



**BSc Hons**  
(Chemical Science)  
Degree Programme

# CURRICULUM

Academic Year 2026/2027





# **Institute of Chemistry Ceylon**

## **BSc Hons (Chemical Science) Degree Programme**

# **CURRICULUM**

Academic Year 2026/2027



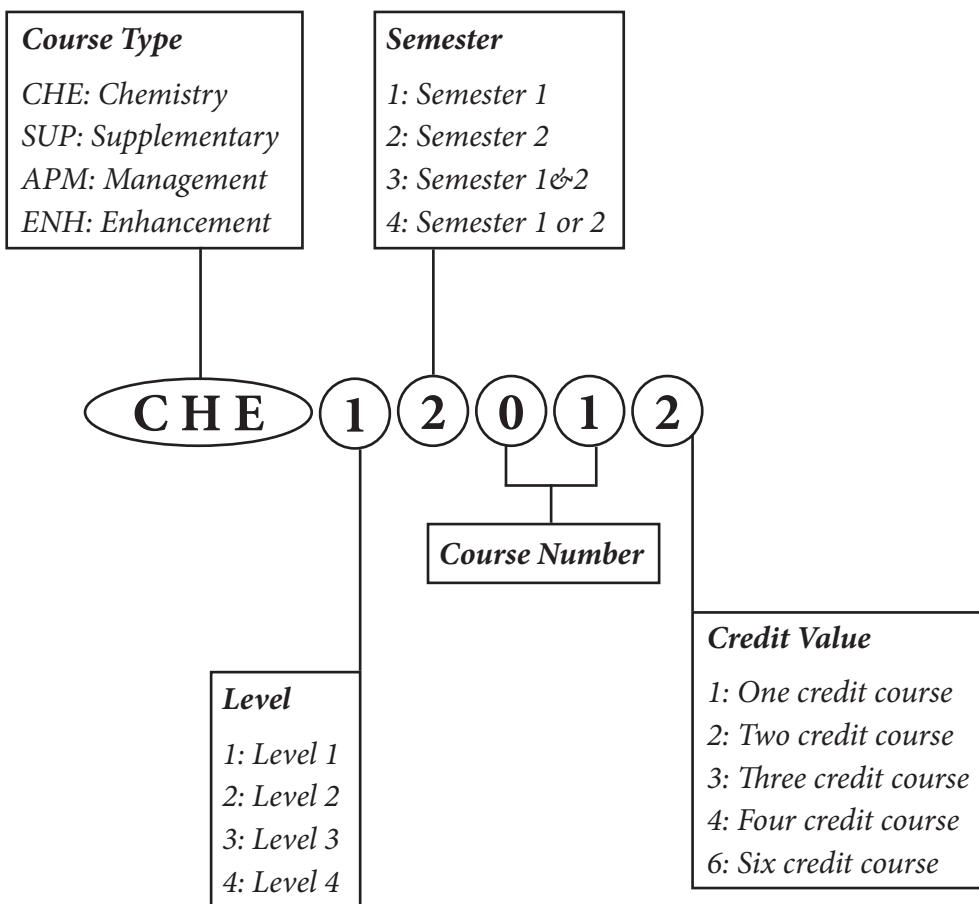
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## BSc Hons Course Code Description

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## BSc Hons Course Contents

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### Orientation Programme

#### *Enhancement*

ENH 11101	Biology for Physical Science Students* or
ENH 11111	Mathematics for Biological Science Students*
ENH 11122	General English and Effective Communication

[*Note: \*Students who have faced GCE A/L or London A/L in the physical science stream are required to complete ENH 11101 (Biology for Physical Science Students) and students who have faced GCE A/L or London A/L in the bioscience stream are required to complete ENH 11111 (Basic Mathematics)*].

### Level 1

#### Semester 1

##### *Chemistry*

CHE 11012	Principles of Chemistry
CHE 11022	Organic Chemistry- I
CHE 11032	Chemistry of Main Group and <i>d- &amp; f</i> - Block Elements
CHE 11041	Classical Methods in Chemical Analysis- I
CHE 11051	Fundamentals of Biochemistry-I
CHE 11061	Elementary Chemistry Laboratory

##### *Management*

APM 11072	Principles of Management
APM 11082	Optimization Methods in Management Science

##### *Supplementary*

SUP 11092	Statistics for Chemistry
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##### *Enhancement*

ENH 11131	Basic Mathematics for Chemistry
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**Total Credits : 15**

**Enhancement Credits : 01**

#### Semester 2

##### *Chemistry*

CHE 12012	Concepts in Inorganic Chemistry-I
CHE 12022	Principles of Physical Chemistry-I

CHE 12031	Fundamentals of Biochemistry-II
CHE 12042	Organic Chemistry-II
CHE 12051	Classical Methods in Chemical Analysis-II
CHE 12061	Analytical Chemistry Laboratory

*Management*

APM 12072	Introduction to Industrial Economics
APM 12082	Accounting Concepts and Costing

*Supplementary*

SUP 12092	Physics and Basic Electronics for Chemists
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**Total Credits : 15****Level 2****Semester 1***Chemistry*

CHE 21012	Organic Synthesis and Spectroscopy
CHE 21022	Principles of Physical Chemistry-II
CHE 21032	Separation Methods and Atomic Spectroscopy
CHE 21041	Organic Chemistry Laboratory

*Management*

APM 21052	Principles of Human Resource Management and Leadership
APM 21062	Marketing Management
APM 21072	Total Quality Management

*Supplementary*

SUP 21081	Mathematics for Chemistry I
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**Total Credits : 14****Semester 2***Chemistry*

CHE 22012	Concepts in Inorganic Chemistry-II
CHE 22022	Heterocyclic Chemistry and Natural Products
CHE 22032	Principles of Physical Chemistry-III
CHE 22041	Introduction to Metabolisms in Biochemistry
CHE 22052	Environmental Chemistry
CHE 22061	Green Chemistry
CHE 22071	Physical Chemistry Laboratory

*Management*

APM 22082	Computer Based Tools for Management
APM 22092	Operations Management

*Supplementary*

SUP 22101	Mathematics for Chemistry II
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*Enhancement*

ENH 22111	English for Scientific Writing
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***Compulsory Credits* : 16**

***Enhancement Credits* : 01**

**Level 3****Semester 1***Chemistry*

CHE 31012	Advanced Topics in Inorganic Chemistry-I
CHE 31022	Physical Organic Chemistry, Pericyclic Reactions and Advanced Natural Products Chemistry
CHE 31032	Quantum Chemistry and Molecular Spectroscopy
CHE 31042	Electroanalytical Chemistry and Optical Spectroscopy
CHE 31052	Polymer Chemistry
CHE 31062	Advanced Physical Chemistry Laboratory
CHE 31071	Advanced Biochemistry-I
CHE 31081	Advanced Inorganic Chemistry Laboratory
CHE 31091	Industrial Analytical & Environmental Chemistry Laboratory

***Total Credits* : 15**

**Semester 2***Chemistry*

CHE 32012	Advanced Synthetic Organic Chemistry
CHE 32021	Supramolecular Chemistry
CHE 32033	Seminar Presentations and Essays
CHE 32042	Advanced Coordination Chemistry
CHE 32052	Advanced Topics in Physical Chemistry-I
CHE 32062	Advanced Chromatography
CHE 32072	Advanced Organic Chemistry Laboratory
CHE 32081	Biochemistry Laboratory

*Enhancement*

ENH 32091	Industrial Training
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**Compulsory Credits : 15**

**Enhancement Credits : 01**

## Level 4

### Semester 1

#### *Chemistry*

CHE 43016	Research Project
CHE 41012	Special Topics in Inorganic Chemistry
CHE 41022	Advanced Topics in Physical Chemistry-II
CHE 41032	Advanced Spectroscopic Techniques and Photochemistry
CHE 41042	Molecular Modeling and Molecular Simulations (T + P)
CHE 41051	Advanced Biochemistry-II
CHE 41062	Material Science
CHE 41072	Generative AI for Chemistry and Chemical Industry

#### *Management*

APM 41082	Innovation and New Product Development
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**Total Credits : 15**

### Semester 2

#### *Chemistry*

CHE 43016	Research Project (continuation)
CHE 42022	Chemical and Process Engineering for Chemical Industry
CHE 42051	Mineral Resources and Processing

#### *Management*

APM 42032	Project Management
APM 42042	Professional Practices

**Compulsory Credits : 13**

**Elective Credits : 02**

## Level 4 - Elective Courses

#### *Elective*

CHE 42062	Chemical Education
CHE 42072	Pharmaceutical Chemistry
CHE 42082	Food Chemistry & Technology

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## Course Summary

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<b>BSc (Hons)</b>									
Level	1		2		3		4		Total
Semester	1	2	1	2	1	2	1	2	
Chemistry compulsory	9	9	7	11	15	15	13	9	<b>88</b>
Chemistry elective	0	0	0	0	0	0	0	2	<b>2</b>
Supplementary	2	2	2	0	0	0	0	0	<b>6</b>
Management	4	4	6	4	0	0	2	4	<b>24</b>
Enhancement	4	0	0	1	0	1	0	0	<b>6</b>
Total GPA credits	15	15	15	15	15	15	15	15	<b>120</b>
Total credits per year	30		30		30		30		
Total non GPA credits	4	0	0	1	0	1	0	0	<b>6</b>

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# LEVEL 1

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## CHE 11012 - Principles of Chemistry

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|                                        |                                                                                     |                  |                             |                                |
|----------------------------------------|-------------------------------------------------------------------------------------|------------------|-----------------------------|--------------------------------|
| <b>Course Unit Code</b>                | CHE 11012                                                                           |                  |                             |                                |
| <b>Course Unit Name</b>                | Principles of Chemistry                                                             |                  |                             |                                |
| <b>Credit value</b>                    | 2                                                                                   |                  |                             |                                |
| <b>Compulsory/Elective/Enhancement</b> | Compulsory                                                                          |                  |                             |                                |
| <b>Prerequisites</b>                   | GCE A/L Chemistry or an equivalent                                                  |                  |                             |                                |
| <b>Hourly breakdown</b>                | <b>Theory</b>                                                                       | <b>Practical</b> | <b>Independent learning</b> | <b>Notional learning hours</b> |
|                                        | 30                                                                                  | -                | -                           | 100                            |
| <b>Objective of the Course Unit</b>    | to provide the basic knowledge in atomic structure and concepts of chemical bonding |                  |                             |                                |
| <b>Evaluation Method</b>               | Continuous Assessments 30%                                                          |                  | Final Assessment 70%        |                                |

### Intended Learning Outcomes (ILO)

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

- ILO 1: apply quantum theory of radiation and basic wave mechanics to explain the atomic structure
- ILO 2: compare properties of quarks with those of leptons
- ILO 3: determine the electrical charge of a proton, neutron and mesons based on the quark structure
- ILO 4: apply conservation laws to predict whether a given particle decay process would occur or not;
- ILO 5: apply Valance Shell Electron Pair Repulsion Theory, Valance Bond Theory and Molecular Orbital Theory to explain bonding/geometry/magnetic properties of molecules;
- ILO 6: explain energetics of ionic solids
- ILO 7: identify the intermolecular forces present between molecules.

### Course Content

#### 1. Quantum theory and atomic structure (6 h)

Evolution of Atomic Theory: Early Greek Theories, Dalton's Atomic Model, Thomson's Cathode Ray Tube Experiment and Rutherford's Gold Foil Experiment.

The quantum theory of radiation: Wave nature of light, Planck's Postulate of Quantization, photoelectric effect; Wave mechanics: Wave-particle duality of matter, de Broglie equation, Introduction to the Heisenberg Uncertainty Principle.

Bohr Theory: The Bohr Theory of the hydrogen atom, Bohr radius, hydrogen spectrum

and origin of the line spectrum, application of Bohr Theory to hydrogen like systems, Rydberg's Empirical Formula.

Quantum numbers: quantum numbers and atomic orbitals, electron spin and Pauli Exclusion Principle, orbital shapes and energies.

## 2. Subatomic particles and nuclear properties (6 h)

Subatomic particles: Examples for subatomic particles; introduction to fundamental particles, composite particles, fermions & bosons; flavors and properties of quarks and leptons; color confinement; force carrier particles; introduction to the Standard model, particles and antiparticles.

Atomic nucleus: Fundamental forces and their properties; role of fundamental forces and force carrier particles; introduction to hadrons, baryons and mesons; determination of the electric charge of a proton, neutron and mesons based on their quark structure

Conservation Laws and Particle decay: Introduction to Lepton numbers, baryon number and strangeness number, conservation laws for charge, lepton number, baryon number, strangeness number and energy; application of conservation laws to predict whether a given particle decay process would occur or not,  $\beta$ -decay at quark level, Higgs bosons, dark matter

## 3. Chemical bonding (18 h)

Slater rules.

Basic concepts: Lewis Symbols; Types of chemical bonds (ionic, covalent, metallic), properties of covalent bonds (energy and length); octet rule, exceptions to octet rule; definition for electronegativity (Pauli, Muliken, Allred and Rochow), bond polarity and dipole moment, net molecular dipole moment and examples ( $\text{NH}_3$ ,  $\text{NF}_3$ ,  $\text{NCS}^-$  etc.); polarization of ions and Fajan's rules; rules to draw Lewis structure, resonance structures and resonance hybrids of neutral polyatomic molecules (e.g.  $\text{N}_2\text{O}$ ) and polyatomic ions (e.g.  $\text{SO}_4^{2-}$ )

Shapes of molecules and ions: VSEPR Theory: Application of the VSEPR theory to predict shapes of neutral molecules  $\text{EX}_n$  (e.g.  $\text{BF}_3$ ) and  $\text{EmX}_n$  (e.g.  $\text{N}_2\text{O}$ ), ions  $[\text{E}_m]^-$  (e.g.  $\text{N}^{3-}$ ),  $[\text{E}_m\text{X}_n]^{p+/}$  (e.g.  $\text{SO}_4^{2-}$ ) and hetero-polyatomic ions such as  $\text{NCS}^-$ ; effect of lone pairs on bond angles and the shape of the molecule/ion ( $\text{NH}_3$ ,  $\text{NO}_3^-$  etc.)

Theories of covalent bonding

- Valence Bond Theory (VBT): Introduction; hybridization of atomic orbitals and corresponding molecular shapes; application of VBT for homonuclear diatomic molecules (e.g.  $\text{H}_2$ ), heteronuclear polyatomic molecules  $\text{AX}_n$  (e.g.  $\text{CH}_4$ ) and heteronuclear polyatomic ions having multiple bonding (e.g.  $\text{NO}_3^-$ )
- Molecular Orbital Theory: LCAO method (s-s, s-p, p-p, p-d, and d-d)

combinations of atomic orbitals); molecular orbital energy level diagrams for homonuclear diatomic molecules (e.g.  $H_2$ ), hetero-diatomc molecules (e.g. CO) and polyatomic molecules/ions with  $\sigma$  bonding only (e.g.  $BeCl_2$ ) and  $\sigma$  and delocalized  $\pi$ - bonding (e.g.  $NO_2^-$ ,  $O_3$ ); Molecular orbital energy level diagram of organic molecules/ions (e.g. ethylene, acetylene, allyl ion, butadiene, cyclobutadiene, cyclopentadienyl anion, benzene, 1,3,5-hexatriene, and formaldehyde), Prediction of bond order and magnetism of molecules/ions based on molecular orbital energy level diagrams.

Energetics of ionic solids: Lattice energy, estimation of lattice energy by electrostatic model, Madelung constant, Born exponent, Born–Landé equation and Born- Mayers equation; estimation of lattice energy by Born-Haber cycle; calculated versus experimental lattice energy, energetics of the dissolution of an ionic salt.

Intermolecular forces

- Types of intermolecular forces: Ion-dipole, dipole-dipole, ion-induced dipole, dipole-induced dipole, hydrogen bonding, and instantaneous dipole-induced dipole.
- Effect of intermolecular forces on properties of liquids: e.g. Surface tension, capillarity and viscosity.

### Methods of Teaching and Learning

A combination of lectures, tutorial discussions, small group discussions and computer assisted learning.

### Recommended Readings

- Housecroft, C. E.; Sharpe, A. G.. (2012), Inorganic chemistry, 4<sup>th</sup> Edition, Pearson.
- Brown, T. E.; LeMay, E. H.,; Bursten, B. E.; Murphy C. (2017). Chemistry: The Central Science, 14<sup>th</sup> Edition, Pearson.
- Lee, J. D. (2006). Concise Inorganic Chemistry, 5<sup>th</sup> Edition, Blackwell science,
- Pfennig, B.W. (2021). Principles of Inorganic Chemistry, 2<sup>nd</sup> Edition, John Wiley & sons.
- Zumdahl, S. S.; Zumdahl S.A. (2009), Chemistry, 9<sup>th</sup> Edition, Houghton Mifflin Company,
- Atkins, P.W.; Overton, T.L.; Rourke, J. P.; Weller, M. T.; Armstrong, F. (2010). Shriver & Atkins Inorganic Chemistry, 5<sup>th</sup> Edition, W. H. Freeman and Company, New York.
- McMurry J. I.,; Fay R. C. (2020). Chemistry, 8<sup>th</sup> Edition Pearson.
- Ebbing D. D; Gammon, S. D. (2016). General Chemistry, 11<sup>th</sup> Edition, CENGAGE Learning

## CHE 11022 - Organic Chemistry I

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|  |   |                  |                             |                                |
|--|---|------------------|-----------------------------|--------------------------------|
| <b>Course Unit Code</b>                | CHE 11022   |                  |                             |                                |
| <b>Course Unit Name</b>                | Organic Chemistry I   |                  |                             |                                |
| <b>Credit value</b>                    | 2   |                  |                             |                                |
| <b>Compulsory/Elective/Enhancement</b> | Compulsory  |                  |                             |                                |
| <b>Prerequisites</b>                   | None  |                  |                             |                                |
| <b>Hourly breakdown</b>                | <b>Theory</b>   | <b>Practical</b> | <b>Independent learning</b> | <b>Notional learning hours</b> |
|  | 30  | -                | -                           | 100                            |
| <b>Objective of the Course Unit</b>    | To introduce basic principles and reaction in Organic Chemistry |                  |                             |                                |
| <b>Evaluation Method</b>               | Continuous Assessments 30%                                      |                  | Final Assessment 70%        |                                |

### Intended Learning Outcomes (ILO)

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

ILO 1: differentiate between stereo isomers as well as conformational isomers

ILO 2: compose the structure of an organic molecule based on the IUPAC nomenclature and vice versa

ILO 3: correlate reaction mechanisms with bonding aspects of the functional group and propose synthetic pathways for conversion of functional groups of aliphatic and aromatic compounds

### Course Content

#### 1. Structure, nomenclature and stereochemistry of organic compounds (10 h)

Basic concepts in organic chemistry: Resonance, IUPAC nomenclature of organic compounds, hybrid atomic orbitals, bond polarity, intermolecular forces.

Isomerism: Geometrical (E and Z) and optical (R and S) isomerism, optical activity, enantiomers, diastereomers, meso compounds, chiral compounds without asymmetric atoms, Fisher projections, Newman projection, conformational isomers of acyclic and cyclic compounds, structural isomerism, stereoisomerism.

#### 2. Chemistry of Alkanes Alkenes, Alkynes Alkyl halides and Alcohols, ether and epoxides (12 h)

Structure and reactivity of alkanes, alkenes, alkynes, alkyl halides, alcohols, ethers, epoxides.

Alkanes: Substitution reactions (free radical mechanism)

Alkenes: Synthesis, reactions (electrophilic addition, oxidation) and mechanisms

Alkynes: Synthesis, reactions (hydroboration/oxidation, reduction) and mechanisms

Alkyl halides: Synthesis, reactions and mechanisms ( $S_N2$ ,  $S_N1$ , E2 and E1)

Alcohols: Synthesis, reactions (reduction, oxidation) and mechanisms. Ethers and

Epoxides: Synthesis, reactions and mechanisms.

### 3. Chemistry of Carbonyl Compounds (8 h)

Carbonyl Compounds: Nucleophilic addition reactions (including Wittig reaction). Nucleophilic addition followed by Elimination of water (derivatives of carbonyl compounds). Reactions at the  $\alpha$ -carbon (Aldol condensation and related reactions, Iodoform reaction)

#### Methods of Teaching and Learning

A combination of lectures, tutorial discussions, small group discussions and computer assisted learning.

#### Recommended Readings

- Solomons, T. W. G.; Fryhle, C. B.; Snyder, S. A. (2013). Organic Chemistry, 11<sup>th</sup> Edition, John Wiley.
- McMurry, J. E. (2011). Organic Chemistry, 8<sup>th</sup> Edition, Brooks Cole.
- Wade Jr, L. G. (2012). Organic Chemistry, 8<sup>th</sup> Edition, Pearson.
- Bruice, P. Y. (2013). Organic Chemistry, 7<sup>th</sup> Edition, Prentice Hall.
- Ebbing D. D.; Gammon, S. D. (2016). General Chemistry, 11<sup>th</sup> Edition, CENGAGE Learning,

**CHE 11032 -**  
**Chemistry of Main Group and *d* & *f* block elements**

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|                                        |                                                                                                      |                  |                             |                                |
|----------------------------------------|------------------------------------------------------------------------------------------------------|------------------|-----------------------------|--------------------------------|
| <b>Course Unit Code</b>                | CHE 11032                                                                                            |                  |                             |                                |
| <b>Course Unit Name</b>                | Chemistry of Main Group and <i>d</i> & <i>f</i> block elements                                       |                  |                             |                                |
| <b>Credit value</b>                    | 2                                                                                                    |                  |                             |                                |
| <b>Compulsory/Elective/Enhancement</b> | Compulsory                                                                                           |                  |                             |                                |
| <b>Prerequisites</b>                   | None                                                                                                 |                  |                             |                                |
| <b>Hourly breakdown</b>                | <b>Theory</b>                                                                                        | <b>Practical</b> | <b>Independent learning</b> | <b>Notional learning hours</b> |
|                                        | 30                                                                                                   | -                | 15                          | 100                            |
| <b>Objective of the Course Unit</b>    | to provide the basic knowledge in chemistry of Main Group and <i>d</i> - & <i>f</i> -block elements. |                  |                             |                                |
| <b>Evaluation Method</b>               | Continuous Assessments 30%                                                                           |                  | Final Assessment 70%        |                                |

### Intended Learning Outcomes (ILO)

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

- ILO 1: discuss chemistry of main group elements
- ILO 2: explain 3-centre 2-electron bonding
- ILO 3: compare chemistry of the first element of a main group with the rest of the elements in the same group
- ILO 4: describe possible uses of main group elements and their compounds
- ILO 5: discuss colour and magnetic properties of transition elements
- ILO 6: compare chemistry of lanthanides with actinides
- ILO 7: describe reasons for lanthanide contraction.

### Course Content

#### 1. Chemistry of Main Group Elements (13 h)

##### Modern periodic table and periodicity

Introduction to modern periodic table, periodicity in atomic properties and other properties of the main group elements, introduction to diagonal relationship

##### Chemistry of *s*-block elements

Occurrence; electronic configuration of the valance shell, trends in important physical and chemical properties of the elements and some selected compounds down their respective groups, anomalous properties of Li and Be, diagonal relationship, uses; Hydrogen - properties of hydrogen, classification of hydrides, Protonic concept of acids and bases

(Bronsted – Lowry concept)

### **Chemistry of *p*-block elements**

Occurrence; electronic configuration of the valence shell of Group 13 to 18, common oxidation states and valence, General features of *p*-block elements, (gases/liquids/solids; nonmetals/metalloids/metals, allotropes, *d*-block contraction, inert pair effect etc.), trends in physical (atomic/ionic radius, IE, EA, EN, MPts etc.) and chemical properties (catenation, ionic/covalent nature,  $p\pi$ - $p\pi$  and  $p\pi$ - $d\pi$  bonding, consequences of inert pair effect, electron deficiency in Group 13, hydrolysis of covalent compounds) of the elements and some selected compounds, acidity of hydrides and oxoacids etc.

### **Chemistry of some selected elements, Boron and Silicon**

Hydrides, electron deficiency in  $BH_3$  and  $B_2H_6$ , 3-center 2 electron bonding in  $B_2H_6$ , boron trihalides: Lewis acid property and  $\pi$ -bonding; borates, silicates and silicones; hydrolysis of halides and  $B_2H_6$ ,  $H_3BO_3$ , structures of silicon complex ions having higher coordination numbers, B-N compounds, diagonal relationship between B and Al, uses.

### **Nitrogen and phosphorus**

Bonding in  $N_2$  and  $P_4$ , Oxides of N and P, P-N compounds, Liquid  $NH_3$  as a non-aqueous solvent, Anomalous properties of N, uses

### **Oxygen and sulfur**

Bonding in dioxygen, acidic/basic/amphoteric/neutral oxides, Anomalous properties of O, structure of S compounds having higher coordination numbers, uses

### **Halogens**

Trends in bond dissociation enthalpy of  $X_2$ , standard reduction potentials and oxidizing power of halogens, acidity of aqueous solutions of HX, halogen oxides, interhalogen compounds, Anomalous properties of fluorine, uses

### **Noble Gases**

Properties of noble gases, structure and bonding in fluorides, oxides and oxofluorides of xenon, uses

## **2. Chemistry of *d*-block Elements (10 h)**

*d*-block elements vs. Transition metals

### **First row transition elements**

Properties, Electron configurations, Ionization energies, atomic radii of  $3d$ ,  $4d$ , and  $5d$  transition elements, Melting points, Electronegativity

### **Bond character**

The relationship between electronegativity and oxidation states, the effect of electronegativity on acidic/basic properties

### **General characteristics of transition elements**

Variable oxidation states, Redox potentials, Introduction to color and magnetic properties

of their compounds, Catalytic properties of transition elements, Coordination number and molecular geometries of compounds of transition elements, Kepert model

### 3. Chemistry of *f*-block elements (7 h)

Chemistry of Lanthanides, Electron configurations of lanthanides, Various oxidation states of lanthanides, Lanthanide contraction, Consequences of lanthanide contraction, Colors of lanthanide complexes, Magnetic properties of lanthanide complexes, Separation of lanthanides

Chemistry of Actinides, Properties of actinides, Electron configuration of actinides, Various oxidation states of actinides, Actinide contraction, Consequences of actinide contraction, Colors of actinide complexes. Magnetic properties of actinides

### Methods of Teaching and Learning

A combination of lectures, tutorial discussions, small group discussions and computer assisted learning.

### Recommended Readings

- Housecroft, C. E.; Sharpe, A. G.. (2012), Inorganic chemistry, 4<sup>th</sup> Edition, Pearson.
- Brown, T. E.; LeMay, E. H.; Bursten, B. E.; Murphy C. (2017). Chemistry: The Central Science, 14<sup>th</sup> Edition, Pearson.
- Lee, J. D. (2006). Concise Inorganic Chemistry, 5<sup>th</sup> Edition, Blackwell science.
- Atkins, P.W.; Overton, T.L.; Rourke, J. P.; Weller, M. T.; Armstrong, F. (2010). Shriver & Atkins Inorganic Chemistry, 5<sup>th</sup> Edition, W. H. Freeman and Company, New York.
- Norman, N. C. (1995). Periodicity & the p-block elements, Oxford University Press.

## CHE 11041 - Classical Methods in Chemical Analysis I

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|   |  |                  |                             |                                |
|---|--|------------------|-----------------------------|--------------------------------|
| <b>Course Unit Code</b>                     | CHE 11041  |                  |                             |                                |
| <b>Course Unit Name</b>                     | Classical Methods in Chemical Analysis I   |                  |                             |                                |
| <b>Credit value</b>                         | 1  |                  |                             |                                |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory   |                  |                             |                                |
| <b>Prerequisites</b>                        | None   |                  |                             |                                |
| <b>Hourly breakdown</b>                     | <b>Theory</b>  | <b>Practical</b> | <b>Independent learning</b> | <b>Notional learning hours</b> |
|   | 15   | -                | -                           | 50                             |
| <b>Objective of the Course Unit</b>         | To provide a comprehensive understanding of neutralization titrimetry and gravimetry |                  |                             |                                |
| <b>Evaluation Method</b>                    | Continuous Assessments 30%   |                  | Final Assessment 70%        |                                |

### Intended Learning Outcomes (ILO)

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

- ILO 1: apply appropriate principles to determine concentrations of unknown acids, bases, or mixtures of acids/bases using titration data, considering both mono- and polyprotic species
- ILO 2: construct titration curves for various scenarios, including titrations involving strong acids and bases, weak acids and bases, polyprotic acids and bases, mixtures of acids or bases and titrations involving salt hydrolysis
- ILO 3: select acid-base indicators for specific titrations based on the expected pH range and the nature of the titrants involved.
- ILO 4: apply conditional solubility product concepts in cation analysis
- ILO 5: assess the properties of a good precipitate to select appropriate gravimetric methods for specific analytical scenarios.

### Course Content

#### 1. Introduction to chemical analysis (1 h)

Overview of analytical chemistry and chemical analysis: Qualitative and quantitative analysis; Classical and Instrumental analysis; Different analytical methods used in analysis. Introduction to accuracy and precision in quantitative analysis.

#### 2. Neutralization titrations (8 h)

Criteria for the reaction used in titration; Principles of neutralization titrations: primary and secondary standards, neutralization titrations (strong, weak and poly functional acids,

hydrolysis of salts), titration curves, theory of indicators; Buffer solutions: Henderson–Hasselbach equation, buffer capacity and buffer value for a buffer system, preparation of buffer solutions.

### 3. Precipitation methods of analysis (6 h)

Solubility products in qualitative analysis: Conditional solubility product; solubility product applications in cation analysis; Gravimetric methods of analysis: basic principles, Von Weimarn's precipitation theory, common ion effect, properties of a good precipitate, applications of gravimetry; Contamination of a precipitate, precipitation from homogeneous solution (PFHS), post-precipitation, minimizing of post-precipitations, simple applications of volatilization gravimetry.

### Methods of Teaching and Learning

A combination of lectures, tutorials, peer assisted student support (PASS) sessions and small group discussions.

### Recommended Readings

- Skoog, D. A.; West, D. M.; Holler, F. J.; Crouch, S. R., Fundamentals of Analytical Chemistry. Cengage Learning: 2013.
- Day, Underwood, Quantitative Analysis. Prentice Hall PTR: 1991.
- Harris, D. C.; Lucy, C. A., Quantitative Chemical Analysis. WH Freeman: 2018.

