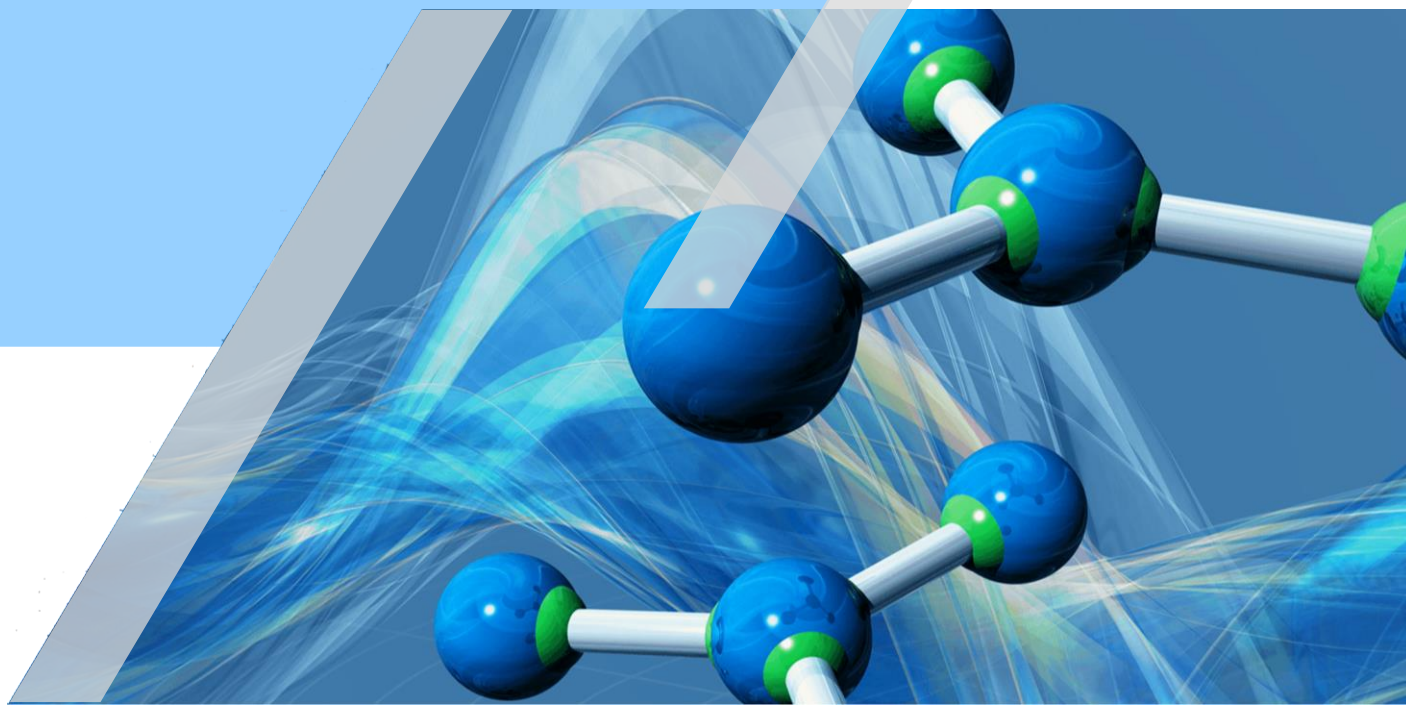
Rajiv Gandhi University

Syllabus for B.Sc. (Honours) in Chemistry

Choice Based Credit System (CBCS)



Course Effective from Academic Year 2021-22

05/7/2021

सयुक्त कुलसचिव (शैक्षणिक एवं सम्मेलन)
राजीव गांधी विश्वविद्यालय
Jt. Registrar (Acad. & Conf.)
Rajiv Gandhi University
Rono Hills, Doimukh (A.P.)

Contents

05/7/2021
संयुक्त कुलसचिव (शैक्षणिक एवं सम्मेलन)
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Ability Enhancement Compulsory Courses (AEC)

Skill Enhancement Courses (SEC)

Generic Elective (GE) Courses (for other disciplines)

05/7/2021

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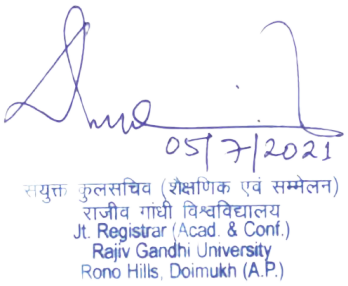
PREAMBLE

The higher education system in India has undergone substantial changes in recent years leading to both qualitative and quantitative development of the beneficiaries. Quality higher education involve innovation that can be useful for efficient governance of higher education institutions, systems and society at large. The quality of chemistry education profoundly impacts not only the academia but also research and innovation of a country.

Keeping in view the need to impart learner-centric education; a syllabus based on Learning Outcome-based Curriculum Framework (LOCF) is adopted to provide a focused, outcome-based learning at the undergraduate level with an objective to make the teaching-learning process student-centric. The LOCF approach has been adopted to strengthen students' experiences as they engage themselves in the programme of their choice. The undergraduate programme will prepare the students for both, academia and employability.

The curriculum has been prepared with an aim to support a uniform, advanced and effective Chemistry curriculum for undergraduate studies in Chemistry. The concerns, needs and interests of students, teachers as well as societal expectations has been taken into consideration while developing this syllabus. Each course aims to present learning targets and objectives, and thus provide learning and teaching strategies, assessment and resources. The programmes also state the attributes that it offers to inculcate at the graduation level. The graduate attributes encompass values related to well-being, emotional stability, critical thinking, social justice and also skills for employability.



1. CHOICE BASED CREDIT SYSTEM (CBCS) IN B.Sc. (HONOURS) CHEMISTRY

Under the credit-based semester system, the requirement for awarding and conferring a degree is prescribed in terms of number of credits to be completed by the students. Regulations on Choice Based Credit System (CBCS) of Rajiv Gandhi University apply to all undergraduate degree awarded and conferred by Rajiv Gandhi University. The CBCS provides choice for students to select courses from a pool of elective and ability enhancement courses offered in other subjects.

The learning outcome-based curriculum framework (LOCF) offers a flexibility and innovation in design of the programme, its assessment, and expect graduate attributes demonstrating the level of learning outcome. It is further expected to provide effective teaching-learning strategies including periodic review of the programme and its academic standard. The LOCF based programme will ensure that students get a clear purpose to focus their learning efforts and enable them to make a well-judged choice regarding the course they wish to study. This will enable the students to build a strong foundation in the subject and gain in-depth knowledge that suit the present day needs of students in terms of securing their paths towards higher studies or employment.

2. NATURE AND EXTENT OF THE B.Sc. (HONOURS) CHEMISTRY PROGRAMME

The new curriculum of B.Sc. (Honours) Chemistry offer courses in the areas of inorganic, organic, physical, materials and analytical chemistry. All the courses are having defined objectives and Learning Outcomes, which will help prospective students in choosing the elective courses to broaden their skills in the field of chemistry and interdisciplinary areas. New interdisciplinary subjects like nanomaterials, biomaterials, etc. and their applications from chemistry point of view provides new dimension to materials chemistry. Thus, the B.Sc. (Honours) programme in chemistry bridges the overlapping areas of chemistry with physics, biology, environmental sciences. Further, a broad range of subjects such as materials chemistry, biomaterials, nanomaterials, environmental chemistry, etc., has also been introduced which can be helpful for students and teachers to broaden their theoretical and experimental knowledge that suits the need of academics and industry.

The curriculum will also equip students for national level competitive exams that they may attempt in future. To ensure implementation of a holistic pedagogical model, students have the option to choose several allied disciplines in this framework, including Physics, Mathematics, Biology and ability enhancement electives. In addition, employability of graduates is given due importance such that their core competency in the subject matter, both theoretical and practical, is ensured. To expand the employability of graduates, a number of skill development courses are also introduced in this framework.

3. AIMS OF THE B.Sc. (HONOURS) CHEMISTRY PROGRAMME

The aim of bachelor's degree programme in chemistry is to provide:

(a) Broad and balanced knowledge in chemistry in addition to understanding of key chemical concepts, principles and theories.

(b) To develop ability and skill of the students to acquire expertise over solving both theoretical and applied chemistry problems.

(c) To provide knowledge and skill to the students' thus enabling them to undertake further studies in chemistry in related areas or multidisciplinary areas that can be helpful for self-employment/ entrepreneurship.

(d) To provide an environment that ensures cognitive development of students in a holistic manner. A complete dialogue about chemistry, chemical equations and its significance is fostered in this framework, rather than mere theoretical aspects.

(e) To provide the latest subject matter, both theoretical as well as practical, such a way to foster their core competency and discovery learning. A chemistry graduate, as envisioned in this framework, would be

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sufficiently competent in the field to undertake further discipline-specific studies, as well as to begin domain-related employment.

(f) To mould a responsible citizen who is aware of most basic domain-independent knowledge, including critical thinking and communication.

4. PROGRAM SPECIFIC OUTCOMES

A student graduating with B.Sc. (Honours) Chemistry should be able to acquire:

PSO 1: ***Disciplinary Knowledge***. A graduate student is expected to acquire comprehensive knowledge and understanding of both theoretical and experimental/applied chemistry knowledge in various fields of interest like Analytical Chemistry, Physical Chemistry, Inorganic Chemistry, Organic Chemistry, Material Chemistry, etc. Further, the student will be able to explain, integrate and apply relevant knowledge to problems that emerge from the broader interdisciplinary and multi-disciplinary areas.

PSO 2: Quantitative, Analytical and Instrument-based Skills. A much-valued learning outcome of this programme is the laboratory skills that students will develop during the course. Hands-on training on various analytical instruments and classical quantitative techniques in this course will enable them to cross branches to join analytical, pharmaceutical, material testing and biochemical labs besides standard chemical laboratories.

PSO 3: Communication Skills. The course curriculum will enable students to prepare the results of scientific work in written and electronic formats and communicate it to the peers and the public at large. It will also enable the students to appreciate the central role of chemistry in our society and use the knowledge to address the problems and issues pertaining to ethical, social, economic, and environment to academia, industry and government.

PSO 4: Critical Thinking. The course curriculum includes components that can be helpful to graduate students to develop critical thinking using basic chemistry knowledge and concepts.

PSO 5: Problem Solving. An integral part of the curriculum is problem solving. The student will be equipped to solve problems of numerical, synthetic and analytical nature that are best approached with critical thinking.

PSO 6: Analytical Reasoning. It is expected that the course curriculum will enable students to develop skills to design and test hypothesis, execute research experiments, conduct chemical syntheses, analyses or other chemical investigations, compile raw data and provide logical conclusions.

PSO 7: Leadership Development. Modern day scientific environment requires students to possess ability to think independently as well as be able to work productively in groups. This requires some degree of balancing. The chemistry honours programme course is designed to take care of this important aspect whereby a student can function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PSO 8: Digital Literacy. The course curriculum has been so designed to impart a good working knowledge in understanding and carrying out data analysis, use of library search tools, and use of chemical simulation software and related computational work.

PSO 9: Moral and Ethical Awareness. A graduate student requires to understand and develop ethical awareness/reasoning which the course curriculum adequately provide.

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PSO 10: Lifelong Learning. The course curriculum is designed to inculcate a habit of learning continuously for personal academic growth as well as to find gainful employment in public and private sector, be accepted for higher education or professional studies, or find employment in various levels as instructors or administrators.

5. DURATION OF THE PROGRAMME

(a) The degree programme leading to the award of Bachelor of Science (B.Sc.) in chemistry shall be of three years duration and include six continuous semesters under Choice Based Credit System (CBCS).

(b) The programme shall be completed in a maximum of five years (10 Semesters), consecutively, from the date of admission to the programme.

6. PROGRAMME STRUCTURE

(a) The syllabi for B.Sc. (Honours) in Chemistry is drafted as per the UGC guidelines for Learning Outcomes based Curriculum Framework (LOCF) based approach with an aim to equip the students with knowledge, skill, values and attitude.

(b) Usually a course refers to a 'paper' and is a component of an academic programme.

(c) The programmes shall include:

(i) **Core Course**: A core course is a compulsory paper to be studied by all the students to complete the requirements for the undergraduate degree.

(ii) **Elective Course**: Elective course is a course which can be chosen from a pool of courses and which may be very specific or specialized or advanced or supportive to the discipline/ subject of study or which provides an extended scope or which enables an exposure to some other discipline/subject/domain or nurtures the candidate's proficiency/skill is called an Elective Course.

1. *Discipline Specific Elective (DSE) Course*: It shall be supportive to the discipline of study, providing an expanded scope, enabling an exposure to some other discipline/domain, and nurturing student's proficiency/skill.
2. *Generic Elective (GE) Course*: An elective course chosen generally from other discipline(s)/subject(s), with an intention to seek exposure is called a Generic Elective.

(iii) **Ability Enhancement Courses:** The Ability Enhancement Courses may be of two kinds:

1. *Ability Enhancement Compulsory Courses (AEC)*: The courses which leads to knowledge enhancement such as Environmental Science, English/MIL Communication etc. These courses are mandatory.
2. *Skill Enhancement Courses (SEC)*: These courses are value-based and/or skill-based and are aimed at providing hands-on-training, competencies, skills, etc. These courses are mandatory and shall be chosen from a pool of courses designed to provide value-based and/or skill-based knowledge.

(d) **To acquire a B.Sc. (Hons.) Chemistry degree, a student shall have to study 14 (fourteen) Core Courses, 4 (four) Discipline Specific Elective (DSE) courses, 4 (four) Generic Elective (GE) courses, 4 (four) Skill Enhancement Courses (SEC) along with 2 (two) Ability Enhancement Compulsory Courses (AEC).**

(e) The student will study two Core Courses each, in Semesters I and II, three Core Courses each in Semesters III and IV and two Core Courses each in Semesters V and VI.

(f) The programme offers several Discipline Specific Elective (DSE) Courses, of which the student will study two in each of the Semesters V and VI. The students are required to take 2 courses from each group A and B respectively.

05/7/2021
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(g) Different Generic Elective courses are offered to students of B.Sc. (Hons) Chemistry Programme by other Departments of the University/College and the student will have the option to choose one GE course each in Semesters I, II, III, and IV. The students may choose four Generic Elective papers either exclusively from one discipline *OR* two papers each from two different disciplines but in both the cases excluding his/her own discipline. Some Universities in India require at least two mathematics papers to be studied by the student for admission into M.Sc. (Chemistry), thus students are advised to choose accordingly.

(h) Students are required to select at least 2 (two) SEC of total 4 credits from his/her concerned discipline to be offered in semester I to IV. For remaining 4 credits, he/she may select course(s) from either from his/her own discipline or other under-graduate disciplines of Science and Technology in the College/University.

(i) The Ability Enhancement Compulsory Courses (AEC) are English Communication, Hindi Sikshan and Environmental Studies and the student will study one each in Semesters I and II.

(j) The number of credits is given in the form L:T:P, where L, T and P indicates lecture, tutorial and practical laboratory credits respectively. Each lecture credit corresponds to one lecture hour per week, each tutorial credit corresponds to one tutorial hour per week while each laboratory credit corresponds to two laboratory hours per week. For example, 4:0:2 credits indicate that the course has 4 lectures, no tutorial session and two laboratory hours each week.

(k) The total credit required to complete the programme shall be a minimum of **148 credits** and a maximum of 160 credits. Students may pursue courses for additional 12 credits on their own (please refer to "RAJIV GANDHI UNIVERSITY REGULATIONS FOR CHOICE BASED CREDIT SYSTEM FOR UNDER-GRADUATE COURSES, 2021").

(l) The detailed structure of courses under B.Sc. (Honours) with Chemistry Programme shall be:

Sl. No.	Details of Courses	Credits		
		Theory	Practical	TOTAL
I	**Core Courses** (6 Credits) (**14 Courses**)	14 × 4 = 56	14 × 2 = 28	84
II	**Elective Courses** (6 Credits) (**8 Courses**)			
	(a) Discipline Specific Elective (DSE) Courses (**4 Courses**)	4 × 4 = 16	4 × 2 = 8	24
	(b) Generic Elective (GE) Courses (**4 Courses**)	4 × 4 = 16	4 × 2 = 8	24
III	**Ability Enhancement Courses**			
	(a) Ability Enhancement Compulsory Courses (AEC) (4 Credits) (**2 Courses**)	2 × 4 = 8		8
	(b) Skill Enhancement Courses (SEC) (2 Credits) (**4 Courses**)	4 × 2 = 8		8
Grand Total Credit				**148**

05/7/2021
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(m) Scheme for Choice Based Credit System (CBCS) in B.Sc. (Honours) with Chemistry

Semester	Core Course (CC)	Elective Course		Ability Enhancement Course	
		Discipline Specific Course (DE)	Generic Elective (GE)	Ability Enhancement (AE) Compulsory Course	Skill Enhancement (SE) Course
I	CC 1, CC 2		GE 1	AEC 1	SEC 1
II	CC 3, CC 4		GE 2	AEC 2	SEC 2
III	CC 5, CC 6, CC 7		GE 3		SEC 3
IV	CC 8, CC 9, CC 10		GE 4		SEC 4
V	CC 11, CC 12	DSE 1, DSE 2			
VI	CC 13, CC 14	DSE 3, DSE 4			

7. CONVERSION OF PERCENTAGE INTO CREDIT(S) AND GRADE(S)

(a) Under the absolute grading system adopted by the University, the marks shall be converted to grades based on pre-determined class intervals. The grading system with the following letter grades shall be adopted in awarding the grades and CGPA under the credit-based semester system.

% of Marks	Grade Point	Grade Letter
95-100	10	O (Outstanding)
85-94	9	A++ (Excellent)
75-84	8	A+ (Very Good)
65-74	7	A (Good)
55-64	6	B+ (Above Average)
45-54	5	B (Average)
35-44	4	C (Pass)
34 and less	0	D (Fail)
Absent	0	AB (Absent)

(b) Conversion to grade point to percentage = Grade Point $\times$ 10.0.

(c) A student obtaining Grade D shall be considered failed and shall be required to reappear in the examination, as provided in the ordinance(s) of the university.

(d) Computation of SGPA and CGPA:

(i) **Semester Grade Point Average (SGPA)** is the sum of the products of the course credit and grade points scored by a student divided by the sum of all course credits offered by the student. It can be calculated in the following manner:

$$SGPA\ (S_i) = \frac{\sum(C_i \times G_i)}{\sum C_i}$$

Where, C_i is the number of credits of the i^{th} course and G_i is the grade point scored by the student in the i^{th} course.

(ii) **Cumulative Grade Point Average (CGPA)** is the sum of the products of the total number of credits of all courses taken by a student in a semester with the SGPA in that semester divided by the total number of credits of all courses taken. It can be calculated in the following manner:

$$CGPA = \frac{\sum(C_i \times S_i)}{\sum C_i}$$

Where, S_i is the SGPA of the i^{th} semester and C_i is the number of credits in that semester.

05/7/2021
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(e) Illustration of computation of SGPA and CGPA

Course	Marks Obtained (Internal Assessment + End semester exam)	Grade Letter	Grade Point (G)	Credit (C)	Credit Point	SGPA
Semester I						
CC 1	78	A+	8	6	8 × 6 = 48	**7.33** (176/24)
CC 2	85	A++	9	6	9 × 6 = 54	
GE 1	73	A	7	6	7 × 6 = 42	
AEC 1	52	B	5	4	5 × 4 = 20	
SEC 1	62	B+	6	2	6 × 2 = 12	
			Total	**24**	**176**	
Semester II						
CC 3	79	A+	8	6	8 × 6 = 48	**6.92** (166/24)
CC 4	63	B+	6	6	6 × 6 = 36	
GE 2	57	B+	6	6	6 × 6 = 36	
AEC 2	70	A	7	4	7 × 4 = 28	
SEC 2	89	A++	9	2	9 × 2 = 18	
			Total	**24**	**166**	
Semester III						
CC 5	79	B	5	6	5 × 6 = 30	**5.85** (152/26)
CC 6	63	A	7	6	7 × 6 = 42	
CC 7	53	B	5	6	5 × 6 = 30	
GE 3	57	A	7	6	7 × 6 = 42	
SEC 3	89	C	4	2	4 × 2 = 08	
			Total	**26**	**152**	
Semester IV						
CC 8	80	A+	8	6	8 × 6 = 48	**7.62** (198/26)
CC 9	70	A	7	6	7 × 6 = 42	
CC 10	77	A+	8	6	8 × 6 = 48	
GE 4	84	A+	8	6	8 × 6 = 48	
SEC 4	60	B+	6	2	6 × 2 = 12	
			Total	**26**	**198**	
Semester V						
CC 11	79	A+	8	6	8 × 6 = 48	**8.25** (198/24)
CC 12	86	A++	9	6	9 × 6 = 54	
DSE 1	81	A+	8	6	8 × 6 = 48	
DSE 2	76	A+	8	6	8 × 6 = 48	
			Total	**24**	**198**	
Semester VI						
CC 13	87	A++	9	6	8 × 6 = 54	**8.50** (204/24)
CC 14	86	A++	9	6	9 × 6 = 54	
DSE 3	75	A+	8	6	8 × 6 = 48	
DSE 4	76	A+	8	6	8 × 6 = 48	
				24	204	

Thus,

$$\boldsymbol{CGPA} = \frac{(24 \times 7.33) + (24 \times 6.92) + (26 \times 5.85) + (26 \times 7.62) + (24 \times 8.25) + (24 \times 8.50)}{148}$$

$$= 7.39$$

Which is equivalent to 73.9 %

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8. SEMESTER-WISE DISTRIBUTION OF COURSES FOR B.SC. (HONOURS) CHEMISTRY PROGRAMME UNDER CBCS AND CREDIT DISTRIBUTION

(a) Core Courses

Semester	Course Code	Course Title	Credit (L:T:P)	Total Credit
I	CHE-CC-111	Inorganic Chemistry I	4:0:2	6
	CHE-CC-112	Physical Chemistry I	4:0:2	6
II	CHE-CC-121	Organic Chemistry I	4:0:2	6
	CHE-CC-122	Physical Chemistry II	4:0:2	6
III	CHE-CC-231	Inorganic Chemistry II	4:0:2	6
	CHE-CC-232	Organic Chemistry II	4:0:2	6
	CHE-CC-234	Physical Chemistry III	4:0:2	6
IV	CHE-CC-241	Inorganic Chemistry III	4:0:2	6
	CHE-CC-242	Organic Chemistry III	4:0:2	6
	CHE-CC-243	Physical Chemistry IV	4:0:2	6
V	CHE-CC-351	Organic Chemistry IV	4:0:2	6
	CHE-CC-352	Inorganic Chemistry IV	4:0:2	6
VI	CHE-CC-361	Physical Chemistry V	4:0:2	6
	CHE-CC-362	Organic Chemistry V	4:0:2	6

(b) Discipline Specific Elective (DSE) Courses

Semester	Course Code	Course Title	Credit (L:T:P)	Total Credit
V (Any two for DSE 1 and DSE 2)	CHE-DE-351	Analytical Methods in Chemistry	4:0:2	6
	CHE-DE-352	Industrial Chemicals & Environment	4:0:2	6
	CHE-DE-353	Polymer Chemistry	4:0:2	6
	CHE-DE-354	Applications of Computers in Chemistry	4:0:2	6
	CHE-DE-355	Research Methodology for Chemists	4:2:0	6
VI (Any two for DSE 3 and DSE 4)	CHE-DE-361	Inorganic Materials of Industrial Importance	4:0:2	6
	CHE-DE-362	Green Chemistry	4:0:2	6
	CHE-DE-363	Instrumental Methods of Chemical Analysis	4:0:2	6
	CHE-DE-364	Novel Inorganic Solids	4:0:2	6
	CHE-DE-365	Dissertation	0:1:5	6

05/7/2021
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(c) **Generic Elective (GE) Courses**

(i) Please refer to the syllabus of following departments/disciplines for GE 1 to GE 4
   1. Mathematics
   2. Physics
   3. Computer Science

(ii) The students may choose either four Generic Elective papers exclusively from one department/ discipline *OR* two papers each from two different departments/disciplines.

(iii) Some Universities in India require at least two mathematics papers to be studied by the student for admission into M.Sc. (Chemistry), thus students are advised to choose accordingly.

(d) **Ability Enhancement Courses (AEC)***

Semester	Course Code	Course Title	Credit (L:T:P)	Credit
I (Any One)	ENG-AE-111	Communicative English	3:1:0	4
	HIN-AE-111	हिंदी शिक्षण	3:1:0	4
II	EVS-AE-121	Environmental Studies	4:0:0	4

(e) **Skill Enhancement Courses (SEC)***

Semester		Course Title	Credit (L:T:P)	Credit
I & III	CHE-SE-001	Water Treatment and Analysis I	1:0:1	2
	CHE-SE-003	Soil Chemistry	1:0:1	2
	CHE-SE-005	Chemistry of Food, Cosmetics and Perfumes	1:0:1	2
II & IV	CHE-SE-002	Water Treatment and Analysis II	1:0:1	2
	CHE-SE-004	Fertilizers and Pesticide Chemistry	1:0:1	2
	CHE-SE-006	Pharmaceutical Chemistry	1:0:1	2

(i) A student shall select at least 2 (two) SEC of total 4 credits from his/her concerned discipline.

(ii) For remaining 4 credits, he/she may select course(s) from either from his/her own discipline or other under-graduate disciplines of Science and Technology in the College/University.

(f) **Generic Elective (GE) Courses for other Departments/Disciplines***

Semester	Course Code	Course Title	Credit (L:T:P)	Credit
I	CHE-GE-001	General Chemistry I	4:0:2	6
II	CHE-GE-002	General Chemistry II	4:0:2	6
III (Any One)	CHE-GE-003	General Chemistry III	4:0:2	6
	CHE-GE-004	General Chemistry IV	4:0:2	6
IV (Any One)	CHE GE 005	General Chemistry V	4:0:2	6
	CHE-GE-006	Molecules of Life	4:0:2	6

**These Generic Elective (GE) courses are intended to be studied by students from other departments/disciplines.*

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9. TEACHING LEARNING PROCESS

B.Sc. (Hons) Chemistry programme is a three-year degree programme designed to provide students with a sound theoretical background and practical training in all aspects of chemistry and helps them develop an appreciation of the importance of chemistry in different contexts. The programme includes foundational as well as in-depth courses that span the traditional sub-disciplines of chemistry. Along with the above Core Courses there are Discipline Specific Elective Courses, Generic Elective Courses and Ability Enhancement Courses which will address the need of the hour.

