

**UG (B Sc) Curricular Framework, Department of Chemistry
HNB Garhwal University as per NEP 2020**

	Core Paper 6 credits each (4+2)	Additional Inter Disciplinary Paper 4 credit each (2+2)	SC* 2credits each
Semester I	A Core Paper I (Theory) (Code:SOS/CHEM/CT-001) Inorganic Chemistry -I Organic Chemistry- I (Practical): (Code: SOS/CHEM/CP-001)	Additional Inter- Disciplinary Paper-I (Theory) Code: SOS/CHEM/AID T-I AID-Inorganic Chemistry- I AID-Organic Chemistry- I Practical: Code SOS/CHEM/AID P-I	SC -I Code : SOS/CHEM/ SC-I Basic Analytical Chemistry I OR Green Methods in Chemistry
Semester II	Core Paper II (Theory) (Code:SOS/CHEM/CT-002) Physical Chemistry- I Organic Chemistry-II (Practical): (Code: SOS/CHEM/CP-002)	AID- Paper II (Theory) (Code: SOS/CHEM/AIDT-002) AID-Physical Chemistry- I AID-Organic Chemistry-II (Practical): (Code: SOS/CHEM/AIDP-002)	SC -II Code : SOS/CHEM/ SC-II Basic Analytical Chemistry II or Pesticidal Chemistry
Semester III	Core Paper III (Theory) (Code:SOS/CHEM/CT-003) Physical Chemistry-II Organic Chemistry-III (Practical): (Code: SOS/CHEM/CP-003)	AID-Paper III (Theory) (Code: SOS/CHEM/AIDT-003) AID-Physical Chemistry-II AID-Organic Chemistry-III (Practical): (Code: SOS/CHEM/AIDP-003)	SC -III Code : SOS/CHEM/ SC-III Basic Analytical Chemistry I OR Green Methods in Chemistry
Semester IV	Core Paper IV (Theory) (Code:SOS/CHEM/CT-004) Inorganic Chemistry-II Physical Chemistry- III (Practical): (Code: SOS/CHEM/CP-004)	AID Paper IV (Theory) (Code: SOS/CHEM/AIDT-004) AID-Inorganic Chemistry-II AID-Physical Chemistry- III (Practical): (Code: SOS/CHEM/AIDP-004)	SC -IV Code : SOS/CHEM/ SC-IV Basic Analytical Chemistry II or Pesticide Chemistry

*** Note: Students can opt skill course of chemistry either in 1st Year (1-2 Semester) or in 2nd year (3-4 semester)**

SYLLABUS OF H N B GARHWAL UNIVERSITY AS PER NEP-2020
PROGRAM: B Sc
SUBJECT: CHEMISTRY

1st Year (Semester I)

1. CORE PAPER – I

**Title of paper: Inorganic Chemistry –I,
Organic Chemistry- I (Theory)**

**(Atomic Structure, Bonding and General Organic
Chemistry)**

Code: (SOS/CHEM/CT-001)

Credits- 04

SYLLABUS:

Section A: Inorganic Chemistry-1(30 lectures)

Atomic Structure:

Review of: Bohr's theory and its limitations, dual behaviour of matter and radiation, de Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to Atomic structure.

Quantum mechanics, Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ and ψ^2 , Schrödinger equation for hydrogen atom. Radial and angular parts of the hydrogenic wave functions (atomic orbitals) and their variations for $1s$, $2s$, $2p$, $3s$, $3p$ and $3d$ orbitals (Only graphical representation). Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distance with special reference to $1s$ and $2s$ atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers m and m_s . Shapes of s , p and d atomic orbitals, nodal planes. Discovery of spin, spin quantum number (s) and magnetic spin quantum number (m_s).

Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.

Chemical Bonding and Molecular Structure (14 Lectures)

Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.

Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements. Concept of resonance and resonating structures in various inorganic and organic compounds.

MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for *s-s*, *s-p* and *p-p* combinations of atomic orbitals, nonbonding combination for orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of *s-p* mixing) and heteronuclear diatomic molecules such as CO, NO and NO⁺. Comparison of VB and MO approaches.

Section B: Organic Chemistry-1 (30 Periods)

Fundamentals of Organic Chemistry

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis. Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals. Strength of organic acids and bases: Comparative study with emphasis on factor affecting pK values. Aromaticity: Benzenoids and Huckel's rule.

Stereochemistry (8 lectures)

Conformations with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (upto two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). Threo and erythro; D and L; *cis-trans* nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and E/ Z Nomenclature (for upto two C=C systems).

Aliphatic Hydrocarbons (12 lectures)

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.

Alkanes: (Upto 5 Carbons). *Preparation:* Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. *Reactions:* Free radical Substitution: Halogenation.

