

Syllabus for BA/BSc Course in Chemistry (GENERAL)

TO BE EFFECTIVE FROM THE ACADEMIC SESSION 2011-2012



West Bengal State University

Berunanpukuria, Malikapur

Barasat, North 24 Parganas

West Bengal – 700126

Effective from academic session 2011-2012

B.Sc Part-I (1st Year) Chemistry (General)

Total Marks 100 (Theory = 100)

Paper I

Courses : CEMGT 11A, 11B, 11C, 11D

(Each 25 marks : Total 100 marks)

CEMGT 11A

Unit I. Basic physical chemistry I

(12 Marks)

Physical states of matter:

(a) Gaseous state:

Kinetic theory of gas, collision and gas pressure, average kinetic energy of translation, Boltzmann constant.

Maxwell's distribution law of molecular speeds (without derivation), most probable, average and root mean square speed of gas molecules, concept of degrees of freedom and principle of equipartition of energy (without derivation). Mean free path and collision frequencies. Heat capacity of gases (molecular basis); viscosity of gases.

Real gases, compressibility factor, deviation from ideality, van der Waals equation of state, critical phenomena, (principle of continuity of states), critical constants.

(b) Liquid state:

Physical properties of liquids and their measurements: surface tension and viscosity.

(c) Crystalline state:

Types of bonding in solids, law of constancy of angles, concept and types of unit cell (viz. simple cubic, bcc, fcc) coordination number, law of rational indices, Miller indices.

Unit II. Basic physical chemistry II

(13 Marks)

Thermodynamics I:

(a) Definition of thermodynamic terms: Intensive and extensive variables, isolated, closed and open systems. Cyclic, reversible and irreversible processes. Thermodynamic functions and their differentials. Zeroth law of thermodynamics, concept of heat (q) and work (w); IUPAC nomenclature of work and heat.

(b) First law of thermodynamics, internal energy (U) and enthalpy (H); relation between C_p and C_v , calculation of w, q, ΔU and ΔH for expansion of ideal gas under isothermal and adiabatic conditions for reversible and irreversible processes including free expansion, P, V, T relationship for adiabatic reversible process, Joule's Law Joule-Thomson Coefficient and inversion temperature.

(c) Application of First law of thermodynamics: standard state, standard enthalpy changes of physical and chemical transformations: fusion, sublimation, vaporization, solution, dilution, neutralization, ionization. Hess's law of constant heat summation. Bond-dissociation energy, Kirchhoff's equation, relation between ΔH and ΔU of a reaction.

CEMGT 11B

Unit I. General Chemistry

(12 Marks)

Extra-nuclear Structure of atoms: Bohr's theory for hydrogen atom (simple mathematical treatment), atomic spectra of hydrogen and Bohr's model, Sommerfeld's model, quantum numbers and their significance, Pauli's exclusion principle, Hund's rule, electronic configuration of many-electron atoms, *Aufbau* principle and its limitations.

Radioactivity and Nuclear Structure of Atoms: Natural radioactivity; radioactive disintegration series, group displacement law, law of radioactive decay, half-life of radio elements. Atomic Nucleus: Stability of atomic nucleus, n/p ratio, nuclear binding energy, mass defect. Nuclear reactions: fission, fusion, transmutation of elements.

Unit II: Principles of organic and Inorganic qualitative analysis:

(13 Marks)

Reactions involving the detection of special elements N, S and Cl in an organic compound (only Lassaigne's test).

Reactions involving the detection of the following functional groups:

Aromatic primary amino group (Diazo-coupling reaction); Nitro group (Mulliken Barker's test); Carboxylic acid group (reaction with NaHCO_3); Phenolic OH (FeCl_3 test); Carbonyl (aldehyde and ketone) group (DNP Test, etc.).

Formation of sublimates; principle of flame test, borax-bead test, cobalt nitrate test, fusion test, chromyl chloride test, analytical reactions for the detection of nitrate, nitrite, halides, phosphate, sulphide, sulphate, borate, boric acid. Analytical reactions for the

detection of Cr^{3+} , Fe^{3+} , Ni^{2+} , Cu^{2+} , Mn^{2+} , Importance of common-ion effect in the separation of Group II cations and Group III cations.