These courses shall be delivered through classroom, laboratory work, projects, case studies and field work in a challenging, engaging, and inclusive manner that accommodates a variety of learning styles and tools (PowerPoint presentations, audio visual resources, e-resources, seminars, workshops, models, software).

The laboratory training complements the theoretical principles learned in the classroom and includes synthesis of molecules, measurement of chemical properties and phenomenon, hands-on experience with modern instruments, computational data analysis, modelling and laboratory safety procedures.

10. ASSESSMENT METHODS, CONDUCT OF EXAMINATIONS, ELIGIBILITY CONDITIONS, AND DECLARATION OF RESULTS

The primary objective of the assessment of the academic performance of a student in various courses is to assess the learning outcomes of the course in tune with the broad outcomes of strengthening core theoretical knowledge and practical laboratory skills.

Academic performance in various courses i.e., core, discipline electives, generic electives and skill enhancement courses are to be considered as parameters for assessing the achievement of students. All students shall be subjected to the process of continuous evaluation and assessment. A number of appropriate assessment methods will be used to determine the extent to which students demonstrate desired learning outcomes. Marks allocation for Internal Assessment and End Semester Examinations, Question paper pattern, Duration of examination for various courses, Attendance and other eligibility conditions for appearing in the examination, and Declaration of results shall be done in accordance with the relevant provisions as stipulated in the "Rajiv Gandhi University Regulations for Choice Based Credit System for Under-Graduate Courses, 2021" and also the Ordinance(s) of the University.

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Rajiv Gandhi University
Rono Hills, Doimukh (A.P.)

CORE COURSES

SEMESTER I

CHE-CC-111

Inorganic Chemistry I

Credit: 6 (L 4 – T 0 – P 2)
Total Lectures: 120 (Theory – 60; Practical – 60)

Course Objectives

The course reviews the structure of the atom, which is a necessary pre-requisite to understand the nature of chemical bonding in compounds. It provides knowledge about the three main types of bonding viz. ionic, covalent and metallic bonding. It discusses periodic properties of elements, especially in reference to the *s*- and *p*-block elements elaborately, which is necessary to understand their group chemistry.

Learning Outcomes

On completion of this course the students will be able to:

1. Understand quantum mechanical model of atom, quantum numbers, electronic configuration, radial and angular distribution curves, shapes of *s*, *p*, and *d* orbitals, and periodicity in atomic radii, ionic radii, ionization energy and electron affinity of elements.
2. Acquire knowledge on the bonding theories (VBT, MOT & Band theory) used to explain various types of bonds (ionic, covalent and metallic).
3. Deduce the shape (geometry) of molecules using radius ratio rules & VSEPR theory.
4. Draw MO diagrams for a few homo- & hetero-nuclear diatomic molecules and to calculate the bond order.
5. Understand the concept of lattice energy using Born-Landé and Kapustinskii expression.
6. Rationalize the conductivity of metals, semiconductors and insulators based on the band theory.
7. Understand the importance of chemical bonds, inter-molecular and intramolecular weak chemical forces and their effect on melting points, boiling points, solubility and energetics of dissolution.
8. Estimate metal contents in different samples using titration techniques.

UNIT 1: Atomic Structure

Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's uncertainty principle and its significance, Schrödinger's wave equation, significance of ψ and ψ^2. Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of *s, p, d* and *f* orbitals.
Pauli's exclusion principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number.

(15 Lectures)

UNIT 2: Periodicity of Elements

s, p, d, f block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to *s* and *p*-block.

(a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table.
(b) Atomic radii (van der Waals)
(c) Ionic and crystal radii.
(d) Covalent radii (octahedral and tetrahedral).
(e) Ionization enthalpy, successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy.

(f) Electron gain enthalpy, trends of electron gain enthalpy.
(g) Electronegativity, Pauling's/ Mulliken's/ Allred Rachow's/ and Mulliken-Jaffé's electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity. Sanderson's electron density ratio.

(15 Lectures)

UNIT 3: Chemical Bonding I

Ionic Bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, solvation energy.

Covalent Bond: Ionic and covalent bonding (characteristics and properties), Valence bond theory. Application of hybridisation (*sp*, sp^2, sp^3, dsp^3 and d^2sp^3) to explain structure of simple molecules. Bent's rule, resonance and resonance energy. Polarity in covalent molecules, dipole moment, percentage ionic character and electro negativity difference. Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding (σ and π bond approach) and bond lengths.

(15 Lectures)

UNIT 4: Chemical Bonding II

Molecular orbital theory. Molecular orbital diagrams of diatomic (N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions) and simple polyatomic (HCl, BeH_2, CO_2, XeF_2) molecules. *s-p* mixing and orbital interaction.

Metallic Bond: Qualitative idea of band theory. Semiconductors and insulators.

Weak Chemical Forces: van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment). Effects of chemical force, melting and boiling points, solubility energetics of dissolution process.

(15 Lectures)

PRACTICAL

Inorganic Chemistry I

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1. Acid-Base Titrations
   (a) Determination of alkali content of antacid tablets using HCl.
   (b) Estimation of calcium content in chalk as calcium oxalate.
   (c) Estimation of carbonate and hydroxide present together in mixture.
   (d) Estimation of carbonate and bicarbonate present together in a mixture.
   (e) Estimation of free alkali present in different soaps/detergents
2. Oxidation-Reduction Titrations
   (a) Estimation of Fe(II) and oxalic acid using standardized $KMnO_4$ solution.
   (b) Estimation of oxalic acid and sodium oxalate in a given mixture.
   (c) Estimation of Fe(II) with $K_2Cr_2O_7$ using internal (diphenylamine, anthranilic acid) and external indicator.

Recommended Books

Theory

1. Lee, J. D., *Concise Inorganic Chemistry*, 5th Ed., Wiley India (2008).
2. Miessler, G.; Tarr, D. A., *Inorganic Chemistry*, 3rd Ed., Pearson Education India (2008).
3. Housecroft, C. E; Sharpe, A. G., *Inorganic Chemistry*, 5th Ed., Pearson Education (2018).
4. Atkins, P.; Overton, T.; Rouke, J.; Weller, M.; Armstrong, F.; Hagerman, M., *Shriver Atkins's Inorganic Chemistry*, 6th Ed., Oxford University Press India (2015).
5. Huheey, J. E.; Keiter, E. A.; Keiter, R. L.; Medhi, O. K., *Inorganic Chemistry: Principles of Structures and Reactivity*, 4th Ed., Pearson Education India (2006).
6. Cotton, F. A.; Wilkinson, G.; Gaus, P. L., *Basic Inorganic Chemistry*, 3rd Ed., Wiley India (2007).
7. Puri, B. R.; Sharma, L. R.; Kalia, K. C., *Principles of Inorganic Chemistry*, 33rd Ed., Vishal Publishing (2017).

Practical

1. Raj, G., *Advanced Practical Inorganic Chemistry*, Krishna Prakashan, Meerut (2013).
2. Mendham, J.; Denney, R. C., Barnes, J. D.; Thomas, M.; Sivasankar, B., *Vogel's Quantitative Chemical Analysis*, 6th Ed., Pearson Education India (2009).

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SEMESTER I

CHE-CC-112
Physical Chemistry I

Credit: 6 (L 4 – T 0 – P 2)
Total Lectures: 120 (Theory – 60; Practical – 60)

Course Objectives
The course covers the basic and advance concepts regarding the three states of matter. It deals with various mathematical equations that express different physical properties of gases, liquids and solids. It also discusses chemical equilibrium, equilibrium constants and the relationship between three different types of equilibrium constants in details.

Learning Outcomes
On completion of this course the students will be able to:

1. Understand the differences between ideal and real gases, to evaluate molecular velocities (average, root mean square and most probable) and average kinetic energy of gases.
2. Derive mathematical expressions for different properties of gas, liquid and solids and to understand their physical significances.
3. Understand the different physical properties of liquids and the factors effecting it.
4. Get introduced to the concept of symmetry: symmetry elements, operations, point groups, etc.
5. Have elementary idea on crystalline structure of solids, different crystal systems and Bravais lattices.
6. Apply the concepts of gas equations, Le Chatelier's principle, Gibbs free energy of reaction etc., while studying other chemistry courses and everyday life.
7. Determine surface tension and viscosity practically of different liquid samples.
8. Practically determine the chemical equilibrium of a reaction.

UNIT 1: States of Matter I
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.
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, introduction of equations of state; 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.

(15 Lectures)

UNIT 2: States of Matter II
Gaseous Sate: Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities.
Liquid State: Qualitative treatment of the structure of the liquid state; Radial distribution function; physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Temperature variation of viscosity of liquids and comparison with that of gases. Qualitative discussion of structure of water.

(15 Lectures)

UNIT 3: States of Matter III

Solid State: Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Defects in crystals. Glasses and liquid crystals.

(15 Lectures)

UNIT 4: Chemical Equilibrium

Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases, concept of fugacity. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient. Coupling of exoergic and endoergic reactions. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Free energy of mixing and spontaneity; thermodynamic derivation of relations between the various equilibrium constants K_p, K_c and K_x. Le Chatelier's principle (quantitative treatment); equilibrium between ideal gases and a pure condensed phase.

(15 Lectures)

PRACTICAL

Physical Chemistry I

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1. Surface tension measurements.
   (a) Determine the surface tension by (i) drop number (ii) drop weight method.
   (b) Study the variation of surface tension of detergent solutions with concentration.
2. Viscosity measurement using Ostwald's viscometer.
   (a) Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature.
   (b) Study the variation of viscosity of sucrose solution with the concentration of solute.
3. Indexing of a given powder diffraction pattern of a cubic crystalline system.
4. Determine the equilibrium constant of the following reaction by distribution method.

$$KI + I_2 \rightleftharpoons KI_3$$

Recommended Books

Theory

1. Atkins, P. W.; de Paula, J.; Keeler, J., *Physical Chemistry*, 11th Ed., Oxford University Press India (2018).
2. Bahl, A.; Bahl, B. S.; Tuli, G. D., *Essentials of Physical Chemistry*, S. Chand and Company (2014).
3. Negi, A. S.; Anand, S. C., *Physical Chemistry*, New Age International Publishers (2007).
4. Puri, B. R.; Sharma, L. R.; Pathania, M. S., *Principles of Physical Chemistry*, 47th Ed., Vishal Publishing (2017).
5. Kapoor, K. L., *A Textbook of Physical Chemistry: States of Matter and Ions in Solution*, Vol. I, 6th Ed., McGraw Hill Education India (2019).

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Practical

1. Viswanathan, B.; Raghavan, P. S., *Practical Physical Chemistry*, Viva Books India (2014).
2. Yadav, J. B., *Advanced Practical Physical Chemistry*, Krishna Prakashan, Meerut (2015).

SEMESTER II

CHE-CC-121
Organic Chemistry I

Credit: 6 (L 4 – T 0 – P 2)
Total Lectures: 120 (Theory – 60; Practical – 60)

Course Objectives
This core course is designed to revisit the fundamental concepts of organic chemistry in details so that the students can acquire the must needed foundation for better understanding of other organic chemistry topics in subsequent semesters. Stereochemistry is introduced to visualize the organic molecules in a three-dimensional space. To establish the application of these concepts, the functional groups- alkanes, alkenes, alkynes and aromatic hydrocarbons are introduced.

Learning Outcomes
On completion of this course the students will be able to:

1. Understand the role of various electronic factors (such as inductive, electromeric, resonance and mesomeric effects) in various physical and chemical properties like stability, polarity, acidity, basicity etc. of different organic species of both neutral and charged in nature.
2. Have clear idea on aromaticity and its influence in stabilizing ring compounds and ions.
3. Acquire knowledge on different types of organic reaction mechanisms and simple stereochemistry involved therein.
4. Draw three dimensional molecules in two-dimensional plane using different projection formulae.
5. Have idea on syntheses, properties and reactions of various classes of aliphatic and aromatic hydrocarbons.
6. Have practical experiences on simple crystallization techniques of organic compounds from different solvents.
7. Detect various elements present in an unknown organic compound.
8. Check the purity and to determine the number of components present in a supplied organic sample with the help of chromatographic technique.

UNIT 1: Basics of Organic Chemistry
Organic Compounds: Classification and nomenclature, hybridization, shapes of molecules, influence of hybridization on bond properties.
Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; dipole moment; organic acids and bases and their relative strength.
Aromaticity: Hückel's rule, aromatic character in arenes, cyclic carbocations/carbanions and heterocyclic compounds.
Homolytic and heterolytic fission with suitable examples. Electrophiles and nucleophiles; nucleophlicity and basicity; types, shape and relative stability of carbocations, carbanions, free radicals and carbenes.
Introduction to types of organic reactions and their mechanisms: Addition, elimination (E1, E2 and E1cb) and substitution reactions (S_N1, S_N2 and S_Ni).

(15 Lectures)

UNIT 2: Stereoisomerism
Geometrical Isomerism: Determination of configuration of geometric isomers, cis-trans, sequence rules and *E* & *Z* system of nomenclature.
Fischer, Newmann, Sawhorse Projection formulae and their interconversions

Optical Isomerism: Optical activity, specific rotation, chirality/asymmetry, enantiomers, molecules with two or more chiral-centres, distereoisomers, meso structures, racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations. CIP rules.
Conformational Isomerism: Difference between configuration and conformation. Conformational analysis of alkanes, Bayer & Pitzer strain, conformations of cyclohexane, axial and equatorial bonds. Energy profile diagram of cyclohexane molecule: chair, boat and twist boat forms.

(15 Lectures)

UNIT 3: Aliphatic Hydrocarbons

Chemistry of Alkanes: Formation of alkanes, Würtz reaction, Würtz-Fittig reactions, free radical substitutions: Halogenation, relative reactivity and selectivity.
Chemistry of Alkenes: Formation of alkenes (Saytzeff and Hofmann eliminations). Electrophilic addition reactions and their mechanisms (Markownikoff / Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, reduction reactions, *syn* and *anti*-hydroxylation (oxidation). 1,2- and 1,4- addition reactions in conjugated dienes, introduction to Diels-Alder reaction; allylic and benzylic bromination (including mechanism) of propene, 1-butene, toluene, ethyl benzene.
Chemistry of Alkynes: Formation of alkynes. Acidic property of terminal alkynes. Electrophilic and nucleophilic additions. Hydration reaction of alkynes (carbonyl compounds formation), alkylation of terminal alkynes.

(15 Lectures)

UNIT 4: Aromatic Hydrocarbons

Aromatic electrophilic substitution, mechanism, role of sigma and pi complexes, energy profile diagram, mechanism of nitration, halogenations, sulphonation, mercuration and Friedel-Craft's reactions. Substitution of mono substituted benzenes, activating and deactivating groups; directive effect of substituents present.
Introduction to aromatic nucleophilic substitution.

(15 Lectures)

PRACTICAL
Organic Chemistry I

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1. Purification of organic compounds by crystallization using Water /Alcohol /Alcohol-Water and determination of their melting points.
2. Detection of elements (nitrogen, sulphur and halogens) in unknown organic compounds.
3. Chromatography
   (a) Checking the purity of supplied organic sample using paper/thin layer chromatographic technique.
   (b) Determination of the number of components present in a supplied organic mixture using paper/thin layer chromatographic technique.
   (c) Separation of a mixture of two amino acids by paper chromatography and determination of R_f.
   (d) Separation of a mixture of *o*-and *p*-nitrophenol or *o*- and *p*-aminophenol by thin layer chromatography (TLC) and determination of R_f of each of the component.

Recommended Books

Theory

1. Greeves, N.; Clayden, J.; Warren, S., *Organic Chemistry*, 2nd Ed., Oxford University Press India (2014).
2. Smith, M. B.; March, J., *March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure*, 7th Ed., Wiley India (2015).
3. Solomons, T. W. G.; Fryhle, C. B., *Organic Chemistry*, 11th Ed., Wiley India (2015).
4. Bruice, P. Y., *Organic Chemistry*, 7th Ed., Pearson Education India (2013).
5. Ghosh, S. K., *Advanced General Organic Chemistry, Part-I & Part-II*, 3rd Ed., New Central Book Agency (2010).
6. Bhal, B. S.; Bhal, A., *A Textbook of Organic Chemistry*, 22nd Ed., S. Chand and Company (2016).
7. Nasipuri D., *Stereochemistry of Organic Compounds: Principles and Applications*, 3rd Ed., New Age International Publishers (2018).
8. Sengupta, S., *Basic Stereochemistry of Organic Molecules*, 2nd Ed., Oxford University Press India (2018).

Practical

1. Agarwal, O. P., *Advanced Practical Organic Chemistry*, Krishna Prakashan, Meerut (2014).
2. Ahluwalia, V. K.; Aggarwal, R., *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*, Universities Press (2000).
3. Furniss, B. S.; Hannafold, A. J.; Smith, P. W. G.; Tatchell, A. R., *Vogel's Textbook of Practical Organic Chemistry*, 5th Ed., Pearson Education India (2003).
4. Clarke, H. T., *A Handbook of Organic Analysis: Qualitative and Quantitative*, 4th Ed., CBS Publishers India (2007).

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SEMESTER II

CHE-CC-122
Physical Chemistry II

Credit: 6 (L 4 – T 0 – P 2)
Total Lectures: 120 (Theory – 60; Practical – 60)

Course Objectives
This course aims to make the students understand some of the most important topics in physical chemistry like thermodynamic concepts, laws of thermodynamics, thermochemistry, dependence of thermodynamic parameters on composition, ionic equilibrium, solutions and colligative properties. Discussion on topics like dissociation of strong and weak electrolytes, hydrolysis of salts, solubility and solubility product of sparingly soluble salts, pH, buffers and different colligative properties will enable the learners to understand the chemistry of everyday life.

Learning Outcomes
On completion of this course the students will be able to:

1. Understand the laws of thermodynamics, concept of state and path functions, extensive and intensive properties.
2. Calculate bond energy, bond dissociation energy and resonance energy from thermochemical data.
3. Derive expressions for different free energy function (Gibbs & Helmholtz).
4. Understand the concept of partial molar properties and the influence of composition on thermodynamic properties.
5. Derive expressions for pH for aqueous solutions of various salts and Henderson equation for different buffer solutions.
6. Have fair knowledge on the four colligative properties and their application.
7. Determine heat capacity, enthalpy of neutralization, enthalpy of ionization etc. practically.
8. Carry out pH metric titration for acid/base strength determination.

UNIT 1: Chemical Thermodynamics I
Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics.

First Law: Concept of heat, *q*, work, *w*, internal energy, *U*, and statement of first law; enthalpy, *H*, relation between heat capacities, calculations of *q*, *w*, *U* and *H* for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions.

Second Law: Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes.

Third Law: Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules.

(15 Lectures)

UNIT 2: Chemical Thermodynamics II
Thermochemistry: Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations) and pressure on enthalpy of reactions. Adiabatic flame temperature, explosion temperature.

Free Energy Functions: Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other

thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.
Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs-Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases.

(15 Lectures)

UNIT 3: Ionic Equilibria

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di-and triprotic acids (exact treatment).
Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications; buffer capacity, buffer range, buffer action and applications of buffers in analytical chemistry and biochemical processes in the human body.
Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of acid–base indicators; selection of indicators and their limitations. Multistage equilibria in polyelectrolyte systems; hydrolysis and hydrolysis constants.

(15 Lectures)

UNIT 4: Solutions and Colligative Properties

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, (iv) osmotic pressure] and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.

(15 Lectures)

PRACTICAL

Physical Chemistry II

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1. Determine the water equivalent of a calorimeter.
2. Calculate the heat of ionization of acetic acid.
3. Determine the heat of hydration of $CuSO_4$, i.e., the heat of crystallization of $CuSO_4 \cdot 5H_2O$.
4. Determine the solubility product of $Ba(IO_3)_2$ at room temperature.
5. pH metry
   (a) Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
   (b) Preparation of buffer solutions of different pH (i) acetic acid-sodium acetate (ii) ammonium hydroxide-ammonium chloride.
   (c) pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
   (d) Determination of dissociation constant of a weak acid.

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Recommended Books

Theory

1. Atkins, P. W.; de Paula, J.; Keeler, J., *Physical Chemistry*, 11th Ed., Oxford University Press India (2018).
2. Bahl, A.; Bahl, B. S.; Tuli, G. D., *Essentials of Physical Chemistry*, S. Chand and Company (2014).
3. Negi, A. S.; Anand, S. C., *Physical Chemistry*, New Age International Publishers (2007).
4. Puri, B. R.; Sharma, L. R.; Pathania, M. S., *Principles of Physical Chemistry*, 47th Ed., Vishal Publishing (2017).
5. Kapoor, K. L., *A Textbook of Physical Chemistry: Thermodynamics and Chemical Equilibrium*, Vol. II, 6th Ed., McGraw Hill Education India (2019).

Practical

1. Viswanathan, B.; Raghavan, P. S., *Practical Physical Chemistry*, Viva Books India (2014).
2. Yadav, J. B., *Advanced Practical Physical Chemistry*, Krishna Prakashan, Meerut (2015).

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SEMESTER III

CHE-CC-231

Inorganic Chemistry II

Credit: 6 (L 4 – T 0 – P 2)
Total Lectures: 120 (Theory – 60; Practical – 60)

Course Objectives

The course reviews the general principles of metallurgy, *s*-, *p*-block elements & compounds, theories of acids & bases as well as inorganic rings, cages and polymers. It discusses various methods of purification of metals, such as electrolytic, oxidative refining, Van Arkel-De Boer process and Mond's process etc. and their working principles. It further discusses the patterns and trends exhibited by *s* and *p* block elements and their compounds with emphasis on synthesis, structure, bonding and uses. Learners will have detail reading in acid base chemistry, various theories including Pearson's HSAB concept and elementary idea on inorganic rings, cages and polymers.

Learning Outcomes

On completion of this course the students will be able to:

1. Learn the fundamental principles of metallurgy, extraction and purification process of a few metals.
2. Have knowledge on relative stability of different oxidation states of *s* & *p*-block elements and their complex formation behaviour.
3. Understand oxidation states with reference to elements in unusual and rare oxidation states like carbides and nitrides.
4. Understand various theories of acids and bases.
5. Have idea on Pearson's HSAB principle and its applications.
6. Have understanding in ring, cage and polymers of B, Si & P.
7. Estimate metal and non-metal contents using iodometric titrations.
8. Carry out preparation of metal salts including double salts.

UNIT 1: General Principles of Metallurgy and Chemistry of *s*- and *p*-Block Elements

General Principles of Metallurgy: Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon as reducing agent. Hydrometallurgy, Methods of purification of metals (Al, Pb, Ti, Fe, Cu, Ni, Zn): electrolytic, oxidative refining, Kroll process, Parting process, van Arkel-de Boer process and Mond's process. Zone refining.

Chemistry of s- and p-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. Complex formation tendency of *s* and *p* block elements.

(15 Lectures)

UNIT 2: Compounds of *s*-, *p*-block Elements

Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses.

(a) Boron: Boric acid and borates, boron nitrides, borohydrides (diborane).
(b) Carbon: Types of carbide, CaC_2, SiC, Al_4C_3- preparation, properties and uses
(c) Silicon: Silanes, silicon halides.
(d) Nitrogen & Phosphorus: ammonia-manufacture (Haber's process), Oxides and oxoacids of nitrogen and phosphorus.
(e) Sulphur: Sulphuric acid and its properties as dehydrating agent, oxidizing property and action on metals and non-metals. Peroxo acids of sulphur.

(f) Halogen: interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens.

(15 Lectures)

UNIT 3: Acids and Bases

Arrhenius, Brönsted-Lowry, and Lewis concepts of acids and bases, Proton transfer equilibria in water, solvent levelling, Classification of acids and bases as hard and soft. Pearson's HSAB concept, acid-base strength and hardness and softness. Theoretical basis of hardness and softness, electronegativity and hardness and softness. Applications of acid base chemistry in qualitative analysis and catalysis, superacids and superbases.

(15 Lectures)

UNIT 4: Inorganic Rings, cages and Polymers

Types of inorganic polymers. Comparison with organic polymer, synthesis, structural aspects and applications of Borazine or borazole, boron nitrides, boranes, carboranes, metallocarboranes, silicates, silicones, siloxanes. Phosphazenes.

(15 Lectures)

PRACTICAL

Inorganic Chemistry II

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1. Iodometric Titrations
   (a) Estimation of Cu(II) and $K_2Cr_2O_7$ using sodium thiosulphate solution.
   (b) Estimation of (i) arsenite and (ii) antimony in antimony potassium tartarate.
   (c) Estimation of available chlorine in bleaching powder.
2. Inorganic preparations
   (a) Cuprous Chloride (Cu_2Cl_2) from copper sulphate.
   (b) Preparation of Manganese phosphate ($MnPO_4 \cdot xH_2O$) from manganese nitrate [$Mn(NO_3)_2$].
   (c) Preparation of chrome alum [$K_2SO_4 \cdot Cr_2(SO_4)_3 \cdot 24H_2O$] and potash alum [$K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$].

