# The University of Burdwan
# Syllabus for B.Sc. General
# (1+1+1 Pattern)
# in
# Chemistry
# with effect from 2014-2015

Category A: For students with honours in subjects other than chemistry

Total Marks: 200 (theoretical) + 100 (Practical) = 300

Category B: For pass course students only

Total Marks: 265 (theoretical) + 135 (Practical) = 400

**PART I**

| **Theoretical** | | **Marks** |
|---|---|---|
| Paper I: | Group A: General principles | 50 |
| | Group B: Organic | 50 |
| | **Total:** | 100 |
| **Practical** | | 20 |

Examination will be conducted by the college and marks will be kept for final addition with the Practical Examination of **Part II**.

**PART II**

| | | |
|---|---|---|
| Paper II: | Group A: Inorganic | 50 |
| | Group B: Physical | 50 |
| | Total: | 100 |
| **Practical** | | **Marks** |
| Paper III: | Qualitative (Inorganic + Organic) | 65 |
| | Laboratory Note Book | 05 |
| | Viva-Voce | 10 |

**PART III**

For pass course (Category B) students only

| **Theoretical** | | **Marks** |
|---|---|---|
| Paper IV: | Chemistry (General) | 65 |
| **Practical** | | |
| Paper V: | Inorganic Quantitative | 35 |
| | Total: | 100 |

# PART I

**Paper I**

## Group A

## General Principles (Full Marks: 50)

### 1. Atomic Structure

Bohr's theory: energy and radius calculations for H-like atoms, dual nature of matter and light, de Broglie's relationship, Heisenberg's uncertainty principle (qualitative), quantum numbers, Pauli exclusion principle, qualitative introduction of orbitals, shapes of orbitals, electron distribution of elements - Aufbau principle and Hund's rule.

### 2. Radioactivity

Theory of disintegration, rate constant, half life period (their interrelationship – deduction) idea of disintegration series, artificial transmutation and artificial radioactivity, uses and abuses of radioactivity. Stability of atomic nucleus, n/p ratio, mass defect, binding energy.

### 3. Periodic Table and Periodic Properties

Periodic law, Periodic classification of elements on the basis of electron distribution, s-, p- and d-block elements, connection among valencies, electron distribution and positions of the elements in the long form of the periodic table. Periodic properties: atomic radii, ionic radii, covalent radii, ionisation energy, electron affinity, electronegativity and its different scales.

### 4. Chemical Forces and Molecular Structure

Ionic bond, covalent bond (octet rule and expanded octet), dative bond, deformation of ions and Fajan's rules, Born-Haber cycle, hydrogen bond: intra- and intermolecular, bond polarity and dipole moment. Bond lengths, bond angles and qualitative description of shapes of some simple molecules like $CO_2$, $SO_2$, $H_2O$, $BeCl_2$, $BF_3$, $NH_3$, $CH_4$, $C_2H_4$, $C_2H_2$, $C_6H_6$.

### 5. Oxidation and Reduction

Electronic concepts, oxidation number, ion-electron method of balancing equations, application of redox reactions, idea of standard potential and formal potential. Derivation of thermodynamic quantities of cell reactions ($\Delta G$, $\Delta H$ and $\Delta S$).

### 6. Acids and Bases, Buffers and Ionic Equilibrium

Different concept of acids and bases, ionic product of water, salt hydrolysis, pH and its colorimetric determination, Strengths of strong and weak acids and bases, Ostwald dilution law, Henderson equation, neutralization and acid-base indicators, buffers, common ion effect, solubility product (application in analytical chemistry)

## Group B

## Organic Chemistry (Full Marks: 50)

### 1. Functional Nature of Organic Compounds

Classification of organic compounds in terms functional groups, their IUPAC nomenclature and valence bond structures.

### 2. Electron Displacement in Molecules

Concept of Inductive effect, Electromeric effect, Hyperconjugation, Resonance, Aromaticity and Tautomerism.

