

DEPARTMENT OF CHEMISTRY  
UNIVERSITY OF DHAKA

**1st Year**

<b>Course Type</b>	<b>Course No.</b>	<b>Course Name</b>	<b>Credits 2010-2011</b>	<b>Credits 2011-2012</b>
Major	CHEM 7101	Physical Chemistry I	4	4
	CHEM 7121	Organic Chemistry I	4	4
	CHEML 7122	Organic Chemistry Laboratory I	2	2
	CHEM 7141	Principles of Inorganic Chemistry	4	4
	CHEML 7142	Qualitative Inorganic Analysis, Synthetic Inorganic Chemistry and Elementary Crystal Chemistry	4	4
	CHEM 7161	Fundamental Analytical Chemistry	2	2
	CHEM 7162	Oral/Seminar	2	2
Minor	MATH 102	Calculus I	2	2
	MATH 103	Analytic and Vector Geometry	2	2
	MATH 104	Linear Algebra	2	2
	PHY 111	Mechanics and Waves	2	2
	PHY 122	Electricity and Magnetism	2	2
			32 Credits	32 Credits

## 1ST YEAR

### CHEM 7101: PHYSICAL CHEMISTRY I

4 CREDITS

1. **State of matter:** Microscopic and macroscopic systems. Physical properties. Properties of molecules. Potential and kinetic energies of molecules. Degrees of freedom of motion: translational, rotational and vibrational energy of systems. Quantization of energy of particles. Spectroscopy and molecular structure. Principle of equipartition of energy. Intermolecular forces. States of aggregation of matter. Phase and phase equilibria.
2. **Gaseous state:** Review of gas laws. Ideal and real gases. Equation of state: Ideal gas equation. Kinetic theory of gases: application to ideal gases, Collision number, mean free path. Boltzman distribution of molecules. Deviation from ideal behaviour: van der Waals equation. Critical constants. Principle of corresponding states.
3. **Properties of liquids and solutions:** Vapour pressure: measurement, temperature variation. Surface tension of liquids. Viscosity of liquids. Solutions: Raoult's law, Ideal and non-ideal solutions. Temperature-composition diagram for pairs of miscible liquids. Fractional distillation, steam distillation. Colligative properties: measurements and applications.
4. **Energetics in chemistry:** Observables in macroscopic systems. Work and heat. Internal energy. The first law of thermodynamics. State functions and exact differentials. Enthalpy. Work of expansions: reversible and adiabatic expansions. Joule-Thomson effect. Heat capacities at constant pressure and constant volume. Enthalpy changes in various chemical and physical processes. Measurements of enthalpy changes. Hess's law and its applications. Born-Haber cycle.
5. **Chemical equilibrium:** Equilibrium in chemical reactions and the equilibrium law.  $K_p$ ,  $K_x$  and  $K_c$  and their determination. Degree of dissociation, response of equilibrium to temperature, concentration and pressure changes. Principle of Le Chatelier and Brown. Applications. Dissociation in solution. Ostwald dilution law. Ionic equilibria. Dissolution of solids. Solubility product. Common ion effect. pH, pOH and buffer solution.
6. **Electrochemical cells:** Electrolytic and Galvanic cells. Electrodes. Half cell reaction, Cell reaction, Cell notation. Reduction potentials. e.m.f. of cells, Standard hydrogen electrode.
7. **Rates of Chemical reaction:** Measurement of reaction rates. Rate equation, order and rate constant. Determination of order and rate constants. Elementary and complex reactions. Molecularity. Effect of temperature on the rate of reaction. Activation energy. Collision theory of reaction rates. Catalysis.

#### Books Recommended:

1. Physical Chemistry by P. W. Atkins. (5th Edition). Oxford.
2. General Chemistry by D. Ebbing.
3. Chemistry by S. S. Zumdahl
4. Physical Chemistry by G. W. Castellan.
5. A text Book of Physical Chemistry by S. Glasstone.
6. Principles of Physical Chemistry by S. H. Maron and C. F. Pruton
7. A-level Chemistry by E.N. Ramsden.

### CHEM 7121: ORGANIC CHEMISTRY I

4 CREDITS

1. **Basic Principles of Organic Chemistry:** Atomic structure and chemical bonding, atomic orbital, molecular orbital. Shapes of molecules with reference to alkanes, alkanes, alkynes and arenes. Bond angle, bond length and bond energy.
2. **Alkanes:** Structure and reactivity of aliphatic hydrocarbons. Chain reaction of methane and its mechanism. Carbon-carbon single bond compounds, conformation of ethane and butane. Optical activity of asymmetric carbon compounds. Natural gas, petroleum, gasoline, petrochemicals and petroleum fraction. Octane Number, antiknocking agent-TEL ect.
3. **Alkenes :** Structure and synthesis, Electrophilic addition to alkenes, hydrogenation, bromination, hydrohalogenation and ozonolysis. Homolytic and heterolytic addition of hydrogen halides to unsymmetrical alkenes (Markovnikov and anti Markovnikov rules) and their mechanism. Reaction of alkenes with  $\text{KMnO}_4$ ,  $\text{OsO}_4$ , peracids etc. Polymers of ethane, isoprene (rubber and gutta percha), styrene, tetrafluoro ethene, vinyl chloride etc. Geometrical isomerism-cis-trans, E/Z-system. Determination of configuration of geometrical isomers.