CEMGT 11C

Unit I. Basic organic chemistry I

(12 Marks)

a) Inductive effect, resonance and resonance energy. Homolytic and heterolytic bond breaking, electrophiles and nucleophiles; carbocations, carbanions and radicals (stability and reactivity)

b) Alkanes, alkenes and alkynes: Synthesis and chemical reactivity of alkanes, mechanism of free-radical halogenation of alkanes, general methods of synthesis of alkenes, electrophilic addition reaction, mechanism of bromination and hydrohalogenation, Markownikoff's addition, peroxide effect, hydroboration, ozonide formation, polymerization reaction of alkenes (definition and examples only), general methods of synthesis, acidity, hydration and substitution reactions of alkynes.

c) Aromatic Hydrocarbons: Structure of benzene, general mechanism of electrophilic substitution, reactions of benzene, synthesis of aromatic compounds using nitration, halogenation, Friedel-Craft's reactions.

Unit II. Basic organic chemistry II

(13 Marks)

a) Stereochemistry of carbon compounds: Different types of isomerism, geometrical and optical isomerism, optical activity, asymmetric carbon atom, elements of symmetry (plane and centre), chirality, enantiomers and diastereomers, R and S nomenclature, E and Z nomenclature, D and L nomenclature, Fischer projection formula of simple molecules containing one and two asymmetric carbon atoms.

b) Alkyl and Aryl halides: $\text{S}_{\text{N}}1$, $\text{S}_{\text{N}}2$, $\text{E}1$ and $\text{E}2$ reactions (elementary mechanistic aspects), Saytzeff and Hoffmann elimination reactions. Nucleophilic aromatic substitution.

c) Alcohol and Ether : Method of synthesis , physical properties , distinction of primary, secondary and tertiary alcohol and their chemical reactions and uses of ethers .

d) Organometallic compounds: Grignard reagents – preparations and reactions, application of Grignard reagents in organic synthesis. [1° , 2° and 3° alcohols, aldehydes, ketones and carboxylic acids.]

CEMGT 11D

Unit I. Basic inorganic chemistry I

(12 Marks)

Ionic bonding: General characteristics of ionic compounds, sizes of ions, radius ratio rule and its limitation. Lattice energy, Born Haber cycle.

Covalent bonding: General characteristics of covalent compounds, valence-bond approach, directional character of covalent bond, hybridization involving s-, p-, d orbitals, multiple bonding, Valence Shell Electron Pair Repulsion (VSEPR) concept, shapes of simple molecules and ions (examples from main group chemistry). Bond moment and dipole moment, partial ionic character of covalent bonds, Fajan's rules.

Hydrogen bonding and its effect on physical and chemical properties.

Unit II. Basic inorganic chemistry II

(13 Marks)

Chemical Periodicity: classification of elements on the basis of electronic configuration: general characteristics of s-, p-, d- and f-block elements. Positions of hydrogen and noble gases. Atomic and ionic radii, ionization potential, electron affinity, and electronegativity; periodic and group-wise variation of above properties in respect of s- and p- block elements.

Comparative study of p-block elements: Group trends in electronic configuration, modification of pure elements, common oxidation states, inert pair effect, and their important compounds in respect of the following groups of elements:

- i) B-Al-Ga-In-Tl
- ii) C-Si-Ge-Sn-Pb
- iii) N-P-As-Sb-Bi
- iv) O-S-Se-Te
- v) F-Cl-Br-I

B.Sc Part-II (2nd Year) Chemistry (General)

Total Marks 200 (Theory = 100, Practical = 100)

Paper II

Courses : CEMGT 22A, 22B, 22C, 22D

(Each 25 marks : Total 100 marks)

CEMGT 22A

Unit I. Basic physical chemistry III

(12 Marks)

Thermodynamics II:

(a) Spontaneous processes, heat engine, Carnot cycle and its efficiency, Second law of thermodynamics, Entropy (S) as a state function, molecular interpretation of entropy, entropy changes in simple transformations; including entropy change of ideal gas during expansion, Free energy: Gibbs function (G) and Helmholtz function (A), Gibbs-Helmholtz equation, criteria for thermodynamic equilibrium and spontaneity of a process.

(b) Chemical equilibrium: chemical equilibria of homogeneous and heterogeneous systems, derivation of expression of equilibrium constants; temperature, pressure and concentration dependence of equilibrium constants (K_p , K_c , K_x); Le Chatelier's Principle of dynamic equilibrium.

(c) Phase equilibrium

Definitions of phase, component and degrees of freedom. Phase rule. Definition of phase diagram. Phase equilibria for one component system – water, CO₂.

Heterogeneous systems : Nernst Distribution Law, miscibility and distillation of binary liquid mixtures, azeotropic mixture, Critical Solution temperature, steam distillation.

Unit II. Basic physical chemistry IV

(13 Marks)

(a) Chemical kinetics and catalysis:

Order and molecularity of reactions, rate laws and rate equations for first order and second order reactions (differential and integrated forms); zero order reactions. Determination of order of reactions. Temperature dependence of reaction rate, the Arrhenius equation; special emphasis on temperature coefficient, energy of activation.

