Scheme of Examinations
Rules & Regulations
and
Syllabus

(for Academic Session 2026-2027)

M.Sc. Chemistry

Third Semester Examination, December 2026
Fourth Semester Examination, June 2027

as per

National Education Policy (NEP)-2020 &
Choice Based Credit System (CBCS)

Faculty of Science

UNIVERSITY OF KOTA

MBS Marg, KOTA (Rajasthan)-324 005

INDIA

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M.Sc. Chemistry: Semester wise Consolidated Scheme of Examinations

Year / Semester	Number, Code and Nomenclature of Paper				Duration of Exam. (in Hrs)	Teaching Hours / Week & Credit Points			Distribution of Maximum Marks			Minimum Passing Marks	
	Number of Paper	Code of Paper	Code for Exam.	Nomenclature of Paper		Teaching Hours Th.	Pr.	Credit Points	Internal Assess.	Semester Assess.	Total Marks	Internal Assess.	Semester Assess.
1st Year	Paper-1.1	CHE-511-T	12001	Inorganic Chemistry	3	4	--	4	30	70	100	12	28
	Paper-1.2	CHE-512-T	12002	Organic Chemistry	3	4	--	4	30	70	100	12	28
I Semester	Paper-1.3	CHE-513-T	12003	Physical Chemistry	3	4	--	4	30	70	100	12	28
	Paper-1.4	CHE-514A/B-T	12004/05	Mathematics for Chemists / Biology for Chemists	3	4	--	4	30	70	100	12	28
	Paper-1.5	CHE-515-P	12006	Chemistry Practical	12	--	16	8	--	200	200	--	100
				Total (I Semester)	**24**	**16**	**16**	**24**	**120**	**480**	**600**	**48**	**212**
1st Year	Paper-2.1	CHE-521-T	12011	Inorganic Chemistry	3	4	--	4	30	70	100	12	28
	Paper-2.2	CHE-522-T	12012	Organic Chemistry	3	4	--	4	30	70	100	12	28
II Semester	Paper-2.3	CHE-523-T	12013	Physical Chemistry	3	4	--	4	30	70	100	12	28
	Paper-2.4	CHE-524-T	12014	Computer Applications in Chemistry	3	4	--	4	30	70	100	12	28
	Paper-2.5	CHE-525-P	12015	Chemistry Practical	12	--	16	8	--	200	200	--	100
	Paper-2.6	VAC--------	-------	Value Added Course *(Opt from Pool-A of the Value-Added Course)*	4	--	4	2	50	--	50	25	--
				Total (II Semester)	**28**	**16**	**20**	**26**	**170**	**480**	**650**	**73**	**212**
2nd Year	Paper-3.1	CHE-631-T	12021	*Common Paper:* Chromatography	3	4	--	4	30	70	100	12	28
	Paper-3.2	CHE-632-T	12022	*Common Paper:* Spectroscopy	3	4	--	4	30	70	100	12	28
III Semester	Paper-3.3	CHE-633-T	120…	*Specialization Paper-I : Group I / II / III / IV / V*	3	4	--	4	30	70	100	12	28
	Paper-3.4	CHE-634-T	120…	*Specialization Paper-II : Group I / II / III / IV / V*	3	4	--	4	30	70	100	12	28
	Paper-3.5	CHE-635-P	120…	*Specialization Paper-III : Group I / II / III / IV / V*	12	--	16	8	--	200	200	--	100
	Paper-3.6	VAC--------	-------	Value Added Course *(Opt from Pool-B of the Value-Added Course)*	4	--	4	2	50	--	50	25	--
				Total (III Semester)	**28**	**16**	**20**	**26**	**170**	**480**	**650**	**73**	**212**
2nd Year	Paper-4.1	CHE-641-T	12041	*Common Paper:* Environmental Chemistry	3	4	--	4	30	70	100	12	28
	Paper-4.2	CHE-642-T	12042	*Common Paper:* Recent Methods of Organic Synthesis	3	4	--	4	30	70	100	12	28
IV Semester	Paper-4.3	CHE-643-T	120…	*Specialization Paper-I : Group I / II / III / IV / V*	3	4	--	4	30	70	100	12	28
	Paper-4.4	CHE-644-T	120…	*Specialization Paper-II : Group I / II / III / IV / V*	3	4	--	4	30	70	100	12	28
	Paper-4.5	CHE-645-P	120…	*Specialization Paper-III : Group I / II / III / IV / V*	12	--	16	8	--	200	200	--	100
				Total (IV Semester)	**24**	**16**	**16**	**24**	**120**	**480**	**600**	**48**	**212**
				Grand Total (I + II + III + IV Semester)	**104**	**64**	**72**	**100**	**580**	**1920**	**2500**	**242**	**848**

Note: Value Added Courses (VAC) may be opted from Pool-A and Pool-B. List of the VAC for Pool-A and Pool-B is uploaded separately on the University website *i.e.* **www.uok.ac.in**.

Groups of Specializations in M.Sc. Chemistry

Year / Sem.	Specialization Papers	Code or ID	Group-I: Inorganic Chemistry	Group-II: Organic Chemistry	Group-III: Physical Chemistry	Group-IV: Analytical Chemistry	Group-V: Industrial Chemistry
2nd Year III Semester	*Specialization Paper-I*	CHE - -- - T	Bio-inorganic Chemistry	Organic Synthesis	Nuclear Chemistry	Advanced Analytical Techniques	Fundamentals of Industrial Process Calculations
	Specialization Paper-II	CHE - -- - T	Photo-inorganic Chemistry	Heterocyclic Chemistry	Physical Organic Chemistry	Analysis of Commercial Products	Fuel, Petrochemicals and Energy Technology
	Specialization Paper-III	CHE - -- - P	Inorganic Chemistry Practical	Organic Chemistry Practical	Physical Chemistry Practical	Analytical Chemistry Practical	Industrial Chemistry Practical
2nd Year IV Semester	*Specialization Paper-I*	CHE - -- - T	Organo-transition Metal Chemistry	Chemistry of Natural Products	Electrochemistry	Instrumental Methods of Analysis	Chemical Process Industries
	Specialization Paper-II	CHE - -- - T	Polymers	Medicinal Chemistry	Chemical Dynamics	Analysis of Consumers Products	Industrial Management, IPR & Regulatory Affairs
	Specialization Paper-III	CHE - -- - P	Inorganic Chemistry Practical	Organic Chemistry Practical	Physical Chemistry Practical	Analytical Chemistry Practical	Industrial Chemistry Practical

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M.Sc. Chemistry: Inorganic Chemistry Specialization

Semester wise Scheme of Examinations

Year / Semester	Number, Code and Nomenclature of Paper				Duration of Exam. (in Hrs)	Teaching Hours / Week & Credit Points			Distribution of Maximum Marks			Minimum Passing Marks	
	Number of Paper	Code of Paper	Code for Exam.	Nomenclature of Paper		Teaching Hours Th.	Pr.	Credit Points	Internal Assess.	Semester Assess.	Total Marks	Internal Assess.	Semester Assess.
1st Year	Paper-1.1	CHE-511-T	12001	Inorganic Chemistry	3	4	--	4	30	70	100	12	28
	Paper-1.2	CHE-512-T	12002	Organic Chemistry	3	4	--	4	30	70	100	12	28
I Semester	Paper-1.3	CHE-513-T	12003	Physical Chemistry	3	4	--	4	30	70	100	12	28
	Paper-1.4	CHE-514A/B-T	12004/05	Mathematics for Chemists / Biology for Chemists	3	4	--	4	30	70	100	12	28
	Paper-1.5	CHE-515-P	12006	Chemistry Practical	12	--	16	8	--	200	200	--	100
				Total (I Semester)	**24**	**16**	**16**	**24**	**120**	**480**	**600**	**48**	**212**
1st Year	Paper-2.1	CHE-521-T	12011	Inorganic Chemistry	3	4	--	4	30	70	100	12	28
	Paper-2.2	CHE-522-T	12012	Organic Chemistry	3	4	--	4	30	70	100	12	28
II Semester	Paper-2.3	CHE-523-T	12013	Physical Chemistry	3	4	--	4	30	70	100	12	28
	Paper-2.4	CHE-524-T	12014	Computer Applications in Chemistry	3	4	--	4	30	70	100	12	28
	Paper-2.5	CHE-525-P	12015	Chemistry Practical	12	--	16	8	--	200	200	--	100
	Paper-2.6	VAC--------	-------	Value Added Course *(Opt from Pool-A of the Value-Added Course)*	4	--	4	2	50	--	50	25	--
				Total (II Semester)	**28**	**16**	**20**	**26**	**170**	**480**	**650**	**73**	**212**
2nd Year	Paper-3.1	CHE-631-T	12021	Chromatography	3	4	--	4	30	70	100	12	28
	Paper-3.2	CHE-632-T	12022	Spectroscopy	3	4	--	4	30	70	100	12	28
III Semester	Paper-3.3	CHE-633-T	12023	Bio-inorganic Chemistry	3	4	--	4	30	70	100	12	28
	Paper-3.4	CHE-634-T	12024	Photo-inorganic Chemistry	3	4	--	4	30	70	100	12	28
	Paper-3.5	CHE-635-P	12025	Inorganic Chemistry Practical	12	--	16	8	--	200	200	--	100
	Paper-3.6	VAC--------	-------	Value Added Course *(Opt from Pool-B of the Value-Added Course)*	4	--	4	2	50	--	50	25	--
				Total (III Semester)	**28**	**16**	**20**	**26**	**170**	**480**	**650**	**73**	**212**
2nd Year	Paper-4.1	CHE-641-T	12041	Environmental Chemistry	3	4	--	4	30	70	100	12	28
	Paper-4.2	CHE-642-T	12042	Recent Methods of Organic Synthesis	3	4	--	4	30	70	100	12	28
IV Semester	Paper-4.3	CHE-643-T	12043	Organo-transition Metal Chemistry	3	4	--	4	30	70	100	12	28
	Paper-4.4	CHE-644-T	12044	Polymers	3	4	--	4	30	70	100	12	28
	Paper-4.5	CHE-645-P	12045	Inorganic Chemistry Practical	12	--	16	8	--	200	200	--	100
				Total (IV Semester)	**24**	**16**	**16**	**24**	**120**	**480**	**600**	**48**	**212**
				Grand Total (I + II + III + IV Semester)	**104**	**64**	**72**	**100**	**580**	**1920**	**2500**	**242**	**848**

Note: Value Added Courses (VAC) may be opted from Pool-A and Pool-B. List of the VAC for Pool-A and Pool-B is uploaded separately on the University website *i.e.* **www.uok.ac.in**.

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M.Sc. Chemistry: Organic Chemistry Specialization

Semester wise Scheme of Examinations

Year / Semester	Number, Code and Nomenclature of Paper				Duration of Exam. (in Hrs)	Teaching Hours / Week & Credit Points			Distribution of Maximum Marks			Minimum Passing Marks	
	Number of Paper	Code of Paper	Code for Exam.	Nomenclature of Paper		Teaching Hours Th.	Pr.	Credit Points	Internal Assess.	Semester Assess.	Total Marks	Internal Assess.	Semester Assess.
1st Year	Paper-1.1	CHE-511-T	12001	Inorganic Chemistry	3	4	--	4	30	70	100	12	28
	Paper-1.2	CHE-512-T	12002	Organic Chemistry	3	4	--	4	30	70	100	12	28
I Semester	Paper-1.3	CHE-513-T	12003	Physical Chemistry	3	4	--	4	30	70	100	12	28
	Paper-1.4	CHE-514A/B-T	12004/05	Mathematics for Chemists / Biology for Chemists	3	4	--	4	30	70	100	12	28
	Paper-1.5	CHE-515-P	12006	Chemistry Practical	12	--	16	8	--	200	200	--	100
				Total (I Semester)	**24**	**16**	**16**	**24**	**120**	**480**	**600**	**48**	**212**
1st Year	Paper-2.1	CHE-521-T	12011	Inorganic Chemistry	3	4	--	4	30	70	100	12	28
	Paper-2.2	CHE-522-T	12012	Organic Chemistry	3	4	--	4	30	70	100	12	28
II Semester	Paper-2.3	CHE-523-T	12013	Physical Chemistry	3	4	--	4	30	70	100	12	28
	Paper-2.4	CHE-524-T	12014	Computer Applications in Chemistry	3	4	--	4	30	70	100	12	28
	Paper-2.5	CHE-525-P	12015	Chemistry Practical	12	--	16	8	--	200	200	--	100
	Paper-2.6	VAC--------	-------	Value Added Course *(Opt from Pool-A of the Value-Added Course)*	4	--	4	2	50	--	50	25	--
				Total (II Semester)	**28**	**16**	**20**	**26**	**170**	**480**	**650**	**73**	**212**
2nd Year	Paper-3.1	CHE-631-T	12021	Chromatography	3	4	--	4	30	70	100	12	28
	Paper-3.2	CHE-632-T	12022	Spectroscopy	3	4	--	4	30	70	100	12	28
III Semester	Paper-3.3	CHE-633-T	12026	Organic Synthesis	3	4	--	4	30	70	100	12	28
	Paper-3.4	CHE-634-T	12027	Heterocyclic Chemistry	3	4	--	4	30	70	100	12	28
	Paper-3.5	CHE-635-P	12028	Organic Chemistry Practical	12	--	16	8	--	200	200	--	100
	Paper-3.6	VAC--------	-------	Value Added Course *(Opt from Pool-B of the Value-Added Course)*	4	--	4	2	50	--	50	25	--
				Total (III Semester)	**28**	**16**	**20**	**26**	**170**	**480**	**650**	**73**	**212**
2nd Year	Paper-4.1	CHE-641-T	12041	Environmental Chemistry	3	4	--	4	30	70	100	12	28
	Paper-4.2	CHE-642-T	12042	Recent Methods of Organic Synthesis	3	4	--	4	30	70	100	12	28
IV Semester	Paper-4.3	CHE-643-T	12046	Chemistry of Natural Products	3	4	--	4	30	70	100	12	28
	Paper-4.4	CHE-644-T	12047	Medicinal Chemistry	3	4	--	4	30	70	100	12	28
	Paper-4.5	CHE-645-P	12048	Organic Chemistry Practical	12	--	16	8	--	200	200	--	100
				Total (IV Semester)	**24**	**16**	**16**	**24**	**120**	**480**	**600**	**48**	**212**
				Grand Total (I + II + III + IV Semester)	**104**	**64**	**72**	**100**	**580**	**1920**	**2500**	**242**	**848**

Note: Value Added Courses (VAC) may be opted from Pool-A and Pool-B. List of the VAC for Pool-A and Pool-B is uploaded separately on the University website *i.e.* **www.uok.ac.in**.

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M.Sc. Chemistry: Physical Chemistry Specialization

Semester wise Scheme of Examinations

Year / Semester	Number, Code and Nomenclature of Paper				Duration of Exam. (in Hrs)	Teaching Hours / Week & Credit Points			Distribution of Maximum Marks			Minimum Passing Marks	
	Number of Paper	Code of Paper	Code for Exam.	Nomenclature of Paper		Teaching Hours Th.	Pr.	Credit Points	Internal Assess.	Semester Assess.	Total Marks	Internal Assess.	Semester Assess.
1st Year	Paper-1.1	CHE-511-T	12001	Inorganic Chemistry	3	4	--	4	30	70	100	12	28
	Paper-1.2	CHE-512-T	12002	Organic Chemistry	3	4	--	4	30	70	100	12	28
I Semester	Paper-1.3	CHE-513-T	12003	Physical Chemistry	3	4	--	4	30	70	100	12	28
	Paper-1.4	CHE-514A/B-T	12004/05	Mathematics for Chemists / Biology for Chemists	3	4	--	4	30	70	100	12	28
	Paper-1.5	CHE-515-P	12006	Chemistry Practical	12	--	16	8	--	200	200	--	100
				Total (I Semester)	**24**	**16**	**16**	**24**	**120**	**480**	**600**	**48**	**212**
1st Year	Paper-2.1	CHE-521-T	12011	Inorganic Chemistry	3	4	--	4	30	70	100	12	28
	Paper-2.2	CHE-522-T	12012	Organic Chemistry	3	4	--	4	30	70	100	12	28
II Semester	Paper-2.3	CHE-523-T	12013	Physical Chemistry	3	4	--	4	30	70	100	12	28
	Paper-2.4	CHE-524-T	12014	Computer Applications in Chemistry	3	4	--	4	30	70	100	12	28
	Paper-2.5	CHE-525-P	12015	Chemistry Practical	12	--	16	8	--	200	200	--	100
	Paper-2.6	VAC--------	-------	Value Added Course *(Opt from Pool-A of the Value-Added Course)*	4	--	4	2	50	--	50	25	--
				Total (II Semester)	**28**	**16**	**20**	**26**	**170**	**480**	**650**	**73**	**212**
2nd Year	Paper-3.1	CHE-631-T	12021	Chromatography	3	4	--	4	30	70	100	12	28
	Paper-3.2	CHE-632-T	12022	Spectroscopy	3	4	--	4	30	70	100	12	28
III Semester	Paper-3.3	CHE-633-T	12029	Nuclear Chemistry	3	4	--	4	30	70	100	12	28
	Paper-3.4	CHE-634-T	12030	Physical Organic Chemistry	3	4	--	4	30	70	100	12	28
	Paper-3.5	CHE-635-P	12031	Physical Chemistry Practical	12	--	16	8	--	200	200	--	100
	Paper-3.6	VAC--------	-------	Value Added Course *(Opt from Pool-B of the Value-Added Course)*	4	--	4	2	50	--	50	25	--
				Total (III Semester)	**28**	**16**	**20**	**26**	**170**	**480**	**650**	**73**	**212**
2nd Year	Paper-4.1	CHE-641-T	12041	Environmental Chemistry	3	4	--	4	30	70	100	12	28
	Paper-4.2	CHE-642-T	12042	Recent Methods of Organic Synthesis	3	4	--	4	30	70	100	12	28
IV Semester	Paper-4.3	CHE-643-T	12049	Electrochemistry	3	4	--	4	30	70	100	12	28
	Paper-4.4	CHE-644-T	12050	Chemical Dynamics	3	4	--	4	30	70	100	12	28
	Paper-4.5	CHE-645-P	12051	Physical Chemistry Practical	12	--	16	8	--	200	200	--	100
				Total (IV Semester)	**24**	**16**	**16**	**24**	**120**	**480**	**600**	**48**	**212**
				Grand Total (I + II + III + IV Semester)	**104**	**64**	**72**	**100**	**580**	**1920**	**2500**	**242**	**848**

Note: Value Added Courses (VAC) may be opted from Pool-A and Pool-B. List of the VAC for Pool-A and Pool-B is uploaded separately on the University website *i.e.* **www.uok.ac.in**.

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M.Sc. Chemistry: Analytical Chemistry Specialization

Semester wise Scheme of Examinations

Year / Semester	Number, Code and Nomenclature of Paper				Duration of Exam. (in Hrs)	Teaching Hours / Week & Credit Points			Distribution of Maximum Marks			Minimum Passing Marks	
	Number of Paper	Code of Paper	Code for Exam.	Nomenclature of Paper		Teaching Hours Th.	Pr.	Credit Points	Internal Assess.	Semester Assess.	Total Marks	Internal Assess.	Semester Assess.
1st Year	Paper-1.1	CHE-511-T	12001	Inorganic Chemistry	3	4	--	4	30	70	100	12	28
	Paper-1.2	CHE-512-T	12002	Organic Chemistry	3	4	--	4	30	70	100	12	28
I Semester	Paper-1.3	CHE-513-T	12003	Physical Chemistry	3	4	--	4	30	70	100	12	28
	Paper-1.4	CHE-514A/B-T	12004/05	Mathematics for Chemists / Biology for Chemists	3	4	--	4	30	70	100	12	28
	Paper-1.5	CHE-515-P	12006	Chemistry Practical	12	--	16	8	--	200	200	--	100
				Total (I Semester)	**24**	**16**	**16**	**24**	**120**	**480**	**600**	**48**	**212**
1st Year	Paper-2.1	CHE-521-T	12011	Inorganic Chemistry	3	4	--	4	30	70	100	12	28
	Paper-2.2	CHE-522-T	12012	Organic Chemistry	3	4	--	4	30	70	100	12	28
II Semester	Paper-2.3	CHE-523-T	12013	Physical Chemistry	3	4	--	4	30	70	100	12	28
	Paper-2.4	CHE-524-T	12014	Computer Applications in Chemistry	3	4	--	4	30	70	100	12	28
	Paper-2.5	CHE-525-P	12015	Chemistry Practical	12	--	16	8	--	200	200	--	100
	Paper-2.6	VAC--------	-------	Value Added Course *(Opt from Pool-A of the Value-Added Course)*	4	--	4	2	50	--	50	25	--
				Total (II Semester)	**28**	**16**	**20**	**26**	**170**	**480**	**650**	**73**	**212**
2nd Year	Paper-3.1	CHE-631-T	12021	Chromatography	3	4	--	4	30	70	100	12	28
	Paper-3.2	CHE-632-T	12022	Spectroscopy	3	4	--	4	30	70	100	12	28
III Semester	Paper-3.3	CHE-633-T	12032	Advanced Analytical Techniques	3	4	--	4	30	70	100	12	28
	Paper-3.4	CHE-634-T	12033	Analysis of Commercial Products	3	4	--	4	30	70	100	12	28
	Paper-3.5	CHE-635-P	12034	Analytical Chemistry Practical	12	--	16	8	--	200	200	--	100
	Paper-3.6	VAC--------	-------	Value Added Course *(Opt from Pool-B of the Value-Added Course)*	4	--	4	2	50	--	50	25	--
				Total (III Semester)	**28**	**16**	**20**	**26**	**170**	**480**	**650**	**73**	**212**
2nd Year	Paper-4.1	CHE-641-T	12041	Environmental Chemistry	3	4	--	4	30	70	100	12	28
	Paper-4.2	CHE-642-T	12042	Recent Methods of Organic Synthesis	3	4	--	4	30	70	100	12	28
IV Semester	Paper-4.3	CHE-643-T	12052	Instrumental Methods of Analysis	3	4	--	4	30	70	100	12	28
	Paper-4.4	CHE-644-T	12053	Analysis of Consumers Products	3	4	--	4	30	70	100	12	28
	Paper-4.5	CHE-645-P	12054	Analytical Chemistry Practical	12	--	16	8	--	200	200	--	100
				Total (IV Semester)	**24**	**16**	**16**	**24**	**120**	**480**	**600**	**48**	**212**
				Grand Total (I + II + III + IV Semester)	**104**	**64**	**72**	**100**	**580**	**1920**	**2500**	**242**	**848**

Note: Value Added Courses (VAC) may be opted from Pool-A and Pool-B. List of the VAC for Pool-A and Pool-B is uploaded separately on the University website *i.e.* **www.uok.ac.in**.

University of Kota, Kota

M.Sc. Chemistry: Industrial Chemistry Specialization

Semester wise Scheme of Examinations

Year / Semester	Number, Code and Nomenclature of Paper				Duration of Exam. (in Hrs)	Teaching Hours / Week & Credit Points			Distribution of Maximum Marks			Minimum Passing Marks	
	Number of Paper	Code of Paper	Code for Exam.	Nomenclature of Paper		Teaching Hours Th.	Pr.	Credit Points	Internal Assess.	Semester Assess.	Total Marks	Internal Assess.	Semester Assess.
1st Year	Paper-1.1	CHE-511-T	12001	Inorganic Chemistry	3	4	--	4	30	70	100	12	28
	Paper-1.2	CHE-512-T	12002	Organic Chemistry	3	4	--	4	30	70	100	12	28
I Semester	Paper-1.3	CHE-513-T	12003	Physical Chemistry	3	4	--	4	30	70	100	12	28
	Paper-1.4	CHE-514A/B-T	12004/05	Mathematics for Chemists / Biology for Chemists	3	4	--	4	30	70	100	12	28
	Paper-1.5	CHE-515-P	12006	Chemistry Practical	12	--	16	8	--	200	200	--	100
				Total (I Semester)	**24**	**16**	**16**	**24**	**120**	**480**	**600**	**48**	**212**
1st Year	Paper-2.1	CHE-521-T	12011	Inorganic Chemistry	3	4	--	4	30	70	100	12	28
	Paper-2.2	CHE-522-T	12012	Organic Chemistry	3	4	--	4	30	70	100	12	28
II Semester	Paper-2.3	CHE-523-T	12013	Physical Chemistry	3	4	--	4	30	70	100	12	28
	Paper-2.4	CHE-524-T	12014	Computer Applications in Chemistry	3	4	--	4	30	70	100	12	28
	Paper-2.5	CHE-525-P	12015	Chemistry Practical	12	--	16	8	--	200	200	--	100
	Paper-2.6	VAC--------	-------	Value Added Course *(Opt from Pool-A of the Value-Added Course)*	4	--	4	2	50	--	50	25	--
				Total (II Semester)	**28**	**16**	**20**	**26**	**170**	**480**	**650**	**73**	**212**
2nd Year	Paper-3.1	CHE-631-T	12021	Chromatography	3	4	--	4	30	70	100	12	28
	Paper-3.2	CHE-632-T	12022	Spectroscopy	3	4	--	4	30	70	100	12	28
III Semester	Paper-3.3	CHE-633-T	12035	Fundamentals of Industrial Process Calculations	3	4	--	4	30	70	100	12	28
	Paper-3.4	CHE-634-T	12036	Fuel, Petrochemicals and Energy Technology	3	4	--	4	30	70	100	12	28
	Paper-3.5	CHE-635-P	12037	Industrial Chemistry Practical	12	--	16	8	--	200	200	--	100
	Paper-3.6	VAC--------	-------	Value Added Course *(Opt from Pool-B of the Value-Added Course)*	4	--	4	2	50	--	50	25	--
				Total (III Semester)	**28**	**16**	**20**	**26**	**170**	**480**	**650**	**73**	**212**
2nd Year	Paper-4.1	CHE-641-T	12041	Environmental Chemistry	3	4	--	4	30	70	100	12	28
	Paper-4.2	CHE-642-T	12042	Recent Methods of Organic Synthesis	3	4	--	4	30	70	100	12	28
IV Semester	Paper-4.3	CHE-643-T	12055	Chemical Process Industries	3	4	--	4	30	70	100	12	28
	Paper-4.4	CHE-644-T	12056	Industrial Management, IPR and Regulatory Affairs	3	4	--	4	30	70	100	12	28
	Paper-4.5	CHE-645-P	12057	Industrial Chemistry Practical	12	--	16	8	--	200	200	--	100
				Total (IV Semester)	**24**	**16**	**16**	**24**	**120**	**480**	**600**	**48**	**212**
				Grand Total (I + II + III + IV Semester)	**104**	**64**	**72**	**100**	**580**	**1920**	**2500**	**242**	**848**

Note: Value Added Courses (VAC) may be opted from Pool-A and Pool-B. List of the VAC for Pool-A and Pool-B is uploaded separately on the University website *i.e.* **www.uok.ac.in**.

University of Kota
Kota

Scheme of Examination of Value-Added Courses (VAC) of Chemistry for Pool-A and Pool-B
(as per NEP-2020 and CBCS)

VAC of Chemistry for Pool-A:

Semester (Year)	Code and Nomenclature of Paper		Duration of Exam. (in Hrs)	Teaching Hours / Week and Credits			Distribution of Assessment Marks			Minimum Pass Marks		
				Theory	Practical	Credits	Int. Assess.	Sem. Assess.	Total Marks	Int. Assess.	Sem. Assess.	Total Marks
II Semester (1st Year)	CHOI-A--	Analysis of Juices, Jams and Jellies	4	--	4	2	50	--	50	25	--	25
		Analysis of Edible Oils and Fats	4	--	4	2	50	--	50	25	--	25
		Analysis of Milk and Milk Products	4	--	4	2	50	--	50	25	--	25
		Analysis of Food and Food Products	4	--	4	2	50	--	50	25	--	25

VAC of Chemistry for Pool-B:

Semester (Year)	Code and Nomenclature of Paper		Duration of Exam. (in Hrs)	Teaching Hours / Week and Credits			Distribution of Assessment Marks			Minimum Pass Marks		
				Theory	Practical	Credits	Int. Assess.	Sem. Assess.	Total Marks	Int. Assess.	Sem. Assess.	Total Marks
III Semester (2nd Year)	CHOI-B--	Air Analysis	4	--	4	2	50	--	50	25	--	25
		Soil Analysis	4	--	4	2	50	--	50	25	--	25
		Water Analysis	4	--	4	2	50	--	50	25	--	25
		Drug Analysis	4	--	4	2	50	--	50	25	--	25

Note:

1. As per required facilities available in the Department/College to run the VAC, any one of the VAC of the chemistry of Pool-A and Pool-B may be offered by the concerned Department/College to the students of any discipline.
2. Theory part of the above-mentioned VAC of the chemistry shall be taught and thereafter practical work of these VAC shall be performed by the Teaching Departments as per the required infrastructure and/or facilities available in the Teaching Department.
3. Assessment of these VAC of the chemistry shall be made internally at Teaching Department level and marks will be uploaded on the University Examination Portal by the concern faculty member/teaching department.

Rules & Regulations

Programme Learning Objectives:

Chemistry is an important part of the science. It deals scientific study of properties and behavior of the matter. The chemistry occupies an intermediate position between physical and biological sciences. It is, sometimes, called the central science because it provides a foundation for understanding both basic and applied scientific disciplines at a fundamental level. On the basis of nature of study, the chemistry may be categorized in various branches like Inorganic Chemistry, Organic Chemistry, Physical Chemistry, Analytical Chemistry, Industrial Chemistry, Environmental Chemistry, Medicinal Chemistry, Pharmaceutical Chemistry, Biochemistry, Enzyme Chemistry, Protein Chemistry, Polymer Chemistry, Surface Chemistry, Geochemistry, Nano-chemistry, Green Chemistry, Forensic Science Chemistry, *etc*.

The existence of a large number of research organizations, institutions and industries including pharmaceutical, agrochemical, petrochemical, heavy & fine chemical, fertilizer, polymer, rubber, cement, glass & ceramic, dye & pigment, pulp & paper, soap & detergent, perfumery, sugar, textile, coal & mine industries as well as power plants necessitates deep chemistry education. Hence, our goal for introducing the M.Sc. Chemistry programme is to educate the chemistry students in an effective manner so that the chemistry professionals could be prepared to serve different fascinating fields of the chemistry. The major objectives of M.Sc. Chemistry programme are:

- To impart fundamental to advanced knowledge of all the branches of the chemistry.
- To develop deep understanding of experimentation, observation and data analysis suitable for any chemistry-based industry/institution/organization.
- To develop cognitive research skills to pursue higher education in the chemistry.
- To prepare chemistry professionals to serve different fascinating fields like colleges, universities, institutions, organizations, industries, *etc*.

Programme Learning Outcomes:

After completion of the M.Sc. Chemistry programme, students will be able to understand the theoretical and practical knowledge of chemistry, competent in solving scientific problems through experimental, computational and/or data analysis models, learn with modern analytical and spectroscopic tools and their applications, learn the interdisciplinary nature of chemistry and to integrate the knowledge with a variety of chemical problems, to learn, design and demonstrate sustainable chemical reactions within realistic constraints, work effectively both as an individual and as a collaborative team member, *etc*.

Programme Duration:

The duration for the degree of Master of Science in Chemistry shall be two academic years which are divided in to four equal semesters. Each semester consists of minimum 120 working days.

Eligibility for Admission in M.Sc. Chemistry First Semester:

A candidate who has passed any one of the following qualifying examinations with Chemistry as a major subject from any University recognized by the UGC shall be permitted to take admission in M.Sc. First Semester Chemistry to award M.Sc. degree in Chemistry with specialization in Inorganic Chemistry / Organic Chemistry / Physical Chemistry /

Analytical Chemistry / Industrial Chemistry from this University after completion of a course of study of two academic years divided in the four-semester scheme of examination:

- B.Sc. with Chemistry as a main subject of study, or
- B.Sc. with specialization in any branch of Chemistry such as Industrial Chemistry, Polymer Chemistry, Applied Chemistry, Pharmaceutical Chemistry, Medicinal Chemistry, Pharmaceutical Chemistry, Polymer Chemistry, *etc.* or
- Three / Four-year B.Sc. (Hons.) with Chemistry or with specialization in any branch of Chemistry such as Industrial Chemistry, Applied Chemistry, Medicinal Chemistry, Pharmaceutical Chemistry, Polymer Chemistry, *etc.* or
- Four-year Bachelor of Science and Technology (B.Sc.-Tech.) or Bachelor of Science and Education (B.Sc.-B.Ed.) with Chemistry as a paper.

Minimum Marks required in Qualifying Examination:

- ❖ Qualifying examination passed from any recognised University which is situated in Rajasthan State:
  - General Category = 55%.
  - SC / ST / OBC / SBC or MBC = Minimum Pass Marks
- ❖ Qualifying examination passed from any recognised University which is situated at outside the Rajasthan State:
  - All Categories = 60%.

Eligibility for Admission in M.Sc. Chemistry Third Semester:

A candidate may be promoted in the next academic session (odd semester *i.e.* III semester) if he/she has cleared collectively at least 50% of the papers of both semesters (semester I & II) of previous academic session with 50% of the aggregate marks. The candidate who does not fulfill the above condition will remain as an ex-student and will re-appear in the due papers' examinations along with next odd/even semester examinations.

A candidate who has passed B.Ed. examination as a regular course of study after completing first and second semester examinations from this University shall also be eligible to take admission in third semester examination as a regular candidate.

Criteria for Opting Specialization in M.Sc. Chemistry Third Semester:

In third semester, a student will have an option to choose any specialization (Inorganic Chemistry / Organic Chemistry / Physical Chemistry / Analytical Chemistry / Industrial Chemistry) subject to availability of the specialization and number of seats in a particular specialization as well as the required infrastructure and faculty members of that specialization in the Department. If number of candidates will be more than available seats in a particular specialization, the admission in the specialized course shall be given on the basis of merit (aggregate percentage of first and second semester examinations) after receiving the option forms from the students with preferences for all the available specializations.