- Dienes:** Synthesis, orbital picture of 1, 3-butadiene and cumene. Isomerism of 1, 3-butadiene-s-cis and s-trans. Addition of halogen and hydrogen halides to, 1, 3-butadiene; 1,2 and 1, 4-addition.
- Alkynes:** Structure and synthesis Acidic properties of alkynes. Comparison among alkanes, alkenes and alkynes.
- Alicyclic Compounds:** Small and normal-size rings, their formation, conformation on stability and reactions. Baeyer's strain theory, cis-trans isomerism in alicyclic system.
- Aromatic Hydrocarbons Arenes:** Structure and resonance of benzene. Aromaticity of benzene Huckel  $4n+2$  rule. Source of benzene. Electrophilic substitution in aromatic system-nitration, sulphonation halogenation, alkylation and acylation. Aromaticity of some common heterocyclic compounds.
- Halogeno Compounds:** Chemistry of alkyl-, aryl-, allyl- and vinyl halides, their synthesis and reactions. Reactions of halogeno alkanes with alkali-substitution vs elimination. Reactions with metals-Grignard and Wurtz reaction. Halocarbons-DDT, gammexane, their uses and residual effect in the environment.
- Hydroxyl Compounds:** Alcohols and phenols, their synthesis and reactions. Hybridization of oxygen in alcohols and phenols. Hydrogen bonding. Resonance, acidity and reactivity of phenols. Comparison between alcohols and phenols.
- Ethers and Epoxides:** A brief description of synthesis and reaction of ethers and epoxides.
- Carbonyl Compounds:** Synthesis and reactions of aldehydes and ketones, Orbital picture, hybridization of carbonyl carbon and carbonyl oxygen. Nucleophilic reactions. Oxidation and reduction. Relative reactivity of carbonyl compounds.
- Carboxylic Acids:** Orbital picture, hydrogen bonding. Synthesis and manufacture of methanoic, ethanoic, ethanedioic and butane-1,4-, dioic acids. Preparation of acid halides, acid anhydrides and amides. Relative reactivity of carboxylic acid derivatives.

#### Book Recommended:

- T. Morrison and R. N. Boyd: Organic Chemistry, Sixth Edition, Plentice-Hall of Inida, New Delhi, 1989, Problems and their solution in Organic chemistry.
- Hendrickson and Pyne: Organic Chemistry, McGraw-Hill.
- Finar: Organic Chemistry Vol. I & II, ELBS, Fifth edition, 1985, Problems and their solution in Organic Chemistry, ELBS, 1979.
- W. Solomons: Fundamentals o Organic Chemistry, John Wiley & Sons, New York, 1982.
- Streitweiser and C. H. Heathcock: Introduction to Organic Chemistry, 3rd edition, Machmillan Publishing Company, New York, 1985.
- M. U. Ahmed: Advanced Organic Chemistry (Bengali, Bangla Academy, 1987.

#### CH EM 7141: PRINCIPLES OF INORGANIC CHEMISTRY

4 CREDITS

- Atomic Structure:** Atomic nucleus, fundamental particles, nuclear forces, nuclear binding energy, nuclear stability, radioactivity, isotopes, mass spectrometry, cathode rays, mass and charge of an electron,  $\alpha$ -particle scattering, Rutherford atom model, Planck's quantum theory, Bohr's theory for hydrogen atom, electromagnetic radiation, absorption and emission spectra, ionization energy from absorption spectrum, emission spectrometer, emission spectrum of atomic hydrogen, dual behaviour of electron, de Broglie equation, Heisenberg's uncertainty principle, quantum mechanics, Schrödinger wave equation for hydrogen atom, wave function and its significance, quantum numbers, atomic orbitals and their energies, shapes and orientation, Pauli exclusion principle, Aufbau principle, Hund's rule, electronic configurations.
- Periodic Classification:** Periodic law, periodic table, prediction of elements, elements in groups, periods and blocks, naming of all elements, electronic configuration of groups and periods, metals, nonmetals and metalloids, diagonal relationship, periodicity of atomic and molecular properties e.g. ionization energy, electron affinity, electronegativity, atomic/ionic radii, metallic character, melting and boiling points, lattice energy etc., properties of main group elements, usefulness and limitation of periodic table.

