# UNIVERSITY OF CALCUTTA

## SYLLABI

## FOR

## THREE-YEAR B.Sc. HONOURS & GENERAL COURSES OF STUDIES

Chemistry

2010

**w.e.f. 2010-2011**

## Chemistry General: Syllabus Scheme in modular form

### Course names and distribution

PART – I (Year 1), total marks = 100 (Theory = 100)
CGT 11a, 11b each 25 marks, Theory
CGT 12a, 12b each 25 marks, Theory

PART – II (Year 2), total marks = 200 (Theory = 100, Practical = 100)
CGT 21a, 21b each 25 marks, Theory
CGT 22a, 22b each 25 marks, Theory
CGP 23 50 marks, Practical
CGP 24 50 marks, Practical

PART – III (Year 3), total marks = 100 (Theory = 75, Practical = 25)
CGT 31a, 31b, 31c each 25 marks, Theory
CGP 32 25 marks, Practical

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Abbreviations:
CGT: Chem General Theory; CGP: Chem General Practical
First digit refers to year, second to paper

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Each CGT Exam = 1½ hr for 50 marks, or as stated later
Each CGP Exam = 3 hr for 25/50 marks on each day, or as stated later

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Notes:
1. A Theory module of 25 marks would contain units I (marks = 15) and II (marks = 10).

2. Number of class hours = number of marks (Theory)
   Number of class hours = 2-3 times the number of marks (Practical)

Chemistry Gen: Course Description
Year 1
PART - I

## CGT 11a

Unit I. General Chemistry

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.

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.

Unit II. Principles of organic qualitative analysis

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.).

## CGT 11b

Unit I. Basic organic chemistry I

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

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.

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.

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

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.

Alkyl and Aryl halides: $S_N1$, $S_N2$, E1 and E2 reactions (elementary mechanistic aspects), Saytzeff and Hoffmann elimination reactions. Nucleophilic aromatic substitution.

## CGT 12a

Unit I. Basic inorganic chemistry I

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.

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).

Unit II. Basic inorganic chemistry II

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

## CGT 12b

Unit I. Basic organic chemistry III

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 ($B_{AC}2$ and $A_{AC}2$ only)

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

Organometallic compounds: Grignard reagents – preparations and reactions, application of Grignard reagents in organic synthesis. [$1^0$-, $2^0$- and $3^0$-alcohols, aldehydes, ketones and carboxylic acids.]

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]

Unit II. Basic organic chemistry IV

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 chain-shortening (Ruff's method) in aldoses.

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.

Chemistry Gen: Course Description
Year 2
PART - II

## CGT 21a

Unit I. Basic physical chemistry I

Gaseous state: Gas laws, kinetic theory of gas, collision and gas pressure, derivation of gas laws from kinetic theory, average kinetic energy of translation, Boltzmann constant and absolute scale of temperature, Maxwell's distribution law of molecular speeds (without derivation), most probable, average and root mean square speed of gas molecules, 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, continuity of states, critical constants.

Liquid state: physical properties of liquids and their measurements: surface tension and viscosity.

Unit II. Basic physical chemistry II

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

## CGT 21b

Unit I. Principles of qualitative inorganic analysis

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, arsenate, arsenite, sulphide, thiosulphate, sulphate, thiocyanate, borate, boric acid, carbonate. Analytical reactions for the detection of $Cr^{3+}$, $Fe^{3+}$, , $Ni^{2+}$, $Cu^{2+}$, $As^{3+}$, $Mn^{2+}$, Importance of common-ion effect in the separation of Group II cations, and Group III cations.

Unit II. Basic inorganic chemistry III

Comparative study of s-block elements: Group trends in electronic configuration, modification 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.

## CGT 22a

Unit I. Basic physical chemistry III

Thermodynamics: 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).

