Tribhuvan University

Institute of Science and Technology

4 Years B.Sc. 4th Year Chemistry Course

(Revised-2073)

Course Title: General Chemistry-II | **Full Marks**: 100

Course No.: CHE 401 (major) | **Pass Marks**: 35

Nature of the Course: Theory | **Year**: IV

Course Objectives:

- To develop student's ability to communicate in appropriate ways.
- To encourage student's to apply their chemical knowledge and understanding to familiar and unfamiliar higher studies in chemistry.
- To pursue higher studies in chemistry.
- To explain the social, economic, environmental and technological implications of chemistry.
- To explain the fundamentals organic synthesis.
- To explain the mechanism, stereochemistry and scope of widely used organic reactions.
- To introduce phase equilibrium & surface chemistry.
- To explain solid structures & its defects.
- To introduce the basic concepts of quantum & statistical mechanics.
- To provide mechanistic approaches of organic reactions.

Group A: Inorganic Chemistry

Reactions in Nonaqueous Solvents: Protic and non protic solvents, criteria of selection of non aqueous solvents, reactions of NH_3, reactions of SO_2. **6 hrs**

Inorganic Polymers: Introduction, review, types of polymerization, homopolymers and heteropolymers, organosilicon compounds and silicones, phosphonitrilic compounds, polythiazyles $(SN)_x$, geopolymer, Silicon nitrides. **10 hrs**

Organometallic Compounds: Non transition metals: general survey of types, synthetic methods, metal alkyls of group I, II and III elements, transition metals: transition metal to carbon σ bonds, alkene complexes, haptonomenclature, alkyne complexes, allyl complexes, metallocenes (preparation, properties, structure and elementary approach of bonding with reference to ferrocene), Homogeneous catalysis, Heterogeneous catalysis, Selection of criteria of catalyst.

10 hrs

Bioinorganic Chemistry: Introduction, Roles of metals in biological system, Essential and trace elements in biological system, Metals and its complex as therapeutic agents, Iron and copper as oxygen carriers in biological system, The chemistry of elements in medicine, Chelation therapy and anticancer drugs, Introduction to anticancer drugs and its mechanism with reference to cis-platin. **13 hrs**

Lanthanides and actinides: Lanthanides: Comparative study of lanthanide elements, with respect to electronic configuration, atomic radii, oxidation state and complex formation, colour and spectra, magnetic properties, lanthanide contraction, occurrence and principles of separation of lanthanides, General features and chemistry of actinides, principles of separation of Np, Pu, Am from U. Trans-uranium elements: Introduction, synthesis of transuranium elements from $_{93}$Np to $_{103}$Lr). **11 hrs**

Group B: Organic Chemistry

Name Reactions: Introductory study of glossary of at least 30 name reactions, their simple mechanism, applications and the utilities of the synthetic reagents involved therein under the following heading of reaction types– oxidation, reduction, condensation, rearrangement, addition and elimination (name reactions are given in the Appendix I) **16 hrs**

Introduction of Green Chemistry: Introduction, definition of green chemistry, price of achievements of green chemistry, foundation pillars of green chemistry, future status of green chemistry, green catalyst (phase transfer catalyst). **2 hrs**

Organic Synthesis: Retrosynthetic Analysis by Disconnection Approach– Gradual development of organic synthesis, Retrosynthesis, Monofunctional disconnection (Examples of alcohol, alkene, ketone, carboxylic acid and their derivative, alkane, amine disconnections), Bifuntional disconnection, Microwave assisted organic synthesis, Protection of functional groups, Introduction, Protection of C-H bond, C=C bond, alcoholic-OH, amino group, aldehydes and ketones, carboxylic group, solid support synthesis, combinatorial synthesis, common solid supports, peptide synthesis on solid support. **12 hrs**

Introduction to Supramolecular Chemistry: Host-Guest Chemistry– Introduction, cation binding host molecules, selectivity of host molecules, a few synthetic cation binding host molecules, some uses of cation binding host compounds, anion binding host compounds, neutral molecule trapping host compounds. **6 hrs**

Drugs: Chemotherapeutic and Pharmacodynamic Agents: Introduction, classification of drugs, chemotherapeutic agents, antibacterial drugs, antibiotics, synthetic antibacterial agents, antiprotozoal drugs, antifungal agents, antiviral drugs, action of chemotherapeutic agents against microorganisms, pharmacodynamic agents, analgesic and anti-inflammatory agents, psycotropic drugs, antihistamines, antidiabetic drugs, drugs for cardiovascular diseases, antineoplastic drug, drug resistance, new development in drug research, drug designing, computer aided drug designing. synthetic dyes, classification and uses of dyes, brightening agents. **14 hrs**

Group C: Physical Chemistry

Phase Equilibrium:

Introduction, definition and meaning of the terms–phase, component and degree of freedom, Gibbs phase rule, phase diagram, phase equilibrium of one component system: water.

Phase equilibrium of two component system (solid-liquid system)– Introduction and cooling curves, simple eutectic Pb–Ag system, desilverization of lead, system involving compound formation with congruent melting point (phase diagram of Mg–Zn) and system involving compound formation with incongruent melting point (phase diagram of NaCl-water).

Binary liquid systems– Completely miscible liquid pairs, ideal and non-ideal liquid mixture, distillation of binary liquids, ratio of distillate to residue, fractional distillation, azeotropes.

Partial miscible liquid pairs– Phenol–water system, tri–ethylamine water system, nicotine water system, lower and upper consolute temperatures, Henry's law, Nernst distribution law and applications, distribution of solute between two phases, solvent extraction.