Attendance:

Every teaching faculty, handling a course, shall be responsible for the maintenance of Attendance Register for candidates who have registered for the course. The teacher of the course must intimate the Head of the Department at least seven calendar days before the last instruction day in the semester about the attendance particulars of all students. Each student should earn 75% attendance in the courses of the particular semester failing which he or she will not be permitted to sit in the End-Semester Examinations. However, it shall be open to the authorities to grant exemption to a candidate who has failed to obtain the prescribed 75%

attendance for valid reasons and such exemptions should not under any circumstance be granted for attendance below 65%.

Paper Number, Code and Nomenclature:

The paper code for PG programme may be given by taking first three alphabets of the subject, following by the five numerical digits of examination code for a particular paper that subject and T/P alphabet. T and P correspond to theoretical nature and practical nature of the subject respectively. For example, if the subject is Chemistry, then the paper codes will be CHE12001T and CHE12002P for theory and practical paper respectively.

Programme Structure:

The Master of Science (M.Sc.) in Chemistry programme consists Discipline Centric Core (DCC) Courses/Papers and Discipline Specific Elective (DSE) Courses/Papers and Value-Added Courses (VAC) under Choice Based Credit System (CBCS) as per the details of the course structure given below:

S. No.	Nature of Paper / Course	Semesters Wise Papers/Course along with Credits of Theory and Practical Components				Total Credits
		I	II	III	IV	
1.	Discipline Centric Core (DCC) Course	Subject-I (4T = 4 Cr) Subject-II (4T = 4 Cr) Subject-III (4T = 4 Cr) Subject-IV (4T = 4 Cr) Subject-V (16P = 8 Cr)	Subject-I (4T = 4 Cr) Subject-II (4T = 4 Cr) Subject-III (4T = 4 Cr) Subject-IV (4T = 4 Cr) Subject-V (16P = 8 Cr)	Subject-I (4T = 4 Cr) Subject-II (4T = 4 Cr)	Subject-I (4T = 4 Cr) Subject-II (4T = 4 Cr)	**64**
2.	Discipline Specific Elective (DSE) Course	--	--	Subject-III (4T = 4 Cr) Subject-IV (4T = 4 Cr) Subject-V (16P = 8 Cr)	Subject-III (4T = 4 Cr) Subject-IV (4T = 4 Cr) Subject-V (16P = 8 Cr)	**32**
3.	Value Added Course (VAC)	--	VAC (4P = 2 Cr) (from Pool-A)	VAC (4P = 2 Cr) (from Pool-B)	--	**04**
Total Credits		**24**	**26**	**26**	**24**	**100**

Dissertation(s), project work(s), training(s), field work(s), industrial visit(s), *etc.* (which is/are approved by the concerned Department) may be performed/executed by the students in the government/public/private organization(s), institution(s), industry(ies), firm(s), enterprise(s), *etc.* for advanced learning and more practical exposures.

Maximum Marks and Credits:

Maximum marks of a theory and practical paper shall be decided on the basis of their contact hours / per week. One teaching hour per week shall equal to one credit and carry 25 maximum marks. Therefore, 4 teaching hours/week having 4 credit points shall carry 100 maximum marks for each theory paper/course. While two contact hours per week for a laboratory or practical work shall be equal to one credit point. Therefore, 16 contact hours / week shall equal to 8 credits and shall carry 200 maximum marks.

Teaching Methodologies:

The classroom teaching would be through conventional lectures or use of OHP or power point presentations (PPT) or any modern ICT tools. The lecture would be such that the student should participate actively in the discussion. Student seminars would be conducted and scientific discussions would also be arranged to improve their communicative skill. In the laboratory, instruction would be given for the experiments followed by demonstration and finally the students have to do the experiments individually. A special attention would be given to the slow learner students.

Assessment Pattern:

The assessment of the student shall be divided into two parts in which first part is continuous assessment/mid-term assessment/internal assessment (30% weightage of the maximum marks) and second part is semester assessment / end-term assessment / external assessment (70% weightage of the maximum marks).

(i) Continuous/Mid-Term/Internal Assessment:

(a) The continuous or mid-term or internal assessment for each theory paper shall be taken by the faculty members in the Department during each semester. Internal assessment part is further divided in two parts of equal weightage of marks as per the details given below:

Continuous Assessment	**Modes of Assessments**		**Max. Marks**
	Collegiate (Regular) Students	**Non-collegiate (Private) Students**	
Cont. Assess-I	Written Examination	Report Writing	20
Cont. Assess-II	Assignment / Project Report / Seminar / Presentation / Quiz / GD / Viva-voce	Viva-voce	10

Note: *In the Continuous/Mid-Term/Internal Assessment-I, written examination shall be of one hour duration for each theory paper and shall be taken according to the academic calendar which will be notified by the Department. Time duration for Continuous/Mid-Term/Internal Assessment-II is not allotted. It will be decided by the faculty member which will be taking second internal assessment.*

(b) For practical papers, there will not be continuous or mid-term or internal assessment. There will be only one external or end-term or semester assessment having 100% weightage of maximum marks.

(c) A student, who remains absent (defaulter) or fails or wants to improve the marks in the continuous or mid-term or internal assessment, may be permitted to appear in the desired paper(s) in same semester and one time only with the permission of the concern Head of the Department. Defaulter/improvement fee of Rupees 250/- per paper shall be taken from such candidates. Duly forwarded application of such student by the Head of the Department, who may permit the such candidates to appear in the continuous or mid-term or internal assessment after production of satisfactory evidence about the reason of his/her absence in the test(s) and deposition of the defaulter/improvement fee, shall be sent to the concerned teacher to take the continuous or mid-term or internal assessment of such candidates. A record of such candidates shall be kept in the Department.

(d) Regular attendance of the student shall be considered in the internal assessment. Marks (equal to 10% of internal assessment) may be given to the student(s) for

regularity who is/are taken classes regularly. If the attendance/regularity factor is similar for all the students, then weightage marks for regularity may be merged in the weightage of second internal assessment (seminar / presentation / assignment / dissertation / quiz / group discussion / viva-voce, *etc.*).

(e) Paper wise consolidated marks for each theory paper and dissertation / seminar (*i.e.* total marks obtained during various modes of internal assessment) obtained by the students (out of the 30% weightage of the maximum marks of each paper) shall be forwarded by the Head of the Department (in two copies) to the Controller of Examinations of the University within a week from the date of last internal assessment test for incorporation in the tabulation register.

(f) The consolidated marks obtained by the students be also made known to them before being communicated by the concerned Head of the Department to the University for final incorporation in the tabulation register. If any discrepancies are discovered or pointed out by the students, the same shall be looked into by the concerned faculty member and corrections made, wherever necessary. The decision of the Head of the Department before the communication of marks to the University shall be final. No corrections shall be made in the internal assessment marks after the declaration of the result by the University.

(g) Consolidated marks of internal assessment obtained out of the 30% weightage of maximum marks of each theory paper which will be communicated to the University shall be in whole number and not in fraction. Marks awarded for the various internal assessments in each paper shall be added up and then round off to the next whole number to avoid any fraction.

(h) All test copies and other material related to the internal assessment shall also be sent to the Controller of Examinations of the University to keep in record as per the University guidelines.

(i) The concerned Head of the Department shall be responsible for proper conduct of internal assessment tests and for communication of the consolidated marks to the University within the prescribed time.

(j) The Head of the Department shall keep a record of the marks and also notify the same to the candidates immediately so that if any candidate is not satisfied with the award in any test or seasonal work, he / she should represent the matter to the higher authority.

(ii) Semester/End-Term/External Assessment:

(a) The semester or end-term or external assessment (70% weightage of the maximum marks) shall be 03 hours duration to each theory paper and twelve hours duration (spread over two days with six hours per day) for each practical paper and shall be taken by the University at the end of each semester.

(b) The syllabus for each theory paper is divided into five independent units and question paper for each theory (70 Marks) will be divided into two sections as mentioned below:

- ***Section-A*** *will carry one compulsory question comprising 10 short answer type questions (answer about in 10-20 words) by taking two questions from each unit with no internal choice. Each short answer type question will have 2 marks and hence Section-A will carry total 20 marks.*

- ***Section-B*** *will carry 50 marks equally divided into five long answer type questions (answer about in 400-500 words) with one question from each unit with internal choice (another question will be given in option or question may be divided in to sub-divisions). Paper setter shall be advised to set one question from each unit along with one option of each question and students are instructed to attempt total five questions by selecting one question from each unit. Each long answer type question will have 10 marks and hence Section-B will carry total 50 marks*

(c) The syllabus of practical paper is divided according to main streams of chemistry including Inorganic Chemistry, Organic Chemistry, Physical Chemistry, Analytical Chemistry, Environmental Chemistry, Heterocyclic Chemistry, Medicinal Chemistry, Organic Synthesis, *etc.* as well as according to various types of industries. Marks shall be awarded on the basis of major & minor experiments, viva-voce, practical record, regularity factor, lab skills and maintain cleanness of the workplace.

Question Paper Pattern:

(A) Continuous/Mid-Term/Internal Assessment:

30% weightage of Maximum Marks (30 Marks out of 100 Maximum Marks).

For Collegiate (Regular) Students

(i) Continuous/Mid-Term/Internal Assessment-I:
(Max. Marks: 20)

Department of .....
University / College: .....
Address: .....

First Internal Assessment Test 20… - 20….
(Written Examination)

Name of Class/Course :	Max. Marks : 20 Marks
Name of Semester :	Duration of Exam. : 1.00 Hr
No. & Name of Paper :	Date of Exam. :

Q. No. 1. …… 05 Marks
or
……

Q. No. 2. …… 05 Marks
or
……

Q. No. 3. …… 05 Marks
or
……

Q. No. 4. …… 05 Marks
or
……

(ii) Continuous/Mid-Term/Internal Assessment-II: (Max. Marks: 10)

Department of .....
University / College: .....
Address .....

Second Internal Assessment Test 20… - 20….
(Seminar / Presentation / Project Report / Quiz / GD / Viva-voce)

Name of Class/Course:	Max. Marks : 10 Marks
Name of Semester :	Mode of Assessment:
No. & Name of Paper:	Date of Assessment :

Format for Compilation of Marks/Awards of Continuous / Mid-Term / Internal Assessment-I & II for Collegiate (Regular) Students

Department of .....
University / College: .....
Address .....

Name of Class/Course : .....
Name of Semester : .....
No. & Name of Paper : .....
Max. Marks : .....

S. No.	Name of Student	Father's Name	Marks Obtained			
			Internal Assessment-I (Written Examination)	Internal Assessment-II (Assignment / Project Report / Seminar / Presentation / Quiz / GD / Viva-voce)	Total Marks (in Figure)	Total Marks (in Words)
1.						

Name & Signature of the Faculty Member

For Non-collegiate (Private) Students

(i) Continuous/Mid-Term/Internal Assessment-I: (Max. Marks: 20)

Report Writing

Each private student of UG program will prepare a report on any topic of each course in minimum 1000 words from the prescribed syllabus of the concerned theory paper/course. The student needs to report the Concerned Department/College at the time prescribed by the College/University to submit the report and the College will arrange a Viva-voce on that report. It is proposed that the engaged teacher will be paid at the rate of per answer book per student charges. The examination section will generate an option of bill when the teacher fills the continuous assessment marks on examination portal (same as for external answer book evaluation). The various components of the report may be:

- Name of Course/Class :
- Name of Student :

- Father's/Husband Name :
- Examination Form No. :
- Enrolment No. :
- Name of College (Centre) :
- Name of Paper :
- Title of Topic :
- No. of Unit of Topic (as per prescribed syllabus):
- Introduction about the Topic :
- Details/Analysis about the Topic :
- Conclusion of the Topic :
- References :

(ii) Continuous/Mid-Term/Internal Assessment-II: (Max. Marks: 10)

Only Viva-voce will be taken by the concerned faculty member at Department level.

Format for Compilation of Marks/Awards of Continuous / Mid-Term / Internal Assessment-I & II for Non-collegiate (Private) Students

Department of .....
University / College: .....
Address .....

Name of Class/Course : .....
Name of Semester : .....
No. & Name of Paper : .....
Max. Marks : .....

S. No.	Name of Student	Father's Name	Marks Obtained			
			Internal Assessment-I (Report Writing)	Internal Assessment-II (Viva voce)	Total Marks (in Figure)	Total Marks (in Words)
1.						

Name & Signature of the Faculty Member

(B) Semester/End-Term/External Assessment:

70% weightage of Maximum Marks (70 Marks out of 100 Maximum Marks).

Question Paper Pattern for Semester Examination

[Common for Collegiate (Regular) and Non-collegiate (Private) Students]

Duration of Examination: 3 Hours **Max. Marks: 70**

Note: *The syllabus is divided into five independent units and question paper will be divided into two sections:*

- ***Section-A*** *will carry one compulsory question comprising 10 short answer type questions (answer about in 10-20 words) by taking two questions from each unit with no internal choice. Each short answer type question will have 2 marks and hence Section-A will carry total 20 marks.*

- ***Section-B*** *will carry 50 marks equally divided into five long answer type questions (answer about in 400-500 words) with one question from each unit with internal choice (another question will be given in option or question may be divided in to sub-divisions). Paper setter shall be advised to set one question from each unit along with one option of each question and students are instructed to attempt total five questions by selecting one question from each unit. Each long answer type question will have 10 marks and hence Section-B will carry total 50 marks.*

Section-A

Q. No. 1: Comprising 10 Short Answer Type Questions

Unit-I

(i) …… 02 Marks
(ii) …… 02 Marks

Unit-II

(iii) …… 02 Marks
(iv) …… 02 Marks

Unit-III

(v) …… 02 Marks
(vi) …… 02 Marks

Unit-IV

(vii) …… 02 Marks
(viii) …… 02 Marks

Unit-V

(ix) …… 02 Marks
(x) …… 02 Marks

Section-B

Unit-I

Q. No. 2: …….. 10 Marks

Or

……

Unit-II

Q. No. 3: …….. 10 Marks

Or

……

Unit-III

Q. No. 4: …….. 10 Marks

Or

……

Unit-IV

Q. No. 5: …….. 10 Marks

Or

……

Unit-V

Q. No. 6: …….. 10 Marks

Or

……

Practical/Project Work Examinations:

Continuous/Mid-Term/Internal Assessment:

Not applicable in Practical/Project Examinations.

Practical Work:

Duration of Exam: 12 Hours (6 Hrs. per Day) **Maximum Marks: 200**

Distribution of Maximum Marks:

S. No.	Name of Exercise	Marks
1.	Exercise No. 1: Major Experiment	30
2.	Exercise No. 2: Major Experiment	30
3.	Exercise No. 3: Major Experiment	30
4.	Exercise No. 4: Minor Experiment	15
5.	Exercise No. 5: Minor Experiment	15
6.	Exercise No. 6: Minor Experiment	15
7.	Practical Record	15
8.	Laboratory Skills, Regularity Practicals, *etc.*	10
9.	Comprehensive Viva-voce	40
	Total Marks	**200**

Project Work:

The project work may also be undertaken in place of the practical work in the last semester of the M.Sc. Chemistry programme, if necessary infrastructural facilities as well as faculty members are available in the Department of the University or its affiliated colleges. The project work shall be based on experiments or hands-on-trainings. For this purpose, the students will be allotted to the faculty members to carry out the experiments, hands-on-trainings, *etc.* during the last semester of the M.Sc. Chemistry. A dissertation / project completion report has to be submitted by each student in the given prescribed format along with plagiarism report. The dissertation / project completion report will be evaluated and a comprehensive viva-voce will also be taken by the panel of examiners provided by the University. A presentation will also be made by each student to present the project work briefly at the time of comprehensive viva-voce. Marks/grade will be given to the student by the panel of examiners.

Format for Dissertation/Project Completion Report

Title Page
Bonafide Certificate
Dissertation Work Page No

1. Introduction …
2. Review of Literature …
3. Materials and Methods …
4. Results and Discussion …
5. Summary …
6. Conclusion …
7. References …
8. Publication, if any …

Acknowledgement

Format of the Cover Page and Title Page

-------TITLE OF THE DISSERTATION / PROJECT REPORT-------

A Dissertation / Project Report

Submitted in part fulfilment of the requirement for the award of the Degree of

Master of Science in …….
with specialization in …….

of the **University of Kota, Kota**

Submitted by
(**Name and Enrolment Number of Student**)

Submitted to
(Name of Supervisor / Mentor)
(Designation)
Department of ……..
(Name of College, if any)
University of Kota
Kota
(Month, Year)

Format for Bonafide Certificate

CERTIFICATE

This is to certify that the dissertation / project report entitled ″----------″ submitted in part fulfilment of the requirement of the degree of Master of Science in Chemistry with specialization in ---------- to the University of Kota is a record of bonafide research work carried out by ---------- under my supervision and guidance and that no part of the dissertation has been submitted for the award of any degree, diploma, fellowship or other similar titles or prizes and that the work has not been published in part or full in any scientific or popular journals or magazines in India or abroad.

Date:	Signature	Signature
Place:	(Student)	(Supervisor / Mentor)

Distribution of Maximum Marks of Project Work:

S. No.	Name of Exercise	Marks
1.	Submission of Dissertation / Project Report	100
2.	Presentation of Dissertation / Project Report	50
3.	Comprehensive Viva-voce	50
	Total Marks	**200**

Minimum Pass Marks and Rules regarding Determination of Results:

Each semester shall be regarded as a unit for working out the result of the candidates. The result of each semester examination shall be worked out separately (even if the candidate has appeared at the paper(s) of the lower semester examination along with the papers of higher semester examination) in accordance with the following conditions:

(i) A candidate, for a semester examination, shall be offered all the papers prescribed for that semester examination and besides he/she also shall be offered paper(s) not cleared by him/her at any of the lower semester examination subject to the limitation that the number of un-cleared papers of the lower semester examinations shall not be exceed the total number of the papers prescribed for any one semester.

(ii) The candidate shall be declared to have passed the examination, if the candidate secures at least 40% marks in each theory paper separately in continuous or internal or mid-term examination & semester or external or end-term examination and 50% marks in each practical / project / dissertation / seminar with 50% aggregate marks of the maximum marks prescribed for each semester examination. There are no minimum pass marks for the practical record / notebook. However, submission of a practical record / notebook is a mandatory during the practical examination. The candidate should compulsorily attend viva-voce / presentation examination to secure pass in practical / project / dissertation / seminar.

(iii) A candidate, who has been declared as failed/absent in one or more theory paper(s) at any odd semester examination shall be permitted to join the courses of study for the next higher semester *i.e.* permitted to join the course of second semester after first semester examination, permitted to join the course of fourth semester after third semester examination, permitted to join the course of sixth semester after fifth semester examination and so on and eligible to re-appear in that paper(s) as due paper(s) along with next higher semester (next year) examination provided that he/she must have cleared at least 50% of the papers (including practical / project / dissertation / seminar as one paper) collectively prescribed for the first and second semester examinations taken together for promotion to the third semester examination.

(iv) A candidate may be promoted in the next semester (odd semester) if he/she has cleared collectively at least 50% of the papers of both semesters of previous academic session with 50% of the aggregate marks. The candidate who does not fulfill this condition will remain in the same semester as an ex-student and will re-appear in the due papers' examination along with next odd/even semester examinations.

(v) If any student who is provisionally admitted in higher odd semester but could not secure prescribed minimum marks in previous semesters will be treated as ex-student and his/her admission fee will be carry forwarded to the next odd semester of forthcoming academic session.

(vi) A candidate declared as failed in that particular paper he/she can re-appear for that paper in the next year examination as a due paper. However, the internal marks shall be carried forward for the total marks of the due examination.

(vii) A candidate may be given only two additional chances for passing the semester thus maximum tenure for completing the two years' postgraduate course will be limited to four years, for three years postgraduate programme up to five years and so on.

(viii) If the number of papers prescribed at the first and second or third and fourth semester examination is an odd number, it shall be increased by one for the purpose of reckoning 50% of the papers.

(ix) A candidate who passes in 50% or more papers of the first and second semester examination, and thereby becomes eligible for admission to the third semester examination, but chooses not to do so and desires to appear in the remaining papers of first and second semester examination only or to re-appear in all the prescribed papers and practical/dissertation/seminar of the M.Sc. first and second semester examination will be permitted to do so on the condition that in the latter case his previous performance will be treated as cancelled.

(x) If a candidate, who has been promoted to the next semester and wishes to improve his / her performance in the theory paper(s) of previous semester, can be permitted to do so in case of the theory papers only, not in practical / project / dissertation / seminar, belonging to the immediately preceding semester only for one time in these papers in next odd/even semester examinations. In such a case, he/she shall have to appear in these papers along with the papers of his/her own semester.

(xi) A candidate shall be declared as passed after the result of the fourth semester examination, if he/she cleared all papers of the all the four semesters and secure minimum 40% of the aggregate marks of the maximum marks in theory papers and 50% of the aggregate marks of the maximum marks for practical / dissertation / presentation / seminar prescribed for four semesters Master's programme.

(xii) In the case of an ex-student, the marks secured by him/her at his/her last examination as a regular candidate shall be taken into account except in cases where a candidate is re-appearing at the examination as a regular student and in that event, he/she shall have to repeat the internal assessment test which will be finally accounted for working out his result.

(xiii) A candidate who has failed at the M.Sc. third and fourth semester examination but has passed in at least 50% of the papers prescribed for the examination shall be exempted from re-appearing in a subsequent year in the papers in which he/she has passed.

(xiv) If a candidate clears any paper(s) prescribed at the first and second semester (previous) and/or third and fourth semester (final) examination after a continuous period of three years, then for the purpose of working out his/her division, only the minimum pass marks shall be taken into account in respect of such paper(s) as are cleared after the aforesaid period provided that in case where a candidate requires more than 40% marks in order to reach the requisite minimum aggregate, as many marks out of those secured by him/her will be taken in to account as would enable him/her to make up the deficiency in the requisite minimum aggregate.

(xv) In case the candidate is not able to clear his/her due paper(s) in the stipulated period as mentioned above (continuous period of three years), he/she may be given last one mercy attempt to clear due paper(s) subjected to approval of the Vice Chancellor or Board of Management.

(xvi) The grace marks scheme shall be applicable as per the university norms.

Classification of Successful Candidates:

(a) Each student shall be awarded a final letter grade at the end of the semester of the particular course. The letter grades and their corresponding grade points are given as:

Percentage of Marks Obtained	Performance	Grade Letter	Grade Point
90.00 – 100.00	Outstanding	O	10
80.00 – 89.99	Excellent	A^+	9
70.00 – 79.99	Very Good	A	8
60.00 – 69.99	Good	B^+	7
50.00 – 59.99	Above Average	B	6
45.00 – 49.99	Average	C	5
40.00 – 45.99	Below Average / Pass	P	4
00.00 – 39.99	Fail	F	0
--	Absent	AB	0
--	Unfair Means	UM	0
--	Withdrawn	W	0

(b) A candidate who remains absent for any semester examination shall be assigned a letter grade AB along with corresponding grade point zero. He/she will have to re-appear for the said examination in due paper/course.

(c) Semester Grade Point Average (SGPA): Performance of a student in a semester is indicated by a number called 'Semester Grade Point Average' (SGPA). The SGPA is the weighted average of the grade points obtained in all the courses by the student during the semester. For example, if a student takes five papers (theory/practical) in a semester with credits C_1, C_2, C_3, C_4 and C_5 and the student's grade points in these courses are P_1, P_2, P_3, P_4 and P_5 respectively, then students' SGPA is calculated as:

$$SGPA = \frac{C_1P_1 + C_2P_2 + C_3P_3 + C_4P_4 + C_5P_5}{C_1 + C_2 + C_3 + C_4 + C_5} = \frac{\sum_{i=1}^{n} C_iP_i}{\sum_{i=1}^{n} C_i}$$

Where:

C_i: Number of credits earned in the ith paper/course of semester for which SGPA is to be calculated.

P_i: Grade point earned in i^{th} paper/course.

i = 1, 2, 3, 4, …….. n : Represents the number of papers/courses in which a student has appeared in End of Semester Evaluation (EoSE).

The SGPA is calculated, as per example given below, up to two decimal points:

Paper/Course	Credit (C)	Grade Letter	Grade Point (P)	Credit Point (CP)	SGPA
Inorganic Chemistry	4	A	8	4 x 8 = 32	= ΣCP/ΣC
Organic Chemistry	4	B^+	7	4 x 7 = 28	
Physical Chemistry	4	A	8	4 x 8 = 32	= 184/24
Maths. for Chemists	4	B^+	7	4 x 7 = 28	
Chemistry Practical	8	A	8	8 x 8 = 64	
Total	**24**	**--**	**--**	**184**	= **7.66**

It should be noted that, the SGPA for any semester shall take into consideration the F and AB grade awarded in that semester. For example, if a student has a F or AB grade in paper/course 4, the SGPA shall then be computed as:

$$SGPA = \frac{C_1P_1 + C_2P_2 + C_3P_3 + C_4 \text{ x ZERO} + C_5P_5}{C_1 + C_2 + C_3 + C_4 + C_5}$$

(d) Cumulative Grade Point Average (CGPA): The CGPA is calculated with the SGPA of all the semesters up to two decimal points and is indicated in final grade report card / final transcript showing the grades of all the semesters and their papers/courses. The CGPA shall reflect the failed status in case of F grade(s), till the paper(s)/course(s) is/are passed. When the paper(s)/course(s) is/are passed by obtaining a pass grade on subsequent examination(s), the CGPA shall only reflect the new grade and not the fail grades earned earlier. The CGPA is calculated as:

$$CGPA = \frac{C_1S_1 + C_2S_2 + C_3S_3 + C_4S_4 + C_5S_5 + C_6S_6}{C_1 + C_2 + C_3 + C_4 + C_5 + C_6} = \frac{\sum_{i=1}^{n} C_i S_i}{\sum_{i=1}^{n} C_i}$$

Where:
C_1, C_2, C_3, … is the total number of credits for I, II, III, …. Semesters and S_1, S_2, S_3, … is the SGPA of I, II, III, …. Semesters.

The CGPA is calculated, as per example given below, up to two decimal points:

Semester	**Credit (C)**	**SGPA**	**C x SGPA (CS)**	**CGPA**
Semester-I	24	7.66	24 x 7.30 = 183.84	= ΣCP/ΣC
Semester-II	26	7.69	26 x 7.69 = 199.94	
Semester-III	26	7.23	26 x 7.23 = 187.98	= 760.40/100
Semester-IV	24	7.86	24 x 7.86 = 188.64	
Total	**100**	**--**	**760.40**	= **7.60**

(e) The classification of successful candidates after last semester examination shall be as under:

Description of Marks Obtained	**Division / Result**	**CGPA**
• 75% and above marks in a paper with Distinction	First Class with Distinction	CGPA 7.50 and above
• A candidate who has secured aggregate 60% and above marks	First Class/Division	CGPA 6.00 to 7.49
• A candidate who has secured aggregate 50% and above but less than 60% marks	Second Class/Division	CGPA 5.00 to 5.99
• A candidate who has secured aggregate 40% and above but less than 50% marks	Pass	CGPA 4.00 to 4.99
• A candidate who has secured aggregate below to the 40% marks	Fail	CGPA below 4.00

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Syllabus

M. Sc. Chemistry
Third Semester Examination

Paper-3.1 and 3.2: Common Papers for all Specializations
(Inorganic Chemistry, Organic Chemistry, Physical Chemistry, Analytical Chemistry and Industrial Chemistry)

Paper-3.1: CHE-631-T (12021): Chromatography
(Common Paper for all Specializations)

Contact Hours / Week	: 4 Hours	Total Maximum Marks	: 100 Marks
Duration of Examination	: 3 Hours	Continuous Assessment	: 30 Marks
		Semester Assessment	: 70 Marks

Note: *The syllabus is divided into five independent units and question paper will be divided into two sections:*

- ***Section-A*** *will carry one compulsory question comprising 10 short answer type questions (answer about in 10-20 words) by taking two questions from each unit with no internal choice. Each short answer type question will have 2 marks and hence Section-A will carry total 20 marks.*
- ***Section-B*** *will carry 50 marks equally divided into five long answer type questions (answer about in 400-500 words) with one question from each unit with internal choice (another question will be given in option or question may be divided in to sub-divisions). Paper setter shall be advised to set one question from each unit along with one option of each question and students are instructed to attempt total five questions by selecting one question from each unit. Each long answer type question will have 10 marks and hence Section-B will carry total 50 marks.*

Unit-I: General Introduction of Separation: 12-15 L

Nature of separation process, classification of separation methods.

Chromatography:

General introduction, principles and types, physical sate of mobile phase, mechanism and techniques involved in separation.

Paper Chromatography:

Principle, types, choice of paper and solvent, location of spot, development, visualization, measurement of R_f values, applications.

Unit-II: Thin Layer Chromatography (TLC): 12-15 L

Principle, advantage over paper chromatography, types, preparation of thin layer, choice of sorbent and solvent, development, detection and applications.

High Performance Thin Layer Chromatography (HPTLC):

Principle, advantage over TLC, instrumentation, choice of sorbent and solvent, development, detection and applications.

Unit-III: Column Chromatography (CC): 12-15 L

Principle, resolution, stationary phase, column efficiency, factors influencing column efficiency, experimental set up and applications; principle and application of flash chromatography.

Gas Chromatography (GC):

Principle, instrumentation, column efficiency, solid supports, liquid phase, column temperature, detectors, chromatographic identification, multi-dimensional GC, fast GC, applications.

Unit-IV: High Performance Liquid Chromatography (HPLC): 12-15 L

Principle, instrumentation, identification of peaks, effect of temperature and packing material, types of HPLC: partition, adsorption, ion-exchange, size-exclusion or gel; derivatization in HPLC: post and pre-columns, applications.

Ion-Exchange or Ion Chromatography (IC):

Principle, types, regeneration, ion-exchange resins and their capacity, retention, selectivity, factors affecting separation, bonded phase chromatography (BPC), high performance ion chromatography (HPIC), applications.

Unit-V: Electrophoresis: 12-15 L

Theory and classification, factors affecting mobility, electrophoresis phenomena: electrolysis, electro-osmosis, temperature and supporting media; instrumentation, methodology, preparation of gel-staining and de-staining, preparative zone electrophoresis, continuous electrophoresis, applications.

Capillary Electrophoresis (CE):

Principle, theory, instrumentation, sample preparation and applications, capillary electro-chromatography and micellar electro-kinetic capillary chromatography.

Books:

- *Chromatography: Basic Principles, Sample Preparations and Related Methods by Elsa Lundanes, Leon Reubsaet, Tyge Greibrokk, John Wiley and Sons*
- *Introduction to Modern Liquid Chromatography by Lloyd R. Snyder, Joseph J. Kirkland and John W. Dolan, Wiley*
- *Practical HPLC Method Development by Lloyd R. Snyder, Wiley-Interscience*
- *Principles & Practices of Chromatography by R. P. W. Scott, Library for Science*
- *Fundamentals of Analytical Chemistry, VIII Edn., D. A. Skoog, D. M. West, F.J. Holler and S.R. Crouch, Thomson Brooks/Cole Publishers.*
- *Principles of Instrumental Analysis by D.A. Skoog, F.J. Holler and T.A. Nieman, 5th Edition, Harcourt Brace & Company, Florida.*
- *Instrumental Methods of Chemical Analysis, B. K. Sharma, Goel Publishing House, Meerut.*
- *Instrumental Methods of Chemical Analysis, Chatwal and Anand, Himalaya Publishing House, Meerut.*
- *Basic Gas Chromatography 2nd Edition by Harold M. McNair, James M. Miller, John Wiley and Sons.*
- *Comprehensive two-dimensional gas chromatography, Volume 55 (Comprehensive Analytical Chemistry) by Lourdes Ramos, Elsevier*
- *Analytical Gas Chromatography 2nd Edition by Phillip Stremple, Elsevier*
- *Electrophoresis by Duncan J. Shaw. Academic Press*
- *Gel Electrophoresis-Advanced Techniques Edited by Sameh Magdeldin. InTech.*
- *Capillary Electrophoresis Guidebook: Principles, Operation, and Applications by Kevin D. Altria. Springer Science & Business Media.*

Paper-3.2: CHE-632-T (12022): Spectroscopy

(Common Paper for all Specializations)

Contact Hours / Week	: 4 Hours	Total Maximum Marks	: 100 Marks
Duration of Examination	: 3 Hours	Continuous Assessment	: 30 Marks
		Semester Assessment	: 70 Marks

Note: *The syllabus is divided into five independent units and question paper will be divided into two sections:*

- ***Section-A*** *will carry one compulsory question comprising 10 short answer type questions (answer about in 10-20 words) by taking two questions from each unit with no internal choice. Each short answer type question will have 2 marks and hence Section-A will carry total 20 marks.*
- ***Section-B*** *will carry 50 marks equally divided into five long answer type questions (answer about in 400-500 words) with one question from each unit with internal choice (another question will be given in option or question may be divided in to sub-divisions). Paper setter shall be advised to set one question from each unit along with one option of each question and students are instructed to attempt*

total five questions by selecting one question from each unit. Each long answer type question will have 10 marks and hence Section-B will carry total 50 marks.

Unit-I: Ultraviolet-Visible (UV-VIS) Spectroscopy: 12-15 L

Electromagnetic radiation and spectroscopy, principles of absorption spectroscopy, nature of electronic excitations, chromophores, auxochromes, origin of UV bands, types of absorption bands, factors affecting the position of UV bands, calculation of λ_{max} of simple organic compounds, visible spectra, qualitative and quantitative applications.

Infrared (IR) Spectroscopy:

IR regions, molecular vibrations, force constant and bond strengths, calculation of vibrational frequencies, Fermi resonance, combination bands, overtones, hot bands, factors affecting the band positions and intensities, sample handling, anharmonicity, group frequencies, applications.