Recommended Books

Theory

1. Lee, J. D., *Concise Inorganic Chemistry*, 5th Ed., Wiley India (2008).
2. Housecroft, C. E; Sharpe, A. G., *Inorganic Chemistry*, 5th Ed., Pearson Education (2018).
3. Atkins, P.; Overton, T.; Rouke, J.; Weller, M.; Armstrong, F.; Hagerman, M., *Shriver Atkins' Inorganic Chemistry*, 6th Ed., Oxford University Press India (2015).
4. Miessler, G.; Tarr, D. A., *Inorganic Chemistry*, 3rd Ed., Pearson Education India (2008).
5. Huheey, J. E.; Keiter, E. A.; Keiter, R. L.; Medhi, O. K., *Inorganic Chemistry: Principles of Structures and Reactivity*, 4th Ed., Pearson Education India (2006).
6. Cotton, F. A.; Wilkinson, G.; Gaus, P. L., *Basic Inorganic Chemistry*, 3rd Ed., Wiley India (2007).
7. Puri, B. R.; Sharma, L. R.; Kalia, K. C., *Principles of Inorganic Chemistry*, 33rd Ed., Vishal Publishing (2017).

Practical

1. Raj, G., *Advanced Practical Inorganic Chemistry*, Krishna Prakashan, Meerut (2013).
2. Mendham, J.; Denney, R. C., Barnes, J. D.; Thomas, M.; Sivasankar, B., *Vogel's Quantitative Chemical Analysis*, 6th Ed., Pearson Education India (2009).

05/7/2021

संयुक्त कुलसचिव (शैक्षणिक एवं सम्मेलन)
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Jt. Registrar (Acad. & Conf.)
Rajiv Gandhi University
Rono Hills, Doimukh (A.P.)

SEMESTER III

CHE-CC-232
Organic Chemistry II

Credit: 6 (L 4 – T 0 – P 2)
Total Lectures: 120 (Theory – 60; Practical – 60)

Course Objectives
This course covers chemistry of organic molecules bearing a few common functional groups, which include halogenated hydrocarbons and oxygen & sulphur containing functional groups. Synthetic avenues, physical & chemical properties and characteristic reactions of such compounds will be discussed in details. The course also encompasses various named reactions associated with these functional groups and their mechanisms.

Learning Outcomes
On completion of this course the students will be able to:

1. Understand preparation, properties and reactions of haloalkanes, haloarenes, oxygen and sulphur containing functional groups.
2. To draw plausible mechanisms for reactions involving these functional groups.
3. Have knowledge on various named organic reactions associated with these functional groups.
4. Acquire fair idea on fascinating chemistry of epoxides.
5. Carry out detection of *o*-containing functional groups like alcohols, phenols, carbonyl and carboxylic acid group.
6. Prepare various organic compounds by functional group transformations and other common organic reactions.
7. Have some insight into the green practices in organic synthesis.

UNIT 1: Chemistry of Halogenated Hydrocarbons
Alkyl Halides: Methods of preparation, nucleophilic substitution reactions – S_N1, S_N2 and S_Ni mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination.
Aryl Halides: Preparation, including preparation from diazonium salts. nucleophilic aromatic substitution; S_NAr, benzyne mechanism. Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.
Organometallic compounds of Mg and Li; use in the synthesis of organic compounds.

(15 Lectures)

UNIT 2: Alcohols, Phenols, Thiols, Ethers, Thioethers and Epoxides
Alcohols: preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt-Blanc reduction; preparation and properties of glycols: oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement.
Phenols: Preparation and properties; acidity and factors effecting it, ring substitution reactions, Reimer-Tiemann and Kolbe's-Schmidt reactions, Fries and Claisen rearrangements with mechanism.
Preparation and reactions of thiols and thioethers.
Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and $LiAlH_4$.

(15 Lectures)

UNIT 3: Carbonyl Compounds
Structure, reactivity and preparation; nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives and their mechanisms; mechanisms of Aldol and Benzoin

condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α-substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$, MPV and PDC); Addition reactions of unsaturated carbonyl compounds: Michael addition.

Active Methylene Compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.

(15 Lectures)

UNIT 4: Carboxylic Acids and their Derivatives

Preparation, physical properties and reactions of monocarboxylic acids. Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids.

Preparation and reactions of sulphonic acids.

Preparation and reactions of acid chlorides, anhydrides, esters and amides; Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmann bromamide degradation and Curtius rearrangement.

(15 Lectures)

PRACTICAL

Organic Chemistry II

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1. Functional group tests for alcohols, phenols, carbonyl and carboxylic acid group.
2. Organic preparations:
   (a) Benzolyation of phenols (β-naphthol/resorcinol/*p*-cresol) by Schotten-Baumann reaction.
   (b) Oxidation of ethanol/ acetone (Iodoform reaction).
   (c) Nitration of Salicylic acid by green approach (using ceric ammonium nitrate).
   (d) Reduction of *p*-nitrobenzaldehyde/ *m*-nitrobenzaldehyde by sodium borohydride.
   (e) Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone, benzaldehyde.
   (f) *S*-Benzylisothiouronium chloride from thiourea and benzyl chloride.
   (g) Aldol condensation using either conventional or green method.
   (h) Benzil-Benzilic acid rearrangement.

Recommended Books

Theory

1. Greeves, N.; Clayden, J.; Warren, S., *Organic Chemistry*, 2nd Ed., Oxford University Press India (2014).
2. Sykes, P., *A Guidebook to Mechanism in Organic Chemistry*, 6th Ed., Pearson Education India (2003)
3. Ghosh, S. K., *Advanced General Organic Chemistry, Part-I & Part-II*, 3rd Ed., New Central Book Agency (2010).
4. Bhal, B. S.; Bhal, A., *A Textbook of Organic Chemistry*, 22nd Ed., S. Chand and Company (2016).
5. Sengupta, S., *Basic Stereochemistry of Organic Molecules*, 2nd Ed., Oxford University Press India (2018).

Practical

1. Agarwal, O. P., *Advanced Practical Organic Chemistry*, Krishna Prakashan, Meerut (2014).
2. Ahluwalia, V. K.; Aggarwal, R., *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*, Universities Press (2000).
3. Furniss, B. S.; Hannafold, A. J.; Smith, P. W. G.; Tatchell, A. R., *Vogel's Textbook of Practical Organic Chemistry*, 5th Ed., Pearson Education India (2003).
4. Clarke, H. T., *A Handbook of Organic Analysis: Qualitative and Quantitative*, 4th Ed., CBS Publishers India (2007).

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SEMESTER III

CHE-CC-233
Physical Chemistry III

Credit: 6 (L 4 – T 0 – P 2)
Total Lectures: 120 (Theory – 60; Practical – 60)

Course Objectives
This course introduces the learners to phase, co-existence of phases, phase diagram as well as to the concept of photochemistry and various photophysical processes. It aims to expand students' understanding and knowledge in a few other physical chemistry topics that they are already familiar to by taking a deeper dig into these. Students will study the use of steady state approximation in deriving rate expressions for simple and complex reaction systems; features, advantages and drawbacks of homogeneous and heterogeneous catalytic processes and kinetics of enzyme catalysis in details.

Learning Outcomes
On completion of this course the students will be able to:

1. Have fair idea on phase equilibrium, phase rule and phase diagram of systems with one to three components.
2. Understand Nernst distribution law, its applications in extraction processes and limitations.
3. Derive rate expressions for both simple and complex reactions using steady state approximations and to understand temperature dependence on reaction rates.
4. Understand various adsorption processes, adsorption isotherms.
5. Have ideas on varied catalytic processes (both homogeneous and heterogeneous) including enzyme catalysis.
6. Acquire knowledge on various photo-physical processes, terminologies, laws of photochemistry, Jablonski diagram etc.
7. Construct phase diagram and to determine critical solution temperature for simple systems practically.
8. Verify the Freundlich and Langmuir isotherms for simple adsorption processes.

UNIT 1: Phase Equilibria
Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid liquid, liquid-vapour and solid-vapour equilibria, Phase diagram of one component systems (water and sulphur) and two component systems (silver-lead and KI-H_2O).

Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions. Three component systems, water-chloroform-acetic acid system, triangular plots.

Nernst distribution law and its limitations, thermodynamic derivation. Modification of distribution law to cases of association and dissociation of solute and complex formation. Application of the law in the process of extraction.

(15 Lectures)

UNIT 2: Chemical Kinetics
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.

Steady state approximation and kinetics of simple reactions (e.g., decomposition of ozone, reaction between NO and O_2, iodination of acetone, decomposition of gaseous N_2O_5).

Kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions, (iii) consecutive reactions and (iv) chain reactions and their differential rate equations.
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.

(15 Lectures)

UNIT 3: Surface Chemistry & Catalysis

Physical adsorption, chemisorption, adsorption isotherms, nature of adsorbed state.
Homogeneous and heterogeneous catalysis and their significant features; advantages and drawbacks, specificity and selectivity, mechanisms of catalysed reactions at solid surfaces.
Enzyme catalysis; points of difference with general heterogeneous catalysis, characteristics, effect of pH and temperature; kinetics of enzyme catalysed reactions (Michaelis-Menten equation). Acid-Base catalysis.

(15 Lectures)

UNIT 4: 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, Jablonski diagram, simple ideas of fluorescence, phosphorescence, and chemiluminescence.

(15 Lectures)

PRACTICAL

Physical Chemistry III

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1. Determination of critical solution temperature and composition of the phenol-water system.
2. To study the ternary system (acetic acid-water-chloroform) at room temperature and to obtain the binodal curve.
3. Phase equilibria: Construction of the phase diagram using cooling curves or ignition tube method:
   (a) simple eutectic and
   (b) congruently melting systems.
4. Distribution of acetic/ benzoic acid between water and cyclohexane.
5. Study the kinetics of the following reactions.
   (a) Initial rate method: To determine the rate constant of reaction between KI and $K_2S_2O_8$.
   (b) Integrated rate method:
      (i) Determination of rate constant of hydrolysis of methyl acetate catalysed by an acid. Also determine the energy of activation of the reaction.
      (ii) Determination of the order of hydrolysis of ethyl acetate by NaOH.
   (c) Determination of relative strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate.

6. Adsorption
   (a) Verify the Freundlich isotherm for adsorption of acetic acid/oxalic acid on activated charcoal.

Recommended Books

Theory

1. Atkins, P. W.; de Paula, J.; Keeler, J., *Physical Chemistry*, 11th Ed., Oxford University Press India (2018).
2. Bahl, A.; Bahl, B. S.; Tuli, G. D., *Essentials of Physical Chemistry*, S. Chand and Company (2014).
3. Negi, A. S.; Anand, S. C., *Physical Chemistry*, New Age International Publishers (2007).
4. Puri, B. R.; Sharma, L. R.; Pathania, M. S., *Principles of Physical Chemistry*, 47th Ed., Vishal Publishing (2017).
5. Silbey, R. J.; Alberty, R. A.; Bawendi, M. G., *Physical Chemistry*, 4th Ed., Wiley India (2006).
6. Rakshit, P. C., *Physical Chemistry*, Revised Ed. Sarat Book House (2014).
7. Kapoor, K. L., *A Textbook of Physical Chemistry: Dynamics of Chemical Reactions, Statistical Thermodynamics, Macromolecules and Irreversible Processes*, Vol. V, 4th Ed., McGraw Hill Education India (2020).

Practical

1. Viswanathan, B.; Raghavan, P. S., *Practical Physical Chemistry*, Viva Books India (2014).
2. Yadav, J. B., *Advanced Practical Physical Chemistry*, Krishna Prakashan, Meerut (2015).
3. Khosla, B. D.; Garg, V. C.; Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co., New Delhi (2011).

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SEMESTER IV

CHE-CC-241

Inorganic Chemistry III

Credit: 6 (L 4 – T 0 – P 2)
Total Lectures: 120 (Theory – 60; Practical – 60)

Course Objectives

The course introduces the students to coordination compounds which find manifold applications in diverse areas like qualitative and quantitative analysis, metallurgy, catalysis, paints and pigments as well as in life. It also includes topics in bioinorganic chemistry which plays vital role in living bodies. Students will also be familiarized to the d and f block elements and will acquire the knowledge on horizontal similarity in a period in addition to vertical similarity in a group.

Learning Outcomes

On completion of this course the students will be able to:

1. Have good understanding of chemical bonding in metal complexes, application of Valence Bond Theory to predict the structure and magnetic behaviour of complexes.
2. Know the terms Δ_o, Δ_t pairing energy, CFSE, high spin and low spin complexes etc. as well as their significances on physical & chemical properties like colour, magnetism, lattice enthalpy, hydration enthalpy etc.
3. Acquire knowledge on types and numbers of isomers possible in complexes with 4 and 6 coordination numbers.
4. Understand the important properties of transition metals such as variable oxidation states, colour, magnetic and catalytic properties; use of Latimer diagrams in identifying reducing, oxidizing and undergoing disproportionation nature of species.
5. Understand the role of various metals in human bodies, toxicity of metal ions and the reason thereof.
6. Have knowledge on preparation, properties and shapes of compounds of noble gases.
7. Estimate metal ions by gravimetric analyses.
8. Carry out laboratory preparation of metal complexes as well as chromatographic separation of metal ions.

UNIT 1: Coordination Chemistry

Werner's theory, valence bond theory (inner and outer orbital complexes), electroneutrality principle and back bonding. Crystal field theory, measurement of 10 D*q* (Δ_o), CFSE in weak and strong fields, pairing energies, factors affecting the magnitude of 10 D*q* (Δ_o, Δ_t). Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar geometry. Qualitative aspect of Ligand field and MO Theory.

IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with 4 and 6 coordination numbers. Chelate effect, polynuclear complexes, Labile and inert complexes.

(15 Lectures)

UNIT 2: Transition Elements

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 EMF (Latimer & Ebsworth diagrams). Difference between the first, second and third transition series.

Chemistry of Ti, V, Cr Mn, Fe and Co in various oxidation states (excluding their metallurgy)

(15 Lectures)

UNIT 3: Bioinorganic Chemistry

Metal ions present in biological systems, classification of elements according to their action in biological system. Geochemical effect on the distribution of metals. Na^+/K^+ pump, carbonic anhydrase and carboxypeptidase. Role of calcium in muscle contraction, blood-clotting. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, use of chelating agents in medicine.

Iron and its application in bio-systems, haemoglobin; storage and transfer of iron.

(15 Lectures)

UNIT 4: Chemistry of Lanthanoids, Actinoids and Noble Gases

Electronic configuration, oxidation states, colour, spectral and magnetic properties, lanthanide contraction, separation of lanthanides (ion-exchange method only).

Rationalization of inertness of noble gases, 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), shapes of noble gas compounds using VSEPR theory.

(15 Lectures)

PRACTICAL

Inorganic Chemistry III

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1. Gravimetric Analysis
   (a) Estimation of nickel (II) using dimethylglyoxime (DMG).
   (b) Estimation of copper as cuprous thiocyanate (CuSCN).
   (c) Estimation of iron as Fe_2O_3.
   (d) Estimation of calcium as calcium oxalate monohydrate.
   (e) Al(III) by precipitating with oxine and weighing as $Al(oxine)_3$.
2. Inorganic Preparations
   (a) Tetraamminecopper(II) sulphate ($[Cu(NH_3)_4]SO_4 \cdot H_2O$)
   (b) *cis*- and *trans*-Potassium dioxalatodiaquachromate(III) ($K[Cr(C_2O_4)_2 \cdot (H_2O)_2] \cdot 2H_2O$)
   (c) Tetraamminecarbonatocobalt(III) nitrate ($[Co(CO_3)(NH_3)_4]NO_3$)
   (d) Potassium trisoxalatoferrate(III) trihydrate ($K_3[Fe(C_2O_4)_3] \cdot 3H_2O$)
3. Paper chromatographic separation of following metal ions:
   (a) Ni(II) and Co(II)
   (b) Fe(III) and Al(III)

Recommended Books

Theory

1. Lee, J. D., *Concise Inorganic Chemistry*, 5th Ed., Wiley India (2008).
2. Housecroft, C. E.; Constable, E. C. *Chemistry-An Introduction to Organic, Inorganic and Physical Chemistry*, 4th Ed., Pearson Education (2010).
3. Atkins, P.; Overton, T.; Rouke, J.; Weller, M.; Armstrong, F.; Hagerman, M., *Shriver Atkins's Inorganic Chemistry*, 6th Ed., Oxford University Press India (2015).
4. Miessler, G.; Tarr, D. A., *Inorganic Chemistry*, 3rd Ed., Pearson Education India (2008).
5. Huheey, J. E.; Keiter, E. A.; Keiter, R. L.; Medhi, O. K., *Inorganic Chemistry: Principles of Structures and Reactivity*, 4th Ed., Pearson Education India (2006).

6. Cotton, F. A.; Wilkinson, G.; Gaus, P. L., *Basic Inorganic Chemistry*, 3rd Ed., Wiley India (2007).
7. Puri, B. R.; Sharma, L. R.; Kalia, K. C., *Principles of Inorganic Chemistry*, 33rd Ed., Vishal Publishing (2017).

Practical

1. Raj, G., *Advanced Practical Inorganic Chemistry*, Krishna Prakashan, Meerut (2013).
2. Mendham, J.; Denney, R. C., Barnes, J. D.; Thomas, M.; Sivasankar, B., *Vogel's Quantitative Chemical Analysis*, 6th Ed., Pearson Education India (2009).

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SEMESTER IV

CHE-CC-242

Organic Chemistry III

Credit: 6 (L 4 – T 0 – P 2)
Total Lectures: 120 (Theory – 60; Practical – 60)

Course Objectives

This course covers details of Nitrogen containing functional groups, introduction of polynuclear hydrocarbons, heterocyclic systems and natural compounds *viz.* alkaloids and terpenes. Various named reactions associated with varieties of functional groups as well as named synthetic processes for different heterocycles will be discussed. It will introduce students to natural product chemistry. This course will also provide scopes to discuss some of the key applications of each class of compounds in diverse fields.

Learning Outcomes

On completion of this course the students will be able to:

1. Acquire better understanding of chemistry of compounds having nitrogen containing functional groups, heterocyclics, polynuclear hydrocarbons, alkaloids and terpenes.
2. Learn various named reactions and synthetic processes and their mechanisms associated with these classes of compounds.
3. Understand aromaticity in heterocycles and its influence in stability and reactivity of molecules.
4. Have introductory idea about natural product chemistry which includes occurrence, structural elucidation and syntheses of a few selected alkaloid and terpene molecules.
5. Carry out laboratory detection N-containing functional groups such as nitro, amine and amide.
6. Have practical experience in functional group transformation of $-NO_2$ to $-NH_2$ group, functionalization $-NH_2$ group as well as in carrying out aromatic electrophilic substation reaction at nitro, amine and amide containing aromatic ring.
7. Have an exposure to the extraction processes of natural products (caffeine & piperine).

UNIT 1: Nitrogen Containing Functional Groups

Preparation and important reactions of nitro compounds, nitriles and isonitriles.

Amines: Effect of substituent and solvent on basicity; preparation and properties: Gabriel phthalimide synthesis, carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction; distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid.

Diazonium Salts: Preparation and their synthetic applications.

(15 Lectures)

UNIT 2: Heterocyclic Compounds

Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom (pyrrole, furan, thiophene and pyridine); synthesis, reactions and mechanism of substitution reactions of: furan, pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), thiophene, pyridine (Hantzsch synthesis), pyrimidine, structure elucidation of indole, Fischer indole synthesis and Madelung synthesis), structure elucidation of quinoline and isoquinoline, Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner-Miller synthesis, Bischler-Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch reaction.

Derivatives of furan: Furfural and furoic acid.

(15 Lectures)

UNIT 3: Polynuclear Hydrocarbons

Structures and reactions of naphthalene, phenanthrene and anthracene. Preparation and structure elucidation of important derivatives of naphthalene and anthracene.

(15 Lectures)

UNIT 4: Alkaloids & Terpenes

Natural occurrence of alkaloids, General structural features, Isolation and their physiological action. Hoffmann's exhaustive methylation, Emde's modification, structure elucidation and synthesis of nicotine. Medicinal importance of nicotine, hygrine, quinine, morphine, cocaine, and reserpine. Occurrence of terpenes, classification, isoprene rule; elucidation of structure and synthesis of citral and α-terpineol.

(15 Lectures)

PRACTICAL

Organic Chemistry III

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1. Functional group tests for nitro, amine and amide groups.
2. Organic preparations:
   (a) Acetylation of amines (aniline/ *o*-, *m*-, *p*-toluidine/ *o*-, *m*-, *p*-anisidine) by using green approach.
   (b) Benzolyation of amines (aniline/ *o*-, *m*-, *p*-toluidine/ *o*-, *m*-, *p*-anisidine).
   (c) Bromination of acetanilide by green approach
   (d) Nitration of acetanilide/nitrobenzene by conventional method.
   (e) Selective reduction of *m*-dinitrobenzene to *m*-nitroaniline.
3. Natural product extraction:
   (a) Isolation of caffeine from tea leaves
   (b) Isolation of piperine from black pepper

Recommended Books

Theory

1. Ghosh, S. K., *Advanced General Organic Chemistry, Part-I & Part-II*, 3rd Ed., New Central Book Agency (2010).
2. Bhal, B. S.; Bhal, A., *A Textbook of Organic Chemistry*, 22nd Ed., S. Chand and Company (2016).
3. Finar, I. L. *Organic Chemistry, Vol. 1*, 6th Ed., Pearson Education India (2002).
4. Finar, I. L. *Organic Chemistry* (*Volume 2: Stereochemistry and the Chemistry of Natural Products*), 5th Ed., Pearson Education India (2002).
5. Agarwal, O. P. *Organic Chemistry Natural Products, Vol. I,* Krishna Prakashan, Meerut (2015).

Practical

1. Agarwal, O. P., *Advanced Practical Organic Chemistry*, Krishna Prakashan, Meerut (2014).
2. Furniss, B. S.; Hannafold, A. J.; Smith, P. W. G.; Tatchell, A. R., *Vogel's Textbook of Practical Organic Chemistry*, 5th Ed., Pearson Education India (2003).
3. Ahluwalia, V. K.; Aggarwal, R., *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*, Universities Press (2000).

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SEMESTER IV

CHE-CC-243
Physical Chemistry IV

Credit: 6 (L 4 – T 0 – P 2)
Total Lectures: 120 (Theory – 60; Practical – 60)

Course Objectives
This course aims to make the students understand conductance, conductivity, chemical cells, Nernst equation, and applications of EMF measurements in determining various physical chemistry parameters. The course also encompasses introductory topics on electrical & magnetic properties of atoms and molecules.

Learning Outcomes
On completion of this course the students will be able to:

1. Understand conductance and conductivity, application of conductance measurement in determining various physical chemistry parameters.
2. Understand standard electrode potential of half cells and calculation of EMF of a cell using Nernst equation.
3. Apply EMF measurements in determining various parameters like free energy, enthalpy, entropy, equilibrium constants, etc.
4. Have basic knowledge on concentration cells with and without transference.
5. Learn the principle of potentiometric titration.
6. Understand basic concepts of dielectric constants and electrical properties of atoms and molecules.
7. Have elementary ideas on magnetic properties of atoms and molecules such as diamagnetism, paramagnetism, magnetic susceptibility, etc.
8. Have practical experiences on conductometric and potentiometric titrations.

UNIT 1: Conductance
Arrhenius theory of electrolytic dissociation. Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Kohlrausch law of independent migration of ions. Debye-Hückel-Onsager equation. Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants of salts.

(15 Lectures)

UNIT 2: Electrochemistry I
Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry.
Chemical cells, reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells.

(15 Lectures)

UNIT 3: Electrochemistry II
Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values using hydrogen, quinone-hydroquinone, glass and SbO/Sb_2O_3 electrodes. Concentration cells with and without

transference, liquid junction potential; determination of activity coefficients and transference numbers. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation).

(15 Lectures)

UNIT 4: Electrical & Magnetic Properties of Atoms and Molecules

Basic ideas of electrostatics, Electrostatics of dielectric media, Clausius-Mosotti equation, Lorenz-Laurentz equation, Dipole moment and molecular polarizabilities and their measurements. Diamagnetism, paramagnetism, magnetic susceptibility and its measurement, molecular interpretation.

(15 Lectures)

PRACTICAL

Physical Chemistry IV

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1. Conductometry
   (a) Determination of cell constant of a given conductivity cell.
   (b) Determination of equivalent conductance of a weak electrolyte at different concentration and the dissociation constant of the electrolyte.
   (c) Study the kinetics of saponification of ethyl acetate by NaOH at two temperatures by conductance measurements and hence determine the energy of activation of the reaction.
   (d) Perform the following conductometric titrations:
      (i) Strong acid vs. strong base
      (ii) Weak acid vs. strong base
      (iii) Mixture of strong acid and weak acid vs. strong base
      (iv) Strong acid vs. weak base
2. Perform the following potentiometric titrations:
   (a) Strong acid vs. strong base
   (b) Weak acid vs. strong base
   (c) Dibasic acid vs. strong base

Recommended Books

Theory

1. Atkins, P. W.; de Paula, J.; Keeler, J., *Physical Chemistry*, 11th Ed., Oxford University Press India (2018).
2. Bahl, A.; Bahl, B. S.; Tuli, G. D., *Essentials of Physical Chemistry*, S. Chand and Company (2014).
3. Negi, A. S.; Anand, S. C., *Physical Chemistry*, New Age International Publishers (2007).
4. Puri, B. R.; Sharma, L. R.; Pathania, M. S., *Principles of Physical Chemistry*, 47th Ed., Vishal Publishing (2017).
5. Silbey, R. J.; Alberty, R. A.; Bawendi, M. G., *Physical Chemistry*, 4th Ed., Wiley India (2006).
6. Rakshit, P. C., *Physical Chemistry*, Revised Ed. Sarat Book House (2014).
7. Kapoor, K. L., *A Textbook of Physical Chemistry: States of Matter and Ions in Solution*, Vol. I, 6th Ed., McGraw Hill Education India (2019).

8. Kapoor, K. L., *A Textbook of Physical Chemistry: Thermodynamics and Chemical Equilibrium*, Vol. II, 6th Ed., McGraw Hill Education India (2019).

Practical

1. Viswanathan, B.; Raghavan, P. S., *Practical Physical Chemistry*, Viva Books India (2014).
2. Yadav, J. B., *Advanced Practical Physical Chemistry*, Krishna Prakashan, Meerut (2015).
3. Khosla, B. D.; Garg, V. C.; Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co., New Delhi (2011).