Alkenes: (Upto 5 Carbons) *Preparation:* Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); *cis* alkenes (Partial catalytic hydrogenation) and *trans* alkenes (Birch reduction). *Reactions:* *cis*-addition (alk. KMnO₄) and *trans*-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymercuration-demercuration, Hydroboration-oxidation.

Alkynes: (Upto 5 Carbons) *Preparation:* Acetylene from CaC₂ and conversion into higher alkynes; by dehalogenation of tetrahalides and dehydrohalogenation of vicinal-dihalides.

Reactions: formation of metal acetylides, addition of bromine and alkaline KMnO₄, ozonolysis and oxidation with hot alk. KMnO₄.

ReferenceBooks:

Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.

Cotton, F.A., Wilkinson, G. & Gaus, P.L. *Basic Inorganic Chemistry*, 3rd ed., Wiley.

Douglas, B.E., McDaniel, D.H. & Alexander, J.J. *Concepts and Models in Inorganic Chemistry*, John Wiley & Sons.

Huheey, J.E., Keiter, E.A., Keiter, R.L. & Medhi, O.K. *Inorganic Chemistry: Principles of Structure and Reactivity*, Pearson Education India, 2006.

Graham Solomon, T.W., Fryhle, C.B. & Snyder, S.A. *Organic Chemistry*, John Wiley & Sons (2014).

McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.

Sykes, P. *A Guide book to Mechanism in Organic Chemistry*, Orient Longman, New Delhi (1988).

Eliel, E.L. *Stereochemistry of Carbon Compounds*, Tata McGraw Hill education, 2000.

Finar, I.L. *Organic Chemistry* (Vol. I & II), E.L.B.S.

Morrison, R.T. & Boyd, R.N. *Organic Chemistry*, Pearson, 2010.

Bahl, A. & Bahl, B. S. *Advanced Organic Chemistry*, S. Chand, 2010.

2. CORE PAPER – I

Title of paper: Inorganic Chemistry –I,
Organic Chemistry- I (Practical)
(Atomic Structure, Bonding and General Organic
Chemistry)
Code: (SOS/CHEM/CP-001)

Credits- 02

SYLLABUS:**Section A: Inorganic Chemistry-Volumetric Analysis**

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of oxalic acid by titrating it with KMnO_4 .
3. Estimation of water of crystallization in Mohr's salt by titrating with KMnO_4 .
4. Estimation of Fe(II) ions by titrating it with $\text{K}_2\text{Cr}_2\text{O}_7$ using internal indicator.
5. Estimation of Cu(II) ions iodometrically using $\text{Na}_2\text{S}_2\text{O}_3$.

Section B: Organic Chemistry

1. Detection of extra elements (N, S, Cl, Br, I) inorganic compounds (containing upto two extra elements)

2. Separation of mixtures by Chromatography: Measure the R_f value in each case (combination of two compounds to be given)

Identify and separate the components of a given mixture of 2 amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography.

Identify and separate the sugars present in the given mixture by paper chromatography.

ReferenceBooks:

- Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.
- Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.

- Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Text book of Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
 - Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman, 1960.
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3. ADDITIONAL INTER-DISCIPLINARY PAPER – I

Title of paper: Basic Inorganic Chemistry and Fundamentals of Organic Chemistry (Theory)

Code: (SOS/CHEM/AID T-001)

Credits- 02

SYLLABUS:

Basic Inorganic Chemistry

Atomic Structure

Review of Bohr's theory and its limitations, dual behaviour of matter and radiation, de Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Quantum numbers, significance of quantum numbers, shapes of s, p and d atomic orbitals. Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations

Chemical Bonding and Molecular Structure

Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Born-Haber cycle and its applications.

Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements.

Fundamentals of Organic Chemistry

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis. Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals.

4. ADDITIONAL INTER-DISCIPLINARY PAPER – I PRACTICAL

Title of paper: Basic Inorganic Chemistry and Fundamentals of Organic Chemistry (Practical)

Code: (SOS/CHEM/AID P-001)

Credits- 02

SYLLABUS:

Section A: Inorganic Chemistry-Volumetric Analysis

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of water of crystallization in Mohr's salt by titrating with KMnO_4 .

Section B: Organic Chemistry

1. Detection of extra elements (N,S,Cl,Br,I) inorganic compounds (containing upto two extra elements).

5A. SKILL (CHEMISTRY) PAPER – I

Title of paper: **BASIC ANALYTICAL CHEMISTRY- I**

Code: **(SOS/CHEM/SKILL -001)**

Credits- 02

SYLLABUS:

Introduction: Introduction to Analytical Chemistry and its inter disciplinary nature. Concept of sampling. Importance of accuracy, precision and sources of error in analytical measurements. Presentation of experimental data and results, from the point of view of significant figures.