Unit-II: Nuclear Magnetic Resonance (NMR) Spectroscopy: 12-15 L

Nuclear angular momentum, nuclear spin, magnetization & nuclear precession, types of NMR spectrometers, free induction decay, population densities of nuclear spin states, basic theory, equivalent & non-equivalent protons, shielding and de-shielding of nuclei, chemical shift and its measurements, factors affecting chemical shift, spin-spin interactions: theory, types, factors affecting coupling constant "J". typical ^{1}H NMR absorption signals of various type of compounds. spin systems & classification of spectra, splitting patterns of AB and AX; A_2B_2 and A_2X_2, ABX and AMX spin systems. simplification of spectra: shift reagents and spin decoupling; proton exchange, nuclear Overhauser effect, applications of NMR spectroscopy.

Unit-III: Carbon-13 NMR Spectroscopy: 12-15 L

Carbon-13 nucleus, operating frequency, chemical shifts and their calculation, factors affecting chemical shifts, spin-spin coupling, proton-coupled, proton-decoupled and off-resonance carbon-13 spectra. applications of ^{13}C NMR spectroscopy.

Electron Spin Resonance (ESR) Spectroscopy:

Basic principle, zero field splitting and Kramer's degeneracy, factors affecting the 'g' value, hyperfine splitting, isotropic and anisotropic hyperfine coupling constants, spin-orbit coupling, significance of g-tensor, spin Hamiltonian, spin densities and McConnell relationship, measurement techniques and applications.

Unit-IV: Mass Spectrometry: 12-15 L

Basic principle, production of ions by electron impact, chemical ionization and field desorption techniques, separation and detection of ions. mass spectrum: molecular ion peak, base peak, isotopic peak, metastable peak; fragmentation patterns of organic molecules with examples of various classes of compounds, McLafferty rearrangement, factors affecting the fragmentation pattern and governing the reaction pathways, identification of molecular ion peaks, determination of molecular weight and molecular formula of compounds, hydrogen deficiency index, nitrogen rule, negative ion mass spectrometry, brief introduction to high resolution mass spectrometry (HRMS) and combined or hyphenated techniques likes GC-MS and LC-MS; applications mass spectrometry.

Unit-V: Structure Elucidation: 12-15 L

Structure elucidation of organic compounds by using analytical data including CHNS/O percentage and spectral data (UV, IR, NMR, MS, *etc.*) including organic reaction sequences.

Books:

- *Encyclopedia of Spectroscopy and Spectrometry, Three-Volume Set: Encyclopedia of Spectroscopy and Spectrometry, Second Edition: 3 volume set*
- *NMR Spectroscopy: Basic Principles, Concepts, and Applications in Chemistry, Harald Günther, Wiley; 2e, 1995.*
- *Carbon-13 NMR spectroscopy, Hans-Otto Kalinowski, Stefan Berger, Siegmar Braun, Wiley, 1988.*
- *Introduction to Spectroscopy, Donald L. Pavia, Cengage Learning, 2009*
- *Organic Structure Determination Using 2-D NMR Spectroscopy: A Problem-Based Approach, Jeffrey H. Simpson, Academic Press, 2008.*
- *High-Resolution NMR Techniques in Organic Chemistry, Timothy D. W. Claridge, Elsevier, 1999*
- *Identification of Organic Compounds, R. M. Silverstein, G. C. Hassler and T. C. Morill, John Wiley.*
- *Organic Spectroscopy, Jag Mohan, Narosa Publication.*
- *Spectroscopy of Organic Compounds, P. S. Kalsi, New Age International.*
- *NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R. V. Parish, Ellis Harwood.*
- *Physical Methods in Chemistry, R. S. Drago, Saunders College.*
- *Introduction to Magnetic Resonance, A. Carrington and A. D. Maclachalan, Harper & Row.*
- *LC/MS: A Practical User's Guide by Marvin McMaster, Wiley-Interscience*
- *Gas Chromatography and Mass Spectrometry: A Practical Guide, Second Edition by O. David Sparkman, Academic Press.*
- *Instrumental Methods of Chemical Analysis, Gurdeep Raj Chatwal and Shyam Anand, Himalaya Publications.*

Paper-3.3, 3.4 and 3.5: Specialization wise Papers

(Inorganic Chemistry, Organic Chemistry, Physical Chemistry, Analytical Chemistry and Industrial Chemistry)

Group-I: Inorganic Chemistry Specialization

Paper-3.3: CHE-633-T (12023): Bio-inorganic Chemistry

(Only for Inorganic Chemistry Specialization)

Contact Hours / Week	: 4 Hours	Total Maximum Marks	: 100 Marks
Duration of Examination	: 3 Hours	Continuous Assessment	: 30 Marks
		Semester Assessment	: 70 Marks

Note: *The syllabus is divided into five independent units and question paper will be divided into two sections:*

- ***Section-A*** *will carry one compulsory question comprising 10 short answer type questions (answer about in 10-20 words) by taking two questions from each unit with no internal choice. Each short answer type question will have 2 marks and hence Section-A will carry total 20 marks.*
- ***Section-B*** *will carry 50 marks equally divided into five long answer type questions (answer about in 400-500 words) with one question from each unit with internal choice (another question will be given in option or question may be divided in to sub-divisions). Paper setter shall be advised to set one question from each unit along with one option of each question and students are instructed to attempt total five questions by selecting one question from each unit. Each long answer type question will have 10 marks and hence Section-B will carry total 50 marks.*

Unit-I: Metal Ions in Biological Systems: 12-15 L

Bulk and trace metals with special reference to Na, K, Mg, Ca, Fe, Cu, Zn and Co.

K^+/Na^+ pump: role of metal ions in biological processes.

Bioenergetics and ATP Cycle: DNA polymerization, glucose storage, metal complexes in transmission of energy; chlorophylls, photosystem-I and photosystem-II in cleavage of water.

Nitrogen fixation: Biological nitrogen fixation, and its mechanism, nitrogenase, Chemical nitrogen fixation.

Unit-II: Transport and Storage of Dioxygen: 12-15 L

Heam proteins and oxygen uptake structure and function of haemoglobin, myoglobin, haemocyanin and hemerythrin, model synthetic complexes of iron, cobalt and copper. **Electron Transfer in Biology:** Structure and function of metal of proteins in electron transport, processes cytochromes and ion-sulphur proteins, synthetic models.

Unit-III: Metal Storage and Transport and Biomineralization: 12-15 L

Ferritin, transferrin and siderophores.

Calcium in Biology: Calcium in living cells, transport and regulation, molecular aspects of intra-molecular processes, extracellular binding proteins.

Metal-Nucleic Acid Complexes: Metal ions and metal complex interactions. Metal complex nucleic acids.

Unit-IV: Metalloenzymes: 12-15 L

Zinc enzymes: carboxypeptidase and carbonic anhydrase. Iron enzymes-catalase, peroxidase and cytochrome P-450. Copper enzymes-superoxide dismutase. Molybdenum oxatransferase enzymes-xanthine oxidase. Coenzyme vitamin B_{12}.

Unit-V: Metals in Medicine: 12-15 L

Metal deficiency and disease, toxic effects of metals, metals used for diagnosis and chemotherapy with particular reference to anticancer drugs.

Books:

- *Principles of Bioinorganic Chemistry. S.J. Lippard and J.M. Berg University Science Books.*
- *Bioinorganic Chemistry, I Bertini, H.B. Gray. S.J. Lippard and J.S. Valentine, University Sci. Books.*
- *Inorganic Biochemistry Vols I and II Ed. G.L. Eichhorn, Elsevier.*
- *Progress in Inorganic Chemistry Vols. 18 G.L. Eichhorn, Elsevier and 38 Ed J.J. Lippard Wiley.*

Paper-3.4: CHE-634-T (12024): Photo-inorganic Chemistry

(Only for Inorganic Chemistry Specialization)

Contact Hours / Week	: 4 Hours	Total Maximum Marks	: 100 Marks
Duration of Examination	: 3 Hours	Continuous Assessment	: 30 Marks
		Semester Assessment	: 70 Marks

Note: *The syllabus is divided into five independent units and question paper will be divided into two sections:*

- ***Section-A*** *will carry one compulsory question comprising 10 short answer type questions (answer about in 10-20 words) by taking two questions from each unit with no internal choice. Each short answer type question will have 2 marks and hence Section-A will carry total 20 marks.*
- ***Section-B*** *will carry 50 marks equally divided into five long answer type questions (answer about in 400-500 words) with one question from each unit with internal choice (another question will be given in option or question may be divided in to sub-divisions). Paper setter shall be advised to set one question from each unit along with one option of each question and students are instructed to attempt total five questions by selecting one question from each unit. Each long answer type question will have 10 marks and hence Section-B will carry total 50 marks.*

Unit-I: Basic of Photochemistry: 12-15 L

Absorption, excitation, photochemical laws, quantum yield, electronically excited states-life times, measurements of the times. Flash photolysis stopped flow techniques. Energy dissipation by radiative and non-radiative processes, absorption spectra, Frank-Condon principle, photochemical stages-primary and secondary processes.

Unit-II: Properties of Excited States: 12-15 L

Structure, dipole moment, acid-base strengths, reactivity. Photochemical kinetics-calculation of rates of radiative processes. Bimolecular deactivation-quenching.

Unit-III: Excited States of Metal Complexes: **12-15 L**

Comparison with organic compounds, electronically excited states of metal complexes, charge transfer spectra, charge transfer excitations, methods for obtaining charge-transfer spectra.

Metal Complex Sensitizers:

Metal complex sensitizers, electron relay, metal colloid systems, semiconductor supported metal or oxide systems, water photolysis, nitrogen fixation and carbon dioxide reduction.

Unit-IV: Ligand Field Photochemistry: **12-15 L**

Photo-substitution, photo-oxidation and photo-reduction, lability and selectivity, zero vibrational levels of ground state and excited state, energy content of excited state, zero-zero spectroscopic energy, development of the equations for redox potentials of the excited states.

Unit-V: Redox Reactions by Excited Metal Complexes: **12-15 L**

Energy transfer under conditions of weak interaction and strong interaction-exciplex formation; condition of the excited states to be useful as redox reactants, excited electron transfer, metal complexes as attractive candidates, (2,2-bipyridine and 1,10-phenanthroline complexes), illustration of reducing and oxidizing character of Ru^{+2}(bipyridal complex, comparison with $Fe(bipy)_3$; role of spin-orbit coupling-life time of these complexes. Application of redox processes of electronically excited states for catalytic purposes, transformation of low energy reactants into high energy products, chemical energy into light.

Books:

- *Concepts of Inorganic Photochemistry, A.W. Adamson and P.D. Fleischauer, Wiley.*
- *Inorganic Photochemistry, J. Chem. Educ. vol. 60 No. 10, 1983.*
- *Progress in Inorganic Chemistry, Vol. 30ed. S.J. Lippard. Wiley.*
- *Coordination Chem. Revs. 1981, vol. 39, 121, 131; 1975, 15, 321; 1990 97, 313.*
- *Photochemistry of Coordination Compounds, V. Balzari and V. Carassiti, Academic Press.*
- *Elements in Inorganic Photochemistry, G.J. Ferraudi, Wiley.*

Paper-3.5: CHE-635-P (12025): Inorganic Chemistry Practical

(Only for Inorganic Chemistry Specialization)

Contact Hours / Week : 16 Hours
Duration of Examination: 12 Hours (6 Hrs. per Day) **Maximum Marks:** 200 Marks

Distribution of Marks:

S. No.	Name of Exercise	Marks
1.	Exercise No. 1: Major Experiment	30
2.	Exercise No. 2: Major Experiment	30
3.	Exercise No. 3: Major Experiment	30
4.	Exercise No. 4: Minor Experiment	15
5.	Exercise No. 5: Minor Experiment	15
6.	Exercise No. 6: Minor Experiment	15
7.	Practical Record	15
8.	Good Laboratory Skills and Regularity in Practicals	10
9.	Comprehensive Viva-voce	40
	Total Marks	**200**

Quantitative Analysis:

Analysis of a three-component mixture of metal ions by gravimetrically and volumetrically:

- Cu^{2+}, Ni^{2+}, Zn^{2+}
- Cu^{2+}, Ni^{2+}, Ag^{+}
- Cu^{2+}, Ni^{2+}, Mg^{2+}
- Cu^{2+}, Ag^{+}, Fe^{2+}
- Ni^{2+}, Zn^{2+}, Fe^{2+}

Inorganic Preparations:

Preparation of selected inorganic compounds and their study by IR, electronic, Mossbauer, ESR and magnetic susceptibility measurements. Handling of air and moisture sensitive compounds involving vacuum lines. Selection can be made from the following:

- $Na_3[Co(ONO)_6]$
- $[CoCl(NH_3)_5]Cl_3$
- TiO $(C_9H_8NO)_2 2H_2O$
- $Na[Cr(NH_3)_2(SCN)_4]$
- $[Co(NH_3)_6]$ $[Co(NO_2)_6]$
- cis-$[Co(trien)\ (NO_2)_2]$ $Cl.H_2O$
- $Hg[Co(SCN)_4]$
- $[Cu(NH_3)_4]SO_4H_2O$
- Sodium tetrathionate Na_2S4O_6.
- Sodium amide. *Inorg. Synth.,* 1946, 2, 128.
- PhBce Dichlorophenylborane - Synthesis in vacuum line.
- Hexa-bis(4-nitrophenoxy)cyclotriphosphazene.
- Preparation of Tin(IV) iodide, Tin(IV) chloride and Tin(II) iodide, Inorg, *Synth.,* 1953, 4, 119.

Spectrophotometry:

- Determination of equilibrium constant of reaction $KI+I_2=KI_3$ spectrophotometrically
- Determination of stoichiometry and stability constant of Ferric isothiocyanate complex ion in solution.
- Determination of rate constant of alkaline bleaching of Malachite green and effect of ionic strength on the rate of reaction.
- Determination of the amount of each copper and bismuth or copper and iron (III) from the given mixture at 745 nm by spectrophotometric titration using solution of EDTA.
- Determination of $A1^{3+}$, Ti^{3+}, Fe^{3+} using 8-Hydroxyquinoline.
- Determination of Fe^{2+} using 1,10-phenanthroline method.
- Determination of Cr^{3+} diphenyl carbazide method.
- Determination of Ni^{2+} by DMG method.
- Estimation of purity of a given azo dye by colorimetry.
- Determination of fluoride/nitrite/phosphate spectrophotometrically.

Electroanalytical Methods of Analysis:

(i) Oxidation-Reduction Titrations

- Standardization with sodium oxalate of $KMnO_4$ and determination of Ca^{2+} ion.
- Standardization of ceric sulphate with Mohr's salt and determination of Cu^{2+}, NO_3^{-1} and $C_2O_4^{-2}$ ions.

- Standardization of $K_2Cr_2O_7$ with Fe^{2+} and determination of Fe^{3+} (Ferric alum)
- Standardization of hypo solution with potassium iodate / $K_2Cr_2O_7$ and determination of available Cl_2 in bleaching powder, Sb^{3+} and Cu^{2+}.
- Determination of hydrazine with KIO_3 titration.

(ii) Precipitation Titrations

- $AgNO_3$ standardization by Mohr's method by using adsorption indicator.
- Volhard's method for Cl^- determination.
- Determination of ammonium / potassium thiocyanate.
- Estimation of magnesium or cadmium as oxinate by titration with standard bromate solution.
- Estimation of KBr in the given solution by titrating against std. $AgNO_3$ solution using eosin as indicator.

(iii) Complexometric Titrations:

- Determination of Cu^{2+} and Ni^{2+} by using masking reagent by EDTA titration.
- Determination of Ni^{2+} (back titration).
- Determination of Ca^{2+} (by substitution method).
- Estimation of the purity of oxalic acid employing standard Ce(IV) solution.
- Estimation of various transition elements like Zn/Ni/Co/Cd/Al from various commercial samples by complexometric titrations on potentiometer by using mercury electrode.

(iv)Voltametric Titrations:

- Determination of trace metal impurities present in a polluted water sample by anodic stripping voltametric procedure.

(v) Electrogravimetric Titrations:

- Electrogravimetric estimation of barium, copper, chromium, lead, nickel present in the solution at ppm level.

(vi)Amperometric Titrations:

- Amperometric determination of Zinc with standard EDTA solution.
- Amperometric titration of lead with standard potassium dichromate solution.
- Amperometric determination of magnesium (or cadmium) by precipitating it as oxinate and titrating against standard $KBrO_3$ solution.
- Estimation of the mercapto group in thioglycolic acid by titrating with standard $AgNO_3$ solution amperometrically.
- Amperometric titration of (i) thiourea v/s silver nitrate (ii) vitamin C v/s ferric nitrate
- Amperometric titration of (a) Pb v/s SO_4^{2-} (b) Pb v/s $K_2Cr_2O_7$ (c) Ni v/s DMG.
- Estimation of sulphadiazine in sulpha tablet by amperometric titration method.

Flame Photometric Determinations:

- Sodium and potassium when present together.
- Lithium/Calcium/barium/strontium.
- Cadmium and magnesium in tap water.

Note: *Any other relevant experiments may be added / performed.*

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Group-II: Organic Chemistry Specialization

Paper-3.3: CHE-633-T (12026): Organic Synthesis

(Only for Organic Chemistry Specialization)

Contact Hours / Week	: 4 Hours	Total Maximum Marks	: 100 Marks
Duration of Examination	: 3 Hours	Continuous Assessment	: 30 Marks
		Semester Assessment	: 70 Marks

Note: *The syllabus is divided into five independent units and question paper will be divided into two sections:*

- ***Section-A*** *will carry one compulsory question comprising 10 short answer type questions (answer about in 10-20 words) by taking two questions from each unit with no internal choice. Each short answer type question will have 2 marks and hence Section-A will carry total 20 marks.*
- ***Section-B*** *will carry 50 marks equally divided into five long answer type questions (answer about in 400-500 words) with one question from each unit with internal choice (another question will be given in option or question may be divided in to sub-divisions). Paper setter shall be advised to set one question from each unit along with one option of each question and students are instructed to attempt total five questions by selecting one question from each unit. Each long answer type question will have 10 marks and hence Section-B will carry total 50 marks.*

Unit-I: Disconnection Approach-I: **12-15 L**

Introduction, synthons and synthetic equivalents, functional group interconversions, order of events, one and two group C-X disconnections, chemoselectivity, reversal of polarity, cyclization reactions, amine synthesis.

Protecting Groups:

Principle of protection of alcohol, amine, carbonyl and carboxyl groups, simple practices / exercises.

Unit-II: Disconnection Approach-II: **12-15 L**

One group C-C-disconnections involving alcohols and carbonyl compounds, stereoselectivity, regioselectivity, alkene synthesis, use of acetylenes.

Two group C-C disconnections in Diels-Alder reactions, 1,3-difunctionalised compounds and α,β-unsaturated carbonyl compounds, control in carbonyl condensations, 1,5-difunctionalised compounds, Michael addition and Robinson annellation.

Unit-III: Oxidation: **12-15 L**

Introduction, different oxidative processes, oxidation of hydrocarbons: alkenes, saturated C-H groups (activated and inactivated), aromatic rings; alcohols and diols; aldehydes and ketones, ketals, carboxylic acids, amines, hydrazines and sulfides; oxidations with ruthenium tetraoxide, iodobenzene diacetate and thallium (III) nitrate.

Unit-IV: Reduction: **12-15 L**

Introduction, different reductive processes, reduction of hydrocarbons: alkenes, alkynes and aromatic rings; carbonyl compounds: aldehydes, ketones; acids and their derivatives; epoxides; nitro, nitroso, azo and oxime groups; hydrogenolysis.

Unit-V Molecular Rearrangements: **12-15 L**

General mechanistic considerations, nature of migration, migratory aptitude, memory effects, a detailed study of the rearrangements on carbon, nitrogen and oxygen atoms: Pinacol-pinacolone, Wagner-Meerwein, Tiffeneu-Demjanov, Dienone-Phenol, Wolff; Beckmann, Hoffman, Curtius, Lossen, Schmidt; Baeyer-Villiger, Benzil-Benzilic

acid, Favorskii, Neber; electrophilic rearrangement: Wittig rearrangement; aromatic rearrangements: Fries, Benzidine rearrangement.

Books:

- *Organic Synthesis: The Disconnection Approach, Stuart Warren, John Wiley & Sons.*
- *Organic Synthesis through Disconnection Approach, P. S. Kalsi*
- *Organic Synthesis, Smith M. B. McGraw Hill*
- *Modern Organic Synthesis, G. S. Zweifel and M. H. Nantz, Freeman and Company, New York.*
- *Modern Synthetic Reactions. H.O. House, W.A. Benjamin.*
- *Some Modern Methods of Organic Synthesis, W. Carruthers, Cambridge Univ. Press.*
- *Structure and Mechanism in Organic Chemistry, C.K. Ingold, Cornell University Press.*
- *Organic Chemistry, Claydon, Nick Geeves and Stuart Warren, Oxford University Press Principles of Organic Synthesis, R.O.C. Norman and J.M. Coxon, Blackie Academic & Professional.*
- *Advanced Organic Chemistry, Reactions Mechanisms and Structure, J. March. John Wiley.*

Paper-3.4: CHE-634-T (12027): Heterocyclic Chemistry

(Only for Organic Chemistry Specialization)

Contact Hours / Week	: 4 Hours	Total Maximum Marks	: 100 Marks
Duration of Examination	: 3 Hours	Continuous Assessment	: 30 Marks
		Semester Assessment	: 70 Marks

Note: *The syllabus is divided into five independent units and question paper will be divided into two sections:*

- ***Section-A*** *will carry one compulsory question comprising 10 short answer type questions (answer about in 10-20 words) by taking two questions from each unit with no internal choice. Each short answer type question will have 2 marks and hence Section-A will carry total 20 marks.*
- ***Section-B*** *will carry 50 marks equally divided into five long answer type questions (answer about in 400-500 words) with one question from each unit with internal choice (another question will be given in option or question may be divided in to sub-divisions). Paper setter shall be advised to set one question from each unit along with one option of each question and students are instructed to attempt total five questions by selecting one question from each unit. Each long answer type question will have 10 marks and hence Section-B will carry total 50 marks.*

Unit-I: Nomenclature of Heterocycles: 12-15 L

Trivial, systematic (Hantzsch-Widman system), fusion and replacement systems of nomenclature for monocyclic, fused, spiro and bridged heterocycles.

Aromatic Heterocycles:

Aromaticity in heterocycles: relationship with carbocyclic aromatic compounds, criteria of aromaticity (structural, electronic, energetic and magnetic criteria); heteroaromatic ring systems, tautomerism in aromatic heterocycles.

Non-aromatic Heterocycles:

Strain, bond angle and torsional strains and their consequences in small ring heterocycles, conformation of flexible heterocycles: five-membered and six-membered heterocycles; stereo-electronic effects in saturated six-membered heterocycles: anomeric and related effects; attractive interactions through space (hydrogen bonding and nucleophilic-electrophilic interactions).

Unit-II: Three-membered Heterocycles: 12-15 L

Three-membered heterocycles with one heteroatom: syntheses and reactions of aziridines, azirines, oxiranes, oxirenes, thiiranes and thiirenes.

Three-membered heterocycles with two heteroatoms: syntheses and reactions of diazirdines, diazirines and oxaziridines.

Four-membered Heterocycles:
Four-membered heterocycles with one nitrogen heteroatom: syntheses and reactions of azetidines and azetidinones.

Four-membered heterocycles with one oxygen heteroatom: syntheses and reactions of oxetanes and oxetanones.

Four-membered heterocycles with one sulphur heteroatom: syntheses and reactions of thietanes.

Unit-III: Five-membered Heterocycles: 12-15 L

Five-membered heterocycles with one heteroatom: structure, stability, basicity, aromaticity, reactivity, synthesis and reactions of pyrrole, furan, thiophene.

Five-membered heterocycles with two heteroatoms: structure, reactivity, synthesis, reactions and some medicinal importance of imidazole, oxazole and thiazole.

Five-membered heterocycles with more than two heteroatoms: synthesis, reactions and some medicinal importance of triazoles and tetrazoles.

Benzo-fused five-membered heterocycles with one and two nitrogen heteroatoms: synthesis, reactions and some medicinal importance of indole.

Unit-IV: Six-membered Heterocycles-I: 12-15 L

Six-membered heterocycles with nitrogen heteroatoms: synthesis, reactions and some medicinal importance of azines (pyridines), diazines (pyrimidine) and triazines (s-triazines).

Benzo-fused six-membered heterocycles with one nitrogen heteroatoms: synthesis, reactions and some medicinal importance of quinoline and isoquinoline.

Benzo-fused six-membered heterocycles with two nitrogen heteroatoms: synthesis, reactions and some medicinal importance of quinazoline and quinoxaline.

Unit-V: Six-membered Heterocycles-II: 12-15 L

Six-membered heterocycles with one oxygen heteroatom: synthesis and reactions of pyrylium salts and pyrones.

Benzo-fused six-membered heterocycles with one oxygen heteroatom: synthesis, reactions and some medicinal importance of benzopyrylium salts, coumarins and chromones.

Seven-membered Heterocycles:
General introduction, synthesis and some medicinal importance of benzodiazepines, benzoxazepines and benzothiazepines.

Books:

- *Heterocyclic Chemistry Vol. 1, II and III, R.R. Gupta, M. Kumar and V. Gupta, Springer Verlag.*
- *The Chemistry of Heterocycles, T. Eicher and S. Hauptmann, Thieme.*
- *Heterocyclic Chemistry, J.A. Joule, K. Mills and G.F. Smith, Blackhall.*
- *Heterocyclic Chemistry, T.L. Gilchrist, Longman Scientific Technical.*
- *Contemporary Heterocyclic Chemistry, G.R. Newkome and W.W. Paudler, Wiley-Inter Science.*
- *An Introduction to the Heterocyclic Compounds, R.M. Acheson, John Wiley.*
- *Comprehensive Heterocyclic Chemistry, A.R. Katritzky and C.W. Rees, eds. Pergamon Press.*

Paper-3.5: CHE-635-P (12028): Organic Chemistry Practical

(Only for Organic Chemistry Specialization)

Contact Hours / Week : 16 Hours
Duration of Examination: 12 Hours (6 Hrs. per Day) **Maximum Marks:** 200 Marks

Distribution of Marks:

S. No.	Name of Exercise	Marks
1.	Exercise No. 1: Major Experiment	30
2.	Exercise No. 2: Major Experiment	30
3.	Exercise No. 3: Major Experiment	30
4.	Exercise No. 4: Minor Experiment	15
5.	Exercise No. 5: Minor Experiment	15
6.	Exercise No. 6: Minor Experiment	15
7.	Practical Record	15
8.	Good Laboratory Skills and Regularity in Practicals	10
9.	Comprehensive Viva-voce	40
	Total Marks	**200**

Qualitative Analysis:

Separation, purification and identification of the components of a mixture of three organic compounds (three solids or two liquids and one solid or two solids and one liquid), using TLC for checking the purity of the separated compounds, chemical analysis, IR, PMR and mass spectral data.

Chromatographic Analysis:

Separation and identification of compounds (*e.g.* amino acids, carbohydrates and other organic compounds) by following chromatographic techniques:

- Paper Chromatography
- Thin Layer Chromatography
- Column Chromatography
- Flash Chromatography
- Gas Chromatography
- Liquid Chromatography
- Electrophoresis

Three-steps / Multi-steps Organic Syntheses:

The exercises should illustrate the use of organic reagents and may involve purification of the products by chromatographic techniques:

- Aniline → Acetanilide → *p*-nitroacetanilide → *p*-nitroaniline
- Aniline → Acetanilide → *p*-bromoacetanilide → *p*-bromoaniline
- Benzene → Benzophenone → Benzpinacol → Benzpinacolone
- Benzene → Benzophenone → Benzophenoneoxime → Benzanilide
- Benzene → 3-benzoyl propanoic acid → 4-Phenyl butanoic acid → α-Tetralone
- Benzaldehyde → Benzoin → Benzil → Benzinilic acid

Note: *The products may be characterized by spectral techniques.* Other relevant preparations / syntheses may be performed.

Spectrophotometric (UV/VIS) Estimations:

- Amino acids
- Proteins
- Carbohydrates
- Cholesterol
- Aspirin
- Paracetamol
- Ibuprofen
- Promethazine
- Verapamil
- Propranolol
- Fluconazole
- Ciprofloxacin

- Ascorbic acid
- Caffeine
- Methyldopa
- Penicillin
- Griseofulvin
- Diazepam

Analysis of Fuel / Petroleum / Petroleum Products:

- Determination of calorific value of fuel and coal
- Estimation of moisture in given coal sample.
- Estimation of ash content in given coal sample.
- Estimation of proximate value of given coal sample.
- Determination of the strong acid number or inorganic acidity of oil
- Determination of viscosity and surface tension of oil / liquid.
- Determination of saponification value of oil
- Determination of bromine / hydroxyl / iodine value of oil.
- Determination of aniline point of oil.
- Determination of cloud point and pour point of oil.
- Determination of flash point & fire point of oil.
- Determination of aniline point of liquid fuel
- Determination of carbon residue of liquid fuel
- Determination of octane & cetane number
- Determination of sulphur / lead / other elements in petroleum products / coal
- Determination of alkalinity / salinity / rancidity / water content / diesel index of oil / petroleum sample.
- Determination of organic and inorganic chloride in oil / petroleum sample.
- The ultimate analysis of given sample of soft coke.
- Determine the viscosity of a given sample of oil in centistokes at room temperature and at 40°, 50°, 60° 65°, 70°C. Plot a graph between kinematic viscosity and temperature in degree centigrade

Analysis of Agrochemicals:

- Analysis of soil sample, soil micronutrients for Ca, Fe and P content
- Analysis of pigments with respect to Zn and Cr.
- Analysis of pesticide residue and toxicological effects.
- Analysis of malathion by colorimetry.
- Determination of organic carbon in soil by Walk Ley and Black method.
- Determination of available chlorine in bleaching powder by Bunsen method.
- Determination of total chlorine in pesticide formulation.
- Determination of copper in fungicide.
- Estimation of nitrogen from given fertilizer by Kjeldahl method.
- Estimation of phosphorus from given fertilizer by volumetry / colourimetry.
- Estimation of potassium from given fertilizer by gravimetry / Flame photometry.
- Determination of K_2O content in given sample of potash fertilizer.
- Determination of P_2O_5 content in give n sample of phosphatic fertilizers.
- Determination of moisture content in given sample of urea
- Analysis of insecticides: DDT, BHC, aldrin, endosulfon, malathion, parathion.
- Analysis of herbicides: 2,4-Dichlorophenoxyacetic acid, dalapon, paraquat, Banalin, Butacarb.
- Analysis of fungicides: Boardeaux mixture, copper oxychloride, zineb, benomyl.

Analysis of Polymers:

- Determination of acid, saponification, iodine, hydroxyl and carboxyl values of a plastic material.
- Determination of molecular weight of a polymer.

Ion Chromatography

(i) Chemical Applications

- Determination of anions in toothpaste by Ion Chromatography.
- Determination of anions and cations in high purity water by Ion Chromatography.
- Determination of metals and polyphosphates in given sample by Ion Chromatography.
- Determination of azide in aqueous samples by Ion Chromatography.
- Determination of dissolved hexavalent Cr in drinking water, groundwater & industrial waste.
- Determination of diethanolamine and triethanolamine in surface finishing, wastewater and scrubber solutions water effluents by Ion Chromatography
- Determination of fluoride in acidulated phosphate topical solution.
- Determination of oxalate and other anions in Bayer liquor using Ion Chromatography.
- Determination of amino acids, carbohydrates, alcohols, and glycols in fermentation Broths
- Determination of calcium, magnesium, manganese and iodine in Brine
- Determination of trace anions and cations in concentrated bases using auto-neutralization pre-treatment/Ion Chromatography.
- Determination of trace anions in organic solvents and concentrated HF.
- Determination of trace transition metals in reagent grade acids, bases, salts, and organic solvents using chelation Ion Chromatography.
- Determination of polyphenols
- Determination of N,N-dimethyl-o-toluidine and N,N-diethyl-o-toluidine in ethylene gas samples.
- Determination of transition metals at ppt levels in High-Purity Water and SC2 (D-clean) Baths

(ii) Petroleum Refining

- Extraction of total petroleum hydrocarbon contaminants (diesel & oil) in soils
- Extraction of hydrocarbon contaminants (BTEX, Diesel, and TPH) in soils
- Extraction of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans
- Extraction of PAHs from environmental samples by ASE
- Determination of thiosulfate in refinery and other wastewaters
- Automated solid phase extraction (SPE) of total petroleum hydrocarbons.
- Determination of biofuel sugars by Ion Chromatography
- Determination of cations in biodiesel using a Reagent-Free Ion Chromatography.
- Determination of 32 low molecular mass organic acids in biomass by Ion Chromatography Mass Spectrometry

(iii) Safety and Security Applications

- Extraction of explosives from soils by accelerated solvent extraction (ASE)
- Determination of monovalent cations in explosives

(iv) Cosmetics

- Rapid Determination of benzalkonium chloride in cosmetics

(v) Polymers

- Polysialic acid analysis: Separating polymers with high degrees of polymerization

Note: *Any other relevant experiments may be added / performed.*

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Group-III: Physical Chemistry Specialization

Paper-3.3: CHE-633-T (12029): Nuclear Chemistry

(Only for Physical Chemistry Specialization)

Contact Hours / Week	: 4 Hours	Total Maximum Marks	: 100 Marks
Duration of Examination	: 3 Hours	Continuous Assessment	: 30 Marks
		Semester Assessment	: 70 Marks

Note: *The syllabus is divided into five independent units and question paper will be divided into two sections:*

- ***Section-A*** *will carry one compulsory question comprising 10 short answer type questions (answer about in 10-20 words) by taking two questions from each unit with no internal choice. Each short answer type question will have 2 marks and hence Section-A will carry total 20 marks.*
- ***Section-B*** *will carry 50 marks equally divided into five long answer type questions (answer about in 400-500 words) with one question from each unit with internal choice (another question will be given in option or question may be divided in to sub-divisions). Paper setter shall be advised to set one question from each unit along with one option of each question and students are instructed to attempt total five questions by selecting one question from each unit. Each long answer type question will have 10 marks and hence Section-B will carry total 50 marks.*

Unit-I: Introduction of Radioactivity: 12-15 L

Nuclear models, mass defect, binding energy, mean binding energy of stable nuclei, disintegration theory: nuclear stability and group displacement law; synthesis of radioisotopes: ^{14}C, ^{3}H, ^{32}P, ^{35}S, ^{36}Cl, ^{82}Br, ^{131}I; contribution of the discovery of artificial radioactivity in the field of heavy element chemistry.