**3. Introduction to Organic Reaction Mechanism**

Homolytic and heterolytic bond cleavage; Reaction intermediates: carbocation, carbanion, free radical.

Classification of organic reactions (substitution, elimination, addition and rearrangement) and reagent types (electrophiles, nucleophiles, acids and bases), Ideas of organic reaction mechanism ($S_N1$, $S_N2$, E1 and E2).

**3. Chemistry of Hydrocarbons**

a) Free radical substitutions of alkanes; b) Formation of alkenes, electrophilic addition reactions of alkenes (upto four carbon atoms), Markwonikoff's rule, peroxide effect, ozonolysis, radical addition and catalytic reductions; c) Formation of alkynes, their partial and complete reductions and hydration. Halogen derivatives of alkanes, their nucleophilic substitutions and elimination reactions.

**4. Mono and Bifunctional Compounds**

Preparations and properties of primary, secondary and tertiary monohydric alcohols, ethers, ethylene glycol, pinacol and glycerol; aldehydes and ketones; monocarboxylic acids and their derivatives: acid chlorides, anhydrides, esters, amides; amines; unsaturated alcohol (allyl alcohol), unsaturated aldehyde (acrolein), unsaturated carboxylic acid ( acrylic acid), unsaturated ester (methyl acrylate), di- and tribasic acids (oxalic, malonic, succinic acids; malic and citric acids).

**5. Stereochemistry**

Concept of optical activity, optical properties of lactic acid and tartaric acid, *D,L* and *R,S* nomenclature; Geometrical isomerism with reference to fumaric acid and maleic acid; *cis-trans* and *E, Z* nomenclature.

**6. Chemistry of Aromatic Compounds**

Modern concept of structure of benzene, general mechanism of aromatic electrophilic substitution reactions, preparations and properties of toluene, xylene, halobenzenes, benzyl chloride, benzoyl chloride, benzotrichloride, nitrobenzene, dinitrobenzene, TNT, aniline, methyl and dimethyl aniline, benzyl amine benzene diazonium chloride, phenols, benzyl alcohol, benzaldehyde, acetophenone, benzoic acid, anhydride, amides, esters; phenyl acetic acid, salicylic acid, cinnamic acid, sulphanilic acid, phenyl hydrazine, nitrophenols and picric acid.

**7. Organic Synthesis**

Preparation and synthetic uses of diethyl malonate and ethylacetoacetate. Application of Grignard reagents in synthesis of ketones, secondary and tertiary alcohols and carboxylic acids.

**8. Carbohydrates**

Open-chain and ring structures glucose, fructose and their mutarotation, idea of dissacharides with reference to cane sugar.

# PART II

**Paper II**

## Group A

## Inorganic Chemistry (Full Marks: 50)

1. **Coordination Chemistry**

Double and complex salts, Werner's theory, ligands, coordination number, inner metallic complexes, chelate effect, different types of isomerism, IUPAC nomenclature.

2. **Group Chemistry**

A **comparative study** of the elements belonging to a particular group to be made in brief on the basis of their electron distribution and position in the periodic table. Structures (excluding stereochemistry) and properties of important compounds mentioned to be explained.

**Group 1**: Hydrogen – isotopes and binary hydrides, lithium and its similarities and differences from other alkali metals, diagonal relationship with magnesium, lithium aluminium hydrides.

**Group 2:** Calcium, stroncium and barium, hydrolith, calcium cyanamide, gypsum and plaster of paris.

**Group 12:** Zinc, cadmium and mercury. Nesslar's reagent, Millon's base.

**Group 13:** Diborane, boron trifluoride, sodium borohydride, inorganic benzene.

**Group 14:** Carbon, silicon, tin and lead, carbide, silicon carbide, silica, sodium silicate. Silica gel, hydrofluorosilicic acid, silicon tetra chloride, glass, fullerene.