Catalytic reactions: homogeneous and heterogeneous catalytic reactions, autocatalytic reactions, catalyst poisons, catalyst promoters (typical examples).

(b) Photochemistry

Grothus-Draper Law, Lambert-Beer's Law, molar extinction coefficient, Stark-Einstein Law of photochemical equivalence and quantum yield, examples of low and high quantum yields, Luminiscence: Fluorescence and phosphorescence.

CEMGT 22B

Unit I. Basic physical chemistry V

(12 Marks)

(a) Acids-bases and solvents:

Modern aspects of acids and bases: Arrhenius theory, theory of solvent system, Bronsted and Lowry's concept, Lewis concept with typical examples, applications and limitations. Strengths of acids and bases (elementary idea).

Ionization of weak acids and bases in aqueous solutions, application of Ostwald's dilution law, ionization constants, ionic product of water, pH-scale, buffer solutions and calculation of pH values, buffer actions; hydrolysis of salts.

(b) Solutions of electrolytes:

Electrolytic conductance, specific conductance, equivalent conductance and molar conductance of electrolytic solutions. Influence of temperature and dilution on conductivity of strong and weak electrolytes, conductometric titration – acid-base, precipitation.

Electrode potential:

Electrode potentials, Nernst Equation, Reference electrodes, Normal Hydrogen Electrode and calomel electrodes, Emf of electrochemical cells and its measurement, electrode potential series and its applications, measurement of pH using glass calomel electrode.

Unit II. Basic physical chemistry VI

(13 Marks)

(a) Solutions of non-electrolytes:

Colligative properties of solution, Henry's Law, Raoult's Law, relative lowering of vapor pressure, osmosis and osmotic pressure; Elevation of boiling point and Depression of freezing point of solvents – (without deduction), calculation of molecular weight of solute from measurement of colligative properties of solutions.

(b) Colloids:

Colloids and crystalloids, classification of colloids, preparation and purification of colloids: ferric hydroxide sol and gold sol. Properties of colloids: Brownian motion, peptization, dialysis, Tyndal effect and its applications. Protecting colloids, gold number, isoelectric points, coagulation of colloids by electrolytes, Schulze-Hardy rule.

CEMGT 22C

Unit I. Basic organic chemistry III

(12 Marks)

a) Aldehydes and ketones: the nature of carbonyl group, methods of synthesis, physical properties, Cannizzaro reaction, relative reactivities and distinction of aldehydes and ketones, Aldol condensation (with mechanism), Perkin reaction, Benzoin condensation, Claisen condensation, Oxidation and reduction reactions.

b) Carboxylic acids and their derivatives: acidity of carboxylic acids and effects of substituents on acidity, chemical reactivity, mechanism of esterification of carboxylic acids and hydrolysis of esters (BAC2 and AAC2 only)

c) Carbohydrates: Introduction, occurrence and classification of carbohydrates, constitution of glucose, osazone formation, reactions of glucose and fructose, mutarotation, cyclic structures – pyranose and furanose forms (determination of ring-size excluded), epimerization, chain-lengthening (Kiliani –Fischer method) and chainshortening (Ruff's method) in aldoses.

Unit II. Basic organic chemistry IV

(13 Marks)

a) Phenols: synthesis, acidic character and chemical reactions of phenols, Kolbe reactions, Reimer-Tiemann reaction, Fries rearrangement, Claisen rearrangement.

b) Organic compounds containing nitrogen: aromatic nitro compounds – reduction under different conditions. [acidic, neutral and alkaline]. Methods of synthesis of aliphatic amines, Heinsberg's method of amine separation, Hofmann degradation, Gabriel's phthalimide synthesis, distinction of primary, secondary and tertiary amines; methods of synthesis of aromatic amines, basicity of aliphatic and aromatic amines. Diazotization and coupling reactions and their mechanisms; synthetic applications of benzene diazonium salts. [Sandmeyer's reaction, preparation of nitro compounds, phenols, carboxylic acids and hydrocarbons thereby].

c) Amino acids, Proteins: methods of synthesis of α –amino acids (glycine and alanine using Gabriel's phthalimide synthesis and Strecker synthesis). Physical properties. Zwitterion structures, isoelectric point.

CEMGT 22 D:

Unit I. Basic inorganic chemistry III

(12 Marks)

Coordinate bonds and Coordination compounds: complex salts and double salts, Warner's theory of coordination, chelate complexes, stereochemistry of coordination numbers 4 and 6. IUPAC nomenclature of coordination complexes (mononuclear complexes only).