Unit-II: Radioactive Decay Processes: 12-15 L

Alpha decay-penetration of potential barriers hindered alpha decay, alpha decay energies; beta decay-Fermi theory, Curie plots, comparative half-lives, electron capture, selection rules, forbidden transitions, non-conservation of parity, neutrinos; gamma decay- life-time of excited states, multi-pole radiation and selection rules, isomeric transition, internal conversion and Auger effect.

Unit-III: Detection and Measurement of Radioactivity: 12-15 L

Ionization chamber, Geiger-Muller, proportional, scintillation counters, Wilson cloud chamber, health physics, Instrumentation: Film badges, pocket ion chambers, portable counters and survey meters, accelerators: Van de Graff and cyclotron.

Unit-IV: Isotope Effects and Isotopic Exchange Reactions: 12-15 L

Isotope effect: Definition, physical and chemical isotope effects, generalities of isotope effects; Isotopic exchange: basic concept, characteristics of isotopic exchange, mechanism of isotopic exchange, kinetics of homogenous and heterogeneous isotopic exchange reactions, self-diffusion, and surface measurements.

Tracers:

Selection of radioisotopes as tracer, application of radioisotopes as tracers-analytical, physico-chemical, medical, agriculture and industrial applications, neutron activation analysis, radiometric titrations and isotope dilution techniques, radiopharmaceutical, radioimmunoassay and radiation sterilization.

Unit-V: Nuclear Reactors: 12-15 L

Basic principles of chain-reacting systems, characteristics of nuclear reactors and their applications, classification of reactors, breeder reactor, reactor associated problems, nuclear reactors in India, the four-factor formula: The reproduction factor, reactor

power, life and critical size of reactor, reactor safety, fuel cycle, re-processing of spent fuel, nuclear waste management.

Books:

- *Nuclear Chemistry and its applications – By. Haissionsky – Addison Wesley*
- *Nuclear and Radio Chemistry – By. G. Friedlander, J. W. Kennedy, E. S. Macias and J. M. Miller – A Wiley – Interscience Publication, John Wiley and Sons – III Edition.*
- *Radio Chemistry – By An. N. Nesmeyanov, Mir Publishers.*
- *Artificial Radioactivity by K. Narayana Rao and H. J. Arnikar Tata McGraw Hill, New Delhi*

Paper-3.4: CHE-634-T (12030): Physical Organic Chemistry

(Only for Physical Chemistry Specialization)

Contact Hours / Week	: 4 Hours	Total Maximum Marks	: 100 Marks
Duration of Examination	: 3 Hours	Continuous Assessment	: 30 Marks
		Semester Assessment	: 70 Marks

Note: *The syllabus is divided into five independent units and question paper will be divided into two sections:*

- ***Section-A*** *will carry one compulsory question comprising 10 short answer type questions (answer about in 10-20 words) by taking two questions from each unit with no internal choice. Each short answer type question will have 2 marks and hence Section-A will carry total 20 marks.*
- ***Section-B*** *will carry 50 marks equally divided into five long answer type questions (answer about in 400-500 words) with one question from each unit with internal choice (another question will be given in option or question may be divided in to sub-divisions). Paper setter shall be advised to set one question from each unit along with one option of each question and students are instructed to attempt total five questions by selecting one question from each unit. Each long answer type question will have 10 marks and hence Section-B will carry total 50 marks.*

Unit-I Concepts in Molecular Orbital (MO) and Valence Bond (VB) Theory: 12-15 L

Introduction to Huckel molecular orbital (HMO) method as a mean to explain modern theoretical methods. Advanced techniques in PMO and FMO theory. Molecular mechanics, semi empirical methods and *ab initio* and density functional methods.

Quantitative MO Theory:

HMO method as applied to ethene, allyl and butadiene. Qualitative MO theory ionization potential. Electron affinities. MO energy levels. Orbital symmetry. Orbital interaction diagrams. Valence bond (VB) configuration mixing diagrams. Relationship between VB configuration mixing and resonance theory.

Unit-II Principles of Reactivity: 12-15 L

Mechanistic significance of entropy, enthalpy and Gibb's free energy. Arrhenius equation. Transition state theory. Uses of activation parameters, Hammond's postulate, Bell-Evans-Polanyi Principle. Potential energy surface model. Marcus's theory of electron transfer. Reactivity and selectivity principles.

Solvation and Solvent Effects:

Qualitative understanding of solvent-solute effects on reactivity. Thermodynamic measure of solvation. Effects of solvation on reaction rates and equilibria. Various empirical indexes of solvation based on physical properties, solvent-sensitive reaction rates, spectroscopic properties and scales for specific solvation. Use of solvation scales in mechanistic studies. Solvent effects from the curve-crossing model.

Unit-III Structural Effects on Reactivity: 12-15 L

Linear free energy relationships (LFER). The Hammett equation, substituent constants, theories of substituent effects. Interpretation of values. Reaction constant.

Deviations from Hammett equation. Dual parameter correlation, inductive substituent constant. The Taft model, σ_i and σ_R scales.

Acids, Bases, Electrophiles, Nucleophiles and Catalysis:
Acid-base dissociation, Electronic and structural effects, acidity and basicity. Acidity functions and their application. Hard and soft acids and bases. Nucleophilicity scales. Nucleofugacity. The α-effect. Ambivalent nucleophiles. Acid-base catalysis-specific and general catalysis. Brőnsted catalysis, Nucleophilic and electrophilic catalysis. Catalysis by noncovalent binding-micellar catalysis.

Steric and Conformation Properties:
Various type of steric strain and their influence on reactivity. Steric acceleration. Rotation around partial double bonds. Winstein-Holness and Curtin-Hammett principle.

Unit-IV Nucleophilic and Electrophilic Reactivity: 12-15 L

Structural and electronic effects on S_N1 and S_N2 reactivity. Solvent effect. Kinetic isotope effects. Intra-molecular assistance. Electron transfer nature of S_N2 reaction. Nucleophilicity and S_N2 reactivity based on curve crossing mode. Relationship between polar and electron transfer reactions $S_{RN}1$ mechanism. Electrophilic reactivity, general mechanism. Kinetic of S_E2 Ar reaction. Structural effects on rates and selectivity. Curve-crossing approach to electrophilic reactivity.

Radical Reactivity:
Radical stability, polar influences, solvent and steric effects. A curve crossing approach to radical addition, factors affecting barrier heights in addition, regioselectivity in radical reactions.

Unit-V Supramolecular Chemistry: 12-15 L

Properties of covalent bonds-bond length, inter-bond angles, force constant, bond and molecular dipole moments. Molecular and bond polarizability, bond dissociation enthalpy, entropy. Intermolecular forces, hydrophobic effects. Electrostatic, induction, dispersion and resonance energy, magnetic interactions, magnitude of interaction energy, forces between macroscopic bodies, medium effects. Hydrogen bond. Principles of molecular association and organization as exemplified in biological macromolecules like enzymes, nucleic acids, membranes and model system like micelles and vesicles. Molecular receptors and design principles. Supramolecular reactivity and catalysis. Molecular channels and transport processes.

Books:

- *Molecular Mechanics, U. Burkrt and N.L. Allinger, ACS Monograph 177, 1982.*
- *Mechanism and Theory in Organic Chemistry, T.H. Lowry and K.C. Richardson, Harper and Row.*
- *Introduction to Theoretical Organic Chemistry and Molecular Modeling.*
- *Supramolecular Chemistry: Concepts and Perspective, J.M. Lehn, VCH.*
- *The Physical Basis of Organic Chemistry: H. Maskill, Oxford University Press.*

Paper-3.5: CHE-635-P (12031): Physical Chemistry Practical

(Only for Physical Chemistry Specialization)

Contact Hours / Week : 16 Hours
Duration of Examination: 12 Hours (6 Hrs. per Day) **Maximum Marks:** 200 Marks

Distribution of Marks:

S. No.	Name of Exercise	Marks
1.	Exercise No. 1: Major Experiment	30

2.	Exercise No. 2: Major Experiment	30
3.	Exercise No. 3: Major Experiment	30
4.	Exercise No. 4: Minor Experiment	15
5.	Exercise No. 5: Minor Experiment	15
6.	Exercise No. 6: Minor Experiment	15
7.	Practical Record	15
8.	Good Laboratory Skills and Regularity in Practicals	10
9.	Comprehensive Viva-voce	40
	Total Marks	**200**

Thermodynamics:

- Determination of partial molar volume of solute (e.g. KCl) and solvent in a binary mixture.
- Determination of the temperature dependence of the solubility of a compound in two solvents having similar intra-molecular in interactions (benzoic acid in water and in DMSO-Water mixture and calculate the partial molar heat of solution.

Spectrophotometry:

- Determination of equilibrium constant of reaction $KI+I_2=KI_3$ spectrophotometrically
- Determination of stoichiometry and stability constant of Ferric isothiocyanate complex ion in solution.
- Determination of rate constant of alkaline bleaching of Malachite green and effect of ionic strength on the rate of reaction.
- Determination of the amount of each copper and bismuth or copper and iron (III) from the given mixture at 745 nm by spectrophotometric titration using solution of EDTA.
- Determination of $A1^{3+}$, Ti^{3+}, Fe^{3+} using 8-Hydroxyquinoline.
- Determination of Fe^{2+} using 1,10-phenanthroline method.
- Determination of Cr^{3+} diphenylcarbazide method.
- Determination of Ni^{2+} by DMG method.
- Estimation of purity of a given azo dye by colorimetry.
- Determination of fluoride/nitrite/phosphate spectrophotometrically.

Electroanalytical Methods of Analysis:

(i) Oxidation-Reduction Titrations

- Standardization with sodium oxalate of $KMnO_4$ and determination of Ca^{2+} ion.
- Standardization of ceric sulphate with Mohr's salt and determination of Cu^{2+}, NO_3^{-1} and $C_2O_4^{-2}$ ions.
- Standardization of $K_2Cr_2O_7$ with Fe^{2+} and determination of Fe^{3+} (Ferric alum)
- Standardization of hypo solution with potassium iodate / $K_2Cr_2O_7$ and determination of available Cl_2 in bleaching powder, Sb^{3+} and Cu^{2+}.
- Determination of hydrazine with KIO_3 titration.

(ii) Precipitation Titrations

- $AgNO_3$ standardization by Mohr's method by using adsorption indicator.
- Volhard's method for Cl^- determination.
- Determination of ammonium / potassium thiocyanate.
- Estimation of magnesium or cadmium as oxinate by titration with standard bromate solution.
- Estimation of KBr in the given solution by titrating against std. $AgNO_3$ solution using eosin as indicator.

(iii) Complexometric Titrations:

- Determination of Cu^{2+} and Ni^{2+} by using masking reagent by EDTA titration.

- Determination of Ni^{2+} (back titration).
- Determination of Ca^{2+} (by substitution method).
- Estimation of the purity of oxalic acid employing standard Ce(IV) solution.
- Estimation of various transition elements like Zn/Ni/Co/Cd/Al from various commercial samples by complexometric titrations on potentiometer by using mercury electrode.

(iv) Voltametric Titrations:

- Determination of trace metal impurities present in a polluted water sample by anodic stripping voltametric procedure.

(v) Electrogravimetric Titrations:

- Electrogravimetric estimation of barium, copper, chromium, lead, nickel present in the solution at ppm level.

(vi) Amperometric Titrations:

- Amperometric determination of Zinc with standard EDTA solution.
- Amperometric titration of lead with standard potassium dichromate solution.
- Amperometric determination of magnesium (or cadmium) by precipitating it as oxinate and titrating against standard $KBrO_3$ solution.
- Estimation of the mercapto group in thioglycolic acid by titrating with standard $AgNO_3$ solution amperometrically.
- Amperometric titration of (i) thiourea v/s silver nitrate (ii) vitamin C v/s ferric nitrate
- Amperometric titration of (a) Pb v/s SO_4^{2-} (b) Pb v/s $K_2Cr_2O_7$ (c) Ni v/s DMG.
- Estimation of sulphadiazine in sulpha tablet by amperometric titration method.

Note: *Any other relevant experiments may be added / performed.*

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Group-IV: Analytical Chemistry Specialization

Paper-3.3: CHE-633-T (12032): Advanced Analytical Techniques

(Only for Analytical Chemistry Specialization)

Contact Hours / Week	: 4 Hours	Total Maximum Marks	: 100 Marks
Duration of Examination	: 3 Hours	Continuous Assessment	: 30 Marks
		Semester Assessment	: 70 Marks

Note: *The syllabus is divided into five independent units and question paper will be divided into two sections:*

- ***Section-A*** *will carry one compulsory question comprising 10 short answer type questions (answer about in 10-20 words) by taking two questions from each unit with no internal choice. Each short answer type question will have 2 marks and hence Section-A will carry total 20 marks.*
- ***Section-B*** *will carry 50 marks equally divided into five long answer type questions (answer about in 400-500 words) with one question from each unit with internal choice (another question will be given in option or question may be divided in to sub-divisions). Paper setter shall be advised to set one question from each unit along with one option of each question and students are instructed to attempt total five questions by selecting one question from each unit. Each long answer type question will have 10 marks and hence Section-B will carry total 50 marks.*

Unit-I: Extraction Methods: 12-15 L

Basic principles, classification of extraction systems, factors affecting extraction process, mechanism of extraction, extraction of liquids, extraction by chelation, extraction by solvation, extraction by ion-pair formation, extraction by sonication,

extraction equilibria for chelates, extraction equilibria for solvation, separation of metals by extraction, solid-phase extraction (SPE), supercritical fluid extraction (SFE), supramolecular extraction, centrifugation and ultra-centrifugation, membrane separation.

Unit-II: Isolation and Purification Techniques: 12-15 L

Filtration (simple, micro, *etc.*), recrystallization in aqueous & non-aqueous solutions, at low temperature, in inert atmosphere, semi-micro, micro, *etc*., use of decolourising carbon, difficulties in recrystallization, drying of liquids, freezing, sublimation, distillation (simple, steam, fractional, vacuum, high vacuum or molecular, *etc*.), nucleation and crystal growth, crystal hydrates and solvates, chemical methods for separation, determination of physical constants (mp, mixed mp, bp, m. wt., density, optical rotator power, RI, *etc.*).

Unit-III: High Frequency Titrations: 12-15 L

Principle, instrumentation-cells, oscillator circuit and high frequency titrimeters, theory, correlation of high frequency titration curves with low frequency titration curves. Applications- acid base, complexometric, measurement of dielectric constant and analysis of mixture of organic compounds. Advantages and disadvantages of high frequency methods.

Unit-IV: Polarography: 12-15 L

Principles, classification of polarographic techniques, types of polarographic currents, instrumentation, factors affecting polarographic wave, pulse polarography, and differential pulse polarograph.

Potentiometry:

Metal electrodes for measuring the metal's cation, metal-metal salt electrodes, redox electrodes, calomel electrode, measurement of potential, determination of concentrations, residual liquid-junction potential, accuracy on direct potentiometric, glass p*H* electrode, ion-selective electrodes.

Unit-IV: Voltammetry: 12-15 L

Voltametric principles, hydrodynamic voltammetry, stripping voltammetry, cyclic voltammetry, criteria of reversibility of electrochemical reactions, quasi-reversible and irreversible processes, qualitative and quantitative analysis.

Amperometry:

Principles and amperometric titration techniques: Dropping mercury electrode, rotating platinum microelectrode and dead stop.

Books:

- *Introduction to Instrumental Analysis, R. D. Braun, McGraw-Hill Book Company, New Delhi*
- *Vogel's Textbook of Quantitative Chemical Analysis, 6th Edn. Pearson Education Asia*
- *Analytical Chemistry, An Introduction, D. A. Skoog, D. M. West, F. J. Holler, and S. R. Crouch, 7th. Edn., Saunders College publishing, N. Y.*
- *Principles of Instrumental Analysis, D. A. Skoog and J. J. Leary, 4th Edn., N. Y.*
- *The Principles of Electrochemistry, A. Duncan, Mac Innes Dover Publication Inc. N. Y.F. Scholz, Electroanalytical methods, Springer, 2002.*
- *P. Monk, Fundamentals of electroanalytical chemistry, Wiley, 2001.*
- *A.P.F. Turner I. Karube, I. G. Wilson, Biosensors- Fundamentals and applications. Oxford University Press, New York, 1987.*
- *Organic electro chemistry by Henning Lund & Ole Hammerich, 4th edition, Publisher: Marcel Dekker, Inc, New York.*

Paper-3.4: CHE-634-T (12033): Analysis of Commercial Products

(Only for Analytical Chemistry Specialization)

Contact Hours / Week	: 4 Hours	Total Maximum Marks	: 100 Marks
Duration of Examination	: 3 Hours	Continuous Assessment	: 30 Marks
		Semester Assessment	: 70 Marks

Note: *The syllabus is divided into five independent units and question paper will be divided into two sections:*

- ***Section-A*** *will carry one compulsory question comprising 10 short answer type questions (answer about in 10-20 words) by taking two questions from each unit with no internal choice. Each short answer type question will have 2 marks and hence Section-A will carry total 20 marks.*
- ***Section-B*** *will carry 50 marks equally divided into five long answer type questions (answer about in 400-500 words) with one question from each unit with internal choice (another question will be given in option or question may be divided in to sub-divisions). Paper setter shall be advised to set one question from each unit along with one option of each question and students are instructed to attempt total five questions by selecting one question from each unit. Each long answer type question will have 10 marks and hence Section-B will carry total 50 marks.*

Unit-I: Analysis of Petrochemicals: 12-15 L

Constituents, petroleum fractionation, analysis of petroleum products: specific gravity, viscosity, doctor test, sulphuric acid absorption, aniline point, vapour pressure and colour determination, cloud point, pour point; determination of water, neutralization value (acid and base numbers), ash content, sulphur and mercapton sulphur, determination of lead in petroleum.

Analysis of Fuels:

Proximate and ultimate analysis of fuel, calorific value by Bomb calorimetry, analysis of fuel gases (coal gas, producer gas, water gas).

Unit-II: Analysis of Agrochemicals: 12-15 L

Analysis of Fertilizers: Analysis nitrogen: urea nitrogen, total Kjeldahl nitrogen method, ammonia nitrogen; analysis of phosphorus: total phosphorus, available and non-available, alkalimetric ammonium molybdophosphate method; analysis of potassium: potassium by sodium tetraphenyl borate method.

Analysis of Herbicides:

Atrazine, alachlor; Analysis of Fungicides: nimbin, carbendazim; Analysis of bactericides: chloramine, triclosan, chlorhexidine; Analysis of insecticides: DDT, BHC, aldrin, endosulfan, malathion, monochrotophos; Analysis of nematicides: aldicarb; Analysis of rodenticides: warfarin, bromadiolone.

Unit-III: Analysis of Polymers: 12-15 L

Chemical Methods of Analysis: Introduction, preparation of the sample, determination of purity, physical tests, preliminary examination, burning characteristics, transition points, molecular weight, density, refractive index, pyrolytic behaviour, qualitative and quantitative elementary analysis, solubility and acid numbers, acetyl number, iodine number end group analysis, colour tests.

Analysis of Plastics:

Basics of plastic analysis, fundamental conditions for plastic analysis, water test, copper wire test, acetone test, heat test, isopropyl alcohol test, oil test.

Unit-IV: Analysis of Glass and Ceramics: 12-15 L

Introduction, composition, method of analysis-sampling and sampling preparation, composition analysis-preliminary testing, decomposition, chemical method for the individual constituents-Si, B, Pb, Zn, Al, Cl, Ca, Mg, Ti.

Analysis of Cement:
Loss on ignition, insoluble residue, total silica, sesquioxiodes, lime, magnesia, ferric oxide, sulphuric anhydride, air and dust pollution from cement plants, atmospheric dispersion of pollutants in cement industry.

Unit-V: Analysis of Minerals and Ores: 12-15 L

Hematite, pyrolusite, gypsum, dolomite, chromate, bauxite, limestone and uranium ores.

Analysis of Metal and Alloys:
Steel, Cu-Ni alloy, solder, bronze, brass, aluminium alloy, ferroalloys of silicon, chromium, titanium and vanadium.

Books:

- *Standard Methods of Chemical Analysis, F. J. Welcher.*
- *Handbook of Industrial Chemistry – Davis Burner*
- *Pharmacopoeia of India, British & United States.*
- *Hand Book of Food Analysis – S. N. Mahindru.*
- *Analytical Biochemistry – Holme Peck*
- *Agricultural Analysis. By Kanwar.*
- *Encyclopaedia of Industrial Methods of Chemical Analysis. By F D Snell (All senus)*
- *Principle & practice of Analytical chemistry by F.U. Fifield and D. Keuley 3rd, Blackie and sons Ltd.*
- *Laboratory Techniques in Food Analysis by I.M. Kolthof, D. Pearson*
- *Handbook of Analysis and Quality, Control for Fruits and Vegetable Products 2nd by S. Ranganna*
- *Analysis of Food Products (Swan Publishers) by S.N. Mahendur*
- *Textbook of Forensic Pharmacy by B M Mithal 9th edition 1993, National Centre Kolcutta.*
- *Forensic Pharmacy by B.S Kuchekar, and A.M Khadatare Nirali Prakshan)*

Paper-3.5: CHE-635-P (12034): Analytical Chemistry Practical

(Only for Analytical Chemistry Specialization)

Contact Hours / Week : 16 Hours
Duration of Examination: 12 Hours (6 Hrs. per Day) **Maximum Marks:** 200 Marks

Distribution of Marks:

S. No.	Name of Exercise	Marks
1.	Exercise No. 1: Major Experiment	30
2.	Exercise No. 2: Major Experiment	30
3.	Exercise No. 3: Major Experiment	30
4.	Exercise No. 4: Minor Experiment	15
5.	Exercise No. 5: Minor Experiment	15
6.	Exercise No. 6: Minor Experiment	15
7.	Practical Record	15
8.	Good Laboratory Skills and Regularity in Practicals	10
9.	Comprehensive Viva-voce	40
	Total Marks	**200**

Spectrophotometry:

- Determination of equilibrium constant of reaction $KI+I_2=KI_3$ spectrophotometrically
- Determination of stoichiometry and stability constant of Ferric isothiocyanate complex ion in solution.
- Determination of rate constant of alkaline bleaching of Malachite green and effect of ionic strength on the rate of reaction.

- Determination of the amount of each copper and bismuth or copper and iron (III) from the given mixture at 745 nm by spectrophotometric titration using solution of EDTA.
- Determination of $A1^{3+}$, Ti^{3+}, Fe^{3+} using 8-Hydroxyquinoline.
- Determination of Fe^{2+} using 1,10-phenanthroline method.
- Determination of Cr^{3+} diphenyl carbazide method.
- Determination of Ni^{2+} by DMG method.
- Estimation of purity of a given azo dye by colorimetry.
- Determination of fluoride/nitrite/phosphate spectrophotometrically.

Electroanalytical Methods of Analysis:

(i) Oxidation-Reduction Titrations

- Standardization with sodium oxalate of $KMnO_4$ and determination of Ca^{2+} ion.
- Standardization of ceric sulphate with Mohr's salt and determination of Cu^{2+}, NO_3^{-1} and $C_2O_4^{-2}$ ions.
- Standardization of $K_2Cr_2O_7$ with Fe^{2+} and determination of Fe^{3+} (Ferric alum)
- Standardization of hypo solution with potassium iodate / $K_2Cr_2O_7$ and determination of available Cl_2 in bleaching powder, Sb^{3+} and Cu^{2+}.
- Determination of hydrazine with KIO_3 titration.

(ii) Precipitation Titrations

- $AgNO_3$ standardization by Mohr's method by using adsorption indicator.
- Volhard's method for Cl^- determination.
- Determination of ammonium / potassium thiocyanate.
- Estimation of magnesium or cadmium as oxinate by titration with standard bromate solution.
- Estimation of KBr in the given solution by titrating against std. $AgNO_3$ solution using eosin as indicator.

(iii) Complexometric Titrations:

- Determination of Cu^{2+} and Ni^{2+} by using masking reagent by EDTA titration.
- Determination of Ni^{2+} (back titration).
- Determination of Ca^{2+} (by substitution method).
- Estimation of the purity of oxalic acid employing standard Ce(IV) solution.
- Estimation of various transition elements like Zn/Ni/Co/Cd/Al from various commercial samples by complexometric titrations on potentiometer by using mercury electrode.

(iv) Voltametric Titrations:

- Determination of trace metal impurities present in a polluted water sample by anodic stripping voltammetric procedure.

(v) Electrogravimetric Titrations:

- Electrogravimetric estimation of barium, copper, chromium, lead, nickel present in the solution at ppm level.

(vi) Amperometric Titrations:

- Amperometric determination of Zinc with standard EDTA solution.
- Amperometric titration of lead with standard potassium dichromate solution.
- Amperometric determination of magnesium (or cadmium) by precipitating it as oxinate and titrating against standard $KBrO_3$ solution.
- Estimation of the mercapto group in thioglycolic acid by titrating with standard $AgNO_3$ solution amperometrically.
- Amperometric titration of (i) thiourea v/s silver nitrate (ii) vitamin C v/s ferric nitrate

- Amperometric titration of (a) Pb v/s SO_4^{2-} (b) Pb v/s $K_2Cr_2O_7$ (c) Ni v/s DMG.
- Estimation of sulphadiazine in sulpha tablet by amperometric titration method

Analysis of Alloys & Ores:

- Analysis of Nichrome alloy:
  - Cr by colorimetry
  - Ni by gravimetry
- Analysis of Zinc blend ore
  - Zn by complexometry
  - Fe by volumetry
- Analysis of Calcite ore
  - Ca by complexometry
  - Fe by colorimetry
- Analysis of felspar ore
- Analysis of steel and ferrous alloy:
  Carbon, silicon, manganese, phosphorous, sulphur, selenium, copper, nickel, chromium, vanadium, tungsten, molybdenum, cobalt, aluminium, titanium, nitrogen, lead, niobium, iron

Analysis of Ferrous Slugs:

- Determination of iron, calcium and magnesium, total oxides

Analysis of Cement and building materials:

- Analysis of cement and building materials: Silicon dioxide, aluminium oxide, ferric oxide, calcium oxide, magnesium oxide, sulphurtrioxide, sulphide- sulphur, loss on ignition, insoluble residue, sodium and potassium oxide.

Analysis of Quartzes:

- Volatile residue, zirconium dioxide, aluminium oxide, calcium and magnesium oxides, sodium and potassium oxide.

Analysis of Clays and Feldspars:

- Determination of moisture, silicon dioxide, total oxides, ferric oxide, titanium dioxide, aluminium oxide, calcium oxide, magnesium oxide.

Analysis of Glasses:

- Determination of various parameters of glass
- Determination of lead and lead glass.

Analysis of Ceramics:

- Determination of titanium dioxides and aluminium oxide from oxide ceramics.

Analysis of Fuel / Petroleum / Petroleum Products:

- Determination of calorific value of fuel and coal
- Estimation of moisture in given coal sample.
- Estimation of ash content in given coal sample.
- Estimation of proximate value of given coal sample.
- Determination of the strong acid number or inorganic acidity of oil
- Determination of viscosity and surface tension of oil / liquid.
- Determination of saponification value of oil
- Determination of bromine / hydroxyl / iodine value of oil.
- Determination of aniline point of oil.
- Determination of cloud point and pour point of oil.
- Determination of flash point & fire point of oil.

- Determination of aniline point of liquid fuel
- Determination of carbon residue of liquid fuel
- Determination of octane & cetane number
- Determination of sulphur / lead / other elements in petroleum products
- Determination of alkalinity / salinity / rancidity / water content / diesel index of oil / petroleum sample.
- Determination of organic and inorganic chloride in oil / petroleum sample.
- The ultimate analysis of given sample of soft coke.
- Determine the viscosity of a given sample of oil in centistokes at room temperature and at 40º, 50º, 60º, 65º, 70ºC. Plot a graph between kinematic viscosity and temperature in degree centigrade.

Analysis of Agrochemicals:

- Analysis of soil sample, soil micronutrients for Ca, Fe and P content
- Analysis of pigments with respect to Zn and Cr.
- Analysis of pesticide residue and toxicological effects.
- Analysis of malathion by colorimetry.
- Determination of organic carbon in soil by Walk Ley and Black method.
- Determination of available chlorine in bleaching powder by Bunsen method.
- Determination of total chlorine in pesticide formulation.
- Determination of copper in fungicide.
- Estimation of nitrogen from given fertilizer by Kjeldahl method.
- Estimation of phosphorus from given fertilizer by volumetry / colourimetry.
- Estimation of potassium from given fertilizer by gravimetry / Flame photometry.
- Determination of K_2O content in given sample of potash fertilizer.
- Determination of P_2O_5 content in give n sample of phosphatic fertilizers.
- Determination of moisture content in given sample of urea
- Analysis of insecticides: DDT, BHC, aldrin, endosulfon, malathion, parathion.
- Analysis of herbicides: 2,4-Dichlorophenoxyacetic acid, dalapon, paraquat, Banalin, Butacarb.
- Analysis of fungicides: Boardeaux mixture, copper oxychloride, zineb, benomyl.

Analysis of Polymers:

- Determination of acid, saponification, iodine, hydroxyl and carboxyl values of a plastic material.
- Determination of molecular weight of a polymer.

Chromatographic Analysis:

Separation and identification of compounds (*e.g.* amino acids, carbohydrates, ions, inorganic or organic compounds, *etc.*) by following chromatographic techniques:

- Paper Chromatography
- Thin Layer Chromatography
- Column Chromatography
- Flash Chromatography
- Ion-Chromatography
- Electrophoresis

Ion Chromatography

(vi) Chemical Applications

- Determination of anions in toothpaste by Ion Chromatography.
- Determination of anions and cations in high purity water by Ion Chromatography.

- Determination of metals and polyphosphates in given sample by Ion Chromatography.
- Determination of azide in aqueous samples by Ion Chromatography.
- Determination of dissolved hexavalent chromium in drinking water, groundwater and industrial waste.
- Determination of diethanolamine and triethanolamine in surface finishing, wastewater and scrubber solutions water effluents by Ion Chromatography
- Determination of fluoride in acidulated phosphate topical solution.
- Determination of oxalate and other anions in Bayer liquor using Ion Chromatography
- Determination of amino acids, carbohydrates, alcohols, and glycols in fermentation Broths
- Determination of calcium, magnesium, manganese and iodine in Brine
- Determination of trace anions and cations in concentrated bases using auto-neutralization pre-treatment/Ion Chromatography
- Determination of trace anions in organic solvents and concentrated HF.
- Determination of trace transition metals in reagent grade acids, bases, salts, and organic solvents using chelation Ion Chromatography
- Determination of polyphenols
- Determination of N,N-dimethyl-o-toluidine and N,N-diethyl-o-toluidine in ethylene gas samples.
- Determination of transition metals at ppt levels in High-Purity Water and SC2 (D-clean) Baths.

(vii) Petroleum Refining

- Extraction of total petroleum hydrocarbon contaminants (diesel and waste oil) in soils
- Extraction of hydrocarbon contaminants (BTEX, Diesel, and TPH) in soils
- Extraction of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans
- Extraction of PAHs from environmental samples by accelerated solvent extraction
- Determination of thiosulfate in refinery and other wastewaters
- Automated solid phase extraction (SPE) of total petroleum hydrocarbons using Dionex AutoTrace® Instrument
- Determination of biofuel sugars by Ion Chromatography
- Determination of cations in biodiesel using a Reagent-Free Ion Chromatography.
- Determination of 32 low molecular mass organic acids in biomass by Ion Chromatography Mass Spectrometry

(viii) Safety and Security Applications

- Extraction of explosives from soils by accelerated solvent extraction (ASE)
- Determination of monovalent cations in explosives

(ix) Cosmetics

- Rapid Determination of benzalkonium chloride in cosmetics

(x) Polymers

- Polysialic acid analysis: Separating polymers with high degrees of polymerization

Note: *Any other relevant experiments may be added / performed.*

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Group-V: Industrial Chemistry Specialization

Paper-3.3: CHE-633-T (12035): Fundamentals of Industrial Process Calculations

(Only for Industrial Chemistry Specialization)

Contact Hours / Week	: 4 Hours	Total Maximum Marks	: 100 Marks
Duration of Examination	: 3 Hours	Continuous Assessment	: 30 Marks
		Semester Assessment	: 70 Marks

Note: *The syllabus is divided into five independent units and question paper will be divided into two sections:*

- ***Section-A*** *will carry one compulsory question comprising 10 short answer type questions (answer about in 10-20 words) by taking two questions from each unit with no internal choice. Each short answer type question will have 2 marks and hence Section-A will carry total 20 marks.*
- ***Section-B*** *will carry 50 marks equally divided into five long answer type questions (answer about in 400-500 words) with one question from each unit with internal choice (another question will be given in option or question may be divided in to sub-divisions). Paper setter shall be advised to set one question from each unit along with one option of each question and students are instructed to attempt total five questions by selecting one question from each unit. Each long answer type question will have 10 marks and hence Section-B will carry total 50 marks.*

Unit-I: Material Balance: **12-15 L**

Law of conservation of mass, strategy for analyzing material balance problems, classification of material balance problems, solving material balance problems without chemical reactions, various operations with their block diagrams carried out in industries, material balances involving multiple subsystems, material balances with recycle and bypass operations, material balances of unsteady-state operations, calculation procedures for ideal gas system.

