JIWAJI UNIVERSITY

M.Sc. Environmental Chemistry

Choice Based Credit System

Course Structure, Scheme of Examination & Syllabus

2015 -2017

SEMESTER I

Code	Title of Course	Core / Elective	L	T	P	Total Credits	Marks		
							IA	EA	Total
EC-101	Fundamentals of Quantitative Analysis and Separation Methods	Core	3	0	0	3	40	60	100
EC-102	Stereo-chemistry &Thermo-analytical Methods	Core	3	0	0	3	40	60	100
EC-103	Spectro-analytical Methods of Analysis – I	Core	3	0	0	3	40	60	100
EC-104	Electro-analytical Methods of Analysis	Core	3	0	0	3	40	60	100
EC-105	Laboratory-I	Core	0	0	3	3	40	60	100
EC-106	Laboratory-II	Core	0	0	3	3	40	60	100
EC-107	Seminar	Core	0	1	0	1	50	-	50
EC-108	Assignment	Core	0	1	0	1	50	-	50
EC-109	Comprehensive Viva-voce (virtual credit)	Core	0	0	4	4	50	50	100

Total Credit Value: # 24 (20 + 4 virtual credits)

SEMESTER II

Code	Title of Course	Core / Elective	L	T	P	Total Credits	Marks		
							IA	EA	Total
EC-201	Environmental and Pollution Control	Core	3	0	0	3	40	60	100
EC -202	Spectro-analytical Methods of Analysis– II	Core	3	0	0	3	40	60	100
EC -203	Modern Trends in Instrumentation	Core	3	0	0	3	40	60	100
EC -204	Fundamentals of Organic Reactions	Core	3	0	0	3	40	60	100
EC -205	Laboratory-I	Core	0	0	3	3	40	60	100
EC -206	Laboratory-II	Core	0	0	3	3	40	60	100
EC -207	Seminar	Core	0	1	0	1	50	-	50
EC -208	Assignment	Core	0	1	0	1	50	-	50
EC -209	Comprehensive Viva-voce (virtual credit)	Core	0	0	4	4	50	50	100

Total Credit Value: # 24 (20 + 4 virtual credits)

SEMESTER III

Code	Title of Course	Core / Elective	L	T	P	Total Credits	Marks		
							IA	EA	Total
EC-301	Industrial Water and Waste Treatment	Centric Elective	3	0	0	3	40	60	100
EC-302	Environmental Toxicology and Environmental Impact Assessment	Core	3	0	0	3	40	60	100
EC-303	Energy and Environmental Geochemistry	Generic Elective	3	0	0	3	40	60	100

EC-304	Atmospheric Chemistry	Core	3	0	0	3	40	60	100
EC-305	Laboratory-I	Core	0	0	3	3	40	60	100
EC-306	Laboratory-II	Core	0	0	3	3	40	60	100
EC-307	Seminar	Core	0	1	0	1	50	-	50
EC-308	Assignment	Core	0	1	0	1	50	-	50
EC-309	Comprehensive Viva-voce (virtual credit)	Core	0	0	4	4	50	50	100

Total Credit Value: 24 (20+4 virtual credit)

SEMESTER IV

Code	**Title of Course**	**Core / Elective**	**L**	**T**	**P**	**Total Credits**	**Marks**		
							IA	**EA**	**Total**
EC-401	Environmental Laws and Management	Generic Elective	3	0	0	3	40	60	100
EC-402	Organic Pollutants	Centric Elective	3	0	0	3	40	60	100
EC-403	12-16 Week project work/industrial training	Core	0	0	12	12	-	400	400

EC-404	Project viva-voce	Core	0	0	2	2	-	100	100
EC-405	Comprehensive viva-voce (virtual credit)	Core	0	0	4	4	50	50	100

Total Credit Value: # 24 (virtual credit)

NOTE: Lecture (L): 1 hr = 1 Credit: Tutorial (T): 2 hr = 1 Credit . Practical (P): 2 hr = 1 Credit

- The generic credits may be obtained from other departments/faculties/Institutes.
- Elective credits may be obtained from same or other departments of the faculty
- Minimum credits be earned for award of degree - 96 Credit (Valid credits -80 + Virtual Credits - 16)
- Minimum credits for promotion to next semester - 12 valid credits/semester
- As part of skill development new product development will be practiced
- Every student would deliver minimum one seminar in a semester which would be evaluated.
- Comprehensive viva is based on all papers of given semester.
- The grading will be made on 10-point scale as described below:

Letter Grade	Grade Points	Description	Range of Marks (%)
O	10	Outstanding	90-100
A+	9	Excellent	80-89
A	8	Very good	70-79
B+	7	Good	60-69
B	6	Above Average	50-59
C	5	Average	40-49
P	4	Pass	35-39
F	0	Fail	0-34
Ab	0	Absent	Absent

- The Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA) will be calculated as weighted average of valid and virtual credit points secured by the student, except the credits of additional courses, if any. The SGPA and CGPA shall be rounded off up

to 2 decimal places and reported in the grade sheet.

- SGPA is a measure of performance of the student in a semester. It is ratio of total credit points secured by a student in various courses registered in a semester and the total course credits taken during that semester, i.e.

$$SGPA\ (Si) = \sum(Ci \times Gi) / \sum Ci$$

where Ci is the number of credits of the ith course in a semester and Gi is the grade point scored by the student in the ith course.

- CGPA is a measure of overall cumulative performance of a student over all the semesters completed. The CGPA is the ratio of total credit points secured by a student in various courses in all the semesters completed and the sum of the total credits of all courses in all the semesters completed, i.e.

CGPA = $\sum(Ci \times Si) / \sum Ci$

where Si is the SGPA of the ith semester and Ci is the total number of credits in the semester.

