Subject: Chemistry (CHEM)				
General				
	Course Units	**Status**	**Pre-requisite**	**Co-requisite**
Year1 Sem 1	CHEM 11111 Calculations in Chemistry **	C	A/L Chemistry	
	CHEM 11122 General Chemistry and Basic Analytical Chemistry	C	A/L Chemistry	
	CHEM 11132 Basic Physical Chemistry	C	A/L Chemistry	
	CHEM 11141 Basic Chemical Analysis Laboratory	C	A/L Chemistry	CHEM 11122
Year1 Sem 2	CHEM 12152 Basic Inorganic Chemistry I	C	CHEM 11122	
	CHEM 12162 Basic Organic Chemistry	C	CHEM 11122	
	CHEM 12171 Introductory Organic Chemistry Laboratory	C	CHEM 11141	
	CHEM 12182 Chemistry in Context *	A	A/L Chemistry	
Year 2 Sem 1	CHEM 21112 Basic Physical Chemistry II	C	CHEM 11132	
	CHEM 21122 Analytical Chemistry	C	CHEM 11122	
	CHEM 21131 Physical Chemistry Laboratory	C	CHEM 11141 CHEM 11132	CHEM 21112
Year 2 Sem 2	CHEM 22142 Basic Inorganic Chemistry II	C	CHEM 12152	
	CHEM 22152 Organic Spectroscopy, Natural Products and Synthesis	C	CHEM 12162	
	CHEM 22161 Organic Analytical and Synthetic Chemistry Laboratory	C	CHEM 12171	CHEM 22152
	CHEM 22171 Analytical Chemistry Laboratory	C	CHEM 22122	
Year 3 Sem 1	CHEM 31111 Inorganic Synthesis and Analysis Laboratory	C	CHEM 11141	
	CHEM 31122 Material Chemistry, Earth Recourses and Introduction to Quality Management	O	CHEM 22142	
	CHEM 31132 Introduction to Environmental Chemistry	O	CHEM11122/ 22122	
	PRPL 31012 Professional Placement	O	All CHEM compulsory course units offered in Levels 1 & 2	
Year 3 Sem 2	CHEM 32152 Polymer Chemistry	O	CHEM11132/ 21112	
	CHEM 32162 Applied Natural Products Chemistry	O	CHEM 22152	
	CHEM 32171 Environmental Chemistry Laboratory	O	CHEM 31132	
	CHEM 32182 Chemical Informatics	O	CHEM 21122	

** Not counted for GPA
* Offered only to students that do not take Chemistry as a subject

LEVEL-1

First Semester (15 weeks)

Course code : CHEM 11111
Course title : Calculations in Chemistry
Pre-requisites : A/L Chemistry

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

- solve quantitative and qualitative chemical problems using basic mathematical skills.

Course content:
Review of basic mathematics for chemistry. Introduction to error theory, statistical analysis and use of significant figures. Calculations based on stoichiometry, chemical equilibira, chemical kinetics, thermodynamics, diffractions, electrochemistry and quantum chemistry. Use of graphical methods to solve various chemistry related problems.

Method of teaching and learning : A combination of lectures and tutorial discussions

Assessment : Continuous assessment and/or end of course unit examination

Recommended reading:
1. Tebbutt. P., (1998) *Basic Mathematics for Chemists*, John Wiley
2. Gormally. J., (2000) *Essential Mathematics for Chemists*, Prentice Hall

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Course code : CHEM 11122
Course title : General Chemistry and Basic Analytical Chemistry
Pre-requisites : A/L Chemistry

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

- explain certain atomic properties using theories of atomic structure
- recognize various types of chemical bonding and apply the theories of bonding to predict properties of compounds
- view giant molecules as a special class of compounds build up by smaller units and correlate the properties associated with their structure
- apply basic concepts of solubility, precipitation, and titrations in chemical analysis
- design methods to quantify analytes in aqueous media using concepts of titrimetry and gravimetry.

Course content:
Structure and bonding (10 h)
History of atomic theory: electron, proton, neutron; discovery and properties, light and atomic spectra, Bohr theory; Bohr radius, explanation of atomic spectra, Parsons magneton theory, the quantum mechanical atom, quantum numbers, Aufbau principle, Hund's rule, Pauli exclusion principle.
The current view of the atom: fermions and bosons, atomic nucleus and stability, the periodic table and its trends, chemical compounds.
Chemical bonds : ionic, covalent, coordinate and metallic bonds. Theories of covalent bonding- Lewis-Langmuir, Sidwick-Powell, VSEPR and shapes of molecules, valence bond theory, σ bonds and π bonds, hybridization and structure, molecular orbital theory (diatomic molecules), bond polarity & dipole moment, cyclic structures, metallic bond; band theory.
State of matter: intermolecular forces; ion-ion interactions, ion- dipole interactions, dipole-dipole interactions (H-bonding), dipole- induce dipole interactions, ion - induce dipole interactions, London forces, colligative properties. Solids; lattice structure and unit cell, cell type, effective density and number of entities, layered structures and lattice energy.
Giant molecules; basic structural features of common giant molecules.