**Group 15:** Nitrogen, phosphorus, arsenic, antimony and bismuth, hydrazine, hydrazoic acid, hydroxyl amine, hyponitrous acid, phosphorus oxyacids ($H_3PO_2$, $H_3PO_3$, $H_3PO_4$, $H_4P_2O_7$ and $HPO_3$), sodium bismuthate.

**Group 16:** Oxygen and sulphur, composition and structure of ozone, oxyacids of sulphur ($H_2SO_3$, $H_2SO_4$, $H_2S_2O_3$, $H_2S_2O_8$), persulphate

**Group 17:** Fluorine, chlorine, bromine and iodine, oxides and oxyacids of chlorine, isolation of fluorine.

**Group 18:** Rare gases (isolation and uses) with special reference to general fluorides (structure)

**3. Transition Metals**
**Groups 6** and **7:** Chromium, manganese, $K_2CrO_4$, $K_2Cr_2O_7$, $CrO_2Cl_2$, $KMnO_4$, chrome alum.
**Groups 8, 9** and **10:** Iron, cobalt and nickel, principles of isolation of Ni (excluding details), composition and uses of alloys, steels, rusting of iron, galvanization and tin plating
**Group 11**: Cu, Ag, Au, principles of Ag and Au isolation, different valency states

## Group B
## Physical Chemistry (Full Marks: 50)

**1. Kinetic Theory of Gases**

Ideal gas equation, derivation of gas laws, Maxwell's speed and energy distributions (derivation excluded); distribution curves; different types of speeds and their significance, concept of equipartition principle, van der Waals equation, Virial equation, continuity of state, Boyle temperature, critical constants, specific heats and specific ratios, laws of partial pressure, vapour density and density method of determination of molecular weights, limiting density, abnormal vapour density, frequency of binary collisions; mean free path

**2. Thermodynamics**

Thermal equilibrium and zeroth law, First law, reversible and irreversible work, criteria of perfect gas, isothermal and adiabatic expansions, Joule-Thomson effect (derivation excluded); Thermochemistry: Hess's law and its application

Second law and its elementary interpretation, Carnot's cycle and theorems, Clausius inequality, criteria of spontaneity, free energy and entropy

**3. Equilibrium**

Conditions of spontaneity and equilibrium, degree of advancement and Le Chatelier principle; Van't Hoff isotherm, isobar and isochore

**4. Phase Equilibria and Colligative Properties**

Phase rule equation (derivation excluded); phase diagram of water system, Miscibility (phenol-water) and distillation of completely miscible binary liquid mixtures; azeotropes, Steam distillation

Graphical approach of Raoult's law of vapour pressure and colligative properties: osmosis, lowering of freezing point, elevation of boiling point, experimental methods of determination of molecular weights of substances in dilute solutions, van't Hoff 'i' factor and abnormal behaviour of electrolytic solutions

**5. Properties of Matter**

Viscosity of fluids, temperature and pressure dependence, Surface energy and surface tension of liquids: temperature dependence

Unit cell, Bravais lattice; crystal system, Miller indices; Bragg's equation and its applications

**6. Electrochemistry**

Electrolytic conduction, transport number (experimental determination excluded), velocity of ions: specific, equivalent and molar conductances, determination of equivalent conductivity of solutions, Kohlrausch's law, strong and weak electrolytes, Ion atmosphere; electrophoretic and relaxation effects, Debye-Huckel theory (qualitative) and the limiting law.

Electrochemical cells, half-cells (with types and examples), Nernst equation and standard electrode potentials, standard cells

**7. Chemical Kinetics**

Order and molecularity of reactions, integrated rate laws (first and second order), average life period, concept of Arrhenius activation energy

Catalysis, autocatalysis, enzyme catalyst, catalyst poisons, promoters, elementary treatment of mechanism of catalysis

**8. Photochemistry and Spectroscopy**

Absorption, Lambert-Beer's law, photochemical laws, primary photophysical processes, potential energy diagram, Franck-Condon principle, fluorescence and phosphorescence, Jablonsky diagram, Laws of photochemistry, quantum yield, kinetics of HI decomposition, $H_2$-$Br_2$ reactions