Analysis of soil: Composition of soil, Concept of pH and pH measurement, Complexometric titrations, Chelation, Chelating agents, use of indicators.

Determination of pH of soil samples. Estimation of Calcium and Magnesium ions as Calcium carbonate by complexometric titration.

Analysis of water: Definition of pure water, sources responsible for contaminating water, water sampling methods, water purification methods.

Determination of pH, acidity and alkalinity of a water sample. Determination of dissolved oxygen (DO) of a water sample.

Analysis of food products: Nutritional value of foods, idea about food processing and food preservations and adulteration.

Identification of adulterants in some common food items like coffee powder, asafoetida, chilli powder, turmeric powder, coriander powder and pulses, etc. Analysis of preservatives and colouring matter.

OR

5B. SKILL (CHEMISTRY) PAPER – II

Title of paper: **GREEN METHODS IN CHEMISTRY**

Code: **(SOS/CHEM/SKILL -002)**

Credits- 02

SYLLABUS:

1. Introduction: Definitions of Green Chemistry.
2. Brief introduction of twelve principles of Green Chemistry with examples, special emphasis on atom economy, reducing toxicity, green solvents, Green Chemistry and catalysis and alternative sources of energy, Green energy and sustainability
3. The following Real world Cases in Green Chemistry should be discussed:
Surfactants for carbon dioxide–Replacing smog producing and ozone depleting solvents with CO₂ for precision cleaning and dry cleaning of garments.

4. Designing of environmentally safe marine antifoulant.
Rightfit pigment: Synthetic azo pigments to replace toxic organic and inorganic pigments.
An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn.

ReferenceBooks:

Anastas,P.T. & Warner, J.K. *Green Chemistry-Theory and Practical*, Oxford University Press (1998). Matlack, A.S. *Introduction to Green Chemistry*, Marcel Dekker (2001).

1st Year (Semester II)

1. CORE PAPER – II

Title of paper: Physical Chemistry- I, Organic Chemistry-II
(CHEMICAL ENERGETICS, EQUILIBRIA & FUNCTIONAL ORGANIC CHEMISTRY) (Theory)

Code: (SOS/CHEM/CT-002)

Credits- 04

Theory: 60Lectures

SYLLABUS:

Section A: Physical Chemistry-1 (30Lectures)

Chemical Energetics (10 Lectures)

Review of thermodynamics and the Laws of Thermodynamics.

Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of reaction with temperature– Kirchoff's equation.

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

Chemical Equilibrium:(8 lectures)

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between G and G^0 , Le Chatelier's principle. Relationships between K_p , K_c and K_x for reactions involving ideal gases.

Ionic Equilibria : (12 Lectures)

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

SectionB: Organic Chemistry-2 (30Lectures)

Functional group approach for the following reactions (preparations & reactions) to

be studied in context to their structure.

Aromatic hydrocarbons (8 Lectures)

Preparation (Casebenzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid.

Reactions: (Casebenzene): Electrophilic substitution: nitration, halogenations and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (upto 4 carbons on benzene). Side chain oxidation of alkyl benzenes (upto 4 carbons on benzene).

Alkyl and Aryl Halides (8 Lectures)

Alkyl Halides(Upto 5 Carbons) Types of Nucleophilic Substitution (SN1, SN2 and SNi) reactions.

Preparation: from alkenes and alcohols.

Reactions: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis: Elimination vs substitution.

Aryl Halides *Preparation*: (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions.

Reactions (*Chlorobenzene*): Aromatic nucleophilic substitution (replacement by -OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or $\text{NaNH}_2/\text{NH}_3$).

Reactivity and Relative strength of C- Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

Alcohols, Phenols and Ethers (Upto 5 Carbons) (14 Lectures)

Alcohols: *Preparation*: Preparation of 1^o, 2^o and 3^o alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters.

Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. KMnO_4 , acidic dichromate, conc. HNO_3). Oppeneauer oxidation *Diols*: (Upto 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement.

Phenols: (Phenol case) *Preparation*: Cumene hydroperoxide method, from diazonium salts. *Reactions*: Electrophilic substitution: Nitration, halogenations and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Houben-Hoesch Condensation, Schotten-Baumann Reaction.

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

Aldehydes and ketones (aliphatic and aromatic): (Formaldehyde, acetaldehyde, acetone and benzaldehyde)

Preparation: from acid chlorides and from nitriles.

Reactions- Reaction with HCN, ROH, NaHSO_3 , NH_2 -G derivatives. Iodoform test. Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation. Clemensen reduction and Wolff Kishner reduction. Meerwein-Ponndorf Verley reduction.

Reference Books:

- Graham Solomon, T.W., Fryhle, C.B. & Snyder, S.A. *Organic Chemistry*, John

Wiley & Sons(2014).

- McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
 - Sykes, P.A *Guide book to Mechanism in Organic Chemistry*, Orient Longman, NewDelh (1988).
 - Finar, I.L. *Organic Chemistry* (Vol.I & II), E.L.B.S.
 - Morrison, R.T. & Boyd, R.N. *Organic Chemistry*, Pearson, 2010.
 - Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry*, S. Chand, 2010.
 - Barrow, G.M. *Physical Chemistry* Tata McGraw-Hill (2007).
 - Castellan, G.W. *Physical Chemistry* 4th Ed. Narosa (2004).
 - Kotz, J.C., Treichel, P.M. & Townsend, J.R. *General Chemistry* Cengage Learning India Pvt. Ltd., NewDelhi (2009).
 - Mahan, B.H. *University Chemistry* 3rd Ed. Narosa (1998).
 - Petrucci, R.H. *General Chemistry* 5th Ed. Macmillan Publishing Co. :NewYork (1985).
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2. CORE PAPER – II Practical

Title of paper: **Physical Chemistry- I, Organic Chemistry-II
(CHEMICAL ENERGETICS, EQUILIBRIA & FUNCTIONAL
ORGANIC CHEMISTRY) (Practical)**

Code: **(SOS/CHEM/CP-002)**

Credits- 02

SYLLABUS:

Section A: Physical Chemistry

Thermochemistry

1. Determination of heat capacity of calorimeter for different volumes.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Determination of enthalpy of ionization of acetic acid.
4. Determination of integral enthalpy of solution of salts($\text{KNO}_3, \text{NH}_4\text{Cl}$).
5. Determination of enthalpy of hydration of copper sulphate.
6. Study of the solubility of benzoic acid in water and determination of H .

Ionic equilibria :

- a) Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter.
- b) Preparation of buffer solutions:
 - (i) Sodium acetate-acetic acid
 - (ii) Ammonium chloride-ammonium hydroxide

Measurement of the pH of buffer solutions and comparison of the values with theoretical values.

Section B: Organic Chemistry

1. Purification of organic compounds by crystallization (from water and alcohol) and distillation.
2. Criteria of Purity: Determination of melting and boiling points.

3. Preparations: Mechanism of various reactions involved to be discussed.
Recrystallisation, determination of melting point and calculation of quantitative yields to be done.

- (a) Bromination of Phenol /Aniline
- (b) Benzoylation of amines /phenols
- (c) Oxime and 2,4-dinitrophenyl hydrazone of aldehyde/ketone

Reference Books

- Vogel,A.I., Tatchell,A.R., Furnis,B.S., Hannaford,A.J. & Smith,P.W.G., *Text book of Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
 - Mann,F.G. & Saunders,B.C. *Practical Organic Chemistry* Orient-Longman,1960.
 - Khosla,B.D.; Garg,V.C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co. New Delhi(2011).
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3. ADDITIONAL INTER- DISCIPLINARY PAPER – II THEORY

Title of paper: CHEMICAL ENERGETICS & ORGANIC CHEMISTRY
(Theory)

Code: (SOS/CHEM/AID T-002)

Credits- 02

SYLLABUS:

Section A: Physical Chemistry-1

Chemical Energetics

Concept of thermodynamics and the Laws of Thermodynamics.

Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature–Kirchhoff's equation.

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

Section B: Organic Chemistry

Aliphatic Hydrocarbons:

Alkanes:(Upto 5 Carbons). Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent.

Reactions:Free radical Substitution:Halogenation.

Alkenes: (Upto5Carbons) Preparation: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); cisalkenes (Partial catalytic hydrogenation)and trans alkenes (Birch reduction). Reactions: cis-addition (alk. KMnO_4) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration-oxidation.

Alkynes: (Upto 5Carbons) Preparation, Reactions:formation of metal acetylides, addition of bromine and alkaline KMnO_4 ,ozonolysis and oxidation with hot alk. KMnO_4 .

4. ADDITIONAL INTERDISCIPLINARY PAPER – II PRACTICAL

Title of paper: CHEMICAL ENERGETICS & ORGANIC CHEMISTRY
(Practical)
Code: (SOS/CHEM/AID P-002)
Credits- 02

SYLLABUS:

Section :A Inorganic Chemistry

Qualitative analysis of inorganic mixtures: Not more than four ionic species (two anions and two cations).

Section :B Organic Chemistry :

Systematic Qualitative Organic Analysis of Organic Compounds possessing mono functional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.

5C. SKILL (CHEMISTRY) PAPER – III

Title of paper: BASIC ANALYTICAL CHEMISTRY- II
Code: (SOS/CHEM/SKILL-003)
Credits- 02

SYLLABUS:

Chromatography: Definition, general introduction on principles of chromatography, paper chromatography, TLC etc.