- On completing all requirements for award of the degree, the CGPA will be calculated and this value will be indicated on the degree along with Division. The Final degree should also indicate the Division obtained as per follows:

Division	**Criterion**
First division with distinction	The candidate has earned minimum number of credits required for the award of the degree in first attempt with CGPA of 8.00 or above
First division	The candidate has earned minimum number of credits required for the award of the degree with CGPA of 6.50 or above
Second division	The candidate has earned minimum number of credits required for the award of the degree with CGPA of 5.00 or above but less than 6.50
Pass division	The candidate has earned minimum number of credits required for the award of the degree with CGPA of 4.00 or above but less than 5.00

- The student will be promoted to the next semester if he/ she secures at least 12 valid credits in a semester. In case the student secures less than 12 valid credits in any semester, then the student will be asked to repeat the entire semester and that semester will be treated as zero semester.

- The student should not carry more than 5 courses (combining theory and practical) in Ist year, IInd year or IIIrd year to be promoted to the next year.

- Repetition of a theory / practical course is allowed only to those candidates who get F or Ab in the course. The student has to pay the prescribed fee for repeating the course.

- On account of valid reasons, a student may withdraw from a semester. In such case the semester will be treated as zero semester.

- In case of zero semester, the student will not be promoted to the next semester till he/ she clears that semester. The UTD may allow such a student to register in the subsequent semester whenever it is offered by the concerned UTD. The student has to pay semester fee again in such cases. If the student withdraws within one month from starting of the semester then

semester fee will not be charged again.

- The practical course can be repeated as and when it is offered.

- Dissertation / project report/ internship of 3-6 credits will be assessed by the internal supervisor, in general, however, UTD may get it assessed by an internal supervisor and an external expert.

- A comprehensive viva-voce of 4 virtual credits will be conducted at the end of each semester of the programme by a board of four examiners, at least ONE of whom shall be external. The grades awarded in the viva-voce shall be shown separately in the grade-sheet.

- The conversion of CGPA in to percentage will be as follow to facilitate its application in other academic matters:

  Equivalent Percentage = CGPA x10

Syllabus of M.Sc. Environmental Chemistry (2015-2016)

First Semester **M.M.: 60**

EC-101: Fundamentals of Quantitative Analysis and Separation Methods

Unit-I: Concepts involved in Analysis

Role of analytical chemistry, classification of analytical methods-classical and instrumental, types of instrumental analysis, selecting analysis method, neatness and cleanliness, laboratory operations and practices, good laboratory practices, techniques of weighing, errors, volumetric glassware-cleaning and calibration of glassware, sample preparation – dissolution and decompositions, selecting and handling reagents, laboratory notebooks, safety in the analytical laboratory, calibration and detection limits, proficiency testing.

Unit-II: Separation Techniques -I

(A) Solvent Extraction: Fundamental treatment, theoretical principle, classification, and factors favouring extraction, extraction equilibria, applications.

(B) Solid phase extraction and solid phase micro extraction, applications.

(C) Ion- Exchange: Theories, use of synthetic ion exchange in separation, chelating ion exchange resins, liquid ion exchangers, experimental technique.

Unit-III: Separation Techniques -II
An introduction to chromatographic methods, paper, thin layer and column chromatography, theory

of chromatography, classification of chromatographic techniques, retention time, relationship between retention time and partition coefficient, the rate of solute migration, differential migration rates, band broadening & column efficiency, kinetic variables affecting band broadening, Electrophoresis and capillary electrophoresis.

Unit-IV: Separation Techniques -III

GC, Principle of GC, plate theory for GC, instrumentation for GC, working of GC, Detectors used, applications, , HPLC, Principle of HPLC, Components of HPLC, Detectors used, instrumentation, applications in qualitative and quantitative analysis, comparison of GC and HPLC.

Unit-IV: Separation Techniques -IV

Size exclusion chromatography, super critical fluid chromatography, affinity chromatography, HPTLC, Ion chromatography, pyrolytic gas chromatography.

Books Recommended

1. D.A. Skoog, F.J. Holler and T.A. Nieman, Principles of Instrumental Methods, 5th ed.,,Thomson Asia Pvt. Ltd., Singapore (2003).
2. R.A. Day and A.L. Underwood, Quantitative Analysis, 6th ed., Prentice Hall of India Pvt. Ltd (1993).
3. G.D. Christian, Analytical Chemistry, 6th ed, John Wiley & Sons (2001).
4. S.M. Khopker, Environmental Pollution Analysis, 2nd ed., New Age International Pvt. Ltd.(2002).
5. A.I. Vogel, Textbook of Quantitative Chemical Analysis, 5th ed., Addison Wesley Longman Singapore (1999) 1
6. G. W. Eving, Instrumental Methods of Chemical Analysis, 5th ed.,Mc-Graw Hill Book Company (1985).
7. Willard, Merritt, Dean, and Settle, Instrumental Methods of Analysis, 7th ed., C B S Publishers &Distributors (1986).

Syllabus M.Sc. EC..... (2015-2016)

EC-102: Stereochemistry and Thermo -analytical Methods

M.M.: 60

Unit-I: Stereochemistry

(A) Conformational analysis: Conformation of n-butane and cyclohexane, stability of conformers and energy profile diagram.

(B) Optical activity: Criteria for optical activity, stereoisomers, enantiomers and diastereomers, erythro and threo isomers, a general idea of symmetry elements.

(C) Racemic Modifications: Conglomerate, racemate and racemic solid solutions, a general idea of stereo selective synthesis.

(D) Resolution of Racemic modifications: by Chemical separation, chromatography, preferential crystallization and asymmetric transformation (a brief idea only).

Unit-II: Solution reactions: fundamental theory

The Law of Mass Action, Activity and Activity Coefficient, Factors affecting chemical reactions in solution, The ionic product of water, Electrolytic dissociation, Strengths of acids and bases, Solubility Product, Common ion effect, Effect of acid, temperature and solvent on the solubility of the precipitate, Complexation, stability of complexes, Complexones

Unit-III: Titrimetric and Gravimetric Methods of Analysis

General principles: Solvents in analytical chemistry, buffers, acid-base equilibria, concentration systems, stoichiometic calculation, acid-base titration, titration curves, acid base indicators, applications of acid-base titration, complexometric titration, metal-ion indicators, precipitation titration, Mohr's titration, Volhard's titration, adsorption indicators, Fajan's titration, titration curves in oxidation-reduction titration, redox indicators, applications of redox titrations

Unit-IV: Thermo-analytical Methods

Thermogravimetry, factors affecting thermogravimetric curves, derivative thermogravimetry (DTG), thermobalances, applications of thermogravimetry, differential thermal analysis, factors affecting DTA curve, instrumentation, applications of DTA.

