effects. Anisotropic effects in alkene, alkyne, aldehydes and aromatics compounds. Spin-spin splitting. Interpretation of Proton-NMR spectra of simple compounds.

Textbooks

1. Y. R. Sharma, *Elementary Organic Spectroscopy*, 5th Edition, S. Chand & Company Ltd., New Delhi, **2013**
2. R. M. Silverstein, F.X. Webster, *Spectrometric Identification of Organic Compounds*, 8th Edn, John Wiley and Sons, New York, **2015**

Reference

1. W. Kemp, *Organic Spectroscopy*, 3rd Edn., Macmillan, New York, **2008**
2. P. S. Kalsi, *Applications of Spectroscopic Techniques in Organic Chemistry*, 7th Edition, New Age International (P) Ltd., New Delhi, **2016**

Module 2: Polymers **(9 hours)**

Introduction and classification of polymers, structure, different molecular weight averages, Polydispersity Index. Determination of molecular weight by GPC, Glass transition temperature (T_g) of polymers. Polymerisation reactions: addition and condensation. Synthesis and uses of PVC, PMMA, PAN, polyamides (nylon 66, nylon 6), phenol-formaldehyde resin, polyurethanes, rubbers (NR, SBR, NBR, PB, polychloroprene and thiokol rubber). Vulcanization of rubber (hot and cold), biodegradable and conducting polymers with examples, Ziegler Natta catalysed polymerization (basic idea only).

Textbooks

1. V. R. Gowariker, N. V. Viswanathan, J. Sreedhar, *Polymer Science*, New Age International (P) Ltd., **2011**
2. B. K. Sharma, *Polymer Chemistry*, Goel Publishing House, Meerut, **1989**

Reference

1. G. Odian, *Principles of Polymerization*, 4th Edn., Wiley, **2004**
2. F. W. Billmeyer Jr., *Textbook of Polymer Science*, John Wiley and Sons, New Delhi, **2007**
3. M. G. Arora, M. Singh, M.S. Yadav, *Polymer Chemistry*, 2nd Revised Edn., Anmol *Publications* Private Ltd., New Delhi, **1989**
4. M. P. Stevens, *Polymer Chemistry*: An Introduction, 3rd Edn, Oxford University Press, USA, **1998**

Module 3: Dyes **(5 hours)**

Dyes: classification, colour and constitution, mordant and vat dyes. Synthesis and applications of: azo dyes – methyl orange and congo red (mechanism of Diazo Coupling);

triphenyl methane dyes - malachite green, rosaniline and crystal violet; phthalein dyes – phenolphthalein and fluorescein; natural dyes – structure and synthesis of alizarin and indigotin. Edible dyes with examples.

Textbooks

1. P. Y. Bruice, *Organic Chemistry*, 7thEdn., Pearson Prentice Hall, **2011**
2. B. Mehta, M. Mehta, *Organic Chemistry*, PHI Learning Private Limited, **2015**
3. C. Bhakta, *Organic Chemistry*, Bharathi Bhavan Publishers and Distributors, **2014**

Reference

1. V. K. Ahluwalia, *Green Chemistry: Environmentally Benign Reactions*, 2ndEdn., Ane Books India, **2013**
2. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, 3rdEdn., Vishal Publishing Company, **2017**
3. A. Bahl, B. S. Bahl, *Advanced Organic Chemistry*, 20 th Edn., S. Chand Publishers, **2002**

Module 4: Medicinal Chemistry **(4 hours)**

Drugs - Mode of drug action agonist and antagonist, LD_{50}. Classification of drugs, structure and uses of sulpha drugs, chloramphenicol and pencillin. Antimalarial drugs, antipyretic dugs and analgesic drugs (structure, mode of action - basic idea).

Textbooks

1. A. Burger, *Medicinal Chemistry* -A Burger-Wiley Interscience, New York, Vol.I and II, **1990**
2. O. Wilson, O. Giswold, F. George J. G., *Text Book of Organic, Medicinal and Pharmaceutical Chemistry*, Lippincott Company, Philadelphia, 9th Edn., **1991**

Reference

1. A. O. Bentley, J.E. Driver, *Lewis Malcolm Atherden - Bentley and Drivers' Text Book of Pharmaceutical Chemistry,* **1969**
2. G. Patrick, *Medicinal Chemistry*, Garland Science, 5th Edn., **2013**

Module 5: Pericyclic Reactions **(12 hours)**

Pericyclic and photochemical reactions: definition and classification. Electrocyclic reactions: FMO approach, example of electrocyclic reactions (thermal and photochemical) involving 4π and 6π electrons and corresponding cycloreversion reaction. Cycloaddition reactions: FMO approach, Diels Alder reaction, photochemical [2+2] reactions. Sigmatropic

shifts and their orders, [1, 3] and [1, 5] hydrogen shifts and [3, 3] shifts with reference to Claisen and Cope rearrangement.

Textbooks

1. A. Fleming, *Frontier Orbitals and Organic Chemical Reactions*, Wiley, **1976**
2. S. Sankararaman, *Pericyclic Reactions-A Text Book*, Wiley VCH, **2005**

Reference

1. R. O. C Norman, J. M. Coxon, *Principles of Organic Synthesis*. Second Indian reprint, **2012**
2. G. Brahmachari, *Organic Name Reactions*, Narosa Publishing House New Delhi, **2007**

Module 6: Special Reagents **(6 hours)**

Utility of reagents: n – Bu_3SnH, boranes, trimethyl silyl chloride, hydrogen peroxide, N-bromosuccinimide, DDQ, m - CPBA, $Pb(OAc)_4$, periodic acid, osmium tetroxide, Grignard reagents, alkyl lithium compounds and organo copper reagents.

Textbooks

1. S. Delvin, *Organic Reagents and Name Reactions*, Sarup and Sons, New Delhi, **2005**
2. V. K. Ahluwalia, R. K. Parashar, *Organic Reaction Mechanisms*, Alpha Science International, **2007**

Reference

1. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, Vishal Publishing Company, **2015**
2. K. S. Tewari, N. K. Vishnoi, *Organic Chemistry*, 3rd Edn., Vikas Publishing House, **2006**

BBCH611: ADVANCED PHYSICAL CHEMISTRY

Credit: 3 **Total Hours: 54**

Objectives

The major objectives are to:

- understand the electronic levels of molecules and spin states of proton and electron
- interpret the NMR and ESR spectra of simple molecules/radicals
- understand the relevance of statistical mechanics
- understand various concepts in phase equilibria
- give an insight into the kinetics of reactions
- understand the fundamentals of photochemistry

Outcome

After the successful completion of the course, students shall be able to:

- explain the interaction of UV/vis radiation with molecules
- predict the NMR/ESR spectra of simple molecules/radicals
- formulate the statistical distribution of various types of particles in different energy modes
- assess the use of statistical mechanics for explaining the material properties
- explain the properties of dilute solutions
- discuss the kinetics of reactions
- summarize the basics of photochemistry

Module 1: Advanced Spectroscopy **(12 hours)**

Electronic spectroscopy: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation, calculation of electronic transitions of polyenes using free electron model.

Nuclear Magnetic Resonance (NMR) spectroscopy: principles of NMR spectroscopy, Larmor precession, chemical shift, low resolution spectra, different scales, spin-spin coupling and high resolution spectra, interpretation of PMR spectra of simple organic molecules.

Electron Spin Resonance (ESR) spectroscopy: principle, hyperfine structure, ESR of simple radicals like methyl, ethyl etc.

Textbooks

1. N. Banwell, E.M. McCash, *Fundamentals of Molecular Spectroscopy*, 5th Edn., Tata McGraw Hill, **2017**
2. G. Aruldhas, *Molecular Structure and Spectroscopy*, Prentice Hall of India, **2008**

3. P. S. Sindhu, *Fundamentals of Molecular Spectroscopy*, New Age International, **2011**

Reference

1. R. S. Drago, *Physical Methods in Chemistry*, Saunders College, **1992**
2. D. N. Sathyanarayan, *Handbook of Molecular Spectroscopy*, IK International Publishing, **2015**
3. H. S. Randhawa, *Modern Molecular Spectroscopy*, Macmillan India Ltd., **2009**
4. B.R. P uri, L.R. Sharma, M. S. Pathania, *Principles of Physical Chemistry*, Vishal Publishing Company, **2017**
5. H. Gunther, *NMR Spectroscopy*, Wiley, **1995**
6. Atta-ur-Rahman, *Nuclear Magnetic Resonance: Basic Principles*, Springer, **2008**

Module 2: Statistical Mechanics **(6 hours)**

Statistical Mechanics: macrostates and microstates, thermodynamic probability, entropy and probability, statistical interpretation of third law of thermodynamics, equipartition principle and heat capacity. Boltzman exponential law (no derivations), Boltzons, Bosons, Fermions (basic ideas only) and their arrangements.

Textbooks

1. M.C. Gupta, *Statistical Thermodynamics*, New age international, **2007**
2. B K Agarwal, *Statistical Mechanics*, New age international, **2013**

Reference

1. D. A. McQuarrie, *Statistical Mechanics*, University Science Books, **2011**
2. B. Widom, *Statistical Mechanics: A Concise Introduction for Chemists*, Cambridge University Press, **2002**
3. Andrew Cooksy, *Physical Chemistry: Thermodynamics, Statistical Mechanics, and Kinetics*, Pearson Education, **2013**
4. Leonard Kollender Nash, *Elements of Statistical Thermodynamics*, Dover Books, **2006**

Module 3: Phase Equilibrium and Solutions **(18 hours)**

Concept of phases, components and degrees of freedom, Gibbs Phase Rule, One component systems: water and sulphur systems. Two component systems: solid – liquid equilibrium – naphthalene- biphenyl system, potassium iodide – water system, freezing mixtures. Simple eutectic – Lead – silver system. Formation of compounds with congruent melting point – ferric chloride – water system. Incongruent melting point. Solid – gas

equilibrium – salt hydrate. Thermal analysis: cooling curve. Nernst distribution law: derivation and applications.

Solutions: dilute solutions; lowering of vapour pressure, Raoult's and Henry's laws and their applications. Thermodynamic derivation using chemical potential to derive relations between the four colligative properties (i) relative lowering of vapour pressure (ii) elevation of boiling point, (iii) depression of freezing point and (iv) osmotic pressure and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution. van't Hoff factor. Calculations based on these.