Aqueous solution chemistry (20 h)
Significant figures and scientific notation, uncertainty calculations, concentration. Chemical equilibrium; LeChatelier's principle.
Solubility and solubility product; ion product, common ion effect, fractional precipitation, effect of pH on K_{sp}, effect of temperature and solvent on K_{sp}.
Gravimetry; mechanism of precipitation. Contamination of precipitates; co-precipitation, adsorption, occlusion, entrapment, solid solutions, post precipitation. Purification of precipitates; washing, reprecipitation, digestion, aging, drying of precipitates.
Titrimetry; classification, standard solutions- primary and secondary, equivalence point and end point.
Acid-base titrations; Acid base theories, strength of acids and bases, dissociation constants, autoprotolysis of water, titration curves and pH calculations at various points of the curve, titrations of poly functional weak acids with strong bases, titration of anions of weak acids with strong acids, acid base indicators, buffers.
Complexometric titrations; Complex formation constants, ligands, EDTA, titration curves, indicators, types of EDTA titrations.
Redox titrations; Nernst equation, titration curves redox indicators, permanganometry, iodometry and iodimetry, bromometry, dichromate titrations.
Precipitation titrations; methods of endpoint detection, absorbance and colorimetry, colorimetric titrations.

Method of teaching and learning : A combination of lectures and tutorial discussions

Assessment : Continuous assessment and/or end of course unit examination

Recommended reading :

1. Harris, D.C. (2006) *Quantitative Chemical Analysis,* Freeman
2. Mendham, J; Denney, R.C.; Barnes, J.D.; (2002) *Vogel's textbook of Quantitative Chemical Analysis,* Prentice Hall.
3. Sharpe,A.G.; (2005) *Inorganic Chemistry,* Pearson
4. Cotton, F.A.; Wilkinson, G; Gaus, P.L., (2004) *Basic Inorganic Chemistry,* Wiley
5. Lee, J.D. (1996) *Concise Inorganic Chemistry*, Blackwell
6. Porterfield, W.W.; (2005) *Inorganic Chemistry A Unified Approach,* Elsevier

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Course code **:** CHEM 11132
Course title **:** Basic Physical Chemistry I
Pre-requisites **:** A/L Chemistry

Learning outcomes:
Upon successful completion of the course unit, the student should be able to;
- apply the concepts, methods and techniques of thermodynamics, kinetics and electrochemistry to chemical systems and make predictions for these systems
- explain the role of kinetic studies in chemistry across the physical and life sciences and derive rate laws for simple chemical processes from proposed mechanisms
- demonstrate skills to simplify physical problems by making physically reasonable, justifiable and testable assumptions and develop critical analytical thinking and logical reasoning.

Course content:
Thermodynamics (10 h)
First law of thermodynamics; work, heat, internal energy, enthalpy, thermochemistry. Second law of thermodynamics; entropy, Gibbs energy, Helmholtz energy, exogenic and endogenic reactions, reactions at equilibrium, temperature dependence of equilibrium constants, effect of concentration, pressure, volume and temperature on the position of equilibrium, Maxwell relations and chemical potentials.
Chemical kinetics (10 h)
Basic concepts; rates of reactions, elementary reactions, rate expressions, order and the rate constant of a reaction, molecularity. Experimental determination of rate laws; fitting data to rate laws, obtaining data for different timescales. Introduction to theories about reaction rates; collision theory and activated complex theory. Complex reactions and reaction mechanisms; rate determining steps, pre-equilibrium hypothesis, steady-state approximation and their applications. Temperature dependence of reaction rates: Arrhenius rate law and deviation. Chain reactions, fast reactions and catalysis.
Electrochemistry (10 h)

Electrolytic conductance; resistivity, conductivity and molar conductance, molar conductance of ions and Kholrausch law of independent ionic migration, ionic mobility and ionic conductance, application of measurement of conductance. Ion-ion interaction and activity coefficients. Equilibrium electrochemistry; Nernst equation for equilibrium electrode potentials, secondary reference electrodes, metal and membrane electrodes. Potentiometry and application of cell E.M.F. measurements; potentiometric titrations, redox titrations. Non equilibrium electrochemistry; over potential, application of Tafel and Butler-Volmer equations, corrosion and electroplating.

Method of teaching and learning : A combination of lectures and tutorial discussions

Assessment : Continuous assessment and/or end of course unit examination

Recommended reading:

1. Atkins, P. W., De Paula, J., (2005) *The Elements of Physical Chemistry*, Oxford.
2. Atkins, P. W., De Paula, J., (2006) *Physical Chemistry*, Oxford.
3. Levine, I. N., (2001) *Physical Chemistry*, McGraw-Hill.
4. Daniels, F. and Alberty, R. L, (2004) *Physical Chemistry*, John Wiley.
5. Barrow, G. M., (1996) *Physical Chemistry*, McGraw-Hill.

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Course code **:** CHEM 11141
Course title **:** Basic Chemical Analysis Laboratory
Pre-requisites **:** A/L Chemistry
Co-requisites **:** CHEM 11122

Learning outcomes:
Upon successful completion of the course unit the student should be able to;

- adhere to safety rules and good laboratory practice at all times
- effectively use basic laboratory techniques for chemical analysis
- identify and separate cations and anions in inorganic compounds by standard chemical tests
- use titrimetric and gravimetric methods to quantify analytes in aqueous media.
- carry out literature surveys, plan simple experiments, process and present data.

Course content:
Laboratory safety, laboratory rules and regulations, handling of chemicals and glassware. Basic laboratory techniques; filtration, preparation of solutions, dilution, sample preparation etc. Qualitative analysis of basic cations and anions in inorganic compounds; group analysis by precipitation and identification of ions by specific reactions, flame tests. Quantitative analysis of aqueous analytes; acid base titrations, permanganometry, iodometry, dichromate titrations, complexometric titrations, colorimetric titrations and gravimetry. Literature surveys, planning experiments and execution of group projects. Skill development in reporting and presentation of scientific work.