Unit-II: Energy Balance: **12-15 L**

Calculations of enthalpy, general energy balance procedure, sensible heat and heat capacities, relationship between Cp and Cv, energy balances on closed systems, changes using heat capacity equations and enthalpy tables, use of steam tables, heat of reaction, formation and combustion, Hess's law, effect of temperature and pressure on heat reactions, phase change operations, energy balances with chemical reactions, latent heats, energy balance during phase change operations.

Unit-III: Unit Processes: **12-15 L**

Introduction to unit operations, evaporation, distillation, extraction, filtration, crushing, grinding, mixing, crystallization and separation

Unit Operations:

Introduction to unit processes, nitration, sulphonation, halogenations, esterification, polymerization, oxidation and reduction.

Unit-IV: Stoichiometry of Unit Operations: **2-15 L**

Stoichiometry of distillation, gas absorption, crystallization, extraction, leaching and humidification, dew point; relative saturation, molal saturation and absolute saturation (humidity); humid heat and humid volume; psychometric chart for air-water system

Unit-V: Flow of Fluids: **2-15 L**

Nature of fluids, classification of fluids, properties of fluids, hydrostatic pressure, application of fluid statics, manometers, viscosity, average velocity, mass velocity, flow rate, equation of continuity, Bernoulli's equation and its corrections, friction losses, flow of incompressible fluids, flow measurements: venturimeter, orificemeter, pitot tube, rotameter.

Transformation of Fluids:

Methods of transformation of fluids, principles of pipes, fitting and their standards, types and characteristics of valves, pumps.

Books:

- *Introduction to Process Calculations: Stoichiometry. K. A. Gavhane. 20th Edn, 2007, Nirali Prakashan*
- *Unit Operations-I: Fluid flow and Mechanical Operations, K. A. Gavhane. 16th Ed, 2008, Nirali Prakashan*
- *Shreve's Chemical Process Industries. G. T. Austin. 5th Edition. McGrow-Hill International Editions.*
- *Unit Processes in Organic Synthesis. P. H. Groggins. 5th Edition, 2007. Tata McGrow-Hill, New Delhi*

Paper-3.4: CHE-634-T (12036): Fuel, Petrochemicals and Energy Technology

(Only for Industrial Chemistry Specialization)

Contact Hours / Week	: 4 Hours	Total Maximum Marks	: 100 Marks
Duration of Examination	: 3 Hours	Continuous Assessment	: 30 Marks
		Semester Assessment	: 70 Marks

Note: *The syllabus is divided into five independent units and question paper will be divided into two sections:*

- ***Section-A*** *will carry one compulsory question comprising 10 short answer type questions (answer about in 10-20 words) by taking two questions from each unit with no internal choice. Each short answer type question will have 2 marks and hence Section-A will carry total 20 marks.*
- ***Section-B*** *will carry 50 marks equally divided into five long answer type questions (answer about in 400-500 words) with one question from each unit with internal choice (another question will be given in option or question may be divided in to sub-divisions). Paper setter shall be advised to set one question from each unit along with one option of each question and students are instructed to attempt total five questions by selecting one question from each unit. Each long answer type question will have 10 marks and hence Section-B will carry total 50 marks.*

Unit-I: Fuel and Fuel Cell: 12-15 L

Fuel: Types, properties, handling, purification and storage. *Solid Fuels:* Origin, types and analysis of coal; gasification, oxidation, hydrogenation and liquefaction of coal. *Liquid Fuels:* Origin, types and properties of petroleum. *Gaseous Fuels:* Natural gases, methane from coal mines, manufactured gases, producer gas, water gas, refinery gas. *Nuclear Fuels:* Brief idea about types, applications and reactions of nuclear fuels in different power plants. *Hydrogen Fuel:* Production, applications and storage methods.

Fuel Cell: Difference between batteries and fuel cells, components, principle of working, performance characteristics, types: alkaline, polymer electrolyte, phosphoric acid, molten carbonate, solid oxide; problems with fuel cells. applications.

Unit-II: Petroleum and Petrochemicals: 12-15 L

Origin, composition, types, crude oil, general processing of crude oil, fractionation and stippling; cracking process; blending of gasoline: knocking, octane number; aviation gasoline, diesel oil, octane number and cetane number, kerosene, LPG, synthetic petrol (Fischer-Tropsch method). petrochemical and their types, separation and purification, manufacturing process of naphthenes, acetylenes, vinyl chloride, butanol, isopropanol and carbon black.

Unit-III: Petroleum Refining and Petrochemicals: 12-15 L

Introduction of petroleum refining, catalysts for petroleum refining: cracking catalysts, reforming catalysts, hydro treating catalysts; manufacturing of petrochemicals from benzene, toluene and xylenes. manufacturing of petrochemicals

from C_1, C_2, C_3, C_4 cuts, chemicals from methane, ethane, ethylene, acetylene, propane, propylene, butane and their reaction of synthesis.

Unit -IV: Lubricants: 12-15 L

Properties and classification of lubricants, mechanism of lubrication, surface energy, adsorption, laws of friction, viscosity and viscosity index, cloud and pour point, flash and fire point, drop point, aniline point, iodine and saponification value, neutralization number, emulsion number, factors affecting different properties of lubricants, lubricating greases, additives in lubricant, grades of lubricating oils and their designation, deterioration in lubricating oils, selection of lubricants.

Unit-V: Energy Technology : **12-15 L**

Solar Energy: Principles of conversion of solar radiation into heat, solar collectors, solar energy storage system, solar photovoltaic cell, solar hydrogen energy, solar pumps, heaters, dryers, cookers and refrigerators.

Wind Energy: Basic principle and conversions, site selection, wind mills, application and safety system, environmental aspects, wind energy conversion system.

Geothermal Energy: Sources, advantage and disadvantages of geothermal energy over other energy forms, application of geothermal energy

Ocean Wave Energy: Principles of ocean thermal energy conversion open cycle OTES (Claude cycle), ocean thermal energy system, advantages and limitation of tidal power generation, wave energy conversion devices.

Books:

- *Fuel and Energy by Steven Seidenberg, Gareth Stevens, 1992*
- *Fossil Fuels (Energy: Past, Present, and Future) ed. by Robert Curley, Rosen Education Service, 2011*
- *Fossil Fuels by Julie Richards, Benchmark Books, 2009*
- *Hydrogen Fuel (Energy for the Future and Global Warming) by Andrew Solway, Gareth Stevens Publishing, 2007*
- *Energy Autonomy: The Economic, Social & Technological Case for Renewable Energy by Hermann Scheer, Routledge, 2006.*
- *Alternative Energy: Political, Economic, and Social Feasibility by Christopher A. Simon, Lanham, Maryland: Rowman & Littlefield, 2006.*
- *Fuels, Energy, and the Environment by Ghazi A. Karim, CRC Press, 2012*
- *Nuclear Fuel and Energy Policy by S. Basheer Ahmed, Houghton Mifflin Harcourt, 1979*
- *Advances in Biodiesel Production: Processes and Technologies, Edited by R Luque and J A Melero, Woodhead Publishing, 2012.*
- *Biomass for Renewable Energy, Fuels, and Chemicals by Donald L. Klass, Academic Press, 1998.*
- *Fundamentals of Petroleum Refining by M Fahim, Taher Al-Sahhaf and Amal Elkilani, Elsevier, 2009.*
- *Handbook of Biofuels Production: Processes and Technologies Edited by R Luque, J Campelo and J Clark, Woodhead Publishing, 2010.*
- *Natural Gas Conversion Edited by A. Holmen, K.-J. Jens and S. Kolboe, Elsevier, 1991*
- *Handbook of Petrochemicals Production Processes by Robert A. Meyers, McGraw-Hill Professional*
- *Handbook of Petrochemicals and Processes by G. Margaret Wells, Ashgate*
- *Chemical Process Industries by R. N. Shreve.*
- *Riegel's Hand-Book of Industrial Chemistry, Ed. by James A. Kent.*
- *Industrial Chemicals by Faith, Keyes, Clark.*
- *Petrochemical Process Technology by I. D. Mall, Macmillan*
- *Chemistry of Petrochemical Processes by Sami Matar & Lewis F. Hatch, Gulf Professional Publishing*

Paper-3.5: CHE-635-P (12037): Industrial Chemistry Practical

(Only for Industrial Chemistry Specialization)

Contact Hours / Week : 16 Hours
Duration of Examination: 12 Hours (6 Hrs. per Day) **Maximum Marks:** 200 Marks

Distribution of Marks:

S. No.	Name of Exercise	Marks
1.	Exercise No. 1: Major Experiment	30
2.	Exercise No. 2: Major Experiment	30
3.	Exercise No. 3: Major Experiment	30
4.	Exercise No. 4: Minor Experiment	15
5.	Exercise No. 5: Minor Experiment	15
6.	Exercise No. 6: Minor Experiment	15
7.	Practical Record	15
8.	Good Laboratory Skills and Regularity in Practicals	10
9.	Comprehensive Viva-voce	40
	Total Marks	**200**

Atomic Absorption Spectroscopy:

- Determination of metals in given samples by AAS technique.
- Preparation of standard calibration graphs of Pb, Cd, Zn and Fe by AAS.

Fluorimetry & Phosphorimetry:

- Estimation of quinine as quinine sulphate from medicinal tablets
- Determination of amount of vit-B2 in the medicinal tablet fluorometrically.
- Any other experiments related to Spectrofluorometer / phosphorimeter

Nephelometry & Turbidimetry:

- Determination of chloride by turbidimetry.
- Determination of amount of zinc from given sample solution by nephelometric / turbidimetric titration using standard solution of $K_4(Fe(CN)_6)$ in 0.4M HCl
- Determination of amount of sulphate from the given sample solution by nephelometric / turbidimetric titration using standard solution of $Ba(NO_3)_2$ or $Pb(NO_3)_2$

Analysis of Alloys & Ores:

- Analysis of Nichrome alloy:
  - Cr by colorimetry
  - Ni by gravimetry
- Analysis of Zinc blend ore
  - Zn by complexometry
  - Fe by volumetry
- Analysis of Calcite ore
  - Ca by complexometry
  - Fe by colorimetry
- Analysis of felspar ore
- Analysis of steel and ferrous alloy:
  Carbon, silicon, manganese, phosphorous, sulphur, selenium, copper, nickel, chromium, vanadium, tungsten, molybdenum, cobalt, aluminium, titanium, nitrogen, lead, niobium, iron

Analysis of Ferrous Slags:

- Determination of iron, calcium and magnesium, total oxides

Analysis of Fuel / Petroleum / Petroleum Products:

- Determination of calorific value of fuel and coal
- Estimation of moisture in given coal sample.
- Estimation of ash content in given coal sample.
- Estimation of proximate value of given coal sample.
- Determination of the strong acid number or inorganic acidity of oil
- Determination of viscosity and surface tension of oil / liquid.
- Determination of saponification value of oil
- Determination of bromine / hydroxyl / iodine value of oil.
- Determination of aniline point of oil.
- Determination of cloud point and pour point of oil.
- Determination of flash point & fire point of oil.
- Determination of aniline point of liquid fuel
- Determination of carbon residue of liquid fuel
- Determination of octane & cetane number
- Determination of sulphur / lead / other elements in petroleum products / coal
- Determination of alkalinity / salinity / rancidity / water content / diesel index of oil / petroleum sample.
- Determination of organic and inorganic chloride in oil / petroleum sample.
- The ultimate analysis of given sample of soft coke.
- Determine the viscosity of a given sample of oil in centistokes at room temperature and at 40°, 50°, 60° 65°, 70°C. Plot a graph between kinematic viscosity and temperature in degree centigrade.

Analysis of Food & Food Products:

- Analysis of moisture content, ash, fiber, nutrients, anti-nutrients, toxicants, microorganism-spoilage, preservatives.
- Analysis of amino acids, proteins, carbohydrates, lipids and fat.
- Analysis of edible oils, dairy products, pickles etc., fruit and vegetable products
- Analysis of food additives and adulterations.
- Analysis of sugars in food and beverage by HPLC.
- Analysis of sugars and related hydroxyl acids by GC.
- Determination of sucrose in various food products.
- Determination of mono-and disaccharides in sweets and beverages by HPLC with refractometric detection
- Separation of Asparagine-Linked (N-Linked) oligosaccharides
- Estimation of vitamin A in food product by Carr-price method.
- Estimation of vitamin C in fruit juice by iodometry.
- Determination of Vitamin B_2 (Riboflavin) by fluorometry.
- Estimation of proteins, sugars, vitamins, amino acids, crude fiber, total minerals, metals, crude fat and water in foods.
- Estimation of ascorbic acid by ceric ammonium sulphate method.
- Estimation of Glucose and fructose in honey by Lane and Eynone method.
- Determination of Hydroxymethylfurfural in Honey and Biomass
- Estimation of lactose in milk by iodometry.
- Quantitative analysis of iron, calcium and phosphorus in milk powder. (Fe-Colorimetrically, Ca-Complexometrically, P-Colorimetrically)
- Casein isolation from milk by isoelectric precipitation (Yield expected).

- Analysis of lipids: saponification value, acid value and iodine value.
- Determination of tannins, chemical residues and aflatoxins,
- Estimation of preservative and antioxidants.
- Determination of strength of acetic acid from the commercial vinegar sample by potentiometric titration and its confirmation by conductimetric / pH-metric titration using standard solution of NaOH
- Determination of commercial washing soda by potentiometric titration method.
- Estimation of amino acid in protein hydrolysate by Sorenson formal titration method.
- Estimation of pectin as Ca-Pectate colorimetrically
- Determination of Ca in egg shell by flame photometry method.
- Determination of fluoride in tooth paste colorimetrically with alizarins.
- Estimation of sodium benzoate / sodium metabisulphite, boric acid and salicylic acid in food.
- Determination of carbohydrates in coffee.
- Determination of Na/K/Li/Ca in given sample by flame photometry method.
- Chemical analysis of chilli-powder.
- Formulation of rose, jasmine, sandal wood, lavender

Electro-analytical Methods of Analysis:

(i) Oxidation-Reduction Titrations

- Standardization with sodium oxalate of $KMnO_4$ and determination of Ca^{2+} ion.
- Standardization of ceric sulphate with Mohr's salt and determination of Cu^{2+}, NO_3^{-1} and $C_2O_4^{-2}$ ions.
- Standardization of $K_2Cr_2O_7$ with Fe^{2+} and determination of Fe^{3+} (Ferric alum)
- Standardization of hypo solution with potassium iodate / $K_2Cr_2O_7$ and determination of available Cl_2 in bleaching powder, Sb^{3+} and Cu^{2+}.
- Determination of hydrazine with KIO_3 titration.

(ii) Precipitation Titrations

- $AgNO_3$ standardization by Mohr's method by using adsorption indicator.
- Volhard's method for Cl^- determination.
- Determination of ammonium / potassium thiocyanate.
- Estimation of Mg or Ca as oxinate by titration with standard Br_2 sol.
- Estimation of KBr in the given solution by titrating against std. $AgNO_3$ solution using eosin as indicator.

(iii) Complexometric Titrations:

- Determination of Cu^{2+} and Ni^{2+} by using masking reagent by EDTA titration.
- Determination of Ni^{2+} (back titration).
- Determination of Ca^{2+} (by substitution method).
- Estimation of the purity of oxalic acid employing standard Ce(IV) solution.
- Estimation of various transition elements like Zn/Ni/Co/Cd/Al from various commercial samples by complexometric titrations on potentiometer by using mercury electrode

(iv) Voltametric Titrations:

- Determination of trace metal impurities present in a polluted water sample by anodic stripping voltammetric procedure.

(v) Electrogravimetric Titrations:

- Electrogravimetric estimation of barium, copper, chromium, lead, nickel present in the solution at ppm level.

(vi) Amperometric Titrations:

- Amperometric determination of Zinc with standard EDTA solution.
- Amperometric titration of lead with standard potassium dichromate solution.
- Amperometric determination of magnesium (or cadmium) by precipitating it as oxinate and titrating against standard $KBrO_3$ solution.
- Estimation of the mercapto group in thioglycolic acid by titrating with standard $AgNO_3$ solution amperometrically.
- Amperometric titration of (i) thiourea v/s silver nitrate (ii) vitamin C v/s ferric nitrate
- Amperometric titration of (a) Pb v/s SO_4^{2-} (b) Pb v/s $K_2Cr_2O_7$ (c) Ni v/s DMG.
- Estimation of sulphadiazine in sulpha tablet by amperometric titration method

Spectrophotometry & Colorimetry:

- Study of copper-ethylene diamine complex: Slope-ratio method.
- To determine the amount of each para nitro-phenol and meta nitro-phenol from the given mixture by spectrophotometric titration using standard solution of NaOH (max-280 nm)
- Determination of Fe^{3+} using thiocyanate method.
- Determination of Ni^{2+} in presence of Cu^{2+} using salicyladoxime method.
- Determination of nickel/molybdenum/tungsten/vanadium/uranium by extractive spectrophotometric method.
- Simultaneous spectrophotometric determination of (Cr & Mn) and (Ti & V)
- Determination of an indicator constant and isobestic point of an indicator spectrophotometrically.
- Estimation of pectin as Ca-pectate colorimetrically
- Determination of available phosphorus in soil Olesen's colorimetric method.
- Determine the indicator constant of methyl red spectrophotometrically
- Determination of Cd^{2+}, Zn^{2+}, Co^{2+} using anthranilic acid method.
- Determination of Bi^{3+} using pyrogallol method.
- Determination of Ni^{2+} by rubeanic acid method.
- Colorimetric and spectrophotometric determination of manganese in steel.
- Estimations of copper, iron, nickel, manganese, chromium and zirconium using Nessler technique and/or spectrophotometry.

Ion Chromatography:

(i) Chemical Applications:

- Determination of anions in toothpaste by Ion Chromatography.
- Determination of anions and cations in high purity water by Ion Chromatography.
- Determination of metals and polyphosphates in given sample by Ion Chromatography.
- Determination of azide in aqueous samples by Ion Chromatography.
- Determination of dissolved hexavalent chromium in drinking water, groundwater and industrial waste.
- Determination of diethanolamine and triethanolamine in surface finishing, wastewater and scrubber solutions water effluents by Ion Chromatography
- Determination of fluoride in acidulated phosphate topical solution.
- Determination of oxalate and other anions in Bayer liquor using Ion Chromatography
- Determination of amino acids, carbohydrates, alcohols, and glycols in fermentation Broths

- Determination of calcium, magnesium, manganese and iodine in Brine
- Determination of trace anions and cations in concentrated bases using auto-neutralization pre-treatment/Ion Chromatography
- Determination of trace anions in organic solvents and concentrated hydrofluoric acid.
- Determination of trace transition metals in reagent grade acids, bases, salts, and organic solvents using chelation Ion Chromatography
- Determination of polyphenols
- Determination of N,N-dimethyl-o-toluidine and N,N-diethyl-o-toluidine in ethylene gas samples.
- Determination of transition metals at ppt levels in High-Purity Water and SC2 (D-clean) Baths

(ii) Petroleum Refining:

- Extraction of total petroleum hydrocarbon contaminants (diesel and waste oil) in soils
- Extraction of hydrocarbon contaminants (BTEX, Diesel, and TPH) in soils
- Extraction of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans
- Extraction of PAHs from environmental samples by accelerated solvent extraction (ASE)
- Determination of thiosulfate in refinery and other wastewaters
- Automated solid phase extraction (SPE) of total petroleum hydrocarbons using Dionex AutoTrace® Instrument
- Determination of biofuel sugars by Ion Chromatography
- Determination of cations in biodiesel using a Reagent-Free Ion Chromatography.
- Determination of 32 low molecular mass organic acids in biomass by Ion Chromatography Mass Spectrometry

(iii) Safety and Security Applications:

- Extraction of explosives from soils by accelerated solvent extraction (ASE)
- Determination of monovalent cations in explosives

(iv) Cosmetics:

- Rapid Determination of benzalkonium chloride in cosmetics

(v) Polymers:

- Polysialic acid analysis: Separating polymers with high degrees of polymerization.

Note: *Any other relevant experiments may be added / performed.*

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Syllabus

M. Sc. Chemistry
Fourth Semester Examination

Paper-4.1 and 4.2: Common Papers for all Specializations
(Inorganic Chemistry, Organic Chemistry, Physical Chemistry, Analytical Chemistry and Industrial Chemistry)

Paper-4.1: CHE-641-T (12041): Environmental Chemistry
(Common Paper for all Specializations)

Contact Hours / Week	: 4 Hours	Maximum Marks	: 100 Marks
Duration of Examination	: 3 Hours	Continuous Assessment	: 30 Marks
		Semester Assessment	: 70 Marks

Note: *The syllabus is divided into five independent units and question paper will be divided into two sections:*

- ***Section-A*** *will carry one compulsory question comprising 10 short answer type questions (answer about in 10-20 words) by taking two questions from each unit with no internal choice. Each short answer type question will have 2 marks and hence Section-A will carry total 20 marks.*
- ***Section-B*** *will carry 50 marks equally divided into five long answer type questions (answer about in 400-500 words) with one question from each unit with internal choice (another question will be given in option or question may be divided in to sub-divisions). Paper setter shall be advised to set one question from each unit along with one option of each question and students are instructed to attempt total five questions by selecting one question from each unit. Each long answer type question will have 10 marks and hence Section-B will carry total 50 marks.*

Unit-I: Air Pollution: **12-15 L**

Composition of atmosphere, major sources of air pollution, chemical reactions, smog formation, acid rain, classification and effect of air pollutants, NOx, SOx, COx particulates and ozone; Greenhouse effect and global warming, ozone depletion, automobile emissions, prevention and control of vehicular pollution, alternative fuels: Biodiesel, ethanol, CNG, ultra-low sulphur diesel (ULSD).

Monitoring of Air Pollution:
Principles of environment monitoring, methods for monitoring of air pollutants including NOx, SOx, COx, SPM.

Prevention and Control of Air Pollution:
Control of pollution by fuel selection and utilization, process or equipment modification, devices, site selection, stacks, planting trees and growing vegetation, general methods of air pollution control.

Unit-II: Water Pollution: **12-15 L**

Types of water pollution, sources of water pollution, water pollutants, their classification and effects, water pollution laws and standards.

Analysis of Water:
Chemical and physical examination of water, preservation and pre-concentration, hydrogen ion concentration, acidity, alkalinity, hardness, pH, free CO_2, Cl_2, metals, ions, dissolved chlorine and oxygen, BOD, COD, chlorine dosage, *E. coli* index, general methods of water pollution control.

Unit-III: Soil Pollution: **12-15 L**

Composition and types of soil, mineral and organic matter in soil, soil pollution by industrial wastes, urban wastes, radioactive pollution and agriculture practices.

Soil Analysis:

Analysis of nitrates, nitrites, ammonical nitrogen, total nitrogen, phosphates, organic carbon, potassium, calcium, sodium, magnesium, iron, zinc, etc.

Control of Soil Pollution:

Control of domestic and industrial wastes, soil remediation, environment friendly technologies for agriculture

Unit-IV: Industrial Pollution: **12-15 L**

Environmental pollution from various industries and control of industrial pollution.

Industrial Wastes and their Treatment:

Characteristics and types of industrial wastes, principles of industrial waste treatment, protection of biosphere and surface water from pollution with industrial sewages, sampling and chemical analysis of industrial wastewater, wastewater treatment, solid waste management, hazardous waste management.

Unit-V: Radioactive Pollution: **12-15 L**

Radioactive substances, state of radioactive isotopes in solution, gases and solids; units of radiation, analysis of radionuclides, sources of radioactive pollution, radioactive fallout, nuclear reactors, nuclear installations, radioactive ore processing, nuclear accidents, effects of radioactive pollution on power plants and polymers, control of radioactive pollution.

Books:

- *Environmental Chemistry. B. K. Sharma. 12th Edition, 2011, Goel Publishing House, Meerut.*
- *Environmental Chemistry, Colin Baird, W.H. Freeman Co. New York, 1998.*
- *Environmental Pollution: Principles, Analysis and Control. P. Narayanan. 1st Edition, 2007, CBS Publishers & Distributors, New Delhi.*
- *Environmental Pollution Control Engineering. C. S. Rao. 2nd Edition, 2006, New Age International Publishers, New Delhi.*
- *Environmental Pollution analysis, S.M. Khopkar, Wiley Eastern, New Delhi, 1994.*
- *Pollution Control in Process Industries. S. P. Mahajan. 20th Ed, 2006, Tata McGraw-Hill, New Delhi.*
- *Industrial Pollution. V. P. Kudesia. 5th Edition, 2007, Pragati Prakashan, Meerut.*
- *Environmental Toxicology, J. Rose Gordon and Breach (Ed.), Science Publication, New York, 1993.*

Paper-4.2: CHE-642-T (12042): Recent Methods of Organic Synthesis

(Common Paper for all Specializations)

Contact Hours / Week	: 4 Hours	Total Maximum Marks	: 100 Marks
Duration of Examination	: 3 Hours	Continuous Assessment	: 30 Marks
		Semester Assessment	: 70 Marks

Note: *The syllabus is divided into five independent units and question paper will be divided into two sections:*

- ***Section-A*** *will carry one compulsory question comprising 10 short answer type questions (answer about in 10-20 words) by taking two questions from each unit with no internal choice. Each short answer type question will have 2 marks and hence Section-A will carry total 20 marks.*
- ***Section-B*** *will carry 50 marks equally divided into five long answer type questions (answer about in 400-500 words) with one question from each unit with internal choice (another question will be given in option or question may be divided in to sub-divisions). Paper setter shall be advised to set one question from each unit along with one option of each question and students are instructed to attempt total five questions by selecting one question from each unit. Each long answer type question will have 10 marks and hence Section-B will carry total 50 marks.*

Unit-I: Modern Approaches of Organic Synthesis: 12-15 L

Principles and concepts of green chemistry, atom economy, waste minimization techniques, different approaches to green synthesis.

Reagents: Dimethyl carbonate; polymer supported reagents: chromic acid and per-acids.

Catalysts: Introduction, homogeneous and heterogeneous catalysts, solid acid-base catalysts, metal oxide supported catalysts, oxidation catalysts, basic catalysts, polymer supported catalysts, phase transfer catalysts, biocatalysts.

Unit-II: Solvents for Organic Synthesis: 12-15 L

Introduction, characteristics properties, types and examples of green solvents.

Water: Reasons for using water as green solvent, biphasic systems, synthesis in water (asymmetric aldol reaction, synthesis of quinoxalines, carbon dioxide fixation, preparation of nanoparticles), near critical water.

Supercritical Liquids:
The phase diagram of CO_2, supercritical CO_2, its properties and applications in dry cleaning, decaffeination of coffee and synthesis.

Ionic Liquids: Basic concept, types, physicochemical properties, preparation of ionic liquids: dialkylimidazolium and alkylpyridinium cation based ionic liquids, ionic liquids with fluorine containing anions and chiral ionic liquids; synthetic applications of ionic liquids (alkylation, allylation, oxidation and hydrogenation), concept of supported ionic liquids and their applications.

Unit-III: Microwave Assisted Organic Synthesis: 12-15 L

Introduction of microwave assisted organic syntheses, fundamentals of microwave technology, microwave activation, equipment, time and energy benefits, limitations; applications, reactions in organic solvents: Esterification, Diels-Alder reaction; solvent free reactions (solid state reactions): saponification, alkylation of reactive methylene compounds.

Unit-IV: Ultrasound Assisted Organic Synthesis: 12-15 L

Basics of sonochemistry, ultrasound cavitation, sonochemical effect, experimental parameters, transducers, reactors, homogeneous and heterogeneous sonochemistry, Kornblum-Russell reaction, Hetero-Michael reaction, preparation of Grignard's reagent.

Electrochemical Organic Synthesis:
Basic principle, anodic oxidations, cathodic reductions, elimination reactions, Kolbe reaction, synthesis of sebacic acid.

Unit-V: Organic Synthesis Using Reactors: 12-15 L

General introduction and types of reactors, chemical reactor design, simulation and optimization; mass and energy balance, mass and energy transfer. *Batch reactors:* Basic concepts, types and reactions; concepts of laboratory and pilot scale organic syntheses.

Vapour Phase Reactors:
Types and design. Raw materials, process flow diagrams, product syntheses, separations, purifications and waste compositions at industrial scale productions of pharmaceuticals, agrochemicals, organic fertilizers and dyes.

Books:

- *Green Chemistry: Theory and Practice, Paul T. Anastos and John C. Warner*
- *Green Chemistry: An Introductory Text by Mike Lancaster, Royal Society of Chemistry*
- *Green Chemistry and Catalysis by Sheldon, Arends and Hanefeld, WILEY-VCH, Germany*
- *Green Solvents, Vol. 5: Reactions in Water. edited by Paul T. Anastas, WILEY-VCH*
- *Green Solvents, Vol. 6: Ionic Liquids. edited by Paul T. Anastos, WILEY-VCH*
- *Ionic Liquids in Synthesis by Wasserscheid and Welton. WILEY-VCH*
- *Microwaves in Organic Synthesis, Antonio de la Hoz (Ed), André Loupy (Ed), Wiley-VCH*
- *Organic Synthesis in Water, Paul A Grieco Blackie.*
- *Organic Synthesis: Special Techniques, V. K. Ahluwalia and Renu Aggrawal*
- *Chemical Reviews 2007, 107, 2167-2820 (Special issue on Green Chemistry)*
- *Fundamentals and Applications of Organic Electrochemistry: Synthesis, Materials, Devices by Toshio Fuchigami, Mahito Atobe, Shinsuke Inagi.*

Paper-4.3, 4.4 and 4.5: Specialization wise Papers

(Inorganic Chemistry, Organic Chemistry, Physical Chemistry, Analytical Chemistry and Industrial Chemistry)

Group-I: Inorganic Chemistry Specialization

Paper-4.3: CHE-643-T (12043): Organo-transition Metal Chemistry

(Only for Inorganic Chemistry Specialization)

Contact Hours / Week	: 4 Hours	Total Maximum Marks	: 100 Marks
Duration of Examination	: 3 Hours	Continuous Assessment	: 30 Marks
		Semester Assessment	: 70 Marks

Note: *The syllabus is divided into five independent units and question paper will be divided into two sections:*

- ***Section-A*** *will carry one compulsory question comprising 10 short answer type questions (answer about in 10-20 words) by taking two questions from each unit with no internal choice. Each short answer type question will have 2 marks and hence Section-A will carry total 20 marks.*
- ***Section-B*** *will carry 50 marks equally divided into five long answer type questions (answer about in 400-500 words) with one question from each unit with internal choice (another question will be given in option or question may be divided in to sub-divisions). Paper setter shall be advised to set one question from each unit along with one option of each question and students are instructed to attempt total five questions by selecting one question from each unit. Each long answer type question will have 10 marks and hence Section-B will carry total 50 marks.*

Unit-I Alkyls and Aryls of Transition Metals: 12-15 L

Types, routes of synthesis, stability and decomposition pathways organo-copper in organic synthesis. Transition metal compounds with bonds to hydrogen.

Unit-II Compounds of Transition Metal-Carbon Multiple Bonds: 12-15 L

Alkylidenes, alkylidynes, low valent carbenes and carbynes-synthesis, nature of bond, structural characteristics, nucleophilic and electrophilic reactions on the ligands, role in organic synthesis.

Unit-III Transition Metal π-Complexes: 12-15 L

Transition metal π-Complexes with unsaturated organic molecules, alkenes, alkynes, allyl, diene, dienyl, arene and trienyl complexes, preparation, properties, nature of bonding and structural features. Important reactions relating to nucleophilic and electrophilic attack on ligands and to organic synthesis.

Unit-IV Homogeneous Catalysis: 12-15 L

Stoichiometric reactions for catalysis, homogeneous catalytic hydrogenation, Zeigler-Natta polymerization of olefins, catalytic reactions involving carbon monoxide such

as hydrocarbonylation of olefins (oxo reaction), oxo palladation reactions, activation of C-H bond.

Unit-V Fluxional Organometallic Compounds: **12-15 L**

Fluxionality and dynamic equilibrium in compounds such as η^2-olefine, η^3-allyl and dienyl complexes.

Books:

- *Principles and Application of Organo-transition Metal Chemistry, J.P. Collman, L.S. Hegsdus, J.R. Norton and R.G. Finke, University Science Books.*
- *The Organometallic Chemistry of the Transition Metals, R.H. Crabtree. John Wiley.*
- *Metallo-organic Chemistry, A.J. Pearson, Wiley.*
- *Organometallic Chemistry, R.C. Mehrotra and A. Singh New Age International.*

Paper-4.4: CHE-644-T (12044): Polymers

(Only for Inorganic Chemistry Specialization)

Contact Hours / Week	: 4 Hours	Total Maximum Marks	: 100 Marks
Duration of Examination	: 3 Hours	Continuous Assessment	: 30 Marks
		Semester Assessment	: 70 Marks

Note: *The syllabus is divided into five independent units and question paper will be divided into two sections:*

- ***Section-A*** *will carry one compulsory question comprising 10 short answer type questions (answer about in 10-20 words) by taking two questions from each unit with no internal choice. Each short answer type question will have 2 marks and hence Section-A will carry total 20 marks.*
- ***Section-B*** *will carry 50 marks equally divided into five long answer type questions (answer about in 400-500 words) with one question from each unit with internal choice (another question will be given in option or question may be divided in to sub-divisions). Paper setter shall be advised to set one question from each unit along with one option of each question and students are instructed to attempt total five questions by selecting one question from each unit. Each long answer type question will have 10 marks and hence Section-B will carry total 50 marks.*

Unit-I Polymers: **12-15 L**

Importance of polymers. Basic concepts: Monomers, repeat units, degree of polymerization Linear, branched and network polymers. Classification of polymers. Polymerization: condensation, addition/radical chain-ionic and co-ordination and copolymerization. Polymerization conditions and polymer reactions. Polymerization in homogeneous and heterogeneous systems.