First law of thermodynamics, internal energy (U) and enthalpy (H); relation between Cp and Cv, calculation of w, q, $\Delta U$ and $\Delta H$ for expansion of ideal gas under isothermal and adiabatic conditions for reversible and irreversible processes including free expansion. Joule-Thomson Coefficient and inversion temperature.

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, Born haber cycle for calculation of lattice energy. Kirchhoff's equation, relation between $\Delta H$ and $\Delta U$ of a reaction.

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. Free energy: Gibbs function (G) and Helmholtz function (A), Gibbs-Helmholtz equation, criteria for thermodynamic equilibrium and spontaneity of a process.

Unit II. Basic physical chemistry IV

Chemical equilibrium: chemical equlibria 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.

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.

## CGT 22b

Unit 1. Basic physical chemistry V

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 their pH values, buffer actions; hydrolysis of salts.

Solutions of electrolytes: Electrolytic conductance, specific conductance, equivalent conductance and molar conductance of electrolytic solutions. Influence of temperature and dilution on weak electrolytes.

Unit II. Basic physical chemistry VI

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.

Solutions of non-electrolytes: Colligative properties of solution, Raoult's Law, relative lowering of vapor pressure, osmosis and osmotic pressure; elevation of boiling point and depression of freezing point of solvents.

## CGP 23

Qualitative Analysis of Single Organic Compound(s)

Experiment A: Detection of special elements (N, Cl, and S) in organic compounds.

Experiment B: Solubility and Classification (solvents: $H_2O$, dil. HCl, dil. NaOH)

Experiment C: Detection of functional groups $-NO_2$, $-NH_2$, -COOH, carbonyl (-CHO, >C=O), -OH (phenolic) in solid organic compounds.

Experiments A - C with unknown (at least 6) solid samples containing not more than two of the above types of functional groups should be done.

## CGP 24

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: $Cl^-$, $Br^-$, $I^-$, $NO_2^{-1}$, $S^{2-}$, $SO_4^{-2}$, $PO_4^{-3}$, $BO_3^{3-}$, $H_3BO_3$.
Basic Radicals: $Na^+$, $K^+$, $Ca^{+2}$, $Sr^{+2}$, $Ba^{+2}$, $Cr^{+3}$, $Mn^{+2}$, $Fe^{+3}$, $Ni^{+3}$, $Cu^{+2}$, $NH_4^+$.

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

Chemistry Gen: Course Description
Year 3
PART - III

## CGT 31a

Unit I. Chemical analysis

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

Volumetric Analysis: Primary and secondary standard substances, principles of acid-base, xidation –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, aluminum, calcium, magnesium (by complexometric EDTA titration). Chromatographic methods of analysis: column chromatography and thin layer chromatography.

Unit II. 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.

## CGT 31b

Unit I. Industrial chemistry I

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).

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

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

Unit II. Industrial chemistry II

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.

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.

Drugs and pharmaceuticals: Concept and necessity of drugs and pharmaceuticals. Preparation, and uses of Aspirin, Paracetamol, Sulphadiazine, Quinine, Chloroquine, Phenobarbital, Metronidazole. Fermentation Chemicals : Production, and purification of ethyl alcohol, citric acid, lactic acid, Vitamin B12, Penicillin.

## CGT 31c

Unit I. Environmental chemistry

The Atmosphere: Composition and structure of the atmosphere: troposphere, stratosphere, mesosphere and thermosphere. Ozone layer and its role. Major air pollutants : CO, $SO_2$, 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

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 gammaxane, 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.