Completely immiscible liquid pairs– Benzene water system, steam distillation. **14 hrs**

Solid State Chemistry:

Interplanar distance in cubic system, Braggs law and its application, crystal structure of NaCl and KCl, defects in crystals: point defects (Frenkel, Schottky and self-interstitial defects), line defects (edge and screw dislocations) and plane defects (grain boundary and stacking faults), color centers and formation of F-centre, classification of solids based on the formation of band: conductor, semiconductor, insulator and superconductor. **14 hrs**

Surface Chemistry:

Adsorption: absorption and sorption, physical and chemical adsorptions, types of physical adsorption isotherms, Gibbs adsorption equation, Freundlich adsorption isotherm & Langmuir adsorption isotherm: postulates, derivation, interpretation and limitation; Brunauer-Emett-Teller (BET) adsorption: postulates, equation, interpretation and limitations, determination of surface area of solid adsorbents **10 hrs**

Quantum & Statistical Mechanics:

Quantum Mechanics– Introduction, history of quantum mechanics (Max Planck to Schrödinger), ultraviolet catastrophe, wave-particle duality, time independent Schrödinger wave equation, wave function and probability, concept of orthogonal and normalized wave functions, postulates of quantum mechanics, quantum mechanical operators, particle in a box (one dimensional and three dimensional).

Statistical Mechanics– Introduction, history of statistical mechanics, concept of phase space, ensemble, entropy and thermodynamic probability, distribution of identical but distinguishable particles, Boltzmann distribution law **12 hrs**

Course Title: General Practical Chemistry-II | **Full Marks**: 50

Course No.: CHE 402 (major) | **Pass Marks**: 20

Nature of the Course: Practical | **Year**: IV

Course Objectives:

- To follow instructions for practical work.
- To make students aware of the importance to scientific method of accurate observation and measurements being aware of possible sources of error.
- To record and interpret accurately and clearly the results of experiments.
- To explain practical techniques, procedures and safe laboratory working practices.

Experiments in Inorganic Chemistry

Quantitative Estimation

- Precipitation titration of silver nitrate in acidic media (Volhard Method).
- Redox titration involving potassium dichromate (Determination of iron in Mohr's salt and haematite). **12 hrs**

Gravimetric Analysis

- Nickel as complex with dimethyl glyoxime; Copper as cuprous thiocyanate; Aluminum as oxinate; Lead as lead chromate; Magnesium as magnesium ammonium phosphate and as pyrophosphate. **27 hrs**

Paper Chromatography

- Qualitative analysis of some inorganic anions and cations by paper chromatography (two each). **6 hrs**

Ion–Exchange chromatography

- Separation of metal ions from mixture.

Preparation of complex

- Preparation of potassium trioxalatoferrate(III) trihydrate and measurements of its conductivity. Estimate the amount of iron present in the above complex. **6 hrs**

Experiments in Organic Chemistry

1. Spectral analysis (spectra of simple organic compounds including aliphatic and aromatic hydrocarbons, alcohols, aldehydes, ketones, carboxylic acid, amines, etc will be provided and students are required to interpret the given spectra and find out the structures of organic compounds).

2. Two-three sets of two steps synthesis.
3. Purification and separation of organic mixtures by paper, thin layer and column chromatographic techniques.
4. Determination of the amount of aspirin present in the given 150 mg aspirin tablet by indirect titration against the standard HCl.
5. Estimation of ascorbic acid in vitamin C tablet iodometrically.
6. Benzoin condensation (a green synthesis using thiamine hydrochloride replacing KCN).
7. Introduction to micro scale organic experiments. **51 hrs**

Experiments in Physical Chemistry

1. To carry out conductometric titration between the mixture of hydrochloric and acetic acids against standard sodium hydroxide solution.
2. To study the kinetics of acid catalyzed iodination of propanone.
3. To study the kinetics of oxidation of ethyl alcohol with potassium dichromate in acidic media.
4. To determine the partition coefficient of iodine between organic liquid and water.
5. To determine the freezing point curve of the mixture of naphthalene and biphenyl and also to construct the phase diagram.
6. To verify the Beer-Lambert's law and to determine the concentration of a color solution of unknown strength using filters colorimeter/spectrophotometer.
7. To determine the critical solution temperature of phenol-water system and the composition of the solution at CST.
8. To study the adsorption of acetic acid from aqueous solution by activated charcoal and to examine the validity of Freundlich and Langmuir's adsorption.

51 hrs

Course Title: General Chemistry-III **Full Marks**: 100

Course No.: CHE 403 (major) **Pass Marks**: 35

Nature of the Course: Theory **Year**: IV

Course Objectives:

- To understand the fundamentals of coordination compounds.
- To know the chemistry of lanthanides and actinides.
- To understand the chemistry of bio-organic molecules.
- To discuss different types of chemical and photochemical reactions, and their kinetics.

- To provide knowledge on modern electrochemistry and its uses.
- To introduce the basic concepts of corrosion sciences.

Group A: Inorganic Chemistry

Coordination Compounds: Isomerism in coordination complexes: (a) polymerization isomerism, (b) ionization isomerism, (c) hydrate isomerism (d) linkage isomerism, (e) coordination isomerism, (f) coordination position isomerism (g) geometric isomerism, (h) optical isomerism, IUPAC nomenclature of coordination compounds, **8 hrs**

Bonding and Application of Coordination Compounds: Valence bond theory, inner and outer orbital complexes, crystal field theory, Jahn Teller distortion in octahedral and tetrahedral complexes, characterization of complexes by spectroscopic, Optical and magnetic methods, chelates and polynuclear complexes, high spin and low spin complexes, stereochemistry of complexes with coordination number 4 and 6, substitution reactions and trans effect, application of complexes in analytical and biological fields.