Differential scanning calorimetry, theory, instrumentation, applications of DSC, thermometric titration, principle, classification, instrumentation and applications of thermometric titration.

Unit-V: Principles of Gravimetric Analysis

Stoichiometry of gravimetric reactions, formation and properties of precipitates, precipitation from homogeneous solution, nucleation, organic precipitations, applications of gravimetric analysis.

Books Recommended

(a) D.A. Skoog, F.J. Holler and Nieman, Principles of Instrumental Methods, 5th ed.,Thomson Asia Pvt. Ltd., Singapore (2003).
(b) R.A. Day and A.L. Underwood, Quantitative Analysis, 6th ed., Prentice Hall of India Pvt. Ltd. (1993).
(c) G.D. Christian., Analytical Chemistry, 6th ed, John Wiley & Sons (2000)
(d) A.I. Vogel, Textbook of Quantitative Chemical Analysis, 5th ed., Addison Wesley Longman Singaporepte Ltd. (1999)
(e) G. W. Eving, Instrumental Methods of Chemical Analysis, 5th ed.,,Mc-Graw Hill Book Company (1985)
6. Ernest L. ELiel and Samuel H. Wilen,Stereochemistry of Organic Compounds , John Wiley & Sons (2003).

EC-103: Spectro-analytical Methods of Analysis-I **M.M.: 60**

Unit-I: Colorimetry and Spectrophotometry

An introduction to spectrophotometric methods, a brief idea of wave properties of electromagnetic radiation, theory of spectrophotometry and colorimetry, conjugated dienes, woodward fieser rules for calculating absorption maxima in dienes,transition probability,types of absorption bands ,types of electronic transitions, chromophores, auxochromes, absorption and intensity shift, limitations of Beer's Law, classification of methods of colour measurement, instrumentation single beam and double beam, photometric error, applications of spectrophotometry to inorganic and organic compounds (quantitative calculations), spectrophotometric titration.

Unit-II: Other Spectro-analytical techniques

(A) Introduction, general principle, instruments for nephelometry and tubidimetry, applications of nephelometry and turbidimetry to analytical chemistry.

(B) Dispersion Refrectometry and Flame photometry

(C) Polarometry, circular dichrosim (CD) and optical rotatory dispersion (ORD).

Unit-III: Emission Spectroscopy

Elementary idea of emission spectroscopy, introduction, elementary theory, instrumentation, types of flames, interferences, factors affecting flame photometry, applications to qualitative and quantitative analysis, limitations.

Unit-IV: Fluorescence and Phosphorescence Spectrophotometry

Theory of fluorescence and phosphorescence, quantum yield, factors affecting fluorescence and phosphorescence, relation between concentration and intensity, instrumentation, applications, an elementary idea of chemiluminiscence.

Unit-V: Kinetic of Slow and Fast reactions (An elementary study keeping in view its applications in analytical chemistry)

(A) Rates of chemical reaction, expression for reaction rate, rate constants, order of reaction, methods for determination of order of reaction, Arrhenius equation, Collision theory, failure of collision theory, Absolute reaction rate theory, unimolecular reactions, mathematical formulation of Lindemann’s theory, catalysed reactions, Theory of homogenous catalysed reactions, kinetics of enzyme catalysed reactions, elementary idea of micellar catalysis.

(B) Study of fast reactions by stopped flow method, relaxation methods, flash photolysis method, photochemical reactions, kinetics of photochemical combination of hydrogen and chlorine, branched chain reactions, oscillatory reactions, applications of kinetic methods in finding out optimum conditions for different reactions.

Books Recommended

1. John. R. Dyer, Applications of Absorption Spectroscopy of Organic compounds,9th ed.. Prentice Hall of India Pvt. Ltd. (1994).
2. Dudley H.Williams and Ian Fleming, Spectroscopic Methods in Organic Chemistry, 4th ed., Tata Mc-Graw Hill Book Company (1998).
3. R.M.Silverstein, G.Clayton Bassler and Terence C. Morrill, Spectroscopic Identification of Organic compounds, 6th ed, John Wiley & Sons (1998).
4. D.A. Skoog, F.J. Holler and Nieman, Principles of Instrumental Methods, 5th ed.,Thomson Asia Pvt. Ltd., Singapore (2003).
5. R.A. Day and A.L. Underwood, Quantitative Analysis, 6th ed., Prentice Hall of India Pvt. Ltd. (1993).
6. G.D. Christian., Analytical Chemistry, 6th ed, John Wiley & Sons (2000)
7. A.I. Vogel, Textbook of Quantitative Chemical Analysis, 5th ed., Addison Wesley Longman Singapore (1999)

EC-104: Electro-analytical Methods of Analysis M.M.: 60

Unit-I: Fundamentals

Electrochemical cells, solution structure, potential in electroanalytical cells, Nernst equation, electrode potential the ideal polarized and non-polarized electrodes, faradiac reaction, variables in electrochemical cells, factors affecting electrode reaction rate and current, decomposition potential, back potential and voltage.

Unit-II: Potentiometry

Introduction, reference electrodes, indicator electrodes, ion-selective electrodes and their applications in chemical analysis, instrumentation and measurement of cell unit, direct potentiometry, potentiometric titration, applications.

Unit-III: Polarography

Direct current polarography, basic principle, instrumentation, advantages and disadvantages of dropping mercury electrode, different kinds of limiting currents, components of poralographic waves, reversible and irreversible waves, pulse and A.C. polargraphy, applications of polarography to inorganic and organic compounds, elementary idea of stripping voltammetry, amperometric titrations.

Unit-IV: Conductometry and Coulometry

Conductometry as an analytical tool, applications of direct conductometric measurements, basis of conductometric titrations, applications of conductometry titration, constant current and controlled potential electro-gravimetry, separation of metals, coulometry at controlled potential, coulometry at constant current, applications.