05/7/2021
संयुक्त कुलसचिव (शैक्षणिक एवं सम्मेलन)
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Rajiv Gandhi University
Rono Hills, Doimukh (A.P.)

SEMESTER V

CHE-CC-351
Organic Chemistry IV

Credit: 6 (L 4 – T 0 – P 2)
Total Lectures: 120 (Theory – 60; Practical – 60)

Course Objectives
This course aims to introduce the learner to bioorganic & pharmaceutical chemistry. Students will learn about the fascinating chemistry of biomolecules such as amino acids, peptides, proteins, lipids and nucleic acids that work within biological systems. It will also help the learners to build the concept of metabolism by studying the chemistry and energetics of biological system. The course also includes topics on chemistry and mechanism of enzyme action.

Learning Outcomes
On completion of this course the students will be able to:

1. Have introductory idea to nucleic acid and lipids.
2. Understand the structure and synthesis of peptide chains and proteins.
3. Have fair idea on chemistry and energetics of food to energy conversion in biological systems.
4. Learn mechanism of enzyme action, coenzymes and cofactors and their roles in biological reactions.
5. Learn the structures, importance and synthetic procedures of a few pharmaceutical compounds.
6. Practically determine saponification value and iodine number of fat and percentage purity of amino acids.
7. Carry out laboratory synthesis of amino acid α-phenylglycine.

UNIT 1: Nucleic Acids & Lipids
Components of nucleic acids, Nucleosides and nucleotides.
Structure, synthesis and reactions of Adenine, Guanine, Cytosine, Uracil and Thymine; Structure of polynucleotides.
Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenation of fats and oils, Saponification value, acid value, iodine number. Rancidity.

(15 Lectures)

UNIT 2: Amino Acids, Peptides and Proteins
Amino acids, Peptides and their classification. Essential and non-essential amino acids.
α-Amino Acids: Synthesis, ionic properties and reactions. Zwitterions, pK_a values, isoelectric point and electrophoresis.
Study of peptides: determination of their primary structures, end group analysis, methods of peptide synthesis. Synthesis of peptides using N-protecting, C-protecting and C-activating groups; Solid-phase synthesis.
Introduction to proteins, primary and secondary structure.

(15 Lectures)

UNIT 3: Energy in Biosystems and Enzymes
Introduction to metabolism (catabolism, anabolism). Conversion of food to energy: Outline of catabolic pathways of carbohydrate- glycolysis, fermentation, Krebs cycle.
ATP: The universal currency of cellular energy, ATP hydrolysis and free energy change. Agents for transfer of electrons in biological redox systems: NAD^+, FAD.
Overview of catabolic pathways of fat and protein.
Interrelationship in the metabolic pathways of protein, fat and carbohydrate. Caloric value of

food, standard caloric content of food types.
Introduction, classification and characteristics of enzymes. Salient features of active site of enzymes.
Mechanism of enzyme action (taking trypsin as example), factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, specificity of enzyme action (including stereospecificity), enzyme inhibitors and their importance, phenomenon of inhibition (competitive, uncompetitive and non-competitive inhibition including allosteric inhibition).

(15 Lectures)

UNIT 4: Pharmaceutical Compounds: Structure and Importance

Classification, structure and therapeutic uses of antipyretics: Paracetamol (with synthesis), Analgesics: Ibuprofen (with synthesis), Antimalarials: Chloroquine (with synthesis). An elementary treatment of Antibiotics and detailed study of chloramphenicol, Medicinal values of curcumin (haldi), azadirachtin (neem), vitamin C and antacid (ranitidine).

(15 Lectures)

PRACTICAL
Organic Chemistry IV

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1. Estimation of glycine by Sorenson's formalin method.
2. Determination of percentage purity of amino acids.
3. Saponification value of an oil or a fat.
4. Determination of Iodine number of an oil/ fat.
5. Strecker amino acid synthesis of α-phenylglycine.
6. Benzoylation of glycine using Schotten-Baumann reaction to synthesize hippuric acid.
7. Estimation of proteins by Lowry's method.
8. Study of the action of salivary amylase on starch at optimum conditions.
9. Effect of temperature on the action of salivary amylase.
10. Isolation and characterization of DNA from onion/ cauliflower/peas.

Recommended Books

Theory

1. Berg, J. M.; Tymoczko, J. L.; Stryer, L., *Biochemistry*, 9th Ed., W. H. Freeman (2019).
2. Voet, D.; Voet, J. G., Pratt, C. W., *Biochemistry*, 4th Ed., John Wiley and Sons (2012).
3. Campbell, M. K.; Farrell, S. O.: McDougal, O. M., *Biochemistry*, 8th Ed., Cengage Learning (2013).
4. Nelson, D. L.; Cox, M. M.; Lehninger, A. L., *Principles of Biochemistry*, 4th Ed., W.H. Freeman and Co. (2009).
5. Murray, R. K.; Granner, D. K.; Mayes, P. A.; Rodwell, V. W., *Harper's Illustrated Biochemistry*. 28th Ed., Lange Medical Books/ McGraw-Hill (2009).

Practical

1. Ahluwalia, V. K.; Aggarwal, R., *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*, Universities Press (2000).

SEMESTER V

CHE-CC-352

Inorganic Chemistry IV

Credit: 6 (L 4 – T 0 – P 2)
Total Lectures: 120 (Theory – 60; Practical – 60)

Course Objectives

This course is designed to make students understand the theoretical principles behind qualitative analyses of inorganic salts as well as inorganic reaction mechanisms. The course also emphasizes on elaborate discussion of organometallic compounds of varied types. Learners will study chemistry of a few important industrial processes involving organometallic species as catalytic systems.

Learning Outcomes

On completion of this course the students will be able to:

1. Understand and explain the basic principles of qualitative inorganic analysis.
2. Have glimpses of inorganic reaction mechanisms, trans effect and substitution reactions on square planar and octahedral complexes.
3. Apply 18-electron rule to rationalize the stability of metal carbonyls and related species.
4. Understand important structural features of the metal alkyls and acquire the concept of multicentre boding in such compounds.
5. Get a general idea of catalysis and describe in detail the mechanism of Wilkinson's catalyst, Zeigler-Natta catalyst and synthetic gasoline manufactured by Fischer-Tropsch process.
6. Have an introduction to metallocene (ferrocene), its structure and understanding on its aromatic property.
7. Have practical knowledge on qualitative analyses of mixtures containing multiple cations and anions.
8. Carry out laboratory syntheses of complexes with multidentate ligands and to determine λ_{max} values for those.

UNIT 1: Theoretical Principles in Qualitative Analysis

Basic principles involved in analysis of cations and anions and solubility products, common ion effect. Principles involved in separation of cations into groups and choice of group reagents. Interfering anions (fluoride, borate, oxalate and phosphate) and need to remove them after Group II.

Introduction to methods of gravimetric analysis, purity of precipitate, co-precipitation, post precipitation, optimum conditions of precipitation, role of DMG, α-nitroso-β-naphthol and *p* -hydroxyquinoline in gravimetric analysis.

(15 Lectures)

UNIT 2: Reaction Kinetics and Mechanism

Introduction to inorganic reaction mechanisms. Substitution reactions in square planar complexes, Trans-effect, theories of trans effect, Mechanism of nucleophilic substitution in square planar complexes, Thermodynamic and Kinetic stability, Kinetics of octahedral substitution, Ligand field effects and reaction rates, Mechanism of substitution in octahedral complexes.

(15 Lectures)

UNIT 3: Organometallic Compounds I

Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands.

Metal carbonyls: 18 electron rule, electron count of mononuclear, polynuclear and substituted

metal carbonyls of 3*d* series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3*d* series. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT. π-acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding.
Study of the following industrial processes and their mechanism: Alkene hydrogenation (Wilkinson's catalyst), Hydroformylation (Co salts), Wacker process, Synthetic gasoline (Fischer-Tropsch reaction), Synthesis gas by metal carbonyl complexes.

(15 Lectures)

UNIT 4: Organometallic Compounds II

Preparation and structure of Zeise's Salt, evidences of synergic effect and comparison of synergic effect with that in carbonyls.
Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler-Natta Catalyst). Species present in ether solution of Grignard reagent and their structures, Schlenk equilibrium.
Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene.

(15 Lectures)

PRACTICAL

Inorganic Chemistry IV

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1. Qualitative semimicro analysis of mixtures containing 3 anions and 3 cations. Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested:
   CO_3^{2-}, NO^-, S^{2-}, SO_3^{2-}, $S_2O_3^{2-}$, CH_3COO^-, F^-, Cl^-, Br^-, I^-, NO_3^-, BO_3^{3-}, $C_2O_4^{2-}$, PO_4^{3-}, NH_4^+, K^+, Pb^{2+}, Cu^{2+}, Cd^{2+}, Bi^{3+}, Sn^{2+}, Sb^{3+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Mg^{2+}.
   (Mixtures should preferably contain one interfering anion, or insoluble component ($BaSO_4$, $SrSO_4$, $PbSO_4$, CaF_2 or Al_2O_3) or combination of anions e.g., CO_3^{2-} and SO_3^{2-}, NO_2^- and NO_3^-, Cl^- and Br^-, Cl^- and I^-, Br^- and I^-, NO_3^- and Br^-, NO_3^- and I^-. Spot tests should be done whenever possible.)
2. Preparation the following complexes and determine the λ_{max} value.
   (a) Acetylacetonato complexes of Cu^{2+}/Fe^{3+}.
   (b) Tris(thiourea)copper(II) sulphate
   (c) *cis*- and *trans*-bis(glycinato)copper(II) monohydrate.
3. Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentate ligands like acetylacetone, DMG, glycine) by substitution method.

Recommended Books

Theory

1. Svehla, G. *Vogel's Qualitative Inorganic Analysis*, 7th Edition, Prentice Hall (1996).
2. Housecroft, C. E; Sharpe, A. G., *Inorganic Chemistry*, 5th Ed., Pearson Education (2018).

3. Atkins, P.; Overton, T.; Rouke, J.; Weller, M.; Armstrong, F.; Hagerman, M., *Shriver Atkins's Inorganic Chemistry*, 6th Ed., Oxford University Press India (2015).
4. Miessler, G.; Tarr, D. A., *Inorganic Chemistry*, 3rd Ed., Pearson Education India (2008).
5. Huheey, J. E.; Keiter, E. A.; Keiter, R. L.; Medhi, O. K., *Inorganic Chemistry: Principles of Structures and Reactivity*, 4th Ed., Pearson Education India (2006).
6. Cotton, F. A.; Wilkinson, G.; Gaus, P. L., *Basic Inorganic Chemistry*, 3rd Ed., Wiley India (2007).
7. Elias, A.; Gupta, B. D., *Basic Organometallic Chemistry: Concepts, Syntheses and Applications*, 2nd Ed., Universities Press, Hyderabad (2013).
8. Spessard, G. O.; Miessler, G. L., *Organometallic Chemistry*, 3rd Ed., Oxford University Press, Oxford (2015).

Practical

1. Raj, G., *Advanced Practical Inorganic Chemistry*, Krishna Prakashan, Meerut, Meerut (2013).
2. Mendham, J.; Denney, R. C., Barnes, J. D.; Thomas, M.; Sivasankar, B., *Vogel's Quantitative Chemical Analysis*, 6th Ed., Pearson Education India (2009).

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Rono Hills, Doimukh (A.P.)

SEMESTER VI

CHE-CC-361
Physical Chemistry V

Credit: 6 (L 4 – T 0 – P 2)
Total Lectures: 120 (Theory – 60; Practical – 60)

Course Objectives
The course aims to make the students understand the limitations of classical mechanics, the need of quantum chemistry and to familiarize them with postulates of quantum chemistry and apply the same to derive equations for various systems. It elaborately discusses various topics like qualitative treatment of hydrogen atom and hydrogen-like ions, setting up Schrödinger equations for single and multi-electron systems etc. It also aims to introduce the learners to various spectroscopic techniques and to understand the underlying concepts and principles therein.

Learning Outcomes
On completion of this course the students will be able to:

1. Derive Schrödinger equations for particle in one, two and three-dimensional boxes and their significances.
2. Develop an understanding of quantum mechanical operators, quantization, probability distribution, uncertainty principle and application of quantization to spectroscopy.
3. Setting up Schrödinger equations for single and multielectron systems.
4. Understand variation theorem and need of approximation in deriving wave functions for different systems.
5. Have an exposure to quantum chemical approach of chemical bonding.
6. Learn basic principles of various spectroscopic techniques and their importance in structure elucidation of compounds.
7. Study and interpret UV-Visible spectrum.
8. Determine λ_{max} values of a few inorganic and organic compounds by recording UV-Visible spectrum of those.

UNIT 1: Quantum Chemistry I
Limitations of classical mechanics, postulates of quantum mechanics, quantum mechanical operators, quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wavefunctions, probability distribution functions, nodal properties, Schrödinger equation and its application to free particle and particle in a box, Extension to two- and three-dimensional boxes, separation of variables, degeneracy.
Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrödinger equation and discussion of solution and wavefunctions. Vibrational energy of diatomic molecules and zero-point energy.
Angular momentum: Commutation rules, quantization of square of total angular momentum and z-component.
Rigid rotator model of rotation of diatomic molecule. Schrödinger equation, transformation to spherical polar coordinates. Separation of variables. Spherical harmonics. Discussion of solution.

(15 Lectures)

UNIT 2: Quantum Chemistry II
Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, and quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus.
Setting up of Schrödinger equation for many-electron atoms (He, Li). Need for approximation

methods. Statement of variation theorem and application to simple systems (particle in a box, harmonic oscillator, hydrogen atom).
Chemical Bonding: Covalent bonding, valence bond and molecular orbital approaches, LCAO-MO treatment of H_2^+. Bonding and antibonding orbitals. Qualitative extension to H_2. Comparison of LCAO-MO and VB treatments of H_2 (only wavefunctions, detailed solution not required) and their limitations. Refinements of the two approaches (Configuration Interaction for MO, ionic terms in VB). Qualitative description of LCAO-MO treatment of homonuclear and heteronuclear diatomic molecules (HF, LiH). Localised and non-localised molecular orbitals treatment of triatomic (BeH_2, H_2O) molecules. Qualitative MO theory and its application to AH_2 type molecules.

(15 Lectures)

UNIT 3: Molecular Spectroscopy I

Interaction of electromagnetic radiation with molecules and various types of spectra; Born-Oppenheimer approximation.
Rotational Spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.
Vibrational Spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies. Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches.
Raman Spectroscopy: Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.

(15 Lectures)

UNIT 4: Molecular Spectroscopy II

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 and low-resolution spectra, different scales, spin-spin coupling and high-resolution spectra, interpretation of NMR(^{1}H) spectra of organic molecules.
Electron Spin Resonance (ESR) Spectroscopy: Its principle, hyperfine structure, ESR of simple radicals.

(15 Lectures)

PRACTICAL

Physical Chemistry V

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1. Verify Beer-Lambert's law and determine the concentration of $CuSO_4$/$KMnO_4$/$K_2Cr_2O_7$ in a solution of unknown concentration using a spectrophotometer.
2. Determine the composition of a binary mixture containing $KMnO_4$ and $K_2Cr_2O_7$ using a spectrophotometer.
3. Determine the dissociation constant of an indicator (phenolphthalein/methyl red) by spectrophotometric method.
4. Titration of HCl vs. NaOH spectrophotometrically using phenolphthalein indicator.

5. Study the absorbance spectra of $KMnO_4$ and $K_2Cr_2O_7$ (in 0.1 M H_2SO_4) and determine the λ_{max} values. Calculate the energies of the two transitions in different units (J molecule^{-1}, kJ mol^{-1}, cm^{-1}, eV).
6. Study the pH-dependence of the UV-Vis spectrum of $K_2Cr_2O_7$.

Recommended Books

Theory

1. Levine, I. N., *Quantum Chemistry*, 7th Ed., Pearson Education India (2016).
2. Prasad, R. K., *Quantum Chemistry*, 4th Ed., New Age International Publications (2010).
3. McQuarrie, D. A., *Quantum Chemistry*, Viva Books (2016).
4. Banwell C. N.; McCash, E. M., *Fundamentals of Molecular Spectroscopy*, 4th Ed., McGraw Hill Education (2017).
5. Pavia, D. L.; Lampman, G. M.; Kriz, G. S.; Vyvyan, J. A., *Introduction to Spectroscopy*, 5nd Ed., Cengage Learning India (2015).

Practical

1. Viswanathan, B.; Raghavan, P. S., *Practical Physical Chemistry*, Viva Books India (2014).
2. Yadav, J. B., *Advanced Practical Physical Chemistry*, Krishna Prakashan, Meerut (2015).
3. Khosla, B. D.; Garg, V. C.; Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2011).

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SEMESTER VI

CHE-CC-362

Organic Chemistry V

Credit: 6 (L 4 – T 0 – P 2)
Total Lectures: 120 (Theory – 60; Practical – 60)

Course Objectives

The course introduces the learner to UV-Visible & IR spectroscopy as tools for identifying and characterizing organic compounds. This course also deals with a few important classes of organic compounds finding applications in everyday life namely; carbohydrates, polymers & dyes. The chemistry of these compounds in general will be discussed in details.

Learning Outcomes

On completion of this course the students will be able to:

1. Know the occurrence, classification and biological importance of carbohydrates.
2. Understand the chemistry of ring size determination of glucose and fructose.
3. Learn various reactions of aldoses and ketoses as well as their interconversions.
4. Understand structural elucidation of a few selected disaccharides.
5. Have fair idea on polymers, various polymerization processes, alkene polymerization by Ziegler-Natta catalyst and natural and synthetic rubbers.
6. Gain insight into the basic principles of UV and IR spectroscopic techniques and their importance in structure determination of organic compounds.
7. Have practical experiences in caffeine extraction, estimation and analyses of sugars.

UNIT 1: Carbohydrates

Occurrence, classification and their biological importance.

Monosaccharides: Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, Haworth projections and conformational structures; interconversions of aldoses and ketoses; Killiani-Fischer synthesis and Ruff degradation;

Disaccharides – Structure elucidation of maltose, lactose and sucrose.

Polysaccharides – Elementary treatment of starch, cellulose and glycogen.

(15 Lectures)

UNIT 2: Polymers

Introduction and classification including di-block, tri-block and amphiphilic polymers; number average & weight average molecular weight, degree of polymerization, polydispersity index.

Polymerisation reactions, addition and condensation, mechanism of cationic, anionic and free radical addition polymerization; metallocene-based Ziegler-Natta polymerisation of alkenes; preparation and applications of plastics, thermosetting (phenol-formaldehyde, polyurethanes) and thermosoftening (PVC, polythene)

Fabrics, natural and synthetic (acrylic, polyamido, polyester); rubbers - natural and synthetic: Buna-S, chloroprene and neoprene; vulcanization; polymer additives; introduction to liquid crystal polymers; biodegradable and conducting polymers with examples.

(15 Lectures)

UNIT 3: Dyes

Classification, colour and constitution; mordant and vat dyes; chemistry of dyeing; 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 elucidation and synthesis of alizarin and indigotin; edible dyes with examples.

(15 Lectures)

UNIT 4: Organic Spectroscopy

General principles Introduction to absorption and emission spectroscopy.

UV Spectroscopy: Types of electronic transitions, λ_{max}, chromophores and auxochromes, bathochromic and hypsochromic shifts, intensity of absorption; application of Woodward rules for calculation of λ_{max} for the following systems: α,β unsaturated aldehydes, ketones, carboxylic acids and esters; conjugated dienes: alicyclic, homoannular and heteroannular; extended conjugated systems (aldehydes, ketones and dienes); distinction between *cis* and *trans*-isomers.

IR Spectroscopy: Fundamental and non-fundamental molecular vibrations; IR absorption positions of O, N and S containing functional groups; effect of H-bonding, conjugation, resonance and ring size on IR absorptions; Fingerprint region and its significance; application in functional group analysis.

(15 Lectures)

PRACTICAL

Organic Chemistry V

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1. Qualitative analysis of unknown organic compounds containing monofunctional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups (salicylic acid, cinnamic acid, nitrophenols, etc.).
2. Estimation of glucose/sucrose by Fehling solution method.
3. Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars.
4. Preparation of Nylon-66 & phenol-formaldehyde resin (Bakelite).
5. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.
6. Preparation of azo dyes: Methyl orange & methyl red.

Recommended Books

Theory

1. Morrison, R. T.; Boyd, R. N.; Bhattacharjee, S. K. *Organic Chemistry*, 7th Ed., Pearson Education India: New Delhi (2010).
2. Billmeyer, F. W. *Textbook of Polymer Science*, John Wiley & Sons, Inc.
3. Gowariker, V. R.; Viswanathan, N. V. & Sreedhar, J. *Polymer Science*, New Age International (P) Ltd. Pub.
4. Finar, I. L. *Organic Chemistry: Volume 1 & 2*, 6th Ed., Pearson Education (2002).
5. Graham Solomons, T.W. *Organic Chemistry*, John Wiley & Sons, Inc.
6. Singh, J.; Ali, S. M. & Singh, J. *Natural Product Chemistry*, Prajati Prakashan (2010).
7. Pavia, D. L.; Lampman, G. M.; Kriz, G. S.; Vyvyan, J. A., *Introduction to Spectroscopy*, 5nd Ed., Cengage Learning India (2015).

Practical

1. Vogel, A. I. *Quantitative Organic Analysis,* Pearson Education India (2012).
2. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)
3. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry,* 5th Ed., Pearson (2003)
4. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis,* University Press (2000).

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DISCIPLINE SPECIFIC ELECTIVE (DSE) COURSES

SEMESTER V

CHE-DE-351
Analytical Methods in Chemistry

Credit: 6 (L 4 – T 0 – P 2)
Total Lectures: 120 (Theory – 60; Practical – 60)

Course Objectives
This course is designed to complement the needs of students who wish to learn more about the qualitative/quantitative characterization and separation techniques. The content of this course aims to cover basic concepts, principles, and techniques of modern analytical chemistry that would empower students with an analytical aptitude and abilities to solve diverse analytical problems in an efficient way. The aim of the laboratory component is to give the students hands-on experience with modern instrumental techniques and chemical analysis.

Learning Outcomes
On successful completion of this course, students will be able to:

1. Learn various terminologies and concepts relevant to qualitative and quantitative aspects of analyses.
2. Develop an understanding of the importance of separation and analytical techniques in chemistry.
3. Learn various analytical techniques used for qualitative and quantitative characterization of samples.
4. Understand the chemical methods employed for elemental and compound analysis.
5. Do chromatographic separation of inorganic ions and organic compounds.
6. Experimentally determine pH values of substances like soil, aerated drinks, fruit juices, shampoos, soaps, etc.
7. Get introduced to spectrophotometry.

UNIT 1: Qualitative and Quantitative Aspects of Analysis
Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression. Normal law of distribution of indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals.
Estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers. Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method. Structural illustration through interpretation of data, Effect and importance of isotope substitution.

(15 Lectures)

UNIT 2: Spectroscopic Analysis
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.
Infrared Spectrometry: Basic principles of instrumentation (choice of source, monochromator & detector) for single and double beam instrument; sampling techniques.
Flame Atomic Absorption and Emission Spectrometry: Basic principles of instrumentation (choice of source, monochromator, detector, choice of flame and Burner designs). Techniques of atomization and sample introduction; sources of chemical interferences and their method of removal. Techniques for the quantitative estimation of trace level of metal ions from water samples.

(15 Lectures)

UNIT 3: Analytical and Separation Methods

Thermal Analysis: Theory of thermogravimetry (TG), basic principle of instrumentation. Techniques for quantitative estimation of Ca and Mg from their mixture.

Electroanalytical Method: Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Techniques used for the determination of p*K*a values.

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.

(15 Lectures)

UNIT 4: Separation Techniques

Chromatography: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods.

Aspects of Chromatographic Methods of Analysis: Ion-chromatography (IC), gas-liquid chromatography (GLC), gel permeation chromatography (GPC), thin-layer chromatography (TLC) and high-performance liquid chromatography (HPLC).

Stereoisomeric Separation and Analysis: Measurement of optical rotation, calculation of Enantiomeric excess (ee)/ diastereomeric excess (de) ratios and determination of enantiomeric composition using NMR, Chiral solvents and chiral shift reagents. Chiral chromatographic techniques using chiral columns (GC and HPLC). Role of computers in instrumental methods of analysis.

(15 Lectures)

PRACTICAL

Analytical Methods in Chemistry

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1. Chromatography:
   (a) Separation of a mixture of cations (Fe^{2+}, Mn^{2+} and Cd^{2+}) by paper chromatography and reporting the R_f values.
   (b) Separation of monosaccharides present in a given mixture (glucose & fructose) by paper chromatography and reporting the R_f values.
   (c) Separation of a mixture of dyes by TLC technique and identify them based on their R_f values.
   (d) Separation of a mixture of amino acids by TLC technique and identify them based on their R_f values.
   (e) Separation of a mixture of cations (Pb^{2+} and Cd^{2+}) by TLC technique and identify them based on their R_f values.
2. Solvent extractions:
   (a) Extraction of iodine from an aqueous solution
   (b) Separation of a mixture of Ni^{2+} & Fe^{2+} by complexation with DMG and extracting the Ni^{2+}-DMG complex in chloroform, and determine its concentration by spectrophotometry.
3. Determine the pH of the given aerated drinks fruit juices, shampoos and soaps.

4. Analysis of soil:
   (a) Determination of pH of soil.
   (b) total soluble salt.
   (c) estimation of calcium, magnesium, phosphate, nitrate.
5. Spectrophotometry:
   (a) Determination of p*K*a values of indicator using spectrophotometry.
   (b) Determine the composition of the Ferric-salicylate/ ferric-thiocyanate complex by Job's method.
   (c) Determination of λ_{max} of an aqueous solution of dye.