Stability constant or formation constant: Kinetic stability (Labile and inert complexes), thermodynamic stability, (stable and unstable complexes), stepwise stability constant and overall stability constant of complexes, factors influencing the formation of complexes (thermodynamic and kinetic stability). **22 hrs**

Inorganic Reaction Mechanism:

Fundamentals of ligand substitution reaction: Activated complex, Labile and inert complexes, mechanism of substitution reaction: 1. dissociative (d) mechanism, 2. Associative (a) mechanism, basic idea of redox reaction in coordination complexes: atom transfer mechanism and electron transfer mechanism.

10 hrs

Elementary study of carbonyls and nitrosyls: General method of preparation, bonding, application of 18 electron rule, structure of carbonyls, polynuclear carbonyls and nitrosyls.

10 hrs

Group B: Organic Chemistry

Bio-organic Chemistry: Biological oxidation and reduction, (ethanol and acetaldehyde), biological oxidation and reduction (deuterium labeling experiments), stereochemistry of biological oxidation and reduction, organic chemistry of vision, biosynthesis of fatty acids, mechanism of enzyme action (chymotrypsin). **10 hrs**

Carbohydrates: Introduction, definition and classification, (+)–glucose as an aldohexose, (-)-fructose as a 2-keto hexose, stereo isomers of (+) –glucose, oxidation (effect of alkali, osazone formation (epimers), lengthening and shortening the carbon chain of aldoses, conversion of an aldose into its epimer, conversion of aldose into ketose and vice versa, configuration of (+)–glucose (the Fischer proof), configuration of aldoses, optical families D and L, tartaric acid,

families of aldoses (absolute configuration), open and cyclic structure of glucose, configuration about C-1, methylation, determining ring size, conformation. **18 hrs**

Lipids: Lipids, occurrence and composition of fats, hydrolysis of fats, fats as a source of pure acids and alcohols, detergents, unsaturated fats, phosphoglycerides, cell membrane, steroids. **6 hrs**

Proteins & Nucleic Acid: Protein, structure of amino acids, amino acids as dipolar ions, isoelectric point, configuration of natural amino acids, preparation of amino acids, reactions of amino acids, Dopa mine and its uses in medicine peptides (geometry of peptide linkage), determination of structure of peptides, synthesis of peptides, proteins (classification and functions), structure of protein, peptide chain, side chain (isoelectric point, electrophoresis), conjugated proteins, secondary structure of protein, nucleoproteins and nucleic acids, the genetic code. **16 hrs**

Group C: Physical Chemistry

Chemical Kinetics:

Consecutive reaction, parallel reaction, opposing reaction, theories of reaction rates: collision theory of a bimolecular and unimolecular reactions, transition state theory, chain reaction, kinetics of some gas phase photochemical reactions: (a) decomposition of ozone, (b) hydrogen and chlorine (c) hydrogen and bromine, kinetics of condensation polymerization **15 hrs**

Modern Electrochemistry:

Ion-solvent and ion-ion interactions: Ion-solvent interaction, solvation (thermodynamic and spectroscopic approaches) and dielectric effects, quantitative treatment of the Debye-Hückel (ion cloud) theory of ion-ion interactions, Debye-Hückel theory of activity coefficient and its limitations **15 hrs**

Polarization & Commercial Cell:

Polarization of electrochemical cell, types of polarization (activation, concentration & overvoltage), determination of hydrogen overvoltage, application of overvoltage (deposition of metal), commercial cells; principles, applications and limitations of primary cell (Leclanche cell) and secondary cells (lead-acid and nickel-cadmium cells), fuel cells (introduction & types) **8 hrs**

Corrosion of Metallic Materials:

Introduction, cost & importance of corrosion study, types of corrosion: based on corroded surfaces & environments (aqueous, atmospheric, soil & concrete), fundamentals of corrosion cells, brief discussion of corrosion control methods (including inhibitors and cathodic protection techniques) **12 hrs**

Full Marks: 50

Course Title: General Practical Chemistry-III

Course No.: CHE 404 (major) **Pass Marks**: 20

Nature of the Course: Practical **Year**: IV

Course Objectives:

- To follow instructions for practical work.
- To make students aware of the importance to scientific method of accurate observation and measurements being aware of possible sources of error.
- To know the principles of qualitative and quantitative analysis of chemical substances.
- To record and interpret accurately and clearly the results of experiments.
- To explain practical techniques, procedures and safe laboratory working practices.

Experiments in Inorganic Chemistry

Qualitative analysis of salt mixture containing 6 radicals (including interfering radicals) **30 hrs**

Iodometric Titration **6 hrs**

1. Estimation of available chlorine in bleaching powder iodometrically.
2. Determination of dissolved oxygen in water sample by Winkler's iodometric method.

Complexometric Titration **6 hrs**

1. Determination of amount of Magnesium and Manganese in a given mixture solution by EDTA.
2. Determination of amount of Copper and Iron in a given mixture solution by $K_2Cr_2O_7$ solution.

Colorimetric Analysis **9 hrs**

1. Determination of Pb as dithizone complex colorimetrically.
2. Colorimetric determination of PO_4^{-3} by molybdenium blue method.

Experiments in Organic Chemistry

1. Quantitative analysis of any two: (OH-group, nitrogen, sulphur, glucose, carbonyl group),
2. Isolation of the following natural products (any two): lactose, caffeine, camphor, essential oil.
3. Perform the characteristic reactions of carbohydrates, fats and protein.
4. Determination of acid value of fats or oil.