Unit-V: Voltammetry

AC polarography, current sampled (TAST) polarography, normal pulse and differential pulse polarography, stripping voltammetry, linear sweep and cyclic voltammetry, chonopotentiometry, chronoamperometry.

Books Recommended

1. Allen J. Bard and Larry R. Faulkner, Electro-chemical Methods,2nd ed., John Wiley & Sons (2001).
2. G.D. Christian, Analytical Chemistry, 6th ed, John Wiley & Sons (2001).
3. A.I. Vogel, Textbook of Quantitative Chemical Analysis, 5th ed., Addison Wesley Long man Singapore Ltd. (1999)
4. Galen W. Eving, Instrumental Methods of Chemical Analysis, 5th ed., Mc-Graw Hill Book company (1985).
5. Willard, Merritt, Dean, and Settle, Instrumental Methods of Analysis, 7th ed., C B S Publishers & Distributors (1986).

Second Semester

EC -201: Environmental and Pollution Control

M.M.: 60

Unit-I: Air Pollution

Atmospheric pollution, classification of air pollutants, sources of air pollution and methods of control, sampling of aerosols, sampling of gaseous pollutants, analysis of SO_x, NO_x, CO-CO_2, hydrocarbons, effects of air pollutants on animals, ozone layer, chlorofluorocarbons, acid rain, green house effect.

Unit-II: Water Pollution

Sampling and preservation of water, physical examination of water-colour, alkalinity, TDS, conductivity, temperature, odour, turbidity, hardness, chemical examination of water-determination of carbonates and bicarbonates, sulphate, chloride and flouride, nitrite and nitrate, iron, manganese, silica, cadmium, arsenic, chromium, lead, mercury, biological examination of water-dissolved oxygen, BOD, COD, MPN. Organic pollutant analysis-phenols and detergents.

Unit-III: Water treatment

Quality of water, standards of raw and treated water, objectives of waste water treatment, A brief idea of sedimentation, coagulation and flocculation, filtration, disinfection of water, activated sludge process, trickling filters, sludge treatment and disposal.

Unit-IV: Softening of water, corrosion and its control, removal of nitrogen and phosphorus. Removal of toxic compounds and refractory organics, removal of dissolved inorganic substances, Reverse osmosis.

Unit-V: (A) Soil Pollution

A brief idea of chemistry of soil. Trace element analysis in soil-B, Cd, Cu, Fe, Mn, Mo, Zn, Pb, Pesticides and pollution, classification and degradation of pesticides, methods of pesticides analysis.

(B) Noise Pollution

Sources, measurement, effects and control.

Books Recommended

1. Gilbert M. Masters, Introduction to Environmental Engineering and Science, 3rd ed. Prentice Hall of India Pvt. Ltd.(1998)

2. C.S.Rao, Environmental Pollution Control Engineering, 3rd ed., Wiley Eastern Ltd.New Age International Pvt.Ltd. (1995).

3. Metcalf & Eddy, Waste Water Engineering, Tata McGraw Hill, New Delhi (2003).

4. C.Harold Wright, A Hand book of Soil Analysis, 4th ed., Logas press New Delhi –

5. Thomous S. Spiro and William M. Stiglicini, Chemistry of the Environment, Prentice Hall of India Pvt. Ltd. (2002).

6. Nicholas P. Cherimisinoff, Biotechnology for Waste and wastewater treatment, Prentice Hall of India Pvt. Ltd. (2001).

7. Jarry A. Nathanson, Basic Environmental Technology, 4th ed., Prentice Hall of India Pvt. Ltd. (2003). 8. Raymond W. Miller and Roy L. Donalvee, Soil in Our Environment, 7th ed, Prentice Hall of India Pvt. Ltd. (1997).

9. Nylie C. Brady, The Nature and Properties of Soil, 10th ed., Prentice Hall of India Pvt. Ltd. (1996).

EC -202: Spectro-analytical Methods of Analysis- II M.M.: 60

Unit-I: Atomic Absorption and Emission Spectroscopy.

Theory of atomic spectroscopy, the origin of spectral transition, the populations of energy levels, the factors influencing spectral width, atomic absorption spectroscopy (AAS), instrumentation, interferences, applications, various non-flame emission sources, applications of atomic emission spectroscopy, comparison of atomic emission and atomic absorption methods, Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES), instrumentation of ICP-AES, applications of ICP-AES, Comparison of ICP-AES with AAS.

Unit-II: Infrared Spectroscopy

Theory of Infrared absorption, vibrational modes, vibrational coupling, Near IR Spectroscopy ,instrumentation, dispersive and non-dispersive instrument, FTIR, sampling techniques qualitative applications and interpretation of spectra, quantitative applications. A brief idea of Raman spectroscopy.

Unit-III: Nuclear Magnetic Resonance Spectroscopy

Theory of NMR, chemical shift and spin-spin splitting, relaxation process of saturation, environmental effects on NMR spectra, instrumentation, CW or FT NMR instrument, Rules governing the interpretation of first order spectra, applications to quantitative analysis.

Unit-IV: Carbon-13 NMR

Historical development, proton decoupling-broad band, Off-resonance and pulsed or gated decoupling, nuclear overhauser enhancement, polarization transfer experiments-DEPT and INEPT chemical shifts, spin-spin coupling impacts, application of ^{13}C NMR to structure determination, two-dimensional NMR spectroscopy, principle, the COSY experiment, the COSY experiment with double quantum filter (COSY-DQF), the NOESY experiment, three-dimensional NMR experiment, APT and INADEQUATE techniques.

Unit-V: Mass Spectrometry

Theory of mass spectrometry, practical considerations, ion production, depletion of ions, ion detector, calibration, other ionization techniques: chemical ionization, fast atom bombardment (FAB), and electrospray, interpretation of the mass spectrum of the compound,Mc Lafferty rearrangement ,Mass analyzers, determination of molecular formula, nitrogen rule, general fragmentation modes, applications of mass spectrometry.