Paper chromatographic separation of mixture of metal ion (Fe^{3+} and Al^{3+}).

To compare paints samples by TLC method.

Ion-exchange: Column, ion-exchange chromatography etc.

Determination of ion exchange capacity of anion / cation exchangers in (using batch procedure if use of column is not feasible).

Analysis of cosmetics: Major and minor constituents and their function. Analysis of deodorants and antiperspirants, Al, Zn, boric acid, chloride, sulphate.

Determination of constituents of talcum powder: Magnesium oxide, Calcium oxide, Zinc oxide and Calcium carbonate by complexometric titration.

Reference Books:

Willard, H.H., Merritt, L.L., Dean, J. & Settoe, F.A. *Instrumental Methods of Analysis*. 7th Ed. Wadsworth Publishing Co. Ltd., Belmont, California, USA, 1988.

Skoog,D.A. Holler F.J.& Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning India Ed.

Skoog,D.A.; West,D.M. & Holler,F.J. *Fundamentals of Analytical Chemistry 6th Ed.*, Saunders College Publishing, FortWorth (1992).

Harris,D.C. *Quantitative Chemical Analysis*, W.H. Freeman. Dean , J.A. *Analytical Chemistry Note book*, McGraw Hill.

Day, R. A. & Underwood, A.L. *Quantitative Analysis*, Prentice Hall of India. Freifelder, D.

Physical Biochemistry 2nd Ed. ,W .H. Freeman and Co., N.Y.USA (1982). Cooper, T.G. *The Tools of Biochemistry*, John Wiley and Sons, N.Y.USA. 16 (1977).

Vogel,A.I. *Vogel's Qualitative Inorganic Analysis 7th Ed.*, Prentice Hall.

Robinson,J.W. *Undergraduate Instrumental Analysis 5th Ed.*, Marcel Dekker, Inc., New York (1995).

OR

5D: SKILL (CHEMISTRY) PAPER -IV

Title of paper: PESTICIDE CHEMISTRY
Code: (SOS/CHEM/SKILL-004)

Credits- 02

SYLLABUS:

General introduction to pesticides (natural and synthetic), Types : Insecticides, Herbicides, benefits and adverse effects, changing concepts of pesticides, structure activity relationship. Biopesticides, uses and future perspectives
Pesticidal poisoning, synthesis and technical manufacture and uses of representative pesticides in the following classes:
Organochlorines: Gammexene, Organophosphates(Malathion, Parathion, pyrethroids), Carbamates (Carbofuran and carbaryl); Quinones. Pheromones, repellents and rodenticides.

ReferenceBook:

Cremllyn, R. *Pesticides. Preparation and Modes of Action*, John Wiley & Sons, NewYork,1978

2ND Year (Semester III)

1. CORE PAPER – III (Theory)

Title of paper: Physical Chemistry-II, Organic Chemistry-III
**(SOLUTIONS, PHASE EQUILIBRIUM, CONDUCTANCE,
ELECTROCHEMISTRY & FUNCTIONAL GROUP ORGANIC
CHEMISTRY-II) (Theory)**

Code: (SOS/CHEM/CT-003)

Credits- 04

SYLLABUS:

Section A: Physical Chemistry (30 Lectures)

Solutions (8 Lectures)

Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law- non- ideal solutions. Vapour pressure- composition and temperature-composition curves of ideal and non ideal solutions. Distillation of solutions. Lever rule. Azeotropes. Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids. Immiscibility of liquids Principle of steam distillation. Nernst distribution law and its applications, solvent extraction.

Phase Equilibrium (8 Lectures)

Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule and its thermodynamic derivation. Derivation of Clausius Clapeyron equation and its importance in phase equilibria. Phase diagrams of one-component systems (water and sulphur) and two component systems involving eutectics, congruent and incongruent melting points(lead-silver, FeCl₃-H₂O and Na-K only).

Conductance

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

Electrochemistry (6 Lectures)

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

Calculation of equilibrium constant from EMF data. Concentration cells with transference and without transference. Liquid junction potential and salt bridge. pH determination using hydrogen electrode and quinhydrone electrode.

Potentiometric titrations –qualitative treatment(acid-base and oxidation-reduction only).

Section B: Organic Chemistry-3(30Lectures)

Functional group approach for the following reactions(preparations& reactions) to be studied in context to their structure.

Carboxylic acids and their derivatives

Carboxylic acids (aliphatic and aromatic) *Preparation:* Acidic and Alkaline hydrolysis of esters. *Reactions:* Hell–Vohlard-Zelinsky Reaction.