Recommended Books

Theory

1. Willard, H. H.; Merritt, L. L.; Dean, J. A.; Settle, F. A., *Instrumental Methods of Analysis*, 7th Ed, CBS Publishers, New Delhi (2007).
2. Christian, G. D., *Analytical Chemistry*, 7th Ed. Wiley India, New Delhi (2003).
3. Khopkar, S. M., *Basic Concepts of Analytical Chemistry*, New Age International, New Delhi (2008).
4. Skoog, D. A.; Holler F. J.; Crouch, S. R., *Principles of Instrumental Analysis*, 6th Ed, Cengage Learning India, New Delhi (2014).

Practical

1. Mendham, J.; Denney, R. C., Barnes, J. D.; Thomas, M.; Sivasankar, B., *Vogel's Quantitative Chemical Analysis*, 6th Ed., Pearson Education India (2009).

05/7/2021
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Rono Hills, Doimukh (A.P.)

SEMESTER V

CHE-DE-352
Industrial Chemicals and Environment

Credit: 6 (L 4 – T 0 – P 2)
Total Lectures: 120 (Theory – 60; Practical – 60)

Course Objectives
This course will introduce the students to various industrial gases and inorganic chemicals, their manufacturing processes, applications, storage and hazards in handling them. Major causes of air and water pollution and their effects on living organisms and the environment will also be taught. Students are also expected to learn about metallurgy, energy generation and pollution threat posed by various industries. This course also discusses about management of the different kinds of wastes and their safe disposal.

Learning Outcomes
After successful completion of the course, students will be able to:

1. Learn about the manufacture, applications and safe ways of storage and handling of gaseous and inorganic industrial chemicals.
2. Have ideas of industrial metallurgy and energy generation industries.
3. Learn the effect of environmental pollution caused by various gaseous, liquid and nuclear wastes on living bodies.
4. Have fair idea on industrial waste management, their safe disposal and the importance of environment friendly “green chemistry” in chemical industry.
5. Experimentally determine a few parameters (dissolved oxygen, dissolved CO_2, COD) used to measure the water quality.
6. Learn experimental determination of chlorine content in bleaching powder.
7. Estimate total alkalinity of water samples.

UNIT 1: Industrial Materials
Industrial Gases: Large-scale production, uses, storage and hazards in handling of the following gases: oxygen, nitrogen, argon, neon, helium, hydrogen, acetylene, carbon monoxide, chlorine, fluorine, sulphur dioxide and phosgene.
Inorganic Chemicals: Manufacture, application, analysis and hazards in handling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, caustic soda, common salt, borax, bleaching powder, sodium thiosulphate, hydrogen peroxide, potash alum, chrome alum, potassium dichromate and potassium permanganate.
Industrial Metallurgy: Preparation of metals (ferrous and nonferrous) and ultrapure metals for semiconductor technology.

(15 Lectures)

UNIT 2: Environment and its Pollution
Ecosystems. Biogeochemical cycles of carbon, nitrogen and sulphur.
Air Pollution: Major regions of atmosphere. Chemical and photochemical reactions in atmosphere. Air pollutants: types, sources, particle size and chemical nature; Photochemical smog, its constituents and photochemistry. Environmental effects of ozone, major sources of air pollution. Pollution by SO_2, CO_2, CO, NO_x, H_2S and other foul-smelling gases. Methods of estimation of CO, NO_x, SO_x and control procedures. Effects of air pollution on living organisms and vegetation. Greenhouse effect and Global warming, Ozone depletion by oxides of nitrogen, chlorofluorocarbons and Halogens, removal of sulphur from coal. Control of particulates.

(15 Lectures)

UNIT 3: Water Pollution and its Treatment

Hydrological cycle, water resources, aquatic ecosystems, sources and nature of water pollutants, techniques for measuring water pollution, impacts of water pollution on hydrological and ecosystems.

Water purification methods, effluent treatment plants (primary, secondary and tertiary treatment). Industrial effluents from the following industries and their treatment: electroplating, textile, tannery, dairy, petroleum and petrochemicals, agro, fertilizer, etc. Sludge disposal.

Industrial waste management, incineration of waste. Water treatment and purification (reverse osmosis, electro dialysis, ion exchange). Water quality parameters for wastewater, industrial water and domestic water.

(15 Lectures)

UNIT 4: Energy, Environment and Biocatalysis

Energy & Environment: Sources of energy - Coal, petrol and natural gas. Nuclear fusion / fission, solar energy, hydrogen, geothermal, tidal and hydel, etc.

Nuclear Pollution: Disposal of nuclear waste, nuclear disaster and its management.

Biocatalysis: Introduction to biocatalysis, importance in "Green Chemistry" and chemical Industry.

(15 Lectures)

PRACTICAL

Industrial Chemicals and Environment

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1. Determination of dissolved oxygen in water.
2. Determination of Chemical Oxygen Demand (COD)
3. Determination of Biological Oxygen Demand (BOD)
4. Determination of percentage of available chlorine in bleaching powder.
5. Measurement of chloride, sulphate and salinity of water samples by simple titration method ($AgNO_3$ and potassium chromate).
6. Estimation of total alkalinity of water samples (CO_3^{2-}, HCO_3^-) using double titration method.
7. Measurement of dissolved CO_2.
8. Preparation of borax/ boric acid.

Recommended Books

Theory

1. De, A. K., *Environmental Chemistry*, 9th Ed., New Age International, New Delhi (2018).
2. Khopkar, S. M., *Environmental Pollution Analysis*, 2nd Ed, New Age International, New Delhi (2020).
3. Manahan, S. E., *Environmental Chemistry*, 10th Ed, CRC Press (2017).
4. Benvenuto, M. A., *Industrial Inorganic Chemistry*, De Gruyter (2015).
5. Dara, S. S.; Umare, S. S., *A Textbook of Engineering Chemistry*, S. Chand & Company, New Delhi (2004).

Practical

1. Gopalan, R., *A Laboratory Manual for Environmental Chemistry*, Wiley India (2020).

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SEMESTER V

CHE-DE-353
Polymer Chemistry

Credit: 6 (L 4 – T 0 – P 2)
Total Lectures: 120 (Theory – 60; Practical – 60)

Course Objectives
This course is designed with the aim to introduce the theory and applications of polymer chemistry to the students. They will also learn kinetics of polymerization, study of a few industrially important polymers including conducting polymers which are promising classes of polymeric materials for next generation devices.

Learning Outcomes
After completion of this course the students will be able to:

1. Learn the basic concepts, definition and classifications of polymers.
2. Acquire fair knowledge in kinetics of polymerization.
3. Understand the concept of different types of molecular weight of polymers and the theories involved in their determination.
4. Understand various properties of polymers and their solutions.
5. Get introduced to preparation, structure and properties of some industrially important and technologically promising polymers.
6. Carry out laboratory syntheses of a few simple and common polymeric materials.
7. Determine the molecular weight of polymers in laboratory.

UNIT 1: Polymeric Materials and their Functionality
Different schemes of classification of polymers, polymer nomenclature, molecular forces and chemical bonding in polymers, texture of polymers.
Criteria for synthetic polymer formation, classification of polymerization processes, relationships between functionality, extent of reaction and degree of polymerization. bi-functional systems, poly-functional systems.

(15 Lectures)

UNIT 2: Kinetics of Polymerization
Mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations, mechanism and kinetics of copolymerization, polymerization techniques. Determination of molecular weight of polymers (M_n, M_w, etc.) by end group analysis, viscometry, light scattering and osmotic pressure methods. Molecular weight distribution and its significance. Polydispersity index.

(15 Lectures)

UNIT 3: Properties of Polymer and Polymer Solution
Determination of crystalline melting point and degree of crystallinity, morphology of crystalline polymers, Factors affecting crystalline melting point. Nature and structure of polymers, structure property relationships. Glass transition temperature (T_g) and determination of T_g, free volume theory, Williams-Landel-Ferry (WLF) equation, factors affecting glass transition temperature (T_g). Polymer Solution: Criteria for polymer solubility, solubility parameter, thermodynamics of polymer solutions, entropy, enthalpy, and free energy change of mixing of polymers solutions, Flory-Huggins theory, lower and upper critical solution temperatures. Properties of polymers (physical, thermal, flow & mechanical properties).

(15 Lectures)

UNIT 4: Synthesis of Polymers

Brief introduction to preparation, structure, properties and application of the following polymers: polyolefins, polystyrene and styrene copolymers, poly(vinyl chloride) and related polymers, poly(vinyl acetate) and related polymers, acrylic polymers, fluoro polymers, polyamides and related polymers. Phenol formaldehyde resins (bakelite, novalac), polyurethanes, silicone polymers, polydienes, polycarbonates. Conducting polymers [polyacetylene, polyaniline, poly(p-phenylene sulphide polypyrrole, polythiophene)].

(15 Lectures)

PRACTICAL

Polymer Chemistry

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1. Polymer Synthesis:
   (a) Oxidative polymerization of aniline using ammonium peroxydisulphate.
   (b) Free radical solution polymerization of (i) styrene and (ii) Acrylic acid (AA).
   (c) Preparation of nylon 66/6
   (d) Precipitation polymerization of acrylonitrile
   (e) Preparation of urea-formaldehyde resin
   (f) Preparations of novalac resin
2. Polymer Characterization
   (a) Determination of molecular weight of poly vinylproplylidine (PVP) in water by viscometry method.
   (b) Determination of the viscosity-average molecular weight of poly(vinyl alcohol) (PVOH) and the fraction of "head-to-head" monomer linkages in the polymer.
   (c) Determination of molecular weight of polyethylene glycol (PEG) (OH group) by end group analysis.
3. Polymer Analysis
   (a) Estimation of the amount of HCHO in the given solution by sodium sulphite method
4. Instrumental Techniques
   (a) IR studies of polymers

Recommended Books

Theory

1. Odian, G., *Principles of Polymerization*, 4th Ed., Wiley India Pvt. Ltd. (2004).
2. Billmeyer, F.W., *Textbook of Polymer Science*, 3rd Ed., Wiley Interscience (2007).
3. Ghosh, P., *Polymer Science & Technology*, 3rd Ed., Tata McGraw-Hill Education (2017).
4. Flory, P. J., *Principles of Polymer Chemistry*, Asian Books, New Delhi (2006)
5. Gowariker, V. R.; Viswanathan, N. V.; Sreedhar, J., *Polymer Science*, 3rd Ed., New Age International (2019).

Practical

1. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*, University Press (2000).

SEMESTER V

CHE-DE-354

Applications of Computers in Chemistry

Credit: 6 (L 4 – T 0 – P 2)
Total Lectures: 120 (Theory – 60; Practical – 60)

Course Objectives

This course intends to make learners familiar with basics of computer language, computer programming, and handling of experimental data, curve fitting, etc. to analyse experimental results. This basic knowledge will help the students to perform and interpret results of various chemistry practical.

Learning Outcomes

On completion of this course, students will be able to:

1. Review the basics of computer, bits, bytes, binary & ASCII formats, etc.
2. Have a glimpse on various numerical methods and mathematics pertaining to computers.
3. Get introduced to the elementary idea of molecular modelling.
4. Do simple numerical using computers.

UNIT 1: Basics of Computers

Basics: Constants, variables, bits, bytes, binary and ASCII formats, arithmetic expressions, hierarchy of operations, inbuilt functions. Elements of the BASIC language. BASIC keywords and commands. Logical and relative operators. Strings and graphics. Compiled versus interpreted languages. Debugging. Simple programs using these concepts.

(15 Lectures)

UNIT 2: Numerical Methods I

Matrix addition and multiplication. Statistical analysis.
Roots of equations: Numerical methods for roots of equations: Quadratic formula, iterative method, Newton-Raphson method, Binary bisection and Regula-Falsi.
Differential calculus: Numerical differentiation.

(15 Lectures)

UNIT 3: Numerical Methods II

Integral calculus: Numerical integration (Trapezoidal and Simpson's rule), probability distributions and mean values.
Simultaneous equations: Matrix manipulation: addition, multiplication. Gauss-Siedal method.
Interpolation, extrapolation and curve fitting: Handling of experimental data.

(15 Lectures)

UNIT 4: Molecular Modelling

Conceptual background of molecular modelling: Potential energy surfaces. Elementary ideas of molecular mechanics and practical MO methods.

(15 Lectures)

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PRACTICAL
Applications of Computers in Chemistry

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1. Computer programs based on numerical methods for roots of equations: (e.g., volume of van der Waals gas and comparison with ideal gas, pH of a weak acid).
2. Numerical differentiation (e.g., change in pressure for small change in volume of a van der Waals gas, potentiometric titrations).
3. Numerical integration (e.g., entropy/ enthalpy changes from heat capacity data), probability distributions (gas kinetic theory) and mean values.
4. Matrix operations. Application of Gauss-Siedel method in colourimetry.
5. Simple exercises using molecular visualization software.

Recommended Books

Theory

1. Jansen, F. A., Introduction to Computational Chemistry, 2nd Ed., Wiley (2007).
2. Balagurusamy, E., *Numerical Methods*, Tata McGraw Hill, New Delhi (1999).
3. Noggle, J. H., *Physical Chemistry on a Microcomputer*, Little Brown & Co. (1985).
4. Venit, S. M., *Programming in BASIC: Problem Solving with Structure and Style*. Jaico Publishing House: Delhi (1996).

Practical

1. Balagurusamy, E., *Numerical Methods*, Tata McGraw Hill, New Delhi (1999).
2. McQuarrie, D. A., *Mathematics for Physical Chemistry*, University Science Books (2008).
3. Mortimer, R., *Mathematics for Physical Chemistry*. 3rd Ed., Elsevier (2005).
4. Yates, P., *Chemical Calculations*, 2nd Ed. CRC Press (2007).
5. Venit, S. M. *Programming in BASIC: Problem solving with structure and style*, Jaico Publishing House, Delhi (1996).

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SEMESTER V

CHE-DE-355
Research Methodology for Chemists

Credit: 6 (L 4 – T 2 – P 0)
Total Lectures: 90

Course Objectives
This course is introduced to impart knowledge about the basic concepts of research and to provide a road map for conducting research. Students are expected to identify, explain and apply basic concepts of research; acquire information, recognize various issues related to research and to learn instrumental methods required for research in chemistry.

Learning Outcome
After completion of this course, students will be able to:

1. Know about various print and e-resources, search engines needed for carrying out literature survey in a topic.
2. Have some idea about writing literature survey report, review and scientific article.
3. Learn about plagiarism and how to avoid it.
4. Learn about safe storage of chemicals, disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals.
5. Acquire basic understanding of data analyses.

UNIT 1: Literature Survey
Print: Sources of information-Primary, secondary, tertiary sources; Journals: Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples.
Digital: Web resources, E-journals, Journal access, TOC alerts, Hot articles, Citation index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups and communities, Blogs, Preprint servers, Search engines, Scirus, Google Scholar, ChemIndustry, Wiki-Databases, ChemSpider, Science Direct, SciFinder, Scopus.

(15 Lectures)

UNIT 2: Resources and Writing Scientific Papers
Information Technology and Library Resources: The Internet and World Wide Web. Internet resources for chemistry. Finding and citing published information.
Methods of Scientific Research and Writing Scientific Papers: Reporting practical and project work. Writing literature surveys and reviews. Organizing a poster display. Giving an oral presentation.
Writing scientific papers – justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work. Writing ethics. Avoiding plagiarism.

(15 Lectures)

UNIT 3: Chemical Safety and Ethical Handling of Chemicals
Safe working procedure and protective environment, protective apparel, emergency procedure and first aid, laboratory ventilation. Safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric – safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for

laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.

(15 Lectures)

UNIT 4: Data Analysis

The Investigative Approach: Making and recording measurements. SI units and their use. Scientific method and design of experiments. Analysis and presentation of data: Descriptive statistics. Choosing and using statistical tests. Chemometrics. Analysis of variance (ANOVA), Correlation and regression, Curve fitting, fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, general polynomial fitting, linearizing transformations, exponential function fit, *r* and its abuse. Basic aspects of multiple linear regression analysis.

(15 Lectures)

TUTORIAL

Research Methodology for Chemists

As a part of the tutorial class students are expected to:

1. Acquaint themselves with chemistry related software and online scientific databases like Google Scholar, SciFinder, Scopus etc.
2. Undertake hands-on-sessions to identify research misconduct and predatory publications.
3. Acquaint the students with Indexing and citation databases, open access publications, research metrics (citations, h-index, Impact Factor, etc.) and plagiarism tools.

Recommended Books

1. Kothari, C. K.; Garg, G. *Research Methodology-Methods and Techniques*, 3rd Ed., New Age International, New Delhi (2014).
2. Kumar, R. *Research Methodology–A Step-By-Step Guide for Beginners*; 2nd Ed., Pearson Education: New Delhi (2005).
3. Montgomery, D. C. *Design & Analysis of Experiments*; 8th Ed., Wiley India: Noida (2013).
4. Dean, J. R.; Jones, A. M.; Holmes, D.; Reed, R.; Weyers, J.; Jones, A. *Practical Skills in Chemistry*, 2nd Ed. Prentice-Hall, Harlow (2011).
5. Hibbert, D. B.; Gooding, J. J., *Data Analysis for Chemistry*. Oxford University Press (2006).
6. Topping, J., *Errors of Observation and their Treatment*, 4th Ed., Chapman Hall, London (1984).
7. Harris, D. C., *Quantitative Chemical Analysis*, 6th Ed., Freeman (2007) Chapters 3-5.

05/7/2021

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SEMESTER VI

CHE-DE-361

Inorganic Materials of Industrial Importance

Credit: 6 (L 4 – T 0 – P 2)
Total Lectures: 120 (Theory – 60; Practical – 60)

Course Objectives

The objective of this course is to teach students the synthetic process, properties and the utility of the industrially important inorganic materials (such as silicates, ceramics, cements, fertilizers, paints, batteries, alloys and explosives). It will also provide students an opportunity to learn some of the industrial processes such as surface coating and catalysis in relevant to industry.
Experiments are aimed at helping learners acquire hands on experience in qualitative and quantitative analysis of the inorganic materials, which are basically manufactured in chemical industries.

Learning Outcome

After completion of the course, the students will be able to:

1. Establish the basic foundation of industrial inorganic chemistry which will be helpful for pursuing further studies in industrial chemistry in future.
2. Have a good understanding of silicate industries.
3. Have knowledge on chemistry of fertilizers and surface coating.
4. Acquire knowledge on alloys and different catalytic processes.
5. Understand the working principles different kinds of batteries.
6. Learn how to estimate the metal contents in different alloys practically.
7. Determine calcium and phosphorous content in calcium ammonium nitrate and superphosphate fertilizer respectively.

UNIT 1: Silicate Industries

Glass: Glassy state and its properties, classification (silicate and non-silicate glasses). Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armoured glass, safety glass, borosilicate glass, fluorosilicate, coloured glass, photosensitive glass.
Ceramics: Important clays and feldspar, ceramic, their types and manufacture. High technology ceramics and their applications, superconducting and semiconducting oxides, fullerenes carbon nanotubes and carbon fibre.
Cements: Classification of cement, ingredients and their role, Manufacture of cement and the setting process, quick setting cements.

(15 Lectures)

UNIT 2: Fertilizers and Surface Coatings

Fertilizers: Different types of fertilizers. Manufacture of the following fertilizers: Urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates, polyphosphate, superphosphate compound and mixed fertilizers, potassium chloride, potassium sulphate.
Surface Coatings: Objectives of coatings surfaces, preliminary treatment of surface, classification of surface coatings. Paints and pigments formulation, composition and related properties. Oil paint, vehicle paint, modified oils, pigments, toners and lakes pigments, fillers, thinners, enamels, emulsifying agents. Special paints (heat retardant, fire retardant, eco-friendly paint, plastic paint), dyes, wax polishing, water and oil paints, additives, metallic coatings (electrolytic and electroless), metal spraying and anodizing.

(15 Lectures)

UNIT 3: Alloys and Catalysis

Alloys: Classification of alloys, ferrous and non-ferrous alloys, specific properties of elements in alloys. Manufacture of Steel (removal of silicon decarbonisation, demanganisation, desulphurisation dephosphorisation) and surface treatment (argon treatment, heat treatment, nitriding, carburizing). Composition and properties of different types of steels.

Catalysis: General principles and properties of catalysts, homogenous catalysis (catalytic steps and examples) and heterogeneous catalysis (catalytic steps and examples) and their industrial applications. Deactivation or regeneration of catalysts.

Phase transfer catalysts, application of zeolites as catalysts.

(15 Lectures)

UNIT 4: Batteries and Chemical Explosives

Batteries: Primary and secondary batteries, battery components and their role, Characteristics of battery. Working of following batteries: Pb acid, Li-Battery, solid-state electrolyte battery. Fuel cells, solar cell and polymer cell.

Chemical explosives: Origin of explosive properties in organic compounds, preparation and explosive properties of lead azide, PETN, cyclonite (RDX). Introduction to rocket propellants.

(15 Lectures)

PRACTICAL

Inorganic Materials of Industrial Importance

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1. Determination of NH_4^+ and SO_4^{2-} ions in ammonium sulphate fertilizer and its free acidity.
2. Estimation of calcium in calcium ammonium nitrate (CAN) fertilizer.
3. Estimation of phosphoric acid in superphosphate fertilizer.
4. Determination of composition of dolomite by complexometric titration.
5. Analysis of (Cu, Ni); (Cu, Zn) in alloy or synthetic samples.
6. Analysis of Cement.
7. Preparation of pigment (zinc oxide).

Recommended Books

Theory

1. West, A. R., *Solid State Chemistry and Its Application*, 2nd Ed., Wiley India, New Delhi (2014).
2. Smart, L. E.; Moore, E. A., *Solid State Chemistry: An Introduction*, 4th Ed, CRC Press (2012).
3. Kingery, W. D.; Bowen, H. K.; Uhlmann, D. R., *Introduction to Ceramics*, 2nd Ed, Wiley Publishers, New Delhi (2012).
4. Kent, J. A., *Riegel's Handbook of Industrial Chemistry*, 9th Ed, CBS Publishers, New Delhi (1997).
5. Jain, P. C.; Jain, M., *Engineering Chemistry*, Dhanpat Rai & Sons, Delhi (2016).
6. Sharma, B. K.; Gaur, H., *Industrial Chemistry*, Goel Publishing House, Meerut (2016).

Practical

1. Svehla, G.; Sivasankar, B., *Vogel's Qualitative Inorganic Analysis*, 7th Ed, Pear Education India (2012).

SEMESTER VI

CHE-DE-362
Green Chemistry

Credit: 6 (L 4 – T 0 – P 2)
Total Lectures: 120 (Theory – 60; Practical – 60)

Course Objectives
This course is designed to introduce the students to green chemistry. They will be taught about the emerging discipline of green chemistry, its applications in sustainable development and some real world cases.

Learning Outcomes
After the completion of this course, the students will be able to:

1. Learn the need, goal and the basic principles of green chemistry.
2. Have knowledge on the concept of atom economy, calculation of atom economy and various green solvents.
3. Learn green syntheses of a few important organic and inorganic compounds.
4. Learn the use of alternative energy sources (microwave & ultrasonic irradiation) in chemical reactions.
5. Learn about a few tragic accidents originated from chemical industries.
6. Have practical experiences in a few green organic syntheses.
7. Learn preparation of biodiesels from vegetable/ waste cooking oil.

UNIT 1: Introduction and Principles of Green Chemistry
Introduction to green chemistry: What is green chemistry? Need for green chemistry. Goals of green chemistry. Limitations/ obstacles in the pursuit of the goals of green chemistry.
Principles of green chemistry and designing a chemical synthesis: Twelve principles of green chemistry with their explanations and examples. Designing a green synthesis using these principles. Prevention of waste/ byproducts; maximum incorporation of the materials used in the process into the final products, Atom economy, calculation of atom economy of the rearrangement, addition, substitution and elimination reactions. Prevention/ minimization of hazardous/ toxic products; designing safer chemicals and different basic approaches to do so.
Green solvents: Supercritical fluids, water as a solvent for organic reactions, ionic liquids, fluorous biphasic solvent, PEG, solventless processes, immobilized solvents and how to compare greenness of solvents.

(15 Lectures)

UNIT 2: Green Synthesis
Energy requirements for reactions–alternative sources of energy: use of microwaves and ultrasonic energy. Selection of starting materials; avoidance of unnecessary derivatization–careful use of blocking/protecting groups. Use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; catalysis and green chemistry, comparison of heterogeneous and homogeneous catalysis, biocatalysis, asymmetric catalysis and photocatalysis. Prevention of chemical accidents designing greener processes, inherent safer design, principle of ISD "What you don't have cannot harm you", greener alternative to Bhopal Gas Tragedy (safer route to carcarbaryl) and Flixiborough accident (safer route to cyclohexanol) subdivision of ISD, minimization, simplification, substitution, moderation and limitation. Strengthening/ development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes.

(15 Lectures)

UNIT 3: Real World Cases of Green Synthesis

Green Synthesis of the following compounds: adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis).

Microwave assisted reactions in water: Hofmann elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols; microwave assisted reactions in organic solvents Diels-Alder reaction and decarboxylation reaction.

Ultrasound assisted reactions: Sonochemical Simmons-Smith Reaction (Ultrasonic alternative to Iodine).

Surfactants for carbon dioxide, replacing smog producing and ozone depleting solvents with CO_2 for precision cleaning and dry cleaning of garments.

Designing of environmentally safe marine antifoulant.

(15 Lectures)

UNIT 4: Green Chemistry in Sustainable Development

Right fit pigment: synthetic azo-pigments to replace toxic organic and inorganic pigments.

An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn.

Healthier fats and oil by green chemistry: Enzymatic inter esterification for production of no trans-fats and oils.

Development of fully recyclable carpet: Cradle to cradle carpeting.

Future trends in green chemistry: Oxidation reagents and catalysts; biomimetic multifunctional reagents, combinatorial green chemistry, proliferation of solvent less reactions, co-crystal controlled solid state synthesis (C_2S_3), green chemistry in sustainable development.