## CHE 11051 - Fundamentals of Biochemistry I

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|                                             |                                                                                                                                                                                                                                                                                                                   |                                 |                                 |                                    |
|---------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 11051                                                                                                                                                                                                                                                                                                         |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Fundamentals of Biochemistry I                                                                                                                                                                                                                                                                                    |                                 |                                 |                                    |
| <b>Credit value</b>                         | 1                                                                                                                                                                                                                                                                                                                 |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory                                                                                                                                                                                                                                                                                                        |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | E/ENH 11101 or GCE/AL Biological Science                                                                                                                                                                                                                                                                          |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>                                                                                                                                                                                                                                                                                                     | <b>Practical /<br/>Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|                                             | 15                                                                                                                                                                                                                                                                                                                | 2                               | -                               | 50                                 |
| <b>Objective of the<br/>Course Unit</b>     | To provide the students with a basic understanding of the molecular architecture of cells and the associated biomolecules, the fundamental processes that maintain a viable cellular environment conducive for life and the protein catalysts that facilitate the molecular interactions that make life possible. |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Continuous Assessments 30%                                                                                                                                                                                                                                                                                        |                                 | Final Assessment 70%            |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: Explain the concept of pH, buffer concepts, calculations and its applications in biological systems
- ILO 2: Describe the important biomolecules found in the human body and their significance.
- ILO 3: Describe the structure of biological membranes and their function.
- ILO 4: Describe the principles of enzyme, isoenzymes, types of enzyme inhibition and their catalytic action and applications.

### Course Content

#### 1. pH & Buffers. (3 h)

Principle of pH, biological range, calculation & importance for life. Buffers, calculation of pH & their action. Buffering systems present in organisms.

#### 2. Biomolecules, Structure & functions. (5 h)

Carbohydrates – structure & functions, Lipids & functions, Proteins & functions. Prion proteins & their significance.

#### 3. Cell membrane. (3 h)

Basic structure of the biological membrane. Molecular components of membranes. Role

of Cholesterol in membrane. Methods of Transport of material across membranes.

#### **4. Enzymology. (4 h)**

Enzymes, classification and nomenclature. Enzyme catalysis and basic Kinetics. Enzyme inhibitions & relevance to regulation of Metabolisms in living organisms. Isoenzymes & why they are there in living systems. Diagnostic, analytical and Industrial applications.

#### **Methods of Teaching and Learning**

A combination of lectures, tutorials, small group discussions and computer assisted learning.

#### **Recommended Readings**

- Abali, E. E.; Cline, S. D.; Franklin, D. S.; Viselli, S. M. Lippincott® Illustrated Reviews: Biochemistry; Lippincott Williams & Wilkins, 2024.

## CHE 11061 - Elementary Chemistry Laboratory

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|   |   |                  |                             |                                |
|---|---|------------------|-----------------------------|--------------------------------|
| <b>Course Unit Code</b>                     | CHE 11061   |                  |                             |                                |
| <b>Course Unit Name</b>                     | Elementary Chemistry Laboratory                       |                  |                             |                                |
| <b>Credit value</b>                         | 1   |                  |                             |                                |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory  |                  |                             |                                |
| <b>Prerequisites</b>                        | Laboratory safety workshop, Fire safety workshop      |                  |                             |                                |
| <b>Hourly breakdown</b>                     | <b>Theory</b>   | <b>Practical</b> | <b>Independent learning</b> | <b>Notional learning hours</b> |
|   | -   | 45               | -                           | 50                             |
| <b>Objective of the Course Unit</b>         | To provide fundamental skills in chemistry laboratory |                  |                             |                                |
| <b>Evaluation Method</b>                    | Attendance 10 %                                       |                  | Lab Reports 10%             |                                |
|   | Mid-term Assessment 20%                               |                  | Final Assessment 60%        |                                |

### Intended Learning Outcomes (ILO)

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

- ILO 1: develop fundamental laboratory skills
- ILO 2: practice correct techniques in performing titrations
- ILO 3: illustrate solubilities and reactions of 's', 'p' and 'd' block elements
- ILO 4: apply the knowledge in neutralization titration in quantitative analysis of samples.
- ILO 5: determine the buffer capacity
- ILO 6: identify the functional groups present in an organic compound using simple tests

### Course Content

#### 1. Elementary chemistry Practice (9 h)

Separation of an inorganic mixture.

#### 2. Chemistry of 's', 'p' and 'd' block elements (9 h)

Solubility of 's' and 'p' block elements, solubility of 'd' block elements, semi micro qualitative analysis of anions and cations.

#### 3. Neutralization titrations (27 h)

Calibration of volumetric glassware; strong acid vs strong base titrations with different indicators; strong acid vs weak base titrations; weak acid vs strong base titrations; titrations of polyprotic acids, titrations of acid mixtures, titrations of carbonate/ bicarbonate and carbonate/ hydroxide mixtures with acids.

### **Methods of Teaching and Learning**

A combination of lab lectures, practical sessions.

### **Recommended Readings**

- Svehla, G. (1996). Vogel's Qualitative Inorganic Analysis, 7th Edition, Prentice Hall.
- Skoog, D. A.; West, D. M.; Holler, F. J.; Crouch, S. R. (2013). Fundamentals of Analytical Chemistry, 9th Edition, Cengage Learning.
- Vogel A.I.; Tatchell A.R.; Furnis B.S.; Hannaford A.J.; Smith P.W.G. (1996). Vogel's Textbook of Practical Organic Chemistry, 5th Edition, Prentice Hall.
- Moting, J.R.; Mofrill, T.C.; Hammond, C.N.; Neckers, D.C. (1999). Experimental Organic Chemistry, Freeman.

## APM 11072 - Principles of Management

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|----------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|-----------------------------|--------------------------------|
| <b>Course Unit Code</b>                | APM 11072                                                                                                                                                                                    |                  |                             |                                |
| <b>Course Unit Name</b>                | Principles of Management                                                                                                                                                                     |                  |                             |                                |
| <b>Credit value</b>                    | 2                                                                                                                                                                                            |                  |                             |                                |
| <b>Compulsory/Elective/Enhancement</b> | Compulsory                                                                                                                                                                                   |                  |                             |                                |
| <b>Prerequisites</b>                   | None                                                                                                                                                                                         |                  |                             |                                |
| <b>Hourly breakdown</b>                | <b>Theory</b>                                                                                                                                                                                | <b>Practical</b> | <b>Independent learning</b> | <b>Notional learning hours</b> |
|                                        | 30                                                                                                                                                                                           | -                | -                           | 100                            |
| <b>Objective of the Course Unit</b>    | To provide students with a foundational understanding of the basic principles of management, including organizational structure, culture, behavior, and the evolution of management thought. |                  |                             |                                |
| <b>Evaluation Method</b>               | Final Assessment 100%                                                                                                                                                                        |                  |                             |                                |

### Intended Learning Outcomes (ILO)

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

- ILO 1: demonstrate understanding of different historical perspectives in management and organization studies;
- ILO 2: demonstrate understanding of the characteristics of contemporary organizations and the different approaches to organizational structure and design;
- ILO 3: demonstrate understanding of the fundamentals of individual, team and group behavior;
- ILO 4: analyze the process of organizational learning, adapting, and change.

### Course Content

#### 1. Organizations and evolution of management thought (4 h)

Concept of organizations, key characteristics and purposes, evolution of management thought.

#### 2. Organizational structure and the environment (14 h)

Organizational structure and design, organization and environment, managerial process: planning, strategic decision making and controlling.

#### 3. Organizational culture (12 h)

Drivers of individual behavior and group/team behavior. Generational diversity in the workplace with focus on Millennials and Gen Z. Organizational culture, learning, and processes of organizational change.

### **Methods of Teaching and Learning**

A combination of lectures, in-class discussions, real world case studies and self-study.

### **Recommended Readings**

- Robbins, S P, DeCenzo, D A and Coulter, M (2015), Fundamentals of Management- Essential Concepts and Applications, Prentice Hall, New Jersey.
- Certo, S (2014), Modern Management, Prentice Hall, Delhi.
- Robbins, SP, and Judge, TA (2010), Organizational Behaviour, Prentice Hall, New Jersey

## APM 11082 - Optimization Methods in Management Science

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|   |  |                                 |                                 |                                    |
|---|--|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | APM 11082  |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Optimization Methods in Management Science   |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2  |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory   |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | None   |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>  | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|   | 30   | -                               | -                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | To equip students with the knowledge and skills to model, analyze, and solve business problems using optimization methods and relevant software tools, enabling effective and informed managerial decision-making. |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Final Assessment 100%  |                                 |                                 |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: identify and analyze business problems and formulate business decision problems as mathematical models and lay out as spreadsheet models;
- ILO 2: apply appropriate quantitative techniques and perform sensitivity analysis in managerial decision-making;
- ILO 3: identify and use software to solve complicated problems;
- ILO 4: communicate the analysis and results of business decision problems.

### Course Content

#### 1. Operations research and linear programming (12 h)

Introduction to operations research, linear programming (LP), problem formulation, algebraic representation, solving LP problems, applications of LP.

#### 2. Performance measurement and resource optimization (15 h)

Data envelopment analysis for performance measurements, evaluation, assignment problem, network modules.

#### 3. Project scheduling (9 h)

Project scheduling with known and uncertain activity times, time and cost trade-offs.

#### 4. Decision analysis and data relationships (9 h)

Decision analysis, correlation analysis and simple linear regression.

#### Methods of Teaching and Learning

A combination of lectures and computer assisted learning.

#### Recommended Readings

- Anderson, D R, Williams, T A and Sweeney, S J (2011), An Introduction to Management Science: Quantitative Approaches to Decision Making, 13<sup>th</sup> Edition, South Western College Pub.
- Fedrick, S. Hiller, G. Lieberman, B. Nag (2014), Introduction to operations research, McGraw-Hill Professional, 9<sup>th</sup> Edition, McGraw Hill Education (India) Pvt. Ltd.
- Kenneth R. Baker (2015) Optimization Modeling with Spread sheets, 3<sup>rd</sup> Edition, Thomson learning academic Resource center.

## SUP 11092 - Statistics for Chemistry

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|----------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|-----------------------------|--------------------------------|
| <b>Course Unit Code</b>                | SUP 11092                                                                                                                                                              |                             |                             |                                |
| <b>Course Unit Name</b>                | Statistics for Chemistry                                                                                                                                               |                             |                             |                                |
| <b>Credit value</b>                    | 2                                                                                                                                                                      |                             |                             |                                |
| <b>Compulsory/Elective/Enhancement</b> | Compulsory                                                                                                                                                             |                             |                             |                                |
| <b>Prerequisites</b>                   | None                                                                                                                                                                   |                             |                             |                                |
| <b>Hourly breakdown</b>                | <b>Theory</b>                                                                                                                                                          | <b>Practical / Tutorial</b> | <b>Independent learning</b> | <b>Notional learning hours</b> |
|                                        | 15                                                                                                                                                                     | 30                          | -                           | 100                            |
| <b>Objective of the Course Unit</b>    | To enhance students critical thinking and decision-making skills and provide solid foundation in statistical methods necessary for conducting and evaluating research. |                             |                             |                                |
| <b>Evaluation Method</b>               | Final Assessment 100%                                                                                                                                                  |                             |                             |                                |

### Intended Learning Outcomes (ILO)

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

- ILO 1: Explain fundamental statistical concepts and terms used in data analysis, including discrete and continuous variables.
- ILO 2: Apply probability and hypothesis testing techniques to analyze experimental data.
- ILO 3: Compute and interpret measures of central tendency, dispersion, and variability, including skewness and kurtosis in frequency distributions.
- ILO 4: Compare different statistical measures and assess relationships between variables.
- ILO 5: Conduct inferential statistical tests, including t-tests, ANOVA, and regression analysis.
- ILO 6: Use statistical software for data analysis, visualization, and interpretation.
- ILO 7: Implement experimental design principles and understand different sources of variability, including independent and dependent variables

### Course Content

#### 1. Introduction to Statistics (Theory: 2 h; Practical: 4 h)

Importance of statistics in scientific research. Descriptive vs. inferential statistics. Data types and measurement scales (nominal, ordinal, interval, ratio)

Sampling methods and sampling error. Discrete and continuous variables.

#### 2. Descriptive Statistics (Theory: 1 h; Practical: 2 h)

Measures of central tendency (mean, median, mode), Measures of dispersion (variance, standard deviation, range, IQR), Skewness and kurtosis in frequency distributions, Data

visualization: histograms, box plots, scatter plots, bar charts.

**3. Probability and Hypothesis Testing (Theory: 2 h; Practical: 4 h)**

Probability theory, conditional probability, Bayes' theorem, Null and alternative hypotheses, significance levels, and p-values, Type I and Type II errors, power of a test, Confidence intervals and their interpretation.

**4. Comparison of Means and Variability (Theory: 2 h; Practical: 4 h)**

Z-tests, t-tests (one-sample, independent, paired t-test), Q-test and Grubbs test for outlier detection, Analysis of Variance (ANOVA: one-way, two-way, repeated measures), Relationship between ANOVA, regression, and correlation.

**5. Regression and Correlation Analysis (Theory: 2 h; Practical: 4 h)**

Simple linear regression, correlation coefficients, Multiple regression models, least squares method, Polynomial, exponential, and logistic regression models.

**6. Categorical Data Analysis (Theory: 2 h; Practical: 4 h)**

Chi-square tests for independence, Odds ratio and risk ratio analysis, Logistic regression for categorical data.

**7. Statistical Software and Applications (Theory: 2 h; Practical: 4 h)**

Introduction to statistical software, Data input, cleaning, and basic analysis. Interpretation of statistical outputs and visualization techniques.

**8. Spreadsheet Applications in Statistical Analysis (Theory: 2 h; Practical: 4 h)**

Data processing, visualization, and analysis using spreadsheets, Curve fitting, trend analysis, and error estimation, Automating calculations with spreadsheet functions.

**Methods of Teaching and Learning**

A combination of lectures, tutorials, small group discussions and computer assisted learning.

**Recommended Readings**

- Agarwal, B. L. (2006). Basic Statistics. New Age International.
- Box, G. E. P., Hunter, J. S., & Hunter, W. G. (2005). Statistics for Experimenters: Design, Innovation, and Discovery (2<sup>nd</sup> ed.). Wiley.
- Cronk, B. C. (2020). How to Use SPSS®: A Step-By-Step Guide to Analysis and Interpretation (11<sup>th</sup> ed.). Routledge. ISBN: 978-0367175144.
- Harris, D. C. (2007). Quantitative Chemical Analysis. W.H. Freeman and Company.
- Moore, D. S., McCabe, G. P., & Craig, B. A. (2017). Introduction to the Practice of Statistics (9<sup>th</sup> ed.). W.H. Freeman and Company. ISBN: 978-1319013387.
- Witte, R. S., & Witte, J. S. (2017). Statistics (11<sup>th</sup> ed.). Wiley. ISBN: 978-1119455385.

## ENH 11101 - Biology for Physical Science Students

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|---|---|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | ENH 11101   |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Biology for Physical Science Students   |                                 |                                 |                                    |
| <b>Credit value</b>                         | 1   |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Enhancement; Compulsory for Physical Science Students   |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | none  |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>   | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|   | 15  | -                               | -                               | 50                                 |
| <b>Objective of the<br/>Course Unit</b>     | Understanding the structure and function of cells is fundamental to the study of biology and life sciences. This course is designed to provide students with a strong foundation in cellular biology, enabling them to comprehend the complexity of living organisms, their biological processes, and genetic principles. |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Continuous Assessments  |                                 |                                 |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: explain the structure of cells in living organisms.
- ILO 2: identify basic features of cells in plants, animals and microorganisms.
- ILO 3: describe the structure and functions of cellular organisms;
- ILO 4: explain the biological processes occurring in an animal and plant cell;
- ILO 5: explain the principles involved inheritance and fundamentals of molecular human genetics

### Course Content

#### 1. The cell (2 h)

Structure of the cell. Comparison of prokaryotic and eukaryotic cells, plant and animal cells. Structure and function of cellular organelles: Nucleus, cell membrane, cytoplasm, endoplasmic reticulum, ribosome, lysosome, mitochondria, cell wall, vacuole, chloroplast.

#### 2. Cell division (2 h)

Karyotypes: Haploid and diploid cells. Cell cycle. Mitosis and meiosis. Microscopic view of different stages of cell division.

#### 3. Important microorganisms (2 h)

Classification of bacteria. Basic characteristics of viruses.

**4. Biological processes (2 h)**

Human biological processes, biological samples for analysis. Plant biological processes: Transport-xylem and phloem, gaseous exchange

**5. Molecular basis of inheritance (3 h)**

DNA and RNA. Protein synthesis.

**6. Genetics (4 h)**

Mendel's laws. Chromosomal basis of inheritance. Mutations. Genetics that deviate from Mendel's laws: Incomplete dominance, co-dominance, polyallelism, gene interaction, polygenic inheritance, gene linkage. Human genetic disorders.

**Methods of Teaching and Learning**

A combination of lectures, tutorials, small group discussions and computer assisted learning.

**Recommended Readings**

- Molecular Biology of the Cell – Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P.
- Essential Cell Biology – Alberts, B., Bray, D., Hopkin, K., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P.
- Genetics: A Conceptual Approach – Pierce, B. A.

## ENH 11111 - Mathematics for Biological Science Students

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|----------------------------------------|-----------------------------------------------------------------------------------|-----------------------------|-----------------------------|--------------------------------|
| <b>Course Unit Code</b>                | ENH 11111                                                                         |                             |                             |                                |
| <b>Course Unit Name</b>                | Mathematics for Biological Science Students                                       |                             |                             |                                |
| <b>Credit value</b>                    | 1                                                                                 |                             |                             |                                |
| <b>Compulsory/Elective/Enhancement</b> | Enhancement; Compulsory for Biological Science students.                          |                             |                             |                                |
| <b>Prerequisites</b>                   | None                                                                              |                             |                             |                                |
| <b>Hourly breakdown</b>                | <b>Theory</b>                                                                     | <b>Practical / Tutorial</b> | <b>Independent learning</b> | <b>Notional learning hours</b> |
|                                        | 15                                                                                | -                           | -                           | 50                             |
| <b>Objective of the Course Unit</b>    | To provide basic knowledge in mathematics required to follow courses in chemistry |                             |                             |                                |
| <b>Evaluation Method</b>               | Continuous Assessments                                                            |                             |                             |                                |

### Intended Learning Outcomes (ILO)

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

- ILO 1: apply the basic mathematical concepts of numbers in solving problems in chemistry  
 ILO 2: solve problems in chemistry using the basic knowledge of algebra and trigonometry  
 ILO 3: draw graphs of various functions

### Course Content

#### 1. Numbers (3 h)

Real numbers, integers, prime numbers, rational and irrational numbers, complex numbers, laws of indices, logarithms, laws and properties of logarithms, natural logarithm and logarithmic functions, relationship between logarithms and exponential terms, permutations and combinations, factorials

#### 2. Basic algebra (4 h)

Expressions and terms, products, factors and quotients, simplification, expansion, types of equations, simple (first degree), quadratic (second degree), simultaneous, formulae, variables/constants; Solving of equations.

#### 3. Functions (2h)

Variables, functions with one and more than one variable, linear and nonlinear functions, exponential functions, partial fractions, infinity, binomial theorem, polynomials

**4. Graphs (2h)**

Equations of straight line and circle, relationships between Cartesian and polar coordinates, tangents to a curve

**5. Basic trigonometry (2h)**

Pythagoras theorem, definition from coordinates, signs of trigonometric functions, important trigonometric formulae, deriving of trigonometric formulae

**6. Problem Solving (2h)**

Solving chemistry-based problems combining above key concepts

**Methods of teaching and learning**

Interactive lectures, tutorial discussions, student-centered small group discussions and think-pair-share activities

**Recommended readings**

- Hanifa, M. R. M. (2009). Mathematics for Chemistry and Biology Students (PSE3117), Open University of Sri Lanka publication
- Ball, H and Pearce C (2018) Pure Mathematics 1,2 & 3 Collins (UK)

## ENH 11122 - General English and Effective Communication

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|   |   |                  |                             |                                |
|---|---|------------------|-----------------------------|--------------------------------|
| <b>Course Unit Code</b>                     | ENH 11122   |                  |                             |                                |
| <b>Course Unit Name</b>                     | General English and Effective Communication   |                  |                             |                                |
| <b>Credit value</b>                         | 2   |                  |                             |                                |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Enhancement; Compulsory   |                  |                             |                                |
| <b>Prerequisites</b>                        | None  |                  |                             |                                |
| <b>Hourly breakdown</b>                     | <b>Theory</b>   | <b>Practical</b> | <b>Independent learning</b> | <b>Notional learning hours</b> |
|   | 15  | 30               | -                           | 100                            |
| <b>Objective of the Course Unit</b>         | To enhance students' English language proficiency and communicative competency in English |                  |                             |                                |
| <b>Evaluation Method</b>                    | Continuous Assessments  |                  |                             |                                |

### Intended Learning Outcomes (ILO)

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

- ILO 1: Demonstrate improved proficiency in reading, writing, speaking, and listening in English, with an expanded vocabulary and more accurate use of grammar.
- ILO 2: Apply principles of effective communication in various contexts, including interpersonal, group, and professional settings, ensuring clarity, coherence, and engagement.
- ILO 3: Analyze and construct well-reasoned arguments in both spoken and written forms, using evidence and logical reasoning to support your ideas.
- ILO 4: Deliver confident and persuasive oral presentations, using appropriate language, tone, and non-verbal communication to engage and inform an audience.
- ILO 5: Produce clear, coherent, and structured written texts for a range of purposes, including reports, essays, emails, and formal correspondence.

### Course Content

#### 1. Language Proficiency Essentials (Theory:2 h; Practical: 4 h)

Vocabulary expansion strategies, grammar fundamentals and common errors, reading comprehension techniques, vocabulary quizzes and flashcard exercises, grammar correction drills and sentence restructuring, reading comprehension exercises with diverse text types

#### 2. Advanced Listening and Speaking (Theory: 2 h; Practical: 4 h)

Active listening skills for different contexts, pronunciation and fluency practice, engaging

in structured dialogues and discussions, listening to various English dialects and summarizing content, role-playing conversations with emphasis on clarity and fluency, participating in debates or group discussions

**3. Writing Effective Laboratory Reports (Theory: 2 h; Practical: 4 h)**

Writing activities: composing lab reports that comprehensively detail scientific experiments, documenting experimental procedures, recording observations made, discussing precautions taken, justifying obtained results, and reporting the conclusions drawn from the experiment

**4. Effective Written Communication Theory: 2 h; Practical: 4 h)**

Structuring essays, reports, and other written documents, formal vs. Informal writing style, proofreading and editing techniques. Writing assignments including essays, business emails, and reports, peer review sessions for feedback on writing, editing exercises to refine written work

**5. Interpersonal and Group Communication (Theory:2 h; Practical: 4 h)**

Definition and features of interpersonal communication, Verbal and non-verbal communication, Elements of effective interpersonal communication, Group dynamics and teamwork communication, Group projects that require collaboration and communication, Simulations of team meetings and decision-making processes

**6. Integrated Communication Projects (Theory:2 h; Practical: 4 h)**

Reflection on personal communication strengths and areas for improvement. Capstone project integrating writing, speaking, and group communication skills, Final presentation or report demonstrating mastery of course content

**7. Professional Presentation Skills (Theory: 3 h; Practical: 4 h)**

Designing and structuring presentations, Effective use of visual aids and body language, Techniques for engaging and persuading an audience, Creating and delivering presentations on selected topics, Peer and instructor feedback sessions, Practice sessions focusing on voice modulation and audience interaction

**Methods of Teaching and Learning**

Teaching methods may vary and include lectures, tutorials, and audio-visual aids. Classroom activities will provide hands-on learning experiences, while group discussions and seminars encourage collaborative learning through peer interaction.

**Recommended readings**

- Helio Fred Garcia (2012). *The Power of Communication: Skills to Build Trust, Inspire Loyalty, and Lead Effectively.*
- Anthony Gutierrez (2014). *Effective Communication in the Workplace: Learn How to*

- Communicate Effectively and Avoid Common Barriers to Effective Communication.
- Soars, L., Soars, J., & Hancock, P. (2019). *Headway. Upper Intermediate, Student's book*. Oxford University Press.
  - Soars, L & Soars, J. (2009). *American Headway: The World's Most Trusted English Course*. Oxford: Oxford University Press.
  - Soars, L & Soars, J. (2003). *New Headway: Advanced Workbook with Key*. Oxford: Oxford
  - *Communication in the Real World: An Introduction to Communication Studies - Open Textbook Library*. (2016). Umn.edu; University of Minnesota Libraries Publishing.
  - Hewings, M. (2002). *Advanced English Grammar*. Cambridge: Cambridge University Press.
  - Meldrum, J. (2013). *Speak Now: Communicate with Confidence*. Oxford: Oxford University Press.

## ENH 11131 - Basic Mathematics for Chemistry

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|----------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|-----------------------------|--------------------------------|
| <b>Course Unit Code</b>                | ENH 11131                                                                                                                                            |                  |                             |                                |
| <b>Course Unit Name</b>                | Basic Mathematics for Chemistry                                                                                                                      |                  |                             |                                |
| <b>Credit value</b>                    | 1                                                                                                                                                    |                  |                             |                                |
| <b>Compulsory/Elective/Enhancement</b> | Enhancement; Compulsory for both biological science and physical science students                                                                    |                  |                             |                                |
| <b>Prerequisites</b>                   | ENH 11111 for Biological Science students                                                                                                            |                  |                             |                                |
| <b>Hourly breakdown</b>                | <b>Theory</b>                                                                                                                                        | <b>Practical</b> | <b>Independent learning</b> | <b>Notional learning hours</b> |
|                                        | 15                                                                                                                                                   | -                | -                           | 50                             |
| <b>Objective of the Course Unit</b>    | To provide students with a fundamental understanding of mathematical principles involving calculus to improve student learning in Physical Chemistry |                  |                             |                                |
| <b>Evaluation Method</b>               | Continuous Assessments                                                                                                                               |                  |                             |                                |

### Intended Learning Outcomes (ILO)

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

- ILO 1: perform differentiation and integration on various functions (algebraic, exponential, trigonometric, logarithmic etc.)
- ILO 2: solve chemistry-related problems using differentiation techniques
- ILO 3: solve chemistry-related problems applying integration
- ILO 4: apply differentiation to determine turning points in various functions in chemistry-related problems

### Course Content

#### 1. Limits (2h)

Limits, definition, limits involving infinity and limits not involving infinity

#### 2. Differentiation (5h)

Introduction, first principles, notations; Differentiation of sums, products, quotients, functions of functions and composite functions; Differentiation of logarithmic, exponential and trigonometric functions; Solving chemistry-based problems involving differentiation including think-pair-share activities.

#### 4. Integration (4h)

Basic integrations, integration by parts, integration by partial fractions, definite and indefinite integrals, applications of integrations.

## 5. Problem Solving (4h)

Solving chemistry-based problems involving differentiation and integration

### Methods of Teaching and Learning

Interactive lectures, tutorial discussions, student-centered small group discussions and think-pair-share activities

### Recommended Readings

- Smith, R.T.; Minton, R.B. (2004). Calculus: Concepts & Connections, 1<sup>st</sup> Edition, McGraw-Hill
- Himonas, A.; Howard, A. (2002). Calculus: Ideas & Applications, Abridged Edition, John- Wiley
- Connelly, J. A.; Fratangelo, R. A. (1979). Elementary Technical Mathematics with Calculus, Macmillan

## CHE 12012 - Concepts in Inorganic Chemistry I

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|   |  |                  |                             |                                |
|---|--|------------------|-----------------------------|--------------------------------|
| <b>Course Unit Code</b>                     | CHE 12012  |                  |                             |                                |
| <b>Course Unit Name</b>                     | Concepts in Inorganic Chemistry I  |                  |                             |                                |
| <b>Credit value</b>                         | 2  |                  |                             |                                |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory   |                  |                             |                                |
| <b>Prerequisites</b>                        | CHE 11012  |                  |                             |                                |
| <b>Hourly breakdown</b>                     | <b>Theory</b>  | <b>Practical</b> | <b>Independent learning</b> | <b>Notional learning hours</b> |
|   | 30   | -                | -                           | 100                            |
| <b>Objective of the Course Unit</b>         | To provide a comprehensive knowledge on radio and nuclear chemistry, Structure and properties of inorganic solids. |                  |                             |                                |
| <b>Evaluation Method</b>                    | Continuous Assessments 30%   |                  | Final Assessment 70%        |                                |

### Intended Learning Outcomes (ILO)

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

- ILO 1: correlate nuclear stability with radioactivity
- ILO 2: calculate binding energy per nucleon, energy release in fission/fusion reactions, half-life and age of fossils
- ILO 3: describe detection methods for radioactivity
- ILO 4: explain structures and properties of inorganic solids
- ILO 5: apply band theory to metals, semiconductors and insulators;
- ILO 6: apply X-ray diffraction methods in the study of solids

### Course Content

#### 1. Nuclear and Radiochemistry (15 h)

Definition for Nuclear chemistry, radiochemistry, nuclides, isotopes, isobars, isotones and radioactive nuclei; Stable and unstable isotopes, formation of radioisotopes and their properties; Introduction to mass defect, Einstein equation, binding energy and binding energy per nucleon; Calculation of binding energy and binding energy per nucleon; Properties of  $\alpha$ ,  $\beta$  and  $\gamma$  particles. Stability of the nucleus,

Stability of the nucleus: Explain the stability of the nucleus by using nuclear models - liquid drop model and shell model, odd-even rule, magic numbers, n/p ratio & band of stability and variation of binding energy per nucleon with mass number. Radioactive decay: Types of radioactive decay; Prediction of mode of decay/ possible products due to decay processes; Radioactive displacement law; Radioactive decay series:  $4n$ ,  $4n+1$ ,  $4n+2$

and  $4n+3$ ; Radioactivity of actinides with special reference to thorium and uranium.

Kinetics of radioactive decay: Half-life, Rate of decay, Radioactive decay law, derivation of equations; Calculation of radioactive decay constant.

Nuclear power: Induced nuclear reactions by neutron bombardment, Charged particle accelerators, transuranium elements; Introduction to Nuclear fission, critical mass, fission of  $^{235}\text{U}$ ; Energy balance of fission process, calculation of energy released from fission process; Introduction to Nuclear fusion; Chain reactions; Controlled and uncontrolled nuclear reactions, Principal components of a nuclear power plant and process involved, Nuclear reactors, Difference between a nuclear reactor and an atomic bomb, Fusion reactions in the sun.

Measurement of radiation:

Geiger Muller Counter; principle, instrumentation, plateau graph; Scintillation counter; Dosimeter.

Uses of radioisotopes:

In the Food industry. Nuclear medicine - Diagnostic and therapeutic purposes, radiopharmaceuticals:  $\text{Tcm}99$ ,  $\text{I}131$ ,  $\text{P}32$ ,  $\text{Inm}113$ ; synthesis of transuranium elements; Radiocarbon dating, Calculation of half-life and age of fossils; Isotope dilution analysis; activation analysis; Isotope exchange reactions.

## 2. Inorganic solids (15 h)

Definition of solid; classification of solids as crystalline and amorphous; Classification of crystalline solids as ionic, covalent, molecular and metallic.