5. Determination saponification value of fats or oil.
6. Determination of iodine number of fat or oil.

51 hrs

Experiments in Physical Chemistry

1. To determine the size of a molecule of the given compound by viscosity measurement.
2. To determine concentration of Cl^- in KCl or I^- in KI solution titrating with standard silver nitrate solution potentiometrically.
3. To determine rate constant for the saponification of ethyl acetate by sodium hydroxide by conductivity method.
4. To determine the concentration of phosphoric acid in cola beverage using pH meter.
5. To study the effect of concentration of catalysts on the reaction rate for acid catalyzed hydrolysis of methyl acetate.
6. To determine the activation energy for the reaction between potassium persulfate and potassium iodide by iodine clock method.
7. To determine the λ_{max} and molar absorbtivity coefficient (ε) for ferric-thiocynate complex and also to determine the concentration of iron in a given sample of water.
8. To carry out potentiometric titration of acetic acid with sodium hydroxide using quinhydrone electrode and to determine the dissociation constant.

51 hrs

Text Books: for theory courses CHE 401 & CHE 403:

1. J. D. Lee, *Concise Inorganic Chemistry*, 5th Edition, John Wiley and Sons. Inc., 2007.
2. F. A. Cotton, G. Wilkinson & C. Gaus, *Basic Inorganic Chemistry*, 3rd Edition, John Wiley & Sons (Asia), Pvt., Ltd., 2007.
3. M. R. Pokhrel & B. R. Poudel, *A Textbook of Inorganic Chemistry*, 2nd Edition, National Book Centre, Kathmandu, 2011.
4. D. F. Shriver & P. W. Atkins, *Inorganic Chemistry*, 5th Edition, Oxford University Press.
5. J. E. Huheey, E. A. Keiter & R. L. Keiter, *Inorganic Chemistry, Principles of structure and Reactivity*- Addison Wesley Publishing House, 1990.
6. S. Pimplapure, R. Jain, A. Sahai & U. Soni, *Inorganic Polymer Chemistry*, Pragati Prakashan, Meerut, 2012.
7. W. U. Malik, G. D. Tuli & R. D. Madan, *Selected Topics in inorganic chemistry*, .S. Chand & Company, New Delhi, 1995.
8. B. Doglas, D. MacDaniel & J. Alexander, *Concepts and Models of Inorganic Chemistry*, Recent edition

9. F. Basolo & R. G. Pearson, *Inorganic Reaction Mechanism*, 2nd edition, Wiley, New York, 1967.
10. R. B. Jordan, *Reaction Mechanism of Inorganic and Organometallic Systems*, 3rd edition, oxford University Press, 2007.
11. R. T. Morrison, R. N. Boyd & S. K. Bhattacharjee, *Organic Chemistry*, 7th Edition, Prentice- Hall of Pearson, 2012.
12. J. March, *Advanced Organic Chemistry*, 4th Edition, Wiley Eastern Ltd., India, 2005.
13. Jonathan Clayden, *Organic Chemistry*, 2nd Edition, Oxford University Press, India.
14. F. Carey, R, Giuliano, *Organic Chemistry*, McGraw-Hill 8th Edition, 2010.
15. S. H. Maron & C. Prutton, *Principles of Physical Chemistry*, 4th Edition, Oxford & IBH Pub. Co., 1992.
16. J. O'M Bockris & A. Reddy, *Modern Electrochemistry*, **Vol. I**, 2nd Edition, Plenum Pub. Corp., New York, 1998.
17. P. Atkins & J. de Paula, *Elements of Physical Chemistry*, 5th Edition, Oxford University Press Inc., Printed in India by Saurabh Printers Pvt. Ltd., New Delhi, 2009.
18. R. W. Revie & H. H. Uhlig, *Corrosion and Corrosion Control; an Introduction to Corrosion Science and Engineering*, 4th Edition, John Wiley & Sons, Inc., New York, 2008.
19. S. O. Pillai, *Solid State Chemistry*, Wiley Eastern Ltd., 1994.
20. A. K. Chandra, *Introductory Quantum Chemistry*, 4th Edition, Tata McGraw-Hill, New Delhi, India, 1994.

Reference Books: for theory courses CHE 401 & CHE 403:

1. R. D. Madan & Satya Prakash, *Modern Inorganic Chemistry*, S. Chand & Company Ltd., 1994.
2. A. K. Bhagi & G. R. Chatwal, *Bioinorganic and Supramolecular Chemistry*, Himalaya Publishing House, Mumbai.
3. A. Sharpe, *Inorganic Chemistry*, 2nd Edition, ELBS & Longman, Singapore, 1986, (Recent edition).
4. M. L. Sharma & P. N. Chaudhary, *A Textbook of B. Sc. Chemistry* (Volume I and II), Second Edition, Ekta Books Nepal, 2007.
5. K. N. Upadhyaya, *A Textbook of Inorganic Chemistry*, 2nd Edition, Vikash Publishing House Pvt., Ltd., 1995
6. C. Agrawal, *Modern Inorganic Chemistry*, Wiley Eastern, New Delhi, 1981, (Latest edition).
7. I. L. Finar, *Organic Chemistry*, Vol. I and Vol. II, Prentice Hall, London, (Latest edition).