Textbooks

1. B. R Puri, L. R Sharma, M. S. Pathania, *Principles of Physical Chemistry*, Vishal Publishing Company, Jalandhar, **2010**
2. K. L. Kapoor, *Physical Chemistry*, Vol. I, II, III & IV, Mac Millan (India) Ltd., **2000**

Reference

1. P. Atkins, J. de Paula, *Atkin's Physical Chemistry*, 7th Edn., Oxford University Press, **2006**
2. I. N. Levine, *Physical Chemistry*, 6thEdn., Mc Graw Hill, **2009**
3. K. J. Laidler, J. H.Meiser, *Physical Chemistry*, 2nd Edn., **1995**

Module 4: Kinetics and Photochemistry **(18 hours)**

Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated form of rate expressions up to second order reactions, experimental methods of the determination of rate laws, kinetics of complex reactions (integrated rate expressions up to first order only): (i) opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions. Determination of order of reactions.

Temperature dependence of reaction rates: Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates.

Photochemistry: Characteristics of electromagnetic radiation, Lambert-Beer's law and its limitations, physical significance of absorption coefficients. Laws of photochemistry, quantum yield, actinometry, examples of low and high quantum yields, photochemical equilibrium and the differential rate of photochemical reactions, photosensitised reactions,

quenching. Role of photochemical reactions in biochemical processes, photostationary states, chemiluminescence, Jablonski diagram.

Textbooks

1. B. R Puri, L. R Sharma, M. S. Pathania, *Principles of Physical Chemistry*, Vishal Publishing Company, Jalandhar, **2010**
2. K. L. Kapoor, *Physical Chemistry*, Vol. I, II, III & IV, Mac Millan (India) Ltd., **2000**

Reference

1. Mc Quarrie, J. D. Simon, *Physical Chemistry – A molecular Approach*, Viva Books Pvt. Ltd, **2011**
2. G. K. Vemulapalli, *Physical Chemistry*, Prentice Hall of India Pvt. Ltd., **1998**

BBCH612: ELECTROCHEMISTRY AND SURFACE CHEMISTRY

Credit: 3 **Total Hours: 54**

Objectives

The major objectives are

- understanding the fundaments of conductometric and potentiometric titrations
- studying electrochemical cells
- learning ionic equilibria
- familiarizing with adsorption isotherms
- understanding the classification of catalysis

Outcome

After the successful completion of the course, the students shall be able to:

- explain the applications of conductance measurements
- describe the theory of acids and bases
- outline different adsorption isotherms
- exemplify various types of catalysts
- discuss the electrical properties of molecules

Module 1: Electrical Conductance and EMF **(18 hours)**

Conductance: Faraday's laws of electrolysis, measurement of conductance, cell constant, specific conductance and molar conductance. Variation of specific and equivalent conductance with dilution for strong and weak electrolytes. Kohlrausch's law of independent migration of ions, ion conductance and ionic mobility. Equivalent and molar conductance at infinite dilution and their determination for strong and weak electrolytes. Ostwald's dilution law. Debye-Huckel model (physical idea only). Application of conductance measurement (determination of solubility product and ionic product of water). Conductometric titrations. Determination of transport number by moving boundary method.

Electrochemical Cells: types of electrochemical cells and examples, cell reactions, emf and change in free energy, ΔH and ΔS and equilibrium constant of cell reactions from emf measurements. Thermodynamic derivation of Nernst equation. Standard cells, half cells/electrodes, different types of electrodes (with examples). Standard electrode potential (IUPAC convention) and principles of its determination. Determination of pH values using hydrogen, quinone-hydroquinone and glass electrodes. Potentiometric titrations: acid-base

and redox. Rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry.

Concentration cells: electrode concentration cell and electrolyte concentration cells. Types of electrolyte concentration cells – with transference and without transference, liquid junction potential. Over voltage, oxygen over voltage, factors affecting over voltage. Polarography, half wave potential, Ilkovic equation and application in quantitative analysis (elementary ideas only).

Textbooks

1. B. R Puri, L. R Sharma, M. S. Pathania, *Principles of Physical Chemistry*, Vishal Publishing Company, Jalandhar, **2010**

Reference

1. K. L. Kapoor, *Physical Chemistry*, Vol. I, II, III & IV, Mac Millan (India) Ltd., **2000**
2. P. Atkins, J. de Paula, *Atkin's Physical Chemistry*, 7th Edn., Oxford University Press, **2006**
3. F. A. Alberty, R. J. Silby, *Physical Chemistry*, *3 rd*Edn., John Wiley & Sons, **2004**

Module 2: Ionic Equilibrium **(18 hours)**

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization. Theories of acids and bases: Lewis concept, Lux-Flood definition, Usanovich definition, hard and soft acids and bases. Effect of solvents on the strength of acids and bases, levelling effect. Ionization of weak acids and bases, dissociation constant, dissociation constants of polybasic acids, relative strengths of weak acids and bases, ionic product of water, pH and pOH.

Common ion effect, buffer solutions, buffer capacity, buffer range, buffer action, pH of buffer solutions, applications of buffers in analytical chemistry and biochemical processes in the human body.

Salt hydrolysis: calculation of hydrolysis constant, degree of hydrolysis and pH for different salts.

Theory of acid - base indicators, action of phenolphthalein and methyl orange, titration curves of strong acid against strong base and weak acid with strong base, mathematical treatment of acid base titrations.

Solubility product, relation between solubility product and molar solubility of sparingly soluble salts, applications of solubility product principle.

Textbooks

1. B. R Puri, L. R Sharma, M. S. Pathania, *Principles of Physical Chemistry*, Vishal Publishing Company, Jalandhar, **2010**

Reference

1. K. L. Kapoor, *Physical Chemistry*, Vol. I, II, III & IV, Mac Millan (India) Ltd., **2000**
2. P. Atkins, J. de Paula, *Atkin's Physical Chemistry*, 7th Edn., Oxford University Press, **2006**
3. F. A. Alberty, R. J. Silby, *Physical Chemistry*, *3rd* Edn., John Wiley & Sons, **2004**

Module 3: Surface Chemistry and Catalysis **(12 hours)**

Surface Chemistry: adsorption and surface phenomena, physisorption and chemisorption of gases, adsorption isobar, isostere and isotherms, Freundlich adsorption isotherm, derivation of Gibbs and Langmuir isotherm, BET equation (derivation not required) and its use in surface area determination, nature of adsorbed state, adsorption and heterogeneous catalysis, surface film.

Colloids: electrical double layer and colloid stability, electrokinetic phenomena, soaps and detergents, micelle formation and critical micelle concentration.

Catalysis: types of catalyst, specificity and selectivity, mechanisms of catalysed reactions at solid surfaces. Autocatalysis, enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

Textbooks

1. B. R Puri, L. R Sharma, M. S. Pathania, *Principles of Physical Chemistry*, Vishal Publishing Company, Jalandhar, **2010**
2. Gurdeep Raj, *Surface Chemistry*, Goel Publishing House, **2006**

Reference

1. A. W. Adamson, A. P Gast, *Physical Chemistry of Surfaces*, 6th Edn., Wiley, **1997**
2. P. Atkins, J. de Paula, *Atkin's Physical Chemistry*, 7th Edn., Oxford University Press, **2006**
3. B. R Puri, L. R Sharma, M. S. Pathania, *Principles of Physical Chemistry*, Vishal Publishing Company, Jalandhar, **2010**

Module 4: Electrical Properties of Substances **(6 hours)**

Electrical properties of molecules: polarisability of atoms and molecules, dielectric constant and polarisation, molar polarisation for polar and non-polar molecules. Clausius -

Mosotti equation and Debye equation and their application. Determination of dipole moments.

Textbooks

1. B. R Puri, L. R Sharma, M. S. Pathania, *Principles of Physical Chemistry*, Vishal Publishing Company, Jalandhar, **2010**

Reference

1. K. L. Kapoor, *Physical Chemistry*, Vol. IV, Mac Millan (India) Ltd., 2**000**
2. P. Atkins, J. de Paula, *Atkin's Physical Chemistry*, 7thEdn., Oxford University Press, **2006**

PRACTICAL

SEMESTER V AND VI

BBCH6P03: ORGANIC CHEMISTRY PRACTICAL - II

Credit: 3 **Total Hours: 108**

Chromatography

TLC

Separation and identification - Determination of R_f value of o - and p – nitroanilines, benzil and o-nitroaniline ortho and para chloroanilines or any two amino acids.

Column Chromatography

Purification of o - nitro aniline, m - dinitro benzene, benzene azo-β-naphthol. (non-evaluative).

Organic preparations involving single step (Evaluative)

(Any 5 preparations to be done in the laboratory. The following are only a few examples)

1. Acylation (benzoylation of aniline, phenol, β - naphthol)
2. Esterification (benzoic acid)
3. Iodoform from acetone or ethyl methyl ketone
4. Side chain oxidation (benzyl chloride to benzoic acid)
5. Claisen – Schmidt (dibenzal acetone from benzaldyde)
6. Nitration of benzoic acid and acetanilide

Quantitative analysis (Non-evaluative)

1. Milk analysis
2. Oil analysis- saponification value, iodine value
3. Latex analysis

Reference

1. A. O. Thomas, *Practical Chemistry*, 7th Edn., Scientific Book Centre, Kannur, **1999**
2. Brian S. Furniss, Antony J. Hannaford, Peter W. G. Smith, Austin R. Tatchell, *Vogel's Textbook of Practical Organic Chemistry*, Longman Scientific and Technical, **1989**
3. F. G. Mann, B. C. Saunders, *Practical Organic Chemistry*, 4thEdn., Pearson Education, **2009**

4. V. K. Ahluwalia, S. Dhingra, *Comprehensive Practical Organic Chemistry: Preparations and Quantitative Analysis*, Universities Press, **2004**
5. A. I. Vogel, *A Textbook of Quantitative Inorganic Analysis Including Elementary Instrumental Analysis*, 3rdEdn., Longman, **1971**

BBCH6P04: PHYSICAL CHEMISTRY PRACTICAL

Credit: 2 **Total Hours: 72**

1. Critical solution temperature - phenol-water system
2. Determination of molecular weight by Rast's Method (using naphthalene, camphor or biphenyl as solvent and acetanilide, p-dichlorobenzene as solute)
3. Kinetics of simple reactions (acid hydrolysis of methyl acetate)
4. Potentiometric titration – Fe^{2+} *vs.* $Cr_2O_7^{2-}$, I^- *vs.* MnO_4^-, strong acid- strong base, weak acid-strong base
5. Data analysis of kinetic experiments using spread sheet program (determination of rate constant)
6. Determination of equivalence point of potentiometric and conductometric titrations using spread sheet program
7. Colorimetric analysis