Method of teaching and learning :
A 3 hour laboratory class per week (15 weeks) Pre labs and assignments

Assessment : Continuous assessment and end of course unit examination

Recommended reading:

1. Mendham, J; Denney, R.C.; Barnes, J.D.; (2002) *Vogel's Textbook of Quantitative Chemical Analysis*. Prentice Hall.
2. Svehal, G; (2001) *Vogel's Qualitative Inorganic Analysis,* Longmans

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Second Semester (15 weeks)

Course code **:** CHEM 12152
Course title **:** Basic Inorganic Chemistry I
Pre-requisites **:** CHEM 11122

Learning outcomes:
Upon successful completion of the course unit, the student should be able to:
- explain the periodic trends of physical and chemical properties of the main group and *d* block elements
- compare chemistry of the main group elements with that of *d* block and *f* block elements
- name coordination compounds systematically according to IUPAC nomenclature
- draw the structures of the different types of isomers of coordination compounds
- explain magnetic properties, colors, hybridizations, geometries, and distortions of coordination complexes using the bonding theories of coordination compounds.

Course content:
Main group and transition elements (15 h)
Chemistry of *s, p, d* and *f* block elements; *s*-block-reactivity, extraction, flame colors, solubility of salts, hydration energy and lattice energy, complex formation, Fajan's rules.
P-Block; physical properties, metallic bonding, complex formation, halides of boron, formation of π bonds in $N(SiH_3)_3$, silicate structures, inert pair effect, bond angle and donor properties of the hydrides of group 15. Compounds of *s* and *p*. Halogens; reactions with water, acidity of the oxoacids, hybridization and complex formation, pseudohalides and ployhalides, clathrate compounds. *d*-Block elements; physical properties and metallic bonding, electronic configurations, reactivity of metals, atomic radii, variable oxidation states and stability of oxidation states, colors, magnetic properties, complex formation and catalytic importance. *f*-Block elements; electron configurations, magnetic and spectral properties, lanthanide contraction, lanthanide separation, comparison of the chemistry of actinides with that of *d* and *f* block elements.
Coordination chemistry (15 h)
History, isomerism and nomenclature of coordination compounds, Lewis theory, valence bond theory, crystal field theory. Applications of crystal field theory; colors, magnetic properties etc., spectrochemical series, factors affecting the crystal field splitting, Jahn-Teller distortion, introduction of other bonding theories.

Method of teaching and learning : A combination of lectures and tutorial discussions

Assessment : Continuous assessment and/or end of course unit examination

Recommended reading :

1. Greenwood, N. N. and Earnshaw, A., (1997) *Chemistry of the Elements*, Oxford.
2. Shriver, D. F., Atkins, P.W. and Langford, C.H., (1991) *Inorganic Chemistry*, Oxford.
3. Liptrot, G. F., (1993) *Inorganic Chemistry*, London Mills and Boon.
4. Rodgers, G. E., (1991) *Introduction to Coordination, Solid State and Descriptive Inorganic Chemistry*, New York, Mc Graw Hill.

Course code **:** CHEM 12162
Course title **:** Basic Organic Chemistry
Pre-requisites **:** CHEM 11122

Learning outcomes:
Upon successful completion of the course unit, the student should be able to;
- draw the structures of isomers and conformers of organic molecules and assign absolute configurations of chiral centers of organic molecules.
- name simple organic compounds and draw structures corresponding to their names
- identify and recognize key organic functional groups and their reactions
- predict and rationalize potential reaction pathways for selected organic reactions using kinetics and thermodynamics.
- transform one simple organic functional group to another

- identify aromatic compounds, and rationalize their stability.
- write basic reaction mechanisms of heteroaromatic compounds

Stereochemistry and reaction mechanisms (10h)
Isomerism in carbon compounds; structural isomers, stereoisomers, optical activity, measurement of optical activity, conformational isomers of cyclic and acyclic alkanes; chirality, R and S convention, Fisher projections, importance of chirality.
Chemistry of reaction intermediates (carbocations, carbanions and radicals) and mechanistic aspects of organic reactions (S_N1, S_N2, E1, E2, Ad_E and S_E reactions)
Nomenclature and reactions of organic compounds (10h)
Selected reactions of aliphatic and aromatic alkanes, alkenes, alkynes, halides, alcohols, ethers, carbonyl compounds, carboxylic acids, acid derivatives, nitro compounds and amines.

Aromaticity and heterocyclic compounds (10h)
Aromatic character; application of Huckle rule, Frost circles, aromatic hydrocarbon ions, annulenes. antiaromatic hydrocarbons. Nomenclature, structure and physical properties of five, six, and bicyclic heteroaromatic compounds with one heteroatom, reactivity and electrophilic addition at hetero atom, electrophilic / nucleophilic / radical substitution at carbon, oxidation and reduction of heterocyclic ring.

Method of teaching and learning : A combination of lectures and tutorial discussions

Assessment : Continuous assessment and/or end of course unit examination

Recommended reading:

1. Solomons, T. W.G., (2003) *Organic Chemistry,* John Wiley
2. Brown, W.H. (1995) *Organic Chemistry*, Harcourt Brace.
3. McMurry, J. (1996) *Organic Chemistry*, Brooks & Cole
4. Gupta, R.R., Kumar, M., Gupta, V. (1998) *Heterocyclic Chemistry,* Springer
5. Acheson, R.M. (1977) *An Introduction to the Chemistry of Heterocyclic Compounds*, John WIley

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Course Code **:** CHEM 12171
Course title **:** Introductory Organic Chemistry Laboratory
Pre-requisites **:** CHEM 11141

Learning outcomes:
Upon successful completion of the course unit, the student should be able to;
- adhere to safety rules governing an organic laboratory
- identify functional groups of unknown organic compounds by standard chemical tests
- apply techniques to separate, purify, derivatize and characterize organic compounds present in mixtures
- perform semi-microscale synthesis, identify limiting reagents and calculate theoretical and experimental yields of chemical reactions.