Structure of ionic solids and metallic solids. Introduction to limiting radius ratio and structures, unit cell, close packing (cubic and hexagonal close packing) and non- close packing (body centered); interstitial holes; structures of ionic solid types AX and AX<sub>2</sub>, layer structures; defects in solids. state lattices: Stoichiometric and non-stoichiometric defects, colour centers; structures of metallic solids.

Electronic/electrical, magnetic and optical properties of inorganic solids. Electronic/ electrical properties of inorganic solids. Band theory: (applications only) Fermi level, band gap, electrical conductivity and classification of solids; Ionic conductivity, Superconductivity (explanation only).

Magnetic properties of inorganic solids. Origin of magnetism; Classification of magnetic behavior, Paramagnetic, diamagnetic, ferromagnetic; Temperature dependence of magnetism, curie temperature, Applications of magnetic materials

Optical properties of inorganic solids. Dielectric properties, Interaction of inorganic solids with electromagnetic radiation, How metals, semiconductors and insulators interact with

electromagnetic radiation; Nanoparticles and how they interact with electromagnetic radiation and the origin of the color of nanoparticles; Examples for application of solid materials in optical devices; X-ray powder diffraction and X-ray crystallography: unit cell parameters, crystal systems, Miller indices, application of above two methods in the study of solids. Synthesis and preparation of materials. Particles, ceramics, layers and coatings, chemical and physical processes, diffusion in solids.

Alloys and intermetallic compounds. Substitutional alloys, interstitial alloys, intermetallic compounds.

### **Methods of Teaching and Learning**

A combination of lectures, tutorials, and small group discussions.

### **Recommended Readings**

- Housecroft, C. E; and Sharpe A.G. (2012). Inorganic chemistry, 4<sup>th</sup> edition, Pearson, England
- Brown, T. E.; H. Eugene H. LeMay, E. H.; Bursten, B. E.; and Murphy, C. (2017). Chemistry: The Central Science, 14<sup>th</sup> edition
- Stout G. H.; & Jensen, L. H.; X-ray Structure Determination. (1991), 2<sup>nd</sup> Ed, Wiley.
- Giacovazzo, C. Fundamentals of Crystallography (2011). Edited by F.M. Henry, Chapman and Hall Ltd.
- J. D. Lee, J. D. (2006). Blackwell science, Concise Inorganic Chemistry, 5<sup>th</sup> Edition, Pearson, England,
- Pfennig, B. P.; (2015). Principles of Inorganic Chemistry, John Wiley & sons

## CHE 12022 - Principles of Physical Chemistry I

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|---------------------------------------------|------------------------------------------------------------------------|------------------|-----------------------------|--------------------------------|
| <b>Course Unit Code</b>                     | CHE 12022                                                              |                  |                             |                                |
| <b>Course Unit Name</b>                     | Principles of Physical Chemistry I                                     |                  |                             |                                |
| <b>Credit value</b>                         | 2                                                                      |                  |                             |                                |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory                                                             |                  |                             |                                |
| <b>Prerequisites</b>                        | none                                                                   |                  |                             |                                |
| <b>Hourly breakdown</b>                     | <b>Theory</b>                                                          | <b>Practical</b> | <b>Independent learning</b> | <b>Notional learning hours</b> |
|                                             | 30                                                                     | -                |                             | 100                            |
| <b>Objective of the Course Unit</b>         | To provide knowledge on states of matter, thermodynamics and kinetics. |                  |                             |                                |
| <b>Evaluation Method</b>                    | Continuous Assessments 30%                                             |                  | Final Assessment 70%        |                                |

### Intended Learning Outcomes (ILO)

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

- ILO 1: describe properties of ideal and real gasses using gas laws.
- ILO 2: analyze chemical reactions using energetics.
- ILO 3: calculate various thermodynamic parameters.
- ILO 4: establish the rate law of a chemical reaction.
- ILO 5: apply principles of chemical kinetics to different systems.

### Course Content

#### 1. States of matter (3 h)

Gaseous state of matter, properties of gases, perfect gases, real gases, review of the ideal gas equation of state, deviation of gases from ideal behaviour, van der Waals equation of state and other equations of state, kinetic molecular theory of gases, liquefaction of gases, reduced equation of state and law of corresponding states. Liquid state, random and orderly arrangement of molecules, solid state, crystalline and amorphous solids, plasma.

#### 2. Introduction to thermodynamics (15 h)

Zeroth law of thermodynamics; First law of thermodynamics: Concepts of work, heat and energy, different types of work, isochoric, isobaric, isothermal and adiabatic processes; Thermal capacity, enthalpy, variation of internal energy and enthalpy with temperature; Thermochemistry: Hess' Law, standard state, enthalpy change of reactions, Kirchoff's equation; Univariant systems; Second law of thermodynamics and entropy functions, calculation of entropy changes, entropy as a criterion for spontaneity and equilibrium;

Introduction to the concept of free energy, Gibbs and Helmholtz functions. Temperature, volume and pressure coefficients of  $\Delta A$  and  $\Delta G$ ; Change in thermodynamic functions during isobaric, isochoric, isothermal and adiabatic processes. Standard change in Gibbs energy and equilibrium constant.

### 3. Introduction to kinetics (12 h)

Review of basic concepts; Zeroth order, first order and second order reactions; Elementary reactions and complex reactions; Experimental determination of rate, rate constant and order of a reaction, factors affecting the rate of a reaction, Arrhenius equation, determination of activation energy of a reaction; Introduction to complex reactions: Parallel and consecutive reactions, first order reversible reactions, first order consecutive reactions; Mechanism of a reaction, rate determining step, influence of electromagnetic radiation; Quantitative description of the rate determining step; Steady state approximation and its applications; Enzyme catalyzed reactions; Kinetics of atomic and free radical reactions; Introduction to chain reactions.

### Methods of Teaching and Learning

A combination of lectures and tutorial discussions.

### Recommended Readings

- Atkins, P.; de Paula, J. (2014). Physical Chemistry, 9<sup>th</sup> Edition, W H Freeman.
- Levine, I.N.(2007). Physical Chemistry, 5<sup>th</sup> Edition, Tata McGraw-Hill.

## CHE 12031 - Fundamentals of Biochemistry II

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|   |  |                 |                             |                                |
|---|--|-----------------|-----------------------------|--------------------------------|
| <b>Course Unit Code</b>                     | CHE 12031  |                 |                             |                                |
| <b>Course Unit Name</b>                     | Fundamentals of Biochemistry II  |                 |                             |                                |
| <b>Credit value</b>                         | 1  |                 |                             |                                |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory   |                 |                             |                                |
| <b>Prerequisites</b>                        | CHE 11051  |                 |                             |                                |
| <b>Hourly breakdown</b>                     | <b>Theory</b>  | <b>Tutorial</b> | <b>Independent learning</b> | <b>Notional learning hours</b> |
|   | 15   | 2               | -                           | 50                             |
| <b>Objective of the Course Unit</b>         | To provide the students an understanding of the structure and function of the Genetic Material of the living world and the different types of errors that can occur in it. |                 |                             |                                |
| <b>Evaluation Method</b>                    | Continuous Assessments 30%   |                 | Final Assessment 70%        |                                |

### Intended Learning Outcomes (ILO)

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

- ILO 1: explain the structure of nucleosides, nucleotides, DNA & RNA, (mRNA & tRNA).  
 ILO 2: explain DNA damage, mutations, their effects and repair mechanisms  
 ILO 3: explain the biological processes associated with DNA & RNA  
 ILO 4: explain the gene, genetic code, its expression, regulation & function of telomeres

### Course Content

#### 1. Nucleic acids. (3 h)

Structure and nomenclature of nucleosides & nucleotides. Molecular structure of DNA and forces stabilizing & different types of RNA and their functions.

#### 2. Functions of Nucleic acids. (4 h)

DNA replication (semiconservative) process. Enzymes involved.

Replication on leading & lagging strands. Transcription process – synthesis of mRNA. Translation process (protein synthesis). Role of mRNA & tRNA in protein synthesis. 2nd genetic code.

Proof reading of mRNA translation. Signal peptide & function.

#### 3. The gene, gene expression & regulation. (4 h)

The Gene – structure & function. The genetic code (triplet code, codon), The characteristics of code. Regulation of gene expression – operon concept.

**4. DNA Mutations, DNA Damage and repair & telomeres. (4 h)**

Types of DNA mutations and their effects. DNA damage – causes of DNA repair mechanisms. Telomeres, their functions.

**Methods of Teaching and Learning**

A combination of lectures, guided Learning Sessions & tutorials.

**Recommended Readings**

- Abali, E. E.; Cline, S. D.; Franklin, D. S.; Viselli, S. M. Lippincott® Illustrated Reviews: Biochemistry; Lippincott Williams & Wilkins, 2024.
- Rodwell, V. W.; Bender, D. A.; Botham, K. M.; Kennelly, P. J.; Weil, P. A. Harper's Illustrated Biochemistry 31E; 2018.
- Devlin, T. M. Textbook of Biochemistry with Clinical Correlations; Wiley-Liss, 2002

## CHE 12042 - Organic Chemistry II

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|----------------------------------------|-------------------------------------------------------------------|------------------|-----------------------------|--------------------------------|
| <b>Course Unit Code</b>                | CHE 12042                                                         |                  |                             |                                |
| <b>Course Unit Name</b>                | Organic Chemistry II                                              |                  |                             |                                |
| <b>Credit value</b>                    | 2                                                                 |                  |                             |                                |
| <b>Compulsory/Elective/Enhancement</b> | Compulsory                                                        |                  |                             |                                |
| <b>Prerequisites</b>                   | CHE 11022                                                         |                  |                             |                                |
| <b>Hourly breakdown</b>                | <b>Theory</b>                                                     | <b>Practical</b> | <b>Independent learning</b> | <b>Notional learning hours</b> |
|                                        | 30                                                                | -                | -                           | 100                            |
| <b>Objective of the Course Unit</b>    | To introduce further principles and reaction in Organic Chemistry |                  |                             |                                |
| <b>Evaluation Method</b>               | Continuous Assessments 30%                                        |                  | Final Assessment 70%        |                                |

### Intended Learning Outcomes (ILO)

Upon successful completion of the course unit, the student should be able to;

- ILO 1: Identify intermediates encountered in Organic reaction and to rationalize their stability
- ILO 2: Illustrate the feasibility of a reaction using energy profiles
- ILO 3: Propose mechanisms for reaction proceeding through the reactive intermediates
- ILO 4: Identify aromatic, antiaromatic and nonaromatic compounds
- ILO 5: Propose pathway for intramolecular and multistep reaction
- ILO 6: Predict the rate and orientation of electrophilic substitution of substituted benzene
- ILO 7: Propose pathways for Nucleophilic Aromatic substitution

### Course Content

#### 1. Chemistry of Functional groups in Organic Chemistry II (6 h)

Carboxylic acids and their derivatives: Preparation, Nucleophilic substitution reaction. Reactions at the  $\alpha$ -carbon (Claisen condensation and related reactions). Amides and Amines: Preparation and reactions (including Hoffman Degradation, Hoffmann exhaustive elimination).

#### 2. Aromatic Compounds (9 h)

Aromaticity: Huckel rule, overview of aromatic, anti-aromatic and non-aromatic compounds. Non benzenoid aromatic Compounds. Electrophilic aromatic substitution: energy profile, activating, deactivating groups and position of electrophilic substitution of substituted benzenes.

Acidity of phenol and substituted phenols. Basicity of aliphatic amines and substituted

aromatic amines. Nucleophilic aromatic substitution. Addition-elimination mechanism involving carbanion intermediate; effect of electron withdrawing group at ortho, para positions and effect of leaving group on the rate of reaction as illustrated through energy profiles. Elimination- addition mechanism involving bezyne as intermediate.

### 3. Reactive intermediates in Organic Chemistry (7 h)

Structure and factors affecting stability of: Carbocations, carbanions, free radicals, carbenes, nitrenes. Reactions and rearrangement reactions involving these intermediates. Carbocations – Pinacol Pinacolone, Carbanions - Benzoin condensation, Carbene – Riemer Tieman Reaction, Nitrene – Curtius rearrangement and Lossen rearrangement. Doubly Stabilized carbanions (active hydrogen compounds) – Reactions of ethyl acetoacetate and diethyl malonate.

### 4. Synthetically useful Organic reactions (8 h)

Green and solvent free organic synthesis. Green Chemistry Principles, Applications of green solvents and solvent free methods in organic synthesis Alternative solvent free methods (ionic liquids, fluorinated solvents, bio-solvents), Intramolecular reactions (intramolecular aldol, Dieckmann condensation). Multi step (Knoevenagel reaction, Micheal Addition, Robinson annulation. Extensions to Wittig reaction, Multi step reactions. Kinetically controlled and thermodynamically controlled products of reactions.

### Methods of Teaching and Learning

A combination of lectures, tutorials, small group discussions and computer assisted learning.

### Recommended Readings

- Solomons, T. W. G.; Fryhle, C. B.; Snyder, S. A. (2013). Organic Chemistry, 11<sup>th</sup> Edition, John Wiley.
- McMurry, J. E. (2011). Organic Chemistry, 8<sup>th</sup> Edition, Brooks Cole.
- Wade Jr, L. G. (2012). Organic Chemistry, 8<sup>th</sup> Edition, Pearson.
- Ege, S. N. (2003). Organic Chemistry, Structure and Reactivity, 5<sup>th</sup> Edition, Houghton Mifflin Harcourt.

## CHE 12051 - Classical Methods in Chemical Analysis II

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|   |   |                  |                             |                                |
|---|---|------------------|-----------------------------|--------------------------------|
| <b>Course Unit Code</b>                     | CHE 12051   |                  |                             |                                |
| <b>Course Unit Name</b>                     | Classical Methods in Chemical Analysis II                                       |                  |                             |                                |
| <b>Credit value</b>                         | 1   |                  |                             |                                |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory  |                  |                             |                                |
| <b>Prerequisites</b>                        | CHE 11041   |                  |                             |                                |
| <b>Hourly breakdown</b>                     | <b>Theory</b>   | <b>Practical</b> | <b>Independent learning</b> | <b>Notional learning hours</b> |
|   | 15  | -                | -                           | 50                             |
| <b>Objective of the Course Unit</b>         | To provide a comprehensive understanding of redox and complexometric titrimetry |                  |                             |                                |
| <b>Evaluation Method</b>                    | Continuous Assessments 30%  |                  | Final Assessment 70%        |                                |

### Intended Learning Outcomes (ILO)

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

- ILO 1: sketch redox titration curves for single step and multistep titrations involving different thermodynamic properties
- ILO 2: explain conditional formation constants
- ILO 3: apply complexometric titrations in analysis

### Course Content

#### 1. Redox titrations (7 h)

Redox titrations and titration curves, selection of redox indicators, thermodynamic aspects of redox titrations, iodometric titrations.

#### 2. Complexometric titrations (8 h)

pM calculations, theoretical titration curves, conditional formation constants, effect of pH on conditional formation constant; Indicators for complexometric titrations.

### Methods of Teaching and Learning

A combination of lectures, tutorials, peer assisted student support (PASS) sessions and small group discussions.

### Recommended Readings

- Skoog, D. A.; West, D. M.; Holler, F. J.; Crouch, S. R., Fundamentals of Analytical Chemistry. Cengage Learning: 2013.
- Day, Underwood, Quantitative Analysis. Prentice Hall PTR: 1991.
- Harris, D. C.; Lucy, C. A., Quantitative Chemical Analysis. WH Freeman: 2018.

## CHE 12061 - Analytical Chemistry Laboratory

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|---------------------------------------------|-------------------------------------------------------|------------------|-----------------------------|--------------------------------|
| <b>Course Unit Code</b>                     | CHE 12061                                             |                  |                             |                                |
| <b>Course Unit Name</b>                     | Analytical Chemistry Laboratory                       |                  |                             |                                |
| <b>Credit value</b>                         | 1                                                     |                  |                             |                                |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory                                            |                  |                             |                                |
| <b>Prerequisites</b>                        | CHE 12051                                             |                  |                             |                                |
| <b>Hourly breakdown</b>                     | <b>Theory</b>                                         | <b>Practical</b> | <b>Independent learning</b> | <b>Notional learning hours</b> |
|                                             | -                                                     | 45               | -                           | 50                             |
| <b>Objective of the Course Unit</b>         | To provide fundamental skills in chemistry laboratory |                  |                             |                                |
| <b>Evaluation Method</b>                    | Attendance 10 %                                       |                  | Lab Reports 10%             |                                |
|                                             | Mid-term Assessment 20%                               |                  | Final Assessment 60%        |                                |

### Intended Learning Outcomes (ILO)

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

- ILO 1: prepare buffer solutions;
- ILO 2: determine analyte concentration using complexometric titrations
- ILO 3: practice techniques in gravimetry
- ILO 4: perform quantitative analysis in colorimetry

### Course Content

#### 1. Redox titrations (18 h)

Titration with potassium permanganate and potassium dichromate, iodometric titrations.

#### 2. Complexometric titrations (18 h)

Differentiation of Mg and Ca ions in a mixture, elimination of interferences in EDTA titrations.

#### 3. Gravimetry (6 h)

Homogeneous precipitation, weight measurement techniques, gravimetry using sintered glass crucibles, gravimetry using sample ignition techniques.

### Methods of Teaching and Learning

A combination of Lab lectures, practical sessions.

### **Recommended Readings**

- Svehla, G. (1996). Vogel's Qualitative Inorganic Analysis, 7<sup>th</sup> Edition, Prentice Hall.
- Skoog, D. A.; West, D. M.; Holler, F. J.; Crouch, S. R. (2013). Fundamentals of Analytical Chemistry, 9<sup>th</sup> Edition, Cengage Learning.

## APM 12072 - Introduction to Industrial Economics

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|---|---|------------------|-----------------------------|--------------------------------|
| <b>Course Unit Code</b>                     | APM 12072   |                  |                             |                                |
| <b>Course Unit Name</b>                     | Introduction to Industrial Economics  |                  |                             |                                |
| <b>Credit value</b>                         | 2   |                  |                             |                                |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory  |                  |                             |                                |
| <b>Prerequisites</b>                        | None  |                  |                             |                                |
| <b>Hourly breakdown</b>                     | <b>Theory</b>   | <b>Practical</b> | <b>Independent learning</b> | <b>Notional learning hours</b> |
|   | 30  | -                | -                           | 100                            |
| <b>Objective of the Course Unit</b>         | To equip students with the principles and tools of industrial economics for analysing investments and making informed business decisions under varying economic conditions. |                  |                             |                                |
| <b>Evaluation Method</b>                    | Final Assessment 100%   |                  |                             |                                |

### Intended Learning Outcomes (ILO)

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

- ILO 1: explain difference between microeconomics and macroeconomics;
- ILO 2: explain scarcity, choice, opportunity cost, demand, supply, production, cost and revenue;
- ILO 3: evaluate alternative capital investments;
- ILO 4: explain current economic challenges related to investment projects and expansion of business operations;
- ILO 5: explain how to deal with inflation, taxes, depreciation and uncertainty;
- ILO 6: assess risks and uncertainty associated with industrial economic decisions.

### Course Content

#### 1. Introduction to economics (6 h)

Microeconomics, macroeconomics. Demand, supply, production, cost and revenue.

#### 2. Capital investment alternatives (6 h)

Capital investment alternative, present worth (PW), annual cash flow analysis, rate of return analysis, future worth analysis, benefit-cost ratio analysis, payback period, sensitivity and breakeven analyses

#### 3. Introduction to Industrial economics (9 h)

The role and purpose of industrial and engineering economic analysis, costs and cost estimating, interest and equivalence, income and cash flow fundamentals.

#### **4. Depreciation, Taxation, and Inflation in Decision-Making (9 h)**

Basic aspects of depreciation, causes of depreciation, depreciation for tax purposes, depreciation and asset disposal, taxation and capital cost allowance, impact of taxes on decisions, impact of inflation on economic decisions.

#### **Methods of Teaching and Learning**

Lectures, case discussions, presentations

#### **Recommended Readings**

- Williams, J, Haka, S, Bettner, M and Carcello, J (2009), Financial Accounting, 14<sup>th</sup> Edition, McGraw- Hill/Irwin.
- Hilton, R W (2011), Managerial Accounting: Creating Value in a Dynamic Business Environment, 9<sup>th</sup> Edition, McGraw-Hill/Irwin.

## APM 12082 - Accounting Concepts and Costing

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|---------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|-----------------------------|--------------------------------|
| <b>Course Unit Code</b>                     | APM 12082                                                                                                                                                   |                  |                             |                                |
| <b>Course Unit Name</b>                     | Accounting Concepts and Costing                                                                                                                             |                  |                             |                                |
| <b>Credit value</b>                         | 2                                                                                                                                                           |                  |                             |                                |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory                                                                                                                                                  |                  |                             |                                |
| <b>Prerequisites</b>                        | None                                                                                                                                                        |                  |                             |                                |
| <b>Hourly breakdown</b>                     | <b>Theory</b>                                                                                                                                               | <b>Practical</b> | <b>Independent learning</b> | <b>Notional learning hours</b> |
|                                             | 30                                                                                                                                                          | -                | -                           | 100                            |
| <b>Objective of the Course Unit</b>         | To equip students with essential accounting and costing skills for preparing financial statements, reconciling accounts, and supporting business decisions. |                  |                             |                                |
| <b>Evaluation Method</b>                    | Final Assessment 100%                                                                                                                                       |                  |                             |                                |

### Intended Learning Outcomes (ILO)

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

- ILO 1: explain the principles of financial and managerial accounting
- ILO 2: record economic transactions and develop the key financial statements for the enterprise
- ILO 3: reconcile a bank statement
- ILO 4: identify and estimate the cost components for a product or service

### Course Content

#### 1. Fundamentals of financial accounting (6 h)

Concepts and principles of financial accounting.

#### 2. Bookkeeping and financial statements (14 h)

Practice of bookkeeping including books of prime entry, ledgers and trial balance; preparation of trading, profit and loss account, and balance sheet; cash flow statement; bank reconciliation.

#### 3. Managerial use of accounting information and costing (10 h)

Application of accounting information for managerial decision-making in planning and control; cost classification; estimation and analysis; job-order costing, variable costing, and activity-based costing.

### **Methods of Teaching and Learning**

Lectures, case discussions, presentations

### **Recommended Readings**

- Williams, J, Haka, S, Bettner, M and Carcello, J (2009), Financial Accounting, 14<sup>th</sup> Edition, McGraw- Hill/Irwin.
- Hilton, R W (2011), Managerial Accounting: Creating Value in a Dynamic Business Environment, 9<sup>th</sup> Edition, McGraw-Hill/Irwin.

## SUP 12092 - Physics and Basic Electronics for Chemists

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|   |   |                                 |                                 |                                    |
|---|---|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | SUP 12092   |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Physics and Basic Electronics for Chemists  |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2   |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory  |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | None  |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>   | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|   | 30  | -                               | -                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | To impart knowledge on the application of physics in explaining chemical phenomena and electronics in signal measurement. |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Final Assessment 100%   |                                 |                                 |                                    |

### Intended Learning Outcomes (ILO)

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

ILO 1: apply optical principles to explain chemical instrumentation.

ILO 2: apply wave mechanics to molecular spectroscopy.

ILO 3: explain the working principles of basic electronic circuits used for chemical measurements.

ILO 4: explain the use of semiconductor devices in chemical instrumentation.

ILO 5: explain basic digital circuits, and the role of memory elements in simple digital systems.

### Course Content

#### 1. Optics (8 h)

Geometric Optics: Reflection, refraction, Snell's Law, lens equations (thin lenses); Optical systems in chemistry (e.g., microscopes, spectrophotometers).

Polarization & Optical Activity: Linear polarization, Malus's Law, circular/elliptical polarization; Polarizers and optical activity (chirality in molecules, sugar concentration measurements).

Wave Optics & Diffraction: Interference: Young's double slit, coherence; Diffraction: Single/double slit, diffraction gratings (spectroscopy applications).

X-ray diffraction: Bragg's Law, crystal structure analysis (emphasis on chemical applications).

Mass Spectrometry Basics: Ion production/detection, basic MS principles (time-of-flight, quadrupole).

## 2. Waves and Vibrations (10 h)

Harmonic Motion & Resonance: Simple harmonic motion (SHM), damped/forced vibrations; Resonance in molecular spectroscopy (IR, NMR).

Wave Physics: Wave equation, phase/group velocity (pulse propagation); Impedance matching (e.g., ultrasound in material analysis); Fourier analysis (brief intro to spectral decomposition).

Sound & Acoustics: Speed of sound, Doppler effect (ultrasonic); Acoustics in labs (noise reduction, pressure level measurements); Applications of Electromagnetic Radiations: Microwave, Ultrasound.

## 3. Circuit Theory (4 h)

DC & AC Circuits: Voltage/current sources, RMS values, resistor networks; Thevenin's theorem (circuit simplification for sensors).

Transients & Signal Processing: RC/RL circuits (time constants, filtering noise in instruments); LC oscillations (brief, for NMR/RF applications).

## 4. Analog Electronics (5 h)

Semiconductors & Diodes: Introduction to p-type & n-type semiconductors; p-n junction diode: Forward & reverse bias; Diode as a circuit element (rectifiers, Zener diodes for voltage regulation); Applications in chemistry (LEDs, photodiodes in spectroscopy)

Transistors & Amplifiers: Bipolar junction transistor (BJT): n-p-n operation & biasing; Transistor as an amplifier (common emitter configuration); Transistor as a switch (basic concept); Brief introduction to FETs (JFET/MOSFET)

Operational Amplifiers (Op-Amps): Inverting & non-inverting amplifiers; Summing amplifiers (basic applications); Op-amp in chemical instrumentation (e.g., signal conditioning)

## 5. Digital Electronics (3 h)

Logic Gates & Boolean Algebra: Basic logic gates (AND, OR, NOT, NAND, NOR); Boolean laws & simplification techniques; Designing simple combinational circuits.

Karnaugh maps, Adders & Memory Elements: K-maps; minimization (2 variable example), Half adder circuit (brief introduction), Flip-flop as memory (basic concept).

## Methods of Teaching and Learning

Lectures, tutorial discussions, small group discussions and computer assisted learning.

### **Recommended Readings**

- University Physics with Modern Physics Technology by Hugh D. Young Roger A. Freedman 13<sup>th</sup> Edition, 2014.
- Vibrations and waves, George C. King, John Wiley & Sons Ltd., 2009.
- Practical Electronics for Inventors, Paul Scherz and Simon Monk, 4<sup>th</sup> Edition, McGraw-Hill, 2016.
- The Art of Electronics, Paul Horowitz & Winfield Hill, Cambridge University Press, 3<sup>rd</sup> Edition, 2015.
- Basic Electronics for Scientists, J. J. Brophy, McGraw-Hill College, 1990.
- Digital Systems Principles and Applications, Ronald J. Tocci, Neil Widmer and Greg Moss, Pearson, 11<sup>th</sup> Edition, 2010.

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# LEVEL 2

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## CHE 21012 - Organic Synthesis and Spectroscopy

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|---------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 21012                                                                                                                                   |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Organic Synthesis and Spectroscopy                                                                                                          |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2                                                                                                                                           |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory                                                                                                                                  |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | CHE 12042                                                                                                                                   |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>                                                                                                                               | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|                                             | 30                                                                                                                                          | -                               | -                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | To introduce intermediary level Organic Synthesis and to introduce Spectroscopic methods to elucidate structure of simple Organic Compounds |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Continuous Assessments 30%                                                                                                                  |                                 | Final Assessment 70%            |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: propose pathways to synthesize simple organic molecules
- ILO 2: devise routes for the transformation of functional groups
- ILO 3: strategize pathways for multi-step synthesis
- ILO 4: illustrate rearrangement reactions using mechanisms
- ILO 5: identify and describe the fundamental principles of electromagnetic radiation and its applications in ultraviolet and visible spectroscopy
- ILO 6: analyze and interpret the molecular vibrations and absorption characteristics of functional groups using infrared spectroscopy
- ILO 7: demonstrate the understanding of nuclear magnetic resonance (NMR) spectroscopy, including  $^1\text{H}$  and  $^{13}\text{C}$  NMR techniques
- ILO 8: evaluate and apply the principles of mass spectrometry for molecular ion identification and fragmentation pattern analysis

### Course Content

#### 1. Organic Synthesis (12 h)

Polynuclear aromatic hydrocarbons. Properties, Synthesis and reactions of naphthalene, anthracene and phenanthrene. Synthetically useful Organic reactions Knoevenagel reaction, Dieckmann condensation, Micheal Addition, Robinson annulation. Extensions to Wittig reaction.

Rearrangement reactions. Benzil to Benzilic acid conversion, Favroski, Claisen and para Claisen rearrangements, Bayer Villiger oxidation, Beckmann rearrangement, Cope rearrangement. Transition metal complex catalyzed reactions in organic synthesis. Baldwin's rule for ring closure reactions.

## 2. Organic Spectroscopy (18 h)

Introduction to Electromagnetic Spectrum. Basics of UV-visible spectroscopy, Chromophores, auxochromes, and solvent effects; applications. Infrared Spectroscopy; Introduction to infrared spectroscopy, Molecular vibrations and absorption characteristic of functional groups and Interpretation of infrared spectra. Nuclear Magnetic Resonance (NMR) Spectroscopy; Magnetic properties of nuclei and nuclear excitation, Principles of  $^1\text{H}$  NMR spectroscopy: chemical shifts, spin-spin coupling, coupling constants, Interpretation of  $^1\text{H}$  NMR spectra, Chemical shifts in  $^{13}\text{C}$  NMR spectroscopy, Off-resonance spectra and broadband decouple  $^{13}\text{C}$  NMR. Principles of mass spectrometry: Molecular ion and fragmentation patterns, Analysis and interpretation of mass spectra.

### Methods of Teaching and Learning

A combination of lectures, tutorial, discussions.

### Recommended Readings

- Solomons, T. W. G.; Fryhle, C. B.; Snyder, S. A. (2013). Organic Chemistry, 11<sup>th</sup> Edition, John Wiley.
- McMurry, J. E. (2011). Organic Chemistry, 8<sup>th</sup> Edition, Brooks Cole.
- Wade Jr, L. G. (2012). Organic Chemistry, 8<sup>th</sup> Edition, Pearson.
- Organic Chemistry Volume 2, 3<sup>rd</sup> Edition, I L Finar
- Spectrometric Identification of Organic Compounds, Silverstein, Webster, and Kiemle
- Organic Structures from Spectra, Leslie D. Field, Sebastian K. Schunung, Alan G. Maunder
- Interpretation of Mass Spectra, Fred W. McLafferty, Frantisek Turecek
- Introduction to Organic Spectroscopy, Laurence M. Harwood, Timothy D. W. Claridge

## CHE 21022 - Principles of Physical Chemistry II

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|   |  |                                 |                                 |                                    |
|---|--|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 21022  |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Principles of Physical Chemistry II  |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2  |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory   |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | ENH 11131  |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>  | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|   | 30   | -                               | -                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | To provide basic knowledge in quantum mechanics and molecular spectroscopy |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Continuous Assessments 30%   |                                 | Final Assessment 70%            |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: describe the fundamentals of quantum mechanics and its postulates.  
 ILO 2: construct operators and normalize wave function.  
 ILO 3: solves the Schrodinger equation for a particle in 1-D, 2D, 3-D box models, calculate eigenvalues and expectation values.  
 ILO 4: describe rotational and vibrational spectra of diatomic molecules, interpret spectra, in terms of selection rules, accounts for the effect of anharmonicity in spectral features.