Reference

1. A. O. Thomas, *Practical Chemistry*, 7th Edn., Scientific Book Centre, Kannur, **1999**
2. W. G. Palmer, *Experimental Physical Chemistry*, Cambridge University Press, **2009**
3. J. B. Yadav, *Advanced Practical Physical Chemistry*, 29thEdn., Krishna Prakashan Media Pvt. Ltd., **2010**
4. R. C. Das, B. Behera, *Experiments in Physical Chemistry*, Tata McGraw-Hill, **1983**
5. K. K. Sharma, *An Introduction of Practical Chemistry*, Vikas Publishing House, New Delhi, **2003**

BBCH6P05: GRAVIMETRIC ANALYSIS

Credit: 3 **Total Hours: 108**

1. Estimation of barium as $BaSO_4$
2. Estimation of sulphate as $BaSO_4$
3. Estimation of iron as Fe_2O_3
4. Estimation of nickel as dimethyl glyoxime complex
5. Estimation of copper as CuCNS

Reference

1. A. O. Thomas, *Practical Chemistry*, 7th Edn., Scientific Book Centre, Kannur, **1999**
2. A. I. Vogel, A *Textbook of Quantitative Inorganic Analysis Including Elementary Instrumental Analysis*, 3rdEdn., Longman, **1971**
3. G. H. Jeffery, J. Bassett, J. Mendham, R. C. Denney, *Vogel's Text Book of Quantitative Chemical Analysis*, 5thEdn., Longman Scientific and Technical, **1989**

BBCH6P06: VOLUMETRIC ANALYSIS

Credit: 2 **Total Hours: 72**

Acidimetry and Alkalimetry

1. Strong acid – Weak base
2. Strong base – Weak acid
3. Estimation of Na_2CO_3 and $NaHCO_3$ in a mixture
4. Estimation of NaOH and Na_2CO_3 in a mixture
5. Estimation of ammonia in ammonium salts by direct and indirect methods

Permanganometry

1. Estimation of oxalic acid
2. Estimation of Mohr's salt
3. Estimatrion of calcium
4. Estimation of ferric iron

Dichrometry

1. Estimation of ferrous iron using internal indicator
2. Estimation of ferrous iron using external indicator
3. Estimation of ferric iron using internal indicator
4. Estimation of ferric iron using external indicator

Complexometry

1. Estimation of Zn using EDTA
2. Estimation of Mg using EDTA
3. Estimation of Mg and Ca in a mixture
4. Estimation of Ni
5. Determination of hardness of water

Reference

1. A. O. Thomas, *Practical Chemistry*, 7th Edn., Scientific Book Centre, Kannur, **1999**
2. D. A. Skoog, D. M. West, F. James Holler, S. R. Crouch, *Fundamentals of Analytical Chemistry*, 8th Edn., Brooks/Cole, **2004**

3. J. Mendham, R. C. Denney, J. D. Barnes, M. J. K. Thomas, *Vogel's Textbook of Quantitative Chemical Analysis* 6thEdn., Prentice Hall, **2000**
4. G. D. Christian, *Analytical Chemistry*, 6thEdn., John Wiley and Sons, **2003**
5. R. A. Day, A. L. Underwood, *Quantitative Analysis*,6thEdn., Prentice Hall, 1**991**

ELECTIVE COURSES

(Any **one** course to be opted from the following courses)

BBCH6E01: MATERIALS CHEMISTRY

Credit: 3 **Total Hours: 54**

Objectives

The major objectives are to:

- study inorganic polymers
- understand the role of metal ions and enzymes in biological systems
- learn the fundamentals of nanomaterials and refractories
- understand various analytical methods in chemical analysis

Outcome

After the successful completion of the course, students shall be able to:

- differentiate between inorganic and organic polymers
- describe various chemical reactions in the biological systems
- explain the synthesis of nanomaterials
- outline the application of spectroscopic and thermal methods in chemical analysis

Module 1: Inorganic Polymers and Bio-inorganic Chemistry (18 hours)

Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes, phosphazenes

Bioinorganic chemistry: Elements of life - essential major, trace and ultra trace elements. Basic chemical reactions in the biological systems and the role of metal ions (specially Na^+, K^+, $Mg^{2+,}$ Ca^{2+}, $Fe^{3+/2+}$, $Cu^{2+/+}$, and Zn^{2+}). Metal ion transport across biological membrane Na^+ ion pump, ionophores. Biological functions of haemoglobin and myoglobin, cytochromes and ferredoxins, carbonate bicarbonate buffering system and carbonic anhydrase. Biological nitrogen fixation. Photosynthesis: Photosystem - I and Photosystem - II. Toxic metal ions and their effects, chelation therapy (examples only), Pt and Au complexes as drugs (examples only).

Textbooks

1. J. E. Huheey, E. A. Keiter, R. L. Keiter, *Inorganic Chemistry: Principles of Structure and Reactivity*, 4thEdn. Pearson Education, **2006**

2. J. D. Lee, *Concise Inorganic Chemistry*, 5thEdn., Chapman & Hall, **2002**

Reference

1. B. R. Puri, L. R. Sharma, K. C. Kalia, *Principles of Inorganic Chemistry*, Vikas Publishing Co., Jalandhar, **2013**
2. D. F. Shriver, P. W. Atkins, *Inorganic Chemistry*, 3rd Edn., Oxford University Press, New Delhi, **2004**
3. B. R. Puri, L. R. Sharma, K. C. Kalia, *Principles of Inorganic Chemistry*, Vikas Publishing Co., Jalandhar, **2013**
4. F. A. Cotton, G. Wilkinson, *Advanced Inorganic Chemistry*, 1st - 6thEdns., Wiley Interscience, **1962, 1966, 1972, 1980, 1988, 1999**

Module 2: Metallurgy and Chemistry of Materials (18 hours)

Metallurgy: occurrence of metals based on standard electrode potential, methods of concentration of ores, reduction to free metal, electrometallurgy, hydrometallurgy. Refining of metals, electrolytic, ion exchange, zone refining, vapour phase refining and oxidative refining. Thermodynamics of the oxidation of metals to metal oxides - Ellingham diagrams

Nanomaterials – classification, synthesis – chemical precipitation, mechanic-chemical method, micro emulsion method, reduction technique, chemical vapour deposition and sol-gel method (brief study). Fullerenes and carbon nanotubes (elementary idea only).

Refractory materials: carbides, nitrides, borides. Graphite and graphite oxide, intercalation compounds of alkali metals, carbon monofluoride, intercalation compounds of graphite with metal halides, glass, silicates, zeolites, ultramarines and ceramics.

Textbooks

1. A. Cottrel, *An Introduction to Metallurgy*, 2nd Edn., Universities Press, **1975**
2. T. Pradeep, *Nano; The Essentials*, Mc Graw-Hill Education, New Delhi, **2006**
3. F. A. Cotton, G. Wilkinson, *Advanced Inorganic Chemistry*, 6th Edn., Wiley Interscience, **1999**
4. B. R. Puri, L. R. Sharma, K. C. Kalia, *Principles of Inorganic Chemistry*, Vikas Publishing Co., Jalandhar, **2013**

Reference

1. V. S. Muraleedharan, A. Subramania, *Nanosciece and Nanotechnology*, Ane Books Pvt. Ltd., New Delhi, **2009**
2. J. E. Huheey, E. A. Keiter, R. L. Keiter, *Inorganic Chemistry: Principles of Structure and Reactivity*, 4th Edn. Pearson Education, **2006**

Module 3: Analytical Methods in Chemical Analysis (18hours)

Optical methods of analysis: origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer - Lambert's law.

UV - Visible spectrometry: basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument; Basic principle of quantitative analysis: estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers.

Infrared spectrometry: basic principle, instrumentation (choice of source, monochromator and detector) for single and double beam instrument; sampling techniques, and applications.

Flame atomic absorption and emission spectrometry: basic principle, instrumentation (choice of source, monochromator, detector, choice of flame and burner designs). Techniques of atomization, sample introduction, analysis and application (basic idea only).

Thermal method of analysis: theory of thermogravimetry (TGA), basic principle and instrumentation. Techniques for quantitative estimation of Ca and Mg from their mixture.

Electro analytical methods: classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence point.

Textbooks

1. G. R. Chatwal, S.K. Anand, *Instrumental Methods Of Chemical Analysis*, Himalaya Publishing House, **2011**
2. S. K. Anand, G.R. Chatwal, *Instrumental Methods Of Chemical Analysis,* Himalaya Publishing House, **2014**

Reference

1. G. D Christian, *Analytical Chemistry*, 6thEdn. New York, John Wiley, **2004**
2. S. M. Khopkar, *Basic Concepts of Analytical Chemistry*, New Age, International Publisher, **2009**
3. D. A. Skoog, F. James Holler, Stanley R. Crouch, *Principles of Instrumental Analysis*, 6th Edn, Thomson Asia Pvt. Ltd., London, **2006**
4. P. A. Salunke, M. R. Usman, *A Text Book of Instrumental Methods of Analysis,* S. Vikas and Company, **2018**

BBCH6E02: POLYMER CHEMISTRY

Credit: 3 **Total Hours: 54**

Objectives

The major objectives are to:

- understand the history of polymers
- familiarize with mechanism of polymerisation
- learn the structure-property relationship of polymers
- give an insight into various polymerisation techniques

Outcome

After the successful completion of the course, students shall be able to:

- classify polymers based on their structure and origin
- to explain the mechanism of polymerization
- to calculate the molecular weight of polymers
- outline the preparation and properties of common polymers

Module 1: Introduction **(9 hours)**

Brief history of macromolecular science, general characteristics of polymers in comparison with common organic compounds, Polymers and macromolecules – Monomers – Homo and hetero polymers – Copolymers - Classification based on origin (natural, semi synthetic and synthetic), synthesis (addition and condensation), structure (linear, branched chain and cross linked) and intermolecular forces (elastomers, fibres, thermoplastics and thermosetting polymers).

Textbooks

1. V. R. Gowariker, N. V. Viswanathan, J. Sreedhar, *Polymer Science*, New Age International (P) Ltd., **2011**
2. B.K. Sharma, *Polymer Chemistry*, Goel Publishing House, Meerut, **1989**

Reference

1. G. Odian, *Principles of Polymerization*, 4th Edn., Wiley, **2004**
2. F. W. Billmeyer Jr., *Textbook of Polymer Science*, John Wiley and Sons, New Delhi, **2007**
3. R. Bahadur, N.V. Sastry, *Principles of Polymer Science*, Narosa, New Delhi, **2003**

Module 2: Mechanism of Polymerisation (6 hours)

Chain and step growth polymerisations – Free radical, ionic (both cationic and anionic) and coordination polymerisations with mechanism – Zeigler-Natta polymerization (mechanism expected) and its advantages. Mechanism of copolymerization. Ring-opening & group transfer polymerizations.