Unit-II Structure and Properties: **12-15 L**

Morphology and order in crystalline polymers-configurations of polymers chains. crystal structure of polymers. Morphology of crystalline polymers, strain-induced morphology, crystallization and melting. Polymer structure and physical properties-crystalline melting point (Tm), melting point of homogenous series, effect of chain flexibility and other steric factors, entropy and heat of fusion. The glass transition temperature (Tg), relationship between Tm and Tg, effect of molecular weight, diluents, chemical structure, chain topology, branching and cross linking.

Unit-III Polymer Characterization: **12-15 L**

Polydispersion-average molecular weight concept. Number, weight and viscosity average molecular weights. Polydispersity and molecular weight distribution. The practical significance of molecular weight. Measurement of molecular-weights, end-group, viscosity, light scattering, osmotic and ultracentrifugation methods. Analysis and testing of polymers-Chemical analysis of polymers, spectroscopic methods, X-ray

diffraction study. Microscopy. Thermal analysis and physical testing tensile strength. Fatigue, impact. Tear resistance, hardness and abrasion resistance.

Unit-IV Polymer Processing: 12-15 L

Plastics, elastomers and fibers. Compounding. Processing techniques: Calendaring, die casting, rotational casting, film casting, injection molding, blow molding, extrusion molding, thermoforming, foaming, reinforcing and fiber spinning.

Unit-V Inorganic Polymers: 12-15 L

Structure, Properties and Applications of

- Polymers based on Boron-borazines, boranes and carboranes.
- Polymers based on Silicon-silicones, polymetalloxanes, polymetallosiloxanes, silazanes.

Structure, Properties and Applications of

- Polymers based on Phosphorous-Phosphazenes, Polyphosphates
- Polymers based on Sulphur-Tetra Sulphur tetranitride and related compounds.

Books:

- *Inorganic Chemistry, J.E. Huheey, Harper Row.*
- *Developments in Inorganic polymer Chemistry, M.F. Lappert and G.J. Leigh.*
- *Inorganic polymers, Graham and Stone.*
- *Inorganic Rings and Cages: D.A. Armitage.*
- *Textbook of Polymers Science, F.W. Billmeyer Jr. Wiley.*
- *Contemporary Polymer Chemistry, H.R. Al cock and F.W. Lambe, Prentice Hall.*
- *Polymer science, V.R. Gowariker, N.V. Viswanthan and J. Shreedhar Wiley-Eastern.*

Paper-4.5: CHE-645-P (12045): Inorganic Chemistry Practical

(Only for Inorganic Chemistry Specialization)

Contact Hours / Week : 16 Hours
Duration of Examination: 12 Hours (6 Hrs. per Day) **Maximum Marks:** 200 Marks

Distribution of Marks:

S. No.	Name of Exercise	Marks
1.	Exercise No. 1: Major Experiment	30
2.	Exercise No. 2: Major Experiment	30
3.	Exercise No. 3: Major Experiment	30
4.	Exercise No. 4: Minor Experiment	15
5.	Exercise No. 5: Minor Experiment	15
6.	Exercise No. 6: Minor Experiment	15
7.	Practical Record	15
8.	Good Laboratory Skills and Regularity in Practicals	10
9.	Comprehensive Viva-voce	40
	Total Marks	**200**

Inorganic Preparations:

Preparation of selected inorganic compounds and their study by IR, electronic, Mossbauer, ESR and magnetic susceptibility measurements. Handling of air and moisture sensitive compounds involving vacuum lines. Selection can be made from the following:

- Synthesis and thermal analysis of group II metal oxalate hydrate. *J. Chem. Ed.,* 1988, 65, 1024.
- Atomic absorption analysis of Mg and Ca.

- Trialkoxyboranes-IR and NMR spectra.
- Relative Stability of Tin (IV) and Pb (IV).
- Preparation of ammonium hexachlorostannate $(NH_4)_2$ $SnCl_6$ ammonium hexachlorophlumbate $(NH_4)_2PbCl_6$.
- Metal complexes of dimethyl sulfoxide (IR): $CuCl_2$.2DMSO, $PdCl_2$. 2DMSO, $RuCl_2$. 4DMSO. *J. Chem. Edu.,* 1982, 59, 57.
- Magnetic moment of Cu $(acac)_2H_2O$.
- Separation of optical isomer of cis-$[Co(en)_2CI_2]Cl$. *J. Chem. Soc.,* 1960. 4369.
- Determination of Cr(III) complexes. $[Cr(H_2O)_6]NO_3.3HO$, $[Cr(H_2O)_4Cl_2]Cl.{}_2H_2O$, $[Cr(en)_3]Cl_3$, $Cr(acac)_3$. *Inorg. Synths.,* 1972, 13, 184.
- Preparation and use of Ferrocene. J. Chem. Edu. 1966, 43, 73; 1976, 53, 730.
- Preparation of phosphine Ph_3P and its transition metal complexes.
- Preparation of [Co(phenathroline-5,6 quinone)].
- Any other experiment such as conversion of p-xylene to terephtalic acid catalyzed by $CoBr_2$ (homogeneous catalysis).
- Synthesis of trichlorodiphenylantimony (V) hydrate. Inorg. Synths., 1985, 23, 194
- Synthesis of metal acethylacetonate: Magnetic moment, IR, NMR, *Inorg. Synths,* 1957, 5, 130, 1963, 1, 183.
- Bromination of $Cr(acac)_3$. *J. Chem. Edu.,* 1986, 63, 90.
- Ion exchange separation of oxidation state of vanadium. *J. Chem. Edu.,* 1980, 57, 316; 1978, 55, 55.
- Preparation of N,N bis (salicycladehyde) ethylenediamine, silane H_2. Co(Silane) *J. Chem. Edu.,* 1977, 54, 443; 1973, 50, 670.
- Preparation of Fe(II) chloride (use it as Friedel-Craft chlorination source) *J. Org. Chem.*, 1978, 43, 2423; *J. Chem. Edu.,* 1984, 61, 645; 1986, 63, 361.
- Reaction of Cr(III) with a multidentate ligand: a kinetics experiment (visible spectra Cr-EDTA complex) *J. Am. Chem. Soc.,* 1953, 75, 6570.
- Preparation of copper glycine complex-cis and trans bis (glycinato Copper (II). J. Chem. Soc. Dalton, 1979, 1901, *J. Chem. Edu.,* 1982, 59, 1052.

Conductometry:

- Determination of relative strength of acetic acid, chloroacetic acid and trichloroacetic acid through measuring their Ka-value by conductivity measurement method.
- Conductometric titration of (i) strong acid, monobasic weak acid or polybasic weak acid with strong base (ii) zinc with EDTA and (iii) KCl v/s $AgNO_3$.
- Determination of the strength of $HCl+CH_3COOH$ mixture against standard NaOH solution.
- Conductometric titration of triple mixture $(HCl+NH_4Cl+KCl)$ with (i) NaOH and (ii) $AgNO_3$.
- Determination of thermodynamic ionization constant of a monobasic acid by (i) conductometry and (ii) potentiometry.
- To study the effect of solvent on the conductance of $AgNO_3$/acetic acid and to determine the degree of dissociation and equilibrium constant in different solvents and in their mixtures (DMSO, DMF, dioxane, acetone, water) and to test the validity of Debye-Hűckel-Onsager theory.
- Determination of the activity coefficient of zinc ions in the solution of 0.002 M zinc sulphate using Debye Hűckel's limiting law.

- Titration of $ZnSO_4$ / $MgSO_4$ against $BaCl_2$ and $Ba(CH_3COO)_2$ and calculation of amount of sulphate present.
- Determination of solubility and solubility product of sparingly soluble salts (*e.g.* $PbSO_4$, $BaSO_4$) conductometrically.

Potentiometry / pH metry:

- Determination of EMF of Daniel cell.
- Determination of standard electrode potential (Eo) value of the ferrous-ferric system by titrating ferrous ammonium sulphate against potassium dichromate potentiometrically.
- Determination of pKa of dibasic acid (oxalic acid, succinic acid, *etc*).
- Determination of the formation constant of Ag-ammonia complex and stoichiometry of the complex potentiometrically.
- Determination of hydrolysis constant and degree of hydrolysis of aniline hydrochloride pH metrically
- Determination of thermodynamic parameters for electrochemical reactions (To determine ΔGo, ΔHo and ΔSo for the formation of 1 mole cadmium in 1 wt.% amalgam at 25°C and activity coefficient of solution)
- Estimate the number of halides present in the given mixture by titrating with $AgNO_3$ solution.
- Determination of strength of acetic acid from the commercial vinegar sample by potentiometric titration and its confirmation by conductometric / pH metric titration using standard solution of NaOH.
- Micro-determination of glucose using potassium ferrocyanide as internal reagent and Ce (IV) solution as standard titrant.
- Determination of the dissociation constant of acetic acid in DMSO, DMF, acetone and dioxane by titrating it with KOH.
- Estimation of various transition elements like Zn/Ni/Co/Cd/Al from various commercial samples by complexometric titrations on potentiometer by using mercury electrode.
- Determine the amount of HCl by using weak base (NH_4OH) potentiometrically.
- Fabrication of ion-selective electrodes for Co, Ni, Cu, Zn, Pd, Cd, *etc.* ions and record the electrode response and sensitivity.
- Titrate a phosphoric acid solution against alkali using glass electrode potentiometrically and calculate the first and second ionization constants of the acid.
- Estimation of heavy metal toxicity using ion-selective electrodes: Pb, Cd, Hg,
- Electrochemical Impedance study of metal/solution interface.
- Cyclic Voltammetry of the $[Fe(CN)6]^{3-}$/$[Fe(CN)6]^{4-}$ system.

Chromatographic Separations:

- Cadmium and zinc
- Zinc and magnesium.
- Thin-layer chromatography-separation of nickel, manganese, cobalt and zinc. Determination of R_f values.
- Separation and identification of the sugars present in the given mixture of glucose, fructose and sucrose by paper chromatography and determination of R_f values.

Note: *Any other relevant experiments may be added / performed.*

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Group-II: Organic Chemistry Specialization

Paper-4.3: CHE-643-T (12046): Chemistry of Natural Products

(Only for Organic Chemistry Specialization)

Contact Hours / Week	: 4 Hours	Total Maximum Marks	: 100 Marks
Duration of Examination	: 3 Hours	Continuous Assessment	: 30 Marks
		Semester Assessment	: 70 Marks

Note: *The syllabus is divided into five independent units and question paper will be divided into two sections:*

- ***Section-A*** *will carry one compulsory question comprising 10 short answer type questions (answer about in 10-20 words) by taking two questions from each unit with no internal choice. Each short answer type question will have 2 marks and hence Section-A will carry total 20 marks.*
- ***Section-B*** *will carry 50 marks equally divided into five long answer type questions (answer about in 400-500 words) with one question from each unit with internal choice (another question will be given in option or question may be divided in to sub-divisions). Paper setter shall be advised to set one question from each unit along with one option of each question and students are instructed to attempt total five questions by selecting one question from each unit. Each long answer type question will have 10 marks and hence Section-B will carry total 50 marks.*

Unit-I: Terpenoids and Carotenoids: **12-15 L**

Classification, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule, stereochemistry and synthesis of citral, geraniol, α-terpineol, menthol, farnesol, zingiberene, abietic acid and β-carotene.

Unit-II: Alkaloids: **12-15 L**

Definition, nomenclature and physiological action, occurrence, isolation, identification (qualitative idea only), general methods of structure elucidation, degradation, classification (based on nitrogen heterocyclic ring), role of alkaloids in plants; structure, stereochemistry and synthesis of ephedrine, coniine, nicotine, atropine, quinine and morphine.

Unit-III: Steroids and Hormones: **12-15 L**

Occurrence, nomenclature, basic skeleton, Diel's hydrocarbon and stereochemistry, isolation, identification (qualitative idea only), structure determination and synthesis of cholesterol, bile acids, androsterone, testosterone, oestrone, progesterone, aldosterone.

Unit-IV: Porphyrins: **12-15 L**

Structure and synthesis of haemoglobin and chlorophyll.

Plant Pigments: Occurrence, nomenclature, isolation, general methods of structure determination and synthesis of apigenin, luteolin, quercetin, myricetin, daidzein, cyanidin, cyanidin-7-arabinoside, hirsutidin.

Biosynthesis of Flavonoids: Acetate pathway and shikimic acid pathway.

Unit-V: Prostaglandins: **12-15 L**

Occurrence, nomenclature, classification, biogenesis and physiological effects, synthesis of PGE_2 and $PGF_{2\alpha}$.

Pyrethroids and Rotenones: Synthesis and reactions of pyrethroids and rotenones (for structure elucidation, emphasis is to be placed on the use of spectral parameters wherever possible).

Books:

- *Natural Products: Chemistry and Biological Significance, J. Mann, R.S. Davidson, J.B. Hobbs, D.V. Banthrope adn J.B. Harbome, Longman, Essex.*
- *Organic Chemistry: Vol. 2, I.L. Finar, ELBS.*

- *Stereoselective Synthesis: A Practical Approach, M. Norgradi, VCH.*
- *Chemistry, Biological and Pharmacological Properties of Medicinal Plants from the Americas, Ed. Kurt Hostettmann, M.P. Gupta and A. Marston. Harwood Academic Publishers.*
- *Introduction to Flavonoids, B.A. Bohm. Harwood Academic Publishers.*

Paper-4.4: CHE-644-T (12047): Medicinal Chemistry

(Only for Organic Chemistry Specialization)

Contact Hours / Week	: 4 Hours	Total Maximum Marks	: 100 Marks
Duration of Examination	: 3 Hours	Continuous Assessment	: 30 Marks
		Semester Assessment	: 70 Marks

Note: *The syllabus is divided into five independent units and question paper will be divided into two sections:*

- ***Section-A*** *will carry one compulsory question comprising 10 short answer type questions (answer about in 10-20 words) by taking two questions from each unit with no internal choice. Each short answer type question will have 2 marks and hence Section-A will carry total 20 marks.*
- ***Section-B*** *will carry 50 marks equally divided into five long answer type questions (answer about in 400-500 words) with one question from each unit with internal choice (another question will be given in option or question may be divided in to sub-divisions). Paper setter shall be advised to set one question from each unit along with one option of each question and students are instructed to attempt total five questions by selecting one question from each unit. Each long answer type question will have 10 marks and hence Section-B will carry total 50 marks.*

Unit-I: Drug Design and Development: 12-15 L

Drug Discovery and Development: Introduction, procedures followed in drug design and development; Lead compounds: Concept, identification, structural modifications, role in drug discovery; Physico-chemical properties of drugs: Acid-base properties, relative acid strength, water solubility; Stereochemistry and drug action: Enantiomers and diastereomers, biological activity.

Isosterism and Bioisosterism: Introduction, classifications, methods of identification, applications of bioisosteres in drug design.

Pro-drugs and Soft Drugs: Introduction, properties, classification, major applications.

Molecular Modelling and Drug Design: Introduction, quantum mechanics and molecular mechanics, molecular dynamics, simulation, *in silico* drug design, structure-based and ligand-based drug design, virtual screening, ADME predictions.

Structure Activity Relationships (SARs): Introduction, physico-chemical parameters (lipophilic, electronic, steric, molar refractivity, surface activity and redox potentials); molecular descriptors: Definition, types, classification and applications; Quantitative methods: Hansch analysis, Free-Wilson analysis, Free-Wilson and Hansch analysis, Topliss scheme, Craig's plot; QSAR models: development, validation and applications.

Unit-II: Pharmacokinetics & Pharmacodynamics: 12-15 L

General introduction of pharmacology, clinical pharmacology.

Pharmacokinetics: Introduction, dosage forms of drugs, routes of drug administration, membrane transport, ADME and toxicity profile; Drug absorption: Physico-chemical factors, bioavailability, bioequivalence; Drug disposition: Apparent volume, clearance, blood brain barriers, peak time, peak plasma concentration, plasma protein binding; Drug metabolism (biotransformation): First pass metabolism, pathways of drug metabolism (phase I and II transformations), factors affecting, genetic polymorphism, significance; Drug elimination: Renal excretion, kinetics of elimination, drug toxicity.

Pharmacodynamics: Drug receptors: Classification, biological response, affinity and efficacy, dose-response relationships, ED_{50}, LD_{50}, TD_{50}, MIC, therapeutic index, agonists & antagonists, regulations, adverse drug effects; factors affecting bioactivity and drug action, drug-receptor interactions, theories of drug-receptor interactions: Occupancy theory, induced-fit theory, rate theory, macromolecular perturbation theory, activation-aggregation theory, two-state (multi-state) receptor theory; enzyme inhibition and enzyme stimulation; membrane active drugs: Introduction, theories and types.

Unit-III: Anti-cancer Drugs: **12-15 L**

Cellular apoptosis, oncogenes, tumor suppressor genes, cancer chemotherapy; mechanism of action of alkylating agents *i.e.* nitrogen mustards (nitrogen mustard), ethylenimines (thiotepa), nitrosoureas (carmustine), alkylsulfonates (busulfan), methyl hydrazines (procarbazine), triazines (dacarbazine), organoplatins (cisplatin); anti-metabolites (methotrexate, 5-fluorouracil); microtubule damaging agents / mitosis inhibitors (paclitaxel); topoisomerase inhibitors (irinotecan); antibiotics (actinomycin); targeted drugs *i.e.* tyrosine kinase inhibitors (imatinib), EGF receptor inhibitors (gefitinib), angiogenesis inhibitors (sunitinib), proteasome inhibitors (bortezomib); hormonal drugs (prednisolone, ethinyl estradiol, tamoxifen); synthesis of procarbazine, methotrexate, paclitaxel, irinotecan, imatinib, actinomycin, tamoxifen.

Anti-viral Drugs:

Structure and classification of viruses, viral replication and pathogenesis, mechanism of action of anti-viral drugs (non-retroviral): anti-herpes virus drugs (acyclovir), anti-influenza virus drugs (zanamivir), anti-hepatitis virus-B and C drugs (tenofovir); mechanism of action and structure activity relationship of anti-viral drugs (anti-retroviral): NRTIs (zidovudine), NNRTIs (nevirapine) and PIs (ritonavir); synthesis of acyclovir, zanamivir, zidovudine, nevirapine, ritonavir.

Unit-IV: Cardiovascular Drugs: **12-15 L**

Cardiac electrophysiology, central intervention of cardiovascular output, intermediatory myocardial metabolism, mechanism of action of cardiac glycosides (digoxin), anti-anginal drugs (glyceryl trinitrate), anti-arrhythmic agents (procainamide, lidocaine), centrally acting drugs (methyldopa, clonidine), calcium channel blockers (amlodipine), α- and β-blockers (propranolol, metoprolol); synthesis of digoxin, procainamide, amlodipine, propranolol, metoprolol.

Anti-hypertensive Drugs:

Blood pressure, classes of anti-hypertensive drugs, renin-angiotensin-aldosterone pathway, mechanism of action of ACE inhibitors (captopril, enalapril), angiotensin receptor blockers (losartan, valsartan), calcium channel blockers (verapamil, diltiazem), α-blockers (prazosin, doxazosin), potassium channel blockers (nicorandil), diuretics (hydrochlorothiazide), vasodilators (hydralazine); synthesis of captopril, losartan, verapamil, diltiazem, doxazosin.

Unit-V: Sedative and Hypnotic Drugs: **12-15 L**

Classification of sedative and hypnotic drugs, GABA receptors, physiology of sleep, mechanism of action and SAR of benzodiazepines (diazepam, alprazolam), imidazopyridines (zolpidem), barbiturates (phenobarbital, pentobarbital) and melatonin receptor antagonists (melatonin, ramelteon); synthesis of diazepam, alprazolam, zolpidem, phenobarbital, melatonin.

Anti-depressant Drugs:
Biological basis of depression, mechanism of action of selective norepinephrine reuptake inhibitors (amoxapine), selective serotonin reuptake inhibitors (citalopram), norepinephrine and serotonin reuptake inhibitors (amitriptyline), dopamine and norepinephrine reuptake inhibitors (bupropion), serotonin receptor modulators (trazodone).

Anti-psychotic Drugs:
Schizophrenia, neurotransmitters, neurochemistry of mental diseases, introduction of anti-psychotic drugs, mechanism of action of reserpine alkaloids, phenothiazines and thioxanthenes (chlorpromazine, fluphenazine), butyrophenones (haloperidol), benzazepines (clozapine, quetiapine); synthesis of reserpine, chlorpromazine, clozapine, quetiapine.

Books:

- *Burger's Medicinal Chemistry and Drug Discovery All Volumes, Wiley.*
- *Foye's Principles of Medicinal Chemistry, David A. Williams, LWW.*
- *Wilson Giswold's Textbook of Organic Medicinal and pharmaceutical Chemistry, Ed. R. F. Dorge.*
- *Goodman and Gilman's Pharmacological Basis of Therapeutics, Mc Graw-Hill.*
- *Essentials of Medical Pharmacology, 8th Edition, KD Tripathi, Jaypee Brothers Medical Publishers*
- *Medicinal Chemistry, Ashutosh Kar, New Age International, New Delhi.*
- *Introduction to Medicinal Chemistry, A Gringuage, Wiley- VCH.*
- *Introduction to Medicinal Chemistry, Graham L. Patrick, Oxford University Press*
- *Introduction to Drug Design, S. S. Pandeya and J. R. Dimmock, New age International.*
- *The Organic Chemistry of Drug Design and Drug Action, R.B. Silverman, Academic press.*
- *Strategies for Organic Drug Synthesis and Design, D. Lednicer, John Wiley.*

Paper-4.5: CHE-645-P (12048): Organic Chemistry Practical

(Only for Organic Chemistry Specialization)

Contact Hours / Week : 16 Hours
Duration of Examination: 12 Hours (6 Hrs. per Day) **Maximum Marks:** 200 Marks

Distribution of Marks:

S. No.	Name of Exercise	Marks
1.	Exercise No. 1: Major Experiment	30
2.	Exercise No. 2: Major Experiment	30
3.	Exercise No. 3: Major Experiment	30
4.	Exercise No. 4: Minor Experiment	15
5.	Exercise No. 5: Minor Experiment	15
6.	Exercise No. 6: Minor Experiment	15
7.	Practical Record	15
8.	Good Laboratory Skills and Regularity in Practicals	10
9.	Comprehensive Viva-voce	40
	Total Marks	**200**

Extraction of Organic Compounds from Natural Sources:

- Isolation of nicotine from tobacco.
- Isolation of caffeine from tea leaves.
- Isolation of lycopene from tomatoes.
- Isolation of β-carotene from carrots.
- Isolation of limonene from citrus fruits

- Isolation of casein from milk.
- Isolation of lactose from milk.
- Isolation of oleic acid from olive oil.
- Isolation of eugenol from clove.
- Isolation of cinchonine from cinchona bark.
- Isolation of piperine from black pepper.

Note: *Students are required to try some typical colour reactions and check purity of compounds by paper chromatography and TLC by reporting Rf values and determine the density and refractive index wherever it is possible.*

Organic Synthesis:

The exercises should illustrate the use of organic reagents, eco-friendly synthetic techniques and may involve purification of the products by chromatographic techniques and characterization by UV, IR, NMR, MS, LC-MS, GC-MS, XRD, particle size analyzer, *etc.*:

- Fischer Indole synthesis: Preparation of 2-phenylindole from phenyl hydrazine
- Skraup synthesis: Preparation of quinoline from aniline.
- Bischler-Napieralski Synthesis: Preparation of isoquinoline from β-phenylethylamine.
- Fries rearrangement: Preparation of acetophenones.
- Vilsmeier-Haack reaction: Preparation of aromatic aldehydes.
- Wittig reaction: Preparation of alkenes.
- Microwave Assisted Organic Synthesis: any one reaction of acylation, alkylation, substitution, addition, condensation.
- Ultrasound Assisted Organic Synthesis: any one reaction of acylation, alkylation, substitution, addition, condensation.
- Synthesis using PTC: Alkylation, oxidation, Wittig reaction, synthesis of 3-alkyl coumarins.
- Electrochemical synthesis: Synthesis of sebacic acid and adiponitrile.
- Enzymatic synthesis: Reduction of ethyl acetoacetate using Baker's yeast to yield enantiomaric excess of S(+)-ethyl-3-hydroxybutanoate and determine its optical activity.
- Vapour Phase Synthesis: Oxidation of toluene, esterification of acetic acid using isoamyl alcohol.
- Biosynthesis: Synthesis of ethanol from sucrose, synthesis of metronidazole from 2-aminoimidazole.

Drug Synthesis:

Synthesis, separation and characterization of some of the following drugs:

- Antipyretic Analgesic: Paracetamol, Phenacetin, Aspirin, Salol, Benorilate, Cinchophen, Mefenamic acid.
- Anti-inflammatory: Ibuprofen, Diclofenac
- Antibiotics : Penicillin V, Amoxicillin, Cefixime, Streptomycin, Chloramphenicol
- Sulphonamides : Sulphanilamide, Sulphapyridine, Sulphadiazine
- Anthelmintics : Albendazole, Thiabendazole
- Anti-bacterial : Fluconazole
- Local Anesthetics : Benzocaine, Procaine
- Anti-malarial : Chloroquine, Primaquine, Pyrimethamine.
- Sedative and Hypnotic: Barbital, allobarbital, phenobarbital, diazepam, alprazolam, zolpidem

- Anti-psychotic : Chlorpromazine, clozapine, olanzapine, quetiapine, citalopram
- Cardiovascular : Hydralazine, procainamide, propranolol, labetalol
- Anti-hypertensive: Chlorothiazide, Acetazolamide, captopril, losartan, verapamil, diltiazem, doxazosin.
- Anti-cancer : Mechlorethamine, methotrexate, imatinib, tamoxifen.
- Anti-viral : Idoxuridine, zanamivir, zidovudine, nevirapine, ritonavir

Note: *The products may be characterized by spectral techniques. Other relevant preparations / syntheses may be performed.*

Drug Analysis:

- Preparation and characterization of active pharmaceutical ingredients with purity assay.
- Complete assay of aspirin / ibuprofen / paracetamol / sulpha drugs
- Limit test for impurities like Pb, As, Fe, moisture, chloride, sulfate, boron, free halogen, selenium, *etc*.
- Determination of moisture in drug sample by Karl-Fischer titration.
- Estimation of mixture of benzoic acid / salicylic acid / iron in pharmaceutical preparation.
- Estimation of ascorbic acid
- Estimation of Benzoic acid in ointment by titrimetry
- Non-aqueous titration method for estimation of isoniazid and sodium benzoate.
- Estimation of sulphadiazine in sulpha tablets
- Determination of aspirin in drug tablet by pH metry titration with NaOH.
- Determination of viscosity of ointment / syrup / liquid, *etc*.
- Analysis of the aminoglycoside antibiotics kanamycin and amikacin matches USP requirements.
- Determination of viscosity of ointment/syrup/oils using Brookfield viscometer.

Clinical Analysis:

- Analysis of assay of enzymes (pepsin, monoamine, oxidase, tyrosinase), vitamins (thiamine, ascorbic acid, Vit. A, etc.) and hormones (progesterone, oxytocin, insulin) chemical, instrumental and biological assay wherever applicable.
- Separation and identification of plasma proteins.
- Estimation of Cholesterol in egg yolk or blood serum.
- Estimation of amino acid in protein hydrolysate by Sorenson formal titration method.
- Estimation of blood glucose, protein, chloride, sodium, potassium, urea, uric acid
- Determination of cortisol from blood and urine samples; determination of estrogens from urine samples.

Analysis of Food & Food Products:

- Analysis of moisture content, ash, fiber, nutrients, anti-nutrients, toxicants, microorganism-spoilage, preservatives.
- Analysis of amino acids, proteins, carbohydrates, lipids and fat.
- Analysis of edible oils, dairy products, pickles etc., fruit and vegetable products
- Analysis of food additives and adulterations.
- Analysis of sugars in food and beverage by HPLC.
- Analysis of sugars and related hydroxyl acids by GC.
- Determination of sucrose in various food products.
- Determination of mono-and disaccharides in sweets and beverages by HPLC with refractometric detection

- Separation of Asparagine-Linked (N-Linked) oligosaccharides
- Estimation of vitamin A in food product by Carr-price method.
- Estimation of vitamin C in fruit juice by iodometry.
- Determination of Vitamin B_2 (Riboflavin) by fluorometry.
- Estimation of proteins, sugars, vitamins, amino acids, crude fiber, total minerals, metals, crude fat and water in foods.
- Estimation of ascorbic acid by ceric ammonium sulphate method.
- Estimation of Glucose and fructose in honey by Lane and Eynone method.
- Determination of Hydroxymethylfurfural in Honey and Biomass
- Estimation of lactose in milk by iodometry.
- Quantitative analysis of iron, calcium and phosphorus in milk powder. (Fe-Colorimetrically, Ca-Complexometrically, P-Colorimetrically)
- Casein isolation from milk by isoelectric precipitation (Yield expected).
- Analysis of lipids: saponification value, acid value and iodine value.
- Determination of tannins, chemical residues and aflatoxins,
- Estimation of preservative and antioxidants.
- Determination of strength of acetic acid from the commercial vinegar by potentiometric titration and its confirmation by conductometric/pH-metric titration using standard solution of NaOH.
- Determination of commercial washing soda by potentiometric titration method.
- Estimation of amino acid in protein hydrolysate by Sorenson formal titration method.
- Estimation of pectin as Ca-Pectate colorimetrically
- Determination of Ca in eggshell by flame photometry method.
- Determination of fluoride in tooth paste colorimetrically with alizarins.
- Estimation of sodium benzoate / sodium metabisulphite, boric acid and salicylic acid in food.
- Determination of carbohydrates in coffee.
- Determination of Na/K/Li/Ca in given sample by flame photometry method.
- Chemical analysis of chilli-powder

Forensic Chemistry:

- Determination of lethal dose, LD-50 and LC-50.
- Determination of cyanide, organophosphate and snake venom.
- Estimation of poisonous materials such as lead, mercury and arsenic in biological samples.

Environmental Chemistry:

- Determination of pH, DO, BOD, COD, free CO_2, hardness of water sample.
- Determination of pH, total nitrogen & nitrate, total phosphorous & phosphate, total organic carbon, silica & lime and slats in soil.
- Determination of sodium, potassium, sulphur, magnesium and manganese in soil.
- Monitoring and analysis of SO_2 concentration in ambient air samples using high volume sampler.
- Monitoring and analysis of CO concentration in ambient air samples.
- Monitoring and analysis of NOx concentration in ambient air samples using high volume sampler.
- Monitoring and analysis of ozone concentration in ambient air samples using ozone analyzer.
- A comparison of particulate composition of high polluted and low polluted sites with respect to carbon.

Ion Chromatography:

(i) Medical Science Applications

- Determination of sulfate counter ion and anionic impurities in aminoglycoside drug substances by IC with Suppressed Conductivity Detection
- Determination of tobramycin and impurities Using HPAE-PAD
- Determination of neomycin B and impurities Using HPAE-PAD
- Determination of streptomycin and impurities Using HPAE-PAD
- Determination of galactosamine containing organic impurities in heparin by HPAE-PAD Using the Dionex CarboPac PA20 Column
- Determination of hemoglobin variants by cation-exchange chromatography
- Determination of transition metals in serum and whole blood by Ion Chromatography
- Analysis of ions in physiological fluids
- Analysis of choline and acetylcholine
- Analysis of fatty acids.
- Determination of oxalate and carbohydrate in urine by Ion Chromatography
- Determination of protein concentrations using AAA-Direct.
- Monitoring protein deamidation by cation-exchange Chromatography
- Analysis of mannose-6-phosphate
- Determination of nucleotides by Ion Chromatography with UV absorbance detection
- Determination of residual trifluoroacetate in protein purification buffers and peptide preparations by Reagent-Free Ion Chromatography
- Determination of tryptophan using AAA-Direct.
- Identification of a hydroxylysine-containing peptide using AAA-Direct.
- High-resolution analysis and purification of oligonucleotides with the DNAPac PA100 Column
- High-resolution cation-exchange alternative to peptide mapping for protein ID and QA/QC

(ii) Food and Beverage Applications

- Determination of mercury contamination in herbal medicines
- Rapid separation of anthocyanins in Cranberry and Bilberry extracts using a Core-Shell Particle Column
- Determination of trace sodium in cranberry powder
- Determination of sudan dyes I–IV in curry paste.
- Determination of mono-, di-, and triphosphates and citrate in Shrimp by Ion Chromatography
- Determination of phytic acid in soybeans and black Sesame seeds
- Determination of nitrate and nitrite Ion Chromatography determination in milk samples
- Separation of organic acids and common inorganic anions in wine
- Determination of hydroxymethylfurfural in honey and biomass
- Fast determination of anthocyanins in pomegranate juice
- Determination of lactose in lactose-free milk products by high-performance anion-exchange Chromatography with Pulsed Amperometric Detection
- Fast HPLC Analysis of dyes in foods and beverages

(iii) Electronics Applications

- Determination of trace anion contamination in the extracts of electronic components
- Determination of sodium at the ppt level in the presence of high concentrations of ethanolamine in power plant waters
- Determination of inorganic anions and organic acids in fermentation broths
- Determination of phosphite in electroless nickel plating bath
- Determination of chloride, suppressors, additives and byproducts in acid copper plating baths
- Determination of saccharin in electrolytic nickel sulfate baths
- Determination of an anionic fluorochemical surfactant (FC-95) in a steel bath
- Determination of an anionic fluorochemical surfactant in a semiconductor Etch Bath.
- Monitor trace anion contamination in the extracts of electronic components.
- Determination of cations and amines in hydrogen peroxide by Ion Chromatography Using a RFIC™ (Reagent-Free) System
- Determination of dissolved silica and common Anions Using Dual Detection

(iv) Agrochemicals

- Determination of perchlorate in high ionic strength fertilizer extracts by Ion Chromatography

Interpretation of some following organic compounds using UV, IR, NMR and MS spectra:

- Acetone
- Phenylacetone
- Acetaldehyde
- Crotonaldehyde
- Cinnamaldehyde
- Furfuraldehyde
- Glycerol
- Ethyl alcohol
- Isopropyl alcohol
- t-Butyl alcohol
- *p*-aminophenol
- *p*-Bromophenol
- *p*-Methoxybenzyl alcohol
- Acetic acid
- Benzoic acid
- Cinnamic acid
- Phthalic acid
- Ethyl bromide
- Propyl chloride
- Benzyl bromide
- n-Propylamine
- Triethylamine
- Aniline
- Nitrobenzene
- Acetylene
- Styrene
- Cyclohexane
- Toluene
- Xylenes
- 1,3,5-Trimethylbenzene
- *p*-Dichlorobenzene
- Urea
- Acetamide
- Benzamide
- Acetonitrile
- Benzonitrile
- Anisole
- Cresols
- Toluidines
- Anisidines
- Pyridine
- 4-Picoline
- s-Triazine
- 2-Methoxyethyl acetate
- Vinyl acetate
- Diethyl phthalate
- Acetic anhydride
- Phthalic anhydride

Note: *Any other relevant experiments may be added / performed.*

…… x …… x …… x ……..