(15 Lectures)

PRACTICAL

Green Chemistry

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1. Safer starting materials:
   (a) Preparation and characterization of silver nanoparticles using plant leaves.
2. Using renewable resources:
   (a) Preparation of biodiesel from vegetable/ waste cooking oil.
3. Green synthesis route:
   (a) Preparation of acetanilide
   (b) Synthesis of dibenzalpropanone
   (c) Preparation of 4-nitrosalicyclic acid
   (d) Preparation of 1, 1-bis-2-naphthol
4. Avoiding waste:
   (a) Use of molecular model kit to stimulate the reaction to investigate how the atom economy can illustrate Green Chemistry.
   (b) Preparation of propene by two methods can be studied
      (i) Triethylamine ion + OH^- $\rightarrow$ Propene + trimethylpropene + water.
      (ii) 1-propanol $\rightarrow$ propene + water.
5. Use of enzymes as catalysts:
   (a) Benzoin condensation using Thiamine Hydrochloride as a catalyst instead of cyanide.
6. Alternative sources of energy:
   (a) Photoreduction of benzophenone to benzopinacol in the presence of sunlight.

Recommended Books

Theory

1. Anastas, P. T.; Warner, J. C., *Green Chemistry: Theory and Practice*, Oxford University Press, Oxford (2005).
2. Ahluwalia, V. K.; Kidwai, M. R., *New Trends in Green Chemistry*, Springer India, New Delhi (2012).
3. Matlack, A., *Introduction to Green Chemistry*, 2nd Ed., CRC Press (2016).
4. Cann, M. C.; Connely, M. E., *Real-World cases in Green Chemistry*, American Chemical Society, Washington (2000).
5. Lancaster, M. *Green Chemistry: An Introductory Text*, 3rd Ed., RSC Publishing (2016).

Practical

1. Sharma, R. K.; Sidhwani, I. T.; Chaudhari, M. K., *Green Chemistry Experiment: A Monograph*, IK International Publishing House (2012).
2. Kirchoff, M.; Ryan, M.A., *Greener Approaches to Undergraduate Chemistry Experiment*. American Chemical Society, Washington DC (2002).
3. Ryan, M. A., *Introduction to Green Chemistry*, American Chemical Society, Washington DC (2002).

05/7/2021

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Rono Hills, Doimukh (A.P.)

SEMESTER VI

CHE-DE-363

Instrumental Methods of Chemical Analysis

Credit: 6 (L 4 – T 0 – P 2)
Total Lectures: 120 (Theory – 60; Practical – 60)

Course Objectives

Students will be introduced to the fundamental concepts/theory and application of different instrumental methods and analytical techniques used in chemistry. It also aims to develop interest among students to take chemistry research in their career ahead.

Learning Outcomes

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

1. Get introduced to a few instrumental methods and analytical techniques needed in chemistry research.
2. Have basic understanding of elemental analyses.
3. Have knowledge on instrumentation part of IR, UV-Vis spectrometry.
4. Learn the concepts behind various chromatographic techniques.
5. Understand the basic concept of mass spectrometry including different ionization processes of samples.
6. Learn separation of binary mixture (metal ions, dyes, organic compound) by chromatographic method in laboratory.

UNIT 1: Introduction and Elemental Analysis

Introduction to spectroscopic methods of analysis: Recap of the spectroscopic methods covered in detail in the core chemistry syllabus: Treatment of analytical data, including error analysis. Classification of analytical methods and the types of instrumental methods. Consideration of electromagnetic radiation. Elemental analysis: Atomic spectroscopy, atomic absorption, atomic emission, and atomic fluorescence.

Excitation and getting sample into gas phase (flames, electrical discharges, plasmas), wavelength separation and resolution (dependence on technique), detection of radiation (simultaneous/scanning, signal noise), interpretation (errors due to molecular and ionic species, matrix effects, other interferences).

(15 Lectures)

UNIT 2: Molecular Spectroscopy

Infrared spectroscopy: Interactions with molecules: absorption and scattering. Means of excitation (light sources), separation of spectrum (wavelength dispersion, time resolution), detection of the signal (heat, differential detection), interpretation of spectrum (qualitative, mixtures, resolution), advantages of Fourier Transform (FTIR). Samples and results expected. Applications: Issues of quality assurance and quality control, Special problems for portable instrumentation and rapid detection.

UV-Visible/ Near IR: Emission, absorption, fluorescence and photoaccoustic. Excitation sources (lasers, time resolution), wavelength dispersion (gratings, prisms, interference filters, laser, placement of sample relative to dispersion, resolution), Detection of signal (photocells, photomultipliers, diode arrays, sensitivity and S/N), Single and double beam instruments, interpretation (quantification, mixtures, absorption vs. fluorescence and the use of time, photoaccoustic, fluorescent tags).

(15 Lectures)

UNIT 3: Separation Techniques and Mass Spectroscopy

Chromatography: Gas chromatography, liquid chromatography, supercritical fluids. Importance of column technology (packing, capillaries), Separation based on increasing number of factors (volatility, solubility, interactions with stationary phase, size, and electrical field), Detection: simple vs. specific (gas and liquid), detection as a means of further analysis (use of tags and coupling to IR and MS), electrophoresis (plates and capillary) and use with DNA analysis.

Mass Spectrometry: Making the gaseous molecule into an ion (electron impact, chemical ionization), making liquids and solids into ions (electrospray, electrical discharge, laser desorption, fast atom bombardment), separation of ions on basis of mass to charge ratio, magnetic, time of flight, electric quadrupole. Resolution, time and multiple separations, detection and interpretation (how this is linked to excitation).

(15 Lectures)

UNIT 4: Spectroscopic and Analytical Methods

NMR Spectroscopy: Principle, instrumentation, factors affecting chemical shift, spin- coupling, and applications.

Electroanalytical Methods: potentiometry & voltammetry

Radiochemical Methods. X-ray analysis and electron spectroscopy (surface analysis)

(15 Lectures)

PRACTICAL

Instrumental Methods of Chemical Analysis

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1. Determination of the isoelectric pH of a protein.
2. Titration curve of an amino acid.
3. Determination of the void volume of a gel filtration column.
4. Determination of a mixture of cobalt and nickel (UV/vis spec.)
5. Study of electronic transitions in organic molecules (i.e., acetone in water)
6. IR absorption spectra (Study of aldehydes and ketones)
7. Determination of calcium, iron, and copper in food by atomic absorption.
8. Quantitative analysis of mixtures by gas chromatography (i.e., chloroform and carbon tetrachloride).
9. Separation of carbohydrates by HPLC.
10. Potentiometric titration of a chloride-iodide Mixture.
11. Separation of binary mixture (metal ions; dyes, organic compound) by chromatographic method.

Recommended Books

Theory

1. Willard, H. H.; Merritt, L. L.; Dean, J. A.; Settle, F. A., *Instrumental Methods of Analysis*, 7th Ed, CBS Publishers (2004).
2. Christian, G. D., *Analytical Chemistry*, 7th Ed. Wiley India Pvt. Ltd. (2003).
3. Khopkar, S. M., *Basic Concepts of Analytical Chemistry*. New Age International Publisher (2008).
4. Skoog, D. A.; Holler F. J.; Crouch, S. R., *Principles of Instrumental Analysis*, 6th Ed, Cengage Learning India (2016).

5. Banwell, C. N.; McCash, E. M., *Fundamentals of Molecular Spectroscopy*, 4th Ed. Tata McGraw-Hill, New Delhi (2006).
6. Nakamoto, K., *Infrared and Raman Spectra of Inorganic and Coordination compounds, Part A: Theory and Applications in Inorganic Chemistry*, 6th Ed., Wiley-Blackwell, New York (2009).
7. Nakamoto, K., *Infrared and Raman Spectra of Inorganic and Coordination compounds, Part B: Applications in Coordination, Organometallic, and Bioinorganic Chemistry*, 6th Ed., Wiley-Blackwell, New York (2009).

Practical

1. Skoog, D. A.; Holler F. J.; Crouch, S. R., *Principles of Instrumental Analysis*, 6th Ed., Cengage Learning India (2016).
2. Mendham, J.; Denney, R. C., Barnes, J. D.; Thomas, M.; Sivasankar, B., *Vogel's Quantitative Chemical Analysis*, 6th Ed., Pearson Education India (2009).

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SEMESTER VI

CHE-DE-364
Novel Inorganic Solids

Credit: 6 (L 4 – T 0 – P 2)
Total Lectures: 120 (Theory – 60; Practical – 60)

Course Objectives
This introductory course intends to make learners familiar with a wide variety of technologically important and emerging materials. It will prepare the learners for studying materials further at the master's level.

Learning Outcomes
After the completion of this course, students will be able to:

1. Learn syntheses of advanced material.
2. Understand the connections between the structure and properties of solids
3. Learn about the theory and methods that can be applied to the development of new materials with particular desired properties and thereby enabling them to opt for studying an interdisciplinary master's programme with an emphasis on the synthesis and applications of various materials.
4. Get introduced to various engineering materials used for mechanical construction.
5. Acquire knowledge in ceramics and refractory materials.
6. Have firsthand experience in synthesizing a few simple conducting polymers.
7. Carry out laboratory synthesis of nanoparticles.

UNIT 1: Inorganic Solids and Pigments
Synthesis and modification of inorganic solids: Conventional heat and beat methods, co-precipitation method, sol-gel methods, hydrothermal method, ion-exchange and intercalation methods.
Inorganic solids of technological importance: Solid electrolytes – cationic, anionic, and mixed. Inorganic pigments-coloured solids, white and black pigments.

(15 Lectures)

UNIT 2: Advanced Materials
Molecular material and fullerides, molecular materials & chemistry – one-dimensional metals, molecular magnets, inorganic liquid crystals.
Nanomaterials: Overview of nanostructures and nanomaterials; classification.
Preparation of gold and silver metallic nanoparticles, self-assembled nanostructures-control of nano architecture-one dimensional control. Carbon nanotubes and inorganic nanowires. Bio-inorganic nanomaterials, natural and artificial nanomaterials, bio-nanocomposites.

(15 Lectures)

UNIT 3: Engineering Materials
Introduction to engineering materials for mechanical construction: Composition, mechanical and fabricating characteristics and applications of various types of cast irons, plain carbon and alloy steels, copper, aluminium and their alloys like duralumin, brasses and bronzes cutting tool materials, super alloys thermoplastics, thermosets and composite materials.
Composite materials: Introduction, limitations of conventional engineering materials, role of matrix in composites, classification, matrix materials, reinforcements, metal-matrix composites.

(15 Lectures)

UNIT 4: Specialty Polymers and Ceramics

Conducting polymers-Introduction, conduction mechanism, polyacetylene, polyparaphenylene and polypyrrole, applications of conducting polymers. Polymer-matrix composites, fibre-reinforced composites, environmental effects on composites, applications of composites.
Ion-exchange resins and their applications.
Ceramic & Refractory: Introduction, classification, properties, raw materials, manufacturing and applications.

(15 Lectures)

PRACTICAL

Novel Inorganic Solids

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1. Synthesis of conducting polymers (polyaniline and polypyrrole).
2. Determination of cation exchange capacity.
3. Determination of total dissolved solids.
4. Synthesis of hydrogel by co-precipitation method.
5. Synthesis of silver and gold metal nanoparticles.

Recommended Books

Theory

1. Atkins, P.; Overton, T.; Rourke, J.; Weller, M.; Armstrong, F., *Shriver & Atkins Inorganic Chemistry*, 5th Ed, Oxford University Press (2011-2012)
2. Kakani, S. L.; Kakani, A., *Material Science*, 3rd Ed., New Age International Publishers, New Delhi (2016).
3. West, A. R., *Solid State Chemistry and its Application*, Wiley India, New Delhi (2007).
4. Smart, L. E.; Moore, E. A., *Solid State Chemistry: An Introduction*, 4th Ed., CRC Press, New Delhi (2017).
5. Poole, C. P. Jr.; Owens, F. J., *Introduction to Nanotechnology*, Wiley India, New Delhi (2007).

Practical

1. Ahluwalia, V. K.; Aggarwal, R., *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*, Universities Press (2000).

05/7/2021
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SEMESTER VI

CHE-DE-365
Dissertation

Credit: 6 (L 0 – T 1 – P 5)

Course Objectives
This course is introduced to provide an opportunity to the UG final semester students to have some experience in chemistry research by taking small projects. Apart from the experimental works, students will also learn to write scientific reports on the project work carried out.

Learning Outcomes
On completion of this course the students will be able to:

1. Understand the aims and objectives research and formulate a research work plan in a scientific manner.
2. Generate good research hypothesis, design appropriate experiments, collect and interpret the data to validate their experiments.
3. Process the data using computer software, analyze the data and critically examine the hypothesis and the conclusions.
4. Obtain and evaluate information from a variety of databases.
5. Communicate effectively in a variety of forms like research publications, patents, etc.

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ABILITY ENHANCEMENT COMPULSORY COURSES (AEC)

SEMESTER I

ENG-AE-111
Communicative English

Credit: 4 (L 3 – T 1 – P 0)
Total Lectures: 40

Course Objectives
The course aims to train learners to be more effective at communicating successfully in interviews, public speaking, letter writing, report writing, presentations, and inter-personal debates and conversations. The learner also imbibes the fundamentals of communication and the art of persuasive speaking and writing which depends crucially on clarity of thought and contextual understanding expressed through appropriate vocabulary.

Learning Outcomes
After completion of the course, learners will be able to master the art of persuasive speech and writing, the art of listening, reading, and analysing; spend the bulk of their time in class in practical exercises of reading and writing; develop critical thinking skills; and they will be introduced to established principles of academic reading and writing. Other specific outcomes:

1. Identify deviant use of English both in written and spoken forms
2. Recognize the errors of usage and correct them and write simple sentences without committing errors of spelling and grammar
3. Developing own competence in using the language
4. Understand and appreciate English spoken by others
5. Use language for speaking with confidence in an intelligible and acceptable manner
6. Understand the importance of reading for life and develop an interest for reading
7. Read independently unfamiliar texts with comprehension
8. Understand the importance of writing in academic life and career.

Module 01: Poetry
William Shakespeare – All the World is a stage; William Wordsworth – I wondered lonely as a Cloud; Ralph Waldo Emerson – The Mountain and the Squirrel; Emily Dickinson – Success is Counted Sweetest; Robert Frost - Stopping by Woods on a Snowy Evening; Rabindranath Tagore – Where the Mind is without Fear; A. K. Meherotra – Songs of the Ganga.

Module 02: Short Stories
R. K. Narayan – Lawly Road; Mulk Raj Anand – Barbar's Trade Union; Somerset Mangham – The Luncheon; Guy De. Maupassant – The Necklace; Anton Chekhov – The Lament; O' Henry – The Last Leaf; Manoj Das – The Submerged Valley.

Module 03: One-Act Plays and Short Fiction
(a) Norman Mckinnell - The Bishop's Candle Sticks; Anton Chekov – A Marriage Proposal; Eugene Lonesco – The Lesson; August Strandberg – Miss Jullie; Fritz Karinthy– Refund; (b) Harper Lee – To kill a Mocking Bird, (Or) R. K. Narayan – Vendor of Sweets.

Module 04: Fundamentals of Grammar
Parts of speech, Articles and Intensifiers, use of tense forms, Use of Infinitives, Conditionals, Adjectives and Adverbs, Prepositions, Making Affirmative, Negative and Interrogative, Making Question Tag.

Module 05: Composition Practice
(a) Comprehension, Précis Writing, Paragraph Writing (150 words), Letter writing – Personal,

Official, Demi-official, Business, Public speaking, Soft Skills, Interviews, Preparing Curriculum Vitae, Report (Meetings and Academic) writing; (b) Communication Practice – Introducing yourself, introducing people to others, Meeting People, Exchanging Greetings, Taking Leave, Answering the Telephone, Asking Someone for Some Purpose, Taking and Leaving Messages, Call for help in emergency.

Module	Weightage of Marks	Theory	Practical
Module 01	20 %	✓	
Module 02	20 %	✓	
Module 03	20 %	✓	
Module 04	20 %	✓	✓
Module 05	20 %	✓	✓

Practical Exercises

The students are required to:

1. know dictionary and its types, mapping a dictionary to locate words, and multiple uses of dictionary/ies
2. know the uses of Thesaurus/Lexicon/Activator/Encyclopaedia
3. know Note making/taking
4. know information transfer exercises
5. know the usage library resources properly
6. know citing references or developing a bibliography
7. Edit a piece of self and peer writing, writing and revising the drafts and preparing the final draft
8. Understand and appreciate the principle of politeness in relation to the speaker/ listener, debating, ex-tempore speeches, and other discourses.

Recommended Books

1. For reading the texts available sources of texts and help of the web source may be taken.
2. Crystal, D. *Rediscover Grammar with David Crystal*, Longman (1985).
3. Hewings, M. *Advanced English Grammar*, Cambridge University Press (1999).
4. Bakshi, R. N. *A Course in English Grammar*, Orient Longman (2000).
5. Krishnaswamy, N. *Modern English: A Book of Grammar, Usage and Composition*, MacMillan India.
6. Bailey, S. *Academic Writing: A Handbook for International Students*, 5th Ed., New York, Routledge (2015).
7. Grellet, F. *Developing Reading Skills: A Practical Guide to Reading Skills*, Cambridge University Press, New York (1981).
8. Hedge, T. *Writing*, Oxford University Press, London (2005).
9. Kumar, S.; Pushp Lata. *Communication Skills*, Oxford University Press, New Delhi (2015).
10. Lazar, G. *Literature and Language Teaching. Cambridge University Press*, Cambridge (2010).
11. Nuttall, C. *Teaching Reading Skills in a Foreign Language*, Macmillan, London (1996).
12. Raman, M.; Sharma, S. *Technical Communication: Principles and Practice*, Oxford University Press, New Delhi (2011).

Note: Students are advised to use latest edition of text books.

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SEMESTER I

HIN-AE-111

हिंदी शिक्षण (Hindi Sikshan)

क्रेडिट (Credit): 4 (L 3 – T 1 – P 0)

व्याख्यान घंटे (Total Lectures): 40

(यह पत्र प्रथम सत्र में हिन्दी कौशलाधारित पाठ्यक्रम चुनने वाले सभी विर्द्यार्थियों के लिये हैं । यह पत्र चार इकाइयों में विभक्त है। प्रत्येक इकाई के लिये व्याख्यानों की संख्या निर्धारित हैं)

उद्देश्यः सामाजिक, व्यवसायिक, कार्यालयी तथा शैक्षणिक परिप्रेक्ष्य में विद्यार्थियों के भाषा-कौशल में निखार लाना । विद्यार्थियों में प्रतिस्पर्धात्मक परीक्षाओं एवं साक्षात्कार हेतु आत्मविश्वास उत्पन्न करना । विद्यार्थियों में रचनात्मक कौशल विकसित करना । भाषा-ज्ञान के माध्यम से विद्यार्थियों को रोजगारोन्मुख शिक्षा प्रदान करना ।

इकाई 1

राष्ट्रीय एवं अन्तरराष्ट्रीय परिप्रेक्ष्य में हिन्दी का महत्त्व; मानक हिन्दी और बोलचाल की हिन्दी में अन्तर; स्वागत भाषण, भाषण, विषय प्रवर्तन तथा धन्यवाद ज्ञापन ।

व्याख्यान -10

इकाई 2

आलेख रचना: सम्पादक के नाम पत्र, सम्पादकीय लेखन, स्तम्भ लेखन, पत्र पत्रिकाओं के लिये आलेख-रचना; आकाशवाणी एवं दूरदर्शन हेतु वार्ता, साक्षात्कार एवं परिचर्चा तैयार करने की विधियाँ ।

व्याख्यान - 10

इकाई 3

व्यावहारिक लेखन: कार्यालयी पत्राचार; प्रेस विज्ञप्ति; सूचना ; ज्ञापन; कार्यसूची; कार्यवृत्त; प्रतिवेदन; सम्पादन; संक्षेपण; आत्मविवरण तथा ईमेल लेखन-, फेसबुक, ब्लॉग और ट्वीटर लेखन।

व्याख्यान - 10

इकाई 4

सृजनात्मक लेखन: कविता, कहानी, नाटक तथा एकांकी, निबंध, यात्रावृत का स्वरूप विवेचन ।

व्याख्यान - 10

उपलब्धियां: हिंदी शिक्षण से सम्बन्धित इस पत्र में विद्यार्थी हिन्दी भाषा के व्यावहारिक स्वरूप तथा प्रयोजनमूलक हिन्दी के क्षेत्र लेखन से जुड़ी बहुविध जानकारियों से परिचित हुए। हिन्दी भाषा की बढ़ती लोकप्रियता और बढ़ते अन्तरराष्ट्रीय महत्त्व के सन्दर्भ में हिन्दी भाषा आधारित कौशल विकास से विद्यार्थियों को अवगत कराया गया। विशेषकर आलेख रचना के अतिरिक्त व्यावहारिक एवं सर्जनात्मक लेखन से जुड़ी बारीकियों को जान सके।

कार्य सम्पादन पद्धति: व्याख्यान, विचारविमर्श-, समूहचर्चा-, सामग्री-समीक्षा और प्रस्तुतीकरण आदि ।

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Module	Weightage of Marks	Theory	Practical / Numerical
Module 01	25 %	✓	✓
Module 02	25 %	✓	✓
Module 03	25 %	✓	✓
Module 04	25 %	✓	

सहायक ग्रन्थ

1. अच्छी हिन्दी : रामचन्द्र वर्मा
2. व्यवहारिक हिन्दी व्याकरण और रचना : हरदेव बाहरी
3. हिन्दी भाषा : डॉ भोलानाथ तिवारी
4. रेडियों लेखन : मधुकर गंगाधर
5. टेलीविजनः सिद्धान्त और टैकनिक : मथुरादत्त शर्मा
6. प्रयोजनमूलक हिन्दी : डॉ दंगल झाल्टे
7. सरकारी कार्यालयों में हिन्दी का प्रयोग : गोपीनाथ श्रीवास्तव, राजकमल, दिल्ली
8. टेलीविजन लेखन : असगर वजाहत / प्रेमरंजन; राजकमल, दिल्ली
9. रेडियो नाटक की कला : डॉ सिद्धनाथ कुमार, राजकमल, दिल्ली
10. रेडियो वार्ता शिल्प : सिद्धनाथ कुमार, राजकमल, दिल्ली

05/7/2021

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SEMESTER II

ENV-AE-121
Environmental Studies

Credit: 4 (L 4 – T 0 – P 0)
Total Lectures: 60

Course Objectives

The objective of this paper is to provide basic concept of on Environment, Ecology, Natural Resources, Importance of biodiversity and need for their conservation along with various environmental issues and Govt. policies, and Environmental movements.

Learning Outcomes

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

1. Understand environment science and its importance
2. Understand the various types of pollution and hazards caused by them.
3. Understand ways to monitor environment and the various green technologies.
4. Know the various Acts enacted for the protection of the environment.

UNIT 1: Basic Concept of Environment

Environment: Definition, scope and importance; Multidisciplinary nature of environmental studies. Concept of sustainability and sustainable development.
Ecosystem – Concept, Structure and function; Energy flow in an ecosystem: food chains, food webs, ecological pyramid. Ecological succession. Ecosystem services.

(12 Lectures)

UNIT 2: Natural Resources

Land as a resource, Land use patterns, land degradation, soil erosion and desertification.
Forest Resources, Use and over-exploitation; Deforestation - causes and impacts on environment.
Water Resources, Use and over-exploitation of surface and ground water; floods, droughts, Case studies on conflicts over water (international & inter-state).
Energy Resources, Renewable and non-renewable energy sources, growing energy needs, use of alternate energy sources.
Traditional ecological knowledge.

(12 Lectures)

UNIT 3: Biodiversity and Conservation

Biodiversity: Definition, levels (genetic, species and ecosystem diversity) and values; Biogeographic zones of India; Biodiversity hot spots. Threats to biodiversity: Habitat loss, poaching of wildlife, man-wildlife conflicts, biological invasions.
Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity.
Ecosystem and biodiversity services: Ecological, economic, social, ethical, aesthetic and Informational value.

(12 Lectures)

UNIT 4: Environmental Issues and Policies

Environmental pollution: types, causes, effects and controls of Air, water, soil, noise, solid waste and nuclear pollution.

Global environmental issues: Climate change, global warming, ozone layer depletion, acid rain and impacts on human communities and agriculture.
Salient features of Environment Laws: Environment Protection Act; Air (Prevention & Control of Pollution) Act; Water (Prevention and control of Pollution) Act; Wildlife Protection Act; Forest Conservation Act. International agreements: Montreal and Kyoto protocols and Convention on Biological Diversity (CBD). Paris agreement, Nagoya Protocol.
Human Communities and the Environment: Human population growth: Impacts on environment, human health and welfare.
Disaster management: Floods, Earthquake, Cyclones and Landslides.
Environmental movements: Chipko, Silent valley, Bishnois of Rajasthan.

(24 Lectures)

Recommended Books

1. Bharucha, E. 2020. *Textbook for Environmental Science for Undergraduate Students*, University Grants Commission, New Delhi (2020).
2. Gupta, A.; Gupta, S. *Environmental Studies: Principles and Practices*, Sage Publications, New Delhi (2021).
3. Ahluwalia, V. K. *Environmental Studies*, 2nd Ed., TERI Press, New Delhi (2015).
4. Kaushik, A.; Kaushik, C. P. *Perspectives in Environmental Studies*, 6th Ed., New Age International, New Delhi (2018).
5. Krishnamurthy, K. V. *An Advanced Textbook on Biodiversity: Principles and Practice*, CBS Publisher and Distributors, New Delhi (2020).
6. Ambasht, R. S.; Ambasht, P. K. *Environment and Pollution an Ecological Approach*, 5th Ed., CBS Publisher and Distributors, New Delhi (2017).
7. Ambasht, R. S.; Ambasht, N. K. *A Textbook of Plant Ecology*, 15th Ed., CBS Publishers and Distributors, New Delhi (2017).
8. Singh, J. S.; Singh, S. P.; Gupta, S. R. *Ecology, Environmental Science and Conservation*, S. Chand Publishing, New Delhi (2014).