Textbooks

1. V. R. Gowariker, N. V. Viswanathan, J. Sreedhar, *Polymer Science*, New Age International (P) Ltd., **2011**
2. B.K. Sharma, *Polymer Chemistry*, Goel Publishing House, Meerut, **1989**

Reference

1. G. Odian, *Principles of Polymerization*, 4th Edn., Wiley, **2004**
2. F.W. Billmeyer Jr., *Textbook of Polymer Science,* John Wiley and Sons, New Delhi, **2007**

Module 3: Structure-Property Relationships of Polymers (12 hours)

Crystallization and Crystallinity: Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point. Molecular weight of polymers***:*** Determination of Molecular Weight of Polymers (*Mn, Mw,* etc) by end group analysis, viscometry, light scattering and osmotic pressure methods. Molecular weight distribution and its significance. Polydispersity index and its significance - Molecular weights and degree of polymerisation. Glass Transition Temperature (Tg): Definition. Factors influencing glass transition temperature (Tg). Tg and molecular weight. Tg and melting point. Importance of Tg. Degradation: Basic idea of thermal, photo and oxidative degradations of polymers.

Textbooks

1. V. R. Gowariker, N. V. Viswanathan, J. Sreedhar, *Polymer Science*, New Age International (P) Ltd., **2011**
2. B.K. Sharma, *Polymer Chemistry*, Goel Publishing House, Meerut, **1989**

Reference

1. G. Odian, *Principles of Polymerization*, 4th Edn., Wiley, **2004**
2. F.W. Billmeyer Jr., *Textbook of Polymer Science,* John Wiley and Sons, New Delhi, **2007**
3. M.G. Arora, M. Singh, M.S. Yadav, *Polymer Chemistry,* 2nd Revised Edn., Anmol *Publications* Private Ltd., New Delhi, **1989**

4. M. P. Stevens, *Polymer Chemistry: An Introduction*, 3rd Edn, Oxford University Press, USA, **1998**

Module 4: Polymerisation Techniques and Processing (9 hours)

Polymerisation Techniques: Bulk, solution, suspension, emulsion, melt condensation and interfacial polycondensation polymerisations.

Polymer Processing: Compression moulding, Injection moulding, Blow moulding, Extrusion moulding, Thermoforming, Die casting, Film casting, Rotational casting, Calendering and Spinning. Polymer industry in India.

Textbooks

1. V. R. Gowariker, N. V. Viswanathan, J. Sreedhar, *Polymer Science*, New Age International (P) Ltd., **2011**
2. B.K. Sharma, *Polymer Chemistry*, Goel Publishing House, Meerut, **1989**

Reference

1. G. Odian, *Principles of Polymerization*, 4th Edn., Wiley, **2004**
2. F.W. Billmeyer Jr., *Textbook of Polymer Science,* John Wiley and Sons, New Delhi, **2007**
3. M.G. Arora, M. Singh, M.S. Yadav, *Polymer Chemistry*, 2nd Revised Edn., Anmol Publications Private Ltd., New Delhi, **1989**
4. M. P. Stevens, *Polymer Chemistry: An Introduction*, 3rd Edn, Oxford University Press, USA, **1998**

Module 5: Commercial Polymers (9 hours)

Preparation, structure, properties and uses of polyethylene (LDPE and HDPE), polypropylene, polystyrene, PVC, PVP, saran, dynel, teflon, PAN, PMMA, super glue, synthetic rubbers (BR, SBR, nitrile rubber, neoprene, butyl rubber and silicone rubber), terylene, glyptal, lexan, kevlar, and. nomex, polyurethanes, poly carbonates, silicones melmac, phenol-formaldehyde resin and urea-formaldehyde resin Plastic identification codes, Pollution due to plastics - Recycling of plastics.

Textbooks

1. V. R. Gowariker, N. V. Viswanathan, J. Sreedhar, *Polymer Science*, New Age International (P) Ltd., **2011**
2. B.K. Sharma, *Polymer Chemistry*, Goel Publishing House, Meerut, **1989**

Reference

1. G. Odian, *Principles of Polymerization*, 4th Edn., Wiley, **2004**

2. F.W. Billmeyer Jr., *Textbook of Polymer Science*, John Wiley and Sons, New Delhi, **2007**

Module 6: Specialty Polymers **(9 Hours)**

High temperature resistant and flame retardant polymers. Biomedical applications of polymers. Controlled drug delivery systems. Conducting polymers - polyacetylene, polyaniline, poly(*p*-phenylene sulphide), polypyrrole, polythiophene. Conduction mechanism and applications. Carbon nanotubes. Synthesis and applications (elementary idea only).

Textbooks

1. F. Mohammad, *Specialty Polymers: Materials and Applications*, I. K. International Pvt Ltd, **2007**
2. R. Bahadur, N. V. Sastry, *Principles of Polymer Science*, Narosa, New Delhi, **2003**

Reference

1. R. W. Lenz. *Organic Chemistry of Synthetic High Polymers*. Interscience Publishers, New York, **1967**
2. R. W. Dyson, *Specialty Polymers*, Chapman and Hall, New York, **1998**

COMPLEMENTARY COURSES

SEMESTER I

BDCH101: BASIC ANALYTICAL AND MATERIAL CHEMISTRY

(Common to Physical Sciences and Life Sciences)

Credit: 2 **Total Hours: 36**

Objectives

The main objectives are to:

- understand the fundamentals of analytical chemistry and chromatographic techniques
- understand the basic analytical techniques used in chemical sciences
- get an overview about the errors in chemical analysis
- introduce the field of nanochemistry

Outcome

Upon successful completion of this course, the student shall

- learn the important analytical and instrumental tools used for practicing chemistry.
- evaluate analytical data, calculate accuracy, precision etc
- practice different methods for the elimination or minimization of errors
- develop a fundamental understanding about the importance and applications of nanochemistry

Module 1: Introduction to Analytical Methods **(18 hours)**

General principle, types of titrations, requirements for titrimetric analysis. Methods of expressing concentration: Molarity, formality, normality, weight percentage, ppm, milli equivalence and milli moles - problems. Primary and secondary standards, criteria for primary standards, preparation of standard solutions, standardization of solutions. Limitation of volumetric analysis, endpoint and equivalence point **(Self study).**

Acid - base equilibria: pH of strong and weak acid solutions. Buffer solutions, Henderson equation, preparation of acidic and basic buffers. Relative strength of acids and bases from K_a and K_b values. Neutralisation-titration curve, theory of indicators (phenolphthalein and methyl orange).

Complexometric titrations: stability of complexes, titration involving EDTA, metal ion indicators and characteristics.

Solubility and solubility products, expressions for solubility products, determination of solubility from solubility products, common ion effect.

Gravimetric method of analysis: general principle-separation by precipitation. Separation and purification techniques: Recrystallization, use of drying agents, sublimation. General principles of distillation, fractional distillation, distillation under reduced pressure. Theory of solvent extraction.

Evaluation of Analytical Data, Units, significant figures, accuracy, precision, types of error. Methods of elimination or minimization of errors.

Textbooks

1. G. R. Chatwal, S. K. Anand, *Instrumental Methods Of Chemical Analysis*, Himalaya Publishing House, **2011**
2. B. R. Puri, L. R. Sharma, K. C. Kalia, *Principles of Inorganic Chemistry*, 33rd Edition, Vishal Publishing Co., **2017**.

Reference

1. D. A. Skoog, D. M. West, F. J. Holler, S. R. Crouch, *Fundamentals of Analytical Chemistry*, 9th Edition, Brooks/Cole, **2013**.
2. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, B. Sivasankar, *Vogel's Textbook of Quantitative Chemical Analysis*, 6th Edition, Pearson Education, **2009**.
3. R. A. Day Junior, A.L. Underwood, *Quantitative Analysis*, 6th Edition, Prentice Hall, **1991**.
4. R. Gopalan, P. S. Subramanian, K. Rengarajan, *Elements of Analytical Chemistry*, S. Chand Publishers, **2003**.
5. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, B. Sivasankar, *Vogel's Textbook of Quantitative Chemical Analysis*, 6th Edition, Pearson Education, **2009**.
6. R. A. Day Junior, A.L. Underwood, *Quantitative Analysis*, 6th Edition, Prentice Hall, **1991**.

Module 2: Chromatographic Techniques (9 hours)

Principle of adsorption and partition chromatography. Column chromatography: adsorbents, classification of adsorbents, solvents, preparation of column, adsorption and applications. Thin Layer Chromatography: choice of adsorbent, choice of solvent, preparation of chromatogram, sample, R_f value and its applications. Paper chromatography, solvent used,

R_f value, factors which affect R_f value. Ion exchange chromatography, resins used, experimental techniques, applications. Gas Chromatography, High performance liquid chromatography principle, and applications.

Textbooks

1. G. R. Chatwal, S. K. Anand, *Instrumental Methods of Chemical Analysis*, Himalaya Publishing House, **2011**
2. B. R. Puri, L. R. Sharma, M. S. Pathania, *Principles of Physical Chemistry*, 47th Edition, *Vishal Publishing Company*, **2017**

Reference

1. D. A. Skoog, D. M. West, F. J. Holler, S. R. Crouch, *Fundamentals of Analytical Chemistry*, 9th Edition, Brooks/Cole, **2013**
2. R. Gopalan, P. S. Subramanian, K. Rengarajan, *Elements of Analytical Chemistry*, Sultan Chand & Sons, **2003**

Module 3: Introduction to Nanochemistry **(9 hours)**

Definition, classification based on dimensions. Size dependence of material properties, variation in electronic and optical properties (detailed discussion not required). Synthesis of nanomaterials – chemical precipitation, reduction technique, chemical vapour deposition and sol-gel method (brief study). Medical applications of nanomaterials-applications in diagnosis and nano based drug delivery (detailed discussion not required). Other applications of nanoparticles – electronics, paints and sensors. Toxicology of nanoparticles.