### Course Content

#### 1. Introduction to quantum mechanics (15 h)

The quantization of radiation: Planck's concept of quantization, black-body radiation, photo- electric effect; Wave properties of matter: de Broglie's hypothesis, wave particle duality, electron diffraction and electron microscope, Heisenberg uncertainty principle; Postulates of quantum mechanics, Schrödinger (time-independent) equation, quantum mechanical operators, eigen functions; Application of Schrodinger equation to simple systems: Particle in one-dimensional box (Hamiltonian operator, boundary conditions, quantization of energy and quantum number, probabilistic interpretation of the wave function); Extrapolation of the particle in 1-D model to 2-D and 3-D boxes; Introduction to quantum mechanical tunneling.

#### 2. Fundamentals of molecular spectroscopy (15 h)

Fundamentals of spectroscopy, electrical and optical properties of molecules, introductory

electronic spectroscopy; Microwave spectroscopy: Pure rotational spectra of diatomic molecules, applications of rotational spectra of diatomic molecules, classification of molecules according to their moment of inertia, positions of peaks in the microwave absorption spectrum of a diatomic molecule, centrifugal distortion; Vibrational spectroscopy: Pure vibrational spectrum of a diatomic molecule, harmonic oscillator approximation and its limitations, anharmonicity, Morse potential, selection rules.

### **Methods of Teaching and Learning**

A combination of lectures, tutorials discussions.

### **Recommended Readings:**

- Atkins, P; de Paula, J. (2014). Physical Chemistry, 9<sup>th</sup> Edition, W H Freeman.
- Levine, I.N.(2007). Physical Chemistry, 5<sup>th</sup> Edition, Tata McGraw-Hill.
- Mcquarrie, D.A. (2007). Quantum Chemistry, 2<sup>nd</sup> Edition, University Science Books.
- Levine, I. N. (2008). Quantum Chemistry, 6<sup>th</sup> Edition, Prentice Hall.
- Bandarage, G; Physical Chemistry Part III, Introduction to molecular spectroscopy, OUSL.
- Bandarage, G; Understanding the basics of molecular spectroscopy, OUSL.

## CHE 21032 - Separation Methods and Atomic Spectroscopy

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|                                             |                                                                                                                                                                                                                                               |                                 |                                 |                                    |
|---------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 21032                                                                                                                                                                                                                                     |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Separation Methods and Atomic Spectroscopy                                                                                                                                                                                                    |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2                                                                                                                                                                                                                                             |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory                                                                                                                                                                                                                                    |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | CHE 12061                                                                                                                                                                                                                                     |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>                                                                                                                                                                                                                                 | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|                                             | 30                                                                                                                                                                                                                                            | -                               | -                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | To provide a fundamental understanding of analytical atomic spectroscopy, including its principles, instrumentation, and quantification.<br>To provide a fundamental understanding of separation methods and theory of elution chromatography |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Continuous Assessments 30%                                                                                                                                                                                                                    |                                 | Final Assessment 70%            |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: apply Beer's law in quantitative analysis
- ILO 2: illustrate the optical configuration of a typical atomic absorption and emission spectrometer
- ILO 3: explain sample preparation methods in atomic spectroscopy
- ILO 4: explain the principles of discontinuous liquid-liquid extraction
- ILO 5: explain the fundamentals of ion exchange
- ILO 6: define basic terminologies and interpret theoretical aspects of elution chromatography

### Course Content

#### 1. Beer's law and quantification techniques (6 h)

Transmittance and absorption; Beer's law, types of electronic transitions, external and standard addition calibration curves, matrix matching, bracketing technique, internal standard methods and related calculations; Sensitivity, limit of detection, practical quantization limit, linear range and linear dynamic range.

#### 2. Atomic absorption and emission spectrometry (7 h)

Basic principles related to atomic emission; Absorption and fluorescence: Spectrometric techniques; Instrumentations for atomic spectrometry: Atom generation devices: Flames,

electric arcs/sparks, furnaces and plasmas; Radiation sources: Line and continuum sources in AAS; Introduction to wavelength selection devices: Monochromators, polychromators and their figures of merit; Radiation detection in atomic spectrometry; Band broadening: Doppler broadening and collisional broadening, spectral line widths; Emission spectral profile and absorption coefficient profile; Interferences in atomic absorption spectrometry: Spectral interferences and background absorption, chemical interferences and methods for minimization of chemical interferences.

### 3. Sample preparation for atomic spectrometry (2 h)

Mineral acid digestion, dry ashing methods and other sample preparation methods. Digestion efficiency and certified reference materials in atomic spectroscopy.

### 4. Solvent extraction and ion-exchange (7 h)

Liquid-liquid extraction (LLE): Basic principles, LLE involving acid-base equilibria, ion speciation, LLE of a metal-ligand complex; Continuous liquid-liquid extraction; Ion exchange (IE): Chemistry of ion exchange resins and selectivity, static and dynamic operation and capacity; Applications; Clay minerals as ion exchangers.

### 5. Principles in elution chromatography (8 h)

Introduction to chromatography: Frontal, displacement and elution chromatography; Components of elution chromatography: The stationary phase, the mobile phase and the analyte; Planar and column chromatography; Adsorption, partition, ion exchange and permeation chromatography; Reversed phase and normal phase chromatography; Basic terminologies in chromatography: Retention time, capacity factor, selectivity factor, volumetric flow rate; Zone broadening: Gaussian shape of chromatographic peaks, the plate theory, quantitative description of column efficiency, the rate theory, van Deemter equation for plate height; Column efficiency and resolution; Thermodynamics of elution chromatography: Enthalpy driven and entropy driven chromatograms.

### Methods of Teaching and Learning

A combination of classroom teaching, demonstrations, visual aids, spreadsheet application workshops and small group discussions.

### Recommended Readings:

- Harris, D. C. (2010). Quantitative Chemical Analysis, 8<sup>th</sup> Edition, W. H. Freeman.
- Robinson, J. W.; Frame, E. M. S.; Frame, G. M., (2004). Undergraduate Instrumental Analysis. 6 ed.; Taylor & Francis.
- Christian, G. D.; Dasgupta, P.; Schug, K., Analytical Chemistry (2013), 7<sup>th</sup> Edition. Wiley Global Education
- Skoog, D. A.; Holler, F. J.; Crouch, S. R. (2007). Principles of Instrumental Analysis, 6<sup>th</sup> Edition, Thomson Brooks/Cole.

## CHE 21041 - Organic Chemistry Laboratory

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|---|--|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 21041  |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Organic Chemistry Laboratory                           |                                 |                                 |                                    |
| <b>Credit value</b>                         | 1  |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory   |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | CHE 11022  |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>  | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|   | -  | 45                              | 10                              | 50                                 |
| <b>Objective of the<br/>Course Unit</b>     | To develop basic practical skills in Organic Chemistry |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Attendance 10 %  |                                 | Lab Reports 10%                 |                                    |
|   | Mid-term Assessment 20%                                |                                 | Final Assessment 60%            |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: identify an organic compound using melting point and mixed melting points
- ILO 2: purify an organic compound using recrystallization
- ILO 3: plan a method and carry out the separation of components of a mixture of organic compounds
- ILO 4: identify an unknown compound by derivatization
- ILO 5: synthesize an organic compound
- ILO 6: analyze the progress of a reaction using thin layer chromatography

### Course Content

#### 1. Purification and identification of organic compounds

Re-crystallizations from single and mixed solvents, identification of compounds by boiling points, melting points and mixed melting point determinations.

#### 2. Separation of mixtures into their components

Acid-neutral; base-neutral, phenol-neutral, acid-phenol, three component mixture and identification of the components.

#### 3. Preparation of derivatives and characterization of organic compounds.

#### 4. Synthesis of simple organic compounds (one pot synthesis).

## 5. Thin layer chromatography

- 5.1. Determination of purity of an organic compound;
- 5.2. Monitoring of the progress of a reaction.

### Methods of Teaching and Learning

A combination of laboratory classes, combination of pre-laboratory and post laboratory assignments, laboratory reports.

### Recommended Readings

- Vogel A.I.; Tatchell A.R.; Furnis B.S.; Hannaford A.J.; Smith P.W.G. (1996). Vogel's Textbook of Practical Organic Chemistry, 5<sup>th</sup> Edition, Prentice Hall.
- Moting, J.R.; Mofrill, T.C.; Hammond, C.N.; Neckers, D.C. (1999). Experimental Organic Chemistry, Freeman.
- Williamson, K.L. (1994). Macroscale and Microscale Organic Experiments, 2<sup>nd</sup> Edition, Heath and Company.

## APM 21052 - Principles of Human Resource Management and Leadership

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|---------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | APM 21052                                                                             |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Principles of Human Resource Management and Leadership                                |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2                                                                                     |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory                                                                            |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | None                                                                                  |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>                                                                         | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|                                             | 30                                                                                    | -                               | -                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | To introduce key HRM functions and leadership styles for effective people management. |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Final Assessment 100%                                                                 |                                 |                                 |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: demonstrate understanding of the theoretical aspects of HRM functions;  
 ILO 2: analyse the application of HRM techniques of staffing, recruitment, selection, training and development, performance appraisal and reward systems in less complex scenarios;  
 ILO 3: identify different leadership styles and their application.

### Course Content

#### 1. Fundamentals of Human Resource Management (HRM) (18 h)

Introduction to HRM, recruitment and selection, performance management and motivation, training and development, influence of groups and environment on personality.

#### 2. Leadership and communication in organizations (12 h)

Introduction to leadership, leadership styles, evaluation of global leaders and their styles of leadership, universal communication model, purpose and modes of organizational communication.

### Methods of Teaching and Learning

Lectures, discussion of cases and self-study

### **Recommended Readings**

- Dessler, Human Resources Management, 12<sup>th</sup> Ed. (2012), Prentice Hall.
- Armstrong M — A Handbook of Human Resource Practice, 12<sup>th</sup> Ed (2012).
- Lesikar, Pettit, and Flatley, (2001). “Basic Business Communication”, Irwin McGraw-Hill.
- Kaagan Stephen S., (1999). “Leadership Games”, Response Books.

## APM 21062 - Marketing Management

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|---|--|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | APM 21062  |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Marketing Management   |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2  |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory   |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | None   |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>  | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|   | 30   | -                               | -                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | To provide students with the knowledge and skills to understand core marketing concepts, analyze diverse marketing situations, and develop effective marketing plans for organizational success. |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Final Assessment 100%  |                                 |                                 |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: explain the increasingly significant role of marketing in modern organizational management;
- ILO 2: identify the variables at work of various marketing situations;
- ILO 3: prepare a comprehensive marketing plan for a business organization.

### Course Content

#### 1. Marketing principles and evolution (6 h)

Evolution of marketing, conceptualization of marketing philosophies and concepts, overview of marketing goals and strategies.

#### 2. Strategies of marketing and consumer behavior (18 h)

Consumer behavior, market segmentation and targeting, marketing mix, strategies for products, pricing, distribution, and promotion, brand strategies and brand management.

#### 3. Marketing planning and implementation (6 h)

Preparation, presentation, and implementation of a marketing plan.

### Methods of Teaching and Learning

Interactive classroom sessions, case analysis, projects

**Recommended Readings**

- Kotler, P (2015), Marketing Management, 15<sup>th</sup> Edition, Prentice Hall.
- Boyd and Walker (2015), Marketing Management.
- Wells W D, Moriarty S and Burnett J (2011), 9<sup>th</sup> Edition, Advertising & IMC; Principles and Practice, Prentice Hall.

## APM 21072 - Total Quality Management

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|---------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | APM 21072                                                                                                                                                                                                                                          |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Total Quality Management                                                                                                                                                                                                                           |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2                                                                                                                                                                                                                                                  |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory                                                                                                                                                                                                                                         |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | None                                                                                                                                                                                                                                               |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>                                                                                                                                                                                                                                      | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|                                             | 30                                                                                                                                                                                                                                                 | -                               | -                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | To provide students with the knowledge and skills to understand quality management concepts, apply quality standards, conduct quality audits, and use statistical process control tools for improving processes in production and service systems. |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Final Assessment 100%                                                                                                                                                                                                                              |                                 |                                 |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: identify the difference between quality control and quality assurance
- ILO 2: implement quality controlling quality assurance parameters
- ILO 3: explain the term “Standards Formulation Process”
- ILO 4: discuss different quality management systems
- ILO 5: carry out a quality audit
- ILO 6: apply statistical process control in production and service systems

### Course Content

#### 1. Fundamentals of quality management (10 h)

Quality, quality control, quality assurance, total quality management, complaint mushroom, quality chain, process definition, Deming cycle, standardization concepts and levels, conformity assessment, accreditation, quality management principles, quality costs, standards formulation process, and the 5S concept.

#### 2. Standards, certification, and quality auditing (10 h)

Product certification schemes, ISO 9001:2015 standard requirements, ISO 14000 standard requirements, ISO 22000 standard requirements, ISO 17025 laboratory management system requirements; quality auditing – definition, types, classification, conducting audits, and audit reporting.

### 3. Quality management tools and process capability (10 h)

Seven quality management tools (Pareto analysis, flow chart, check sheet, histogram, scatter diagram, control chart, cause-and-effect diagram), sampling methods, detailed study of histograms and control charts, variable and attribute control charts, process capability indices (Cp and Cpk).

#### Methods of Teaching and Learning

Lectures, tutorials, group work, seminars, computer assisted learning

#### Recommended Readings

- Evans J.R (2007), "Total quality", 4<sup>th</sup> edition, Thomson-South-Western.
- Freigerbaun A.V. "Total quality", Mc graw-Hill, New York.
- Evans J.R and Lidsay, (2005), "The Management of the control of quality", 6<sup>th</sup> Edition, Cincinnati south-western Publication.
- ISO/IEC 17025:2005-general requirements for the competence of testing and calibration laboratories <http://www.iso.org>.
- Koneiczka Pnaiesnik, J. Quality Assurance and Quality control in the analytical Chemical Laboratory: A practical approach; CRC Press, 2009.

## SUP 21081 - Mathematics for Chemistry I

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|---|--|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | SUP 21082  |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Mathematics for Chemistry I  |                                 |                                 |                                    |
| <b>Credit value</b>                         | 1  |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory   |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | ENH 11131  |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>  | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|   | 15   | -                               | -                               | 50                                 |
| <b>Objective of the<br/>Course Unit</b>     | To provide students with basic knowledge on solving differential equations |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Final Assessment 100%  |                                 |                                 |                                    |

### Intended Learning Outcomes (ILO)

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

ILO1: solve chemistry problems related to partial differentiation

ILO2: determine turning points in non-linear graphs

ILO3: solve chemistry problems applying differential equations

### Course Content

#### 1. Partial differentiation and total differentiations (4h)

Concept of partial derivative, notation, total differential; Turning points, maxima, minima and point of inflexion, exact and inexact differential equations, Eulers' theorem, homogeneous functions

#### 2. Differential equations (4 h)

Introduction to differential equations, solving first-order differential equations and applications in chemical kinetics, second-order differential equations and applications in physical chemistry

#### 3. Applications and Problem solving (7 h)

Applications of partial differentiation and differential equations in solving problems in Chemical Kinetics, Chemical Thermodynamics, Quantum Mechanics, Electrochemistry

**Methods of Teaching and Learning**

Interactive lectures, Classroom discussions, Tutorial discussions, Quizzes, Take home assignments, VLE, LMS based independent learning activities, Interactive videos

**Recommended Readings**

- Smith, R. T.; Minton, R. B. (2004). Calculus: Concepts & Connections, 1<sup>st</sup> Edition, McGraw-Hill
- Himonas, A.; Howard, A. (2002). Calculus: Ideas & Applications, Abridged Edition, John- Wiley
- Connelly, J. A.; Fratangelo, R. A. (1979). Elementary Technical Mathematics with Calculus, Macmillan

## CHE 22012 - Concepts in Inorganic Chemistry II

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|---------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 22012                                                                                                                                              |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Concepts in Inorganic Chemistry-II                                                                                                                     |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2                                                                                                                                                      |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory                                                                                                                                             |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | CHE 12012                                                                                                                                              |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>                                                                                                                                          | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|                                             | 30                                                                                                                                                     | -                               | -                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | To provide a solid foundation in elements of symmetry and symmetry operations, Concepts in Coordination Chemistry and Organotransition metal Chemistry |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Continuous Assessments 30%                                                                                                                             |                                 | Final Assessment 70%            |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: apply symmetry elements and symmetry operations for molecules.
- ILO 2: Determine point group for molecules
- ILO 3: Apply IUPAC nomenclature
- ILO 4: Identify isomerism in coordination complexes
- ILO 5: Calculate overall formation constant
- ILO 6: Predict colour, magnetism and Jahn teller distortion in transition metal complexes
- ILO 7: Apply VBT and MOT for different coordination complexes.
- ILO 8: calculate oxidation state of the metal and total electron count at the metal in organometallic compounds;
- ILO 9: explain bonding in metal- $\pi$ -bonding ligands in organometallic compounds;

### Course Content

#### 1. Molecular symmetry (6 h)

Elements of symmetry and symmetry operations: Basic types of symmetry elements and their operations on molecules. Determination of point groups of simple molecules.

#### 2. Coordination chemistry (18 h)

Definitions & HSAB theory, Central metal atom/ion, ligands and donor atoms, coordination sphere, coordination number, Determination of coordination number and oxidation number, monodentate, bidentate, etc. and polydentate ligands, ambidentate

ligands, bridging ligands, chelate complexes, hard/soft acid base theory. Isomerism and nomenclature of coordination complexes: Types of isomerism, IUPAC nomenclature. Stability of complexes in aqueous solution: Stepwise and overall formation constants, thermodynamic and kinetic stability, Factors affecting stability of complexes: chelate effect, macrocyclic effect. Bonding in coordination complexes. Valence Bond Theory (VBT): Formation of metal-ligand bonds, Back-bonding, Werner's coordination theory, Effective atomic number (EAN), EAN of metal-nitrosyl complexes, Hybridization of octahedral complexes, Application of VBT to four-coordinated systems (tetrahedral and square planar complexes).

Crystal Field Theory: Octahedral and tetrahedral crystal fields, splitting of d-orbitals by octahedral, tetrahedral and square planar fields, determination of crystal field splitting energy and crystal field stabilization energy, factors affecting magnitude of ( $\Delta$ ), pairing energy, high spin and low spin complexes, spectrochemical series, CFT to explain thermodynamic and structural properties of transition metal complexes, colour and magnetism of transition metal complexes, tetragonal distortion, Jahn-Teller effect. Molecular Orbital Theory (MOT): Features of MOT, Types of molecular orbitals, Symmetry designation of molecular orbitals, MOTs of metal complexes with all sigma bonds, MOTs of metal complexes with pi bonding (pi-acceptors and pi-donors), Figuring out octahedral splitting energy of MOTs.

### 3. Introductory organotransition metal chemistry (6 h)

Introduction to organotransition metal chemistry, classification of ligands according to the number of electrons donated, oxidation state formalism, hapticity of a ligand ( $\eta^n$ ). Total valence electron count and geometry Total valence electron count in organometallic compounds, the 18-electron rule, coordinative unsaturation, geometry of organotransition metal complexes.

#### Methods of Teaching and Learning

A combination of lectures, tutorials, peer assisted student support sessions and small group discussions.

#### Recommended Readings

- Housecroft, C. E; and Sharpe A.G. (2012). Inorganic chemistry, 4<sup>th</sup> edition, Pearson, England
- Shriver and Atkins (2010), Inorganic Chemistry, 5<sup>th</sup> Edition.
- Robert H. Crabtree, The Organometallic Chemistry of the Transition Metals, 5<sup>th</sup> Edition
- J. D. Lee, J. D. (2006). Blackwell science, Concise Inorganic Chemistry, 5<sup>th</sup> Edition, Pearson, England,
- Robert H. Crabtree, The Organometallic Chemistry of the Transition Metals, 5<sup>th</sup> Edition

## CHE 22022 - Heterocyclic Chemistry and Natural Products

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|---|---|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 22022   |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Heterocyclic Chemistry and Natural Products   |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2   |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory  |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | CHE 21012   |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>   | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|   | 30  | -                               | -                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | To introduce synthesis and reactivity Organic Compounds containing heteroatoms and natural products |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Continuous Assessments 30%  |                                 | Final Assessment 70%            |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: relate the nature of bonding to structural features, properties and reactivity of the heterocyclic compounds
- ILO 2: to relate basic heterocyclic moieties to important naturally occurring molecules
- ILO 3: provide an overview of the field of natural product chemistry
- ILO 4: identify different types of natural products, their occurrence, structure, biosynthesis and properties
- ILO 5: Describe the chemistry of selected alkaloids, steroids, terpenoids, polyketides and phenyl propanoids
- ILO 6: Evaluate the significance of natural product chemistry in various industries and applications

### Course Content

#### 1. Heterocyclic Chemistry (15 h)

Classification of heterocyclic compounds. Nomenclature of heterocyclic compounds. Molecular orbital picture. Structure and aromaticity of pyrrole, furan, thiophene and pyridine. Methods of synthesis, properties and chemical reactions of Pyrrole, Furan, Thiophene and Pyridine. Dipyrrolyl systems, tetra pyrrolyl systems, porphyrins, naturally occurring pyrrole systems (chlorophyll, haemoglobin, Vit B12), naturally occurring Thiophene (Biotin). Comparison of basicity of Pyridine, Piperidine and Pyrrole. Benzofuran, Benzothiophene and Benzopyrrole. Reactions of Benzopyrrole (Indole), Synthesis of Benzopyrrole (Indole), application of Indole in Drug Synthesis, Synthesis

and Reactions of Benzofuran and Benzothiophene, Applications of the Benzofuran and Benzothiophene ring system in drug synthesis.

Benzopyridines: Reactions of Quinolines, synthesis of quinoline, application of the Quinoline ring system in drug synthesis, synthesis and reactions of Iso-quinolines, application of the Iso-quinoline ring system in drug synthesis. Dibenzopyrones, Pyrilium salts and other Benzopyrones, synthesis and reactions of Coumarins, reactions of Chromones, synthesis of Chromones, synthesis and reactions of dibenzopyrilium Salts, Application of the Coumarin and Chromones ring systems in drug synthesis. DNA and RNA related 2 heteroatom bases (purines and pyrimidines)

## 2. Natural Products Chemistry(15 h)

Introduction to primary and secondary metabolites: Define primary and secondary metabolites, classes of natural products. The importance of secondary metabolites in living organisms. Chemistry of selected terpenes; Classification of terpenes, identification of isoprene units, structures and functions of terpenes, biosynthesis of mono and sesquiterpenes, commercial significance of terpenes. Chemistry of selected steroids; Identify steroids like cholesterol, testosterone, estrone, etc., describe the biosynthesis pathways of steroids, analyze the roles of steroids in the body, discuss the industrial applications of steroids. Chemistry of selected alkaloids; Identify alkaloids such as ephedrine, nicotine, morphine, etc., Describe the structures and biosynthesis of selected alkaloids, Analyze the pharmacological properties of selected alkaloids, discuss the use of selected alkaloids in traditional medicine and modern pharmaceuticals. Polyketides and phenyl propanoids; Structural features of polyketides and phenyl propanoids, biosynthetic pathways of polyketides and phenylpropanoids, functions and biological activities of polyketides.

### Methods of Teaching and Learning

A combination of lectures, tutorials, discussions.

### Recommended Readings

- Gupta, R. R.; Kumar, M.; Gupta, V. (1998) Heterocyclic Chemistry, 1<sup>st</sup> Edition, Springer.
- Acheson, R.M. (1977). An Introduction to the Chemistry of Heterocyclic Compound, John Wiley & Sons
- W. Voelter, and D. G. Daves, (1984). Biologically active principles of natural products. Georg Thieme Verlag.
- Mann, J.; Davidson, R. S.; Hobbs, J.B.; Banthorpe, D.V.; Harbone, J.B. (1996). Natural Products: Their Chemistry and Biological Significance, Longman.
- Natural Products Chemistry: Sources, Separations and Structures” by R. A. Carlson

## CHE 22032 - Principles of Physical Chemistry III

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|---------------------------------------------|------------------------------------------------------------------------------------------------|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 22032                                                                                      |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Principles of Physical Chemistry III                                                           |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2                                                                                              |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory                                                                                     |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | CHE 12022                                                                                      |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>                                                                                  | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|                                             | 30                                                                                             | -                               | -                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | To provide fundamental knowledge in electrochemistry, phase equilibrium and surface chemistry. |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Continuous Assessments 30%                                                                     |                                 | Final Assessment 70%            |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: determine the electromotive force (emf) of galvanic cells, and apply principles of electrochemistry and thermodynamics to electrochemical cells.
- ILO 2: determine conductivity, molar conductivity of electrolytes, apply Kohlrausch's Law to electrolytes.
- ILO 3: calculate ionic strength, activity coefficient and ion activity
- ILO 4: apply phase rule to systems, calculate changes in thermodynamic parameters during phase transitions.
- ILO 5: explain phase diagrams of multicomponent systems.
- ILO 6: calculate surface tension of liquids using experimental methods,
- ILO 7: perform calculations involving adsorption isotherms in different systems, apply surface phenomena to colloids

### Course Content

#### 1. Introduction to electrochemistry (20 h)

Electrode potential, standard electrode potential and reversible electrode potential; Galvanic cells and electrochemical cells, liquid junction potential and salt bridge cell; Electromotive force (emf) and experimental measurement of cell emf; Applications of emf measurements, types of chemically reversible electrodes (metal, metal ion, metal amalgam, etc.); Thermodynamics of Galvanic cells, construction of Galvanic cells, role of a salt bridge in a cell; The Nernst equation, equilibrium constant of a cell reaction; Applications of emf measurements; Electrochemistry of corrosion, introduction to

the measurement of corrosion rates, passivation, corrosion inhibition; Calculation of activity coefficients, Debye-Huckel limiting and extended laws for activity coefficient; Applications of emf measurements; Batteries and fuel cells; Electrolyte solutions, electrical molar conductivity, conductivity cell, relationship between conductivity and composition of solution, Faraday's law, silver coulometry, ion mobilities, transport numbers, Kohlraush law of independent ionic migration, limiting molar conductivity, Onsager limiting law, determination of limiting molar conductivity of weak and strong electrolytes; Introduction to electrotechnology, metal finishing, electroplating, anodizing, electrolysis, electrocatalysis.

## 2. Phase equilibria (10 h)

Introduction, phase rule, phase transition, first and second order transition; Two component liquid systems: Ideal and non-ideal solutions, zeotropy and azeotropy, distillation of liquid mixtures; Two-component solid-liquid systems: Eutectic mixtures, compound formation, congruent and incongruent melting points; Two component solid solutions; Experimental methods for constructing phase diagrams; Thermal analysis; Henry's Law; Applications of phase equilibria in industry and technology: steam distillation, fractional distillation, metallurgy.

### Methods of Teaching and Learning

A combination of lectures, tutorial discussions.

### Recommended Readings

- Atkins, P; de Paula, J. (2014). Physical Chemistry, 9<sup>th</sup> Edition, W H Freeman

## CHE 22041 - Introduction to Metabolisms in Biochemistry

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|---|---|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 22041   |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Introduction to Metabolism in Biochemistry  |                                 |                                 |                                    |
| <b>Credit value</b>                         | 1   |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory  |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | CHE 11051, CHE 12031  |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>   | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|   | 15  | -                               | 2                               | 50                                 |
| <b>Objective of the<br/>Course Unit</b>     | To provide the students an understanding of how living organisms release & trap energy from biofuels (carbohydrates, lipids and proteins), synthesize important lipids, control metabolisms through hormones. |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Continuous Assessments 30%  |                                 | Final Assessment 70%            |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: explain what is implied by Metabolism and in redox reaction within biological systems
- ILO 2: explain role of glycolysis & TCA in the release of energy from glucose, fructose & galactose (Carbohydrates).
- ILO 3: explain biological process and application of phosphorylation, glycolysis, TCA in biological systems
- ILO 4: explain the Chemiosmotic hypothesis.
- ILO 5: outline the synthesis of fatty acids, triglycerides, Phospholipids, cholesterol & prostaglandins.
- ILO 6: explain the endocrine system, hormones & outline the synthesis of hormones and signal transductions.

### Course Content

#### 1. Pathways for the release of energy from biofuels – (6 h)

The glycolytic pathway: Where it occurs and the significance of phosphorylation of glucose as the first step. The molecular logic behind the reaction sequence of Glycolysis. The redox Rns of glycolysis. Regulation of glycolysis. Substrate level phosphorylation in glycolysis & its significance to maintaining life. Aerobic and anaerobic glycolysis & the significance. The logic behind lactate being produced under anaerobic conditions.

Other pathways connected to intermediates of glycolysis. Entry of pyruvate into TCA – the pyruvate). The Pyruvate dehydrogenase enzyme & the vitamins it requires as co – enzymes & its regulation. The TCA cycle. Where it occurs. Outline of the Rns. of TCA. The redox Rns. of TCA. Substrate level phosphorylation of TCA. Release of CO<sub>2</sub> from TCA. Regulation of TCA. Why TCA is inhibited under anaerobic conditions. Anaplerotic Rns. Oxidation. Release of fatty acids from lipids & entry of fatty acids into mitochondria. Regulation of FA entry into mitochondria. Outline of the  $\beta$  oxidation pathway. Why is it called oxidation. The molecular logic behind the Rn sequence. The redox Rns in pathway. Reason for the inhibition of  $\beta$  oxidation in hypoxia. oxidation of unsaturated fatty acids. Oxidation of fatty acids with odd number of Cs.

Entry of Ac CoA into TCA. Oxidative phosphorylation. Outline of arrangement of components of e transport chain – the 4 complexes. Flow of electrons along e transport chain. Entry of reducing equivalents into e transport chain. Complex 5 and its function. Why this ATP synthesis is called Oxidative phosphorylation. Mitchel's chemiosmotic hypothesis. Inhibitors & uncouplers.

## 2. Lipid biosynthesis (fatty acids, Triglycerides, phospholipids, cholesterol & Prostaglandins) (5 h)

Outline of fatty acid synthesis & regulation. Importance of NADPH. Outline of TG synthesis. Outline of phospholipid synthesis. Outline of cholesterol synthesis. The Rn catalyzed by HMG Co A reductase. Effect of statins & propionic acid on cholesterol synthesis. Outline of prostaglandin synthesis and effect of aspirin.