Carboxylic acid derivatives (aliphatic): (Upto 5 carbons) (6 Lectures)

Preparation: Acid chlorides, Anhydrides, Esters and Amides from acids and their interconversion. *Reactions:*Comparative study of nucleophilicity of acyl derivatives. Reformatsky Reaction, Perkin condensation.

Amines and Diazonium Salts (6 Lectures)

Amines (Aliphatic and Aromatic):(Upto5carbons)

Preparation: from alkylhalides, Gabriel’s Phthalimide synthesis, Hofmann Bromamide reaction.

Reactions: Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO_2 , Schotten –Baumann Reaction. Electrophilic substitution (caseaniline): nitration, bromination, sulphonation.

Diazoniumsalts: *Preparation:* from aromatic amines. *Reactions:* conversion to benzene, phenol, dyes.

Amino Acids, Peptides and Proteins (10 Lectures)

Preparation of AminoAcids: Strecker synthesis using Gabriel’s phthalimide synthesis. Zwitterion, Isoelectric point and Electrophoresis.

Reactions of Amino acids: ester of $-\text{COOH}$ group, acetylation of $-\text{NH}_2$ group, complexation with Cu^{2+} ions, ninhydrin test.

Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins.

Determination of Primary structure of Peptides by degradation Edmann degradation (N-terminal) and C-terminal (thiohydantoin and with carboxypeptidase enzyme).

Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid-phase synthesis.

Carbohydrates (8 Lectures)

Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides. Structure of disacharrides (sucrose, cellobiose, maltose, lactose) and polysacharrides (starch and cellulose) excluding their structure elucidation.

ReferenceBooks:

- Barrow, G.M. *Physical Chemistry* Tata McGraw-Hill (2007).

- Castellan, G.W. *Physical Chemistry* 4th Ed. Narosa(2004).
 - Kotz, J.C., Treichel, P.M. & Townsend, J.R. *General Chemistry*, Cengage Learning India Pvt. Ltd. :NewDelhi (2009).
 - Mahan, B.H. *University Chemistry*, 3rd Ed. Narosa (1998).
 - Petrucci, R.H. *General Chemistry*, 5th Ed., Macmillan Publishing Co. :NewYork(1985).
 - Morrison, R. T. & Boyd, R.N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
 - Finar, I.L. *Organic Chemistry (Volume 1)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
 - Finar, I.L. *Organic Chemistry (Volume 2)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
 - Nelson, D.L. & Cox, M.M. *Lehninger's Principles of Biochemistry* 7th Ed., W.H. Freeman.
 - Berg, J.M., Tymoczko, J.L. & Stryer, L. *Biochemistry*, W.H. Freeman, 2002.
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4. **Title of paper:** Physical Chemistry-II, Organic Chemistry-III
**(SOLUTIONS, PHASE EQUILIBRIUM, CONDUCTANCE,
 ELECTROCHEMISTRY & FUNCTIONAL GROUP ORGANIC
 CHEMISTRY-II) (Practical)**

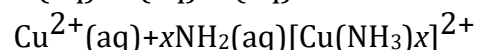
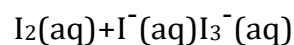
Code: (SOS/CHEM/CP-003)

SYLLABUS:

Section A: Physical Chemistry

Distribution

Study of the equilibrium of one of the following reactions by the distribution method:



Phase equilibria

- Construction of the phase diagram of a binary system (simple eutectic) using cooling curves.
- Determination of the critical solution temperature and composition of the phenol water system and study of the effect of impurities on it.
- Study of the variation of mutual solubility temperature with concentration for the phenol water system and determination of the critical solubility temperature.

Conductance

- Determination of cell constant
- Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
- Perform the following conductometric titrations:
 - Strong acid vs. strong base
 - Weak acid vs. strong base

Potentiometry

Perform the following potentiometric titrations:

- Strong acid vs. strong base
- Weak acid vs. strong base
- Potassium dichromate vs. Mohr's salt

SectionB: Organic Chemistry

I Systematic Qualitative Organic Analysis of Organic Compounds possess in mono functional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.

II

1. Separation of amino acids by paper chromatography
2. Determination of the concentration of glycine solution by formylation method.
3. Titration curve of glycine
4. Action of salivary amylase on starch
5. Effect of temperature on the action of salivary amylase on starch.
6. Differentiation between a reducing and a non reducing sugar.

ReferenceBooks:

- Vogel,A.I., Tatchell,A.R., Furnis,B.S., Hannaford,A.J. & Smith,P.W.G., *Text book of Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
 - Mann,F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman,1960.
 - Khosla,B. D. ;Garg,V.C. & Gulati,A. *Senior Practical Physical Chemistry*, R. Chand & Co.: NewDelhi (2011).
 - Ahluwalia,V.K. & Aggarwal,R. *Comprehensive Practical Organic Chemistry*, Universities Press.
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3. AID PAPER – III (Theory)

Title of paper: Chemical Equilibrium and Aromatic Hydrocarbon (Theory)

Code: (SOS/CHEM/AID T-003)

Credits- 04

SYLLABUS:

Section A: Physical Chemistry-1

Chemical Equilibrium:

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between G and G^0 , LeChatelier's principle. Relationships between K_p , K_c and K_x for reactions involving ideal gases.