Books Recommended

1. John. R. Dyer, Applications of Absorption Spectroscopy of Organic compounds, 9th ed.,Prantice Hall of India Pvt. Ltd. (1994).
2. Dudley H.Williams and Ian Fleming, Spectroscopic Methods in Organic chemistry, 4th ed., Tata Mc-Graw Hill Book company (1998).
3. R.M.Silverstein, G.Clayton Bassler, and Terence C. Morrill, Spectroscopic Identification of Organic Compounds, 6th ed., John Wiley & Sons (1998).
4. C.N. Ban well, Fundamentals of Molecular Spectroscopy, Tata Mc-Graw Hill Book company (1998).
5. Manas Chanda, Atomic Structure and Chemical Bond, Tata Mc-Graw Hill Book company (1998).

203: New trends in Instrumentation

M.M.:60

Unit-I: Statistical Treatment of Data-I

Types of errors, accuracy and precision, rounding off, significant figures, normal distribution of errors, statistical treatment of finite samples (mean, median, range & average deviation), t-test, confidence interval of the mean, standard error of a mean, test of significance, comparison of two means, F-test, rejection of data, Q-test, bivariate data, Quality control charts, relationship between variables, correlation & regression, principle of least squares.

Unit-II: Statistical Treatment of Data-II

Overview of quantitative analysis of drugs, validation of analytical procedure in pharmaceutical formulation (LOD, LOQ, Robustness, Specificity, Accuracy, Precision, Selectivity, Linearity, Ruggedness, Reproducibility, Repeatability), Recovery analysis, Error bars, Study design.

Unit-III: Statistical Treatment of Data-III

Chi square, ANOVA-1 way classification, ANOVA-2 way classification, Lotka-Voltra Model and Lesle's matrix model, Box model and Gaussian Plume Model, normal distribution, skewness.

Unit-IV: Spectro-analytical methods of analysis

Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Scanning Tunneling Microscopy (STM), Atomic Force Microscopy (AFM) and its applications, Microwave Spectroscopy, Comparison of Electron Microscopy with electron spectroscopy.

Unit-V: Photoelectron Spectroscopy

Ultraviolet (U.V.) and X-ray Photoelectron Spectroscopy, basic concepts and applications. Concept of AUGER Photoelectron Spectroscopy and applications. Determination of kinetic energy of an electron by using different methods, Difference between AUGER and Fluorescence phenomenon.

Books Recommended

1. John. R. Dyer, Applications of Absorption Spectroscopy of Organic compounds,9th ed.. Prentice Hall of India Pvt. Ltd. (1994).
2. Dudley H.Williams and Ian Fleming, Spectroscopic Methods in Organic Chemistry, 4th ed., Tata Mc-Graw Hill Book Company (1998).
3. R.M. Silverstein, G.Clayton Bassler and Terence C. Morrill, Spectroscopic Identification of Organic compounds, 6th ed, John Wiley & Sons (1998).
4. D.A. Skoog, F.J. Holler and Nieman, Principles of Instrumental Methods, 5th ed.,Thomson Asia Pvt. Ltd., Singapore (2003).
5. R.A. Day and A.L. Underwood, Quantitative Analysis, 6th ed., Prentice Hall of India Pvt. Ltd. (1993).
6. G.D. Christian., Analytical Chemistry, 6th ed, John Wiley & Sons (2000)
7. A.I. Vogel, Textbook of Quantitative Chemical Analysis, 5th ed., Addison Wesley Longman Singapore (1999)
8. Jagmohan, Organic Spectroscopy-Principles and applications, 2nd ed, Narosa Publishing House, New Delhi
9. C.S. Rao, Environmental Pollution Control Engineering, Wiley Eastern Ltd., New Age International Ltd., (1995)

EC -204: Fundamental of Organic Reactions M.M.:60

Unit-I: Nucleophilic substitution

Mechanism of SN^1 and SN^2 reactions, SN^i and SET mechanism, The neighboring group mechanism, Effects of substrate structure, Attacking nucleophile, Leaving group and reaction medium on SN^1 and SN^2 reactions, Benzyne reaction, Evidences infavour of benzyne reaction.

Unit-II: Electrophilic substitution

Electrophilic substitution reaction of benzyne, Nitration halogenations, Sulphonation , Friedel craft reaction, Energy profile diagram, The ortho/ para ratio, IPSO attack, Diazonium coupling reaction, Gattermann-koch reaction, Vilsmeir reaction.

Unit-III: Elimination reaction

Mechanism of E-1, E-2 and E1CB reactions, Difference between substitution and elimination reactions, Saytzeff rule, The Hoffmann rule, Effects of substrate structure, Nature of base, Nature of solvents and temperature on elimination reactions.

Unit-IV: Addition reaction

Electrophilic additions, Markovnikov's rule, Peroxide effect, Hydroboration, sharpless asymmetric epoxidation, Regio and chemoselectivity, Diel's – Alder reaction, ozonolysis, Hydrogenation of alkene and alkynes, Mechanism of Aldol, Claisen, Perkin and Benzoin condensations.

Unit-V: Free radicals

Stability of free radicals, Polymerization, halogenations of alkanes via chain reaction, Bromination by N- bromo succinimide (NBS), Addition of halogens and halogen acids, Autooxidation, Sandmeyer reaction, Hansdiecker reaction, Free radical rearrangement reaction.

Books Recommended

1. Advanced organic chemistry- reactions, mechanism and structure, Jery March, John Wiley.
2. Organic chemistry, R.T Morrism and R.N. Boyel, Prentice Hall.
3. Reaction mechanism in organic chemistry, S.M. Mukherji and S.P. Singh. Trinity Publisher, New Delhi.
4.Advanced organic chemistry, Jagdamba singh & L.D.S. Yadav. Pragati Prakashan, Meerut.
5. Advanced general organic chemistry, S.K. Ghosh. New central Book Agency(p) ltd. Kolkata

Third Semester

EC-301: Industrial Waste and Water Treatment M.M.: 60

Unit-I: An Introduction to Source, Characteristics and Treatment of Industrial Waste

Undesirable waste characteristics, sources and characteristics of waste water, industrial waste survey, waste characteristics - estimation of organic content, water reuse and in-plant waste control, idea of different technologies for the treatment of industrial waste water and the basis for the selection of treatment technology.