Course content:
Safety aspects in an organic laboratory. Qualitative analysis of functional groups in organic compounds; solubility, tests for unsaturation, alcohols, alkyl halides, ketones, aldehydes, carboxylic acids, phenols, esters, amines (including Hinsberg's test, diazotization, Liebermann's nitroso reaction), nitro compounds, sulphonic acid and amides. Purification of organic compounds; recrystallization, determination of melting points and boiling points, mix melting points, derivatization, separation of mixtures (containing neutral / acid / base / phenol / salts). Study of one step reactions; identification limiting reagent of a reaction, calculation of experimental yield. Introduction to chromatography; monitoring the progress of a reaction by TLC.

Method of teaching and learning : A 3 hour laboratory class per week (15 weeks)

Assessment : Continuous assessment and end of course unit examination

Recommended readings

1. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J., Smith, P.W.G., (1989) *Vogel's Textbook of Practical Organic Chemistry*, Logmans
2. Pavia, D.L., Lampman, G.M., Kriz, G.S., Engel, R.G., (1988) *Introduction to Organic Laboratory Techniques: A Small-Scale Approach*, Brooks Cole
3. Moting, J.R., Mofrrill, T.C., Hammond, C.N. and Neckers, D.C., (1999) *Experimental Organic Chemistry*, Freeman.
4. Williamson, K.L., (2002) *Macroscale and Microscale Organic Experiments*, Heath and Company.

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Course Code : CHEM 12182
Course title : Chemistry in context

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

- explain the chemical basis of certain phenomena and processes encountered in day to day life.

Course content:
Air and the ozone layer, chemistry of global warming, energy and chemistry, the wonder of water, acid rain, nuclear fission and fusion, rubber and polymer, drugs and nutrition, chemistry of heredity.

Method of teaching and learning : A combination of lectures, tutorial discussions and presentations

Assessment: Continuous assessment and/or end of course unit examination

Recommended readings

1. Schwartz, A.T., (1997) *Chemistry in Context,* ACS

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LEVEL-2

First Semester (15 weeks)

Course code : CHEM 21112
Course title : Basic Physical Chemistry II
Pre-requisites : CHEM 11132

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

- explain the limitations of classical mechanics and merits of quantum mechanics
- apply fundamentals of quantum mechanics to basic chemical models
- interpret physical properties of surfaces and colloids using fundamentals
- interpret molecular spectra of simple molecules
- explain phase equilibria and phase transformations of mixtures using phase diagrams.

Course content:
Quantum mechanics (9 h)
Failure of classical mechanics, wave-particle duality, Heisenberg's uncertainty principle, postulates in quantum mechanics, Schrödinger equation, particle in 1, 2 and 3 dimensional boxes, rotation in 2-dimension, harmonic oscillator and the hydrogen atom.
Surface and colloid chemistry (6 h)
Introduction to the fundamental and applications of interfacial phenomena; capillarity, surface and interfacial tension, films, wetting and contact angles, chemical and physical adsorption. Gas-solid adsorption; Langmuir and BET isotherms. Colloids; classification and preparation; properties of colloidal dispersion.
Atomic and molecular spectroscopy (9h)
Interaction of electromagnetic radiation with matter. Rotational spectroscopy; rigid rotor model. vibrational spectroscopy; harmonic and anharmonic oscillator models. Raman spectroscopy and electronic spectroscopy.

Phase equilibria (6 h)
Thermodynamical description of mixtures, partial molar quantities; partial molar volume and Gibbs free energy. Phases, components and degree of freedom, the phase rule, phase diagrams; interpretation, lever rule. Liquid-liquid phase diagrams; phase separation, critical solution temperatures. Temperature-composition diagrams; distillation of mixtures, zeotropes and azeotropes. Liquid solid phase diagrams; eutectics and three component systems.

Method of teaching and learning : A combination of lectures and tutorial discussions

Assessment : Continuous assessment and/or end of course unit examination

Recommended reading:

1. Atkins, P. W., De Paula, J., (2006) *Physical Chemistry*, Oxford.
2. Levine, I. N., (2001) *Physical Chemistry*, McGraw-Hill.
3. Daniels, F. and Alberty, R. L., (2004) *Physical Chemistry*, John Wiley.
4. Barrow, G. M., (1996) *Physical Chemistry*, McGraw-Hill.

Course code **:** CHEM 21122
Course title **:** Analytical Chemistry
Pre-requisites **:** CHEM 11122

Learning outcomes:
Upon successful completion of the course unit, the student should be able to:
- select the most appropriate sampling technique for a particular analytical experiment
- apply fundamentals of separation techniques (solvent extraction and chromatography), spectroscopy and electro analytical techniques for quantitative chemical analysis.