## CGP 32

Experiments:

1. Titration of $Na_2CO_3$ + $NaHCO_3$ mixture vs HCl using phenolphthalein and methyl orange indicators.
2. Titration of HCl + $CH_3COOH$ mixture vs NaOH using two different indicators to find the composition.
3. To find the total hardness of water by EDTA titration.
4. To find the PH of an unknown solution by comparing color of a series of HCl solutions + 1 drop of methyl orange, and a similar series of NaOH solutions + 1 drop of phenolphthalein.
5. To determine the rate constant for the acid catalysed hydrolysis of an ester.
6. Determination of the strength of the $H_2O_2$ sample.
7. To determine the solubility of a sparingly soluble salt, e.g. KHTa (one bottle)

## Appendix 1

Hons. Examination

Paper-wise distribution of modules CHT and CHP

| | | | | |
|---|---|---|---|---|
| Year 1 | | | | |
| Paper IA (50 M): | CHT (12a+12b) | 1day exam | 2 hr | Theory |
| Paper IB (50 M): | CHT (13a+13b) | 1day exam | 2 hr | Do |
| Paper IIA (50 M): | CHT (11a+11b) | 1day exam | 2 hr | Do |
| Paper IIB (50 M): | CHP (14a+14b) | 1day exam | 4 hr | Practical |
| Year 2 | | | | |
| Paper IIIA (50 M): | CHT (22a+22b) | 1day exam | 2 hr | Theory |
| Paper IIIB (50 M): | CHT (23a+23b) | 1day exam | 2 hr | Do |
| Paper IVA (50 M): | CHT (21a+21b) | 1day exam | 2 hr | Do |
| Paper IVB (50 M): | CHP (24a+24b) | 1day exam | 4 hr | Practical |
| Year 3 | | | | |
| Paper V (100 M): | CHT (31a+31b+31c+31d) | 1day exam | 4 hr | Theory |
| Paper VIA (75 M): | CHT (32a+32b+32c) | 1day exam | 4 hr | Do |
| Paper VIIA (75 M): | CHT (33a+33b+33c) | 1day exam | 4 hr | Do |
| Paper VIIIA (50 M): | CHP 34b | 1day exam | 4 hr | Practical |
| Paper VIIIB (50 M): | CHP 35b | 1day exam | 4 hr | Do |
| Paper VIB (25 M) + Paper VIIB (25 M): | CHP (34a+35a) | 1day exam | 4 hr | Do |

Gen. Examination

Paper-wise distribution of modules CGT and CGP

| | | | | |
|---|---|---|---|---|
| Year 1 | | | | |
| Paper I (100 M): | CGT (11a+11b+12a+12b) | 1day exam | 3 hr | Theory |
| Year 2 | | | | |
| Paper IIA (100 M): | CGT (21a+21b+22a+22b) | 1day exam | 3 hr | Theory |
| Paper IIIA (50 M): | CGP 23 | 1day exam | 3 hr | Practical |
| Paper IIIB (50 M): | CGP 24 | 1day exam | 3 hr | Practical |
| Year 3 | | | | |
| Paper IVA (75 M): | CGT (31a+31b+31c) | 1day exam | 3 hr | Theory |
| Paper IVB (25 M): | CGP 32 | 1day exam | 3 hr | Practical |

## Appendix 2

Instructions about Theoretical Examinations
Hons./Genl.

For a Theoretical Examination, any particular module of 25 marks is already subdivided into two units: Unit I (15 marks) and Unit II (10 marks). In any case [Hons./Gen. (yearly)] , the following scheme will be effective.

**Unit – I:** 5 questions of marks 5 each are to be set, out of which 3 are to be answered. Minimum marks for a part of a question will be 2.

**Unit – II:** 3 questions of marks 5 each are to be set, out of which 2 are to be answered. Minimum marks for a part of a question will be 2.

## Appendix 3

General instructions about Practical Examinations
Hons./Genl.

1. Candidates at the practical examinations are required to submit the *day to day record of all types of laboratory works* prescribed in the syllabus, performed by them, and duly signed by their teachers. Candidates failing to submit their laboratory work-books may be debarred from the examination.

2. One experiment/sample shall be assigned to a candidate through single draw lottery.

3. Outline of the procedure, wherever applicable, should be provided.

4. Use of *hazardous/toxic* chemicals should be avoided as far as practicable.

5. Weighing is to be done, wherever applicable, by *digital electronic balance* only.

6. Depending on the time and type of an experiment, *Primary standard solutions are to be provided at the time of examination*. The HE may decide the issue.