05/7/2021
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SKILL ENHANCEMENT COURSES (SEC)

CHE-SE-001

Water Treatment and Analysis I

Credit: 2 (L 1 – T 0 – P 1)
Total Lectures: 45 (Theory – 15; Practical – 30)

Course Objectives

The objective of the course is to develop a basic understanding of water qualities and ability to use principles of water chemistry for water treatment and water quality control in the natural systems.

Learning Outcomes

After the completion of the course, the students will be able to:

1. Learn about various parameters measured for determining the water quality such as alkalinity, hardness, total dissolved solids etc.
2. Apply knowledge of basic water chemistry to solve problems associated with water/ wastewater treatment and natural water quality
3. Understand various water treatment processes.
4. Acquire basic practical knowledge for water sample analyses.

UNIT 1: Water Quality Parameters and Purification

Characteristics of water, alkalinity. Hardness: unit of hardness, total solids, oxidation, transparency, silica content.

Purification of water for drinking purpose: potability of water, clarification, coagulation, contact and electro chemical coagulation, sterilization and disinfection of water, precipitation, aeration, ozonisation, chlorination.

(7 Lectures)

UNIT 2: Water Treatment

Water softening methods: Clark's process, lime soda process, modified lime soda process, permutit or zeolite process, ion exchange process, demineralization of water.

Determination of hardness of water: titration method, complexometric method using EDTA. Expressing hardness: equivalents of calcium carbonate. Problems to determine temporary and permanent hardness.

(8 Lectures)

PRACTICAL

Water Treatment and Analysis I

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1. Water analysis: Sampling techniques for water analysis.
2. Preliminary examination: alkalinity (bicarbonate, carbonate, hydroxide, acidity), chloride, nitrate, sulphate and calcium; temperature, pH and conductivity.
3. Analysis of solids present in water: suspended solids, dissolved solids, free Mg, Fe, Mn, Ag and Zn.

Recommended Books

Theory

1. Sharma, B. K., *Industrial Chemistry (including Chemical Engineering)*, Goel Publishing House, Meerut (2000).

2. Varashney, C. K., *Water Pollution and Management*, 2nd Ed, New Age International (2018).
3. Srivastava, A., *Waste Water Treatment and Water Management: Water Treatment and Management*, Notion Press (2018).

Practical

1. APHA, *Standard Methods for the Examination of Water, Sewage and Industrial Wastes*. 20th Ed., American Public Health Association: Washington, USA (1995).

05/7/2021
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CHE-SE-002
Water Treatment and Analysis II

Credit: 2 (L 1 – T 0 – P 1)
Total Lectures: 45 (Theory – 15; Practical – 30)

Course Objective

The objective of the course is to develop basic understanding of hard water, its treatment and analyses of water samples.

Learning Outcomes

After the completion of the course, the students will be able to:

1. Learn about hard water, its effect and industrial methods of water softening.
2. Learn about various desalination processes for water treatment.
3. Analyse water for chemical and biological substances present therein.
4. Determine hardness, dissolved oxygen and TDS of water practically.

UNIT 1: Hard Water and their Treatment

Hard water and industries, industrial water treatment, boiler feed water method of softening, prevention of plumbo solvency, scales in boilers and consequences, internal conditioning methods.

Desalination of brackish water: elecrodialysis, reverse osmosis, removal of Fe, Mn and silicic acid, effluent treatment of water from paper industry, petrochemical, fertilizer industry and power station.

(7 Lectures)

UNIT 2: Analysis of Water

Analysis of chemical substances affecting health: NH_3, nitrate, nitrite, cyanide, sulphate, sulphide, chloride, fluoride. Measurement of toxic chemical substances, analysis of chemical substances indicative of pollution, dissolved oxygen, bio chemical oxygen demand (BOD), chemical oxygen demand (COD).

Bacteriological examination of water: total count test, E-coli test, E-coli index, most probable number method, biological examination of water, physical examination of water. Radioactivity of water: methods of removing radioactivity from water.

(8 Lectures)

PRACTICAL

Water Treatment and Analysis II

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1. Determination of hardness of water.
2. Determination of dissolved oxygen in water.
3. Determination of chemical oxygen demand (COD).
4. Determination of Biological oxygen demand (BOD).

Recommended Books

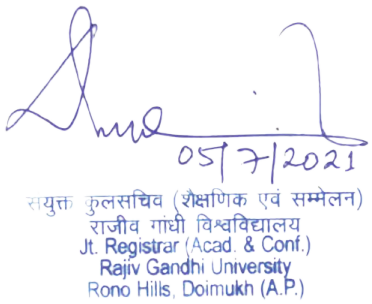
Theory

1. Sharma, B. K., *Industrial Chemistry (Including Chemical Engineering)*, Goel Publishing House, Meerut (2016).

2. Varashney, C. K. *Water Pollution and Management*, 2nd Ed, New Age International, New Delhi (2018).
3. Srivastava, A., *Waste Water Treatment and Water Management: Water Treatment and Management*, Notion Press (2018).

Practical

1. APHA, *Standard Methods for the Examination of Water, Sewage and Industrial Wastes*. 20th Ed., American Public Health Association: Washington, USA (1995).



CHE-SE-003
Soil Chemistry

Credit: 2 (L 1 – T 0 – P 1)
Total Lectures: 45 (Theory – 15; Practical – 30)

Course Objective
The objective of the course is to impart basic knowledge about physical properties of soil, soil chemistry, soil fertility and different nutrients in soil.

Learning Outcomes
After the completion of the course, the students will be able to:

1. Get introduced to various concepts of soil science like soil profile, soil texture, particle density of soil particles, porosity of soils, etc.
2. Learn about soil fertility, essential and beneficial elements present in soil as source of plant nutrients, reclamation of soil fertility, etc.
3. Learn about the effect of fertilizers and insecticides on soil fertility and the method of evaluation of soil fertility.
4. Determine bulk density and particle density, water holding capacity of soils practically.
5. Estimate N, S, P, K content of soils.

UNIT 1: Introduction to Soil Science
Components of soil, soil profile, soil physical properties, soil texture, textural classes, particle size analysis, soil structure, classification, soil aggregates, significance, bulk density and particle density of soils and porosity, their significance and manipulation, soil compaction, soil colour, elementary knowledge of soil classification of India, retention and potentials, soil moisture constants, soil colloids, properties, types and significance, adsorption of ions, ion exchange, CEC and AEC, factors influencing ion exchange and its significance.
Soil organic matter, composition, decomposability, Humus, fractionations of organic matter, carbon cycle, C: N ratio.

(8 Lectures)

UNIT 2: Soil Chemistry, Soil Fertility, Nutrient Management
Soil as a source of plant nutrients, essential and beneficial elements, criteria of essentiality, forms of nutrients in soil, acid, salt affected and calcareous soils, characteristics, nutrient availabilities, reclamation: mechanical, chemical and biological methods.
Fertilizers, insecticides, and their effect on soil water and air, soil fertility: different approaches for soil fertility evaluation.
Methods of soil testing: chemical methods, critical levels of different nutrients in soil.

(7 Lectures)

PRACTICAL
Soil Chemistry

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1. Soil Analysis
   (a) Collection and processing of soil for analysis.
   (b) Soil texture and mechanical analysis.
   (c) Determination of bulk density and particle density, water holding capacity.
   (d) Estimation of available N, P, K, S and Zn in soils, Determination of organic carbon, pH and EC (Soluble cations and anions in soil water extracts).

(e) Estimation of Calcium and Magnesium ions as Calcium carbonate by complexometric titration.

Recommended Books

Theory

1. Biswas, T. D.; Mukherjee, S. K., *Text Book of Soil Science*, 2nd Ed., McGraw Hill Publishing Company, New Delhi (2017).
2. Brady, N. C.; Well, R. R., *The Nature and Properties of Soil*, 14th Ed., Pearson Education India (2013).
3. Troch, F. R.; Thompson, L. M., *Soils and Soil Fertility*, Wiley India, New Delhi (2008).
4. Jaiswal, P. C., *Soil, Plant and Water Analysis*, 3rd Ed., Kalyani Publishers: New Delhi (2014).

Practical

1. Sarkar, D.; Haldar, A. *Physical and Chemical Methods in Soil Analysis*, 2nd Ed., New Age International (2010).
2. Saha, A. K. *Methods of Physical and Chemical Analysis of Soil*, Kalyani Publishers (2008).

05/7/2021
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CHE-SE-004
Fertilizers and Pesticides Chemistry

Credit: 2 (L 1 – T 0 – P 1)
Total Lectures: 45 (Theory – 15; Practical – 30)

Course Objectives
The objective of the course is to make the students aware of the importance and effect of fertilizer and manure on plant growth. In addition, it aims to Imparts knowledge on pesticides and their effect on environment.

Learning Outcomes
After the completion of the course, the students will be able to:

1. Learn the effect of N, P and K on plant growth.
2. Have fair knowledge on different types of fertilizers and manures and their method of production.
3. Acquire knowledge on different pesticides, insecticides & herbicide and their adverse effect on the environment.
4. Learn how N content of urea can be estimated practically.
5. Learn to synthesize simple organophosphates, carbamates etc.

UNIT 1: Fertilizers and Manures
Fertilizers: Effect of nitrogen, potassium and phosphorous on plant growth, classification of fertilizers, requisites of a good fertilizers, nitrogenous fertilizers, phosphatic fertilizers, super phosphate of lime, triple super phosphate, NPK fertilizers, ill effects of fertilizers, effect of mixed fertilizers on soil pH.
Commercial method of preparation of urea and triple superphosphate.
Manures: Organic manures, farmyard manure, handling and storage of: oil cakes, bone meal, meat meal, fish meal, blood meal and green manures.

(8 Lectures)

UNIT 2: Pesticides
General introduction to pesticides (natural and synthetic), benefits and adverse effects, changing concepts of pesticides, structure activity relationship, synthesis and technical manufacture and uses of representative pesticides in the following classes: Organochlorines (DDT, Gammexene); Organophosphates (Malathion, Parathion); Carbamates (Carbofuran and carbaryl); Quinones (Chloranil), Anilides (Alachlor and Butachlor).

(7 Lectures)

PRACTICAL
Fertilizer and Pesticide Chemistry

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1. Estimation of available N in Urea and commercial fertilizers.
2. Calculation acidity/alkalinity in a given sample of commercial pesticide as per BIS specification.
3. Preparation of simple organophosphates and diethyldithiocarbamate.

05/7/2021
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Recommended Books

Theory

1. Ghosh, J., *Fundamental Concept of Applied Chemistry*, S. Chand & Company, New Delhi (2010).
2. Cremlyn R., *Pesticide: Preparation and Modes of Action*, John Wiley & Sons, New York (1978).

Practical

1. Mendham, J.; Denney, R. C.; Barnes, J. D.; Thomas, M.; Sivasankar, B., *Vogel's Textbook of Quantitative Chemical Analysis*, 6th Ed., Pearson Education, New Delhi (2009).
2. Raj, G., *Advanced Practical Inorganic Chemistry*, Krishna Prakashan, Meerut, Meerut (2013).

05/7/2021

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CHE-SE-005

Chemistry of Foods, Cosmetics and Perfumes

Credit: 2 (L 1 – T 0 – P 1)
Total Lectures: 30

Course Objectives

This course is designed to provide students the basic idea on the analysis of food products and cosmetics by different analytical techniques.

Learning Outcomes

After the completion of the course, the students will be able to:

1. Learn about food processing, food preservations and adulteration and analyses of food products.
2. Have idea about constituents of deodorants and antiperspirants.
3. Determine constituents of talcum powder practically.

UNIT 1: Analysis of Food Products

Nutritional value of foods, idea about food processing and food preservations and adulteration. Identification of adulterants in some common food items. Analysis of preservatives and colouring matter. Food Standards: ISI, Agmark, FPO, MPO, PFA, FSSAI.

(7 Lectures)

UNIT 2: Analysis of Cosmetics and Perfumes

A general study including preparation and uses of the following: Hair dye, hair spray, shampoo, suntan lotions, face powder, lipsticks, talcum powder, nail enamel, creams (cold, vanishing and shaving creams), antiperspirants and artificial flavours. Essential oils and their importance in cosmetic industries with reference to Eugenol, Geraniol, sandalwood oil, eucalyptus, rose oil, 2-phenyl ethyl alcohol, Jasmone, Civetone, Muscone.

(8 Lectures)

PRACTICAL

Chemistry of Food, Cosmetics and Perfumes

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1. Analysis of Food Products:
   (a) Identification of adulterants in some common food items like coffee powder, asafoetida, chilli powder, turmeric powder, coriander powder and pulses, etc.
   (b) Determination of moisture content in food, ash content and determination of calcium, iron, vitamin C.
   (c) Quantitative estimation of sugars (glucose, lactose, starch).
   (d) Estimation of acid values, iodine value, saponification value of fats.
2. Analysis of cosmetics: Major and minor constituents and their function
   (e) Analysis of deodorants and antiperspirants, Al, Zn, boric acid, chloride, sulphate.
   (f) Determination of constituents of talcum powder: Magnesium oxide, Calcium oxide, Zinc oxide and Calcium carbonate by complexometric titration.

Recommended Books

Theory

1. Srilakshmi, B., *Food Science*, 7th Ed., New Age International, New Delhi (2018).
2. Subhalakshmi, G.; Udipi, S. A., *Food Processing and Preservation*, New Age International, New Delhi (2018).
3. Potter, N. N.; Hotchkiss, J. H., *Food Science*, 5th Ed., Springer (1999).
4. Sharma, B. K., *Industrial Chemistry (Including Chemical Engineering)*, Goel Publishing House, Meerut (2016).

Practical

1. Mendham, J.; Denney, R. C.; Barnes, J. D.; Thomas, M.; Sivasankar, B., *Vogel's Textbook of Quantitative Chemical Analysis*, 6th Ed., Pearson Education, New Delhi (2009).
2. Raj, G., *Advanced Practical Inorganic Chemistry*, Krishna Prakashan, Meerut, Meerut (2013).

05/7/2021

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CHE-SE-006
Pharmaceutical Chemistry

Credit: 2 (L 1 – T 0 – P 1)
Total Lectures: 30 (Theory – 15; Practical-30)

Course Objectives
The objective of this paper is to develop basic understanding of drugs discovery, drug design, development and their side effects. It also covers the synthesis of major classes of drug. The course is also designed to give an overview of fermentation process and production of certain dietary supplements.

Learning Outcomes
After the completion of the course, the students will be able to:

1. Gain an insight into the synthetic approaches of different classes of drugs.
2. Understand the fermentation processes and production of ethanol, citric acids, antibiotics and a few of vitamins.
3. Carry out laboratory syntheses of a few drug molecules.
4. Determine ascorbic acid content in vitamin C tablets by iodometric or coulometric titrations.

UNIT 1: Drugs and Pharmaceuticals
Drug discovery, design and development, basic retrosynthetic approach. Synthesis of the representative drugs of the following classes: analgesics agents, antipyretic agents, anti-inflammatory agents (aspirin, paracetamol, lbuprofen), antibiotics (chloramphenicol), antibacterial and antifungal agents (sulphonamides, sulphanethoxazol, sulphacetamide, trimethoprim), antiviral agents (acyclovir), central nervous system agents (phenobarbital, diazepam), cardiovascular (glyceryl trinitrate), antilaprosy (dapsone), HIV-AIDS related drugs (AZT- Zidovudine).

(8 Lectures)

UNIT 2: Fermentation
Aerobic and anaerobic fermentation. Production of (i) ethyl alcohol and citric acid, (ii) antibiotics; penicillin, cephalosporin, chloromycetin and streptomycin, (iii) lysine, glutamic acid, vitamin B2, vitamin B12 and vitamin C.

(7 Lectures)

PRACTICAL
Pharmaceutical Chemistry

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1. Preparation and analysis of aspirin, paracetamol, magnesium bisilicate (Antacid), sulphanilamide, sulphaguanidine etc.
2. Determination of ascorbic acid in vitamin C tablets by iodometric or coulometric titrations.
3. Synthesis of ibuprofen.

Recommended Books
Theory

1. Lemke, T. L.; Zito, S. W.; Roche, V. F.; Williams, D. A., Essentials of *Foye's Principles of Medicinal Chemistry*. Wolters Kluwer India, New Delhi (2016).

2. Patrick, G. L., *An Introduction to Medicinal Chemistry*. 5th Ed.; Oxford University Press, New Delhi (2013).
3. Singh, H.; Kapoor, V. K., *Medicinal and Pharmaceutical Chemistry*, Vallabh Prakashan, New Delhi (2012).

Practical

1. Ahluwalia, V. K.; Aggarwal, R., *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*, Universities Press (2000).

05/7/2021
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GENERIC ELECTIVE (GE) COURSES

(For other disciplines)

CHE-GE-001
General Chemistry I

Credit: 6 (L 4 – T 0 – P 2)
Total Lectures: 120 (Theory – 60; Practical – 60)

Course Objectives
This course mainly reviews the basic concepts of chemistry. It discusses structure of atoms, periodic properties of elements (especially the *s*- and *p*-block elements) elaborately. It also provides basic knowledge of chemical bonding (ionic and covalent), along with an introduction to weak chemical forces that determines many physical properties of molecules. The course will also introduce the students with the basic concepts of organic chemistry such as classification of organic compounds, electronic displacement, bond fission and types of organic reactions.

Learning Outcomes
On completion of this course the students will be able to:

1. Understand quantum mechanical model of atom, quantum numbers, electronic configuration, radial and angular distribution curves, shapes of *s*, *p*, and *d* orbitals and periodic trends of the properties of elements.
2. Understand the underlying concepts of covalent and ionic bonds and attractive forces as well as theories (VBT, MOT) explaining those.
3. Deduce the geometry of molecules using radius ratio rules & VSEPR theory.
4. Draw MO diagrams for simple homo- & hetero-nuclear diatomic molecules and to calculate the bond order.
5. Understand the importance of inter- and intramolecular weak chemical forces and their effect on common physical properties like melting points, boiling points and solubility.
6. Understand the role of various electronic factors in stability, polarity, acidity, basicity etc. of different organic species both neutral and charged in nature.
7. Estimate strength of unknown samples by titrimetric techniques (acid-base and redox) and to carry out purification of organic compounds using recrystallization technique.

UNIT 1: Atomic Structure
Bohr's theory and its limitations, atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and ψ^2. Quantum numbers and their significance, orbital angular momentum and quantum numbers m_l and m_s. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of *s*, *p*, *d* and *f* orbitals.
Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.

(15 Lectures)

UNIT 2: Periodicity of Elements
s, *p*, *d* and *f*-block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to *s*- and *p*-block.

(a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table.
(b) Atomic radii (van der Waals)
(c) Ionic and crystal radii.
(d) Covalent radii (octahedral and tetrahedral)
(e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy.

(f) Electron gain enthalpy, trends of electron gain enthalpy.
(g) Electronegativity, electronegativity scales (Pauling, Mülliken, Allred Rachow and Mulliken-Jaffé). Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity. Sanderson's electron density ratio.

(15 Lectures)

UNIT 3: Chemical Bonding

Covalent bond: Characteristics and properties, valence bond theory. Application of hybridisation (*sp*, sp^2, sp^3, dsp^3 and d^2sp^3) to explain structure of simple molecules. Bent's rule, resonance and resonance energy. Polarity in covalent molecules, dipole moment, percentage ionic character and electro negativity difference. Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding (σ and π bond approach) and bond lengths. Molecular orbital theory. Molecular orbital diagrams of diatomic (N_2, O_2, CO, NO, and their ions).
Ionic bond: General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy- their importance in the context of stability and solubility of ionic compounds. Lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.
Weak chemical forces: van der Waals forces, H-bonding and its types, effect of intra- and inter molecular hydrogen bonding on physical properties of molecules.

(15 Lectures)

UNIT 4: Basics of Organic Chemistry

Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties.
Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength.
Homolytic and Heterolytic fission with suitable examples. Electrophiles and Nucleophiles; Nucleophilicity and basicity; Types, shape and their relative stability of Carbocations, Carbanions, Free radicals and Carbenes. Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

(15 Lectures)

PRACTICAL

General Chemistry I

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1. Acid-Base Titrations
   (a) Determination of alkali content of antacid tablets using HCl.
   (b) Estimation of calcium content in chalk as calcium oxalate.
   (c) Estimation of carbonate and hydroxide present together in mixture.
2. Oxidation-Reduction Titrations
   (a) Estimation of oxalic acid by titrating it with $KMnO_4$.
   (b) Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.
   (c) Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator.
3. Purification of organic compounds by crystallization using Water /Alcohol /Alcohol-Water and determination of their melting points.

Recommended Books

Theory

1. Lee, J. D., *Concise Inorganic Chemistry*, 5th Ed., Wiley India (2008).
2. Housecroft, C. E; Sharpe, A. G., *Inorganic Chemistry*, 5th Ed., Pearson Education (2018).
3. Atkins, P.; Overton, T.; Rouke, J.; Weller, M.; Armstrong, F.; Hagerman, M., *Shriver Atkins' s Inorganic Chemistry*, 6th Ed., Oxford University Press India (2015).
4. Miessler, G.; Tarr, D. A., *Inorganic Chemistry*, 3rd Ed., Pearson Education India (2008).
5. Huheey, J. E.; Keiter, E. A.; Keiter, R. L.; Medhi, O. K., *Inorganic Chemistry: Principles of Structures and Reactivity*, 4th Ed., Pearson Education India (2006).
6. Cotton, F. A.; Wilkinson, G.; Gaus, P. L., *Basic Inorganic Chemistry*, 3rd Ed., Wiley India (2007).
7. Puri, B. R.; Sharma, L. R.; Kalia, K. C., *Principles of Inorganic Chemistry*, 33rd Ed., Vishal Publishing (2017).
8. Solomons, T. W. G.; Fryhle, C. B., *Organic Chemistry*, 11th Ed., Wiley India (2015).
9. Bruice, P. Y., *Organic Chemistry*, 7th Ed., Pearson Education India (2013).
10. Bahl, B. S.; Bahl, A., *A Textbook of Organic Chemistry*, 22nd Ed., S. Chand and Company (2016).

Practical

1. Raj, G., *Advanced Practical Inorganic Chemistry*, Krishna Prakashan, Meerut, Meerut (2013).
2. Mendham, J.; Denney, R. C., Barnes, J. D.; Thomas, M.; Sivasankar, B., *Vogel's Quantitative Chemical Analysis*, 6th Ed., Pearson Education India (2009).
3. Furniss, B. S.; Hannafold, A. J.; Smith, P. W. G.; Tatchell, A. R., *Vogel's Textbook of Practical Organic Chemistry*, 5th Ed., Pearson Education India (2003).
4. Clarke, H. T., *A Handbook of Organic Analysis: Qualitative and Quantitative*, 4th Ed., CBS Publishers India (2007).

05/7/2021

संयुक्त कुलसचिव (शैक्षणिक एवं सम्मेलन)
राजीव गांधी विश्वविद्यालय
Jt. Registrar (Acad. & Conf.)
Rajiv Gandhi University
Rono Hills, Doimukh (A.P.)

CHE-GE-002

General Chemistry II

Credit: 6 (L 4 – T 0 – P 2)
Total Lectures: 120 (Theory – 60; Practical – 60)

Course Objectives

This course is designed to make students understand a few more basic chemistry topics that will help them to understand their honours course better. Students will learn about various theories used to explain acid & base chemistry including the Pearson acid-base concept. It also encompasses concepts on dissociation of strong and weak electrolytes, hydrolysis of salts, solubility and solubility product of sparingly soluble salts, pH, buffers and various applications of ionization. Further it will revisit the fundamental concepts of organic chemistry of aliphatic and aromatic hydrocarbons in details.

Learning Outcomes

On completion of this course the students will be able to:

1. Understand various theories of acids and bases.
2. Have idea on Pearson's HSAB principle and its applications.
3. Derive relationships between *Kp*, *Kc* and *Kx* for reactions involving ideal gases.
4. Explain the concept of ionization of electrolytes with emphasis on weak acids and bases and hydrolysis of salt.
5. Have clear idea on aromaticity and its influence in stabilizing ring compounds and ions.
6. Have idea on syntheses, properties and reactions of various classes of aliphatic and aromatic hydrocarbons.
7. Have practical knowledge of detection of elements present in an organic compound.
8. Prepare buffer solutions of varied pH.

UNIT 1: Acid-Base Chemistry

Arrhenius, Brönsted-Lowry, and Lewis concepts of acids and bases, Proton transfer equilibria in water, solvent levelling, Classification of acids and bases as hard and soft. Pearson's HSAB concept, acid-base strength and hardness and softness. Theoretical basis of hardness and softness, electronegativity and hardness and softness. Applications of acid base chemistry in qualitative analysis and catalysis, superacids and superbases.

(15 Lectures)

UNIT 2: Chemical & Ionic Equilibrium

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between ΔG and ΔG°, Le Chatelier's principle. Relationships between K_p, K_c and K_x for reactions involving ideal gases.

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts- applications of the principle of solubility product.

(15 Lectures)

UNIT 3: Chemistry of Aliphatic Hydrocarbons

Alkanes: (Up to five carbons) Preparation: Catalytic hydrogenation, Würtz Reaction, Würtz-Fittig Reactions, Kolbe's synthesis, from Grignard reagent. Reactions: Free radical substitutions: Halogenation.

Alkenes: (Up to five carbons) Preparation, Elimination reactions, Dehydration of alcohols and dehydrohalogenation of alkyl halides (Saytzeff's rule), cis-alkenes (partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions of alkenes: cis-addition (alk.

$KMnO_4$) and trans-addition (bromine), Addition of HX (Markownikoff's and anti Markownikoff's addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration-oxidation.
Alkynes: (Upto five carbons) Preparation: Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides. Reactions: formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alkaline $KMnO_4$.

(15 Lectures)

UNIT 4: Aromatic Hydrocarbons, Alkyl and Aryl Halides

Benzene: Preparation from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid. Reactions of benzene: Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (upto four carbons on benzene). Side chain oxidation of alkyl benzenes (upto four carbons on benzene).
Alkyl Halides (Upto five Carbons): *Preparation:* from alkenes *and* alcohols. Reactions: Nucleophilic Substitution (S_N1, S_N2 and S_Ni) reactions. Hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis: Elimination vs substitution.
Aryl Halides: Preparation of Chloro, bromo and iodo-benzene from phenol, Sandmeyer & Gattermann reactions. Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent in Chlorobenzene. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$).