Course content:
Sampling and chemometrics (6 h)
Sampling methods, selection of approved analytical methods, development of validation methods, data evaluation and statistical analysis, quality assurance of products analyzed and certifications, intellectual property rights.
Analytical spectroscopy: (6 h)
Emission, absorption, fluorescence and scattering processes of radiation. Atomic emission spectrometry; flame photometry, flame atomic emission spectrometry, inductively coupled plasma atomic emission spectrometry. Atomic absorption spectrophotometry; flame and electro-thermal atomic absorption spectrometry, hydride generation and cold vapor generation techniques. X-ray fluorescence spectrometry. Molecular spectrometry, UV-visible spectrometry, fluorescence spectrometry. Techniques based on the light scattering principle; Nephelometry and turbidimetry.
Analytical electrochemistry: (6 h)
Potentiometry; reference electrodes, indicator electrodes, direct potentiometry, potentiometric titrations, ion selective electrodes, solid state chemical sensors.
Voltammetry; classical polarography, two electrode cells, three electrode cells and potentiostats, Tast polarography, pulse polarography, stripping analysis, voltammetry with other working electrodes, cyclic voltammetry and squarewave voltammetry. Amaperometric titrations. Coulometry; electrogravimetry, constant current and controlled potential coulometry.
Analytical separation : (6 h)
Solvent extraction. An introduction to chromatography; gas chromatography, classical liquid chromatography, high performance liquid chromatography, ion exchange chromatography, molecular exclusion chromatography and affinity chromatography.
Analytical instrumentation : (6h)
Instrument performance characteristics; instrument calibration, linear range, linear dynamic range, sensitivity, instrument detection limit, method detection limit, limit of quantization. Signal, noise and signal to noise ratio.

Method of teaching and learning : A combination of lectures and tutorial discussions

Assessment : Continuous assessment and/or end of course unit examination

Recommended reading:

1. Skoog, D.A., James F.H., Nieman. T. A., (1998) *Principles of Instrumental Analysis,* Harcourt Brace College Publishers
2. Gary, D.C., (1994) *Analytical Chemistry*, John Wiley & Sons, Inc.
3. Kealey, D. and Haines, P.J., (2002) *Analytical Chemistry,* BIOS.
4. Miguel V., (2000) *Principles of Analytical Chemistry,* Springer.
5. Skoog, D.A., Donald M. W., James, F.H., (1996) *Fundamentals of Analytical Chemistry,* Saunders College Publishing.
6. Paul, M.S. Monk., (2001) *Fundamentals of Electroanalytical Chemistry,* Wiley.
7. Robert, de L., (1997) *Principles of Quantitative Chemical Analysis,* McGraw Hill
8. Skoog, D.A., Donald, M.W., James, F.H., (1994) *Analytical Chemistry An Introduction,* Saunders College Publishing.
9. Miller J. C., and J. N. Miler (1999) *Statistics for analytical chemistry,* Ellis Horwood and Prentice Hall

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Course code : CHEM 22131
Course title : Physical Chemistry Laboratory
Pre-requisites : CHEM 11141, CHEM 11132
Co-requisite : CHEM 21112

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

- measure physico-chemical properties and evaluate data using fundamental concepts of physical chemistry
- properly operate some basic laboratory equipment and use instrumental techniques in chemical analysis
- use standard mathematical analyses to correctly explain the numerical significance of experimental results.

Course content:
Instrumental techniques for measurement of physicochemical properties based on chemical equilibrium, chemical kinetics, spectroscopy, and electrochemistry. Use of statistical methods for the analysis of experimental data and disciplinary reporting of results.

Method of teaching and learning : A 3 hour laboratory class per week (15 weeks)

Assessment : Continuous assessment and end of course unit examination

Recommended reading:

1. Shoemaker, D. P., Garland, G. W. and Nibler, J. W., (1996) *Experiments in Physical Chemistry*, McGraw-Hill.

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Second Semester (15 weeks)

Course code : CHEM 22142
Course title : Basic Inorganic Chemistry II
Pre-requisites : CHEM 12152

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

- identify and recognize symmetry elements and point groups in chemical species and compounds
- apply basic concepts of X-ray diffraction techniques to identify various crystal structures.
- explain the involvement of electrons in metal-ligand bonding
- propose mechanisms for simple catalytic processes involving homogeneous organometallic catalysts
- describe the radio activity and decay processes of radioactive isotopes and their properties and reactions.

Course content:

Symmetry, crystal structure and diffraction (12 h)

Symmetry elements and operations, point groups, introduction to crystals, crystal structures, metallic structures, binary compounds, ternary compounds, non-stoichiometric compounds, classification of crystals, Bravais lattices and crystal planes, x-ray diffraction, single crystal method and powder diffraction method, application of x-ray crystallography.

Organotransition metal chemistry (10 h)

Importance of organometallic chemistry, organometallic ligands. Formalisms in organometallic chemistry; oxidation state, *d* electron configuration, number of valence electrons, metal–carbon bonding (σ and π bonding), bonding properties of carbon monoxide, alkenes and phosphines. Reactivity of organometallic compounds, homogeneous catalysis, catalytic cycles.

Nuclear and radio chemistry (8 h)

Atomic nucleus, radio isotopes, binding energy, nuclear stability, radioactivity and decay, nuclear reactions, effects of radiation on matter, radio analytical techniques and applications.

Method of teaching and learning : A combination of lectures and tutorial discussions

Assessment : Continuous assessment and/or end of course unit examination

Recommended reading:

1. Cotton, F.A., and Wilkinson, G., (1988) *Advanced Inorganic Chemistry*, New York, John Wiley.
2. Prakash, S., Basu, S.K., Tuli, G. D., and Madan, R.D., (1999) *Advanced Inorganic Chemistry*. Vol (II) Chand, India
3. Parkins and Poller, (1986) *An introduction to Organometallic Chemistry*: Hampshire, McMillan.
4. Atkins, P. W., De Paula, J., (2006) *Physical Chemistry*, Oxford.
5. Ladd, M.F.C., and Palmer, R.A., (2003) *Structure Determination by X-ray Crystallography,* Kluwer Academic.

Course code : CHEM 22152

Course title : Organic Spectroscopy, Synthesis and Natural Products

Pre-requisites : CHEM 12162

Learning outcomes: Upon completion of the course unit, the student should be able to;

- interpret spectra of simple organic compounds
- determine the structure of simple compounds by analyzing spectra
- construct C-C and C-N bonds using efficient synthetic methods
- construct simple organic molecules employing suitable methods, reagents and reaction conditions.
- recognize the major classes of natural products and describe their unique characteristics.
- explain the basic biosynthetic pathway of the above classes of natural products.