## 3. Hormones & mechanism of action. (4 h)

The endocrine system. Functions of hormones and their characteristics. Types of hormones / classification. Synthesis of amine & thyroid hormones. Hormone signal transduction process & types.

### Methods of Teaching and Learning

Lectures, SGDs & tutorials.

### Recommended Readings

- Abali, E. E.; Cline, S. D.; Franklin, D. S.; Viselli, S. M. Lippincott® Illustrated Reviews: Biochemistry; Lippincott Williams & Wilkins, 2024
- Rodwell, V. W.; Bender, D. A.; Botham, K. M.; Kennelly, P. J.; Weil, P. A. Harper's Illustrated Biochemistry 31E; 2018.
- Devlin, T. M. Textbook of Biochemistry with Clinical Correlations; Wiley-Liss, 2002
- Nelson, D. L.; Lehninger, A. L.; Cox, M. M. Lehninger Principles of Biochemistry; Macmillan, 2008.

## CHE 22052 - Environmental Chemistry

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|---------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 22052                                                                                                                                                                                                                                                                                                 |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Environmental Chemistry                                                                                                                                                                                                                                                                                   |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2                                                                                                                                                                                                                                                                                                         |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory                                                                                                                                                                                                                                                                                                |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | CHE 11041, CHE 12051, CHE 12022                                                                                                                                                                                                                                                                           |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>                                                                                                                                                                                                                                                                                             | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|                                             | 30                                                                                                                                                                                                                                                                                                        | -                               | 4                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | This course provides an in-depth understanding of the chemical processes and interactions within the atmosphere, water, and soil systems, equipping learners with the knowledge necessary to address environmental challenges, assess pollution, and promote sustainable management of natural resources. |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Continuous Assessments 30%                                                                                                                                                                                                                                                                                |                                 | Final Assessment 70%            |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: Explain the layered structure of Earth's atmosphere and analyze the role of atmospheric phenomena, such as the greenhouse effect and albedo, in Earth's heat balance.
- ILO 2: Evaluate the chemistry of the troposphere, including photochemical reactions, particulate matter dynamics, and their effects on air quality and public health.
- ILO 3: Analyze the stratospheric ozone cycle, including the Chapman cycle and catalytic destruction, to evaluate the effectiveness of international measures like the Montreal Protocol in mitigating ozone depletion.
- ILO 4: Interpret water quality parameters such as pH, BOD, COD, and turbidity to design strategies for assessing and improving aquatic systems' health.
- ILO 5: Construct pH-pE diagrams to illustrate metal speciation
- ILO 6: Recommend appropriate water purification techniques based on an understanding of water pollution sources and chemical treatment methods.
- ILO 8: Evaluate the impact of climate change on aquatic systems and water conservation techniques.
- ILO 7: Assess soil quality parameters and propose sustainable strategies to manage pollution and solid waste, considering natural and anthropogenic influences on the lithosphere.

## Course Content

### 1. Atmospheric chemistry (10 h)

Layered classification of Earth's atmosphere, global temperature from ice ages to present, Wien's displacement law, albedo, Earth's heat balance, the greenhouse effect, and remote measurements of atmospheric composition. Chemistry of the troposphere: atmospheric carbon dioxide, atmospheric methane, atmospheric water vapor, residence time of atmospheric gases, particulate matter (total suspended particulate test, classifications, health risks, residence time calculations), control of particulate emissions, radiative forcing, photochemical reactions in the troposphere, tropospheric ozone, photochemical smog, acid rain, and indoor air pollution. Chemistry of the stratosphere: Dobson unit, Chapman cycle, steady-state concentration of ozone, catalytic destruction of ozone, Montreal Protocol, Freon numbers, and environmentally friendly refrigerants.

### 2. Aquatic Chemistry (10 h)

Introduction to Hydrosphere: Introduction to hydrosphere; Ground and surface water, Fresh water and saline water systems; distribution of fresh water systems on the earth; hydrological cycle; chemistry related to unique properties of water; stratification of lakes; chemical and biochemical processes in water bodies. Dissolved gases, dissolved inorganic salts and organic matter in water: Dissolved gases: Examples; application of Henry's law; effects of dissolution of acidic gases on water quality; buffer capacity due to  $\text{HCO}_3^-$  ions; species distribution diagram for carbonate species. Dissolved inorganic salts: Examples and their effects on water qualities such as salinity, buffer capacity of sea water, alkalinity and hardness. Organic matter: Humic substances and their effects on water quality, introduction to particulate matter. pE-pH diagrams and redox reactions in natural waters: pE-pH diagrams: Definition and importance of pE; relationship between pE and equilibrium constant, pE and  $\Delta G$ ; introduction to pE-pH diagrams; stability limits of water; pE-pH diagram for iron species in water. Redox reactions in natural waters: Chemical species in reducing and oxidizing environment in water; examples for redox reactions in a water body; calculations using the Nernst equation. Water quality parameters and assessment methods: Physical and chemical water quality parameters; collection, storage, preservation & transportation of water samples; water quality assessment methods; calculation of alkalinity, hardness, BOD, COD etc. Chemistry involved in municipal water treatment - water for drinking: Quality of raw water sources; drinking water quality standards; chemistry relevant to physical and chemical treatment methods used in municipal water treatment process. Water pollution and impacts of climate change on water sector: Water pollution: Water pollution due to animal wastes, detergents, chemical industries etc., point sources and nonpoint sources, parameters to describe the pollution level of water; effects of oxygen consuming pollutants on water quality, introduction to waste water treatment technologies. Climate change: possible impacts of climate change on water sector.

### 3. Soil chemistry (10 h)

Introduction to soil chemistry: Introduction to lithosphere; rocks and minerals, soil formation; phases, and composition of soil. Physical properties of soil: Color, soil structures: primary soil particles, soil aggregates; importance of soil structure; soil pores, definition on soil porosity, soil permeability, infiltration rate and their importance, experimental method to determine soil infiltration rate; properties of sand, silt and clay; introduction to bulk density; soil texture: definition, textural classes, determination of soil type using the soil textural triangle; importance of soil texture. Chemical properties of soil: Acidic soils and alkaline soils: Method to measure soil pH, causes of soil acidification, impacts of soil acidity on agriculture and on soil minerals, Remedial measures for soil acidity, introduction to alkaline soils. Ion exchange in soil: Introduction, involvement of minerals, soil organic matter and root hairs in ion exchange processes; formation of permanent negative charge sites on montmorillonite and variable negative charge sites on humic substances; adsorption of cations on to negative sites and cation exchange process; comparison of the structure, cation exchange capacity and other properties of kaolinite with montmorillonite; effect of soil texture on CEC; nutrient uptake by ion exchange; effect of CEC on buffering action of soils; experimental method to determine cation exchange capacity of soil. Effects of quality of irrigation water on soil properties and soil pollution: Effects of quality of irrigation water on soil properties: Effects of salinity, sodium adsorption ratio (SAR), alkalinity, toxic ions, nutrients etc. of irrigation water on properties of soil; Management practices for irrigation water having high SAR. Soil pollution: Soil pollutants, effects of soil pollution.

#### Methods of Teaching and Learning

Classroom teaching, demonstrations, visual aids, field visits and small group discussions.

#### Recommended Readings

- Girard, J., Principles of Environmental Chemistry. Jones & Bartlett Learning: 2013.
- Manahan, S. E., Environmental Chemistry: Eleventh Edition. CRC Press: 2022.
- Martínez, C. E.; McBride, M. B., Environmental Chemistry of Soils. Royal Society of Chemistry: 2023.
- Spósito, G., The Chemistry of Soils. Oxford University Press: 2008.
- Gopalan, R.; Sugumar, R. W., A Laboratory Manual for Environmental Chemistry. I.K. International Publishing House Pvt. Limited: 2013.

## CHE 22061 - Green Chemistry

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|---|--|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 22061  |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Green Chemistry                                  |                                 |                                 |                                    |
| <b>Credit value</b>                         | 1  |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory                                       |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | CHE 11041, CHE 12061                             |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>                                    | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|   | 15   | -                               | -                               | 50                                 |
| <b>Objective of the<br/>Course Unit</b>     | To provide knowledge in green chemistry concepts |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Continuous Assessments 30%                       |                                 | Final Assessment 70%            |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: judge the fate of pollutants using concepts of material balance in the environment;  
 ILO 2: identify different pollutants and their behavior and fate in the environment;  
 ILO 3: explain environmental concerns of chemical industry;  
 ILO 4: Illustrate fundamentals of green chemistry and sustainable technology

### Course Content

#### 1. Material balance in the environment (2 h)

Mass transfer of pollutants in the environment, steady-state conservative systems; non-conservative pollutants: Batch, steady-state and non-steady state systems.

#### 2. Pollutants in the environment (3 h)

Organic pollutants in the environment: Stockholm convention and persistent organic pollutants (POPs); Persistent, bioaccumulative and toxic Pollutants (PBTs); Polychlorinated biphenyls (PCBs); Pesticides in the environment; Dumping of banned chemical weapons of mass destruction; Contaminants of emerging concern (CECs); Pharmaceutical pollutants and endocrine disruptors in aqueous systems; Biogenic and anthropogenic organic chemicals in the atmosphere; Heavy metal pollutants: The big four - cadmium, lead, mercury and arsenic; Industrial explosions and release of chemicals into the environment - Bhopal disaster; Dioxin release (Seveso, Italy); Minamata disease (methyl mercury); Asbestos diseases; Fetal alcohol syndrome; Bioconcentration, biomagnification and bioaccumulation of pollutants in the environment; Nuclear waste: harmful effects of

radiation on humans; Factors influencing radiation damage; Units of radiation; Harmful limits of radiation; Effect of chain reactions and nuclear accidents.

### 3. Risk assessment (3 h)

Epidemiologic rate comparison: 2×2 matrix method, relative risk, attributable risk, and odds ratio; Dose response assessment - dose response curves for acute toxicity; Median lethal dose and lethal concentration; Carcinogens: UC EPA classification and NIH classification of carcinogens; Potency factor for carcinogens; Incremental lifetime cancer risk; Chronic daily intake; Non-carcinogenic toxins: reference dose and hazard quotient; Exposure limits: permissible exposure limit; Short-term exposure limit; Immediately dangerous to life and health; Signal words: Caution, warning and danger.

### 4. Waste management (2h)

Types of solid waste: industrial, municipal, hazardous, radioactive and clinical; Treatment (processing) of solid waste: composting and biogas production, monitoring environmental impact and quality assurance.

### 5. Fundamentals of green chemistry and sustainable technology (5h)

Fundamentals: concept of green chemistry; Green solvents, earth-friendly plastics, replacing chlorine, replacing toxic materials and environmentally benign pesticides; Carbon footprint and carbon neutrality; Renewable energy: Importance of renewable energy; Biofuels and green fuels; Sustainable consumption and production: Five axioms of sustainability; Putting sustainability into practice.

## Methods of Teaching and Learning

Classroom discussions, Tutorial discussions, Quizzes, Take home assignments, VLE, LMS based independent learning activities, Interactive videos

## Recommended Readings

- Girard, J. E.; Girard, J., Principles of Environmental Chemistry. Jones & Bartlett Learning: 2014.
- Manahan, S. E., Environmental Chemistry, Eighth Edition. Taylor & Francis: 2004.
- Sotheeswaran, S. "Environmental Organic Chemistry" 03<sup>rd</sup> Edition, 2012, Institute of Chemistry Publications, Monograph No: 11

## CHE 22071 - Physical Chemistry Laboratory

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|                                             |                                                                                                                                                    |                                 |                                         |                                    |
|---------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|-----------------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 22071                                                                                                                                          |                                 |                                         |                                    |
| <b>Course Unit Name</b>                     | Physical Chemistry Laboratory                                                                                                                      |                                 |                                         |                                    |
| <b>Credit value</b>                         | 1                                                                                                                                                  |                                 |                                         |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory                                                                                                                                         |                                 |                                         |                                    |
| <b>Prerequisites</b>                        | CHE 11061                                                                                                                                          |                                 |                                         |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>                                                                                                                                      | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b>         | <b>Notional learning<br/>hours</b> |
|                                             | -                                                                                                                                                  | 45                              | -                                       | 50                                 |
| <b>Objective of the<br/>Course Unit</b>     | To provide skills needed to conduct experiments in Physical Chemistry, collect data and estimate parameters, estimate errors and make predictions. |                                 |                                         |                                    |
| <b>Evaluation Method</b>                    | Attendance 10 %<br>Quizzes/Mid-term Assessment 20%                                                                                                 |                                 | Lab Reports 10%<br>Final Assessment 60% |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: Learn to setup experiments, make measurements
- ILO 2: Learn to control conditions during experiments
- ILO 3: Calculate physical parameters using graphical representation of data.
- ILO 4: Identify the sources of errors
- ILO 5: Analyze errors, and propagation of errors

### Course Content

#### Error Calculations (3 h)

Estimation of errors in physical chemistry measurements, Propagation of errors, Graphical methods

#### Experiments (30 h)

Practical sessions covering thermodynamics (Enthalpy change, Gibbs energy change and entropy change), equilibria (Equilibrium constant, temperature dependence), chemical kinetics (order, rate constant, Arrhenius activation energy), phase equilibria (Solid-liquid Composition-temperature phase diagrams, electrochemistry (conductivity, potentiometry), spectroscopy (Optical absorption, Beer-Lambert law, calibration plot).

### **Methods of Teaching and Learning**

Practical sessions (12-14 sessions), pre lab quizzes, laboratory reports, discussions and demonstrations..

### **Recommended Readings**

- Shoemaker, D.P., Garland, C.W. and Nibler, J.W. (1996). Experiments in physical chemistry. McGraw-Hill, New York.

## APM 22082 - Computer Based Tools for Management

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|   |  |                                 |                                 |                                    |
|---|--|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | APM 22082  |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Computer Based Tools for Management  |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2  |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory   |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | None   |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>  | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|   | 30   | -                               | -                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | To equip students with the skills to develop, analyze, and present business models using spreadsheet tools, VBA programming, and decision-support applications for effective managerial decision-making. |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Final Assessment 100%  |                                 |                                 |                                    |

### Intended Learning Outcomes (ILO)

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

ILO 1: apply Visual Basics and spreadsheet modeling in business;

ILO 2: utilize Excel as a decision-making support tool;

ILO 3: emphasize the use of Excel to document and demonstrate models.

### Course Content

#### 1. Spreadsheet modelling for managerial applications (15 h)

Introduction to spreadsheet modelling using Visual Basic for Applications (VBA) to model and solve complex real-world problems in operations research, operations management, statistics, supply chain management, economics, human resource management, and finance.

#### 2. Decision modelling, simulation, and risk analysis (15 h)

Managerial decision modelling, decision making under uncertainty, VBA for simulation and decision making: Goal seek, data tables/scenario manager, solver, precision tree, risk and uncertainty via @Risk, RISK optimizer for Excel.

### Methods of Teaching and Learning

Lectures, in-class discussion of cases, self-study and mini-projects, computer assisted learning

### **Recommended Readings**

- Winston, W and Christian, A S (2009), Practical Management Science, Revised, 3<sup>rd</sup> Edition.
- Winston, WL ( 2007), Microsoft® Office Excel® 2007: Data Analysis and Business Modelling, Microsoft Press.
- Christian A S (2007), VBA for Modelers: Developing Decision Support Systems with Microsoft® Excel, Thomson, Brooks/Cole.
- Stephen, G P and Kenneth, R B (2010), Management Science The Art of Modeling with Spreadsheets 3<sup>rd</sup> Edition.

## APM 22092 - Operations Management

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|---------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | APM 22092                                                                                                                                                                                    |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Operations Management                                                                                                                                                                        |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2                                                                                                                                                                                            |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory                                                                                                                                                                                   |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | None                                                                                                                                                                                         |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>                                                                                                                                                                                | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|                                             | 30                                                                                                                                                                                           | -                               | -                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | To introduce students to the principles, practices, and strategic role of operations management, enabling them to plan, design, and control manufacturing and service processes effectively. |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Final Assessment 100%                                                                                                                                                                        |                                 |                                 |                                    |

### Intended Learning Outcomes (ILO)

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

ILO 1: define the role of operations in an organization;

ILO 2: demonstrate basic competencies in planning and controlling of manufacturing and service operations.

### Course Content

#### 1. Basics of operations management (15 h)

Introduction to operations management, background and development of production management systems, product design and process selection, strategic capacity planning, and quality management.

#### 2. Operations planning, design, and control (15 h)

Facility and work design, plant location and supply chain design, materials planning and control, managing inventories in supply chains, forecasting and demand planning, operations scheduling and sequencing, and recent trends in operations management.

### Methods of Teaching and Learning

Lectures, case analysis and industry visits and product design and development case analysis

**Recommended Readings**

- Stevenson W, (2014), Operations Management, 12<sup>th</sup> Edition, McGraw Hill.
- Chase, J and Aquilano ( 2006), Operations Management for competitive advantage, 11<sup>th</sup> Edition, McGraw Hill–Irwin.

## SUP 22101 - Mathematics for Chemistry II

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|---|--|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | SUP 22101  |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Mathematics for Chemistry II                               |                                 |                                 |                                    |
| <b>Credit value</b>                         | 1  |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory   |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | ENH 11111  |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>  | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|   | 15   | -                               | -                               | 50                                 |
| <b>Objective of the<br/>Course Unit</b>     | To provide students with basic knowledge on matrix algebra |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Final Assessment 100%                                      |                                 |                                 |                                    |

### Intended Learning Outcomes (ILO)

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

ILO 1: solve problems related to vectors in chemistry

ILO 2: perform operations of matrices and determinants

ILO 3: solve chemistry problems involving matrices and determinants

### Course Content

#### 1. Vectors (4 h)

Introduction to vectors, cross product, dot product; Argand diagrams, applications relevant to chemistry

#### 2. Matrices (4 h)

Definition of a matrix, types of matrices, transpose, inverse, diagonal and unit matrix, Addition, subtraction and multiplication of matrices

#### 3. Determinants (2h)

Determinants of a 2 x 2, 3 x 3 matrices, rules of determinants, minors and cofactors, applications in chemistry

#### 4. Applications and Problem solving (5 h)

Applications of matrices, determinants, in solving problems in Quantum Mechanics,

Molecular Symmetry, etc.

### **Methods of Teaching and Learning**

Interactive lectures, Classroom discussions, Tutorial discussions, Quizzes, Take home assignments, VLE, LMS based independent learning activities, Interactive videos

### **Recommended Readings**

- Smith, R. T.; Minton, R. B. (2004). Calculus: Concepts & Connections, 1<sup>st</sup> Edition, McGraw-Hill
- Himonas, A.; Howard, A. (2002). Calculus: Ideas & Applications, Abridged Edition, John- Wiley
- Connelly, J. A.; Fratangelo, R. A. (1979). Elementary Technical Mathematics with Calculus, Macmillan

## ENH 22111 - English for Scientific Writing

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|---------------------------------------------|----------------------------------------------------------------------------|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | ENH 22111                                                                  |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | English for Scientific Writing                                             |                                 |                                 |                                    |
| <b>Credit value</b>                         | 1                                                                          |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Enhancement                                                                |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | ENH 11122                                                                  |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>                                                              | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|                                             | 30                                                                         | -                               | -                               | 50                                 |
| <b>Objective of the<br/>Course Unit</b>     | To provide the basic English language skills needed for scientific writing |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Continuous Assessments                                                     |                                 |                                 |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: attain at least an upper-intermediate proficiency in the four language skills: listening, speaking, reading and writing;
- ILO 2: be competent in the use of compound and complex sentence structures;
- ILO 3: use of advanced vocabulary in writing tasks individually;
- ILO 4: be able to make speeches (prepared and impromptu) and presentations;
- ILO 5: be competent language users related to their professional environments;
- ILO 6: be able to use English in subjects related to Science and Management;
- ILO 7: be able to effectively write, understand, conceptualize and analyse information through charts, tables, diagrams and graphs;
- ILO 8: transfer information into another format or mode.

### Course Content

#### 1. Effective presentations (Theory: 2 h; Practical: 5 h)

Introduction to the course, presentation skills and introducing the standard format for a presentation.

#### 2. Academic writing I (Theory: 2 h; Practical: 5 h)

Preparing, analyzing and describing charts, tables, graphs, processes and diagrams; Developing skills in referencing (adhere to the accepted method).

#### 3. Academic writing II (Theory: 2 h; Practical: 5 h)

Writing a literature review on a given topic and preparing a paper which is to be presented;  
Use of proper citations and quotations according to the accepted referencing method.

#### 4. Academic writing III (Theory: 1 h; Practical: 5 h)

Data interpretation and research ethics.

#### Methods of teaching and learning

The eclectic approach will be used in teaching English to promote skills of conceptualization as well as a learner-centered approach in the teaching-learning process. The lecturer will incorporate the suitable methods and strategies such as task-based language learning to guarantee the best possible learning experience. The lecturer will particularly focus on individual, pair and group work, incorporate teaching approaches such as known-to-unknown and learning to learn and will consider the different learning styles of the students (multiple intelligences) in the teaching-learning process.

#### Recommended readings

- Evans, T.D. & Bates, M. (1976). Nucleus: General Science: English for Science and Technology. New York: Prentice Hall Press.
- Hewings, M. (2002). Advanced English Grammar. Cambridge: Cambridge University Press.
- Maciver, A. (1986). The New First Aid in English. Glasgow: Robert Gibson & Sons, Ltd.
- Meldrum, J. (2013). Speak Now: Communicate with Confidence. Oxford: Oxford University Press.
- Richards, J.C. New Interchange: English for International Communication. New Delhi: Cambridge University Press India Pvt. Ltd.
- Soars, L & Soars, J. (2009). American Headway: The World's Most Trusted English Course. Oxford: Oxford University Press.
- Soars, L & Soars, J. (2003). New Headway: Advanced Workbook with Key. Oxford: Oxford University Press.

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# LEVEL 3

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## CHE 31012 - Advanced topics in Inorganic Chemistry-I

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|---|--|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 31012  |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Advanced Topics in Inorganic Chemistry-I   |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2  |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory   |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | CHE 12012, CHE 22012   |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>  | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|   | 30   | -                               | 4                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | This course unit is designed to provide skills in interpretation/prediction of spectroscopic data of inorganic molecules and advanced knowledge in organotransition metal compounds. |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Continuous Assessments 30%   |                                 | Final Assessment 70%            |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: explain the theories of UV-visible, IR, NMR, ESR, NQR and Mossbauer spectroscopy  
 ILO 2: Determine structures of inorganic complexes using various spectroscopic methods  
 ILO 4: explain metal-ligand bonding for various ligands  
 ILO 5: identify type of organometallic reaction involved in a given reaction  
 ILO 6: design suitable catalysts for selected industrial synthesis processes

### Course Content

#### 1. Physical methods in inorganic chemistry (15 h)

Energy requirements for different transitions, Introduction to various types of spectroscopic methods for structure elucidation of inorganic molecules/complexes

UV-visible spectroscopy: Theory, Frank-Condon Principle, spin and Laporte selection rules for electronic transitions and deviations, d-d transitions vs, charge transfer transitions, factors affecting the energy requirements of charge transfer transitions

IR spectroscopy: Theory, Potential energy curve, molecular vibrations, Fundamental transitions, overtone bands and combination bands, bond dipole moment vs. molecular dipole moment, types of vibrational modes, selection rule, IR vibrational modes of homonuclear and heteronuclear diatomic molecules, polyatomic molecules, determination of molecular geometry through IR vibrations, Factors affecting IR frequency, fingerprint for molecular identifications.

NMR spectroscopy: Selection rules, Chemically and magnetically equivalent nuclei, splitting tree diagrams, spin decoupling, theory and application of NMR spectroscopy for inorganic compounds/transition metal complexes containing (i) spin  $\frac{1}{2}$  nuclei (e.g.  $^1\text{H}$ ,  $^{19}\text{F}$ ,  $^{31}\text{P}$ ,  $^{195}\text{Pt}$  etc.) (ii) spin  $>1/2$  nuclei (e.g.  $^{11}\text{B}$ ,  $^{14}\text{N}$ ), fluxional molecules

Electron paramagnetic resonance spectroscopy (EPR): Instrumentation, selection rules, g-factor, hyperfine coupling and Zero field splitting, electron-nucleus hyperfine interaction, hyperfine splitting involving (i) more than one equivalent proton (ii) n-number of non-equivalent protons, (iii) several sets of non-equivalent protons, Kramer's degeneracy, (iv) nuclei with spin  $>1/2$

Nuclear quadrupole resonance (NQR) spectroscopy: Instrumentation, Theory and selection rule, structural information from NQR.

Mossbauer spectroscopy: Instrumentation, Theory, Mossbauer spectroscopy for Fe and Sn compounds/complexes

## 2. Advanced organotransition metal chemistry (15 h)

Metal-ligand bonding: ligands; dinitrogen ( $\text{N}_2$ ), isocyanide (RNC), nitric oxide (NO), thiocarbonyls (CS), carbenes, carbynes, alkynes, ( $\eta^1$  and  $\eta^3$ ) allyl,  $\eta^4$ -cyclobutadienyl,  $\eta^3$ -cyclopentadienyl anion,  $\eta^6$ -benzene,  $\eta^6$ -cycloheptatriene,  $\eta^7$ -cycloheptaphenylcation.

Reactivity patterns of organometal compounds: Oxidative addition, reductive elimination, elimination ( $\alpha$ ,  $\beta$ ,  $\gamma$ , E), insertion, association, dissociation, substitution, oxidative coupling).

Homogeneous catalysis: Free energy change profiles for catalyzed and non-catalyzed reaction, industrial application, alkene isomerization, alkene hydrogenation, alkene hydroformylation, alkene hydrocyanation, alkene hydrosilation, Monsanto acetic acid synthesis, alkene oligomerization, water-gas shift reaction, olefin metathesis, Heck reaction, Wacker process.

Heterogeneous catalysis: Industrial application; Alkene polymerization (Ziegler-Natta Catalysis), Fischer-Tropsch synthesis.

### Methods of Teaching and Learning

A combination of lectures, tutorials, peer assisted student support sessions and small group discussions.

### Recommended Readings

- Drago, R. (2012). Physical Methods in Inorganic Chemistry, East-West Press (Pvt.) Ltd., New York.
- Perera, K.S.D. "Inorganic NMR Spectroscopy", Institute of Chemistry Ceylon, Monograph No 25
- Parish R. V. (1990). NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic

Chemistry, E. Horwood

- Housecroft, C. E., and Alan G Sharpe, A. G. (2012), *Inorganic chemistry*, 4<sup>th</sup> Edition. Pearson, England
- Atkins, P.W.; Overton, T.L.; Rourke, J. P.; Weller, M. T.; Armstrong, F. (2010). *Shriver & Atkins Inorganic Chemistry*, 5<sup>th</sup> Edition, W. H. Freeman and Company, New York
- Garry M. L., Donald A. T., “*Inorganic Chemistry*” 4<sup>th</sup> Edition, (2010), Prentice Hall

**CHE 31022 -**  
**Physical Organic Chemistry, Pericyclic Reactions and**  
**Advanced Natural Products Chemistry**

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|                                        |                                                                                                                                                                                                   |                             |                             |                                |
|----------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|-----------------------------|--------------------------------|
| <b>Course Unit Code</b>                | CHE 31022                                                                                                                                                                                         |                             |                             |                                |
| <b>Course Unit Name</b>                | Physical Organic Chemistry, Pericyclic Reactions and Advanced Natural Products Chemistry                                                                                                          |                             |                             |                                |
| <b>Credit value</b>                    | 2                                                                                                                                                                                                 |                             |                             |                                |
| <b>Compulsory/Elective/Enhancement</b> | Compulsory                                                                                                                                                                                        |                             |                             |                                |
| <b>Prerequisites</b>                   | CHE 22022                                                                                                                                                                                         |                             |                             |                                |
| <b>Hourly breakdown</b>                | <b>Theory</b>                                                                                                                                                                                     | <b>Practical / Tutorial</b> | <b>Independent learning</b> | <b>Notional learning hours</b> |
|                                        | 30                                                                                                                                                                                                | -                           | -                           | 100                            |
| <b>Objective of the Course Unit</b>    | To expose students to correlation of structure of organic compounds to reactivity; to aspects of Pericyclic Reactions; extended knowledge of biosynthesis, synthesis and uses of Natural Products |                             |                             |                                |
| <b>Evaluation Method</b>               | Continuous Assessments 30%                                                                                                                                                                        |                             | Final Assessment 70%        |                                |

### Intended Learning Outcomes (ILO)

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

- ILO 1: correlate free energy changes with structural changes for a given reaction;  
 ILO 2: predict the effect of solvents and isotopes on reactivity of organic reactions;  
 ILO 3: determine the mechanism and products formed in concerted reactions;  
 ILO 4: predict biosynthetic pathways for a given secondary metabolite.

### Course Content

#### 1. Physical organic chemistry (10 h)

Linear free energy relationships: Quantitative treatment of the effects of structures on reactivity, use of Hammett equation, substituent constant  $\sigma$ ,  $\sigma_+$ ,  $\sigma_-$ , reaction constant  $\rho$  and its significance and applications, free energy diagrams, failures and modifications of Hammett equation Yukawa-Tsuno equation and its applications, use of  $\sigma_+$ ,  $\sigma_-$  values, Taft equation, steric effects in organic reactions; solvent and kinetic effects on reactivity: Protic, aprotic and dipolar aprotic solvents on reactivity, significance and application of  $m$  and  $\gamma$  constants, kinetic isotopic effect, two phase reactions in organic chemistry.

#### 2. Pericyclic reactions (10 h)

Cycloaddition, electrocyclic and sigmatropic reactions, aromaticity, anti-aromaticity, molecular orbitals of conjugated polyenes and allyl systems, correlation diagrams, concept

of HOMO and LUMO - Fuki frontier orbital approach; Selection rules and stereochemistry of electrocyclic reactions, cycloadditions and sigmatropic shifts, applications of frontier molecular orbital approach, correlation diagram approach, Hückel-Mobius approach; Sommelet-Hauser, Cope and Claisen rearrangements.

### 3. Natural products chemistry (10 h)

Advanced extraction and separation methods in of Natural Products Chemistry. Screening natural products. Detailed study of biosynthetic pathways of selected natural products, Chemical and pharmaceutical uses of natural products. Industrial applications of natural products, biopesticides. Value addition to natural products.

#### Methods of Teaching and Learning

A combination of lectures, tutorials, and discussions.