Preparation and uses of the following compounds:

Sodium borohydride, lithium aluminium hydride, calcium carbide, hydrazine, hydroxylamine, sodium bismuthate, sodium thiosulphate, potassium peroxydisulphate, Perchloric acid, potassium bromate, potassium ferrocyanide, Mohr's salt, potassium chromate, potassium dichromate and potassium permanganate.

Unit II: Basic inorganic chemistry IV

(13 Marks)

Comparative study of s-block elements: Group trends, electronic configuration, isolation of pure elements, common oxidation states, inert pair effect, chemical properties and reactions in respect of the following group elements:

i) Li-Na-K

ii) Be-Mg-Ca-Sr-Ba

Extraction and purification of elements from natural sources: Li, Cr, Ni, Ag, Au.

Electroplating, galvanizing and anodizing.

Paper III (Practical)

Courses : CEMGP 23A, 23B

Course CEMGP 23A (50 marks)

UNIT 1 : Qualitative Analysis of Single Organic Compound (Solid)

UNIT-2 : Qualitative Analysis of Inorganic Mixture

UNIT-3 : VIVA- VOCE

UNIT-4 : Laboratory Records

Details of Practical Courses

UNIT 1 : Qualitative Analysis of Single Organic Compound (Solid)

The solid sample should be pure compound containing not more than two types of functional groups.

Experiment A: Test for special element (N, S, Cl, Br and I)

Experiment B: Solubility tests and solubility classification.

Experiment C: Test for the following functional groups.

Aromatic $-\text{NO}_2$, Aromatic $-\text{NH}_2$, $-\text{OH}$ (phenolic), Carbonyl (aldehyde and ketone),
 $-\text{COOH}$ and olefinic unsaturation.

Experiment D: Determination of the melting point of the compound.

Note : At least 6(six) unknown organic samples are to be analyzed by each student during Laboratory Session.

CEMGP 23B (50Marks)

Qualitative Analysis of Inorganic Mixtures

Experiments A: Preliminary Tests for Acid and Basic radicals in given samples.

Experiments B: Wet tests for Acid and Basic radicals in given samples.

Experiments C: Confirmatory tests.

Acid Radicals: Cl⁻, Br⁻, I⁻, NO₃¹⁻, S²⁻, SO₄²⁻, S₂O₃²⁻, PO₄³⁻, BO₃³⁻, H₃BO₃.

Basic Radicals: Cu⁺², Cr⁺³, Fe⁺³, Ni⁺², Mn⁺², Co⁺², Ca⁺², Sr⁺², Ba⁺², Na⁺, K⁺, , NH₄⁺

Insoluble: BaSO₄, SrSO₄, Cr₂O₃.

Note: At least 6 unknown samples are to be analyzed by each student during the Laboratory session.

B.Sc Part-III (3rd Year) Chemistry (General)

Total Marks 100 (Theory = 75, Practical = 25)

Paper IV

Courses : CEMGT 34A, 34B, 34C, CEMGP 34D

(Each 25 marks : Total 100 marks)

CEMGT 34A

Unit I. Chemical analysis

(12 Marks)

Gravimetric Analysis: Solubility product and common ion effect. Requirements of gravimetry. Gravimetric estimation of chloride, sulphate, lead, barium and nickel.

Error analysis and computer applications

Accuracy and precision of quantitative analysis, determinate-, indeterminate-, systematic- and random-errors. Methods of least squares and standard deviations.

General introduction to computers, different components of a computer, hardware and software, input and output devices, binary numbers and arithmetic. Introduction to computer languages, programming and operating systems.

Unit II: Volumetric Analysis

(13 Marks)

Primary and secondary standard substances, principles of acid-base, oxidation –reduction, and complexometric titrations; acid-base, redox and metal-ion indicators. Principles of estimation of mixtures of NaHCO_3 and Na_2CO_3 (by acidimetry); iron, copper, manganese, chromium (by redox titration); zinc, calcium, magnesium (by complexometric EDTA titration). Chromatographic methods of analysis: column chromatography and thin layer chromatography.

CEMGT 34B

Unit I. Industrial chemistry I

(12 Marks)

a) Fuels: Classification of fuel, heating values. Origin of coal, carbonization of coal, coal gas, producer gas, water gas, coal based chemicals. Origin and composition of petroleum, petroleum refining, cracking, knocking, octane number, anti-knock compounds,

Kerosene, liquefied petroleum gas (LPG), liquefied natural gas (LNG), petrochemicals (C1 to C3 compounds and their uses).

b) Fertilizers: Manufacture of ammonia and ammonium salts, urea, superphosphate, biofertilizers.

c) Glass and Ceramics: Definition and manufacture of glasses, optical glass and coloured glass. Clay and feldspar, glazing and vitrification, glazed porcelain, enamel. Portland cement: composition and setting of cement, white cement.