Course content:

Spectroscopic methods in structure elucidation of organic chemistry (14 h)

Electromagnetic spectrum and organic molecules; UV and visible spectroscopy, molecular orbital description, color of compounds, chromophores, solvent effects, Beer Lambert's law, UV spectrometer. Infra red spectroscopy; stretching frequencies of functional groups, effects of hydrogen bonding, IR spectrometer and experimental considerations. ^{1}H-Nuclear magnetic resonance spectroscopy; theory, secondary magnetic fields, chemical shift values of aliphatic and aromatic compounds, including annulenes, chemical equivalence, peak area measurement and integration, spin-spin splitting, effect of hydrogen bonding, D_2O exchange, NMR spectrometer and experimental considerations. ^{13}C-NMR; theory, chemical shift assignments, effect of neighboring protons, proton coupled ^{13}C-NMR spectrum, off resonance decoupled spectra, experimental considerations. Mass spectroscopy; theory, mass spectrometer and mass spectrum, molecular ion and fragmentation patterns of compounds, use of molecular formula, N-rule, high resolution mass spectra. Interpretation of the spectra of organic compounds.

Organic synthesis (8 h)

Carbon-carbon single bond formation; carbonyl condensations, inter and intra molecular condensations, specific enolates, base promoted alkylations. Carbon- carbon double bond formation; Wittig reaction. The use of organometallics in synthesis; Mg and Cu reagents. Carbon-nitrogen bond formation, use of rearrangements in synthesis; Baeyer Villiger and Claisen rearrangements. Functional group transformations in synthesis including oxidation and reduction.

Natural products (8 h)

Diversity and classification, link between primary and secondary metabolites, pharmaceutical, ayurvedic and agricultural interests of natural products; polyketide, macroide, antibiotics, antioxidants, terpenes, steroids and alkaloids, structural features and properties and biosynthesis of major classes of natural products; terpenes, steroids and alkaloids.

Method of teaching and learning : A combination of lectures and tutorial discussions

Assessment : Continuous assessment and/or end of course unit examination

Recommended reading:

1. Sanders. J.M., Hunter, B.K., (1993) *Modern NMR Spectroscopy A Guide for Chemists*, Oxford University press
2. Williams, D.H., (1989) *Spectroscopic methods in Organic chemistry,* Mc Graw and Hill
3. Pavia, D. L., Lapman G M and Kriz G S (1979) Introduction to Spectroscopy, Saunders.
4. Norman, R. O. C., and Coxon J.M., (1993) *Principles of Organic synthesis*, Chapman & Hill.
5. Mann J., Davidson R S, Hobbs J.B., Banthorpe DV and Harbone J.B., (1996) *Natural Products: Their chemistry and biological significance,* Longman.
6. Finar IL (1991) *Organic Chemistry*, Vol II, Longmann

Course code : CHEM 22161
Course title : Organic Analytical and Synthetic Chemistry Laboratory
Pre-requisites : CHEM 12171
Co-requisite : CHEM 22152

Learning outcomes:

At the end of the course unit, the student should be able to;

- isolate and separate of natural products using chromatographic techniques
- perform structure elucidation of simple organic compounds using NMR, IR, UV and mass spectra
- perform single/multi step syntheses, isolate and purify products
- use alternative environmental friendly synthetic methods in organic chemistry.

Course content:

Structure elucidation of simple organic compounds by the use of spectroscopy; ^{1}H NMR, ^{13}C NMR, MS, FTIR and UV. Isolation; steam distillation, cold and hot extraction, portioning. Separation; chromatographic techniques-column and TLC and analysis of natural products. Purification techniques; distillation, fractional distillation, vacuum distillation, sublimation. Synthesis of simple organic compounds via Diels-Alder reaction and Aldol condensation and characterization of products. Introduction to green organic chemistry; microwave synthesis of organic compounds.

Method of teaching and learning :

A 3 hour laboratory class per week (15 weeks)

Assessment :

Continuous assessment and end of course unit examination

Recommended reading:

1. Kappe, G.O., Stadler, A., (2005) *Microwaves in organic and medicinal chemistry*, Volume 25, John Wiley
2. Tierney, J.P., (2005) *Microwave assisted organic synthesis*, Blackwell.
3. Campbell, B.N. and McCarthy, M., (1994) *Organic chemistry Experiments, Microscale and Semimicroscale*, Brooks and Cole Publishing Co.
4. Williamson, K.L., (1989) *Macroscale and microscale organic experiments,* D.C. Herath and Co.
5. Nimitz, J.S., (1990) *Experiments in Organic Chemistry*, Prentice-Hall
6. Sanders. J.M., Hunter, B.K., *Modern NMR Spectroscopy A Guide for Chemists* (second edition), Oxford University press
7. Williama, D.H., (1989) *Spectroscopic methods in Organic chemistry,* McGraw and Hill

8. Pavia, D. L., Lapman G. M., and Kriz, G.S., (1979) *Introduction to Spectroscopy*, Saunders.

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Course code : CHEM 22171
Course title : Analytical Chemistry Laboratory
Pre-requisites : CHEM 21122

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

- perform an appropriate sampling technique prior to chemical analysis
- apply the best analytical technique for an unknown sample to be characterized chemically
- validate the analytical method and data obtained by chemometric techniques
- identify, differentiate and demonstrate the classical and instrumental methods of chemical analysis.