- Chemical Bonds:** Chemical bond, types of chemical bonds, ionic bond: energetics of ionic bond formation, properties of ionic compounds, factors influencing the formation of ionic bond, radius ratio rule, Born-Haber cycle, Fajan's rule; covalent bond: sigma and pi bond, properties associated with covalent compounds, limitation of covalency, polar covalent bond, Lewis formulation, formal charge, valence shell electron pair repulsion (VSEPR) theory and molecular geometry, valence bond theory, energy change during formation of molecules, hybridization of bond orbitals, molecular orbital theory, bonding and antibonding orbitals and their significance, bond order, stability of molecules, MO diagram of simple diatomic H<sub>2</sub> to Ne<sub>2</sub> molecules, coordination bond, metallic bond, hydrogen bond, van der Waal's forces.
- Inorganic Nomenclature:** Prefixes and affixes used in inorganic nomenclature, use of enclosing marks, numbers, letters, and italic letters, names for cations, anions, radicals and heteropolyanions, names of acids, salts, and salt like compounds.
- Solids:** Types of solids, characteristics of crystalline and amorphous solids, unit cell, crystal lattice, seven crystal systems, crystal defects, description of NaCl, CsCl, graphite, diamond and ice structures.
- Acids and Bases:** Various concepts on acids and bases, conjugate acids and bases, neutralization reactions, acid - base strength, hard and soft acids and bases, hard and soft acids and bases in qualitative analysis, acid - base properties of oxides, hydroxides and salts, effect of structures on acid - base properties.
- Types of Reactions:** Oxidation - reduction reactions, oxidizing and reducing agents, assigning oxidation states to bounded atoms, redox half reactions, rules for balancing redox reactions, Ellingham diagram, Latimer diagram, and Frost diagram, standard reduction potential, the electrochemical series, disproportionate reactions, double decomposition reactions, Metathetic or precipitation reactions and solubility product principle, common ion effect, acid - base reactions, substitution reactions, condensation reactions, addition reaction, elimination reactions, isomerization reaction, polymerization reactions, nuclear reactions, nuclear disintegration.

#### Books Recommended:

- General Chemistry, D. D. Ebbing and S. D. Gammon, Houghton Mifflin Co.
- Introduction to Modern Inorganic Chemistry, S. Z. Haider, Friends International.
- Inorganic Chemistry, D. F. Shriver and P. W. Atkins, Oxford University Press.
- General Chemistry, P. W. Atkins and J. A. Beran, Scientific American Books, W. H. Freeman and Company.
- Chemistry – The Molecular Nature of Matter and Change, M. Silberberg, WCB/McGraw-Hill.
- Chemistry, S. S. Zumdahl, D. C. Heath and Company.
- Chemistry, J. McMurry and R. A. Pribush, Prentice-Hall Inc.
- General Chemistry, J. B. Russel, International Edition, McGraw-Hill Inc.
- Basic Inorganic Chemistry, F. A. Cotton, G. Wilkinson, and P. L. Gaus, John Wiley & Sons.
- Inorganic Chemistry, A. G. Sharp, Longman Scientific and Technical.
- Introduction to Inorganic Chemistry, G. I. Brown, Longman Group UK Limited.
- Principles of Descriptive Inorganic Chemistry, G. Wulfsberg, University Science Books, Mill Valley.
- Inorganic Chemistry, G. L. Miessler and D. A. Tarr, Pearson Education. Inc.

#### CHEM 7161: FUNDAMENTALS OF ANALYTICAL CHEMISTRY

2 CREDITS

- Basic Concepts in Analytical Chemistry:** Classical and modern concepts of analytical detection and quantification, sensitivity, selectivity, specificity, concentration limit, dilution limit etc. of chemical reactions, sample containers, sample preservation, sampling, sample dissolution, wet ashing and dry ashing, reagents and reactions, group separation, elemental analysis, and analysis of insoluble materials, precision and accuracy, mean and median, types of errors, significant figure convention.
- Acid-Base Reactions:** Acid-base equilibria and buffers in analytical chemistry, indicators, titrations of acid-base, titration in non-aqueous solvents - solvent choice and advantages.
- Redox Reactions:** Oxidation-reduction equilibria in chemical analysis, redox titration curve, indicators for oxidation-reduction titrations, KMnO<sub>4</sub> as a standard oxidants, titrations with K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> and cerium(IV), redox titrations involving iodine, iodometric and iodimetric methods.

4. **Gravimetric Methods of Analysis:** Principle of gravimetric method, properties of precipitates and precipitating agents, coagulation and peptization of precipitates, treatment of colloidal precipitates, co-precipitation and post precipitation, drying and ignition of precipitates, results and calculation.
5. **Spectrophotometric Analysis:** Ultraviolet and visible radiation, absorbance, transmittance, absorptivity, the Beer-Lambert's law, limitations of Beer-Lambert's law, wavelength selection, basic components of a spectrophotometer, qualitative and quantitative analysis, stoichiometric determination of metal-ligand complexes, derivative spectrophotometry.