(15 Lectures)

PRACTICAL

General Chemistry II

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1. Distribution of acetic/ benzoic acid between water and cyclohexane.
2. pH-metry
   (a) Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
   (b) Preparation of buffer solutions of different pH (i) Sodium acetate-acetic acid (ii) Ammonium chloride-ammonium hydroxide
3. Detection of elements (nitrogen, sulphur and halogens) in unknown organic compounds.

Recommended Books

Theory

1. Atkins, P.; Overton, T.; Rouke, J.; Weller, M.; Armstrong, F.; Hagerman, M., *Shriver Atkins's Inorganic Chemistry*, 6th Ed., Oxford University Press India (2015).
2. Atkins, P. W.; de Paula, J.; Keeler, J., *Physical Chemistry*, 11th Ed., Oxford University Press India (2018).
3. Bahl, A.; Bahl, B. S.; Tuli, G. D., *Essentials of Physical Chemistry*, S. Chand and Company (2010).
4. Negi, A. S.; Anand, S. C., *Physical Chemistry*, New Age International Publishers (2007).
5. Puri, B. R.; Sharma, L. R.; Pathania, M. S., *Principles of Physical Chemistry*, 47th Ed., Vishal Publishing (2017).

6. Solomons, T. W. G.; Fryhle, C. B., *Organic Chemistry*, 11th Ed., Wiley India (2015).
7. Bruice, P. Y., *Organic Chemistry*, 7th Ed., Pearson Education India (2013).
8. Bahl, B. S.; Bahl, A., *A Textbook of Organic Chemistry*, 22nd Ed., S. Chand and Company (2016).

Practical

1. Viswanathan, B.; Raghavan, P. S., *Practical Physical Chemistry*, Viva Books India (2014).
2. Yadav, J. B., *Advanced Practical Physical Chemistry*, Krishna Prakashan, Meerut (2015).
3. Agarwal, O. P., *Advanced Practical Organic Chemistry*, Krishna Prakashan, Meerut (2014).
4. Ahluwalia, V. K.; Aggarwal, R., *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*, Universities Press (2000).

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Jt. Registrar (Acad. & Conf.)
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Rono Hills, Doimukh (A.P.)

CHE-GE-003

General Chemistry III

Credit: 6 (L 4 – T 0 – P 2)
Total Lectures: 120 (Theory – 60; Practical – 60)

Course Objectives

The course reviews the general properties of the *s*- and *p*-block elements. Students will learn about the phase, co-existence of phases, phase diagram and distribution law. The course will enable the students to understand conductance, conductivity, chemical cells, Nernst equation, and applications of EMF measurements in determining various physical chemistry parameters. They will also learn chemistry of organic molecules bearing a few common functional groups, which include alcohols, phenols aldehydes and ketones.

Learning Outcomes

On completion of this course the students will be able to:

1. Learn about structure, bonding, preparation, properties and uses of compounds of *s*- and *p*-block Elements.
2. Understand phase equilibrium, phase rule, phase diagram clearly.
3. Understand Nernst distribution law, its applications in extraction processes and limitations.
4. Understand conductance and conductivity, application of conductance measurement in determining various physical chemistry parameters.
5. Understand standard electrode potential of half cells and calculation of EMF of a cell using Nernst equation.
6. Have knowledge on concentration cell.
7. Learn about the property, reactivity and synthetic importance of *O*-containing functional groups like alcohols, phenols, carbonyl group.
8. Learn detection of *O*-containing functional groups in organic compounds.

UNIT 1: Compounds of *s*- and *p*-block Elements

Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses.

(a) Boron: Boric acid and borates, boron nitrides, borohydrides (diborane).
(b) Carbon: Types of carbide, CaC_2, SiC, Al_4C_3- preparation, properties and uses.
(c) Silicon: Silane, silicon halides, silicones and siloxanes.
(d) Nitrogen & Phosphorus: ammonia-manufacture (Haber's process), Oxides and oxoacids of nitrogen and phosphorus.
(e) Sulphur: Sulphuric acid and its properties as dehydrating agent, oxidizing property and action on metals and non-metals. Peroxo acids of sulphur.
(f) Halogen: interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens.

(15 Lectures)

UNIT 2: Phase Equilibria

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapour and solid-vapour equilibria, Phase diagram of one component systems (water and sulphur) and two component systems (silver-lead and KI-H_2O).

Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions. Three component systems, water-chloroform-acetic acid system, triangular plots.

Nernst distribution law and its limitations, thermodynamic derivation. Modification of distribution law to cases of association and dissociation of solute and complex formation. Application of the law in the process of extraction.

(15 Lectures)

UNIT 3: Electrochemistry & Conductance

Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG, ΔH and ΔS from EMF data.

Calculation of equilibrium constant from EMF data. Concentration cells with transference and without transference. Liquid junction potential and salt bridge. pH determination using hydrogen electrode and quinhydrone electrode. Potentiometric titrations -qualitative treatment (acid-base and oxidation-reduction only).

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions. Transference number and its experimental determination using Hittorf and Moving boundary methods. Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid base).

(15 Lectures)

UNIT 4: Alcohols, Phenols, Ethers and Carbonyl Compounds

Alcohols: Properties and relative reactivity of 1°, 2°, 3° alcohols, general methods of preparation of monohydric alcohols. Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement.

Phenols: Preparation from cumene hydroperoxide and from diazonium salts. Reactions of phenol: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Houben-Hoesch Condensation, Schotten-Baumann Reaction.

Ethers: (aliphatic and aromatic) Cleavage of ethers with HI.

Aldehydes and Ketones (aliphatic and aromatic): (Formaldehye, acetaldehyde, acetone and benzaldehyde) Preparation: from acid chlorides and from nitriles. Reaction with HCN, ROH, $NaHSO_3$, ammonia group derivatives. Iodoform test. Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation. Clemensen reduction and Wolff-Kishner reduction. Meerwein-Pondorff-Verley reduction.

(15 Lectures)

PRACTICAL

General Chemistry III

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1. Viscosity measurement using Ostwald's viscometer.
   (a) Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar (any one of the three at room temperature.
2. To determine the distribution coefficient of succinic acid between ether and water.
3. Functional group tests for alcohols, phenols, carbonyl and carboxylic acid group.

Recommended Books

Theory

1. Lee, J. D., *Concise Inorganic Chemistry*, 5th Ed., Wiley India (2008).
2. Puri, B. R.; Sharma, L. R.; Kalia, K. C., *Principles of Inorganic Chemistry*, 33rd Ed., Vishal Publishing (2017).
3. Atkins, P. W.; de Paula, J.; Keeler, J., *Physical Chemistry*, 11th Ed., Oxford University Press India (2018).
4. Bahl, A.; Bahl, B. S.; Tuli, G. D., *Essentials of Physical Chemistry*, S. Chand and Company (2010).
5. Negi, A. S.; Anand, S. C., *Physical Chemistry*, New Age International Publishers (2007).
6. Puri, B. R.; Sharma, L. R.; Pathania, M. S., *Principles of Physical Chemistry*, 47th Ed., Vishal Publishing (2017).
7. Solomons, T. W. G.; Fryhle, C. B., *Organic Chemistry*, 11th Ed., Wiley India (2015).
8. Bruice, P. Y., *Organic Chemistry*, 7th Ed., Pearson Education India (2013).
9. Bahl, B. S.; Bahl, A., *A Textbook of Organic Chemistry*, 22nd Ed., S. Chand and Company (2016).

Practical

1. Viswanathan, B.; Raghavan, P. S., *Practical Physical Chemistry*, Viva Books India (2014).
2. Yadav, J. B., *Advanced Practical Physical Chemistry*, Krishna Prakashan, Meerut (2015).
3. Agarwal, O. P., *Advanced Practical Organic Chemistry*, Krishna Prakashan, Meerut (2014).
4. Ahluwalia, V. K.; Aggarwal, R., *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*, Universities Press (2000).

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Rono Hills, Doimukh (A.P.)

CHE-GE-004

General Chemistry IV

Credit: 6 (L 4 – T 0 – P 2)
Total Lectures: 120 (Theory – 60; Practical – 60)

Course Objectives

This course covers a few important topics in physical, inorganic and organic chemistry that are very important for students of cognate departments of chemistry. They will learn about various thermodynamic systems, laws governing chemical thermodynamics, thermodynamics of ideal solutions, colligative properties and their relationships. They will also learn chemistry of organic molecules bearing a few common functional groups, which include alcohols, phenols aldehydes and ketones. It also discusses the underlying principles of qualitative and quantitative (titrimetric and gravimetric) analysis and chromatographic separation techniques.

Learning Outcomes

On completion of this course the students will be able to:

1. Understand the laws of thermodynamics, concept of state and path functions, extensive and intensive properties.
2. Calculate bond energy, bond dissociation energy and resonance energy from thermochemical data.
3. Explain the thermodynamic basis of colligative properties and applications in surroundings.
4. Understand and explain the basic principles of qualitative and quantitative analysis.
5. Understand the theoretical basis of chromatographic techniques and application in the analysis of simple mixtures.
6. Learn about the property, reactivity and synthetic importance of *O*-containing functional groups like alcohols, phenols, carbonyl group.
7. Learn detection of *O*-containing functional groups in organic compounds.

UNIT 1: Chemical Thermodynamics

Review of thermodynamic terms and basic concepts; thermodynamic systems (open, closed and isolated system); state and path functions; state variables, extensive and intensive properties, thermodynamic processes (isothermal, adiabatic, isochoric and isobaric process). Zeroth law of thermodynamics.

First law of thermodynamics: Concept of heat, work, internal energy and statement of first law; enthalpy, relation between heat capacities. The limitations of the first law of thermodynamics.

Thermochemistry: Heats of reactions: standard states; enthalpy of formation and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations) and pressure on enthalpy of reactions. Hess's law of constant heat summation

Second law of thermodynamics: Spontaneous process; criteria of spontaneity; concept of entropy; statement of second law.

Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.

(15 Lectures)

UNIT 2: Solutions and Colligative Properties

Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law- non-ideal solutions. Vapour pressure-composition and temperature-composition curves of ideal and non-ideal solutions.

Colligative properties: Relation between four colligative properties (i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) depression of freezing point and (iv) osmotic pressure with amount of solute. Applications of colligative properties in calculating

molar masses of normal, dissociated and associated solutes in solution. Abnormal colligative properties and Van't Hoff factor.

(15 Lectures)

UNIT 3: Analytical Chemistry and Separation Techniques

Principles of separation and identification of a mixture of cations and anions (qualitative analysis).

Principles of estimation of metals quantitatively by complexometric methods, Principle of acid-base titration, Theory of indicators.

Introduction to methods of gravimetric analysis, purity of precipitate, co-precipitation, post precipitation, optimum conditions of precipitation, role of DMG, α-nitroso-β-naphthol and *p*-hydroxyquinoline in gravimetric analysis.

Basic principles of chromatography, classification, principles of chromatographic separation, nature of adsorbent, solvent system; R_f values. Column, thin layer and paper chromatography.

(15 Lectures)

UNIT 4: Alcohols, Phenols, Ethers and Carbonyl Compounds

Alcohols: Properties and relative reactivity of 1°, 2°, 3° alcohols, general methods of preparation of monohydric alcohols. Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement.

Phenols: Preparation from cumene hydroperoxide and from diazonium salts. Reactions of phenol: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Houben-Hoesch Condensation, Schotten-Baumann Reaction.

Ethers: (aliphatic and aromatic) Cleavage of ethers with HI.

Aldehydes and Ketones (aliphatic and aromatic): (Formaldehye, acetaldehyde, acetone and benzaldehyde) Preparation: from acid chlorides and from nitriles. Reaction with HCN, ROH, $NaHSO_3$ and ammonia group derivatives. Iodoform test. Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation. Clemensen reduction and Wolff-Kishner reduction. Meerwein-Pondorff Verley reduction.

(15 Lectures)

PRACTICAL

Generic Elective IV

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1. Viscosity measurement using Ostwald's viscometer.
   (a) Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar (any one of the three) at room temperature.
2. Functional group tests for alcohols, phenols, carbonyl and carboxylic acid group.
3. Chromatography
   (a) Separation of a mixture of two amino acids by paper chromatography.
   (b) Separation of a mixture of *o*-and *p*-nitrophenol or *o*- and *p*-aminophenol by thin layer chromatography (TLC).

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Recommended Books

Theory

1. Atkins, P. W.; de Paula, J.; Keeler, J., *Physical Chemistry*, 11th Ed., Oxford University Press India (2018).
2. Bahl, A.; Bahl, B. S.; Tuli, G. D., *Essentials of Physical Chemistry*, S. Chand and Company (2010).
3. Negi, A. S.; Anand, S. C., *Physical Chemistry*, New Age International Publishers (2007).
4. Puri, B. R.; Sharma, L. R.; Pathania, M. S., *Principles of Physical Chemistry*, 47th Ed., Vishal Publishing (2017).
5. Svehla, G. *Vogel's Qualitative Inorganic Analysis*, 7th Edition, Prentice Hall (1996).
6. Solomons, T. W. G.; Fryhle, C. B., *Organic Chemistry*, 11th Ed., Wiley India (2015).
7. Bruice, P. Y., *Organic Chemistry*, 7th Ed., Pearson Education India (2013).
8. Bahl, B. S.; Bahl, A., *A Textbook of Organic Chemistry*, 22nd Ed., S. Chand and Company (2016).

Practical

1. Viswanathan, B.; Raghavan, P. S., *Practical Physical Chemistry*, Viva Books India (2014).
2. Yadav, J. B., *Advanced Practical Physical Chemistry*, Krishna Prakashan, Meerut (2015).
3. Agarwal, O. P., *Advanced Practical Organic Chemistry*, Krishna Prakashan, Meerut (2014).
4. Ahluwalia, V. K.; Aggarwal, R., *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*, Universities Press (2000).
5. Furniss, B. S.; Hannafold, A. J.; Smith, P. W. G.; Tatchell, A. R., *Vogel's Textbook of Practical Organic Chemistry*, 5th Ed., Pearson Education India (2003).

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CHE-GE-005

General Chemistry V

Credit: 6 (L 4 – T 0 – P 2)
Total Lectures: 120 (Theory – 60; Practical – 60)

Course Objectives

The course introduces the students to coordination compounds which find manifold applications in diverse areas like qualitative and quantitative analysis, metallurgy, catalysis and paints and pigments. It also aims to introduce the learners to the application of spectroscopic techniques (UV-visible and IR) in the structure determination of simple organic molecules and to understand the underlying concepts and principles therein.

Learning Outcomes

On completion of this course, students will be able to:

1. Understand the important properties of transition metals such as variable oxidation states, colour, magnetic and catalytic properties; use of Latimer diagrams in identifying reducing, oxidizing and undergoing disproportionation nature of species.
2. Learn about different terminologies like ligand, denticity of ligands, chelate, coordination number etc. and nomenclature of coordination compounds.
3. Have ideas on various types of isomerism possible in complexes with 4 and 6 coordination numbers.
4. Predict the structure and magnetic behaviour of metal complexes using Valence Bond Theory.
5. Have clear understanding of the terms Δ_o, Δ_t, pairing energy, CFSE, high spin and low spin as well as the effect of CFSE on thermodynamic properties like lattice enthalpy and hydration enthalpy.
6. Have knowledge on preparation, properties and shapes of compounds of noble gases as well as polymers of B, Si & P.
7. Learn basic principles of various spectroscopic techniques and their importance in structure elucidation of compounds.
8. Study and interpret UV-Vis spectra.

UNIT 1: *d*- and *f*-Block Elements

General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, and ability to form complexes. Stability of various oxidation states (Latimer diagrams) for Mn, Fe and Cu. Difference between the first, second and third transition series. Lanthanoids and actinoids: Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only).

(15 Lectures)

UNIT 2: Coordination Chemistry

Introduction to coordination chemistry, classification of ligands, Werner's theory, nomenclature of coordination compounds.

Valence Bond Theory (VBT): Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6). Structural and stereoisomerism in complexes with coordination numbers 4 and 6. Drawbacks of VBT. IUPAC system of nomenclature.

Crystal field effect, octahedral symmetry. Crystal field stabilization energy (CFSE), Crystal field effects for weak and strong fields. Tetrahedral symmetry. Factors affecting the magnitude of D. Spectrochemical series. Comparison of CFSE for O_h and T_d complexes, Tetragonal distortion of octahedral geometry. Jahn-Teller distortion, Square planar coordination.

(15 Lectures)

UNIT 3: Noble Gases & Inorganic Polymers

Noble Gases: Rationalization of inertness of noble gases, clathrates, preparation and properties of XeF_2, XeF_4 and XeF_6, bonding in these compounds using VBT and shapes of noble gas compounds using VSEPR Theory

Inorganic Polymers: Types of inorganic polymers and comparison with organic polymers, structural features, classification and important applications of silicates. Synthesis, structural features and applications of silicones. Borazines and cyclophosphazenes – preparation, properties and reactions. Bonding in $(NPCl_2)_3$.

(15 Lectures)

UNIT 4: Application of Spectroscopy to Simple Organic Molecules

Application of visible, ultraviolet and infrared spectroscopy in organic molecules. Electromagnetic radiation, electronic transitions, λ_{max} & ε_{max}, chromophore, auxochrome, bathochromic and hypsochromic shifts. Application of electronic spectroscopy and Woodward rules for calculating λ_{max} of conjugated dienes and *α,β*-unsaturated compounds. Infrared radiation and types of molecular vibrations, functional group and fingerprint region. IR spectra of alkanes, alkenes and simple alcohols (inter and intramolecular hydrogen bonding), aldehydes, ketones, carboxylic acids and their derivatives (effect of substitution on >C=O stretching absorptions).

(15 Lectures)

PRACTICAL

General Chemistry V

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1. Inorganic preparations
   (a) Copper(I) chloride from copper(II) chloride
   (b) Preparation of Manganese(III) phosphate, $MnPO_4 \cdot H_2O$
   (c) Preparation of chrome alum $[K_2SO_4 \cdot Cr_2(SO_4)_3 \cdot 24H_2O]$ and potash alum $[K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O]$.
2. UV/Visible spectroscopy
   (a) Study the absorbance spectra of $KMnO_4$ and $K_2Cr_2O_7$ (in 0.1 M H_2SO_4) and determine the λ_{max} values. Calculate the energies of the two transitions in different units (J molecule^{-1}, kJ mol^{-1}, cm^{-1}, eV).

Recommended Books

Theory

1. Lee, J. D., *Concise Inorganic Chemistry*, 5th Ed., Wiley India (2008).
2. Housecroft, C. E; Sharpe, A. G., *Inorganic Chemistry*, 5th Ed., Pearson Education (2018).
3. Atkins, P.; Overton, T.; Rouke, J.; Weller, M.; Armstrong, F.; Hagerman, M., *Shriver Atkins's Inorganic Chemistry*, 6th Ed., Oxford University Press India (2015).
4. Miessler, G.; Tarr, D. A., *Inorganic Chemistry*, 3rd Ed., Pearson Education India (2008).
5. Huheey, J. E.; Keiter, E. A.; Keiter, R. L.; Medhi, O. K., *Inorganic Chemistry: Principles of Structures and Reactivity*, 4th Ed., Pearson Education India (2006).
6. Cotton, F. A.; Wilkinson, G.; Gaus, P. L., *Basic Inorganic Chemistry*, 3rd Ed., Wiley India (2007).

7. Puri, B. R.; Sharma, L. R.; Kalia, K. C., *Principles of Inorganic Chemistry*, 33rd Ed., Vishal Publishing (2017).
8. Lampman, G. M.; Pavia, D. L.; Kriz, G. S.; Vyvyan, J.R., *Introduction to Spectroscopy*, 5th Ed., Cengage Learning India, New Delhi (2015).
9. Kemp, W., *Organic Spectroscopy*, 3rd Ed., Macmillan Publishers India, New Delhi (2011).

Practical

1. Raj, G., *Advanced Practical Inorganic Chemistry*, Krishna Prakashan, Meerut, Meerut (2013).
2. Mendham, J.; Denney, R. C., Barnes, J. D.; Thomas, M.; Sivasankar, B., *Vogel's Quantitative Chemical Analysis*, 6th Ed., Pearson Education India (2009).
3. Khosla, B. D.; Garg, V. C.; Gulati, A., *Senior Practical Physical Chemistry*, R. Chand & Co., New Delhi (2011).
4. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry* 8th Ed.*;* McGraw-Hill: New York (2003).

05/7/2021
संयुक्त कुलसचिव (शैक्षणिक एवं सम्मेलन)
राजीव गांधी विश्वविद्यालय
Jt. Registrar (Acad. & Conf.)
Rajiv Gandhi University
Rono Hills, Doimukh (A.P.)

CHE-GE-006
Molecules of Life

Credit: 6 (L 4 – T 0 – P 2)
Total Lectures: 120 (Theory – 60; Practical – 60)

Course Objectives

This course is to make students understand the significant features of the chemistry of the biomolecules viz. carbohydrates, proteins, enzymes and lipids. Classification, characteristic reactions, biological importance of these biomolecules will be thoroughly discussed. It also aims to introduce the learners to the application of spectroscopic techniques (UV-visible and IR) in the structure determination of simple organic molecules and to understand the underlying concepts and principles therein.

Learning Outcomes:

On completion of this course, students will be able to:

1. Know the occurrence, classification and biological importance of carbohydrates.
2. Learn various reactions of aldoses and ketoses as well as their interconversions.
3. Understand the structure and synthesis of peptide chains and proteins.
4. Gain knowledge about the mechanism of enzyme action.
5. Get introduced to lipids, oils and fats.
6. Learn basic principles of IR & UV spectroscopy and their importance in structure elucidation of compounds.
7. Determine saponification value of oil and fat.
8. Estimate sugars and amino acids present in an unknown sample practically.

UNIT 1: Carbohydrates

Classification of carbohydrates, reducing and non-reducing sugars, General properties of glucose and fructose, their open chain structure. Epimerisation & mutarotation (including mechanism), anomers. Structure determination of glucose and fructose. Cyclic structure of glucose and fructose. Haworth projections. Interconversion of aldose to ketose and vice versa, Ascending & descending of monosaccharides (Killiani-Fischer synthesis & Ruff degradation), Linkage between monosaccharides, structure of disaccharides (sucrose, maltose, lactose) and polysaccharides (starch and cellulose) excluding their structure elucidation.

(15 Lectures)

UNIT 2: Amino Acids, Peptides, Proteins and Enzymes

Classification of amino acids, zwitterion structure and isoelectric point. Overview of primary, secondary, tertiary and quaternary structure of proteins. Determination of primary structure of peptides, determination of *N*-terminal amino acid (by DNFB and Edman method) and C-terminal amino acid (by thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (up to dipeptides) by *N*-protection (t-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid phase synthesis.

Mechanism of enzyme action, factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, Specificity of enzyme action (including stereospecificity).

(15 Lectures)

UNIT 3: Correlation of Enzymes and Drug Action, Lipids

Enzyme inhibitors and their importance, phenomenon of inhibition (competitive and non-competitive inhibition including allosteric inhibition). Drug action-receptor theory. Structure-activity relationships of drug molecules, binding role of -OH group, $-NH_2$ group, double bond and aromatic ring.

Introduction to lipids, classification. Oils and fats: Common fatty acids present in oils and fats, omega fatty acids, trans fats, hydrogenation, saponification value, iodine number. Biological importance of triglycerides, phospholipids, glycolipids, and steroids (cholesterol).

(15 Lectures)

UNIT 4: Application of Spectroscopy to Simple Organic Molecules

Application of visible, ultraviolet and infrared spectroscopy in organic molecules. Electromagnetic radiation, electronic transitions, λ_{max} & ε_{max}, chromophore, auxochrome, bathochromic and hypsochromic shifts. Application of electronic spectroscopy and Woodward rules for calculating λ_{max} of conjugated dienes and α,β-unsaturated compounds. Infrared radiation and types of molecular vibrations, functional group and fingerprint region. IR spectra of alkanes, alkenes and simple alcohols (inter and intramolecular hydrogen bonding), aldehydes, ketones, carboxylic acids and their derivatives (effect of substitution on >C=O stretching absorptions).

(15 Lectures)

PRACTICAL

Molecules of Life

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1. To determine the concentration of glycine solution by formylation method.
2. Determination of percentage purity of amino acids.
3. To determine the saponification value of an oil/fat.
4. Differentiate between a reducing/ non-reducing sugar.
5. Estimation of sugar by Fehling solution method

Recommended Books

Theory

1. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Berg, J. M.; Tymoczko, J. L.; Gatto Jr., G. J.; Stryer, L., *Biochemistry*, 9th Ed., W. H. Freeman, New York (2019).
3. Nelson, D. L.; Cox, M. M., *Lehninger Principles of Biochemistry*, 7th Ed., W. H. Freeman, New York (2017).
4. Solomons, T. W. G.; Fryhle, C. B., *Organic Chemistry*, 11th Ed., Wiley India (2015).
5. Finar, I. L. *Organic Chemistry*, 5th Ed., Vol. 1, Pearson Education, New Delhi (2011).
6. Finar, I. L. *Organic Chemistry*, 5th Ed., Vol. 2, Pearson Education, New Delhi (2011).
7. Lampman, G. M.; Pavia, D. L.; Kriz, G. S.; Vyvyan, J.R., *Introduction to Spectroscopy*, 5th Ed., Cengage Learning India, New Delhi (2015).
8. Kemp, W., *Organic Spectroscopy*, 3rd Ed., Macmillan Publishers India, New Delhi (2011).

Practical

1. Furniss, B. S.; Hannafold, A. J.; Smith, P. W. G.; Tatchell, A. R., *Vogel's Textbook of Practical Organic Chemistry*, 5th Ed., Pearson Education India (2003).
2. Ahluwalia, V. K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry*, Universities Press.