7. Drawing of linear least square plots, wherever applicable, is to be encouraged.

8. Theoretical classes, explaining the principles, should be taken.

9. Hons. practical examinations involving viva-voce of not less than 10 marks may be replaced by a ***Lab. Quiz Test*** (10 questions, 10 min for 10 marks; roughly one line answer for each question). This step will ensure better uniformity. Questions for different batches will be different. These are to be answered by students at the start of the first day of examination of a given batch. Questions will be prepared by the concerned HE for the specific practical examination during sample preparation. A viva-voce examination for 10 marks should not exceed 10 min.

10. In Appendix 5, different practical examinations are associated with specified "modalities of evaluation". While the concerned HE may not strictly follow it under special circumstances (or, in case of specific experiments set by him), a general adherence to such a splitting pattern is expected to be beneficial to the students.

## Appendix 4

Specific instructions about Practical Examinations

### CHP (14a+14b), 50 M, 4 hr (Year 1)

Note for examination:

1. The sample must contain three, and only three, radicals.
2. Observation must be indicative of some changes in the sample under the experimental conditions. Vague observations such as "no characteristic change, inconclusive observation etc" are not to be entertained.
3. Presence as well as absence of radicals must be incorporated in the 'Inference' column according to observations.
4. Whenever a particular radical is detected in any experiment, its presence may mask the normal observations for the other radicals that are also responsive to the same test. Under the circumstances, the presence of the detected radicals should be shown in the 'Inference' column. It is needless to show the absence of the other radicals in the above experiment.
5. All the candidates must perform the "Preliminary orientational tests". The proforma for the tests will be supplied to them.
6. The indicated radicals in the preliminary tests are to be confirmed by the student by appropriate test of his/her own choice.
7. In the preliminary 'orientational test' the following experiments are to be performed:

A. Dry heating of the sample
B. Flame test
C. Borax-bead test
D. Fusion test
E. Fluorescence test
F. Filtrate of the boiling mixture of the (sample + dil HCl + $KNO_2$ (a pinch)) + DMG +$NH_4OH$ until ammoniacal
G. HCl extract + NaOH until alkaline, boiled and filtered: filtrate +$H_2S$
H. NaOH extract of the sample + $NH_4Cl$ + $H_2O$ – boiled and allowed to settle
I. Iodine-azide test
J. Heating of sample with dil $H_2SO_4$
K. Heating of sample with dil $H_2SO_4$ + Zn-dust
L. Heating of sample with conc. $H_2SO_4$
M. Heating of sample with conc. $H_2SO_4$ + Cu-turnings
N. Heating of sample with conc. $H_2SO_4$ + MeOH and ignition of the evolved gas

O. $HNO_3$ extract + $(NH_4)_2MoO_4$ (excess)
P. $Na_2CO_3$ extract + $HNO_3$ until acidic, boiled + $Ba(NO_3)_2$
Q. $Na_2CO_3$ extract + $HNO_3$ until acidic, boiled + $AgNO_3$
R. $Na_2CO_3$ extract + HCl until acidic, boiled + $FeCl_3$ + $K_3[Fe(CN)_6]$
S. $Na_2CO_3$ extract + HCl until acidic, boiled + KI + starch
T. $Na_2CO_3$ extract + HCl until acidic, boiled + $FeCl_3$

Marks:

| | |
|---|---|
| 1. Orientational tests: | 20 M |
| 2. Confirmatory tests: | 12 M (4x3) |
| 3. Reporting of the radicals: | 3M |
| 4. Lab workbook: | 5 M |
| 5. Lab quiz/viva-voce: | 10 M |

**CHP (24a+24b), 50 M, 4 hr (Year 2)**

At least 4 experiments from 24a and 5 experiments from 24b are to be set in the examination. A student will take any one experiment.