Textbooks

1. T. Pradeep, *A Textbook of Nanoscience and Nanotechnology*, McGraw Hill Education, **2017**

Reference

1. V. S. Muralidharan, A. Subramania, *Nano Science and Technology*, CRC Press, **2008**.
2. J. Klabunde, R. M. Richards, *Nanoscale Materials in Chemistry*, 2nd Edn., Wiley-Interscience, **2009**

SEMESTER II

BDCH202: BASIC ORGANIC CHEMISTRY

(Common to Physical Sciences and Life Sciences)

Credit: 2 **Total Hours: 36**

Objectives

The major objectives are to:

- understand the core concepts of organic chemistry
- study the details of isomerism.
- acquire basic knowledge on organic reaction mechanism
- learn the concept of aromaticity

Outcome

Upon successful completion of the course, the student shall be able to:

- understand the rules for nomenclature
- know the fundamentals of organic reaction mechanism
- understand reaction intermediates.
- understand isomerism

Module 1: Foundation of Organic Chemistry (6 Hours)

IUPAC nomenclature of alkyl halides, alcohols, aldehydes, ketones, carboxylic acids and amines. Structural isomerism: Chain isomerism, position isomerism, functional isomerism, metamerism and tautomerism. Arrow formalism in organic chemistry. Bond fission -homolytic and heterolytic fission. Hybridization in ethane, ethene, ethyne. Polarity of bonds: inductive, mesomeric and hyperconjugative effects. Importance of steric effect.

Module 2: Mechanisms of Organic Reactions (12 hours)

Classification of reagents: electrophiles, nucleophiles. Types of organic reactions: addition, substitution and elimination reactions. Reaction Intermediates: Carbocations, carbanions and free radicals (preparation, structure, hybridization and stability). Types of organic reactions: Addition, Elimination, Substitution, Rearrangement and Redox reactions (definition and one example each).

Substitution reactions: nucleophilic substitution of alkyl halides- S_N1 and S_N2 mechanisms.

Addition reactions: electrophilic addition to ethene, propene and ethyne-the Markownikoff's rule, Peroxide effect.

Elimination reactions: E1 and E2 mechanisms

Module 3: Stereochemistry and Conformation of Organic Compounds (9 hours)

Stereosiomerism – definition, classification.

Geometrical isomerism: *cis* and *trans*- configuration, *E* and *Z* configurations, Determination of configuration and interconversion of *cis-trans* isomers, *E* and *Z* configuration. Optical isomerism: optical activity, meso compounds, chirality, stereogenic centre, enantiomers and diastereomers, racemisation and resolution (basic idea only).

Conformation: Newman projection, saw-horse projection, Conformations of ethane, *n*-butane, Relative stability and energy diagrams. Conformation of cyclohexane and methyl cyclohexane.

Module 4: Aromaticity (9 hours)

Concept of resonance: resonance energy, heat of hydrogenation and heat of combustion of benzene, mention of C-C bond lengths and orbital picture of benzene. Structure of naphthalene and anthracene (molecular orbital diagram and resonance energy).

Concept of aromaticity: aromaticity (definition), Huckel's rule – application to benzenoid - benzene, naphthalene and non - benzenoid compounds - cyclopropenyl cation, cyclopentadienyl anion and tropylium cation.

Reactions: general mechanism of electrophilic substitution, mechanism of halogenation, nitration, Friedel Craft's alkylation and acylation. Orientation of aromatic substitution – definition of ortho, para and meta- directing groups.

Textbooks

1. A. Bahl, B. S. Bahl, *Advanced Organic Chemistry*, 1st Multicolour Edition, S. Chand & Company, New Delhi, **2010**
2. K. S. Tewari, N. K. Vishnoi, S. N. Mehrotra, *A Text Book of Organic Chemistry*, 2nd Edition, Vikas Publishing Pvt. Ltd., **2003**
3. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, Vishal Publishing Co. **2017**
4. S. M. Mukherji, S. P Singh, R. P Kapoor, *Organic Chemistry Vol.1*, New Age International Pvt. Ltd., **2017**

Reference

1. R. T. Morrison and R. N. Boyd, S. K. Bhattacharjee, *Organic Chemistry*, 7th Edition, Pearson Education India, **2010**
2. S. Sengupta, *Basic Stereochemistry of Organic Molecules*, Oxford University Press, **2014**
3. I. L. Finar, *Organic Chemistry, Vol. 1*, 6th Edition, Pearson Education India, **2002**
4. P. Sykes, *A guide to Mechanism in Organic Chemistry*, 6th Edition, Pearson India, **2002**

PRACTICAL

SEMESTER I AND II

BDCH2P01: VOLUMETRIC ANALYSIS

(Common to Physical Sciences and Life Sciences)

Credit: 2 **Total Hours: 72**

Acidimetry and Alkalimetry

1. Standardization of HCl with standard Na_2CO_3 solution
2. Standardization of NaOH with standard oxalic acid solution
3. Estimation of any acid using standard NaOH
4. Estimation of any alkali using standard HCl

Permanganometry

1. Standardization of $KMnO_4$ using (i) oxalic acid (ii) Mohr's salt
2. Estimation of Fe^{2+} in Mohr's salt and crystalline ferrous sulphate using standard $KMnO_4$

Dichrometry

1. Estimation of Ferrous ion (external indicator)
2. Estimation of Ferrous ion (internal indicator)
3. Estimation of $FeSO_4.7H_2O$ (external indicator)

Reference

1. A. O. Thomas, *Practical Chemistry*, 7th Edn., Scientific Book Centre, Kannur, **1999**
2. D. A. Skoog, D. M. West, F. J. Holler, S. R. Crouch, *Fundamentals of Analytical Chemistry*, 9th Edition, Cengage Learning, **2013**
3. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, B. Sivasankar, *Vogel's Textbook of Quantitative Chemical Analysis*, 6th Edition, Pearson Education, **2009**
4. G. D. Christian, *Analytical Chemistry*, 6th Edition., John Wiley and Sons, **2007**
5. R. A. Day, A. L. Underwood, *Quantitative Analysis*, 6th Edition., Prentice Hall, **1991**

SEMESTER III

BDCP303: ADVANCED PHYSICAL CHEMISTRY - I

(For students who have opted Physical Sciences)

Credit: 3 **Total Hours: 54**

Objectives

The major objectives are to:

- give an insight into the kinetics of reactions
- study various laws of thermodynamics
- understand the fundamentals of chemical equilibrium
- understand the concepts of electrochemistry
- study various surface phenomena

Outcome

Upon successful completion of this course, the student shall

- understand the kinetics of chemical reactions
- know the principles of thermodynamics
- get an insight to electrochemistry
- understand various surface phenomena

Module 1: Chemical Kinetics **(12 hours)**

Rate of a reaction, rate law and rate constant, units of rate constant. Effect of temperature on reactions rates, threshold energy, activation energy, Arrhenius equation.

Collision theory of bimolecular gas phase reactions, activated complex theory of bimolecular gaseous reactions -basic concepts, Eyring equation-(no derivation required), Lindemann's theory of unimolecular gaseous reactions.

Equilibrium approximation, steady state approximation, kinetics of opposing and consecutive reactions.

Module 2: Thermodynamics and Equilibria **(18 hours)**

Statement of second law of thermodynamics and their equivalence. Concept of entropy – Definition and physical significance. Entropy as a function of volume and temperature,

Entropy as a function of pressure and temperature. Entropy as a criterion of spontaneity and equilibrium. Entropy changes in various physical processes.

Auxiliary state function - Helmholtz free energy and Gibbs free energy and their significance. Gibbs-Helmholtz equation, dependence of Gibbs free energy change on temperature, volume and pressure. Gibbs free energy as a criterion of spontaneity and equilibrium. Third law of thermodynamics-statement and determination of absolute entropies of substances.

Nernst distribution law–conditions for the validity of the distribution law – application of Nernst Distribution Law in the study of complex ions.

Binary Liquid Systems – Solubility of Partially miscible liquids – different types- Phenol- water system - miscibility temperature and critical solution temperature.

Gibb's Phase rule – definition of terms giving examples. Phase diagram of one component system – water, Two component systems – Simple Eutectic Systems – Examples, Phase diagram of Naphthalene - Biphenyl System – Cooling Curve, Eutectic Point.

Module 3: Electrochemistry **(18 hours)**

Faraday's laws of electrolysis, electrochemical equivalent and chemical equivalent, Specific conductance, equivalent conductance and molar conductance – Variation of conductance with dilution - Kohlrausch's law. Conductometric Titrations – Theory involving strong acid- strong base, strong acid-weak base, weak acid-strong base titration, and advantages.

Debye Huckel Theory of Strong Electrolytes – ionic atmosphere, asymmetry effect, electrophoretic effect, viscous effect, Wein effect, Debye Falkenhagen Effect (derivation not required), Ionic strength.

Galvanic cells - Cell and electrode potentials, Reference electrodes – Standard hydrogen electrode and calomel electrode; Indicator electrodes-metal-metal ion electrodes, Quinhydron electrode and Redox electrodes. Potentiometric titrations – Theory and Advantages - acid-base and redox reactions.

Thermodynamics of cell reactions – determination of ΔH, ΔS, ΔG, ΔH°, ΔS° and ΔG° of cell reactions, Nernst equation, Standard EMF and Equilibrium constant.

Module 4: Chemistry of Surfaces **(6 hours)**

Adsorption – Difference between Chemical and Physical adsorption- Langmuir adsorption isotherm, BET equation (derivation not required), Gibbs adsorption isotherm

(postulates and application). Reactions at surfaces -Langmuir - Hinshelwood mechanism. Mechanism of heterogeneous catalysis – enzyme catalysis – Michaelis Menten theory.

Classification of colloids: Lyophilic, lyophobic, macromolecular, multimolecular and associated colloids with examples.

Surfactants - examples of anionic, cationic, non-ionic and amphoteric surfactants. Micelles - structure, CMC.

Emulsions – micro and macroemulsions, emulsification by surfactants, Importance and applications of colloids.

Textbooks

1. B. R Puri, L. R Sharma, M. S. Pathania, *Principles of Physical Chemistry*, 47th edition, Vishal Publishing Company, **2017**

Reference

1. S. Glasstone, D. Lewis, *Elements of Physical Chemistry*, 2nd Revised Edition, Palgrave Macmillan., **1963**
2. P. Atkins, J. de Paula, *Atkin's Physical Chemistry*, 7th Edition, Oxford University Press, **2006**
3. A. W. Adamson, A. P. Gast, *Physical Chemistry of Surfaces*, 6th Edition, John Wiley, **1997**
4. K. J. Laidler, *Chemical Kinetics*, 3rd Edition, Pearson Education, **2004**

BDCB303: ADVANCED INORGANIC AND ORGANIC CHEMISTRY

(For students who have opted Life Sciences)

Credit: 3 **Total Hours: 54**

Objectives

The major objectives are to:

- understand the role of chemistry in the field of industry
- understand nuclear chemistry and its biochemical applications
- provide information on heterocyclic compounds
- give an insight into pharmaceutical chemistry

Outcome

Upon successful completion of this course, the student shall

- be familiar with industrial applications of chemistry
- recognize the importance of nuclear Chemistry
- develop a fundamental theoretical understanding of heterocyclic chemistry.
- have basic idea about medicinal chemistry

Module 1: Industrial Chemistry **(18 hours)**

Fertilizers: NPK. Manufacture of ammonium salts, urea, superphosphates. Plant growth hormones.