#### Recommended Readings

- Isaacs, N. (1996). Physical Organic Chemistry, 2<sup>nd</sup> Edition, Prentice Hall.
- Costa, M.D.P. De (2010). Pericyclic reactions. Theory and Applications, Revised Edition, Institute of Chemistry Ceylon, Monograph 22.
- W. Voelter, and D. G. Daves, (1984). Biologically Active Principals of Natural Products. Georg Thieme Verlag.
- Mann, J.; Davidson, R. S.; Hobbs, J.B.; Banthorpe, D.V.; Harbone, J.B. (1996). Natural Products: Their Chemistry and Biological Significance, Longman.
- Lewis Mander and Hung-wen Liu; Natural Products: Chemistry and Biology

## CHE 31032 - Quantum Chemistry and Molecular Spectroscopy

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|   |   |                                 |                                 |                                    |
|---|---|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 31032   |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Quantum Chemistry and Molecular Spectroscopy                                |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2   |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory  |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | CHE 21022   |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>   | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|   | 30  | -                               | -                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | Provide advanced knowledge in quantum mechanics and molecular spectroscopy. |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Continuous Assessments 30%  |                                 | Final Assessment 70%            |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: apply Schrödinger equation to such as harmonic oscillator, rigid rotor, H atom and use approximation methods to solve problems in quantum mechanics.
- ILO 2: apply molecular orbital and bonding information to calculate energies of He-like atoms.
- ILO 3: apply symmetry and group theory to predict IR and Raman activity of molecules.
- ILO 4: demonstrate the applicability of microwave, infrared, and Raman spectroscopy to various molecular systems.
- ILO 5: Explain the action of different types of lasers.

### Course Content

#### 1. Quantum Chemistry (15 h)

Harmonic oscillator model, rigid rotor model and angular momentum; Application of the Schrodinger equation to the hydrogen atom, energy levels and stationary states of the hydrogen atom; probabilistic aspects and orbital shapes, effect of a magnetic field on energy levels; Approximate methods, perturbation theory and variation method; Introduction to quantum chemical calculations on atoms and molecules; Born Oppenheimer approximation, Definition of atomic units and status of quantum chemical calculations on helium atom; Application of the above method for multi – electronic systems. Huckel

molecular orbital theory.

## 2. Symmetry and group theory (10 h)

Applications of molecular symmetry, group multiplication and character tables, two dimensional irreducible representations, prediction of IR/Raman active vibrational modes.

## 3. Molecular spectroscopy (15 h)

Spectral lines, line width and intensity. Vibration-rotation spectroscopy of diatomic and poly atomic molecules, Application of Born Oppenheimer approximation, selection rules, origin of P, Q and R branches; Vibrations in polyatomic molecules: Vibrational degrees of freedom, fundamentals, hot bands, overtones in IR spectra; Applications of IR spectroscopy in structure determination of molecules.

Selection rules and effect of nuclear spins on linear molecules with center of symmetry; Raman spectroscopy: Classical and quantum theory of Raman effect, polarization effects, vibration using IR and Raman data, rotational and vibrational Raman spectroscopy.

Electronic spectroscopy of diatomic molecules, vibrational coarse structure, rotational fine structure, Frank Condon Principle, dissociation energy and dissociation products.

Introduction to Lasers, principles of LASER operations: The nature of stimulated emission.

Resonators and pumping processes, coherent radiation, standing waves and nodes, the kinetics of laser emission, rate equations, threshold conditions, pulsed vs. continuous emissions, transitions, lifetimes and line widths, three-level and four-level lasers.

### Methods of Teaching and Learning

A combination of lectures, tutorials, discussions.

### Recommended Readings

- Atkins, P.W.; Paula, J. D. (2009). Atkins Physical Chemistry, 9<sup>th</sup> Edition, Oxford University Press.
- Levine, I. N. (2008). Quantum Chemistry, 6<sup>th</sup> Edition, Prentice Hall.
- McQuarrie, D. A. (2007). Quantum Chemistry, 2<sup>nd</sup> Edition, University Science Books.
- Vincent, A. Molecular Symmetry & Group Theory (2013) Wiley.
- Davidson, G. (1991). Introductory Group Theory for Chemists, Springer Nature.
- Engle, T. (2012). Quantum Chemistry and Spectroscopy, 3<sup>rd</sup> Edition, Pearson
- Struve, W. S. (1989). Fundamentals of Molecular Spectroscopy, John Wiley & Sons, Inc.
- Pavia, D.L.; Lampman, G.M.; Kriz, G.S.; Vyvyan, J.R. (2007). Introduction to Spectroscopy, 4<sup>th</sup> Edition, Cengage Learning Products.
- Ball, D.W. (2009). The Basics of Spectroscopy, PHI Learning Pvt Ltd.

## CHE 31042 - Electroanalytical Chemistry and Optical Spectroscopy

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|---------------------------------------------|-----------------------------------------------------------------------------------------------------------------|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 31042                                                                                                       |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Electroanalytical Chemistry and Optical Spectroscopy                                                            |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2                                                                                                               |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory                                                                                                      |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | CHE 21022, CHE 22032                                                                                            |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>                                                                                                   | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|                                             | 30                                                                                                              | -                               | 4                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | To offer a foundational understanding of electroanalytical techniques and optical spectroscopy instrumentation. |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Continuous Assessments 30%                                                                                      |                                 | Final Assessment 70%            |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: apply electroanalytical techniques for quantitative and qualitative analysis
- ILO 2: comprehend the factors that must be controlled to obtain reliable and reproducible electroanalytical data
- ILO 3: identify basic components in optical spectrometry
- ILO 4: illustrate optical configurations in molecular absorption spectrometry
- ILO 5: explain the concept of Fourier transform and FTIR instrumentation
- ILO 6: employ signal to noise ratio in instrumental analysis

### Course Content

#### 1. Electroanalytical chemistry (10 h)

Electrodes and potentiometry; Reference electrodes: Calomel electrode, Silver/ silver chloride electrode, liquid junction potentials, double junction reference electrodes; Indicator electrodes: Metallic indicator electrodes; Metal electrodes of the first kind, second kind and redox electrodes; Membrane electrodes: Ion selective electrodes; Response and selectivity of ion selective electrodes; Ion selective electrodes of different types; Glass electrodes, solid state electrodes, liquid-liquid electrodes, precipitate electrodes, compound electrodes; Ion selective field effect transistors; Gas sensing probes; Direct potentiometric measurements; Potentiometric titrations. Electrogravimetry and coulometric methods of analysis: Current-voltage relationship during electrolysis, Ohmic potential drop, concentration polarization, kinetic polarization, over potential, problems associated with two-electrode cells, three-electrode cells and control potential electrolysis.

Coulometry: Controlled working electrode potential Coulometry, Coulometric titrations, mediators. Classical polarography and miscellaneous methods; Chemical analysis using polarography and its limitations; Modified polarographic techniques: Tast Polarography, normal and differential pulse polarography, square wave polarography. Voltammetry: Anodic and cathodic stripping voltammetry, potentiometric stripping analysis; Potential sweep methods: Linear sweep and cyclic voltammetry at solid electrodes; Reversible, irreversible and quasi reversible voltammograms; Randles – Sevcik equation; Mechanistic studies using voltammetry; Amperometry: Amperometric titrations and biamperometry; Voltammetry under convection control; Introduction to convective systems; Hydrodynamic voltammetry; Rotating disk electrode voltammetry; Levich equation; Rotating ring disk electrode voltammetry; Chemical analysis and mechanistic studies using rotating disk electrode voltammetry.

## 2. Optical spectroscopy (8 h)

Optical configuration of basic optical spectrometers: Optical configuration of spectrometers, radiation sources: Thermal and photon emitters, properties of an ideal radiation source; Wavelength selection devices, absorption filters, interference filters, prism and grating monochromators, order sorting, resolution of a monochromator; Spectral bandwidth and effective spectral bandwidth; Transducers: Thermal and photon detectors, photo multiplier tubes, photoconductive cells, photodiode detectors, photodiode array detectors, charge transfer devices.

## 3. Molecular absorption and luminescence spectrometry (4 h)

UV-Vis instrumentation: Single beam, double beam in space, double beam in time UV-Vis spectrometers; Radiation sources in UV-Vis spectrometry, photometric and spectrophotometric titrations; Stray light; Deviation of Beer's law; Instrumentation of luminescence spectroscopy; Absorption vs fluorescence; Collection of a fluorescence spectrum; Fluorimeters and spectrofluorometers; Basics of phosphorimetry.

## 4. Vibrational spectroscopy: instrumentation (4 h)

IR sources, Transducers and detectors. Fourier-transform interferometry and Michelson interferometer; Sample handling in IR spectrometry; Direct IR and reflectance IR spectrometry; Attenuated total reflectance (ATR) and diffuse reflectance.

## 5. Signal and noise in instrumental analysis (4 h)

Signal-to-noise ratio; Sources of noise in instrumental analysis; Instrumental noise: Thermal, shot and flicker noise; Environmental noise; Signal-to-noise enhancement: Grounding and shielding, modulation, synchronous demodulation; Averaging methods.

### Methods of Teaching and Learning

A combination of classroom teaching, demonstrations, visual aids, spreadsheet application workshops and small group discussions.

**Recommended Readings**

- Harris, D. C. (2010). Quantitative Chemical Analysis, 8<sup>th</sup> Edition, W. H. Freeman.
- Robinson, J. W.; Frame, E. M. S.; Frame, G. M., (2004). Undergraduate Instrumental Analysis. 6 ed.; Taylor & Francis.
- Christian, G. D.; Dasgupta, P.; Schug, K., Analytical Chemistry (2013), 7<sup>th</sup> Edition. Wiley Global Education
- Skoog, D. A.; Holler, F. J.; Crouch, S. R. (2007). Principles of Instrumental Analysis, 6<sup>th</sup> Edition, Thomson Brooks/Cole.

## CHE 31052 - Polymer Chemistry

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|   |   |                                 |                                 |                                    |
|---|---|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 31052   |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Polymer Chemistry   |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2   |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory  |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | CHE 12022, CHE 21022  |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>   | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|   | 30  | -                               | -                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | To provide foundational knowledge and practical insight into the synthesis, properties, and applications of polymers, essential for innovations in materials science. |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Continuous Assessments 30%  |                                 | Final Assessment 70%            |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: describe the structure and function of natural polymers
- ILO 2: compare different polymerization reactions
- ILO 3: express the size of polymer molecules in terms of their molecular weight
- ILO 4: identify the differences in behaviour and molecular structure of thermoplastic and thermosetting polymers
- ILO 5: identify functional requirement and applications of conducting polymers

### Course Content

#### 1. Polymer vs. simple molecules (4h)

History of the development of polymers, hydrocarbon molecules, polymer molecules, chemistry of polymer molecules, classification of polymers, natural polymers vs. synthetic polymers, plastics vs. elastomers.

#### 2. Polymerization reactions and mechanisms (4h)

Introduction to addition polymerization, condensation polymerization, ionic polymerization, coordination polymerization, copolymerization.

#### 3. Molar mass of polymers (6h)

Molecular weight of polymers vs. simple molecules, number average molecular weight, weight average molecular weight, viscosity average molecular weight, polydispersity

index, distribution of molecular weight of a typical polymer, practical importance of polymer molar mass.

**4. Microstructure of polymers (4h)**

Molecular shape of polymers, molecular structure of polymers, different types of polymer configurations, geometrical isomerism in polymers, different types of copolymers.

**5. Thermal behavior of polymers (4h)**

Thermoplastic and thermosetting polymers, thermal behaviour of polymers: glass transition temperature, crystallization temperature, melting temperature.

**6. Crystallinity of polymers (4h)**

Morphology of amorphous polymers and semi-crystalline polymers, polymer crystallinity, defects in polymer crystals.

**7. Conducting polymers (4h)**

Synthesis, characteristics and applications

**Methods of Teaching and Learning**

Lectures, tutorial discussions, small group discussions and computer assisted learning

**Recommended Readings**

- Odian, G. (2004). Principles of polymerization. Hoboken, N.J.: Wiley-Interscience. ISBN: 978-0-471- 27400-1
- Young, R. and Lovell, P. (2011). Introduction to polymers. Boca Raton: CRC Press. ISBN-13: 978- 0849339295

## CHE 31062 - Advanced Physical Chemistry Laboratory

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|---------------------------------------------|------------------------------------------------------------------------|---------------------------------|-----------------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 31062                                                              |                                 |                                         |                                    |
| <b>Course Unit Name</b>                     | Advanced Physical Chemistry Laboratory                                 |                                 |                                         |                                    |
| <b>Credit value</b>                         | 2                                                                      |                                 |                                         |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory                                                             |                                 |                                         |                                    |
| <b>Prerequisites</b>                        | CHE 12022, CHE 22032, CHE 22061                                        |                                 |                                         |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>                                                          | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b>         | <b>Notional learning<br/>hours</b> |
|                                             | -                                                                      | 90                              | 4                                       | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | To develop laboratory skills and computational chemistry competencies. |                                 |                                         |                                    |
| <b>Evaluation Method</b>                    | Attendance 10 %<br>Quizzes/Mid-term Assessment 20%                     |                                 | Lab Reports 10%<br>Final Assessment 60% |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: perform experiments to determine thermodynamic and kinetic parameters
- ILO 2: simulate experimental data using computational modeling
- ILO 3: compare various experimental methods and results
- ILO 4: obtain hands on experience on different instruments used in physical chemistry laboratory
- ILO5: apply computer-based software to analyze data

### Course Content

#### Experiments (60 h)

Advanced Physical Chemistry Experiments on, Chemical kinetics, Thermodynamics, Phase equilibria, Electrochemistry: conductometry, potentiometry, voltammetry, Spectrometry (Colorimetry), computational chemistry and quantum chemistry, Surface and colloidal chemistry

### Methods of Teaching and Learning

15 practical sessions and writing lab reports

### Recommended Readings

- Experiments in physical chemistry, 7th Edition, Garland, C. W., Nibler, J. W & Shoemaker, D. P., New York, McGraw-Hill, 2002

- Experimental Physical Chemistry: A Laboratory Textbook, 3rd Edition, A. Halpern and G. McBane, W. H. Freeman, 2006.
- Physical Chemistry, 5<sup>th</sup> Edition, Robert J Silbey Robert A Alberty, George A Papadantonakis, and Mounji G Bawendi, John Wiley Sons, 2022

## CHE 31071 - Advanced Biochemistry I

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|   |  |                                 |                                 |                                    |
|---|--|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 31071  |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Advanced Biochemistry – I  |                                 |                                 |                                    |
| <b>Credit value</b>                         | 1  |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory   |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | CHE 11061, CHE 12061   |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>  | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|   | 15   | -                               | -                               | 50                                 |
| <b>Objective of the<br/>Course Unit</b>     | To provide the students with a basic understanding of structure & function of the main lipoproteins, endogenous & exogenous strong oxidants, their effects & their neutralization and unique metabolisms of microbes and plants. |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Continuous Assessments 30%   |                                 | Final Assessment 70%            |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: Explain why lipoproteins are present, types and functions, synthesis and clinical correlations
- ILO 2: List the types of lipoproteins.
- ILO 3: Name the naturally occurring strong oxidants and explain biological role and pathways associate.
- ILO 4: Explain the glyoxylate cycle and Photosynthetic process.
- ILO 5: Describe the fermentation processes using microbes

### Course Content

#### 1. Lipoproteins (4 h)

Necessity for lipid transport & problems associated with transport of lipids in blood. Structure of Chylomicrons, VLDL & HDL. Functions & metabolism of chylomicrons, VLDL & HDL. Uptake of LDL into tissues. Harmful & beneficial lipoproteins.

#### 2. Strong oxidants & Oxidative Stress (Redox Biology) (3 h)

Strong oxidants (naturally arising & exogenous - including lipid based free radicles arising from lipid peroxidation) and their effects on body.

Hexose monophosphate (HMP) pathway & its role in oxidative stress mitigation.

### 3. Microbial and Plant Metabolism (8 h):

Entner-Duodoroff pathway of gram-negative bacteria. Glyoxylate cycle. Photosynthesis. Fermentation. Production of ethanol by yeast. Production of foods – yogurt, cheese. Weizmann process (acetone-butanol-ethanol fermentation).

#### Methods of Teaching and Learning

A combination of lectures, tutorials, discussions.

#### Recommended Readings

- Abali, E. E.; Cline, S. D.; Franklin, D. S.; Viselli, S. M. Lippincott® Illustrated Reviews: Biochemistry; Lippincott Williams & Wilkins, 2024.
- Rodwell, V. W.; Bender, D. A.; Botham, K. M.; Kennelly, P. J.; Weil, P. A. Harper's Illustrated Biochemistry 31E; 2018.
- Devlin, T. M. Textbook of Biochemistry with Clinical Correlations; Wiley-Liss, 2002
- Nelson, D. L.; Lehninger, A. L.; Cox, M. M. Lehninger Principles of Biochemistry; Macmillan, 2008.

## CHE 31081 - Advanced Inorganic Chemistry Laboratory

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|---------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|-----------------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 31081                                                                                                                                                                                                                                                 |                                 |                                         |                                    |
| <b>Course Unit Name</b>                     | Advanced Inorganic Chemistry Laboratory                                                                                                                                                                                                                   |                                 |                                         |                                    |
| <b>Credit value</b>                         | 1                                                                                                                                                                                                                                                         |                                 |                                         |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory                                                                                                                                                                                                                                                |                                 |                                         |                                    |
| <b>Prerequisites</b>                        | CHE 11061, CHE 12061                                                                                                                                                                                                                                      |                                 |                                         |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>                                                                                                                                                                                                                                             | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b>         | <b>Notional learning<br/>hours</b> |
|                                             | -                                                                                                                                                                                                                                                         | 45                              | -                                       | 50                                 |
| <b>Objective of the<br/>Course Unit</b>     | To provide skills needed to design and synthesize Inorganic complexes, analyze them using different characterization techniques and application of chromatographic methods and solvent extraction for separation of selected metal cations from a mixture |                                 |                                         |                                    |
| <b>Evaluation Method</b>                    | Attendance 10 %<br>Quizzes/Mid-term Assessment 20%                                                                                                                                                                                                        |                                 | Lab Reports 10%<br>Final Assessment 60% |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1 apply different methodologies to synthesize and purify Inorganic complexes
- ILO 2 interpret the theory behind the formation of them.
- ILO 3 analyze the results obtained from different characterization techniques
- ILO 4 apply chromatographic methods and solvent extraction in separations/identification

### Course Content

#### Experiments (30 h)

Synthesis of octahedral and tetrahedral complexes having monodentate ligands; synthesis of chelate complexes, geometrical isomers and optical isomers; recrystallization. Characterization of selected complexes using IR, UV-Vis, AAS, conductivity, oxidation-reduction potentials; Determination of electronic properties of the complexes. Chromatographic methods for identification and separation of selected metal cations (Paper chromatography and ion exchange chromatography); determination of concentration spectrophotometrically. Solvent extraction for separation of metal cations. Analysis of a mineral. Green synthesis of nanoparticles of a metal (e.g. copper) and characterization.

### **Methods of Teaching and Learning**

A combination of laboratory classes with pre-laboratory and post-laboratory assignments and laboratory reports.

### **Recommended Readings**

- Pass, G. and Sutcliff, H. Practical Inorganic Chemistry; 1974, Chapman & Hall, London.
- Jeffry G. H., Basset J., Mendhan J. Denny R.C.; Vogels Textbook of Quantitative Inorganic Analysis.

## CHE 31091 - Industrial Analytical & Environmental Chemistry Laboratory

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|   |   |                                 |   |                                    |
|---|---|---------------------------------|---|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 31091   |                                 |   |                                    |
| <b>Course Unit Name</b>                     | Advanced Inorganic Chemistry Laboratory                               |                                 |   |                                    |
| <b>Credit value</b>                         | 1   |                                 |   |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory  |                                 |   |                                    |
| <b>Prerequisites</b>                        | CHE 11061, CHE 12061  |                                 |   |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>   | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b>         | <b>Notional learning<br/>hours</b> |
|   | -   | 45                              | -                                       | 50                                 |
| <b>Objective of the<br/>Course Unit</b>     | To provide practical skills in analytical and environmental chemistry |                                 |   |                                    |
| <b>Evaluation Method</b>                    | Attendance 10 %<br>Quizzes/Mid-term Assessment 20%                    |                                 | Lab Reports 10%<br>Final Assessment 60% |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: demonstrate skills of independently operating basic analytical instrumentation
- ILO 2: assess quality of water, air and soil
- ILO 3: carryout sampling, preservation and storage in a correct way
- ILO 4: develop an analytical method to meet required quality assurance parameters
- ILO 5: assess quality of water, air and soil
- ILO 6: analyze results by data processing of basic software packages

### Course Content

#### 1. Analytical chemistry laboratory (20 h)

Solvent extractions of metals by chelation, pharmaceutical analysis, hadrochemical analysis of irrigation water samples, analytical method validation, fluorescence spectrophotometry, Use of basic software packages for data processing and reporting of analytical results.

#### 2. Environmental chemistry laboratory (20 h)

Techniques for collection of environmental samples (air, water and soil); air sample analysis, on-site water quality measurements, Sample preparation and sample storage; Study of quality of water, rain water analysis by atomic absorption spectrometry, determination of chemical oxygen demand,

**Methods of Teaching and Learning**

Classroom teaching, demonstrations, visual aids, spreadsheet application workshops and small group discussions.

**Recommended Readings**

- Harris, D. C. (2010). Quantitative Chemical Analysis, 8<sup>th</sup> Edition, W. H. Freeman.
- Robinson, J. W.; Frame, E. M. S.; Frame, G. M., (2004). Undergraduate Instrumental Analysis. 6 ed.; Taylor & Francis.
- Christian, G. D.; Dasgupta, P.; Schug, K., Analytical Chemistry (2013), 7<sup>th</sup> Edition. Wiley Global Education
- Skoog, D. A.; Holler, F. J.; Crouch, S. R. (2007). Principles of Instrumental Analysis, 6<sup>th</sup> Edition, Thomson Brooks/Cole.

## CHE 32012 - Advanced Synthetic Organic Chemistry

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|---------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 32012                                                                                                                         |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Advanced Synthetic Organic Chemistry                                                                                              |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2                                                                                                                                 |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory                                                                                                                        |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | CHE 21012, CHE 22022                                                                                                              |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>                                                                                                                     | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|                                             | 30                                                                                                                                | -                               | -                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | To expose students' intermediate level and advanced aspects of synthetic organic chemistry and modern trends of organic chemistry |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Continuous Assessments 30%                                                                                                        |                                 | Final Assessment 70%            |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: Explain the science of complex molecule synthesis with the strategic use of some reactions in synthesis
- ILO 2: Explain the strategies to enhance the efficiency of multistep organic synthesis
- ILO 3: Describe the developing trends in small molecular synthesis
- ILO 4: Explain the use of modern methods in organic synthesis that are more efficient, specific, safer and environmentally friendly

### Course Content

#### 1. Foundations of Organic Synthesis and Retrosynthesis (5 h)

Introduction: History of organic synthesis (historical prospects and Pioneers of organic synthesis), Selectivity in synthesis (chemoselectivity and regioselectivity), synthetic methods and general strategies (Linear and convergent synthesis), synthesis efficiency (step economy and overall yield).

Retrosynthetic Analysis:

Concepts and strategies of disconnection approach, C-X disconnection strategies, 1,3 and 1,2 di-functional relationship, C-C single bond disconnection, C-C double bond disconnection, C-O and C-N bond disconnection.

## 2. Carbon–Carbon Bond Formation and Olefination Reactions (6 h)

C-C bond forming reactions:

Enolate chemistry and C-C bond forming reactions, organolithium reagents, and cuprates (1,2- and 1,4 additions to carbonyls), 1,2-, 1,4-,1,5- and 1,6-dioxygenated systems. Reversal of polarity.

Alkene and Alkyne synthesis:

C-C double bond forming reactions, modifications to Wittig reaction, Peterson olefination and Julia coupling reactions.

## 3. Ring Synthesis, Oxidation and Reduction Methods (5 h)

Ring synthesis: 3 membered rings (Epoxides, aziridines and cyclopropanes, Simmons Smith reaction, chemistry of sulfur ylides), 5 and 6 membered rings, Cycloadditions and cyclizations: Baldwin's rules and selected macrocyclic synthesis.

Oxidation and reduction reactions in organic chemistry: Selective oxidation reactions (Dess-Martin and Swarn oxidation), selective reductions, Hydride and modified hydride based reducing agents.

## 4. Modern Synthetic Strategies and Organometallic Chemistry (5 h)

Strategic use of protecting groups in organic synthesis, Silicon based protecting groups, protecting group free synthesis.

Selected examples from multistep syntheses of natural products and drugs.

Organometallic reagents in organic synthesis: Transition metals and organometallic reagents in organic synthesis, General Organometallic reaction mechanisms, Pd Catalyzed cross coupling reactions, Cross metathesis and ring closing metathesis (RCM). Selected examples from metal based organic reagents.

## 5. Multicomponent and Solid-Phase Synthesis (5 h)

Multicomponent reactions (MCRs) in organic synthesis

General introduction to MCRs in organic synthesis: Concepts and discovery of MCRs, Aryne based MCRs, Ugi-Smiles and Passerini-Smiles and Mannich reactions and few other selected MCRs from the recent literature, 1,3-dicarbonyls in MCRs, Synthesis and functionalization of heterocycles using MCRs, Applications of MCRs in complex molecular synthesis (Selected recent examples from the literature.

Solid phase organic synthesis (SPOS): General methods of SPOS, (solid supports and linkers used in SPOS), Reaction monitoring and separation techniques used in SPOS, Solid phase Peptides synthesis (SPPS)

Combinatorial synthesis: Concepts and principles in combinatorial chemistry, Combinatorial library synthesis (scaffold-based libraries and backbone-based libraries, Synthesis methods

in combinatorial chemistry (split-pool-synthesis and parallel synthesis, solid phase combinatorial, Synthesis and solvent phase combinatorial synthesis), Characterization methods of combinatorial libraries

#### 6. Green and Two-Phase Organic Synthesis (4 h)

Green and solvent free organic synthesis: Green Chemistry Principles, Applications of green solvents and solvent free methods in organic synthesis Alternative solvent free methods (ionic liquids, fluorinated solvents, bio-solvents),

Two phase reactions in organic chemistry: Phase-Transfer Catalysis, Catalytic Two-Phase Reactions of Carbanions and Other Organic Anions, Catalytic Two-Phase Alkylation of Organic Anions.

#### Methods of Teaching and Learning

A combination of lectures, tutorials, discussions.

#### Recommended Readings:

- Organic synthesis, The Disconnection Approach, Stuart Warren, Paul Wyatt, 2008, John Wiley & Sons Ltd.
- Green Techniques for Organic Synthesis and Medicinal Chemistry, Wei Zhang, Berkeley W. Cue JR., 2012, John Wiley & Sons Ltd.
- Combinatorial Chemistry, Synthesis, Analysis, Screening, Gunther Jung., 2001, Wiley-VCH.
- Multicomponent Reactions in Organic Synthesis, Jieping Zhu, Qian Wang, Meixiang Wang., 2015, Wiley-VCH.
- Solid phase synthesis: A practical guide, Fernando Albericio, 2000, CRC press
- Current Review articles on specific topics

## CHE 32021 - Supramolecular Chemistry

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|---|---|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 32021   |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Supramolecular Chemistry  |                                 |                                 |                                    |
| <b>Credit value</b>                         | 1   |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory  |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | CHE 21012, CHE 22022  |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>   | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|   | 15  | -                               | -                               | 50                                 |
| <b>Objective of the<br/>Course Unit</b>     | To expose students' intermediate level and advanced aspects of synthetic organic chemistry and modern trends of organic chemistry |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Continuous Assessments 30%  |                                 | Final Assessment 70%            |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: Explain the science of complex molecule synthesis with the strategic use of some reactions in synthesis
- ILO 2: Explain the strategies to enhance the efficiency of multistep organic synthesis
- ILO 3: Describe the developing trends in small molecular synthesis
- ILO 4: Explain the use of modern methods in organic synthesis that are more efficient, specific, safer and environmentally friendly.

### Course Content

#### 1. Introduction and Intermolecular Forces (4 h)

Introduction and concepts: Development, Terminology and definitions in supramolecular chemistry, Nature of supramolecular interactions, Solutions and intermolecular forces, Solvent and solution properties, Intermolecular forces (Ion pairing, ion-dipole and dipole-dipole interactions, hydrogen bonding, pi interactions), Binding (binding constants, physical methods for binding constant determination).

#### 2. Recognition Systems and Self-Assembly (5 h)

Concepts of supramolecular chemistry: Host-Guest chemistry, Classification of Host-Guest complexes, binding constant-K, Macrocyclic effect and chelation effect, Magnitude of binding in host-guest complexes.

Molecular recognition: The Lock and Key Analogy, Complementarity and preorganization, Shapes and homochirality, Molecular recognition in water, the hydrophobic effect, coordination chemistry and the chelate effect, Cooperativity and multivalency.

### 3. Host–Guest Chemistry and Molecular Recognition (3 h)

Spherical recognition, Anion recognition, Multiple recognition, Amphiphilic receptors, determination of strength of supramolecular interactions, Solvation and Hydrophobic effect.

Molecular Self-assembly: Self-assembly process, Calixarenes, Rotaxans and molecular machines.

### 4. Analysis and Applications of Supramolecular Chemistry (3 h)

Methods of analyzing supramolecules: Microscopy, NMR, UV-VIS, CD and IR spectroscopy.

Applications of supramolecular chemistry: Supramolecular reactivity and Catalysis, Supramolecular transport processes and carrier design, other new practical applications of supramolecular chemistry.

## Methods of Teaching and Learning

A combination of lectures, tutorials, discussions

## Recommended Readings

- Organic synthesis, The Disconnection Approach, Stuart Warren, Paul Wyatt, 2008, John Wiley & Sons Ltd.
- Green Techniques for Organic Synthesis and Medicinal Chemistry, Wei Zhang, Berkeley W. Cue JR., 2012, John Wiley & Sons Ltd.
- Combinatorial Chemistry, Synthesis, Analysis, Screening, Gunther Jung., 2001, Wiley-VCH.
- Multicomponent Reactions in Organic Synthesis, Jieping Zhu, Qian Wang, Meixiang Wang., 2015, Wiley-VCH.
- Solid phase synthesis: A practical guide, Fernando Albericio, 2000, CRC press
- Current Review articles on specific topics

## CHE 32033 - Seminar Presentations and Essays

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|---------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 32033                                                                                                                             |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Seminar Presentations and Essays                                                                                                      |                                 |                                 |                                    |
| <b>Credit value</b>                         | 3                                                                                                                                     |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory                                                                                                                            |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | ENH 11122, ENH 22101                                                                                                                  |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>                                                                                                                         | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|                                             | 15                                                                                                                                    | -                               | 40                              | 150                                |
| <b>Objective of the<br/>Course Unit</b>     | To provide knowledge and train students to search literature, prepare and deliver presentations, write reports and design experiments |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Continuous Assessments 30%                                                                                                            |                                 | Final Assessment 70%            |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: develop a research proposal for an identified research problem;
- ILO 2: carry out a complete literature survey;
- ILO 3: interpret the research data using statistical tools;
- ILO 4: identify the requirement for scientific writing;
- ILO 5: cite references in a scientific document using a proper style;
- ILO 6: identify the ethical issues with respect to research.
- ILO 7: survey scientific literature critically;
- ILO 8: prepare an overview of the relevant literature for a specific research topic;
- ILO 9: deliver a scientific presentation.