Modalities of Evaluation:

| | | |
|---|---|---|
| 1) | Principle and derivation of working formula | = 5 M |
| 2) | Preparation of primary standard | = 5 M |
| 3) | Tabular presentation of data | = 5 M |
| 4) | Lab quiz/viva voce | = 10 M |
| 5) | Lab. workbook | = 5 M |

| Non-instrumental Expt. | Instrumental Expt. |
|---|---|
| Calculations based on working formula = 5 M | Plotting of data, etc. = 5 M<br>Calculation = 5 M |
| Accuracy = 15 M | Accuracy = 10 M |

**CHP 34a, 25 M, total 4 hr with CHP 35a (Year 3)**

At least 10 spectral analyses are to be set.

Modalities of Evaluation:

| | |
|---|---|
| Expt. A (PMR) | 14 M |
| Expt. B (IR) | 8 M |
| Lab. workbook | 3 M |

**CHP 34b 50 M, 4 hr (Year 3)**

At the practical examination, two experiments, one each from 1 and 2, are to be assigned to a candidate. For qualitative analysis, one unknown solid organic compound containing not more than two of the functional groups included in the syllabus shall be assigned to a candidate. At least 6 different preparations are to be set in experiment 2.

Modalities of Evaluation:

| | | | |
|---|---|---|---|
| Expt. 1A | 3 M | Expt. 2A | 12 M |
| Expt. 1B | 3 M | Expt. 2B | 5 M |
| Expt. 1C | 6x1½= 9 M | Expt. 2C | 3 M |
| Viva voce/Lab quiz | 10 M | Lab workbook | 5 M |

**CHP 35a, 25 M, total 4 hr with CHP 34a (Year 3)**

At least 5 experiments out of 6 are to set in the practical examination.
Modalities of Evaluation:

| | | |
|---|---|---|
| 1) | Working formula | = 2 M |
| 2) | Presentation of data and graphs, if any | = 10 M |
| 3) | Correct calculations and quality of results | = 5+5 M |
| 4) | Lab. workbook | = 3 M |
| | Total Marks | = 25 |

Marks in 2) and 3) may be redistributed depending on the emphasis on graphs or numerical works, as appropriate to a particular experiment.

**CHP 35b, 50 M, 4 hr (Year 3)**

At least 6 experiments out of 9 are to set in the practical examination.
Modalities of Evaluation:

| | | |
|---|---|---|
| 1) | Theory and working formula | = 5 M |
| 2) | Presentation of data and graphs, if any | = 10+5 M |
| 3) | Correct calculations and quality of results | = 10 +5 M |
| 4) | Lab. workbook | = 5 M |
| 5) | Viva-voce/lab quiz test | = 10 M |
| | Total Marks | = 50 |

Marks in 2) and 3) may be redistributed depending on the emphasis on graphs or numerical works, as appropriate to a particular experiment.

**CGP 23, 50 M, 3 hr (Year 2)**

In the practical examination one unknown solid organic compound containing not more than two of the functional groups mentioned shall be assigned to a candidate.
Marks distribution should be as follows:

| | |
|---|---|
| Expt. A: Tests for special elements (positive/negative responses) – | 9 M |
| Expt. B: Solubility tests and classification – | 6 M |
| Expt. C: Tests for the 5 functional groups (positive/negative responses) [5 x 5] - | 25 M |
| Lab record book – | 10 M |

**CGP 24, 50 M, 3 hr (Year 2)**

In the practical examination, one unknown sample shall be assigned to a candidate. The mixture may contain more than two radicals. But, *at least two radicals*, one acid and one basic, are to be reported. Radicals may be detected by systematic analysis or by semimicro tests, or both. Both positive and negative responses are to be recorded.
Marks distribution should be as follows:

| | |
|---|---|
| (a) Dry tests for basic and acid radicals – | 10 M |
| (b) Wet tests for acid and basic radicals – | 15 M |

(c) Confirmatory tests for radicals found – 10 M (2x5)
(d) Correct reporting of two radicals – 5 M
(e) Lab record book – 10 M
[For wrong reporting of both the radicals, ½ mark may be awarded for each correct reporting of absence of a radical.]