8. Streitweiser & Heathcock, *Introductory Organic Chemistry*, Wiley and Sons, New York, 1981.
9. B. S. Bahl & A. Bahl, *A Textbook of Organic Chemistry*, S. Chand Publication, New Delhi, India, 2012.
10. T. W. Graham Solomons, *Organic Chemistry*, (latest edition), John Wiley and Sons, New York.
11. G. M. Loudon, *Organic Chemistry*, Fourth Edition, Oxford University Press, India.
12. R. A. Bansal, *A Textbook of Organic Chemistry*, 2nd Edition, Wiley Eastern Ltd., New Delhi, 1993 (Available recent edition).
13. C. Norman, *Principles of Organic Synthesis*, 2nd Edition, Chapman and Hill. London, 1978, (recent edition)
14. Warren, *Organic Synthesis, The Disconnection Approach*, Wiley, New York, 1982. (available recent edition)
15. H. House, *Modern Synthetic Reactions*, 2nd Edition, W. A. Benjamin. New York, 1972.
16. S. Glasstone & D. Lewis, *Elements of Physical Chemistry*, Mcmillan & Co., Ltd.
17. P. Atkins & J. D. Paula, *Atkin's Physical Chemistry*, 10th Edition, Oxford University Press, 2014 (reprinted).
18. J. O'M Bockris, A. Reddy & M. Gamboa-Aldeco, *Modern Electrochemistry* Vol. 2A, 2nd Edition, Kluwer/Plenum Publishers, New York/London/Moscow, 2000.
19. S. Negi & S. C. Anand, *A Textbook of Physical Chemistry*, New Age International (P) Ltd., New Delhi, 1999.
20. A. Bahl, B. S. Bahl & G. D. Tuli, *Essential of Physical Chemistry,* Revised Multicolor Edition, S. Chand & Co. Ltd., New Delhi, 2009.
21. D. Alberty, *Physical Chemistry*, 6th Edition, Wiley Eastern Ltd., New Delhi, 1992.
22. J. Bhattarai, *Frontiers of Corrosion Science*, 1st Edition, Kshitiz Publication, Kathmandu, 2010.
23. J. Bhattarai & D. B. Khadka, *Surface Characterization and Solid State Chemistry*, Sunlight Publication, Kathmandu, 2010.
24. K. L. Kapoor, *Text Book of Physical Chemistry*, Macmillan India Ltd., Vol. I to Vol.V, 3rd Edition, 2001.
25. D. N. Bajpai, *Advanced Physical Chemistry,* S. Chand & Co., New Delhi.
26. J. N. Gurtu & A. Gurtu, *Advanced Physical Chemistry*, 8th Edition, Pragati Publication, Meerut, India, 2006.
27. H. V. Keer, *Principles of the Solid State*, New Age International (P) Ltd., New Delhi, 2002.
28. V. K. Jha, *Introductory Quantum Mechanics*, Balkhu, Kathmandu, Nepal, 2012.

29. S. K. Gautam, S. K. Kalauni, K. R. Sharma, B. R. Poudel, D. Wagle, *Text Book of Chemistry*, vols 1 & 2, National Book Centre, 2016.

Text Books: for practical courses CHE 402 & CHE 404:

1. A. I. Vogel, *A Text Book of Quantitative Inorganic Analysis, Including Elementary Instrumental Analysis*, ELBS & Longman, 1969, (Preferably available recent edition).
2. R. L. Shriner, R. C. Fusion & D. Y. Cartin, *The Systematic Identification of Organic Compounds, A Laboratory Manual*, John Wiley and Sons, Inc. New York, 1986. (Preferably available recent edition).
3. N. K. Vishnoi, *Advanced Practical Organic Chemistry* (2nd Revised Ed), Vikas Publishing Pvt. Ltd. India.
4. Moti Kaji Sthapit & R. R. Pradhananga, *Experimental Physical Chemistry*, Taleju Prakasan, Kathmandu, 1998.
5. N. M. Khadka, S. D. Gautam & P. N. Yadav, *A Core Experimental Chemistry for B.Sc.* Heritage Publication, Kathmandu, 2016.

Reference Books: for practical courses CHE 402 & CHE 404:

1. Gurdeep Raj, *Advanced Practical Inorganic*, 10th Edition, Goel Publishing House, Meerut, 1994.
2. A. I. Vogel, *A Textbook of Practical Organic Chemistry*, Including Qualitative Organic Analysis, Longmans, (Latest Edition).
3. F. G. Mann & B. C. Saunders, *Practical Organic Chemistry*, Orient Longman, 1986, (recent edition).
4. M. R. Pokhrel, P.N. Yadav & S. Shrestha, *Advanced Practical Inorganic Chemistry for M. Sc.*, Kshitiz Publication, 2009.
5. A. K. De, *Environmental Chemistry*, New age International Ltd Publishers, New Delhi.
6. J. N. Gurtu & A. Gurtu, *Advanced Physical Chemistry Experiments*, 4th Edition, Pragati Prakashan, 2008.
7. J. N. Gurtu & R. Kapoor, *Advanced Experimental Chemistry* (Vol I-III), S. Chand & Co. New Delhi, 1984.
8. J. B. Yadav, *Advanced Practical Physical Chemistry*, 33rd Edition, Goal Publ. House, Meerut, 2014.
9. A. Rajbhandari (Nyachhyon) and S. Pradhananga (Shrestha), *Inorganic Salt Analysis*, 1st Edition, Rajbhandari-Pradhananga Publication, Kathmandu, 2013.

Course Title: Applied Chemistry | **Full Marks:** 100

Course No.: CHE 405 | **Pass Marks:** 35

Nature of the Course: Theory | **Year:** IV

Course Objectives:

The outcome of this course will be:

- To encourage students to apply chemical knowledge in understanding the chemical process involved in the industrial processes.
- To understand the natural wealth of Nepal and develop ideas to apply these resources for the industrial growth of Nepal.
- To develop student's ability in the applied field of chemistry.