### Course Content

#### 1. Scientific method

Identification of a problem, building a hypothesis, designing experiments to test the hypothesis, analyze data, interpret data, draw conclusions, publish results.

#### 2. Literature survey

Search scientific literature, critical understanding, and organize collected information.

#### 3. Scientific writing

Identify major components in a research paper, details to be included in each section.

**4. Research proposal writing**

Major components to be included in a research proposal.

**5. Research ethics**

Practical applications of statistics, graphing, spreadsheet analysis, multi-variant analysis.

**6. Data analysis**

Honesty, objectivity, integrity, openness, respect for intellectual property, confidentiality, authorship of a publication.

**7. Research presentations**

Writing a dissertation/publication and an oral presentation in a scientific way.

Search, select and gather information and organize information on a given topic selected by an academic staff member; Prepare a suitable presentation and present it to an audience of academics; Submission of a survey report.

**Methods of Teaching and Learning**

Lectures, tutorials, assignments, self-studying, Group work, Literature survey, self-study, small group discussion, use of feedback from appointed academic staff member.

**Recommended Readings**

- The ACS Style Guide: effective Communication of Scientific information, An American Chemical Society presentation.
- Anne M Coghill, Lorrin R Garson. (2006). American Chemical Society.
- review article on a selected topic, identified by a senior academic staff member and other related literature.
- Text books, research papers, review articles related to a given topic.

## CHE 32042 - Advanced Coordination Chemistry

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|   |   |                                 |                                 |                                    |
|---|---|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 32042   |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Advanced Coordination Chemistry   |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2   |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory  |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | CHE 31012   |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>   | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|   | 30  | -                               | 4                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | To provide students with a deeper understanding of the behaviour and reactions of transition metal complexes and their importance in modern inorganic, industrial, biological, and materials chemistry. |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Mid-Semester Assessment 30%   |                                 | Final Assessment 70%            |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: apply Molecular Orbital Theory to construct molecular orbital diagrams for M-L bonding in transition metal complexes
- ILO 2: interpret electronic spectra of coordination complexes
- ILO 3: explain substitution reactions in square planar and octahedral coordination complexes
- ILO 4: predict possible electron transfer reactions between octahedral complexes
- ILO 5: predict possible mechanism for reactions of coordination complexes

### Course Content

#### 1. Molecular Orbital Theory (MOT) for Transition Metal Complexes (5 h)

Limitations of Crystal Field Theory; requirements for effective overlapping of atomic orbitals, introduction to symmetry adapted linear combination of atomic orbitals (SALC) and ligand group orbitals (LGOs), symmetry labels of LGOs and metal atomic orbitals, formation of bonding, antibonding and nonbonding molecular orbitals from LGOs and metal orbitals.

Construction of molecular orbital energy level diagrams for metal-ligand bonding: Oh transition metal complexes having (i) M-L sigma bonding only (ii) M-L  $\pi$ -bonding involving (a)  $\pi$ -donor ligands (b)  $\pi$ -acceptor ligands; filling electrons, colours of selected examples. Electronic spectra of octahedral and tetrahedral transition metal complexes:

Multi electron systems; Russel Saunders coupling, Microstates, construction of a table of microstates. Introduction to Term symbols, determination of term symbols and the Ground state terms

## 2. Electronic spectra of octahedral and tetrahedral transition metal complexes (6 h)

Electronic spectral features of 1<sup>st</sup> row transition metal complexes, Types of transitions, Spin and Laporte selection rules; Energy level diagram for (i) d<sup>1</sup> ion in an oh field (ii) d<sup>2</sup>, d<sup>3</sup>, d<sup>7</sup> and d<sup>8</sup> ions (high spin) in octahedral field; Orgel diagrams, assigning of possible electronic transitions in electronic spectra using Orgel diagrams; Racah parameters, Calculation of Racah parameters, Tanabe Sugano diagrams; Evidence for M-L covalent bonding; Nephelauxetic effect,

## 3. Kinetics and Mechanisms of reactions of coordination complexes (10 h)

Stoichiometric and intimate mechanisms related to substitution reactions of square planar and octahedral complexes (A, D, Ia, Id), kinetic and thermodynamic aspects of reactivity of complexes; Activation parameters.

Substitution reactions of square planar complexes: General rate law, intimate mechanisms, factors affecting rates of square planar substitution reaction.

## 4. Substitution reactions of octahedral complexes (5 h)

Water exchange, acid hydrolysis, base hydrolysis and anation reactions, rate laws and their interpretation, Eigen- Wilkins mechanism, leaving and entering group effects, effects of spectator ligands, steric effects, effect of charge, stereochemical changes in octahedral substitution; Mechanism of isomerization.

## 5. Electron transfer reactions between octahedral complexes (4 h)

Elementary steps and rate expressions for outer sphere and inner sphere mechanism, Frank Condon principle, Marcus Theory.

### Methods of Teaching and Learning

Lectures, tutorials, peer assisted student support sessions and small group discussions.

### Recommended Readings

- Drago, R. (2012). Physical Methods in Inorganic Chemistry, East-West Press (Pvt.) Ltd., New York.
- Atkins, P.W.; Overton, T.L.; Rourke, J. P.; Weller, M. T.; Armstrong, F. (2010). Shriver & Atkins Inorganic Chemistry, 5<sup>th</sup> Edition, W. H. Freeman and Company, New York.
- Garry M. L., Donald A. T., "Inorganic Chemistry" 4<sup>th</sup> Edition, (2010), Prentice Hall.
- Crabtree R. (2019), Organometallic Chemistry of the Transition Elements, 7<sup>th</sup> ed. Wiley, 2019.

## CHE 32052 - Advanced Topics in Physical Chemistry I

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|---------------------------------------------|---------------------------------------------------------------------------------------------------------------|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 32052                                                                                                     |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Advanced Topics in Physical Chemistry I                                                                       |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2                                                                                                             |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory                                                                                                    |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | CHE 21022                                                                                                     |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>                                                                                                 | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|                                             | 30                                                                                                            | -                               | -                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | To provide knowledge on advanced concepts in electrochemistry, thermodynamics and statistical thermodynamics. |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Continuous Assessments 30%                                                                                    |                                 | Final Assessment 70%            |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: interpret electrochemical systems using fundamental theories;
- ILO 2: demonstrate the formation of electric double layer; apply rules of electron transfer to electrode reactions.
- ILO 3: apply thermodynamics to predict spontaneity of reactions and calculate various thermodynamic parameters.
- ILO 4: apply Lagrange's method of undetermined multipliers to derive partition function.
- ILO 5: derive thermodynamic properties using statistical mechanics.

### Course Content

#### 1. Advanced electrochemistry (10 h)

The non-structural treatment of ion solvent interactions, Born model, thermodynamics of ion-solvent interactions, ion solvation and solvation number; Debye Hückel theory of ion-ion interactions, activity, activity coefficient and ion-ion interaction, mean activity, limiting and extended forms of Debye-Huckel equation; Electrode-electrolyte interface, electrocapillary equation, experimental evaluation of surface excess, charge density and interfacial capacitance; Structure, theories and models of electrical double layer: Helmholtz-Perrin model, Gouy-Chapman model, Gouy-Chapman-Stern model, Grahame model, Bockris-Devanathan- Muller model, zeta potential; Kinetics of electrode reactions: One step-one electron process, standard rate constant and transfer coefficient, implications of the Butler-Volmer model for the one step-one electron transfer process: Equilibrium condition, exchange current, current over potential equation and characteristics, charge

transfer resistance, Tafel plots.

## 2. Advanced thermodynamics (10h)

Free energy functions: Helmholtz free energy  $A$  and Gibbs free energy  $G$ ; Spontaneity and reversibility; The four fundamental thermodynamic equations; Temperature, volume and pressure coefficients of  $\Delta A$  and  $\Delta G$ ; Maxwell relationships; Thermodynamic equation of state; Gibbs-Helmholtz equation; Standard free energies; Univariant phase transformations: Clapeyron and Clausius-Clapeyron equation; Colligative properties: Ebullioscopy and cryoscopy; Derivation of equation for free energy changes in general chemical reactions in terms of activity/fugacity; Relationship between standard free energy change and equilibrium constant, influence of temperature on equilibrium constant.

## 3. Statistical thermodynamics (10h)

Introduction to statistical thermodynamics, quantum mechanical picture of a system of non-interacting particles, configuration, weight of a configuration, Lagrange's method of undetermined multipliers to find the most probable distribution, molecular partition function, Boltzmann Factor, molecular partition function, translational and vibrational partition functions, distinguishable and indistinguishable particles, concept of ensemble, canonical ensemble, systems partition function, statistical entropy, calculation of thermodynamic parameters. Definitions of micro-canonical and grand-canonical ensembles.

### Methods of Teaching and Learning

Lectures, tutorial discussions

### Recommended Readings

- Atkins, P.; de Paula, J. (2014). Physical Chemistry, 9<sup>th</sup> Edition, W H Freeman.
- Levine, I.N. (2007). Physical Chemistry, 5<sup>th</sup> Edition, Tata McGraw-Hill.
- Ott, J. B.; Goates, J. B. (2000). Chemical Thermodynamics Principles and Applications, 1st Edition, Academic Press.
- Terrell L. Hill. Introduction to Statistical Thermodynamics, Dover Publications.
- Advanced Chemical Thermodynamics, CHU 3030, Open University of Sri Lanka.
- Seddon, J.M. and Gale, J.D. (2004). Thermodynamics and Statistical Mechanics. RSC Publications.

## CHE 32062 - Advanced Chromatography

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|---|---|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 32062   |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Advanced Chromatography   |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2   |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory  |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | CHE 21032   |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>   | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|   | 30  | -                               | 4                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | To provide a fundamental understanding of chromatographic instrumental analysis, related hyphenated techniques and methods of preparative chemical separation for chromatographic analysis. |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Mid-Semester Assessment 30%   |                                 | Final Assessment 70%            |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: appraise principles, instrumentation, and operation and troubleshooting of gas chromatography and high-performance liquid chromatography
- ILO 2: compare different mass analyzers, detectors and different operations of mass spectrometry
- ILO 3: appraise hyphenated chromatographic techniques in analysis
- ILO 4: compare extraction and cleanup techniques for different residues
- ILO 5: propose and justify analytical methodologies to determine an analyte in a given matrix
- ILO 6: describe basic instrumentation of basic mass spectrometry
- ILO 7: Explain the principles of thermal analytical method

### Course Content

#### 1. Gas chromatography and high-performance liquid chromatography (12 h)

Components and their functions of a GC: Gas-liquid chromatography and gas-solid chromatography; GC columns: Packed and open tubular columns: Wall-coated, support-coated and porous-layer open tubular columns; Polarities of open tubular columns, common stationary phases, typical column lengths; Sample injection in GC: Split, splitless and on-column injection; Carrier gasses in GC and the application of Deemter equation in GC; Retention index; GC detectors: Types of detectors, applications and sensitivities: Thermal conductivity, flame ionization, flame photometric, electron capture, nitrogen-

phosphorus, etc.; Method development in GC analysis; GC troubleshooting.

Components and their functions in a HPLC system: HPLC columns: Packing material for reversed and normal phase HPLC, particle diameter, guard columns; HPLC mobile phases: Common mobile phases, mixed mobile phases, selecting a mobile phase, degassing of solvents; HPLC pumping systems: Basic requirements of the pumping system, types of pumps and advantages and disadvantages, reciprocation pump, displacement pump, pneumatic pump; HPLC sample injection: Six port injection valve and its mechanism; Extra column dispersion; HPLC detectors: UV-Vis detectors, fixed wavelength and multi wavelength detectors, fluorescence detectors, refractive index detectors, evaporative light scattering detectors; HPLC troubleshooting; densitometry, HPLC, FPLC, MPLC.

## 2. Other chromatographic methods (2 h)

Ion chromatography: Ion pair chromatography, ion exclusion chromatography, ion exchange chromatography, detectors in ion exchange chromatography, role of ion suppressors in ion exchange chromatography.

## 3. Molecular mass spectrometry (6 h)

Components of a mass spectrometer; Ionization methods: Electron impact, electro spray ionization, atmospheric pressure chemical ionization, desorption electro spray ionization and matrix assisted laser desorption ionization; Hard and soft ionization; Selecting a ion source. Mass analyzers: Quadrupole, time of flight, ion trap, magnetic sector and Fourier transform ion cyclotron resonance; Scan, selected ion monitoring and multiple reaction monitoring mass spectrometry; Tandem mass spectrometry: Triple quadrupole, quadrupole-time of flight mass spectrometers; Chromatography hyphenated with mass spectrometry: GC/MS, LC/MS, GC/MS/MS, LC/MS/MS.

## 5. Preparative chemical separation and chromatographic method development (6 h)

Benefits of sample preparation: Making the sample suitable for analysis, trace enrichment, elimination of matrix interferences and sensitivity enhancement; Overview of sample pretreatment process: Sample collection, storage and preservation, transport, preliminary sample processing, extraction and derivatization; Preliminary sample processing; Method validation: Extraction efficiency, matrix effect and method detection limit; Extraction of non-volatiles and semi-volatiles in liquid samples: Liquid-liquid extraction (LLE), discontinuous and continuous LLE; Solid phase extraction (SPE): Types of SPE, five steps of reversed phase SPE and dispersive SPE; Extraction of non-volatiles and semi-volatiles in solid samples: Solid-liquid extraction, soxhlet extraction, super critical fluid extraction and pressurized liquid extraction; Extraction of volatiles: Grab sampling, impinging, solid phase trapping, static headspace analysis, purge and trap, pyrolysis, solid phase micro extraction (SPME); Active and passive SPME.

## 6. Introductory Thermal analysis (4 h)

Thermogravimetry (TG) and derivative thermogravimetry (DTG), differential thermal analysis (DTA) and differential scanning calorimetry (DSC); Theoretical aspects of thermometric titrimetry, thermometric titration in non-aqueous systems; Catalytic thermometric titrimetry; Aqueous system and the application in analysis of coloured industrial effluents; Direct injection enthalpimetry, unfavorable kinetics and the development direct injection enthalpimetry (DIE); Applications of DIE in clinical area.

### **Methods of Teaching and Learning**

Classroom teaching, demonstrations, visual aids and small group discussions.

### **Recommended Readings**

- Christian, G. D.; Dasgupta, P. K.; Schug, K. A. Analytical Chemistry; Wiley, 2013
- Skoog, D. A.; Holler, F. J.; Crouch, S. R. Principles of Instrumental Analysis; Cengage Learning, 2017
- Harris, D. C.; Lucy, C. A. Quantitative Chemical Analysis; W. H. Freeman, 2019
- Bruno, T. J.; Robinson, J. W.; Frame, G. M.; Frame, E. M. S. Undergraduate Instrumental Analysis; CRC Press, 2023

## CHE 32072 - Advanced Organic Chemistry Laboratory

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|---------------------------------------------|------------------------------------------------------------|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 32072                                                  |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Advanced Organic Chemistry Laboratory                      |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2                                                          |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory                                                 |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | CHE 11022                                                  |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>                                              | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|                                             | -                                                          | 90                              | 4                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | To develop advanced practical skills in organic chemistry. |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Attendance 10 %                                            |                                 | Lab Reports 10%                 |                                    |
|                                             | Mid-term Assessment 20%                                    |                                 | Final Assessment 60%            |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: synthesize heterocyclic compounds and carry out a photochemical reaction
- ILO 2: identify natural products using chromatographic and spectroscopic techniques
- ILO 3: apply environmental friendly methodologies in the organic synthesis
- ILO 4: present results of the group assignments based on natural products
- ILO 5: prepare a report and a presentation on the chemical processes involved in the manufacture of products of a particular industry

### Course Content

#### Experiments

Multi step synthesis. Synthesis heterocyclic compounds. Photochemical reactions in organic synthesis.

Extraction methods and purification methods, soxhlet extraction, cold finger, column chromatography and preparative plate chromatography. Distillation, steam distillation and fractional distillation, microwave assisted synthesis of organic compounds.

Phytochemical screening for classes of natural products (alkaloids, steroids, terpenoids, flavonoids and saponins).

Visits to chemical based and natural product industries; Group assignment based on visits.

**Methods of Teaching and Learning**

A combination of laboratory classes, combination of pre-laboratory and post laboratory assignments, laboratory reports.

**Recommended Readings**

- Schoffstall, A. M.; Barbara, B. A.; Gaddis, A.; Druelinger, M.L.; Schoffstall, A.; Gaddis, B.; Druelinger, M. (2004). *Microscale and Miniscale Organic Chemistry Laboratory Experiments*, 2<sup>nd</sup> Edition, Mc- Grawhill.
- Pavia, D.L.; Lampman, G.L.; Kriz, G.S.; Engel, R.G. (1999). *Introduction to Organic Laboratory Techniques: A Microscale Approach*, 3<sup>rd</sup> Edition, Brooks/Cole.
- Moting, J. R.; Mofrill, T. C.; Hammond, C. N.; Neckers, D. C. (1999). *Experimental Organic Chemistry*, Freeman.
- Williamson, K.L. (1994). *Macroscale and Microscale Organic Experiments*, 2<sup>nd</sup> Edition, Heath and Company.

## CHE 32081 - Biochemistry Laboratory

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|---|--|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 32081  |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Biochemistry Laboratory  |                                 |                                 |                                    |
| <b>Credit value</b>                         | 1  |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory   |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | CHE 11051, CHE 12031   |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>  | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|   | -  | 45                              | 10                              | 50                                 |
| <b>Objective of the<br/>Course Unit</b>     | To develop basic practical skills in Biochemical analysis and biological sample processing |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Attendance 10 %  |                                 | Lab Reports 10%                 |                                    |
|   | Mid-term Assessment 20%  |                                 | Final Assessment 60%            |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: Apply biochemical analytical techniques such as titrimetric, colorimetric, and spectrophotometric methods to quantitatively estimate carbohydrates, proteins, lipids, and nucleic acids in biological samples
- ILO 2: Demonstrate competency in qualitative and quantitative separation techniques
- ILO 3: Interpret experimental results by comparing standard curves, calculating concentrations, and analyzing biochemical properties
- ILO 4: Relate biochemical principles to biological samples by evaluating the composition of real specimens such as milk and urine for their sugar, protein, and metabolite content.
- ILO 5: Develop laboratory skills and good practices including accurate pipetting, preparation of reagents, handling of biomolecules, and safe use of equipment.
- ILO 6: Integrate knowledge of biochemical assays with physiological and clinical contexts by assessing diagnostic parameters relevant to health and disease.

### Course Content

#### Experiments

Estimation of Carbohydrates (Total and Reducing Sugars, Sucrose and Starch by Ferricyanide Method)

Quantitative Estimation of Reducing Sugars: Using the DNS (dinitro salicylic acid) method or

Fehling's solution to determine reducing sugar concentration

Estimation of Glucose by the Glucose Oxidase Method: A spectrophotometric assay to measure glucose levels.

Estimate the Protein Quantitatively in the given sample By Lowry'S Method.

Determination of the acid value of the given fats or oil sample and determine of saponification value of the given fats or oil sample.

Separation and identification of amino acids by ascending paper chromatography Separation and thin layer chromatography.

Quantification of DNA by UV Spectrophotometry; Measure DNA concentration using absorbance at 260 nm Agarose Gel Electrophoresis experiment.

Estimation of sugar and protein content in a milk sample; dialysis practical for proteins and small molecules; Sephadex gel chromatography for separation of proteins; quantification of urease activity using a microplate reader; and analysis of a urine sample for proteins, sugars, and ketone bodies.

### **Methods of Teaching and Learning**

A combination of laboratory classes, combination of pre-laboratory and post laboratory assignments, laboratory reports..

### **Recommended Readings**

- Varley's Practical Clinical Biochemistry. 6<sup>th</sup> Edition by Allen H Gowenlock (2006) CBS Publication and Distributors (Indian Reprint)
- Williamson, K.L. (1994). Macroscale and Microscale Organic Experiments, 2<sup>nd</sup> Edition, Heath and Company.

## ENH 32091 - Industrial Training

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|---------------------------------------------|-----------------------------------------------------------------------------------|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | ENH 32091                                                                         |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Industrial Training                                                               |                                 |                                 |                                    |
| <b>Credit value</b>                         | 1                                                                                 |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Enhancement                                                                       |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | CHE 31012                                                                         |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>                                                                     | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|                                             | -                                                                                 | 60                              | 40                              | 50                                 |
| <b>Objective of the<br/>Course Unit</b>     | To provide a training on industrial process, management and environmental aspects |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Industrial supervisor                                                             |                                 |                                 |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: work in industry as a team player or a leader
- ILO 2: identify problems in industrial processes
- ILO 3: conduct literature survey related to an industrial problem
- ILO 4: undertake industrial projects independently
- ILO 5: carry out measurements, analyze data and perform statistical treatment and interpret
- ILO 6: write reports and present the outcome of industrial project

### Course Content

Students must identify an industry, write a brief report on the nature of training and handover to the course coordinator. Once approval is granted, the project must be carried out under a supervisor from industry. The course coordinator will assign an internal supervisor when necessary.

### Methods of Teaching and Learning

Working in an industrial setup

### Recommended Readings

- Literature relevant to the industrial project

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# LEVEL 4

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## CHE 41012 - Special Topics in Inorganic Chemistry

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|---|---|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 41012   |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Special Topics in Inorganic Chemistry   |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2   |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory  |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | CHE 12012   |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>   | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|   | 30  | -                               | -                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | To provide advanced knowledge on Molecular Polyhedra and Bioinorganic Chemistry |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Mid-Semester Assessment 30%   |                                 | Final Assessment 70%            |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: discuss structural chemistry of boron hydrides
- ILO 2: demonstrate structures of condensed materials having chains, rings, sheets, cages, clusters and frameworks
- ILO 3: predict geometry, structure and bonding in borane clusters, metal clusters etc.
- ILO 4: design synthesis of MOFs based on the requirement
- ILO 5: explain role of metals in biological systems

### Course Content

#### 1. Introduction (2 h)

Introduction to polyhedron structures; structural groups of silicates, boranes and borates; classification of bonds present in boranes/borates; structural relationships between *closo*, *nido* and *arachno* boranes, IUPAC nomenclature of boranes/borates

#### 2. Examples for structures of condensed materials having chains, rings, sheets, cages, clusters and frame works (6 h)

Chains - silanes, single and double chain silicates; rings - borazines, cyclic silicates; sheets - graphite, graphene and phyllosilicates; cages - boranes and fullerenes; clusters - boron clusters and carboranes, metal carbonyls; frameworks - metal organic frame works

#### 3. Determination of geometry structure and bonding (7 h)

Introduction to quadrupole bond and bridging bonds; bonding in boranes, metalloboranes,

metal clusters, metal carbonyls; Styx topology, Wades rule, Isolobal analogy, Wades Mingos rules and capping rule; application of Styx number, skeleton electron pairs and capping rule etc. in the determination of geometry, structure and bonding in higher borane clusters and metal clusters, metal carbonyls, metal halides.

#### 4. Metal Organic Frame works ( 5h)

Classification, synthesis and structures, properties and applications

#### 5. Bioinorganic Chemistry (10 h)

Role of metals in biological systems, speciation and specificity of metal complexes *in vivo*.

Transition metals in biological redox reactions: General mechanism of electron transfer, blue copper proteins, iron sulphur proteins, cytochromes, photosynthetic pathway.

Dioxygen carriers: Dioxygen complexes of transition elements, haemoglobin, nature of haem dioxygen binding, model system; transition metals in biological redox reactions.

Distribution and functions of metals in vivo: Storage and transport of iron, chemistry and biochemistry of nitrogen fixation, Mechanisms & action of zinc, copper, cobalt and molybdenum containing enzymes, enzyme containing vanadium, chromium and nickel.

#### Methods of Teaching and Learning

A combination of lectures, tutorials, discussions and computer assisted learning.

#### Recommended Readings

- Cartherine E Housecroft and Alan G Sharpe (2012), Pearson, England, Inorganic chemistry, 4<sup>th</sup> edition.
- Shriver and Atkins (2010), Inorganic Chemistry, 5<sup>th</sup> edition

## CHE 41022 - Advanced Topics in Physical Chemistry II

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|                                             |                                                                                                            |                                 |                                 |                                    |
|---------------------------------------------|------------------------------------------------------------------------------------------------------------|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 41022                                                                                                  |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Advanced Topics in Physical Chemistry II                                                                   |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2                                                                                                          |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory                                                                                                 |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | CHE 31032                                                                                                  |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>                                                                                              | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|                                             | 30                                                                                                         | -                               | -                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | To provide advanced knowledge in thermodynamics, statistical thermodynamics and symmetry and group theory. |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Continuous Assessment 30%                                                                                  |                                 | Final Assessment 70%            |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: applies transition state theory to reactions
- ILO 2: applies Lindemann theory, RRK theory to unimolecular reactions
- ILO 3: analyzes molecular and crystal symmetry and elucidate crystal structures using principles of crystallography
- ILO 4: applies thermodynamic principles to gases and describe fugacity and chemical potentials of open systems
- ILO 5: Calculate third law entropies

### Course Content

#### 1. Reaction Dynamics (10 h)

Kinetic theory of collision, relationship between critical energy and the activation energy, probability factor; activated complex theory and its applications, thermodynamic interpretation of the overall rate constant; theories of unimolecular reactions: Lindemann theory, the  $[M]^{1/2}$  value of the unimolecular reactions, weaknesses of Lindemann theory, calculation of  $k$  value from Hinshelwood method, treatment of Rice-Ramsperger and Kassel, energized complex, Slater's treatment, Rice -Ramsperger-Kassel-Marcus theory; liquid phase reactions, theories of diffusion- controlled reactions and absolute reaction rates, influence of solvent in liquid phase reactions, single and double sphere models; influence of ionic strength in solutions on reactions.

## 2. X-ray crystallography (10 h)

Solids, lattice, crystal planes, miller indices, powder X-ray diffraction, Single crystal X-ray crystallography, space symmetry in a crystal. Approximate solution of structure, intensities to structure factors. Fourier synthesis, phase problem, Patterson synthesis. Heavy atom method, direct method, refinement, R factor, Fourier refinement. Least squares refinement. Estimation of errors. Comparison with neutron and electron diffraction.

## 3. Chemical thermodynamics (10 h)

The four fundamental Maxwell relations, Open systems: Partial molar properties, Gibbs-Duhem equation; Chemical potential and its variation with temperature and pressure, application of free energy change for a general reaction; Fugacity with special reference to gaseous system: Determination of fugacity in gaseous mixture; Activities and activity coefficients; Third Law of thermodynamics, determination of the third law entropies, Debye T<sup>3</sup> Law, comparison of spectroscopic and colorimetric properties, the molecular basis of entropy, Boltzmann Planck equation.

### Methods of Teaching and Learning

lectures, tutorial discussions

### Recommended Readings

- Laidler K.J. (2003) Pearson India.
- Peter Atkins, Julio de Paula, and James Keeler (2022). Physical Chemistry, Oxford University Press.
- Glusker, J.P. Trueblood, K.N., Crystal Structure Analysis
- Giacovazzo, C. (2011) Fundamentals of Crystallography, Oxford University Press.
- Glasser, L.S.D., (1977) X-Ray Crystallography von nostrand Reinhold
- Ott, J. B.; Goates, J. B. (2000). Chemical Thermodynamics Principles and Applications, 1<sup>st</sup> Edition, Academic Press.
- Advanced Chemical Thermodynamics, CHU 3030, Open University of Sri Lanka.

## CHE 41032 - Advanced Spectroscopic Techniques and Photochemistry

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|   |   |                                 |                                 |                                    |
|---|---|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 41032   |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Advanced Spectroscopic Techniques and Photochemistry  |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2   |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory  |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | CHE 21012, CHE 31032  |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>   | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|   | 30  | -                               | -                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | To expose students to the necessity of Advanced Spectroscopic method in order to elucidate structure of Organic Molecules; to demonstrate photochemically induced organic reactions |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Continuous Assessments 30%  |                                 | Final Assessment 70%            |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: elucidate the structure of complex molecules using different pulse sequences in NMR spectroscopy
- ILO 2: elucidate the structure of an organic molecule
- ILO 3: predict the products of photochemical reactions

### Course Content

#### 1. Advanced organic spectroscopy (18 h)

<sup>1</sup>H NMR: First order spectra, deuterium exchange, isotopic peaks, FID, instrumentation, complex splitting patterns of <sup>1</sup>H NMR and J values, NMR of homotopic, enantiotopic and diastereotopic protons, AB, ABC, ABX and AMX spin systems; Non-first order spectra; C NMR: solvent peak, simplification of <sup>13</sup>C NMR, proton decoupled spectra, double quantum, single quantum and zero quantum spin relaxations, NOE, population inversion, different types of <sup>13</sup>C NMR spectra, NOEDIFF, INEPT, APT, DEPT experiments, 2D NMR; COSY, ROSY, TOCSY, HECTCOR, HSQC, HMBC, NOESY, ROSEY; Mass spectrometry: Ionization methods, GCMS, LCMS, HRMS, fragmentation patterns of selected classes of organic compounds; Joint application of spectroscopic techniques in structure elucidation of organic molecules.

## 2. Photochemistry (12 h)

Selection rules, Jablanski diagram, singlet and triplet excited states, Kinetics of excited state processes such as quenching, energy transfer, triplet sensitization; mechanism of photochemical reactions, secondary reactions, photochemical reactions of carbonyl compounds: Norrish Type I and II reactions, photooxidations, photoreductions, photocycloadditions and photo rearrangements, -di-pi-methane rearrangement, Excited with singlet oxygen; industrial and biological application of photochemical reactions.