Pesticides: Classifications with simple examples. Method of preparation and use of Insecticides: DDT and BHC. Herbicides - structure and function of 2,4,-D and 2,4,5 –T, Fungicides- inorganic and organic- Bordeaux mixture. Biopesticides. Excessive use of pesticides – environmental hazards.

Petroleum: Carbon range and uses of various fractions of petroleum distillation – Petrol - Knocking -Octane number – Anti-knocking compounds – Diesel oil - Cetane number – Flash point –Composition and uses of LPG and CNG. Biodiesel- preparation and advantages.

Soaps and detergents: Types of soaps. TFM, Cleansing action of soaps. Synthetic detergents - classification. ABS and LAS detergents, detergent additives, Enzyme based detergents. Environmental aspects.

Food Additives: Food preservatives, artificial sweeteners, flavours, emulsifying agents, antioxidants, leavening agents and flavour enhancers (definition and examples, structures not required). Commonly used permitted and non-permitted food colours (structures not required). Uses and abuses of these substances in food beverages.

Cosmetics: Introduction, classification. Dental cosmetics, shampoos, hair dyes, skin products, shaving cream, talcum powder, perfumes and deodorants (composition and health effects).

Module 2: Nuclear Chemistry and Biochemical Applications (18 hours)

Atomic Nucleus: fundamental particles of atomic nucleus, atomic number and its significance, Nuclear Stability - Mass defect, Binding energy, Nuclear forces, Magic number, Packing fraction, n/p ratio. Modes of decay – Group displacement law. Isotopes, isobars and isotones with examples. Radioactivity: radioactive decay, average life of radio elements and its relation with half-life, radioactive equilibrium. Nuclear reactions: artificial radioactivity, transmutation of elements, fusion, fission and spallation, Nuclear energy, Nuclear fission- Atom bomb, Nuclear fusion- Hydrogen bomb, Nuclear reactors. Carbon dating and rock dating. Nuclear waste and its impact on environment.

Application of radionuclides in biomedical chemistry (principles): Application of gamma radiation, effect of radiation on biological cells and the chemical basis of radiation damage. Radioisotopes in medicine: diagnosis of thyroid tumour, magnetic resonance imaging of diseased organs (thyroid, brain, kidney), diagnosis of heart disorders, treatment of thyroid cancer and blood cancer, radiation therapy in cancer.

Module 3: Heterocyclic Compounds (9 hours)

Heterocyclic Compounds: Preparation, properties, structure and reactions of furan, pyrrole, thiophene, pyridine and indole. Aromaticity in heterocyclic compounds. Nitrogenous bases- Pyrimidines & purines - adenine, guanine, thymine, cytosine and uracil (Structural and biological aspects only).

Module 4: Drugs (9 hours)

Classification of drugs. Structure, therapeutic uses and mode of action (synthesis not required) of Antibiotics: Ampicillin and Chloramphenicol, Sulpha drugs: Sulphanilamide, Antipyretics: Paracetamol, Analgesics- Aspirin and Ibuprofen, Antacids-Ranitidine, Antimalarials: Chloroquine, Anti-cancer drugs: Chlorambucil and Anti-HIV agents: Azidothymidine (Zidovudine). Psychotropic drugs: Tranquilizers, antidepressants and stimulants with examples. Drug addiction and abuse.

Textbooks

1. B. K. Sharma, *Industrial Chemistry*, 17th Edition, Krishan Prakashan, **2014**
2. S. C. Rastogi, *Biochemistry*, 3rd Edition, McGraw Hill Education, **2010**

3. B. R Puri, L. R Sharma, M. S. Pathania, *Principles of Physical Chemistry*, 47th Edn., Vishal Publishing Company, **2017**

Reference

1. B. Sreelakshmi, *Food Science*, 7th Edition, New Age International Publishers, **2018**
2. H. J. Arnikar, *Essentials of Nuclear Chemistry*, 4thEdition, New Age International Pvt. Ltd., **2011**
3. G. R. Chatwal, *Synthetic Drugs*, Himalaya Publishing House, **2016**
4. J. Ghosh, *A Textbook of Pharmaceutical Chemistry*, S Chand & Company, **2012**
5. I. L. Finar, *Organic Chemistry Vol. I & II*, 6th Edition, Pearson Education India, **2006**

BDCP404: ADVANCED PHYSICAL CHEMISTRY - II

(For students who have opted Physical Sciences)

Credit: 3 **Total Hours: 54**

Objectives

The major objective of this are to:

- develop an idea about photochemistry
- learn the fundamentals of molecular spectroscopy
- understand the basics of solid-state chemistry

Outcome

Upon successful completion of this course, the student shall

- have an understanding of photochemistry
- have an in-depth knowledge on the fundamentals of molecular spectroscopy
- be Familiar solid state chemistry

Module 1: Photochemistry **(9 hours)**

Definition, difference between thermal and photochemical reactions, Jablonski diagram, fluorescence and phosphorescence, Laws of Photochemistry - Beer - Lambert's law, Grothus - Draper law and Stark - Einstein law, Quantum yield –Experimental determination. Examples of reactions with high and low quantum yield and explanation. Photosensitisation, chemiluminescence, Effect of ultrasonic sound and microwave radiation on chemical reactions.

Module 2: Molecular Symmetry and Group Theory **(9 hours)**

Elements of symmetry of molecules: identity, proper axis of rotation, reflection plane, inversion centre, improper axis of rotation, Schonflies notation. Combinations of symmetry operations, mathematical group, point groups of simple molecules - CO_2, BF_3, NH_3, H_2O, *trans*-dichloroethylene. Group multiplication table for C_{2v}, C_{3v} and C_{2h}.

Module 3: Molecular Spectroscopy **(18 hours)**

Interaction of electromagnetic radiation with matter, energy levels in molecules. rotational spectrum, rigid rotator, expression for energy, selection rule, calculation of bond length, moment of inertia. Vibrational spectra of diatomic molecules: simple harmonic oscillator, selection rule, vibrational modes of CO_2 and H_2O, calculation of force constant.

Raman spectroscopy: brief description, Stokes and anti-Stokes lines and their intensity difference, rotational Raman spectrum and its selection rules, mutual exclusion principle. Electronic spectroscopy: UV spectrum, absorption maximum, chromophore, auxochrome, red shift, blue shift, types of transition. Frank - Condon principle, dissociation energy of diatomic molecule. NMR spectroscopy: principle, number of signals, position of signals, chemical shift, intensity of signals, spin-spin coupling, NMR spectra of simple organic molecules. ESR spectroscopy: theory, hyperfine splitting of methyl radical.

Module 4: Solid State **(18 hours)**

Law of constancy of interfacial angles, crystal systems, space lattice, unit cell, Bravais lattices. Law of rational indices, Miller indices, interplanar spacing in a crystal system, Bragg equation – derivation, brief description of rotating crystal method and powder method, x-ray diffraction patterns of cubic system, structure of NaCl and CsCl, types of crystals. Close packing of spheres, hcp, ccp, tetrahedral and octahedral voids. Defects of crystals: Non-stoichiometric and stoichiometric defects, point defects, Schotky and Frenkel defects, metal excess defects, metal deficiency defects. Liquid crystals: classification and its applications (theory not required).

Textbooks

1. B. R Puri, L. R Sharma, M. S. Pathania, *Principles of Physical Chemistry*, 47th edition, Vishal Publishing Company, **2017**
2. P. L. Soni, O. P. Dharmarha, U. N. Dash, *Text book of Physical Chemistry*, 22nd Edition, Sultan Chand & Sons, **2011**
3. Gurdeep Raj, *Advanced Physical Chemistry*, 39th Edition, Krishan Prakashan, **2014**

Reference

1. K. Veera Reddy, *Symmetry and Spectroscopy of Molecules*, New Age International Pvt. Ltd., **1998**
2. L. V. Azaroff, *Introduction to Solids*, 34th Reprint, Mc Graw Hill, **2010**
3. N. B. Hanna, *Solid State Chemistry*, Prentice Hall of India (P) Ltd. **1976**
4. S. Glasstone, D. Lewis, *Elements of Physical Chemistry*, 2nd Revised Edition, Palgrave Macmillan., **1963**
5. P. W. Atkins, *Physical Chemistry*, 9th Edition, Oxford University Press, **2009**

BDCB404: ADVANCED BIO-INORGANIC AND BIO-ORGANIC CHEMISTRY

(For students who have opted Life Sciences)

Credit: 3 **Total Hours: 54**

Objectives

The major objectives of this course are to:

- understand concepts in bioinorganic and bioorganic chemistry
- learn the importance of functions of metals in biological systems
- know the classification and properties of biomolecules
- basic chemistry of natural products

Outcome

Upon successful completion of this course, the student shall be able to

- describe the chemistry of biological systems
- recognize bio-molecules
- understand the chemistry of natural products

Module 1: Bio-inorganic Chemistry **(12 hours)**

Thermodynamics of Living cell- Exergonic and endergonic reactions, coupled reactions. Essential and trace metals in biological Systems: Biochemistry of iron – Metalloporphyrins– Haemoglobin, myoglobin, hemerythrin and cytochromes. Ferredoxin - Mechanism of O_2 and CO_2 transportation. Iron storage and transport in biological systems: ferritin and transferrin. Biochemistry of zinc and cobalt. Toxicity of metal ions such as Hg, Pb, Cd and As and reasons for toxicity. Elementary idea of structure and mechanism of action of sodium potassium pump. Nitrogen fixation: chemistry of nitrogen fixation. Chlorophyll and photosynthesis (mechanism not expected).

Module 2: Bio-organic Chemistry **(18 hours)**

Carbohydrates: Classification with examples. biological importance of carbohydrates. Mutarotation. Structure of starch and cellulose (structure elucidation not expected). Applications of cellulose.