**CGP 32, 25 M, 3 hr (Year 3)**

At least 3 experiments will be set in the practical examination. One experiment will be assigned to a candidate. To avoid accurate weighing by the students, standard solutions should be supplied.
Marks distribution:
Theory/Working formula 05 M
Presentation of data 05 M
Calculations and results 10 M
Lab. Record book 05 M

## Appendix -5

Recommended list of books

### 1. Hons. Course

A. Textbooks

J. E Huheey, E. A. Keiter, R. L. Keiter: Inorganic Chemistry (Principle and structure and reactivity).
N. N. Greenwood, A. Earnshaw: Chemistry of the Elements
D. F. Shriver, P. W. Atkins, C. H. Langford: Inorganic Chemistry
A. G. Sharpe: Inorganic Chemistry
D. S. Skoog, D. M. West, F. G. Holler, S. R. Crouch: Fundamentals of Analytical Chemistry

D. Nasipuri: Stereochemistry of organic compounds: Principles and Applications
P. Sykes: A Guide to Mechanism in Organic Chemistry
J. March: Advanced Organic Chemistry
I. L. Finar: Organic Chemistry (Vol. I)

R. T. Morrison and R. N. Boyd: Organic Chemistry
W. Kemp: Organic spectroscopy
R. O. C. Norman and J. M. Coxon: Principle of organic synthesis
S. Warren: Organic synthesis: The disconnection approach

D. A. Mcquarrie and J. D. Simon: Physical Chemistry – A Molecular Approach
I. N. Levine: Physical Chemistry
G. W. Castellan: Physical Chemistry
P. W. Atkins: Physical Chemistry

B. Reference books

I. Kaplan: Nuclear Physics
S. N. Ghosal: Atomic and Nuclear Physics
F. A. Cotton, G. Wilkinson: Advanced Inorganic Chemistry
G. Wulfsberg: Inorganic Chemistry
D. M. P. Mingos: Essential Trends in Inorganic Chemistry
C. S. C. Phillips and R.J.P. Williams: Inorganic Chemistry

J. Clayden, N. Greeves, S. Warren and P. Wothers: Organic chemistry
J. A. Joule and K. Mills: Heterocyclic Chemistry (4 th Edition)
W. Carruthers: Modern methods of organic synthesis

K. Denbigh: The Principles of Chemical Equilibrium
C. N. Banwell and E.M. McCash: Fundamentals of Molecular Spectroscopy
R. S. Berry, S. A. Rice and J. Ross: Physical Chemistry
T. Engel and P. Reid: Physical Chemistry
W. J. Moore: Physical Chemistry
K. J. Laidler: Chemical Kinetics

C. Practical Chemistry books

G. Svehla: Vogel's Qualitative Inorganic Analysis.

J. Mendham, R. C. Denny, J. D. Barnes, M. J. K. Thomas: Vogel's Text Book of Quantitative Chemical Analysis.

G. N. Mukherjee: Semi-Micro Qualitative Inorganic Analysis (CU Publications)

Vogel's Text Book of Practical Organic Chemistry ($5^{th}$ Edition)

N. G. Mukherjee: Selected Experiments in Physical Chemistry

**2. Gen. Course**

A. Textbooks
P. K. Dutt: General and Inorganic Chemistry ( Vol-I + Vol-II)

S. Sengupta: Organic Chemistry
S. R. Palit: Elementary Physical Chemistry

B. Practical Chemistry book
A. K. Nad, B. Mahapatra and A. Ghoshal: An Advanced Course in Practical Chemistry