Course content:
Experiments based on sampling and data handling, gravimetric analysis of metals using homogeneous precipitation method, complexometric titration of metal mixtures. Experiments based on analytical spectrometry; atomic absorption spectrometry, flame photometry and colorimetry. Electroanlytical techniques; voltammetry, potentiometry, Gran titration using spread sheets and electrogravimetry. Application of analytical techniques in industrial samples; pigments, paints and coatings, dyes etc.

Method of teaching and learning : A 3 hour laboratory class per week (15 weeks)
Pre-labs and assignments.

Assessment : Continuous assessment and end of course unit examination.

Recommended reading:
1. Skoog, D.A., James F.H., Nieman. T. A., (1998) *Principles of Instrumental Analysis,,* Harcourt Brace College Publishers
2. Skoog, D.A., Donald M. W., James, F.H., (1996) *Fundamentals of Analytical Chemistry,* Saunders College Publishing.
3. Harris, D.C., (2006) *Quantitative Chemical Analysis,* Freeman
4. Mendham, J., Denney, R.C.; Barnes, J.D., (2002) *Vogel's textbook of Quantitative Chemical analysis,* Prentice Hall.

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LEVEL-3

First Semester (15 weeks)

Course code : CHEM 31111
Course title : Inorganic Synthesis and Analysis Laboratory
Prerequisites : CHEM 11141

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

- synthesize and isolate air-stable coordination complexes
- analyze the isolated complexes by titrimetric and colorimetric methods
- solve problems and plan schemes related to the analysis of coordination complexes.

Course content:
Synthesis of inorganic complexes and analysis by titrimetric and gravimetric methods. Factors affecting colorimetry; spectrophotometric studies of permanganate –oxalate reaction. Analysis of inorganic complexes by colorimetry, UV and visible spectra of coordination complexes, variable oxidation states of vanadium, catalytic determination of trace copper, and other related experiments. Mini-project and presentations.

Method of teaching and learning : A 3 hour laboratory class per week (15 weeks) and assignments

Assessment : Continuous assessment and end of course unit examination

Recommended reading : Reading materials will be provided during the laboratory classes.

Course code : CHEM 31122
Course title : Material Chemistry, Earth Resources and Introduction to Quality Management
Pre-requisites : CHEM 22142

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

- describe the importance of the earth resources in chemical industry
- identify different inorganic materials and their industrial uses
- explain processing and utilization procedures of various materials, minerals and crude petroleum
- validate methods and data, quality assurance of products and concept of intellectual property rights.

Course content:
Inorganic material chemistry (9 h)
Chemistry, properties and manufacture of glass, cement, ceramics and pigments; raw materials. Structures, preparation and applications of biomaterials, silicones and zeolites.
Minerals and metallurgy (10 h)
Chemistry and identification of mineral resources; ores and deposits, physiochemical properties and uses of minerals and deposits of commercial value. Mineral sands, appetite, dolomite, graphite, quartz and mica. Introduction to extraction of metals; hydrometallurgical, pyrometallurgical and electrometallurgical methods.
Petroleum chemistry (5 h)
Petroleum deposits, cracking processes, separation and refining processes.
Quality management, intellectual property and green chemistry (6 h)
Introduction to quality management, basic norms of intellectual property law, rationale and policy underlying intellectual property law, overview of green chemistry and cleaner production.

Method of teaching and learning : A combination of lectures and tutorial discussions

Assessment : Continuous assessment and/or end of course unit examination

Recommended reading:

1. Schubert, U. and Husong, N., (2000) *Synthesis of Inorganic Materials*, VCH.
2. Buchel, K. H., Moretto, H. H. and Woditsch, P., (2000) *Industrial Inorganic Chemistry*, VCH.
3. James A. K., (1993) *Riegel's Handbook of Industrial Chemistry*, Kluwer
4. Barry A. W., (1997) *Mineral Processing Technology*, Pergamon Press
5. Lancaster, M., (2002) *Green Chemistry*, RSC.

Course code : CHEM 31132
Course title : Introduction to Environmental Chemistry
Pre-requisites : CHEM 11122 / 21122

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

- explain the importance of the environmental chemistry
- describe the fundamentals in atmospheric, aquatic and soil chemistry
- identify and recognize sources, reactions and fate of chemical pollutants in the environment
- explain the importance of waste minimization and waste management.

Course content:
Atomospheric chemistry (8 h)

Importance of atmosphere, components of atmosphere, chemical and photochemical reactions, air pollution and chemistry of air pollutants, enhanced greenhouse effect, photochemical smog, ozone layer depletion, acid rain, nuclear winter, minimization of air pollution.

Aquatic chemistry (8 h)

Various bodies of water, their characterization and significance, interactions between water and air, interactions between water and soil, chemical transformations, water quality, water pollution, waste water and waste water treatment.

Soil chemistry (8 h)

Soil formation, soil minerals and organic matter, surface charges of soil clay particles, soil profile and texture, acidity, alkalinity and salinity of soil, cation exchange capacity (CEC) and base saturation, sodium absorption ratio (SAR).

Pollution and waste management (6 h)

Waste and pollutants in atmosphere, hydrosphere, and geosphere, treatment and disposal of waste and waste minimization.

Method of teaching and learning : A combination of lectures and tutorial discussions

Assessment : Continuous assessment and/or end of course unit examination

Recommended reading:

1. Manahan, S. (1998) *Environmental Chemistry*, Lewis.
2. McBride, M. B. (1994) *Environmental Chemistry of soils*, Oxford.
3. Evangelou, V. P. (1998) *Environmental soil & water Chemistry. Principle and Applications*, John Wiley.
4. Harrison, R. M. (1999) *Understanding our Environment. An introduction to Environmental Chemistry and Pollution*, RSC.