Introduction of Applied Chemistry: **5 hrs**

Introduction, chemical industries-facts and figures.

Unit operation and unit process (outlines of unit operations, general principle applied in studying industry, process and design with focus on block diagrams.

Economics (profitability analysis-capital investment, total production costs, economic analysis (return on investment), principle of economic balance-choice between alternative processes.

Inorganic Chemical Industries: **35 hrs**

Introduction on inorganic chemical industries.

Fertilizer industries: introduction, NPK fertilizers, consumption and scopes.

Nitrogen industries: introduction, consumption and major products.
Urea: properties, consumption pattern, methods of production (from ammonium carbamate decomposition), raw materials, process description, flow sheet, major engineering problems, economics.

Phosphorus industries: introduction, consumption pattern, major products

Calcium phosphate: superphosphate vs triple phosphate, production of superphosphate and triple phosphate, raw materials, process description, flow sheet, major engineering problem, economics

Cement and lime: Introduction, properties (constituents of cement-Portland and its type, high alumina, hydraulic hydrated lime), compressive strength, Cement industries in Nepal, methods of production (Portland cement), raw materials with emphasis on Nepalese context, process description, flow sheet, major engineering problems, economics, overall factors to be considered in cement industries
Lime: properties, consumption patter, methods of production, process description, flow sheet, major engineering problem, economics

Ceramics: Introduction, manufacturing process, raw materials (clay minerals, kaolin, ball clay, fire clay), methods of production: firing, stages of firing, types of kilns, properties, consumption pattern, ceramics industries in Nepal, economics

Water industries: Introduction, sources of water, consumption pattern, water storage and related problems, methods of treating fresh water, process description, flow sheet, major engineering problem, economic considerations, waste water treatment and disposal.

Natural Products Industries: **25 hrs**

Oils: Introduction, raw materials of oils, methods of extractions (mechanical, solvent extraction, purification), hydrogenation of oils (with flow sheet diagram).

Soaps and detergents: Introduction, classification of cleansing compounds, use of soap and detergents, methods of soap production: continuous process for fatty acids, soap, and glycerine, methods of detergent manufacture, consumption pattern.

Paints and varnishes: Introduction, pigments and extenders, functions of oils in paints, uses of driers in paints, uses of resins, diluents in paints and varnishes, economics of paints and varnishes industries.

Fermentation industries: Introduction, characteristics and economics of fermentation industries, kinetics and scale-up of submerged and aerobic fermentation process, air and media sterilization, continuous and batch fermentation, consumption pattern of ethyl alcohol, methods of ethyl alcohol production with flow sheet diagram, economics of ethyl alcohol industry.

Pulp and paper industries: *Pulp:* Introduction, methods of production, sulfate (Kraft) pulp process, comparison of chemical pulping process for cellulose fibers, major engineering problems. *Paper:* introduction, types of paper, raw materials, methods of production (including Nepali paper- Lokta) and economics of paper industries.

Polymerization Industries: **15 hrs**

Polymerization technology: Introduction, classification of polymer applications (adhesive, coatings, fibers, solid shapes).

Polymer manufacturing process: Process description with flow sheet and economics involved in plastic (polyethylene, PVC, epoxide), butadiene-styrene rubber and fibers (nylon).

Metallurgical Industries: **30 hrs**

Iron and Steel: Introduction

Iron: Raw materials, sources of ores with reference to Nepal, production of Pig iron (process description with flow sheet), major engineering problems.

Steel: Raw materials, production of steel, process description with flow sheet-Open Hearth process, major engineering problems and economics.

Aluminum: Raw materials, method of production, process description, major engineering problems and economics.

Copper: Raw materials, method of production with flow sheet diagram.

Lead: Raw materials and production.

Zinc: Raw materials and production.

Electrochemical Industries: **15 hrs**

Introduction

Some practical problems in using electrochemical theory (voltage efficiency (polarization), current efficiency, energy efficiency, decomposition efficiency

Example of electrochemical industries: 1. electroplating of Nickel and chrome on steel; 2. Fuel cells-efficiency, H_2-O_2 fuel cell, development of commercial fuel cell and battery-lead–acid battery; 3. Electro-organic chemical processes: production of adiponitrile and tetraethyl lead-raw materials, flow sheet with process description and major engineering problems; 4. Corrosion and its prevention: selection of materials, proper design, altering environments, inhibitors, coatings

Safety Considerations in Chemical Process Industries: **25 hrs**

Introduction

Chemical storage-safety issues: past experience, layout, safety standards, safety features, operational hazards, packaged chemical storage, safety measures, fire protection and loss prevention

Observations related to safety aspects: management's concern for safety, plant design, hazard identification and safety audit, system and procedures, maintenance, technical services, safety organization, firefighting facilities, emergency preparedness, human inhabitation in the vicinity of chemical plants, factory act and statuary bodies

Specific recommendations for hazard control and improved plant safety: Nepalese Guidelines/acts, Guidelines from developed countries, environment protection act, hazards and safety of chemical plants.

Packaging of chemical and dangerous goods: basic requirements, types of container, sacks, glass carboys, plastic containers, intermediate-bulk containers.

Chemical plant safety-from concept to decommissioning: Technology-selection and development, process design, instrument design, equipment design, plant layout, plant erection, training, plant start-up and commissioning, regular plan operation and maintenance, plant decommissioning or demolition.