Unit-II: Treatment of Industrial Wastes

Different steps in the treatment of industrial waste (equalization, neutralization, sedimentation, oil separation, flotation, coagulation), sources and removal of heavy metals e.g. As, Ba, Cd, Cu, F, Fe, Rb, Mn, Hg, Ni, Se, Ag & Zn)

Unit-III: Advance Water Treatment of Industrial Waste - I

Aeration, air stripping of volatile organics (VOC), biological oxidation - removal of organics (sorption, stripping, biodegradation), nitrification and de-nitrification.

Unit-IV: Advance Water Treatment of Industrial Waste - I

Lagoons and stabilization basins, membrane processes, trickling filtration, adsorption, ion exchange, chemical oxidation, sludge dewatering and disposal.

Unit-V: Waste Water Reuse and Recovery

Treatment, disposal, reuse and recovery of trade waste from (1) Textile Manufacture (2) Distilleries (3) Sugar (4) Paper and Pulp mills (4) Tanneries (5) Food Processing industries (6) Fertilizer Industry.

Books Recommended

1. Thomous S. Spiro and William M. Stiglicini, Chemistry of The Environment, Prentice Hall of India Pvt. Ltd. (2002)
2. Nicholas P. Cherimisinoff, Biotechnology for Waste and Waste Water Treatment, Prentice Hall of India Pvt. Ltd. (2001).
3. Jarry A. Nathanson, Basic Environmental Technology, 4th ed ,Prentice Hall of India Pvt. Ltd. (2003).
4. W.Wesley Eckenfelder, Indusrtrial Water Pollution Control, 2nd ed., Tata Mc-Graw Hill Book Company (1989).
5. P.K. Sinha, Computer Fundamentals, 2nd ed., BPB publication (1992).
6. Richard W. Brightman, Jaffery M. Dimsdale, Using Microcomputers, Galgotia Publications (1994).

EC 302: Environmental Toxicology and Environmental Impact Assessment

M.M.: 60

Unit - I: An Introduction to Impact Assessment

Introduction to EIA, impact assessment methodologies, environmental inventory, environmental impact assessment (planning and management), environmental indices and indicators for describing the affected environment, EIA guidelines, introduction to environmental impact statement, assessment of chlorofluorocarbons and carbon dioxide on the overall environment changes in stratospheric ozone.

Unit – II: A study of Impact Assessment -I

Assessment of impacts on the surface water environment, identification of surface water quality or quality impacts, impact prediction, identification and incorporation of mitigation measures, background information on the soil environment, ground water quantity and quality, conceptual approach for addressing soil and ground water environment impacts, identification of the types and quantities of air pollutants and of their impacts, impact prediction, identification and incorporation of mitigation measures.

Unit -III: A study of Impact Assessment-II

Prediction and assessment of impact on the noise environment, prediction and assessment of impacts on the biological environment; a brief idea of prediction and assessment of impacts on the cultural and socioeconomic environment, preparation of reports of the environmental impact study findings.

Unit - IV: Some Case Studies of Environmental Impact Assessment and Sustainable development.

(A) A brief idea of environmental impacts of oil, natural gas, coal, hydroelectric development, nuclear power, thermal power project, mining & mineral processes.

(B) Concept and strategies of sustainable development, environmental priorities of sustainable development in India.

Unit - V: Environmental Toxicology

(A) Toxicology and Pharmacokinetics: One-Compartment Model, Two-Compartment Model, Applications to Toxicology Testing , Toxic effects and dose response relationship a brief idea of carcinogens and non-carcinogens, Biotransformation, Biomarker, Xenobiotics, Toxicity due to Hydrocarbons and pesticides .

(B) Impact of Toxic Chemical on Enzymes: Biochemical effects of arsenic, cadmium, lead, mercury, carbon monoxide, cyanide

Books Recommended

1. Larry W. Canter. , Environmental Impact Assessment, 2nd ed, Tata Mc Graw Hill (1996).
2. J.M.Dewan and K.N. Sudarshan, Hazardous Waste Management, 1st ed. , Discovery Publishing (1996).
3. Michea D. Lagrega, Hazardous Waste Management, 1st ed., Tata Mc Graw Hill Book Company
4. M. Satake and Y.Midostal, Environmental Toxicology, 1st ed., Discovery Publishing House (1997).
5. Ian C. Shaw and John Chadwick, Principles of Environmental Toxicology, Galgotia Publication Pvt. Ltd. (1998).
6. R.E. Hester and R.M. Harrison, Risk Assessment and Risk Management,1st ed., Royal Society of India (1998).
7. Colin Baird , Environmental chemistry f o u rt he d i t i o n, W. H. freeman and company New York.
8. Frank A. Barile, P r i n c i p l e s of toxicology Testing John's University Queens, New York

E.C 303: Energy and Environmental Geochemistry **M.M.: 60**

Unit-I: Energy, Man and Environment

(A) Energy and energy science: Law of conservation of energy, different forms of energy, fuel and energy resources and forms of energy (conventional and renewable resources for electrical generation), national energy strategies and national energy plan, energy management, conservation and audit.

(B) Alternative and renewable energy sources: Wind energy and wind turbine power plants, energy from ocean, geothermal energy and power plant, nuclear energy – fission and fusion principle and energy resources.

Unit- II: Solar Energy

(A) Introduction, Sun as a source of energy, solar radiation and its spectral characteristics, solar radiation measurements, solar collectors, solar photovoltaic, solar energy storage system, solar ponds, applications of solar energy.

Unit-III: Biomass Energy Resources

Biomass energy resources, resources of conversion of biomass into useful energy, raw biomass material for conversion to biogas, biogas generator (factors affecting biodegradation or generation of gas) significance of biogas plants in India's energy strategy, biogas plants, fuel properties and utilization of biogas, biomass as source of energy.