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Course code **:** PRPL 31012
Course title **:** Industrial / Professional Placement

Learning outcomes:

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

- Use laboratory skills in industrial applications and accumulate work place skills that will help them in their future careers.

Course content:

The students will be placed in selected industries and institutions where they carryout chemistry related work/research for a period of six weeks. The required resource materials will be supplied by the relevant institution/industry.

Method of teaching and learning : Training under the supervision and guidance of research/industrial personnel.

Assessment **:** Oral presentation and report.

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Second Semester (15 weeks)

Course code **:** CHEM 32152
Course title **:** Polymer Chemistry
Pre-requisites **:** CHEM 11132 / CHEM 21112

Learning outcomes:

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

- explain the basics of polymer chemistry

- propose methods of polymer synthesis, their identification, and investigation of properties
- explain various chemical processes involved in polymer related industries in Sri Lanka

Course content: Brief overview of polymer synthesis, characterization and properties. Industries based on polymers; dry-rubber based industry, latex-based industry, plastics, paints, soaps and detergents. Experiments in polymer synthesis and characterization, identification of common polymers, manufacturing of latex based rubber products.

Method of teaching and learning : A combination of lectures and tutorial discussions

Assessment: Continuous assessment and/or end of course unit examination

Recommended reading:

1. Ravve, A., (1995) *Principles of Polymer Chemistry*, Plenum.
2. Billmeyer, F. W., (1984) *Text book of Polymer Science*, John Wiley.
3. Seymour, R.D. and Carraher, Jr. E.R., (1992) *Polymer Chemistry; An Intorduction*, Marcel Dekker Inc., New York

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Course code : CHEM 32162
Course title : Applied Natural Products Chemistry
Prerequisites : CHEM 22152

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

- describe the importance of the natural products in industry
- explain the development of new pharmaceuticals, biopesticides and selected foods
- explain critically the application of herbal remedies and the potential of drug development from natural products.

Applied natural products chemistry (30 h)
Industrial applications of spices and essential oils and selected macromolecules (natural polysaccharides), dye industry, herbal technology. Natural products with pharmaceutical value; anticancer , anti-tumer, anti HIV, antioxidants and hyperglycemic activities etc. Development of bio-pesticides, methodologies in applied natural product chemistry; bioassay guided fractionation, fractionation techniques of bioactive natural products. Use of LC-MS, GC-MS, EAG, GC-EAG in identification of natural products, bioassay methods; antimicrobial assays, anticancer assays, insecticidal bioassays etc.

This course will be complimented by a minimum of one factory/field visit.

Method of teaching and learning : A combination of lectures and tutorial discussions

Assessment: Continuous assessment and/or end of course unit examination

Recommended reading:

1. Voelter, W. and Daves, D. G., (1984) *Biologically active principles of natural products*. Georg Thieme Verlag
2. Szantay, C. S., (1984) *Chemistry and biotechnology of biologically active natural products,* Elsevier
3. Odham, G. Larsson, L. and Mardh, P., (1984) *Gas Chromatography / Mass Spectrometry*, Plenum Press
4. Steiner, R., (1983) *Excited States of Biopolymers*, Springer

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Course code : CHEM 32171
Course title : Environmental Chemistry Laboratory
Pre-requisites : CHEM 31132

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

- describe common sources of atmospheric, soil and water pollutants

- develop skills necessary to identify and quantify soil, water and air pollutants.

Course content:
Soil analysis; phosphates, total nitrogen, ammonia, water soluble chlorides, sulfate and metal ions, soil acidity, alkalinity, cation exchange capacity (CEC) and total organic matter. Water analysis; total solids, conductance, hardness, pH, COD, BOD, oil, grease, dyes, surfactants and other heavy metals. Air analysis; sampling and determination of the levels of NOx and other pollutants in the air. Analysis of food preservatives and bleach samples.

Method of teaching and learning : A 3 hour laboratory class per week (15 weeks)

Assessment : Continuous assessment and end of course unit examination

Recommended reading:

1. Fifield, F. F. and Hanes, P. J., (2000) *Environmental Analytical Chemistry*, Blackwell.
2. Kebbekus, B.B and Mitra, S., (2000) *Environment Chemical Analysis,* Chapman & Hall/CRC
3. Boehnke, D. N. and Delumyea, R.D., (2000) L*aboratory Experiments in Environmental Chemistry,* Printice Hall

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Course code **:** CHEM 32182
Course title **:** Chemical Informatics
Prerequisites **:** CHEM 21122

Learning outcomes: Upon successful completion of the course unit, the student should be able to;
- apply computer-assisted techniques to chemical problems such as information storage and retrieval, the prediction of physical, chemical or biological properties of compounds etc.

Course content:
Chemical information (8h)
Outline of the main databases available, some problems and challenges of finding and analyzing chemical information.
Introduction to bioinformatics (12 h)
Retrieving and analyzing of available information. The use of bioinformatics to address the chemical problems of identifying drug targets and in molecular design.
Computer representation of molecules and molecular data analysis (10 h)
Methods of representing molecules in computers, how different approaches are best for different contexts. Generation of molecular data from molecular representations and analyzing. Methods of property generation and analysis.

Method of teaching and learning :
A combination of lectures, tutorial discussions and computer assignments.

Assessment : Continuous assessment and/or end of course unit examination

Recommended reading:

1. Leach, A. R., Gillet, V. J., (2003) *An Introduction to Chemoinformatics*, Kluwer.
2. Lesk, A. M., (2005) *An Introduction to Bioinformatics,* Oxford

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