Text Book: for theoretical course CHE 405

1. Charles E. Dryden, *Outlines of Chemical Technology*, edited and revised by M. Gopala Rao and Marshall Sittig, affiliated East-West Press Pvt. Ltd. New Delhi, 2010.

Refernce Books: for theoretical course CHE 405

1. K. H. Davi & F.S. Berner, *Handbook of Industrial Chemistry*, Vol. 1 and 2(Edited by S. C. Bhattia, CBS Publishers and Distributors, New Delhi, 2000.
2. Philip Matthews, *Advanced Chemistry*, Cambridge University Press, 1997.
3. Thankamma Jacob, *A Textbook of Applied Chemistry*, Macmillan India Limited, 1997.

4. P. K. Gangopadhyay, *Application Orientated Chemistry*, Book Syndicate Pvt. Ltd., Kolkata, 2009.
5. B. R. Pandey, *An Easy Approach to Applied Chemistry*, Heritage Publishers & Distributors Pvt. Ltd., Kathmandu, 2016.
6. *ISO-Laboratory Safety*-Accreditation by Nepal Bureau of Standards & Metrology, Kathmandu, Nepal.
7. L. P. Poudel, *Mineral Resources of Nepal*: An Analytical Study (**in Nepali**), Devi Dhakal, Kathmandu, 2011 (2068).
8. www.doind.gov.np

Course Title: Basics of Nanoscience and Technology — **Full Marks:** 50

Course No.: CHE 407 — **Pass Marks:** 17.5

Nature of the Course: Theory — **Year:** IV

Course Objectives:

- To provide fundamentals of nanoscience and nanotechnology to the undergraduate student.
- To make the students acquainted with basic techniques of nano-meterials fabrication and characterization.
- To provide the knowledge of nanotechnology and its applications.

Introduction to Nanotechnology: History of nanotechnology, definitions, nanotechnology as interdisciplinary field, nanotechnology in nature, classification of nonstructural materials. **5 hrs**

Preparation Methods of Nano-materials: Bottom up approaches: physical vapor deposition (inert gas condensation, laser ablation) & chemical vapor deposition (thermally activated CVD, plasma-enhanced CVD, spry conversion processing, sol-gel process, wet chemical synthesis, self assembly), top down approaches: mechanical alloying, nanolithography, consolidation of nanopowders: shockwave consolidation, hot isostatic processing & cold isotatic processing, spark plasma sintering. **20 hrs**

Characterization Techniques for Nano-materials: Characterization of nano-materials using X-ray diffraction (Scherrer's equation) and imaging microscopic techniques (scanning electron microscopy, scanning probe microscopy: scanning tunneling microscopy & atomic force microscopy, and transmission electron microscopy), nano-indention. **20 hrs**

Applications of Nano-materials: Nano-electronic, nanotube-based sensors, nano-catalysis, cosmetics and consumers goods, Food and agriculture, nano-medical applications, water

treatment and environment, energy, textile, paints, defense, health risks, applications in structural engineering. **20 hrs**

Nonostructural Materials with High Application Potential: Quantum dots, carbon nanotubes, nanocrystalline ZnO & TiO_2, multilayer films. **10 hrs**

Text Book: for theoretical course CHE 407:

1. B. S. Murthy, P. Shankar, Balvev Rj, B. B. Rath & James Murday. *Textbook of Nanoscience and Nanotechnology*, Series in Metallurgy and Materials Science, Baldev Raj (Ed.), Universities Press Private Hyderabad, India, 2012.

Reference Books: for theoretical course CHE 407

1. K. K. Chattopadadhyay & A. N. Banerjee. *Introduction to Nanoscience and Nanotechnology,* PHI Learning Private Limited, New Delhi, 2012.
2. C. P. Poole & F. J. Owens. *Introduction to Nanotechnology*, Wiley India Limited, 2012.
3. C. N. R. Rao, *Nanoworld: An Introduction to Nanoscience and Nanotechnology,* JNCASR, Bangalore, 2010.
4. J. Bhattarai, *Frontiers of Surface Science*, 1st Edition, Kathmandu, 2012.

Appendix I

List of name reactions:-

Condensation reactions

1. Dieckmann condensation
2. Darzen's reaction
3. Intramolecular Claisen Condensation
4. Knoevenagel condensation
5. Benzoin condensation

Rearrangement reactions

1. Beckmann rearrangement
2. Claisen rearrangement
3. Cope rearrangement
4. Favorskii rearrangement
5. Curtius rearrangement
6. Pinacol-pinacolone rearrangement
7. Wagner–Meerwein rearrangement
8. Wittig rearrangement

9. Benzelic acid rearrangement

Reduction reactions

1. Birch reduction
2. Catalytic hydrogenation reduction
3. Meerwein Ponndorf-Verley reduction

Oxidation reactions

1. Baeyer–Villiger oxidation
2. Oppenauer oxidation
3. Lead tetraacetate oxidation
4. Chromic acid oxidation
5. Permanganate oxidation
6. Peracid oxidation

Elimination reactions

1. Hofmann degradation
2. Pyrolytic elimination

Addition to Carbon Carbon multiple bond andCarbon –Hetero multiple bond

1. Michael reaction
2. Diel's Alder reaction
3. Mannich Reaction
4. Reformatsky Reaction
5. Halogenation of dienes

Tribhuvan University
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Course Title:	Computational Course	**Year:**	IV
Course Code:	COM408	**Full Marks:**	50
Nature of Course:	Theory / Lab	**Pass Marks:**	17.5

Course Description

This course covers the basic concepts of computers and introduction, data representation, database, networks and data communication, multimedia, computer security, GIS.