Ionic Equilibria:

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

Section :B Organic Chemistry

Aromatic hydrocarbons

Preparation (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid.

Reactions: (Case benzene): Electrophilic substitution: nitration, halogenations and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (upto 4 carbons on benzene). Side chain oxidation of alkylbenzenes (upto 4 carbons on benzene).

4. AID PAPER – III (Practical)

Title of paper: **Chemical Equilibrium and Aromatic Hydrocarbon
(Practical)**

Code: **(SOS/CHEM/AID P-003)**

Credits- 02

SYLLABUS:

Physical Chemistry

Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.

Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer.

Organic Chemistry :

1. Determination of melting and boiling points.
 2. Preparation of :
 - (a) m- di- nitrobenzene from benzene
 - (b) p- nitro acetanilide from acetanilide
-

References

Cann,M.C. & Connely,M.E. *Real-World casesin Green Chemistry*, American Chemical Society, Washington (2000).

Ryan,M.A. & Tinnesand,M. *Introduction to Green Chemistry*, American Chemical Society, Washington (2002).

Sharma,R.K.; Sidhwani,I.T. & Chaudhari,M.K. *Green Chemistry Experiments: A monograph* I.K.I nternational Publishing House Pvt Ltd. New Delhi, Bangalore.

Lancaster, M. *Green Chemistry: An introductory text* RSC publishing, 2nd Edition.

Sidhwani,I.T., Saini,G., Chowdhury,S., Garg,D.,Malovika, Garg,N. Wealth from waste: A green method to produce biodiesel from waste cooking oil and generation of useful products from Waste further generated "A Social Awareness Project", *Delhi University Journal of Undergraduate Research and Innovation*, **1(1)**: 2015.

2ND Year (Semester IV)

1. CORE PAPER – IV (Theory)

Title of paper: Inorganic Chemistry-II, Physical Chemistry- III
(COORDINATION CHEMISTRY, STATES OF MATTER &
CHEMICAL KINETICS) (Theory)

Code: (SOS/CHEM/CT-004)

Credits- 04

SYLLABUS:

Theory: 60 Lectures

Transition Elements (3dseries) (12 Lectures)

General group trends with special reference to electronic configuration, Variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states (Latimer diagrams) for Mn, Fe and Cu. Lanthanoids and actinoids: Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only).

Coordination Chemistry (8 Lectures)

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

Drawbacks of VBT. IUPAC system of nomenclature.

Crystal Field Theory (10 Lectures)

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

Section B: Physical Chemistry-3 (30 Lectures)

Kinetic Theory of Gases (8 Lectures)

Postulates of Kinetic Theory of Gases and derivation of the kinetic equation. Deviation of real gases from ideal behaviour, compressibility factor, causes of deviation. Vander Waals equation of state for real gases. Boyle temperature (derivation not required). Critical phenomena, critical constants and their calculation from vander Waals equation. Andrews isotherms of CO_2 .

Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation–derivation not required) and their importance.

Temperature dependence of these distributions. Most probable, average and root mean square velocities (no derivation). Collision cross section, collision number, collision frequency, collision diameter and mean free path of molecules. Viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only).

Liquids (6 Lectures)

Surface tension and its determination using stalagmometer. Viscosity of a liquid and determination of coefficient of viscosity using Ostwald viscometer. Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only).

Solids (8 Lectures)

Forms of solids. Symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of Crystallography - Law of constancy of interfacial angles, Law of rational indices. Miller indices. X-Ray diffraction by crystals, Bragg's law. Structures of NaCl, KCl and CsCl (qualitative treatment only). Defects in crystals. Glasses and liquid crystals.

Chemical Kinetics (8 Lectures)

The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants). Half-life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation.

Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Comparison of the two theories(qualitative treatment only).