Unit II. Industrial chemistry II

(13 Marks)

a) Polymers: Basic concept, structure and types of plastics, polythene, polystyrene, phenol-formaldehydes, PVC; manufacture, physical properties and uses of natural rubber, Synthetic rubber, silicone rubber; synthetic fibres: Nylon-66, polyester, terylene, rayon; Foaming agents, plasticizers and stabilizers.

b) Paints, Varnishes and Synthetic Dyes: Primary constituents of a paint, binders and Solvents for paints. Oil based paints, latex paints, baked-on paints (alkyd resins). Constituents of varnishes. Formulation of paints and varnishes. Synthesis of Methyl orange, Congo red, Malachite green, Crystal violet.

c) Drugs and pharmaceuticals: Concept and necessity of drugs, pharmaceuticals and Vitamins.

Preparation and uses of Aspirin, Paracetamol, Sulphadiazine, Quinine (Structure and Use), Chloroquine (Structure and Use), Phenobarbital, Metronidazole.

Fermentation Chemicals: Production, and purification of ethyl alcohol, citric acid, lactic acid.

CEMGT 34C

Unit I. Environmental chemistry

(12 Marks)

The Atmosphere:

Composition and structure of the atmosphere: troposphere, stratosphere, mesosphere and thermosphere. Ozone layer and its role. Major air pollutants : CO, SO₂, NO and particulate matters –their origins and harmful effects, problems of ozone layer depletion, green house effect, acid rain and photochemical smog. Air pollution episodes. Air quality standard. Air pollution control measures: cyclone collector, electrostatic precipitator, catalytic converter.

The Hydrosphere :

Environmental role of water, natural water sources, water treatment for industrial, domestic and laboratory uses. Water pollutants: action of soaps and detergents, phosphates, industrial effluents, agricultural run off, domestic wastes; thermal pollution radioactive pollution and their effects on animal and plant life, water pollution episodes. Water pollution control measures: waste water treatment: chemical treatment and microbial treatment; water quality standards: DO, BOD, COD, TDS and hardness parameters. Desalination of sea water: reverse osmosis, electro dialysis.

The Lithosphere:

Water and air in soil, waste matters and pollutants in soil, waste classification, treatment and disposal. Soil pollution and control measures.

Unit II. Industrial Chemistry III

(13 Marks)

Fats-Oils-Detergents : Fats and oils, natural fat, edible and inedible oil of vegetable origin. Common fatty acids, glycerides. Hydrogenation of unsaturated oil, production of vanaspati and margarine. Production of toilet and washing soaps, Enzyme based detergents, detergent powder, liquid soaps.

Pesticides: Common pesticides : Production, applications and residual toxicity of gamma-xane, aldrin, parathion, malathion, DDT, paraquat, decamethrin.

Food Additives: Food flavour, food colour, food preservatives, artificial sweeteners, acidulants, alkalies, edible emulsifiers and edible foaming agents, sequesterants – uses and abuses of these substances in food beverages.

CEMGP 34D

Quantitative Chemical Analysis

(25 Marks)

Experiment –I. Preparation of standard (N/20) solution of oxalic acid and standardization of (a) NaOH solution (b) KMnO_4 solution (c) Mohr's salt solution (against KMnO_4).

Experiment –II. Preparation of standard (N/20) $\text{K}_2\text{Cr}_2\text{O}_7$ solution of oxalic acid and standardization of (a) Mohr's salt solution (b) KMnO_4 solution (c) sodium thiosulphate solution.

Experiment –III. Preparation of standard (M/50) Zinc acetate solution and (a) standardization of Na_2EDTA solution and (b) Estimation of unknown solution of single metal ion ($\text{Zn}^{2+}/\text{Ca}^{2+}/\text{Mg}^{2+}$).

Experiment –IV. Acidimetric estimation of NaHCO_3 , Na_2CO_3 mixture using phenolphthalein and methyl orange.

Experiment –V. Alkalimetric estimation of HCl, CH₃COOH mixture

Experiment –VI. Estimation of Fe (II) + Fe (III) mixture using standard (N/20) solution of (a) K₂Cr₂O₇ (b) KMnO₄ as titrants.

Experiment –VII. Estimation of total hardness of water (EDTA method).

Experiment –VIII. Estimation of Vitamin C by iodometric method.

Experiment –IX. Estimation of available oxygen in pyrolusite.