Group-III: Physical Chemistry Specialization

Paper-4.3: CHE-643-T (12049): Electrochemistry

(Only for Physical Chemistry Specialization)

Contact Hours / Week	: 4 Hours	Total Maximum Marks	: 100 Marks
Duration of Examination	: 3 Hours	Continuous Assessment	: 30 Marks
		Semester Assessment	: 70 Marks

Note: *The syllabus is divided into five independent units and question paper will be divided into two sections:*

- ***Section-A*** *will carry one compulsory question comprising 10 short answer type questions (answer about in 10-20 words) by taking two questions from each unit with no internal choice. Each short answer type question will have 2 marks and hence Section-A will carry total 20 marks.*
- ***Section-B*** *will carry 50 marks equally divided into five long answer type questions (answer about in 400-500 words) with one question from each unit with internal choice (another question will be given in option or question may be divided in to sub-divisions). Paper setter shall be advised to set one question from each unit along with one option of each question and students are instructed to attempt total five questions by selecting one question from each unit. Each long answer type question will have 10 marks and hence Section-B will carry total 50 marks.*

Unit-I Conversion and Storage of Electrochemical Energy: 12-15 L

Present status of energy consumption:

Direct energy conversion by electrochemical means. Maximum intrinsic efficiency of an electrochemical converter. Physical interpretation of the Carnot efficiency factor in Electrochemical energy converters. Power outputs. Electrochemical generators (Fuel Cells): History of fuel cells, Hydrogen oxygen cells, Hydrogen Air cell, Hydrocarbon air cell, Alkaline fuel cell, Phosphoric and fuel cell, direct NaOH fuel cells, applications of fuel cells.

Electrochemical Energy Storage:

Properties of Electrochemical energy stores: Measure of battery performance, Charging and discharging of a battery, Storage Density, Energy Density.

Unit-II Classical Batteries: 12-15 L

(i) Lead Acid (ii) Nickel-Cadmium, (iii) Zinc-Manganese dioxide.

Modern Batteries:

(i) Zinc-Air (ii) Nickel-Metal Hydride, (iii) Lithium Battery, Future

Electricity Storers:

Storage in (i) Hydrogen, (ii) Alkali Metals, (iii) Non aqueous solutions.

Bio-electrochemistry:

Bioelectrodics, Membrane Potentials, Simplistic theory, Modern theory, Electrical conductance in biological organism: Electronic, Protonic electrochemical mechanism of nervous systems, enzymes as electrodes.

Unit-III Corrosion and Stability of Metals: 12-15 L

Civilization and surface mechanism of the corrosion of the metals; Thermodynamics and the stability of metals, Potential-pH (or Pourbaix) Diagrams; Corrosion current and corrosion potential-Evans diagrams. Measurement of corrosion rate: (i) Weight Loss method, (ii) Electrochemical Method.

Inhibiting Corrosion:

Cathodic and Anodic Protection. Inhibition (i) by addition of substrates to the electrolyte environment (ii) by charging the corroding metal from external source, anodic protection. Organic inhibitors. The fuller Story. Green inhibitors.

Unit-IV Kinetics of Electrode Processes: **12-15 L**

Essentials of Electrode reaction. Current Density, Over potential, Tafel Equation, Butler-Volmer equation. Standard rate constant (K^o) and Transfer coefficient, Exchange Current.

Irreversible Electrode Processes:

Criteria of irreversibility, information from irreversible wave.

Methods of determining kinetic parameters for quasi-reversible and irreversible waves: Koutecky's methods, Meites Israel method, Gelling's method.

Unit-V Potential Sweep Method: **12-15 L**

Linear sweep Voltammetry, Cyclic Voltammetry, theory and applications. Diagnostic criteria of cyclic voltammetry. Controlled current microelectrode techniques: comparison with controlled potential methods, chronopotentiometry, theory and applications.

Bulk Electrolysis Method: Controlled potential coulometry, controlled coulometry. Electro-organic synthesis and its important applications.

Books:

- *Modern Electrochemistry Vol. I, IIA, Vol. IIB J'OM Bockris and A.K.N. Reddy, Plenum Pub. NY.*
- *Polarographic Techniques by L. Meites, Interscience.*
- *"Fuel Cells: Their electrochemistry". McGraw Hill Book Company, New York.*
- *Modern Polarographic Methods by A.M. Bond, Marcell Dekker.*
- *Polarography and Allied techniques by K. Zutshi, New age International publicatin. New Delhi.*
- *Electroanalytical Chemistry by Basil H. Vessor & Galen W.; Wiley Interscience.*
- *Topics in Pure and Applied Chemistry, Ed. S. K. Rangrajan, SAEST Publication, Karaikudi (India)*

Paper-4.4: CHE-644-T (12050): Chemical Dynamics

(Only for Physical Chemistry Specialization)

Contact Hours / Week	: 4 Hours	Total Maximum Marks	: 100 Marks
Duration of Examination	: 3 Hours	Continuous Assessment	: 30 Marks
		Semester Assessment	: 70 Marks

Note: *The syllabus is divided into five independent units and question paper will be divided into two sections:*

- ***Section-A*** *will carry one compulsory question comprising 10 short answer type questions (answer about in 10-20 words) by taking two questions from each unit with no internal choice. Each short answer type question will have 2 marks and hence Section-A will carry total 20 marks.*
- ***Section-B*** *will carry 50 marks equally divided into five long answer type questions (answer about in 400-500 words) with one question from each unit with internal choice (another question will be given in option or question may be divided in to sub-divisions). Paper setter shall be advised to set one question from each unit along with one option of each question and students are instructed to attempt total five questions by selecting one question from each unit. Each long answer type question will have 10 marks and hence Section-B will carry total 50 marks.*

Unit-I Atmospheric Reactions: **12-15 L**

Physical structure of the atmosphere, chemical composition of the atmosphere, Kinetics and mechanism of NO_x, ClO_x cycles and $H_2 + O_2$ reaction. Mechanism of general methane oxidation. Kinetics and mechanism of low temperature oxidation of methane. Concept of global warming.

Unit-II Transition State: **12-15 L**

A brief aspect of statistical mechanics and transition state theory. Application in calculation of second order rate constant for reactions involving collision of (1) atom + atom (2) atom + molecule (3) molecule + molecule reactions. Static solvent effects

and thermodynamics formulations. Adiabatic electron transfer reactions, energy surfaces.

Kinetics of Enzymes:

Kinetics of one enzymes-Two substrate systems and their experimental characteristics. Enzyme inhibitors and their experimental characteristics. Kinetics of enzyme inhibited reactions.

Unit-III Radiation Chemistry: 12-15 L

Radiation chemistry and photochemistry. Radiation chemistry of water and aqueous solutions. Hydrogen atom and hydroxyl radical-oxidizing and reducing conditions. Kinetics and mechanism of photochemical and photosensitized reactions (One example in each case). Stern-Volmer equation and its application. Hole-concept in the presence of semiconductor type photocatalysts.

Dynamics of Gas-surface Reactions:

Adsorption/desorption kinetics and transition state theory. Dissociative adsorption and precursor state. Mechanism of Langmuir's adsorption of the oxidation of carbon monoxide to carbon dioxide. True and apparent activation energies.

Unit-IV Substitution Reactions: 12-15 L

Classification of ligand substitution mechanism. Anation and base catalyzed kinetics of anation reactions. Aquation and acid catalyzed kinetics of aquation reactions (octahedral complexes). Inner-sphere electron transfer reactions and mechanism. Various types of inner sphere bridges, adjustment and remote attack. Linkage isomerism. Chemical and resonance mechanism. Marcus-Cross relation in outer sphere reactions (no mathematical derivation). Its application in reactions

$$Ce(IV) + Mo(CN)_5^{4-} \rightarrow Ce(III) + Mo(CN)_6^{3-};$$

$$Fe(CN)_6^{3-} + Fe(CN)_6^{4-} \rightarrow Fe(CN)_6^{4-} + Fe(CN)_6^{3-}$$

Bridged outer-sphere electron transfer mechanism. Kinetics of reactions in the presence of cyclodextrins.

Unit-V Metal ion Catalysis and Induced Phenomena: 12-15 L

Metal ion catalyzed reactions, their kinetics and reaction mechanism in solutions. Induced reactions, their characteristics. Mechanism of (i) Fe(II) induced oxidation of iodine by Cr(VI) (ii) As(III) induced oxidation of Mn(II) by chromate in acid solutions. Kinetics and mechanism of induced reactions in metal complexes (octahedral complexes of Cobalt (III) only).

Oscillatory Reactions:

Autocatalysis and oscillatory reactions, Kinetics and mechanism of Belousov-Zhabotinski (B-Z) reactions.

Books:

- *Progress in Inorganic Chemistry, Vol. 30.*
- *R. Lumry and R.W. Raymond, Electron Transfer Reactions, Interscience.*
- *N.L. Bender, Mechanism of Homogeneous Catalysis from protein to protein, Wiley.*
- *A.G. Sykes, Kinetics of Inorganic reactions, Pergamon.*
- *S.W. Benson, Mechanism of Inorganic Reactions, Academic Press.*
- *Physical Chemistry Vol. 2, Ed. Prof Ya Grasimov, Mir publisher.*
- *Inorganic Reaction Mechanism, Basolo and Pearson, J. Wiley.*
- *Electron Transfer Reactions, H. Taube, Oxford Press.*

Paper-4.5: CHE-645-P (12051): Physical Chemistry Practical

(Only for Physical Chemistry Specialization)

Contact Hours / Week : 16 Hours

Duration of Examination: 12 Hours (6 Hrs. per Day) **Maximum Marks:** 200 Marks

Distribution of Marks:

S. No.	Name of Exercise	Marks
1.	Exercise No. 1: Major Experiment	30
2.	Exercise No. 2: Major Experiment	30
3.	Exercise No. 3: Major Experiment	30
4.	Exercise No. 4: Minor Experiment	15
5.	Exercise No. 5: Minor Experiment	15
6.	Exercise No. 6: Minor Experiment	15
7.	Practical Record	15
8.	Good Laboratory Skills and Regularity in Practicals	10
9.	Comprehensive Viva-voce	40
	Total Marks	**200**

Chemical Kinetics:

- Determination of order of reaction with respect to Ag(I) in oxidation of Mn(II) by $S_2O_8^{2-}$ and rate constant for un-catalysed reaction.
- Determination of the primary salt effect on the kinetics of ionic reaction and testing of the Bronsted relationship (iodide ion is oxidised by persulphate ion).
- Determination of energy and enthalpy of activation in the reaction of KMnO4 and benzyl alcohol in acid medium.
- Determination of energy of activation of and entropy of activation from a single kinetic run
- Determination of rate constant and formation constant of an intermediate complex in the reaction of Ce(IV) and Hypo phosphorous acid at ambient temperature.
- Kinetics of decomposition of benzene diazonium chloride.
- Kinetics of decomposition of acidified hydrogen peroxide with potassium iodide and determination of activation energy.
- Kinetics of an enzyme catalyzed reaction.
- Flowing clock reactions.
- Oscillatory reactions.

Conductometry:

- Determination of relative strength of acetic acid, chloroacetic acid and trichloroacetic acid through measuring their Ka-value by conductivity measurement method.
- Conductometric titration of (i) strong acid, monobasic weak acid or polybasic weak acid with strong base (ii) zinc with EDTA and (iii) KCl v/s $AgNO_3$.
- Determination of the strength of $HCl+CH_3COOH$ mixture against standard NaOH solution.
- Conductometric titration of triple mixture ($HCl+NH_4Cl+KCl$) with (i) NaOH and (ii) $AgNO_3$.
- Determination of thermodynamic ionization constant of a monobasic acid by (i) conductometry and (ii) potentiometry.
- To study the effect of solvent on the conductance of $AgNO_3$/acetic acid and to determine the degree of dissociation and equilibrium constant in different solvents and

in their mixtures (DMSO, DMF, dioxane, acetone, water) and to test the validity of Debye-Hűckel-Onsager theory.

- Determination of the activity coefficient of zinc ions in the solution of 0.002 M zinc sulphate using Debye Hűckel's limiting law.
- Titration of $ZnSO_4$ / $MgSO_4$ against $BaCl_2$ and $Ba(CH_3COO)_2$ and calculation of amount of sulphate present.
- Determination of solubility and solubility product of sparingly soluble salts (e.g. $PbSO_4$, $BaSO_4$) conductometrically.

Potentiometry / pH metry:

- Determination of EMF of Daniel cell.
- Determination of standard electrode potential (Eo) value of the ferrous-ferric system by titrating ferrous ammonium sulphate against potassium dichromate potentiometrically.
- Determination of pKa of dibasic acid (oxalic acid, succinic acid, *etc*).
- Determination of the formation constant of Ag-ammonia complex and stoichiometry of the complex potentiometrically.
- Determination of hydrolysis constant and degree of hydrolysis of aniline hydrochloride pH metrically
- Determination of thermodynamic parameters for electrochemical reactions (To determine ΔGo, ΔHo and ΔSo for the formation of 1 mole cadmium in 1 wt.% amalgam at 25°C and activity coefficient of solution)
- Estimate the amount of halides present in the given mixture by titrating with $AgNO_3$ solution.
- Determination of strength of acetic acid from the commercial vinegar sample by potentiometric titration and its confirmation by conductimetric / pH-metric titration using standard solution of NaOH.
- Micro-determination of glucose using potassium ferrocyanide as internal reagent and Ce (IV) solution as standard titrant.
- Determination of the dissociation constant of acetic acid in DMSO, DMF, acetone and dioxane by titrating it with KOH.
- Estimation of various transition elements like Zn/Ni/Co/Cd/Al from various commercial samples by complexometric titrations on potentiometer by using mercury electrode
- Determine the amount of HCl by using weak base (NH_4OH) potentiometrically.
- Fabrication of ion-selective electrodes for Co, Ni, Cu, Zn, Pd, Cd, *etc.* ions and record the electrode response and sensitivity.
- Titrate a phosphoric acid solution against alkali using glass electrode potentiometrically and calculate the first and second ionization constants of the acid
- Estimation of heavy metal toxicity using ion-selective electrodes: Pb, Cd, Hg, *etc.*
- Electrochemical Impedance study of metal/solution interface.
- Cyclic voltammetry of the $[Fe(CN)6]^{3-}$/$[Fe(CN)6]^{4-}$ system.

Electronics

This lab course will have theory as well as practical and the lectures shall be delivered during lab hours.

Basic Electronics

Notations used in the electronic circuit, study of electronic compounds and colour codes. Conversion of chemical quantities into electronic quantities. transducer,

illustration with electrodes, thermocouples and thermistors. Passive components: Resistors, capacitors and inductors with some emphasis on solid state properties of materials. Net-work of resistors. Thevenin's theorem, superposition theorem, loop analysis, RC circuits, LR Circuits, LCR circuits. Illustration of the use of circuits in NQR spectroscopy, Mossbauer spectroscopy cyclic voltammetry and in power supplied as filter circuits.

Active components

Introduction to ordinary diodes and Zener diode with some emphasis on p-n junction as a solid-state property. Use of diode as rectifiers, clipping and clamping circuits. Power supplies. Transistors: An extension of p-n-p and n-p-n transistors. Characteristics of transistors, hybrid parameters; transistor circuits as amplifiers, high impedance (preamplifier) circuits. Darlington pairs, differential amplifiers.

Operational Amplifiers

Ideal characteristics; inverter, summer, integrator, differentiator, voltage follower, illustrative use of operational amplifiers. Introduction to Fourier transformation in instrumentation. List of Experiments in electronics (Do at least five experiments from this section):

1. (a) To plot the diode characteristics and find its dynamic resistance and cut in voltage.
   (b) To plot the characteristics of transistor used as a diode and compare the results with those of (a)
2. (a) To plot the diode characteristics and find its dynamic resistance and cut in voltage. (b) To plot the characteristics of transistor used as a diode and compare the results with those of (a)wave form.
3. To implement a diode damper circuit which damps the positive peak of the input voltage to (a) Zero voltage and (b) a given voltage. Verify the performance.
4. (a) To plot the characteristics of an NPN transistor in CE configuration. (b) To find the h-parameter of the transistor from the characteristics.
5. (a) To plot the characteristics of an NPN transistor in CB configuration. (b) To find the h-parameter of the transistor from the characteristics and compare it with the results of experiment No. 6.
6. (a) To plot the drain and transfer characteristics of a JEET in CS configuration. (b) To find out the pinch off voltage, maximum drain to source saturation current and the transconductance.
7. To obtain the frequency response of an RC coupled amplifier and estimate the bandwidth.
8. (a) To plot the characteristics of Zener diode and find its dynamic resistance under reverse biased condition. To use zener diode for a voltage regulation. (i) Plot the line regulation curve. (ii) Plot the load Regulation curve.
9. (a) To wire a Half wave Rectifier circuit using diode and measure the rms voltage, de voltage and to find Ripple factor.
   (b) To study the performance of half way and full wave double circuits.
10. To plot the characteristics of UJT and find the peak voltage, peak current and valley voltage and use as a relaxation oscillator.

Note: Any other relevant experiments may be added / performed.

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Group-IV: Analytical Chemistry Specialization

Paper-4.3: CHE-643-T (12052): Instrumental Methods of Analysis

(Only for Analytical Chemistry Specialization)

Contact Hours / Week	: 4 Hours	Total Maximum Marks	: 100 Marks
Duration of Examination	: 3 Hours	Continuous Assessment	: 30 Marks
		Semester Assessment	: 70 Marks

Note: *The syllabus is divided into five independent units and question paper will be divided into two sections:*

- ***Section-A*** *will carry one compulsory question comprising 10 short answer type questions (answer about in 10-20 words) by taking two questions from each unit with no internal choice. Each short answer type question will have 2 marks and hence Section-A will carry total 20 marks.*
- ***Section-B*** *will carry 50 marks equally divided into five long answer type questions (answer about in 400-500 words) with one question from each unit with internal choice (another question will be given in option or question may be divided in to sub-divisions). Paper setter shall be advised to set one question from each unit along with one option of each question and students are instructed to attempt total five questions by selecting one question from each unit. Each long answer type question will have 10 marks and hence Section-B will carry total 50 marks.*

Unit-I: X-rays Diffraction: **12-15 L**

Production of X-rays, X-rays spectra, monochromatic X-rays sources, X-rays detectors, X-rays absorption, X-ray fluorescence and X-rays diffraction methods, Bragg's law, determination of crystal structure by Bragg's law, XRD apparatus, applications of XRD in crystalline size determination by using Sherrer formula, determination of cis-trans isomerism, polymer crystallization

X-ray photoelectron spectroscopy (XPS), X-ray fluorescence spectroscopy (XRF), Auger electron spectroscopy (AES), Energy-dispersive X-ray spectroscopy (EDX).

Unit-II: Electron Diffraction: **12-15 L**

Scattering intensity v/s scattering angle, Wierl equation, measurement technique, elucidation of structure of simple gas phase molecules, low energy electron diffraction and structure of surfaces

Neutron Diffraction:

Scattering of neutrons by solids and liquids, magnetic scattering, measurement techniques, elucidation of structure of magnetically ordered unit cell.

Microscopic Methods: General introduction to SEM and TEM.

Unit-III: Thermo-analytical Methods: **12-15 L**

Introduction and classification of thermoanalytical methods; thermogravimetric analysis (TGA): definition, types, instrumentation, TGA curve, factors affecting TGA curves, calculation of percent decomposition and composition of compounds, limitation and advantages of TGA, application of TGA to the thermal behavior including crystalline copper sulphate, calcium oxalate monohydrate, zinc hexafluorosilicate; differential thermal analysis (DTA): definition, theoretical basis, instrumentation, factors affecting the DTA curve, application of DTA, advantages and disadvantages of DTA; differential scanning calorimetry (DSC): Definition, comparison of DTA and DSC techniques, instrumentation, factors affecting DSC curves.

Unit-IV: Radio-analytical Methods: **12-15 L**

Determination of nuclear radiation and counting devices, radioactivity tracers-principal and applications, isotopic analysis-direct and inverse, special analytical

application-radiometric titrations, neutron activation analysis principle, instrumentation, applications and limitations, radio-chromatography and radio-immunoassay.

Nephelometry and Turbidometry:
Introduction, theory, comparison of spectrophotometry, turbidimetry and nephelometry, instrumentation and applications

Unit-V: Polarimetry: **12-15 L**

Polarisation of light, optical activity, theories of optical activity, factors affecting angle of rotation, specific rotation, optical rotator dispersion and circular dichroism-Cotton effect, ORD and CD curves, instrumentation, measurement of rotatory power, applications of polarimetry, optical activity and chemical constitution, representation of optical isomerism, deciding between two structures for a molecule, distinguish between a pair of enantiomorphs, saccharimetry, difference between saccharimetry and polarimetry, saccharimeters, kinetic polarimetry, spectropolarimetry.

Refractometry:
Principle, parameters influencing refraction, significance of critical angle during measurements, refractometers, qualitative and quantitative analysis and analytical applications

Books:

- *D. A. Skoog and D. M. West, Fundamentals of Analytical Chemistry, Holt Rinehart and Winston Publications, IV Edn, 1982.*
- *D.A. Skoog, D.M. West, F.J. Holler and S.R. Crouch, Fundamentals of Analytical Chemistry, Thomson Asia Pte Ltd., Singapore, Viiith Edn., 2004.*
- *D.A. Skoog, Principles of Instrumental Analysis, Saunders College Pub.Co, III Edn., 1985.*
- *J.G. Dick, Analytical Chemistry, McGraw Hill Publishers, 1974.*
- *Willard, Merit, Dean and Settle, Instrumental Methods of Analysis, CBS Publishers and Distributors, IV Edn.,1989*
- *G. D. Christian and J.E.O Reilly, Instrumental Analysis, Allyn and Bacon Inc, II Edn., 1986.*
- *G.W. Ewing, Instrumental Methods of Chemical Analysis, McGraw Hill Pub, 1975.*

Paper-4.4: CHE-644-T (12053): Analysis of Consumers Products

(Only for Analytical Chemistry Specialization)

Contact Hours / Week	: 4 Hours	Total Maximum Marks	: 100 Marks
Duration of Examination	: 3 Hours	Continuous Assessment	: 30 Marks
		Semester Assessment	: 70 Marks

Note: *The syllabus is divided into five independent units and question paper will be divided into two sections:*

- ***Section-A*** *will carry one compulsory question comprising 10 short answer type questions (answer about in 10-20 words) by taking two questions from each unit with no internal choice. Each short answer type question will have 2 marks and hence Section-A will carry total 20 marks.*
- ***Section-B*** *will carry 50 marks equally divided into five long answer type questions (answer about in 400-500 words) with one question from each unit with internal choice (another question will be given in option or question may be divided in to sub-divisions). Paper setter shall be advised to set one question from each unit along with one option of each question and students are instructed to attempt total five questions by selecting one question from each unit. Each long answer type question will have 10 marks and hence Section-B will carry total 50 marks.*

Unit-I: Drug Analysis: **12-15 L**

Introduction to drugs, their classification, sources of impurities in pharmaceutical raw materials (chemical, atmospheric and microbial contaminants etc.); impurity profile, limit test, solubility tests, disintegration test, stability test, narcotic and dangerous

drugs, analysis of some drugs (paracetamol, diclofenac, losartan, inidazole, alprazolam).

Unit-II: Clinical Analysis: 12-15 L

Sampling and selective analysis of biological fluids (using routine and automatic instruments): glucose, bilirubin & biliverdins, total cholesterol, haemoglobin, creatinine, total proteins, albumin, urea-nitrogen, corticosteroids and barbiturates; vitamins and antibiotics; immunological methods of analysis: ELISA and RIA.

Unit-III: Food Analysis: 12-15 L

Sampling and selective analysis of food flavours, food colour, food preservatives, milk and milk products, floor starches, tea, coffee, sugar content analysis of honey, jam & jelly; alcohol content in beverages; analysis of oils and fats: softening point, congent point, titre point, cloud point, iodine value, saponification value, acid value and Polenske value, Elaiden test; pesticide residue analysis.

Unit-IV: Cream & Lotion Analysis: 12-15 L

Composition of creams and lotions, determination of water, propylene glycol, non-volatile matter and ash content, determination of borates, carbonates, sulphates, phosphates, chlorides, titanium and zinc oxides.

Face Powder, Deodorant & Antiperspirant Analysis:

Composition, analysis of fats and fatty acids, boric acid, Mg, Ca, Zn, Fe, Ti, Al, phenol, hexachlorophenone, methanamine, sulphonates and urea.

Unit-V: Soap Analysis: 12-15 L

Method of analysis: sampling, separation, identification; determination of fatty acids, total anhydrous soap and combined alkali, potassium, water, determination of inorganic fillers and soap builders; determination of constituents and other additives.

Detergent Analysis:

Types, method of analysis: sampling, separation, identification of components, determination of surfactants and other constituents.

Books:

- *Standard Methods of Chemical Analysis, F. J. Welcher*
- *Instrumental Methods of Analysis (6th Edition) – H. H. Willard & L. L. Merritt.*
- *A Text Book of Quantitative Inorganic Analysis (3rd Edition) – A. I. Vogel.*
- *Treatise on Analytical Chemistry (Series of Volumes) – I. M. Kolthoff & P. J. Elwing.*
- *Introduction to Instrumental Analysis – R. D. Braun.*
- *Handbook of Industrial Chemistry – Davis Burner*
- *Association of Official Analytical Chemistry (AOAC) – 13th Edition 1980.*
- *Pharmacopoeia of India, British & United States.*
- *Hand Book of Food Analysis – S. N. Mahindru.*
- *Analytical Biochemistry – Holme Peck*
- *Post Graduate Chemistry Practical Part – I – Patel, Gadre & Turkhia.*
- *Agricultural Analysis. By Kanwar.*
- *Encyclopaedia of Industrial Methods of Chemical Analysis. By F D Snell (All senus)*
- *Cosmetics by W D Poucher (Three volumes)*
- *Perfumery Technology (JC1) by B. Bilat and B.V. Well*
- *Laboratory Techniques in Food Analysis by I.M. Kolthof, D. Pearson*
- *Handbook of Analysis and Quality, Control for Fruits and Vegetable Products 2nd Ed by S. Ranganna*
- *Aids to the Analysis of Food and Drug by Nicholls*
- *Analysis of Food Products (Swan Publishers) by S.N. Mahendur*
- *Textbook of Forensic Pharmacy by B M Mithal 9th edition 1993, National Centre Kolcutta.*
- *Forensic Pharmacy by B.S Kuchekar, and A.M Khadatare Nirali Prakshan)*

Paper-4.5: CHE-645-P (12054): Analytical Chemistry Practical

(Only for Analytical Chemistry Specialization)

Contact Hours / Week : 16 Hours
Duration of Examination: 12 Hours (6 Hrs. per Day) **Maximum Marks:** 200 Marks

Distribution of Marks:

S. No.	Name of Exercise	Marks
1.	Exercise No. 1: Major Experiment	30
2.	Exercise No. 2: Major Experiment	30
3.	Exercise No. 3: Major Experiment	30
4.	Exercise No. 4: Minor Experiment	15
5.	Exercise No. 5: Minor Experiment	15
6.	Exercise No. 6: Minor Experiment	15
7.	Practical Record	15
8.	Good Laboratory Skills and Regularity in Practicals	10
9.	Comprehensive Viva-voce	40
	Total Marks	**200**

Conductometry:

- Determination of relative strength of acetic acid, chloroacetic acid and trichloroacetic acid through measuring their Ka-value by conductivity measurement method.
- Conductometric titration of (i) strong acid, monobasic weak acid or polybasic weak acid with strong base (ii) zinc with EDTA and (iii) KCl v/s $AgNO_3$.
- Determination of the strength of $HCl+CH_3COOH$ mixture against standard NaOH solution.
- Conductometric titration of triple mixture ($HCl+NH_4Cl+KCl$) with (i) NaOH and (ii) $AgNO_3$.
- Determination of thermodynamic ionization constant of a monobasic acid by (i) conductometry and (ii) potentiometry.
- To study the effect of solvent on the conductance of $AgNO_3$/acetic acid and to determine the degree of dissociation and equilibrium constant in different solvents and in their mixtures (DMSO, DMF, dioxane, acetone, water) and to test the validity of Debye-Hűckel-Onsager theory.
- Determination of the activity coefficient of zinc ions in the solution of 0.002 M zinc sulphate using Debye Hűckel's limiting law.
- Titration of $ZnSO_4$ / $MgSO_4$ against $BaCl_2$ and $Ba(CH_3COO)_2$ and calculation of amount of sulphate.
- Determination of solubility and solubility product of sparingly soluble salts (e.g. $PbSO_4$, $BaSO_4$) conductometrically.

Potentiometry / pH metry:

- Determination of EMF of Daniel cell.
- Determination of standard electrode potential (Eo) value of the ferrous-ferric system by titrating ferrous ammonium sulphate against potassium dichromate potentiometrically.
- Determination of pKa of dibasic acid (oxalic acid, succinic acid, *etc*).
- Determination of the formation constant of Ag-ammonia complex and stoichiometry of the complex potentiometrically.
- Determination of hydrolysis constant and degree of hydrolysis of aniline hydrochloride pH metrically

- Determination of thermodynamic parameters for electrochemical reactions (To determine ΔGo, ΔHo and ΔSo for the formation of 1 mole cadmium in 1 wt.% amalgam at 25ºC and activity coefficient of solution)
- Estimate the number of halides present in the given mixture by titrating with $AgNO_3$ solution.
- Determination of strength of acetic acid from the commercial vinegar sample by potentiometric titration and its confirmation by conductometric / pH-metric titration using standard solution of NaOH.
- Micro-determination of glucose using potassium ferrocyanide as internal reagent and Ce (IV) solution as standard titrant.
- Determination of the dissociation constant of acetic acid in DMSO, DMF, acetone and dioxane by titrating it with KOH.
- Estimation of various transition elements like Zn/Ni/Co/Cd/Al from various commercial samples by complexometric titrations on potentiometer by using mercury electrode
- Determine the amount of HCl by using weak base (NH_4OH) potentiometrically.
- Fabrication of ion-selective electrodes for Co, Ni, Cu, Zn, Pd, Cd, *etc.* ions and record the electrode response and sensitivity.
- Titrate a phosphoric acid solution against alkali using glass electrode potentiometrically and calculate the first and second ionization constants of the acid
- Estimation of heavy metal toxicity using ion-selective electrodes: Pb, Cd, Hg, *etc.*
- Electrochemical Impedance study of metal/solution interface.
- Cyclic voltammetry of the $[Fe(CN)6]^{3-}/[Fe(CN)6]^{4-}$ system.

Drug Analysis:

- Preparation and characterization of active pharmaceutical ingredients with purity assay.
- Complete assay of aspirin / ibuprofen / paracetamol / sulpha drugs
- Limit test for impurities like Pb, As, Fe, moisture, chloride, sulfate, boron, free halogen, selenium, *etc*.
- Determination of water in drug sample by Karl-Fischer titration.
- Estimation of mixture of benzoic acid / salicylic acid / iron in pharmaceutical preparation.
- Estimation of ascorbic acid
- Estimation of Benzoic acid in ointment by titrimetry
- Non-aqueous titration method for estimation of isoniazid and sodium benzoate.
- Estimation of sulphadiazine in sulpha tablets
- Determination of aspirin in drug tablet by pH metry titration with NaOH.
- Determination of viscosity of ointment / syrup / liquid, *etc*.
- Analysis of the aminoglycoside antibiotics kanamycin and amikacin matches USP requirements
- Determination of viscosity of ointment/syrup/oils using Brookfield viscometer.

Clinical Analysis:

- Analysis of assay of enzymes (pepsin, monoamine, oxidase, tyrosinase), vitamins (thiamine, ascorbic acid, Vit. A) and hormones (progesterone, oxytocin, insulin) chemical, instrumental and biological assay wherever applicable.
- Separation and identification of plasma proteins.
- Estimation of Cholesterol in egg yolk or blood serum.
- Estimation of Cholesterol in egg yolk or blood serum.
- Estimation of amino acid in protein hydrolysate by Sorenson formal titration method.

- Estimation of blood glucose, protein, chloride, sodium, potassium, urea, uric acid
- Determination of cortisol from blood and urine samples; determination of estrogens from urine samples.