Reference Books:

- Barrow, G.M. *Physical Chemistry* Tata McGraw-Hill (2007).
 - Castellan, G.W. *Physical Chemistry* 4th Ed. Narosa (2004).
 - Kotz, J.C., Treichel, P.M. & Townsend, J.R. *General Chemistry* Cengage Learning India Pvt. Ltd., New Delhi (2009).
 - Mahan, B.H. *University Chemistry* 3rd Ed. Narosa (1998).
 - Petrucci, R.H. *General Chemistry* 5th Ed. Macmillan Publishing Co.: New York (1985).
 - Cotton, F.A. & Wilkinson, G. *Basic Inorganic Chemistry*, Wiley.
 - Shriver, D.F. & Atkins, P.W. *Inorganic Chemistry*, Oxford University Press.
 - Wulfsberg, G. *Inorganic Chemistry*, Viva Books Pvt. Ltd.
 - Rodgers, G.E. *Inorganic & Solid State Chemistry*, Cengage Learning India Ltd. ,2008.
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2. CORE PAPER – IV (Practical)

Title of paper: Inorganic Chemistry-II, Physical Chemistry- III
COORDINATION CHEMISTRY, STATES OF MATTER &
CHEMICAL KINETICS (Practical)

Code: (SOS/CHEM/CP-004)

Credits- 02

SYLLABUS:

Section A: Inorganic Chemistry

Semi- micro qualitative analysis using H₂S of mixtures-not more than four ionic species (two anions and two cations and excluding insoluble salts) out of the following:

Cations: NH₄⁺, Pb²⁺, Ag⁺, Bi³⁺, Cu²⁺, Cd²⁺, Sn²⁺, Fe³⁺, Al³⁺, Co²⁺, Cr³⁺, Ni²⁺, Mn²⁺, Zn²⁺, Ba²⁺, Sr²⁺, Ca²⁺, K⁺

Anions: CO₃²⁻, S²⁻, SO₄²⁻, S₂O₃²⁻, NO₃⁻, CH₃COO⁻, Cl⁻, Br⁻, I⁻, NO₂⁻, SO₃²⁻, PO₄³⁻, BO₃³⁻, C₂O₄²⁻, F⁻.

(Spot tests should be carried out wherever feasible)

1. Estimate the amount of nickel present in a given solution as bis(dimethylglyoximate)nickel (II) or aluminium as oximate in a given solution gravimetrically.
2. Draw calibration curve (absorbance at λ_{\max} vs. concentration) for various concentrations of a given coloured compound (KMnO₄/ CuSO₄) and estimate the concentration of the same in a given solution.
3. Determine the composition of the Fe³⁺-salicylic acid complex solution by Job's method.
4. Estimation of (i) Mg²⁺ or (ii) Zn²⁺ by complexometric titrations using EDTA.
5. Estimation of total hardness of a given sample of water by complexometric titration.
6. Determination of concentration of Na⁺ and K⁺ using Flame Photometry.

Section B: Physical Chemistry

- (I) Surface tension measurement (use of organic solvents excluded).
 - a) Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.
 - b) Study of the variation of surface tension of a detergent solution with concentration.
- (II) Viscosity measurement (use of organic solvents excluded).
 - a) Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer.
 - b) Study of the variation of viscosity of an aqueous solution with concentration of solute.

(III) Chemical Kinetics

Study the kinetics of the following reactions.

1. Initial rate method: Iodide-persulphate reaction
2. Integrated rate method:
 - a. Acid hydrolysis of methyl acetate with hydrochloric acid.
 - b. Saponification of ethylacetate.
 - c. Compare the strengths of HCl and H₂SO₄ by studying kinetics of hydrolysis of methylacetate.

Reference Books:

- Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.
 - Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.
 - Khosla, B.D.; Garg, V.C. & Gulati, A. *Senior Practical Physical Chemistry*, R.Chand & Co.: New Delhi (2011).
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3. AID PAPER –IV (Theory)

Title of paper: Physical and Inorganic Chemistry (Solutions, S and P block Elements) (Theory)

Code: (SOS/CHEM/AID T-004)

Credits- 02

SYLLABUS:

Section A: Physical Chemistry

Solutions

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

Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids. Immiscibility of liquids Principle of steam distillation. Nernst distribution law and its applications, solvent extraction.

Section B: Inorganic chemistry

Chemistry of S and P blocks elements:

General characteristics, anomalous behavior, diagonal relationship and role of sodium and potassium ions in biological systems. Oxides of boron, allotropic forms of carbon, carbides, silicates and fertilizers.

Fullerenes and poly halides.

4. **AID PAPER –IV (Practical)**

Title of paper: Physical and Inorganic Chemistry (Solutions, S and P
block Elements) (Practical)

Code: (SOS/CHEM/AID P-004)

Credits- 02

SYLLABUS:

Physical Chemistry

Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoo stop revent damage to the glass electrode) using pH-meter.

Organic Chemistry

1. Separation of amino acids by paper chromatography.
 2. Differentiation between a reducing and a nonreducing sugar.
 3. Determination of COD /BOD and DO of water samples.
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Skill (Chemistry)

Note: Skill paper of 1st semester and 3rd semester (Basic Analytical Chemistry I OR Green Methods in Chemistry) and skill of 2nd semester and 4th semester (Basic Analytical Chemistry II or Pesticidal Chemistry) will be the same