Amino acids: classification, essential and non-essential amino acids, Zwitterions, isoelectric point. Peptides: Peptide bond. Synthesis of dipeptides (any one example).

Proteins: Classification of proteins – Primary, secondary (α-helix and β- pleated sheets) and tertiary structure of proteins– Denaturation of proteins.

Enzymes: nomenclature, characteristics and classification; active site, mechanism of enzyme action (lock and key and induced fit model), coenzymes and cofactors, enzyme inhibitors. Introduction to bio-catalysis - Importance in Green Chemistry and chemical Industry.

Nucleic acids: nucleosides and nucleotides. Composition of RNA and DNA, complementary base- pairings, features of DNA double helix (Watson - Crick Model). Biological functions.

Energy rich molecules: elementary structure of ATP, ADP and AMP.

Module 3: Natural Products (6 hours)

Terpenoids: Classification with examples – Isoprene rule – Isolation of essential oils by steam distillation – Uses of lemongrass oil, structure and uses of citral and geraniol. Natural rubber – structure.

Alkaloids: Classification – Isolation, general properties. Source, structure and physiological activity of nicotine, coniine and piperine.

Module 4: Lipids (6 hours)

Classification – Oils, fats and waxes: definition, structure, biological functions and examples. Reactions and characterization of oils and fats – hydrolysis, hydrogenation and rancidity, acid value, saponification value, iodine value and RM value. Trans fats. Extraction and refining of vegetable oils. Common fatty acids present in oils and fats. Biological functions of phospholipids and glycolipids.

Module 5: Steroids, Carotenoids, Hormones and Vitamins (12 hours)

Steroids and Carotenoids: Importance, cholesterol (structure and significance) HDL & LDL, bile acid, carotenes, lycopene (only structure and brief function).

Hormones: Introduction. Steroid hormones, peptide hormones and amine hormones (examples, endocrine gland and biological functions, structure not required). Artificial hormones (elementary study only)

Vitamins: Classifications. Water soluble vitamins: biological functions of – thiamine, riboflavin, nicotinic acid, pyridoxine, pantothenic acid. vitamin B_{12}, vitamin C and biotin. Fat soluble vitamins: biological functions of vitamin A, D, E, K (structure not required)

Textbooks

1. D. L. Nelson, M. M. Cox, *Lehninger's Principles of Biochemistry*, 6th Edn., W. H. Freeman**, 2012**
2. A. C. Deb, *Fundamentals of Biochemistry*, 9th Edition, New Central Book Agency, **2001**
3. B. R. Puri, L. R. Sharma, K. C. Kalia, *Principles of Inorganic Chemistry*, 33rd Edition, Vishal Publishing Co., **2017**

Reference

1. S. J. Lippard, J. M. Berg, *Principles of Bioinorganic Chemistry*, University Science Books, **1994**
2. J. M. Berg, J. L. Tymoczko, L. Stryer, *Biochemistry*, 8th Edition, W. H. Freeman, **2015**
3. S. V. Bhat, B. A. Naga Sampagi, M. Sivakumar, *Chemistry of Natural Products*, Revised edition, Narosa Pub House, **2014**
4. I. L. Finar, *Organic Chemistry Vol. I & II*, 6th Edition, Pearson Education India, **2006**

PRACTICAL

SEMESTER III AND IV

BDCP4P02: PHYSICAL CHEMISTRY PRACTICAL

(For students who have opted Physical Sciences)

Credit: 2 **Total Hours: 72**

1. Determination of Partition coefficient of a non-volatile solute
2. Transition temperature of salt hydrates
3. Determination of molecular weight by Rast's Method (using naphthalene, camphor or biphenyl as solvent and acetanilide, *p*-dichlorobenzene as solute)
4. Critical solution temperature of phenol water system
5. Effect of electrolytes on the CST of phenol-water system
6. Heat of neutralization
7. Kinetics of simple reactions (acid hydrolysis of methyl acetate)
8. Conductometric titration of strong acid vs. strong base
9. Potentiometric titrations: Fe^{2+} vs. $Cr_2O_7^{2-}$ and Fe^{2+} vs. $KMnO_4$
10. Kinetics of simple reactions

Reference

1. A. O. Thomas, *Practical Chemistry*, 7th Edn., Scientific Book Centre, Kannur, **1999**
2. W. G. Palmer, *Experimental Physical Chemistry*, 2nd Edition, Cambridge University Press, **2009**
3. J. B. Yadav, *Advanced Practical Physical Chemistry*, Krishna Prakashan Media Pvt. Ltd., **2015**
4. R. C. Das, B. Behra, *Experiments in Physical Chemistry*, McGraw-Hill Education, **1984**

BDCB4P02: ORGANIC CHEMISTRY PRACTICAL

(For students who have opted Life Sciences)

Credit: 2 **Total Hours: 72**

1. Tests for elements: nitrogen, halogens and sulphur
2. Determination of physical constants
3. Study of reactions of common functional groups
4. Qualitative analysis with a view to characterization of functional groups and identification of the following compounds: naphthalene, anthracene, chlorobenzene, benzyl chloride, p-dichlorobenzene, phenol, o-, m- and p- cresols, - naphthol, resorcinol, benzaldehyde, accetophenone, benzophenone, benzoic acid, phthalic acid, cinnamic acid, salicylic acid, ethyl benzoate, methyl salicylate, benzamide, urea, aniline, o-, m- and p- toluidines, dimethyl aniline, nitrobenzene, o-nitrotoluene, m-dinitrobenzene and glucose.

   (Systematic Analysis using preliminary, identification and confirmatory tests and derivative preparation with chemical equations for all positive tests expected- Minimum seven compounds to be analysed)
5. Organic preparation involving halogenation, nitration, oxidation, reduction, acetylation, benzoylation, hydrolysis, diazotization

Reference

1. A. O. Thomas, *Practical Chemistry*, 7th Edn., Scientific Book Centre, Kannur, **1999**
2. A. I. Vogel, *A Text Book of Practical Organic Chemistry*, 5th Edition, Prentice Hall, **1989**
3. F. G. Mann, B. C. Saunders, *Practical Organic Chemistry*, 4th Edition. Pearson Education, **2009**
4. V. K. Ahluwalia, S. Dhingra, *Comprehensive Practical Organic Chemistry: Qualitative Analysis*, Sangam Books Ltd, **2001**

OPEN COURSE

BOCH501: CHEMISTRY IN EVERYDAY LIFE

Credit: 3 **Total Hours: 54**

Objectives

The major objectives are

- understanding the basic food additives
- learning the chemical constituents in cosmetics
- studying basic ideas on polymers, dyes and paper
- familiarising different classes of drugs
- generating awareness on ayurvedic plants of Kerala and its uses

Outcome

At the end of the course, the students shall

- explain the effects of food additives
- understand the effects of cosmetics on the body
- identify the use of some important ayurvedic plants in Kerala
- understand principle of water purification

Module 1: Food Additives **(9 hours)**

Food additives – definition. Preservatives, Food colours - permitted and non-permitted. Flavours - natural and synthetic. Artificial sweeteners, Emulsifying agents, Antioxidants, Leavening agents and Flavour enhancers. Softdrinks - formulation and health effects. Health drinks, fast foods and junk foods and their health effects. Food adulteration and its health hazards. Food laws and standards in India

Textbook

1. B. Sreelakshmi, *Food Science*, 5th edition, New Age International, New Delhi, **2015**.

Reference

1. S. R. Mudambi, S. M. Rao, *Food Science*, Revised Edn., New Age International, New Delhi, **2015**.
2. N. N. Potter, *Food science*, 4th Edn., Springer, New York, **2010**

Module 2: Soaps, Detergents and Cosmetics **(12 hours)**

Soaps – Introduction. Types of soaps - Toilet soaps, washing soaps. Liquid soap. TFM and grades of soaps. Cleansing action of soap.

Detergents - Introduction. Types of detergents - anionic, cationic, non-ionic and amphoteric detergents. Common detergent additives. Enzymes used in commercial detergents. Comparison between soaps and detergents. Environmental aspects.

Cosmetics - Introduction. General formulation of different types of cosmetics - Dental cosmetics, Shampoos, Hair dyes, Skin products (creams and lotions, lipstick, perfumes, deodorants and antiperspirants), Bath oil, Shaving cream and Talcum powder. Toxicology of cosmetics.

Textbook

1. B. Sreelakshmi, *Food Science*, 5th Edn, New Age International, New Delhi, **2015**

Reference

1. S. R. Mudambi, S. M. Rao, *Food Science,* RevisedEdn., New Age International, New Delhi, **2015**
2. N.N Potter, *Food science*, 4th Edn., Springer, New York, **2010**

Module 3: Plastics, Paper and Textile Dyes (9 Hours)

Definition of Polymers. Classification of polymers- Natural and synthetic plastics used in everyday life- LDPE, HDPE, PP, PVC and PS. Different grades of plastics, Environmental hazards of plastics. Biodegradable plastics. Recycling of plastics. (general ideas only)

Paper – Introduction. Paper manufacture (basic idea only). Weight and size of paper. Types of paper - News print paper, writing paper, paperboards, cardboards. Environmental impact of paper.

Natural and synthetic textile dyes with examples (elementary idea only).

Textbooks

1. V. R. Gowariker, N. V. Viswanathan, J. Sreedhar, *Polymer Science*, New Age International (P) Ltd., **2011**
2. G S Mishra, *Introductory Polymer Chemistry*, New Age International Ltd Publishers, New Delhi, **2006**

Reference

1. F. W Billimeyer, *Textbook of polymer chemistry*, 3rd Edn, Wiley New York, **2008**
2. P. Bahadur, *Principles of polymer science*, Alpha Science International, **2005**

Module4: Drugs (12 hours)

Definition – History of drugs, Classification of drugs - Analgesics, Antipyretics, Antihistamines, Antacids, Antibiotics and Psychotropic drugs - Tranquilizers, Antidepressants and Stimulants with examples. Drug addiction and abuse.

Assay of Drugs: LD_{50} and ED_{50} therapeutic index.

Some Indian Medicinal Plants*: Asparagus racemosus* (Sathavari), *Piper longum (Thipelli), Aristolochia indica (Garudakodi), Acacia catechu (*Karingali*), Desmodim gangeticum (Orila), Acorus calamus* (Vayambu), *Adathoda beddomei* (Adalodakam), *Aegle marmelos (*Koovalam*), Cassia fistula* (Kanikonna), *Emblica officinalis* (Nelli), *Phyllanthus niruri* (Kizhar Nelli*), Gloriosa superba* (Menthonni), Aloe Vera and Neem plant (Major chemical constituents, general uses and therapeutic uses only).