### Methods of Teaching and Learning

Lectures, Tutorial, discussions

### Recommended Readings

- Isaacs, N. (1996). Physical Organic Chemistry, 2<sup>nd</sup> Edition, Prentice Hall.
- Costa, M.D.P. De (2010). Pericyclic reactions. Theory and Applications, Revised Edition, Institute of Chemistry Ceylon, Monograph 22.
- W. Voelter, and D. G. Daves, (1984). Biologically Active Principles of Natural Products. Georg Thieme Verlag.
- Mann, J.; Davidson, R. S.; Hobbs, J.B.; Banthorpe, D.V.; Harbone, J.B. (1996). Natural Products: Their Chemistry and Biological Significance, Longman.
- Lewis Mander and Hung-wen Liu; Natural Products: Chemistry and Biology

## CHE 41042 - Molecular Modelling and Molecular Simulations (T & P)

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|                                             |                                                                                           |                                 |                                 |                                    |
|---------------------------------------------|-------------------------------------------------------------------------------------------|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 41042                                                                                 |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Molecular Modelling and Molecular Simulations (T & P)                                     |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2                                                                                         |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory                                                                                |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | CHE 31032                                                                                 |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>                                                                             | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|                                             | 20                                                                                        | 30                              | -                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | To provide theoretical and working knowledge on computational chemistry and applications. |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Continuous Assessments 30%                                                                |                                 | Final Assessment 70%            |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: apply electronic structure calculation for small molecules to predict their physical properties
- ILO 2: describe geometry optimization through energy minimization techniques
- ILO 3: simulate macromolecules using molecular dynamics and Monte-Carlo methods
- ILO 4: estimate binding free energies of receptor ligand complexes

### Course Content

#### 1. Electronic Structure Calculations (8 h)

Computational methods of electronic structure calculations, ab initio and semi empirical calculations; Many electron wave function, antisymmetry of wave function and indistinguishability of electrons, Slater determinants, Hartree-Fock and Density functional theory, atomic orbitals, Slater functions and Gaussian functions, basis-sets. Total energy, geometry optimization, potential energy surfaces.

#### 2. Molecular Mechanics (6 h)

Potential energy functional forms; molecular mechanics force field of a molecular system; geometry optimization: Simplex, Steepest decent, and conjugate gradient methods; Use of optimization in molecular system.

#### 3. Molecular Dynamics & MC simulations (6 h)

Introduction to molecular simulation; Monte Carlo simulation and determining chemical

and physical properties; molecular dynamics simulation and determining chemical and physical properties; introduction to Coarse grain and multiscale simulations.

#### **5. Experiments in Molecular Modelling (Practical: 30 h)**

Numerical differentiation and numerical integration using Microsoft excel or other software; protein visualization and explore the active site using VMD software; homology modeling and BLAST search Molecular docking and virtual screening; Computer aided drug designing, building small molecules using GUIs and Z- matrix with correct symmetry. Geometry optimization and vibrational analysis of small molecules using ab initio, DFT and semi empirical methods; introductory molecular dynamic practical, mini project.

#### **Methods of Teaching and Learning**

Lectures, course work, discussions, practical sessions, home assignments, computer assisted learning, mini project

#### **Recommended Readings**

- Leach A.R. (2001) Molecular modeling – Principles and applications, Prentice Hall, 2001
- Levine, I.N. (2002) Physical Chemistry, McGraw Hill Company, Fifth edition, 2002.

## CHE 41051 - Advanced Biochemistry - II

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|   |  |                 |                             |                                |
|---|--|-----------------|-----------------------------|--------------------------------|
| <b>Course Unit Code</b>                     | CHE 41051  |                 |                             |                                |
| <b>Course Unit Name</b>                     | Advanced Biochemistry - II   |                 |                             |                                |
| <b>Credit value</b>                         | 1  |                 |                             |                                |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory   |                 |                             |                                |
| <b>Prerequisites</b>                        | CHE 12031  |                 |                             |                                |
| <b>Hourly breakdown</b>                     | <b>Theory</b>  | <b>Tutorial</b> | <b>Independent learning</b> | <b>Notional learning hours</b> |
|   | 15   | 2               | -                           | 50                             |
| <b>Objective of the Course Unit</b>         | To provide the students with a basic understanding of the techniques used in Molecular Biology & Biotechnology, applications of Molecular Biology in industry & medicine and separation techniques employed in biochemical research. |                 |                             |                                |
| <b>Evaluation Method</b>                    | Continuous Assessments 30%   |                 | Final Assessment 70%        |                                |

### Intended Learning Outcomes (ILO)

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

- ILO 1: Describe and ways of isolating and visualization techniques for DNA / RNA
- ILO 2: List the Enzymes used in Recombinant DNA work.
- ILO 3: Describe making recombinant DNA, plasmids, DNA libraries, hybridization and DNA probes
- ILO 4: Describe different DNA/RNA based techniques (eg: blotting, sequencing, PCR etc.) and applications
- ILO 5: Describe the methods available for crude extraction and different types of chromatographic separations for different bio molecules

### Course Content

#### 1. Introduction to Molecular Biology & Biotechnology, and its applications (9 h)

Brief introduction to the topic, DNA / RNA isolation techniques. Visualization techniques for DNA. Enzymes used in recombinant DNA technology. Creating recombinant DNA. Plasmids used in recombinant DNA technology. DNA libraries. DNA hybridization. DNA probes. Agarose & acrylamide gel electrophoresis. Southern, Northern & Western blotting techniques. Reverse transcription. Transformation techniques. DNA sequencing. PCR technique & applications. Applications in health care, agriculture and industry.

## 2. Separation Techniques in Biochemistry (6 h)

Introduction and selection of samples. Homogenization / crude extractions / Centrifugation. Chromatography. Ion-exchange chromatography. Affinity chromatography TLC. High-performance liquid chromatography (HPLC). Gel filtration (size-exclusion) chromatography. Electrophoresis. SDS-PAGE (Sodium Dodecyl Sulfate Polyacrylamide Gel Electrophoresis). Agarose gel electrophoresis. Capillary electrophoresis. Ultrafiltration (ethanol). Dialysis / Crystallization. Liquid-Liquid Extraction.

### Methods of Teaching and Learning

Lectures, tutorial discussions

### Recommended Readings

- Abali, E. E.; Cline, S. D.; Franklin, D. S.; Viselli, S. M. Lippincott® Illustrated Reviews: Biochemistry; Lippincott Williams & Wilkins, 2024.
- Rodwell, V. W.; Bender, D. A.; Botham, K. M.; Kennelly, P. J.; Weil, P. A. Harper's Illustrated Biochemistry 31E; 2018.
- Devlin, T. M. Textbook of Biochemistry with Clinical Correlations; Wiley-Liss, 2002
- Nelson, D. L.; Lehninger, A. L.; Cox, M. M. Lehninger Principles of Biochemistry; Macmillan, 2008.

## CHE 41062 - Material Science

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|---------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 41062                                                                                                                              |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Material Science                                                                                                                       |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2                                                                                                                                      |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory                                                                                                                             |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | CHE 21032, CHE 22032, CHE 31032                                                                                                        |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>                                                                                                                          | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|                                             | 30                                                                                                                                     | -                               | -                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | To provide foundational knowledge and practical insight into the synthesis, properties, characterization and applications of materials |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Continuous Assessments 30%                                                                                                             |                                 | Final Assessment 70%            |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: provide an overview of different nanomaterials and their uses
- ILO 2: explain physicochemical characteristics of nanomaterials
- ILO 3: describe different preparation methods of nanomaterials and identify suitable techniques to characterize them
- ILO 4: Describe applications of sonochemistry.
- ILO 5: identify the characteristics of liquid crystals for different applications.

### Course Content

#### 1. Molecular Orbital Theory (MOT) for Transition Metal Complexes (5 h)

Limitations of Crystal Field Theory; requirements for effective overlapping of atomic orbitals, introduction to symmetry adapted linear combination of atomic orbitals (SALC) and ligand group orbitals (LGOs), symmetry labels of LGOs and metal atomic orbitals, formation of bonding, antibonding and nonbonding molecular orbitals from LGOs and metal orbitals.

Construction of molecular orbital energy level diagrams for metal-ligand bonding: Oh transition metal complexes having (i) M-L sigma bonding only (ii) M-L  $\pi$ -bonding involving (a)  $\pi$ -donor ligands (b)  $\pi$ -acceptor ligands; filling electrons, colours of selected examples. Electronic spectra of octahedral and tetrahedral transition metal complexes: Multi electron systems; Russell Saunders coupling, Microstates, construction of a table of microstates. Introduction to Term symbols, determination of term symbols and the 4.

### **Methods of Teaching and Learning**

A combination of laboratory classes, combination of pre-laboratory and post laboratory assignments, laboratory reports..

### **Recommended Readings**

- Varley's Practical Clinical Biochemistry. 6<sup>th</sup> Edition by Allen H Gowenlock (2006) CBS Publication and Distributors (Indian Reprint)
- Williamson, K.L. (1994). Macroscale and Microscale Organic Experiments, 2<sup>nd</sup> Edition, Heath and Company.

## CHE 41072 - Generative AI for Chemistry and Chemical Industry

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|   |   |                                 |                                 |                                    |
|---|---|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 41072   |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Generative AI for Chemistry and Chemical Industry   |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2   |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory  |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | CHE 31012   |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>   | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|   | 15  | 30                              | 55                              | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | This course unit is designed to provide students with an understanding of generative artificial intelligence and its applications in the chemistry and chemical industry. It focuses on how generative AI can aid in molecule design, reaction optimization, and material discovery, providing students with the skills to apply AI tools effectively in chemical research and industrial contexts. |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Continuous Assessments 30%  |                                 | Final Assessment 70%            |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: Explain the principles of generative AI and their applications in chemistry
- ILO 2: Utilize AI algorithms for data generation and molecule synthesis
- ILO 3: Analyze case studies on the use of generative AI in chemical and pharmaceutical industries
- ILO 4: Develop basic generative AI models tailored to chemistry-related problems

### Course Content

#### 1. Introduction to Generative AI in Chemistry (Theory 5 h: Practical 10 h)

Basics of generative AI and deep learning. Importance and impact in chemical and pharmaceutical industries.

#### 2. AI Tools for Molecular Design and Reaction Prediction (Theory 5 h: Practical 10 h)

Applications of AI in molecule generation and synthesis, AI-driven reaction prediction models.

### 3. Practical Applications and Case Studies (Theory 5 h: Practical 10 h)

AI in drug discovery and material science. Case studies on industry implementations.

#### Methods of Teaching and Learning

Lectures, Laboratory classes using AI modeling software, Group projects and presentations, Case studies.

#### Recommended Readings

- Smith, J., & Brown, A. Artificial Intelligence in Chemistry: A Practical Guide
- Chen, R., et al. Applications of Generative Models in Molecular Science

## APM 41082 - Innovation and New Product Development

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|                                             |                                                                                                                                                                                      |                                 |                                 |                                    |
|---------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | APM 41082                                                                                                                                                                            |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Innovation and New Product Development                                                                                                                                               |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2                                                                                                                                                                                    |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory                                                                                                                                                                           |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | None                                                                                                                                                                                 |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>                                                                                                                                                                        | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|                                             | 30                                                                                                                                                                                   | -                               | -                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | To equip students with the knowledge and skills to manage the innovation process, integrate marketing and technology perspectives, and successfully develop and launch new products. |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Final Assessment 100%                                                                                                                                                                |                                 |                                 |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: identify importance of new product development to organizational performance
- ILO 2: describe the marketing and technology interface in the process of innovation
- ILO 3: demonstrate the ability to apply the methods of generating, evaluating and testing the product ideas and bringing them into the market.

### Course Content

#### 1. Fundamentals of innovation and product development (10 h)

Types of new products, new products and the product life cycle, product platforms, the innovation process, market creation, market disruption, stage-gate process, and assessing market potential.

#### 2. From idea to market launch (20 h)

Idea generation methods, concept development, product positioning, industrial design, product architecture, prototyping, product and market testing, and product launch.

### Methods of Teaching and Learning

Lectures, assignments, case studies, mini-projects

### **Recommended Readings**

- Paul, T (2010), Innovation Management and New Product Development, 4<sup>th</sup> Edition, Pearson.
- Ettl, J E (2010), Managing Innovation: New technology, new products and new services on a global economy, 2<sup>nd</sup> Edition, Butterworth-Heinemann.
- Material provided in CAL.

## CHE 42022 - Chemical and Process Engineering for Chemical Industry

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|   |  |                                 |                                 |                                    |
|---|--|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 42022  |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Chemical and Process Engineering for Chemical Industry   |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2  |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory   |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | CHE 22032  |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>  | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|   | 30   | -                               | -                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | To provide students a foundational understanding of the principles and applications of process engineering, focusing on key aspects of mass and energy transfer, fluid dynamics, and reactor design. |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Continuous Assessments 30%   |                                 | Final Assessment 70%            |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: Apply material and energy balance for a given system
- ILO 2: Understand basic principles of heat and mass transfer
- ILO 3: Describe principles, applications, equipment related to unit operations, such as distillation, absorption, extraction, mixing and drying
- ILO 4: Apply the basic equations for fluid flow
- ILO 5: Identify reactor types, applications and perform size calculations for simple reactor.

### Course Content

#### 1. Introduction (3 h)

Concept of process development, steady and unsteady processes, batch and continuous processes, introduction to unit operations, mass and energy balance, Introduction to Flow sheeting.

#### 2. Mass transfer theory (3 h)

Introduction to mass transfer, Fick's law and two film theory with applications, concept of mass transfer coefficient.

#### 3. Heat transfer (6 h)

Modes of heat transfer (conduction, convection and radiation) with applications. Types of heat exchangers, concept of heat transfer coefficient and Heat exchanger calculations.

**4. Mass Transfer Operations (6 h)**

Distillation: Introduction to binary and multicomponent distillation, Principle of binary distillation; Flash distillation calculations, Introduction to column distillation, Tray and packed columns, Concept of equilibrium staged separations. Extraction: Liquid-liquid extraction, modes of extraction, Phase equilibrium for partially miscible systems, single stage extraction calculations, solvents used and their selection, solid-liquid extraction, extraction equipment. Absorption and stripping: Gas-liquid equilibrium, Introduction to absorption and stripping, principle, equipment and applications. Drying: Drying theory, use of psychrometry, calculation of drying time, drying equipment.

**5. Fluid dynamics (5 h)**

Introduction to fluid dynamics: Characteristics of fluid flow, Flow classification, Bernoulli's equation and its applications, flow through pipes, selection of pumps for a given application.

**6. Mixing and agitation (3 h)**

Liquid mixing, Types of mixing, mixing mechanisms equipment used.

**7. Reactor Engineering (4 h)**

Introduction to reactor engineering and applications of industrial reactors. Definition to reaction rate. Mole balances for Batch reactors, Continuous Stirred Tank Reactor (CSTR) and continuous flow reactors such as PFR and Packed bed reactors. Design Equations for batch, CSTR and continuous flow reactors. Overview of use of catalysts in industrial reactors.

**Methods of Teaching and Learning**

A combination of lectures, tutorials, small group discussions and computer assisted learning.

**Recommended Readings**

- J. F. Richardson, J. H. Harker, J. R. Backhurst, "Coulson & Richardson's Chemical Engineering, Volume 1, 2 3 and 6, Butterworth- Heinemann.
- K.G. Denbigh and J.C.R Turner, Chemical Reactor Theory.
- A W Nienow , M F Edwards, N. Harnby, Mixing in the process industry, Butterworth-Heinemann

## CHE 42051 - Mineral Resources and Processing

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|---------------------------------------------|-------------------------------------------------------------------------------|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 42051                                                                     |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Mineral Resources and Processing                                              |                                 |                                 |                                    |
| <b>Credit value</b>                         | 1                                                                             |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory                                                                    |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | -                                                                             |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>                                                                 | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|                                             | 15                                                                            | -                               | -                               | 50                                 |
| <b>Objective of the<br/>Course Unit</b>     | Provide knowledge on mineral resources and associated industries in Sri Lanka |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Continuous Assessments 30%                                                    |                                 | Final Assessment 70%            |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: identify the difference between rocks and minerals
- ILO 2: discuss geological formations in Sri Lanka
- ILO 3: classify minerals in Sri Lanka
- ILO 4: discuss possible industries based on mineral resources and value addition in Sri Lanka.

### Course Content

#### 1. Rocks and minerals (5 h)

Difference between rocks and minerals, geological formations in Sri Lanka, igneous sedimentary and metamorphic rocks.

#### 2. Classification of minerals (2 h)

Classification as ferroalloy group, nonferrous group and non-metallic group.

#### 3. Industries based on mineral deposits in Sri Lanka (8 h)

Mineral deposits in Sri Lanka and chemical composition of those minerals, chemistry relevant to industries based on some selected minerals - clay, quartz, calcareous materials, beach mineral sands, apatite, gem stones, graphite; Value addition and aspects of value addition: Potential industries.

### **Methods of Teaching and Learning**

Lectures, tutorials, self-studying, industrial visits

### **Recommended Readings**

- Sri Lankan Mineral and Industries: Resources, Potentialities and current issues (2003),
- M.M.J.W. Herath Geological survey and mines bureau.
- Silica based industries – Future Prospectus (1999), Proceedings of a seminar, Natural Resources, Energy and Science Authority of Sri Lanka.
- Mineral resources of Sri Lanka (1980), J. W. Herath, Geological survey Department.

## CHE 43016 - Research Project

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|---|--|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 43016  |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Research Project   |                                 |                                 |                                    |
| <b>Credit value</b>                         | 6 (during the sem-1 and 2 of the Level 4)  |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory   |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | ENH 22101  |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>  | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|   | -  | 180                             | 20                              | -                                  |
| <b>Objective of the<br/>Course Unit</b>     | To provide basic skills in planning and executing a research project in chemistry or a related area in chemistry and present & defend findings to a scientific community |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Research presentation  |                                 | Thesis                          | Viva                               |

### Intended Learning Outcomes (ILO)

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

- ILO 1: identify a research problem
- ILO 2: conduct a comprehensive literature survey related to the research problem
- ILO 3: design and conduct suitable experiments following scientific methods
- ILO 4: critically analyze the results
- ILO 5: write a dissertation covering a comprehensive literature survey, experimental procedure, analysis of results and discussion
- ILO 6: effectively communicate the findings and defend the work in a professional manner

### Course Content

Literature survey, proposal writing, laboratory and/or field work, data analysis and interpretation, writing dissertation and Presentation

### Methods of Teaching and Learning

Each student will carry out a research project during the Level-4 under the supervision of an assigned supervisor (s).

Components: Literature survey, Proposal writing, laboratory and/or field work, data analysis and interpretation, writing a dissertation and presentation

### Recommended Readings

- Literature relevant to the title of the research project

## APM 42032 - Project Management

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|---------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | APM 42032                                                                                                                                                       |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Project Management                                                                                                                                              |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2                                                                                                                                                               |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory                                                                                                                                                      |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | None                                                                                                                                                            |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>                                                                                                                                                   | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|                                             | 30                                                                                                                                                              | -                               | -                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | To equip students with the skills to plan, execute, and evaluate projects, manage risks, prevent failures, and adapt practices to various project environments. |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Final Assessment 100%                                                                                                                                           |                                 |                                 |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: explain how to initiate, specify, and prioritize projects and to determine various aspects of feasibility;
- ILO 2: explain the foundations of project management, including its definition, scope, and the need for project management in the modern organization;
- ILO 3: explain the phases of the project management lifecycle;
- ILO 4: assess different issues that lead to project failures and addressing them;
- ILO 5: assess the differences between IT/IS projects and general projects.

### Course Content

#### 1. Fundamentals of project management (6 h)

Introduction to project management, project management life cycle, organizational structures for projects, and project selection.

#### 2. Project definition and planning (8 h)

Defining a project, estimating project times and costs, developing a project plan, and scheduling of resources.

#### 3. Project execution, control, and closure (10 h)

Risk management, measuring and evaluating project performance, project auditing, and winding up of projects.

#### **4. Introduction to IT project management (6 h)**

Overview of IT project management concepts, approaches, and challenges.

#### **Methods of Teaching and Learning**

Lectures, case discussions and computer assisted learning

#### **Recommended Readings**

- Kloppenborg, T (2008), Contemporary Project Management, Cengage Learning.
- James, P and Jack, G (2008), Effective Project Management, 3<sup>rd</sup> Edition, Cengage Learning.
- Meredith, J R and Samuel, J M J (2008), Project Management, A Managerial Approach, 5<sup>th</sup> Edition, John Wiley & Sons, Inc

## APM 42042 - Professional Practices

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|   |   |                                 |                                 |                                    |
|---|---|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | APM 42042   |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Professional Practices  |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2   |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Compulsory  |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | None  |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>   | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|   | 30  | -                               | -                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | To develop students' professionalism, ethics, communication, and social intelligence for informed, responsible decision-making. |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Final Assessment 100%   |                                 |                                 |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: describe the characteristics of a professional;
- ILO 2: communicate at a professional level;
- ILO 3: discuss the role of ethics in industry;
- ILO 4: appreciate how to accept responsibility and ownership for yourself and other people under your direction;
- ILO 5: describe the role of professional associations;
- ILO 6: apply own level of social intelligence to his/her own position related to other professionals in the work place and thereby make informed decisions aligned to the professional practice in the industry s/he is involved in.

### Course Content

#### 1. Fundamentals of professionalism (6 h)

Characteristics of a professional, professional associations, professionalism in workplace contexts.

#### 2. Communication and professional relationships (4 h)

Communication fundamentals, inter-relationships between communication and professionalism.

#### 3. Ethics and professional standards (10 h)

Ethics, differentiation between law, morals, and ethics, using standards and codes of

ethics, inter-relationships between professionalism and ethics.

#### **4. Professional judgment and social intelligence (10 h)**

Introduction to decision-making in professional contexts, social intelligence and its role in professional success, professional judgment, inter-relationships between ethics and professional judgment, inter-relationships between professional judgment and social intelligence.

#### **Methods of Teaching and Learning**

Lectures and case analysis

#### **Recommended Readings**

- Bazerman, M H and Moore, D A (2009), Judgment in Managerial Decision Making, 7<sup>th</sup> Edition, John Wiley.
- Fisher, A (2001), Critical Thinking: an introduction, Cambridge University Press.

## CHE 42062 - Chemical Education

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|---------------------------------------------|--------------------------------------------|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 42062                                  |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Chemical Education                         |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2                                          |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Elective                                   |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | None                                       |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>                              | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|                                             | 30                                         | -                               | -                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | To provide knowledge on chemical education |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Final Assessment 100%                      |                                 |                                 |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: design teaching, learning and assessment activities according to psychological theories in education;
- ILO 2: differentiate distinct types of learning and teaching methodologies
- ILO 3: plan course modules in line with taxonomies of education
- ILO 4: explain fundamental aspects of curriculum design
- ILO 5: use historical aspects of chemistry in clearer understanding of chemistry;
- ILO 6: demonstrate fundamental teaching techniques in chemistry education.

### Course Content

#### 1. Psychological and aspects of science education (8h)

Attention span and forgetting curve, components of critical thinking, Kolb's cycle of experimental Learning, SQ4R (survey, question, read, recite, relate, and review), reading method, Curry's onion model of education, Johari Window (Student and peer evaluation), Covey's time management.

#### 2. Technical aspects of teaching, learning and assessment (8h)

Deep and surface learning; Active and passive learning; Teacher-centred vs. student-centred teaching; Taxonomies of education: Cognitive, affective and psychomotor domains of Bloom's Taxonomy; Solo Taxonomy; Perry Model of cognitive development; Chemistry education in the ICT age.

**3. Designing curricula (6h)**

Content-based vs. objective-based teaching; Biggs' constructive alignment; Introduction to Sri Lanka Qualifications Framework (SLQF).

**4. Historical & philosophical development of chemistry (8h)**

Historical landmarks of chemistry; Inspirational life stories of eminent personalities in chemistry; Industrial revolution and the history of global chemical industry, identifying significant human mistakes in the past and the prediction of future based on history; Basic IQ in roots of chemistry.

**5. Demonstrations in chemical education (15h)**

Demonstrations in chemistry: Demonstrations to reinforce classroom material, demonstrations to entertain thermochemistry, chemiluminescence, polymers, coloured metal ion complexes, etc. Use of everyday objects in chemical demonstrations; Classroom assessment: Teaching practice and seminar presentations which carries 20% of the marks for the course.

**Methods of Teaching and Learning**

Lectures, tutorials, class room activities and assignments

**Recommended Readings**

- Biggs, J.; Tang, C.; Kennedy, G., Teaching for Quality Learning at University 5e. McGraw-Hill Education: 2022.
- Ormrod, J. E., Human Learning. Pearson: 2019.
- Ambrose, S. A.; Bridges, M. W.; DiPietro, M.; Lovett, M. C.; Norman, M. K.; Mayer, R. E., How Learning Works: Seven Research-Based Principles for Smart Teaching. Wiley: 2010.

## CHE 42072 - Pharmaceutical Chemistry

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|---|---|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 42072   |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Pharmaceutical Chemistry  |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2   |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Elective  |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | None  |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>   | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|   | 30  | -                               | -                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | To provide knowledge and skills required in pharmaceutical industry |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Final Assessment 100%   |                                 |                                 |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: apply knowledge gained in pharmaceutical chemistry to pharmaceutical technology
- ILO 2: explain preparation methods of various pharmaceutical preparations
- ILO 3: calculate the strength of pharmaceutical preparations
- ILO 4: describe quality control and quality assurance procedures of pharmaceutical preparations
- ILO 5: brief on essential components of pharmaceutical industry

### Course Content

#### 1. Introduction (4 h)

Importance of pharmaceutical technology; Usage of pharmaceutical products; Classification of dosage forms; method of administration, GMPs.

#### 2. Preparation aspects (12 h)

Theory and preparation of various pharmaceutical products, such as tablets, suspensions, emulsions, ointments, gels, pastes, semisolid preparations, suppositories, powders, inhaled products, veterinary preparations; Problems associated with pharmaceutical preparations; Incompatibility issues.

#### 3. Quality control and quality assurance (10h)

Good laboratory practices, good manufacturing practices, good documentation practices; ISO series; Preservation, packaging and storage procedures; Sampling and application of

analytical techniques in quantification; Bioequivalence studies; Methods validation.

#### **4. Pharmaceutical industry (4h)**

History of pharmaceutical industry, modern pharmaceutical industry and challenges faced; Pharmaceutical unit operations, Optimization and scaling up; Pilot scale considerations

#### **Methods of Teaching and Learning**

Lectures, tutorials, industrial visits, computer assisted learning, group work

#### **Recommended Readings**

- S.H. Rasheed, Pharmaceutical Technology-I, SIA Publishers and Distributors (P) Ltd., 2015.
- G. Agarwal and A. Kaushik, Pharmaceutical Technology I, CBS Publishers & Distributors Pvt Ltd., 2017.
- Fah, Voigt's Pharmaceutical Technology, J. Wiley & Sons, 2018.
- R.K. Yadav, A Textbook Of Pharmaceutical Technology-I, Vardhans Publishers.

## CHE 42082 - Food Chemistry & Technology

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|---------------------------------------------|---------------------------------------|---------------------------------|---------------------------------|------------------------------------|
| <b>Course Unit Code</b>                     | CHE 42082                             |                                 |                                 |                                    |
| <b>Course Unit Name</b>                     | Food Chemistry & Technology           |                                 |                                 |                                    |
| <b>Credit value</b>                         | 2                                     |                                 |                                 |                                    |
| <b>Compulsory/Elective/<br/>Enhancement</b> | Elective                              |                                 |                                 |                                    |
| <b>Prerequisites</b>                        | None                                  |                                 |                                 |                                    |
| <b>Hourly breakdown</b>                     | <b>Theory</b>                         | <b>Practical<br/>/ Tutorial</b> | <b>Independent<br/>learning</b> | <b>Notional learning<br/>hours</b> |
|                                             | 30                                    | -                               | -                               | 100                                |
| <b>Objective of the<br/>Course Unit</b>     | To provide knowledge on food industry |                                 |                                 |                                    |
| <b>Evaluation Method</b>                    | Final Assessment 100%                 |                                 |                                 |                                    |

### Intended Learning Outcomes (ILO)

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

- ILO 1: describe the nature of food components
- ILO 2: explain principles of food preservation
- ILO 3: apply technologies used to process and manufacture different food products
- ILO 4: describe standards used in the food industry
- ILO 5: apply safety regulations and quality management
- ILO 6: suggest methods to analyze different food items

### Course Content

#### 1. Carbohydrates, proteins and lipids (3 h)

Occurrence of monosaccharides, disaccharides and polysaccharides in food, their properties and industrial uses; Structure and properties of starch, gelatinization of starch, structure and properties of pectins, gel formation in pectins and uses of pectins in food industry; Food gums, Maillard browning and caramelization reactions; Analysis of carbohydrates in food.

Chemistry of amino acids, peptides and proteins with reference to proteins in milk, meat, fish, eggs and wheat, Iso-electric point and its importance in food manufacture; Denaturation of proteins and its effect on food; Determination of proteins in food (Kjeldhal method, chromatographic methods).

Occurrence of fats and oils in food, structure and properties of saturated and unsaturated

fatty acids in food items, deterioration of fats and oils in food, hydrolytic and oxidative rancidity, chemistry of rancidity and role of antioxidants, determination of saponification value, iodine value, acid value, peroxide value and their importance.

**2. Vitamins and minerals in food (2 h)**

Occurrence, food sources and properties of water soluble and fat-soluble vitamins, stability of vitamins during processing and storage, minerals and trace elements in food; Analysis of vitamin C in food; instrumental methods for the analysis of trace elements present in food.

**3. Sensory properties of food (2 h)**

Natural pigments and flavour compounds in food - flavor and coloured compounds; Structural features of carotenoids, anthocyanins, porphyrins (chlorophyll and heme) and curcumins, occurrence and changes during cooking and processing.

**4. Food additives (2 h)**

Preservatives, antioxidants, artificial colours, emulsifiers and stabilizers, flavor enhancers, analysis of food additives; food adulteration.

**5. Food spoilage and food preservation (2 h)**

Perishability of food related to composition of milk, meat, cereals, nuts, fruits and vegetables, water activity, acidic and non-acidic foods, factors that cause spoilage, chemical and biochemical changes that can occur in food during food manufacturing and processing, methods of controlling spoilage, principles of food preservation, packaging technology.

**6. Food quality and safety (2h)**

Standards and food quality management, food safety and regulations.

**7. Food Technology (7h)**

Food processing and preservation technology: Food processing methods – Heat preservation, dehydration, concentration, freezing, refrigeration, minimal processing, chemical preservation Dairy technology, technology of cereals, technology of fish & meat products, technology of fruits and vegetables, Bakery technology, Confectionary technology. Technology of spices, essential oils and flavors: Sri Lankan spices, processing methods, physical and chemical characteristics, unique characteristics, production of essential oils, production of oleoresins, Quality assurance, methods of determinations.

**8. Food Chemistry and food technology practical (20 h)**

Proximate analysis of food; Determination of reducing sugars in food; Kjeldahl determination of proteins; Determination of saponification value; Acid value and peroxide value of fats and oils; Analysis of Vitamin C in fruits and vegetables; Determination of minerals in food using AAS and UV spectrophotometry; Bakery technology; Fruit and

vegetable technology (Dehydration methods, solar drying).

### **Methods of Teaching and Learning**

Lectures, tutorials, industrial visits, computer assisted learning, laboratory work, group work, Industrial visits

### **Recommended Readings**

- T.Coultate (2009), Food, the chemistry of its components 5<sup>th</sup> Edition. RSC Publication.
- Nandanie Ediriweera (2016), Food Science & technology Vol 1, S. Godage Bros.
- Nandanie Ediriweera (2016), Food Science & Technology Vol 2, S. Godage Bros.





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