Unit- IV: Other Energy Sources and Pollution Control

(A) Chemical Energy Sources: Fuel cells, principle of operation of a fuel cell (also theory), classification and types of fuel cells, advantages and disadvantages of fuel cells, conversion efficiency of fuel cells, applications of fuel cells.

(B) Pollution Control of Major Pollutants: Pollution from use of energy: combustion products of fossil fuels, methods of controls of major pollutants - SO_x [Flue gas desulphurization (FGD) systems], removal of NO_x from flue gas (De-NO_x system)

Unit V: Mineral Resources and Environmental Hazards

(A) Types of mineral deposits, mineral and rock resources, new methods in mineral exploration, marine mineral resources, conservation of mineral resources, impacts of mining activities.

(B) Hydrological hazards: Floods and drought

Atmospheric hazards: Severe storms, temperature extreme and wild fires

Technological hazards: Bhopal Gas Tragedy and Chernobyl

Seismic hazards: Earthquake and volcanoes

Books Recommended

1. Carla W. Montgomery, Environmental Geology, 5th ed., Mc Graw Hill Higher Education (2000).
2. G.D.Rai, Non Conventional Energy Sources, 4th ed., Khanna Publication (1996).
3. S.A. Abbasi, Renewable Energy Sources and Their Environmental Impact, 1st ed. Ashok K. Ghosh, Prentice Hall of India (2001).
4. H.P. Garg and J.Prakash, Solar Energy Fundamentals and Applications, Tata Mc Graw Hill (1992).
5. S.P. Sukhantine, Solar Energy: Principles of Thermal Collection and Storage, 2nd ed., Tata Mc Graw Hill (1992).
6. S.Rao and B. Prulaker, Energy Technology, 1st ed., Khanna Publications (1996).

EC-304 Atmospheric Chemistry **M.M.: 60**

Unit-I: Chemical composition and Meterological aspects of air pollutants

Earth atmosphere, particles, aerosols and clouds, ozone, cyclic processes including carbon cycle, oxygen cycle, nitrogen cycle, sulphur cycle, Temperature lapse rate and stability ,adiabatic lapse rate, atmospheric stability ,Inversion, Plume behavior and Gaussian plume ,Wind velocity and turbulance.

Unit-II: Photochemistry

Photochemical change, photo-dissociation and photo-ionization, reaction of electronically excited species, adiabatic process and the correlation rules.

Application of kinetics to atmosphere (bimolecular reactions, unimolecular and trimolecular reactions, liquid phase reactions, multi-step reaction scheme).

Unit-Ill: Ozone in Earth's Stratosphere

Chemistry of oxygen, Chapman layers, influence of trace constituents, natural sources and sinks of catalytic species, heterogeneous chemistry.
Ionization mechanisms, chemistry of the specific region (F-region processes, E-region processes, D-region positive ion chemistry, D-region negative ion chemistry), a brief idea of ion in stratosphere and troposphere. Solar proton events, solar ultra violet irradiance, El Nino, volcanoes, halocarbon, polar ozone holes consequence of ozone perturbation

Unit-IV: Earth Troposphere
Brief Introduction to Troposphere, sources ,sinks and transport, Oxidation and transformation:- Photochemical chain Initiation , oxidation steps ,importance of NO_X ,The reaction of OH+ CO

Unit-V: Air Modelling and current carbon trends
Air modelling, air monitoring , Chemistry of carbon dioxide in atmosphere , CO_2 sequestration, Carbon trading , Carbon footprint

Books Recommended

1. Richard P. Wayne, Chemistry of Atmosphere 3rd ed., Oxford University Press (2000).
2 Seinfeld, J.H. and Pandis, S.N., Atmospheric Chemistry and Physics, John Wiley, Chichester (1998).
3. Hobbs P.V., Introduction to Atmospheric Chemistry, Cambridge University Press (1999).
4. C.S.Rao, Environmental Pollution Control Engineering, 3rd ed., Wiley Eastern Ltd.New Age International Pvt.Ltd. (1995).

Fourth Semester

EC 401: Environmental Laws and Management M.M.: 60

Unit - I: Pollution Control Through Laws - I

National conservation strategy and policy on environment and development, international and national efforts for environmental protection, Rio declaration, the environment (Protection) Act 1986, hazardous waste (Management and handling) Rules 1989, air (Prevention and Control of Pollution) Act 1981 and rules 1982, the motor vehicle Act 1988.

Unit - II: Pollution Control Through Laws - II

The water (prevention and control of pollution) Act 1974 and rules 1975, global action on ozone 1989, public liability insurance Act, 1991, the national environment appellate authority Act, 1997, forest (conservation) Act, 1980, wild life (protection) Act 1972 amended 1991, Indian Forests Act (Revised) 1982, a brief idea of world conservation strategy (WCS) and national conservation strategy (NCS).

Unit - III: Environmental Management [ISO 14000]

Principles and elements for successful environmental management, elements of environmental management, creating an environmental management system, environmental management commitment and policy, leadership in an environmental management system, environmental management system audit, steps for registration to IS014000. Preparing environmental management system for an organization.

Unit - IV: Natural Resources and Their Conservation

Types of natural resources and the need for their conservation, soil conservation, forest resources, deforestation, desertification, afforestation and protection of forestry, water resource management, a brief idea of rain water harvesting, wet land conservation, waste land and their reclamation, introduction to biodiversity and conservation of biodiversity in India, protection area network (National park, Sanctuary and Biosphere reserve).

Unit – V: Hazardous Waste Management

Definition of hazardous waste, the relationship of toxicology to hazardous waste management, approach to hazardous waste pollution prevention and reduction, the effectiveness for treatment of hazardous waste, transportation and treatment of hazardous waste, environmental audits and site assessment hazardous substance and risk assessment,Solid waste management, e-waste ,nuclear waste,biomedical waste management

Books Recommended

1.Suresh Jain and Vimla Jain, Environmental Laws in India, The Lawyers home, Indore (1989).
2. Don Sayre, Inside ISO 14000, Deep & Deep Publications (1997).
3.S.Dalela Saurath, ISO 9000; A Manual for Total Quality Management, 1st ed. (1992).
4.S.K. Mohanty, Environmental and Pollution Law Manual, 1st ed., Universal Publication (1997).
5.S.P. Mahajan, Pollution Control in Process Industries, 10th ed., Tata Mc Graw Hill (1998).
6.Gary, Vishnoi, and C.P.Malik, Environmental Policies and Laws, 1st ed., Kalyani Publishers (2002).
7. M.C. Mehta Lal's Commentaries on Water and Air Pollution & Environment Protection Law, 4tn ed., Delhi Law House (2002).
8. Gregory P. Johnson, ISO 14000 EMS Audit Handbook, 1st ed., st. Luceie Press (1997).
9. Kenwhite Law, ISO 14001 Env. Systems Handbook, 1st ed., Butter worth-Heinmon (P) Ltd. (1997).