Textbooks

1. V.K Ahluwalia, M. Chopra, *Medicinal Chemistry*, Ane Books Pvt Ltd, **2009**
2. A. K Dhiman, *Ayurvedic Drug Plants*, Daya Publishing House, Delhi, **2006**

Reference

1. G. L Patrick, *An introduction to medicinal chemistry*, 4th Edn, Oxford **2009**
2. D. Sriram, P. Yogeeswari; *Medicinal Chemistry*, 2nd Edn, Pearson, **2011**
3. B. R. Kumar, *Ayurvedic Medicinal Plants of India*, Scientific Publishers, **2011**

Module 5: Water Treatment Processes **(12 hours)**

Types and characteristics of industrial waste water - Aerobic and anaerobic oxidation - Sedimentation, coagulation, filtration, disinfection, desalination and ion exchange. Primary treatment – Secondary treatment - Trickling filters, activated sludge process and sludge digestion - Tertiary treatment – USAB process and deep well injection. Sewage and sewage analysis - Total solids, settlable solids, suspended solids, dissolved oxygen, BOD (Winkler's titration method and dissolved oxygen meter) and COD. Use and conservation of water resources – Rainwater harvesting.

Textbook

1. Stuetz, R.Stuetz, *Principles of Water and Wastewater Treatment Processes*, IWA Publishing, **2010**

Reference

1. G. L. Karia, R.A. Christian, *Wastewater Treatment. Concepts and Design Approach*, PHI Learning Pvt. Ltd, 2nd Edn., **2002**
2. A.K. De; *Environmental Chemistry*, New Age International Ltd., New Delhi, **2006**

ADD ON COURSES

BCHEX01: INSTRUMENTAL METHODS OF ANALYSIS FOR BIOLOGISTS, CHEMISTS AND PHYSICISTS

Credit: 2 **Total Hours: 36**

Objectives: The modern science thinks and works in the lemon light of an interdisciplinary approach. The department of Chemistry at St Berchmans offers an Extra Credit Course entitled Instrumental Methods of Analysis for Biologists, Chemists and Physicists. It introduces a variety of modern analytical techniques which include Mass Spectrometry; UV-Visible, IR, and NMR Spectroscopy; High Performance Liquid Chromatography, Gas Chromatography, Column, Paper and Thin Layer Chromatographic techniques which are useful in all branches of basic science. Besides these, the students can learn the basics of analytical instruments such as pH Meter, Potentiometer, Conductivity Meter, Flame Photometer, Atomic Absorption Spectrometer and Electrochemical Analyzer.

The exposure to modern instrumentation will be advantageous to one seeks career in industry, teaching and research.

Module 1: UV-Visible Spectroscopy

Electromagnetic spectrum, Electronic transitions in molecules, Absorptions, Chromophores, Auxochromes; Instrumentation, UV-Visible Spectral pattern, Finding absorption maxima, Measurement of absorbance and its applications.

Module 2: Infrared Spectroscopy

Vibrations in molecules, Functional Groups and Characteristic Vibrations, Representation of IR spectra; Instrumentation, Applications: Recording and Interpretation of IR spectra.

Module 3: NMR Spectroscopy

Different types of nuclei in nature, classification by spin quantum number; Larmor precession of bosons and fermions; Nuclei in molecules, characterization of molecules by NMR spectroscopy, NMR spectrum, interpretation, and applications in science.

Module 4: Mass Spectrometry

General Principles, Mass Spectral Patterns, Interpretation with examples, Applications.

Module 5: Chromatography

Basic principles of paper, thin layer and column chromatography. Gas Chromatography, HPLC. Applications, Experiments in paper, thin layer and column chromatography at the laboratory.

Module 6: Atomic Absorption Spectrometry

Basic principles and applications. Detection copper, chromium and iron in natural samples using AAS.

Module 7: Electrochemical Analyzer

Basic theory and applications. One or two experiments to familiarize the machine.

Module 8: Elementary Analytical Techniques

Theory and applications of pH meter, Salinometer, Conductivity Meter, Potentiometry, Turbidimetry and Flame Photometer. Experiments.

Reference

1. D. A. Skoog, F. J. Holler, S. R. Crouch, *Principles of Instrumental Analysis*, 6th Edn., Thomson Brooks/Cole, **2007**
2. H. H. Willard, L. L. Merritt, J. A. Dean, *Instrumental Methods of Analysis*, 5th Edn., Van Nostrand, **1974**.
3. G. D. Christian, *Analytical Chemistry*, John Wiley & Sons, 6th Edn, **2004**
4. D. A. Skoog, D. M. West, F. J. Holler, S. R. Crouch, *Fundamentals of Analytical Chemistry*, 8th Edn., Thomson Brooks/Cole, **2007**
5. G H Jeffery, J Bassett, J Mendham, R C Denney, Longman, *Vogel's Text Book of Quantitative Chemical Analysis*, **1989**

Question Paper Pattern for Written Examination (Time: 1½ hrs)

Division	Type	No. of Questions to be Answered	Mark for Each Question	Total Marks
Part A	One word	10 out of 13	1	10
Part B	Short answer	5 out of 8	2	10
Part C	Short Essay	4 out of 6	5	20
			Grand Total	**40**

BCHEX02: CHEMISTRY AND TECHNOLOGY OF RUBBER AND PLASTICS PROCESSING

Credit: 2 **Total Hours: 36**

Objectives: Polymer has emerged as an active discipline of Modern Science and Technology, which has more demand in education and employment market. The term, "POLYMER" refers two classes of materials i.e. Plastic and Rubbers.

Polymer Technology deals with the study of processing and manufacturing of polymer based substances for various purposes. Processing techniques are critical to the performance of polymer products, which are used in a wide range of industries. Advances in polymer processing: From macro- to nano- scales reviews the latest advances in polymer processing, techniques and materials.

Materials like Plastics and Rubbers have become indispensable nowadays, and the areas of application are constantly broadened. The processing and testing of these materials are an integral part of manufacturing, engineering, and research & development in order to prove design concepts and reliability, as well as to ensure quality control, and to meet standards.

The Department of Chemistry at St. Berchmans College offers an Extra Credit Course entitled Chemistry and Technology of Rubber and Plastic Processing. A student of this course learns to conceptualize, design, process and use polymer based substances for manufacturing need-oriented products. As a part of the curriculum, students get hands-on experience on identification and analysis of polymers, polymerization techniques, fabrication and processing of polymers.

THEORY

Module 1: Polymers

Importance, basic concept of polymers and its classification, monomers and polymers, homo and hetero polymers, Polymerization techniques, free radical polymerization, addition polymerization chain polymerization, step polymerization, coordination polymerization, ionic, ring opening, atom transfer radical (ATRP), co polymers, block polymers.

Module 2: Rubbers

Isoprene, chloroprene, various types of rubber, its application and manufacture. Natural rubber, Nitrile rubber, SBR (styrene butadiene rubber), chlorobutyl rubber, butyl rubber, neoprene rubber etc. Properties and advantages. Latex, latex compounding.

Module 3: Plastics

Different types of plastics, thermosets and thermoplastics, applications and manufacture. Elastomers, fibres etc. Manufacture of commercially important plastics like PP, PE, LDPE, PVC, Polystyrene. Resins, importance and synthesis. Epoxy, phenol formaldehyde and urea formaldehyde etc. Properties of thermosets and thermoplastics.

Module 4: Processing of Rubber

Mastication of rubber. Compounding of rubber, additives to be added during compounding, its applications and importance. Activators, accelerators, crosslinking agent, fillers (different types). Two roll mill, compression moulding-application and principle.

Module 5: Processing of Plastics

Different types of methods, its principle and advantages over other methods. Internal mixer, pultrusion, extrusion, injection moulding technique, compression moulding, die casting, resin transfer moulding, calendaring, rotational casting.

Module 6: Recycling of Rubber and Plastics

Different methods of recycling and waste disposal options.

PRACTICALS

- Systematic analysis of polymers, NR, nitrile rubber, SBR, butyl rubber, PVC, polystyrene.
- Synthesis of polymers. Glyptal resin, phenol formaldehyde resin, urea formaldehyde resin.
- Determination of DRC (dry rubber content) and TSC (total solid content) in latex. Volatile fatty acid (VFA) content in latex.
- Mixing of Rubber and Plastics, Compression moulding, latex compounding and product development.

Reference

1. V. R. Gowariker, N. V. Viswanathan, J. Sreedhar, *Polymer Science*, New Age International, **2011**
2. F. W. Billmeyer Jr., *Text book of Polymer Science*, 3rd Edn., John Wiley & Sons, **1984**
3. G. Odian, *Principles of Polymerization*, 4th Edn., John-Interscience, **2004**

4. K. Matyjaszewski, T. P. Davis, *Handbook of Radical Polymerization*, Wiley-Interscience, **2002**
5. M. Chanda and S.K. Roy, *Plastic Technology Hand Book*, Marcel Dekker, **1986**
6. J. R. Fried, *Polymer Science and Technology*, 2nd Edn., Prentice Hall, **2003**
7. J. A. Brydson, *Plastic Materials*, Butterworths-Hieneman, **1999**
8. Anil K. Bhowmick, Malcom M Hall, Henry A Benarey, Eds., *Rubber Products Manufacturing Technology*, Marcel Dekker, **1994**
9. V. Shah, *Handbook of Plastic Testing Technology*, 2nd Edn, John Wiley & Sons, **1998**
10. R. P. Brown, *Physical Testing of Rubber*, 3rd Edn, Springer, **1996**
11. R. Brown, *Handbook of Polymer Testing*, Rapra Technology, **2002**
12. J. Mitchell, *Applied Polymer Analysis and Characterization*, Hanser, **1992**

FIELDWORK OR INDUSTRY AND LAB VISIT

- Industry visit to get the basic knowledge on the functioning of different types of rubber and plastic processing machines.
- Orientation training on rubber based industry.

Question Paper Pattern for Written Examination (Time: 1½ hrs)

Division	Type	No. of Questions to be Answered	Mark for Each Question	Total Marks
Part A	One word	10 out of 13	1	10
Part B	Short answer	5 out of 8	2	10
Part C	Short Essay	4 out of 6	5	20
			Grand Total	**40**

St Berchmans College

Founded 1922

AUTONOMOUS | College with Potential for Excellence | Reaccredited by NAAC with A Grade

Affiliated to Mahatma Gandhi University, Kottayam, Kerala

Changanassery, Kottayam, Kerala, India-686101