Course Objectives

The main objective of this course is to provide students knowledge of fundamental concepts of computers and information technology.

COMPUTATIONAL COURSE [80 hours]

1. **Introduction to Computer:** 1.1 Introduction; Digital and Analog Computers 1.2 Characteristics of Computer 1.3 History of Computer 1.4 Generations of Computer 1.5 Classification of Computer 1.6 The Computer System [6 hours]

2. **Operating System:** 2.1 Introduction: Objectives of Operating System 2.2 Types of OS 2.3 Functions of OS: Process Management; Memory Management; File Management; Device Management 2.4 Examples of Operating Systems: UNIX, LINUX & Windows [6 hours]

3. **Data Communication and Computer Network:** 3.1 Introduction: Importance of Networking 3.2 Data Transmission Media 3.3 Data Transmission Across Media 3.4 Data Transmission and Data Networking 3.5 Computer Network 3.6 Wireless Networking [5 hours]

4. **Internet and Internet Services:** 4.1 Introduction: History of Internet 4.2 Internetworking Protocol 4.3 The Internet Architecture 4.4 Managing the Internet 4.5 Connecting to Internet 4.6 Internet Connections 4.7 Internet Address 4.8 Internet Services [5 hours]

5. **Data Representation:** 5.1 Number System; Conversion from Decimal to Binary, Octal, Hexadecimal 5.2 Conversion of Binary, Octal, Hexadecimal to Decimal; 5.3 Logic Gates 5.4 Database System 5.5 Database System Architectures 5.5 Database Applications: Computational Biology, Data Mining, Virtual Data, Computational Nanoscience, Space Data [12 hours]

6. **Multimedia:** 6.1 Introduction: Multimedia: Definition 6.2 Characteristics of Multimedia System 6.3 Elements of Multimedia 6.4 Multimedia System 6.5 Multimedia Applications [6 hours]

7. **Computer Security:** 7.1 Introduction: Security Threat and Security Attack 7.2 Malicious Software 7.3 Hacking 7.4 Security Services; Security Mechanisms 7.5 Cryptography 7.6 Digital Signature 7.7 Firewall 7.8 Users Identification and Authentication 7.9 Other Security Measures 7.10 Security Awareness; Security Policy [10 hours]

8. **Geographical Information System & Remote Sensing:** 8.1 Introduction: Components of GIS 8.2 Map Projections : Spatial and Non-Spatial data 8.3 Data model and input, data analysis and output 8.4 Remote Sensing Applications: Agriculture – forestry – land use / land cover mapping – water resources – snow and glacier – wetland management [10 hours]

9. **Laboratory Work:** After completing this course, students should have practical knowledge of operating systems like LINUX and Windows, Word Processors, Spreadsheets, Presentation Graphics, Database Management Systems, and Internet and its services. [20 hours]

Note: *The evaluation of this course will be taken through* ***final written examination****. However, during the classes teachers are required to use computer interface through multimedia. Students should practice it in the computer.*

Text Books:

1. Sinha P. K. and Sinha P. - **Computer Fundamental**, JBA (**ISBN** : 8176567523), India (2011)
2. Huisman O. and de By R. A., **Principles of Geographic Information Systems: An introductory textbook**, International Institute for Geo-Information Science and Earth Observation, The Netherlands (2001)

Reference Books:

1. Goel A. - **Computer Fundamentals**, Pearson Education, India (2010)
3. Campbell J.B. - **Introduction to Remote Sensing**, Fourth Edition, Guilford Press (2008)

Tribhuvan University
Institute of Science and Technology

Course Title:	Project Work	**Year:**	IV
Course Code:	**PRO406**	**Full Marks:**	100
Nature of Course:	Project Work / Field Work	**Pass Marks:**	40

Course Description

This course offers students to learn the research works in physics. Students are required to review literature of his/her field of interest to identify a problem in the project work, that problem should be addressed by the students.

PROJECT WORK

RESEARCH

Project Guidelines

1) A student can do project work only if a faculty or a subject teacher agrees to supervise his/her project work. It is the responsibility of TU faculties to carry out educational and research activities.

2) The nature of project work can be field work, theoretical work, computational work, observational work and experimental work. Whatever the nature of the work, students should critically review literature of the area of interest and identify the problem specifically.

3) Students should prepare a proposal and submit it to the department within three month of fourth year final examination. The general format of the proposal should like this:
   (a) Background/Introduction
   (b) Literature Review / Problem Identification
   (c) Motivation/Objectives
   (d) Methodology / Field Survey
   (e) Expected Result / Hypothesis
   (f) References (format should be decided by concerned subject committee)

4) The final VIVA examination should be held within a couple of month of the fourth year final examination. The examination date will be proposed by the concerned colleges and is appointed by the Controller of Examination, TU.

5) The format of the project should be same as the format of M.Sc. dissertation of respective subject. The format will be decided by the Central Department Research Committee (CDRC).

6) The evaluation committee consist 4 members - HoD or program coordinator, supervisor, external and internal examiners. A separate evaluation form will be given to all four members of the evaluation committee during the VIVA examination that contains the following:

(a) Introduction to the subject	10%	(f) Methods	10%
(b) Literature review	10%	(g) Figures/plots/tables	10%
(c) Motivation/Objectives	10%	(h) Interpretation	10%
(d) Originality and creativity:	10%	(i) Comparison: published work	10%
(e) In-depth Research:	10%	(j) Presentation:	10%

7) There will be additional fee for the project. Student needs to pay this amount. A enumeration for the supervisor is recommended. It will be decided by the Dean Office, IoST, TU.