EC-402: Organic Pollutants **M.M.: 60**

Unit-I: Pesticides-I

Organochlorine insecticides, DDT, accumulation and the fate of organochlorine in biological systems, chlorinated cyclopentadiene, detection of pesticides by gas chromatography, organophosphate and carbamate insecticides , biopesticides, new generation pesticides.

Unit-II: Pesticides-II

Herbicides, triazine herbicides, phenoxy herbicides, dioxine contamination of herbicides and wood preservatives, polychlorinated biphenyls (PCBs), furan contamination of PCBs, toxicology of PCBs, trioxins and furans, biodiesel , biofertilizers.

Unit-III

(A) Polynuclear aromatic hydrocarbons (PAHs) as pollutants, mechanism of PAH carcinogenic, environmental estrogens. .

(B) A brief idea of the following: Recycling of household and commercial waste, recycling of paper, recycling of tire, recycling of plastics, green chemistry, bioremediation, phytoremediation.

Unit-IV: Mutagenic Pollutants

Mutation, effect of mutations, induction of mutation (UV-light), ionizing radiations, chemical mutagens, metabolism of chemical carcinogens.

Unit-V: Electrochemistry in Pollution Control

Electrochemistry of water splitting, large-scale solar hydrogen production, fixing of CO_2, electro chemical removal of wastes (waste water, SO_2, removal of metals, destruction of nitrates, organic wastes, sewage disposal).

Books Recommended

1. S.P. Mahajan, Pollution Control in Process Industries, 10th ed., Tata Mc Graw Hill (1998).
2. J.O'M. Bockris and A.K.N. Reddy, Modern Electrochemistry, (volumes 1 & 2), Plenum Press, N.Y. (2001).
3. M.H.Yu., Environmental Toxicology, Lewis Publisher, Washington DC. (2001).

EC – 105 and 106
Ist semester
Practical Examinations

M.M.: 100

One day 6-8 hrs. (Each course)
Two exercises to be given in each examination

CLASSICAL

1. Neutralization titration
   (a) Determination of Acidity.
   (b) Determination of free carbon dioxide.
   (c) Determination of alkalinity.

2. Complexometric titration
   (a) Determination of temporary and permanent hardness.
   (b) Determination of total, calcium and magnesium hardness.

3. Precipitation titration
   (a) Determination of chloride.

4. Redox titration
   (a) Determination of ferrous iron.
   (b) Determination of copper.

INSTRUMENTAL

1. Spectrophotometric/ Colorimetric determination
   (a) Determination of nickel.
   (b) Determination of hexavalent chromium.

2. Conductometric determination
   (a) Determination of strength of acid against standard alkali.
   (b) Find out the strength of mixture of acids in an unknown mixture.

3. pH metric determination
   (a) Determination of strength of acid against standard alkali.
   (b) Find out the strength of mixture of acids in an unknown mixture.

4.Chromatographic determination
   (a) Identification of a sample compound and its separation from a binary mixture by
   (i) Paper chromatography (ii) Thin layer chromatography and(iii)Electrophoresis.

SEPARATION TECHNIQUES

1. Determination of the distribution coefficient of iodine between CCL_4 and water.

EC – 205 and 206
2nd Semester
Practical Examinations

M.M.: 100

One day 6-8 hrs. (Each course)
Two exercises to be given in examination

CLASSICAL

1. Physio-chemical analysis of water
   (a) Determination of total dissolved and suspended solids.
   (b) Determination of residual chlorine.
   (c) Determination of chlorine demand.
   (d) Determination of bicarbonate and carbonate alkalinity.
   (e) Find out the concentration of sulphite.

2. Measurement of organic pollutant in the water
   (a) Determination of Dissolved Oxygen (DO).
   (b) Determination of Biological Oxygen Demand (BOD).
   (c) Determination of Chemical Oxygen Demand (COD).

INSTRUMENTAL

1. Spectrophotometric/ Colorimetric determination
   (a) Determination of nitrite.
   (b) Determination of phosphate.
   (c) Determination of sulphide.

2. Conductometric determination
   (a) Determination of strength of alkali against standard acid.
   (b) Find out the strength of mixture of acids in an unknown mixture against N/10 NaOH.

3. pH metric determination
   (a) Determination of strength of alkali against standard acid.
   (b) Find out the strength of mixture of acids in an unknown mixture against N/10 NaOH.

4. Determination of oil and grease in water sample by gravimetric method.

EC – 305 and 306
3rd semester
Practical Examinations

M.M.: 100

One day 6-8 hrs. (Each course)
Two exercises to be given in examination

CLASSICAL

1. Determination of Organic Nitrogen.
2. Determine the saponification value of given oil sample.
3. Determination of Iodine Value in given oil sample.

INSTRUMENTAL

1.Spectrophotometric/ Colorimetric determination

(b) Find out the composition of binary mixture calorimetrically.
(c) Determination of nitrate.
(d) Determination of sulphide.
(e) Determination of copper.
(f) Determination of iron.
(g) Determination of Ammonnia Nitrogen.

2.Measurement of different parameters in soil

a)Determination of Ash.
b)Determination of moisture.
c)Faecal coliform test & Total coliform test.
d)NPK Value in soil.

3.Determination of sulphate by Turbidometric method.

4.Determination of Noise by Noisemeter.

5.Determination of adsorption isotherm of acetic acid from aqueous solution by using activated charcoal.