Analysis of Food & Food Products:

- Analysis of moisture content, ash, fiber, nutrients, anti-nutrients, toxicants, microorganism-spoilage, preservatives.
- Analysis of amino acids, proteins, carbohydrates, lipids and fat.
- Analysis of edible oils, dairy products, pickles etc., fruit and vegetable products
- Analysis of food additives.
- Analysis of food adulteration.
- Estimation of vitamin A in food product by Carr-price method.
- Estimation of vitamin C in fruit juice by iodometry.
- Determination of Vitamin B_2 (Riboflavin) by fluorimetry.
- Estimation of proteins, sugars, vitamins, amino acids, crude fiber, total minerals, metals, crude fat and water in foods.
- Estimation of ascorbic acid by ceric ammonium sulphate method.
- Estimation of Glucose and fructose in honey by Lane and Eynone method.
- Determination of Hydroxymethylfurfural in Honey and Biomass
- Estimation of lactose in milk by iodometry.
- Quantitative analysis of iron, calcium and phosphorus in milk powder. (Fe-Colorimetrically, Ca-Complexometrically, P-Colorimetrically)
- Casein isolation from milk by isoelectric precipitation (Yield expected).
- Analysis of lipids: saponification value, acid value and iodine value.
- Determination of tannins, chemical residues and aflatoxins,
- Estimation of preservative and antioxidants.
- Determination of saccharin in beverages.
- Determination of strength of acetic acid from the commercial vinegar sample by potentiometric titration and its confirmation by conductometric / pH-metric titration using standard solution of NaOH
- Determination of commercial washing soda by potentiometric titration method.
- Estimation of amino acid in protein hydrolysate by Sorenson formal titration method.
- Estimation of pectin as Ca-Pectate colorimetrically
- Determination of Ca in egg shell by flame photometry method.
- Determination of fluoride in tooth paste colorimetrically with alizarins.
- Estimation of sodium benzoate / sodium metabisulphite, boric acid and salicylic acid in food.
- Estimation of tannin from tea.
- Isolation of caffeine from tea.
- Analysis of iodized table salt.
- Determination of Sialic Acids
- Determination of carbohydrates in coffee.
- Determination of Na/K/Li/Ca in given sample by flame photometry method.
- Chemical analysis of chilli-powder

Forensic Chemistry:

- Determination of lethal dose, LD-50 and LC-50.
- Determination of cyanide, organophosphate and snake venom.
- Estimation of poisonous materials such as lead, mercury and arsenic in biological samples.

Analysis of Soap, Detergent, Shampoo and Cosmetics:

- Preparation of soaps and detergents.
- Estimation of EDTA in detergent and shampoo.
- Assay of soaps and detergent
- Determination of Na/K/Li/Ca in given sample by flame photometry method.
- Determination of washing strength of detergents by surface tension method.
- Determination of CMC of detergents.
- Determination of composition of perfume by GC/MS
- Estimation of fragrance in the perfumes by GC/MS.
- Estimation of Zinc in face powder by gravimetry
- Analysis of suspected allergens in perfumes by GC/MS.
- Estimation of benzoic acid in ointment.

Analysis of Heavy & Fine Chemicals:

- Preparation and characterization of copper sulphate.
- Preparation and characterization of methyl orange and methyl red.
- Estimation of $Na_2CO_3.10H_2O$ in washing soda.
- Determination of thiosulphate content of a commercial hypo solution.
- Estimation of available chlorine in the sample of bleaching powder

Atomic Absorption Spectroscopy:

- Determination of metals in given samples by AAS technique.
- Preparation of standard calibration graphs of Pb, Cd, Zn and Fe by AAS.

Flame Photometric Determinations:

- Estimation of sodium / potassium / lithium / calcium / magnesium / barium / strontium in a given sample flame photometrically.

Fluorimetry & Phosphorimetry:

- Estimation of quinine as quinine sulphate from medicinal tablets
- Determination of amount of vit-B2 in the medicinal tablet fluorometrically.
- Any other experiments related to Spectrofluorometer / phosphorimeter

Nephelometry & Turbidimetry:

- Determination of chloride by turbidimetry.
- Determination of amount of zinc from given sample solution by nephelometric / turbidimetric titration using standard solution of $K_4(Fe(CN)_6)$ in 0.4 M HCl
- Determination of amount of sulphate from the given sample solution by nephelometric / turbidimetric titration using standard solution of $Ba(NO_3)_2$ or $Pb(NO_3)_2$

Thermal Analysis:

Study of temperature effect on organic and inorganic compounds, calculate of percent decomposition and composition studies of given samples including following compounds as examples:

- Copper sulphate pentahydrate
- Calcium oxalate monohydrate
- Zinc hexafluorosilicate

X-Rays Diffraction:

- Determination of structure / packing pattern of solids.
- Any other experiments related to XRD

Ion Chromatography:

(i) Medical Science Applications

- Determination of sulfate counter ion and anionic impurities in aminoglycoside drug substances by IC with Suppressed Conductivity Detection
- Determination of tobramycin, neomycin B, streptomycin and impurities Using HPAE-PAD
- Determination of galactosamine containing organic impurities in heparin by HPAE-PAD Using the Dionex CarboPac PA20 Column
- Determination of hemoglobin variants by cation-exchange chromatography
- Determination of transition metals in serum and whole blood by Ion Chromatography
- Analysis of ions in physiological fluids
- Analysis of choline and acetylcholine
- Analysis of fatty acids.
- Determination of oxalate and carbohydrate in urine by Ion Chromatography
- Determination of protein concentrations using AAA-Direct
- Monitoring protein deamidation by cation-exchange Chromatography
- Analysis of mannose-6-phosphate
- Determination of nucleotides by Ion Chromatography with UV absorbance detection
- Determination of residual trifluoroacetate in protein purification buffers and peptide preparations by Reagent-Free Ion Chromatography
- Determination of tryptophan using AAA-Direct
- Identification of a hydroxylysine-containing peptide using AAA-Direct
- High-resolution analysis and purification of oligonucleotides with the DNAPac PA100 Column
- High-resolution cation-exchange alternative to peptide mapping for protein ID and QA/QC

(ii) Food and Beverage Applications

- Determination of mercury contamination in herbal medicines
- Rapid separation of anthocyanins in Cranberry and Bilberry extracts using a Core-Shell Particle Column
- Determination of trace sodium in cranberry powder
- Determination of sudan dyes I–IV in curry paste
- Determination of mono-, di-, and triphosphates and citrate in Shrimp by Ion Chromatography
- Determination of phytic acid in soybeans and black Sesame seeds
- Determination of nitrate and nitrite Ion Chromatography determination in milk samples
- Separation of organic acids and common inorganic anions in wine
- Determination of hydroxymethylfurfural in honey and biomass
- Fast determination of anthocyanins in pomegranate juice
- Determination of lactose in lactose-free milk products by high-performance anion-exchange Chromatography with Pulsed Amperometric Detection
- Fast HPLC Analysis of dyes in foods and beverages

(iii) Electronics Applications

- Determination of trace anion contamination in the extracts of electronic components

- Determination of sodium at the ppt level in the presence of high concentrations of ethanolamine in power plant waters
- Determination of inorganic anions and organic acids in fermentation broths
- Determination of phosphite in electroless nickel plating bath
- Determination of chloride, suppressors, additives and byproducts in acid copper plating baths
- Determination of saccharin in electrolytic nickel sulfate baths
- Determination of an anionic fluorochemical surfactant (FC-95) in a steel bath
- Determination of an anionic fluorochemical surfactant in a semiconductor Etch Bath
- Monitor trace anion contamination in the extracts of electronic components
- Determination of cations and amines in hydrogen peroxide by Ion Chromatography Using a RFIC™ (Reagent-Free) System
- Determination of dissolved silica and common Anions Using Dual Detection

(iv) Agrochemicals

- Determination of perchlorate in high ionic strength fertilizer extracts by Ion Chromatography

Any other relevant experiments may be added / performed.

……. x …….…… x …..…….…… x …….……..

Group-V: Industrial Chemistry Specialization

Paper-4.3: CHE-643-T (12055): Chemical Process Industries

(Only for Industrial Chemistry Specialization)

Contact Hours / Week	: 4 Hours	Total Maximum Marks	: 100 Marks
Duration of Examination	: 3 Hours	Continuous Assessment	: 30 Marks
		Semester Assessment	: 70 Marks

Note: *The syllabus is divided into five independent units and question paper will be divided into two sections:*

- ***Section-A*** *will carry one compulsory question comprising 10 short answer type questions (answer about in 10-20 words) by taking two questions from each unit with no internal choice. Each short answer type question will have 2 marks and hence Section-A will carry total 20 marks.*
- ***Section-B*** *will carry 50 marks equally divided into five long answer type questions (answer about in 400-500 words) with one question from each unit with internal choice (another question will be given in option or question may be divided in to sub-divisions). Paper setter shall be advised to set one question from each unit along with one option of each question and students are instructed to attempt total five questions by selecting one question from each unit. Each long answer type question will have 10 marks and hence Section-B will carry total 50 marks.*

Unit-I: Cane Sugar Industries: 12-15 L

General idea of carbonation and sulphitation and their comparison, manufacturing of white crystalline sugar, byproducts including beverages.

Pulp & Paper Industries:

Raw materials, methods of pulping, general principles of some mechanical and chemical pulping, production of sulphate and sulphite pulp. production of paper, wet process, paper properties testing, fiber recovery.

Dyes & Paints Industries:

Synthesis and applications of azo, phthalein, xanthene, rhodamine, anthraquinone, indigoid, phthalocyanine dyes. properties of coating, paints, plasticizers, dyes and bioactive additives, paint formulations, testing.

Unit-II: Soap & Detergent Industries: 12-15 L

Introduction, manufacture of soaps and detergents, emulsions and their characteristics, industrial applications: smoke precipitation, purification of water, tanning of leather and sewage disposal.

Cosmetic and Perfume Industries:

Introduction, ingredients of shampoos, lotions, creams, hair sprays & hair dyes, tooth powders & tooth pastes. synthesis of some important synthetics chemicals used in perfume industry: citral, geraniol, linalool, eugenol, civetone, vanillin, citronellol, benzyl acetate, acetyl longifolene; perfume formulation, some representative formulation of rose, jasmine, sandal wood and lavender.

Unit-III: Glass & Ceramic Industries: 12-15 L

Different types of glasses, raw materials, manufacture of glasses, glass fibers, ceramics and refractory, annealing, finishing. Raw materials of ceramics and manufacturing of porcelain and China clay.

Cement Industries:

Types and properties, chemical composition, manufacture of Portland cement, setting and hardening of cement, reaction in the kiln, mixing of additives, manufacturing of lime, gypsum and plaster of Paris.

Unit-IV: Heavy & Fine Chemicals Industries: 12-15 L

Explanation of the terms heavy (bulk) and fine (speciality) chemicals; industrial production and uses of gases / solids: H_2, N_2, O_2, CO_2, NH_3, Cl_2, NaCl, Na_2SO_4; industrial production and uses of acids / bases: HCl, HNO_3, H_2SO_4, NaOH, KOH and Na_2CO_3; industrial importance of boron compounds: Borax and boric acid; industrial oxidizing and reducing agents: $KMnO_4$, $K_2Cr_2O_7$, H_2O_2 and $Na_2S_2O_3$.

Unit-V: Fertilizer Industries: 12-15 L

Industrial manufacturing of urea, ammonium sulphate, ammonium nitrate; manufacturing process of phosphatic fertilizers: single and triple super phosphates; manufacturing of phosphoric acid by electric furnace process; commercial potassic fertilizers: manufacturing process of potassium sulphate, diammonium phosphate. mixed fertilizers, bio-fertilizers.

Polymer Industries:

Mechanism of polymerization, industrial manufacturing of polyethylene, polystyrene, polyvinyl chloride, polyesters and rubbers (synthetic and natural).

Books:

- *Manufacturing and Design: Understanding the Principles of How Things are Made by* Erik Tempelman*,* Bruno Ninaber van Eyben *and* Hugh Shercliff, *Butterworth*-Heinemann Ltd.
- *The Complete Technology Book on Pulp & Paper Industries by NIIR Board of Consultants and Engineers*
- *Environmentally Friendly Production of Pulp and Paper by Pratima Bajpai, John Wiley and Sons*
- *Sugar Processing and By-products of the Sugar Industry by Antonio Valdes Delgado, Carlos de Armas Casanova, Food & Agriculture Org*
- *The World's Cane Sugar Industry Past and Present by H.C. Prinsen Geerligs, Cambridge University Press*
- *Soaps and Detergents Vol. 1 by S.C. Bhatia, CBS Publishers & Distributors*
- *Handbook on Soaps, Detergents & Acid Slurry (3rd Revised Edition) by National Institute of Industrial Research*
- *The Complete Technology Book on Flavours, Fragrances and Perfumes by NPCS Board of Consultants & Engineers*
- *Industrial Organic Chemistry: K. Weissermel and H.J. Arpe.*

Paper-4.4: CHE-644-T (12056): Industrial Management, IPR and Regulatory Affairs

Contact Hours / Week	: 4 Hours	Total Maximum Marks	: 100 Marks
Duration of Examination	: 3 Hours	Continuous Assessment	: 30 Marks
		Semester Assessment	: 70 Marks

Note: *The syllabus is divided into five independent units and question paper will be divided into two sections:*

- ***Section-A*** *will carry one compulsory question comprising 10 short answer type questions (answer about in 10-20 words) by taking two questions from each unit with no internal choice. Each short answer type question will have 2 marks and hence Section-A will carry total 20 marks.*
- ***Section-B*** *will carry 50 marks equally divided into five long answer type questions (answer about in 400-500 words) with one question from each unit with internal choice (another question will be given in option or question may be divided in to sub-divisions). Paper setter shall be advised to set one question from each unit along with one option of each question and students are instructed to attempt total five questions by selecting one question from each unit. Each long answer type question will have 10 marks and hence Section-B will carry total 50 marks.*

Unit-I: Materials Management: **12-15 L**

Material in industry, inventory control model, ABC analysis, safety stock, economic ordering quantity, stores equipment, stores records, bin card, cardex, material handling, carbon credit, carbon tax.

Safety Management:

General occupational safety, flammable material handling and fire fitting equipment, control measures for toxic chemicals, MSDS of hazardous chemicals, industrial hygiene, safety in laboratories and pilot plants, safety in transportation and storage of chemicals, safety assessments and protection of various process industries, safety audit, risk assessments and hazard management.

Unit-II: Disaster Management: **12-15 L**

Types, analysis, hazard and risk, level of disasters, phase of disaster, disaster recovery system, guides for preparation of onsite emergency plan, incineration of hazardous chemicals; identification, classification and segregation of industrial toxic chemicals.

Environmental Management:

Environmental policy of the Government of India and the working of the Ministry of Environment and Forests, Central Pollution Control Board, State Pollution Control Boards; eco-mark; environmental accounts and auditing, green funding and taxes, management of pollution due to chemical, mining and manufacturing industries (glass, ceramics, cement, paper, dye, textile, petroleum, coal, plastic, polymer, paint, leather, fertilizer, agrochemical, pharmaceutical, *etc.*).

Unit-III: Intellectual Property Rights (IPR): **12-15 L**

Concept and fundamentals of IPR, need and economic importance of IPR, detail description of various IP Properties (Patents, Trademarks, Copyrights, Geographical Indications Industrial Designs and Trade secrets), IPR with emphasis on patent regime, factors affecting IP protection, penalties for violation or infringement, trade related aspects of IPR.

Brief concepts of *World Trade Organization (*WTO), *General Agreement on Tariffs and Trade (*GATT)*,* General Agreement on Trade in Services (GATS), Trade-Related Aspects of Intellectual Property Rights (TRIPS), Trade-Related Investment Measures (TRIMs).

Unit-IV: R&D and Technology Transfer: **12-15 L**

Functional structure of R&D, unit research strategies and manufacturing interface, laboratory-industry interface, technology transfer.

Industrial Standards and Control:

General introduction of Government standards like Agmark, Bureau of Indian Standards (BIS) Hallmark, Indian Standards Index (ISI), Central Drugs Standard Control Organization (CDSCO), Indian Pharmacopoeia (IP), British Pharmacopoeia (BP), US Pharmacopoeia (USP); International Organization for Standardization (ISO), British Standard for Occupational Health and Safety management Systems (BS OHSAS), Occupational Safety & Health Administration (OSHA), US Food and Drug Administration **(**USFDA), ICH Guidelines, Fruit Products Order (FPO), Food and Agriculture Organization (FAO), Food Safety and Standards Authority of India (FSSAI), Scale-Up and Post approval Change (SUPAC).

Unit-V: Quality Assurance: **12-15 L**

Concepts of quality assurance (QA), concept of GMP and cGMP, audit: preparation, conduction, analysis, report and follow up; premises: location, design, plant layout, construction and maintenance; control of contamination.

Quality Control:

Concept of quality and quality control, design of QC laboratory for chemical, instrumental and microbiological laboratories, schedule L1, standardization of reagents, labeling of reagents, control samples, data generation and storage, QC documentation, LIMS sampling techniques, sampling plans, six sigma, preparation of control charts, cost reduction & quality improvement.

Books:

- *Industrial Engineering and Management by O.P. Khanna; Dhanpat Rai and Sons, Delhi.*
- *Industrial Organization and Management by Tara Chand; Nem Chand and Brothers; Roorkee.*
- *Environmental and Pollution Awareness by BR Sharma; Satya Prakashan, New Delhi.*
- *Industrial Management by C.L. Mahajan; Saluja Parkashan, New Delhi.*
- *Environment Protection Law & Policy in India: Deep & Deep publication, New Delhi.*
- *Principles of Management by Harold Koontz, H. Weihrich, and A.R. Aryasri, Tata McGraw-Hill*
- *Industrial disaster management and emergency Response, UK Charaborty, Asian Books private Ltd*
- *Basic principles and acquisition of Intellectual Property Rights by Ramakrishna, CIPRA, NSLIU 2005.*
- *Intellectual Property Law Handbook by Dr. B. L.Wadhera, Universal Law Publishing Co. Ltd. 2002.*
- *Intellectual Property Law (Bare Act with short comments)-Universal Law Publishing Co. Ltd. 2007.*
- *The Trademarks Act 1999 (Bare Act with short comments)-Universal Law Publishing Co. Ltd. 2005.*
- *The Patents Act, 1970 (Bare Act with short comments) - as amended by Patents (Amendment) Rules 2006 w.e.f. 5-5-2006. Commercial law publishers (India) Pvt. Ltd. 2006.*
- *GMP/ISO Quality Audit Manual for Healthcare Manufacturers and Their Suppliers by Steinborn L. Sixth Edition, (Volume 1 with Checklists and Software Package). Taylor & Francis; 2003.*

Paper-4.5: CHE-645-P (12057): Industrial Chemistry Practical

(Only for Industrial Chemistry Specialization)

Contact Hours / Week : 16 Hours
Duration of Examination: 12 Hours (6 Hrs. per Day) **Maximum Marks:** 200 Marks

Distribution of Marks:

S. No.	Name of Exercise	Marks
1.	Exercise No. 1: Major Experiment	30
2.	Exercise No. 2: Major Experiment	30

3.	Exercise No. 3: Major Experiment	30
4.	Exercise No. 4: Minor Experiment	15
5.	Exercise No. 5: Minor Experiment	15
6.	Exercise No. 6: Minor Experiment	15
7.	Practical Record	15
8.	Good Laboratory Skills and Regularity in Practicals	10
9.	Comprehensive Viva-voce	40
	Total Marks	**200**

Polymer Synthesis:

- Preparation of following polymers and characterize by UV, IR, NMR, MS spectral data:
  - Polyethylene
  - Polyvinyl chloride
  - Polyacrylamide
  - Polystyrene
  - Nylon-66
  - Phenol-formaldehyde resin
  - Urea-formaldehyde resin
  - Melamine-formaldehyde resin

Analysis of clays and feldspars:

- Determination of moisture, silicon dioxide, total oxides, ferric oxide, titanium dioxide, aluminium oxide, calcium oxide, magnesium oxide.

Analysis of Cement and building materials:

- Analysis of cement and building materials: Silicon dioxide, aluminium oxide, ferric oxide, calcium oxide, magnesium oxide, sulphurtrioxide, sulphide- sulphur, loss on ignition, insoluble residue, sodium and potassium oxide.

Analysis of Quartzes:

- Volatile residue, zirconium dioxide, aluminium oxide, calcium and magnesium oxides, sodium and potassium oxide.

Analysis of Glasses:

- Determination of various parameters of glass
- Determination of lead and lead glass.

Analysis of Ceramics:

- Determination of titanium dioxides and aluminium oxide from oxide ceramics.

Analysis of Heavy & Fine Chemicals:

- Preparation and characterization of copper sulphate.
- Preparation and characterization of methyl orange and methyl red.
- Estimation of $Na_2CO_3.10H_2O$ in washing soda.
- Determination of thiosulphate content of a commercial hypo solution.
- Estimation of available chlorine in the sample of bleaching powder.

Analysis of Polymers:

- Determination of acid, saponification, iodine, hydroxyl and carboxyl values of a plastic material.
- Determination of molecular weight of a polymer.

Thermal Analysis:
Study of temperature effect on organic and inorganic compounds, calculate of percent decomposition and composition studies of given samples including following compounds as examples:

- Copper sulphate pentahydrate
- Calcium oxalate monohydrate
- Zinc hexafluorosilicate

Analysis of Pharmaceuticals:

- Preparation and characterization of active pharmaceutical ingredients with purity assay.
- Complete assay of aspirin / ibuprofen / paracetamol / sulpha drugs
- Limit test for impurities like Pb, As, Fe, moisture, chloride, sulfate, boron, free halogen, selenium, *etc*.
- Determination of water in drug sample by Karl-Fischer titration.
- Estimation of mixture of benzoic acid / salicylic acid / iron in pharmaceutical preparation.
- Estimation of ascorbic acid
- Estimation of Benzoic acid in ointment by titrimetry
- Non-aqueous titration method for estimation of isoniazid and sodium benzoate.
- Estimation of sulphadiazine in sulpha tablets
- Determination of aspirin in drug tablet by pH metry titration with NaOH.
- Determination of viscosity of ointment / syrup / liquid, *etc*.
- Analysis of the aminoglycoside antibiotics kanamycin and amikacin matches USP requirements
- Determination of viscosity of ointment/syrup/oils using Brookfield viscometer.

Clinical Analysis:

- Analysis of assay of enzymes (pepsin, monoamine, oxidase, tyrosinase), vitamins (thiamine, ascorbic acid, Vit. A, etc.) and hormones (progesterone, oxytocin, insulin) chemical, instrumental and biological assay wherever applicable.
- Separation and identification of plasma proteins.
- Estimation of Cholesterol in egg yolk or blood serum.
- Estimation of amino acid in protein hydrolysate by Sorenson formal titration method.
- Estimation of blood glucose, protein, chloride, sodium, potassium, urea, uric acid
- Determination of cortisol from blood and urine samples; determination of oestrogens from urine samples.

Analysis of Agrochemicals:

- Analysis of soil sample, soil micronutrients for Ca, Fe and P content
- Analysis of pigments with respect to Zn and Cr.
- Analysis of pesticide residue and toxicological effects.
- Analysis of malathion by colorimetry.
- Determination of organic carbon in soil by Walk Ley and Black method.
- Determination of available chlorine in bleaching powder by Bunsen method.
- Determination of total chlorine in pesticide formulation.
- Determination of copper in fungicide.
- Estimation of nitrogen from given fertilizer by Kjeldahl method.
- Estimation of phosphorus from given fertilizer by volumetry / colourimetry.
- Estimation of potassium from given fertilizer by gravimetry / Flame photometry.

- Determination of K_2O content in given sample of potash fertilizer.
- Determination of P_2O_5 content in give n sample of phosphatic fertilizers.
- Determination of moisture content in given sample of urea
- Analysis of insecticides: DDT, BHC, aldrin, endosulfon, malathion, parathion.
- Analysis of herbicides: 2,4-Dichlorophenoxyacetic acid, dalapon, paraquat, Banalin, Butacarb.
- Analysis of fungicides: Boardeaux mixture, copper oxychloride, zineb, benomyl

Forensic Chemistry:

- Determination of lethal dose, LD-50 and LC-50.
- Determination of cyanide, organophosphate and snake venom.
- Estimation of poisonous materials such as lead, mercury and arsenic in biological samples.

Ion Chromatography:

(i) Medical Science Applications:

- Determination of sulfate counter ion and anionic impurities in aminoglycoside drug substances by IC with Suppressed Conductivity Detection
- Determination of tobramycin and impurities Using HPAE-PAD
- Determination of neomycin B and impurities Using HPAE-PAD
- Determination of streptomycin and impurities Using HPAE-PAD
- Determination of galactosamine containing organic impurities in heparin by HPAE-PAD Using the Dionex CarboPac PA20 Column
- Determination of hemoglobin variants by cation-exchange chromatography
- Determination of transition metals in serum and whole blood by Ion Chromatography
- Analysis of ions in physiological fluids
- Analysis of choline and acetylcholine
- Analysis of fatty acids.
- Determination of oxalate and carbohydrate in urine by Ion Chromatography
- Determination of protein concentrations using AAA-Direct
- Monitoring protein deamidation by cation-exchange Chromatography
- Analysis of mannose-6-phosphate
- Determination of nucleotides by Ion Chromatography with UV absorbance detection
- Determination of residual trifluoroacetate in protein purification buffers and peptide preparations by Reagent-Free Ion Chromatography
- Determination of tryptophan using AAA-Direct
- Identification of a hydroxylysine-containing peptide using AAA-Direct
- High-resolution analysis and purification of oligonucleotides with the DNAPac PA100 Column
- High-resolution cation-exchange alternative to peptide mapping for protein ID and QA/QC

(ii) Food and Beverage Applications:

- Determination of mercury contamination in herbal medicines
- Rapid separation of anthocyanins in Cranberry and Bilberry extracts using a Core-Shell Particle Column
- Determination of trace sodium in cranberry powder
- Determination of sudan dyes I–IV in curry paste

- Determination of mono-, di-, and triphosphates and citrate in Shrimp by Ion Chromatography
- Determination of phytic acid in soybeans and black Sesame seeds
- Determination of nitrate and nitrite Ion Chromatography determination in milk samples
- Separation of organic acids and common inorganic anions in wine
- Determination of hydroxymethylfurfural in honey and biomass
- Fast determination of anthocyanins in pomegranate juice
- Determination of lactose in lactose-free milk products by high-performance anion-exchange Chromatography with Pulsed Amperometric Detection
- Fast HPLC Analysis of dyes in foods and beverages

(iii) Electronics Applications:

- Determination of trace anion contamination in the extracts of electronic components
- Determination of sodium at the ppt level in the presence of high concentrations of ethanolamine in power plant waters
- Determination of inorganic anions and organic acids in fermentation broths
- Determination of phosphite in electroless nickel plating bath
- Determination of chloride, suppressors, additives and byproducts in acid copper plating baths
- Determination of saccharin in electrolytic nickel sulfate baths
- Determination of an anionic fluorochemical surfactant (FC-95) in a steel bath
- Determination of anionic fluorochemical surfactant in a semiconductor Etch Bath
- Monitor trace anion contamination in the extracts of electronic components
- Determination of cations and amines in hydrogen peroxide by Ion Chromatography Using a RFIC™ (Reagent-Free) System
- Determination of dissolved silica and common Anions Using Dual Detection

(iv) Agrochemicals:

- Determination of perchlorate in high ionic strength fertilizer extracts by Ion Chromatography.

Any other relevant experiments may be added / performed.

……. x ……. x …..……. x …….……..

Sample Question Paper

Paper-1.2: CHE-512-T (12002): Organic Chemistry

Duration of Exam: 3 Hours **Maximum Marks: 70**

Note: *The syllabus is divided into five independent units and question paper will be divided into two sections:*

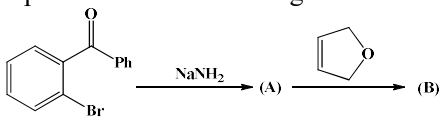
- ***Section-A*** *will carry one compulsory question comprising 10 short answer type questions (answer about in 10-20 words) by taking two questions from each unit with no internal choice. Each short answer type question will have 2 marks and hence Section-A will carry total 20 marks.*
- ***Section-B*** *will carry 50 marks equally divided into five long answer type questions (answer about in 400-500 words) with one question from each unit with internal choice (another question will be given in option or question may be divided in to sub-divisions). Paper setter shall be advised to set one question from each unit along with one option of each question and students are instructed to attempt total five questions by selecting one question from each unit. Each long answer type question will have 10 marks and hence Section-B will carry total 50 marks.*

SECTION-A

Q. 1.

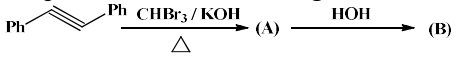
Unit-I

(i) Write the products of the following reaction:



1 + 1 = 2

(ii) Write the products of the following reaction:



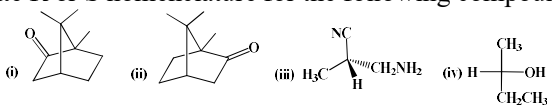
1 + 1 = 2

Unit-II

(iii) Write Fischer projection of D-glucose followed by Howarth formula.

1 + 1 = 2

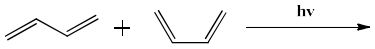
(iv) Write R or S nomenclature for the following compounds:



½ +½ +½ +½ = 2

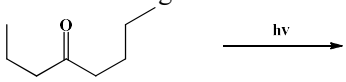
Unit-III

(v) Complete the following reaction:



2

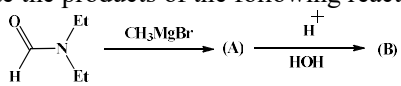
(vi) Complete the following reaction:



2

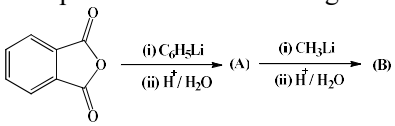
Unit-IV

(vii) Write the products of the following reaction:



1 + 1 = 2

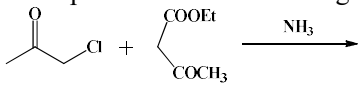
(viii) Write the products of the following reaction:



1 + 1 = 2

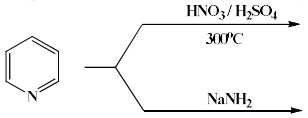
Unit-V

(ix) Write the products of the following reaction:



2

(x) Write the products of the following reaction:



1 + 1 = 2

SECTION-B
Unit-I

Q. 2. Write note on the following (any two):

(i) Resonance
(ii) Tautomerism
(iii) Conjugation
(iv) Aromaticity

5 + 5 = 10

OR

Give an account on formation, stability and chemical reactions of the following:

(i) Carbocations
(ii) Carbenes

5 + 5 = 10

Unit-II

Q. 3. Draw the conformational structures of n-butane and mono- & di-substituted cyclohexane.

4 + 6 = 10

OR

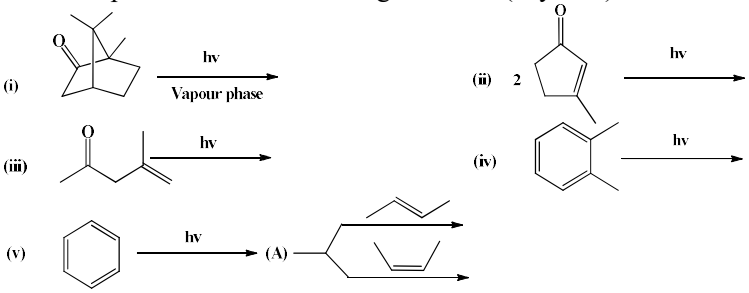
Write note on the following (any two):

(i) Symmetry elements
(ii) Chirality
(iii) Threo & Erythro isomers
(iv) Enantiomers & Diastereomers

5 + 5 = 10

Unit-III

Q. 4. Write the products of the following reactions (any four):



2½+2½+2½+2½ = 10

OR

Discuss in detail:

(i) Paterno-Büchi reaction
(ii) Photochemistry of 1,5-dienes

5 + 5 = 10

Unit-IV

Q. 5. Write note on the following:

(i) Metal hydrides in organic synthesis

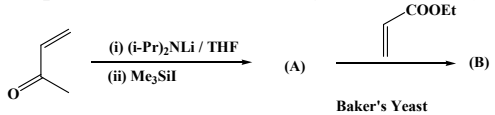
(ii) Phase transfer catalysts

5 + 5 = 10

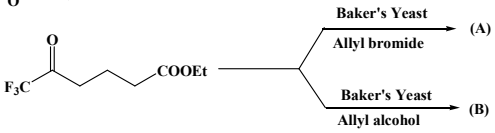
OR

Write the products of the following reactions (any four):

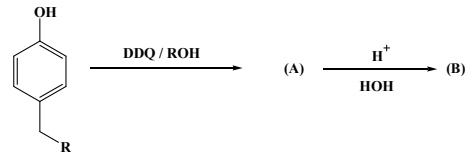
(i)



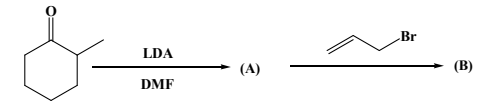
(ii)



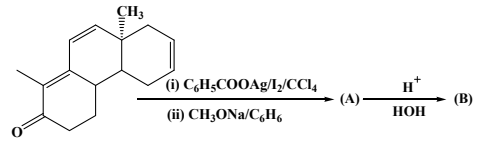
(iii)



(iv)



(v)



1¼+1¼+1¼+1¼ = 5

Unit-V

Q. 6. Give the plausible mechanisms of the following name reactions:

(i) Fischer-indole synthesis

(ii) Doebner-Miller synthesis

(iii) Bischler-Napieralski synthesis

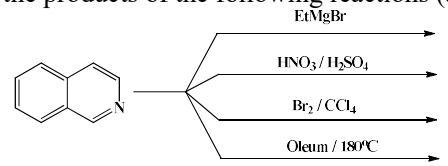
(iv) Skraup synthesis

2½+2½+2½+2½ = 10

OR

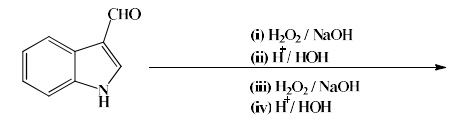
Write the products of the following reactions (any two):

(i)



(ii)

(iii)



5 + 5 = 10

…… x …… x …… x ……..