**Books Recommended:**

1. Quantitative Chemical Analysis, S. E. Manahan, Books/Cole Publishing Co.
2. Modern Methods of Chemical Analysis, R. L. Pecsok, L. D. Shields, T. Cairns, and L. G. McWilliam, John Wiley & Sons.
3. Fundamentals of Analytical Chemistry, D. A. Skoog, D. M. West, F. J. Holler and S. R. Crouch, Saunders College Publishing.
4. Analytical Chemistry, G. D. Christian, John Wiley & Sons.
5. Modern Analytical Chemistry, D. Harvey, McGraw-Hill Higher Education.
6. Analytical Chemistry Principles, J. H. Kennedy, Saunders College Publishing.
7. A Text Book of Macro and Semimicro Qualitative Inorganic analysis, A. I. Vogel, Longman, Green and Co. Ltd.
8. Instrumental Analysis, H. H. Bauer, G. D. Christian and J. E. O'Reilly, Allyn and Bacon, Inc.

**Simple laboratory techniques and their uses in synthesis:**

1. Drying and storage of organic compounds.
2. Determination of melting temperature and mixed melting temperature melting temperature curve
3. Purification of organic compounds by recrystallisation
4. Determination of boiling temperature
5. Purification by distillation. Azeotropic distillation of mixtures of alcohol and water.
6. Separation of organic compounds by solvent extraction
7. Preparation of alkene: Cyclohexene from cyclohexanol.
- 8.. Preparation of alkyl halide: *t*-Butyl chloride from *t*-butyl alcohol.
9. Preparation of alcohol: *t*-Butyl alcohol from *t*-butyl chloride.
10. Oxidation of hydrocarbons : Benzoic acid from toluene.
11. Oxidation of alkene: Adipic acid from cyclohexene.
12. Oxidation of alcohol: Cyclohexanone from cyclohexanol.
13. Acetylation: Acetylation of aniline and salicylic acid.
14. Bromination of phenylamine/phenol, isolation and purification of bromo derivatives.
15. Addition reactions to carbon-carbon double bonds: halogenation of cinnamaldehyde/cinnamic acids.

**Books Recommended:**

1. Brewster, Vanderwef, McEven: Unitized Experiments in Organic Chemistry, Van Nostrand.
2. Ilnstromberg & Baumgarten: Organic Experiments , D. C. Heath & Co.
3. A. I. Vogel: A Text Book of Practical Organic Chemistry, ELBS, Fifth edition.
4. E.A. Clarke: A Hand Book of Organic Analysis.
5. Shriner, Fuson, Curtin and Morrill: Systematic Identification of Organic Compounds, Wiley.

**CHEML7 142: QUALITATIVE INORGANIC ANALYSIS, INORGANIC PREPARATIONS AND  
ELEMENTARY CRYSTAL CHEMISTRY** **4 CREDITS**

1. **Safety:** The twelve rules of safety, safety in the laboratory.
2. **Purification and Preparation of Inorganic Compounds:**
  - (i) Purification of commercial NaCl by recrystallization and salting out processes,
  - (ii) Preparation of ferrous sulphate  $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ , Mohr's salt  $[\text{FeSO}_4 \cdot (\text{NH}_4)_2\text{SO}_4 \cdot 6\text{H}_2\text{O}]$ , potash alum  $[\text{K}_2\text{SO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}]$ , chrome alum  $[\text{K}_2\text{SO}_4 \cdot \text{Cr}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}]$ , sodium carbonate  $\text{Na}_2\text{CO}_3$ , sodium cobaltinitrite  $\text{Na}_3[\text{Co}(\text{NO}_2)_6]$ .
3. **Model Making:** Seven crystal systems model.
4. **Systematic Semimicro Qualitative Analysis of Inorganic Salts:** Qualitative analysis of known and unknown admixtures of inorganic salts consisting of up to five different radicals. This analysis includes: preparation of salt solution, techniques of dry tests of radicals, group separation and confirmation of radicals, removal of interfering radicals, use of solubility product principle and salting effect in analysis, treatment of insoluble substances, etc.

**Books Recommended:**

1. A Text-Book of Macro and Semimicro Qualitative Inorganic Analysis, A. I. Vogel, 4<sup>th</sup> edition, Longmans, Green and Co. Ltd.
2. Semimicro Qualitative Analysis, F. J. Welcher and R. B. Hahn, D. Van Nostrand Co. Inc.
3. Qualitative Analysis, V. Alexeyev, Mir Publishers.