Elementary idea of rotational and vibrational spectra

## Practical

**Paper III** Full Marks: 65

### Inorganic Qualitative (Marks: 35)

Detection of three radicals by analysis of mixture containing not more than three radicals from the following list (insoluble salts excluded)

Silver, lead, mercury, bismuth, copper, cadmium, arsenic, antimony, tin, iron, aluminium, chromium, zinc, manganese, cobalt, nickel, calcium, strontium, barium, magnesium, sodium, potassium, ammonium and their oxides, hydroxides, chlorides, bromides, iodides, sulphates, sulphites, sulphides, thiosulphates, chromates, phosphates, nitrites, nitrates and borates.

### Organic Qualitative (Marks: 30)

Detection of elements (N, S, Cl) and any one of the following groups in organic compounds (solid only): $-NH_2$, $-NO_2$, $-CONH_2$, -OH, >C=O, -CHO, -COOH

**Marks distribution under following headings in Inorganic**

1. Physical characteristics
2. Preliminary tests for basic radicals
   (i) Dry test heating
   (ii) Flame test
   (iii) Borax bead test
3. Special test for basic radicals:
   Mn, Cr, Fe, Co, Ni, Cu etc
4. Preliminary test for acid radicals:
   (i) Dil. $H_2SO_4$
   (ii) Conc. $H_2SO_4$
   (iii) Conc. $H_2SO_4$ + $MnO_2$
   (iv) Conc. $H_2SO_4$ + Cu turnings
5. Tests for interfering acid radicals:
   Special test for $S^{2-}$
6. Solubility Tests
7. Wet and confirmatory tests for acid radicals: solution preparation, confirmation
8. Wet tests for basic radicals: preparation and confirmation
9. Conclusion

**Marks distribution under following headings in Organic**

1. Physical characteristics
2. Detection of elements
3. Solubility test and conclusion from solubility test
4. Functional group (presence or absence)
5. Confirmation
6. Conclusion

## PART III

**Paper IV** Full Marks: 65

### Chemistry (General)

**1. Analytical Chemistry**

(a) Accuracy and precision in analysis, types of errors, data analysis and curve fitting (linear Y = mX + C type), numerical problems, mean, mode and variant

(b) Principles of acid-base titration, use of indicators and indicator constant, titration of $Na_2CO_3$ + $NaHCO_3$ mixture vs HCl using different indicators, estimation of mixture of strong and weak acids, qualitative discussion of salt hydrolysis (no derivation)

(c) Single electrode potential and emf of a chemical cell, principles of redox titration, use of redox potentials, iodometry, iodimetry, use of $K_2Cr_2O_7$ and $KMnO_4$ as oxidant (acid, neutral and alkaline media)

2. **Green Chemistry**

Basic principles of green chemistry. Tools of green chemistry including the use of alternative feed stocks or starting materials, reagents, solvents, target molecules, and catalysts (homogeneous, heterogeneous and biocatalysis), green chemistry as the alternative chemistry for protection of environment.

3. **Chemistry of Selected Biomolecules**

Structural aspects (excluding elucidation and stereochemistry, unless specified) and important function of d/l-sucrose and polysaccarides (starch and cellulose), amino acids (classification, essential amino acids like glycine, alanine, methionine and tryptophan with d/l), proteins (special reference to the peptide bond, action of haemoglobin, idea of denaturation of proteins, classification and functions of enzymes in general), pyrrole, pyridine, pyrimidine and purine, nucleic acids (DNA and RNA), nucleotide and nucleoside.

4. **Medicinal Chemistry**

Antipyretics and analgesics like paracetamol and aspirin, sulpha-drugs like sulphadiazine, antibiotics like penicillin and chloramphenicol,ofloxacin; antiamoebic like metronidazole, anticancer drugs, drugs used for AIDS (detailed structures are not needed, only the nature and function of the drugs)

5. **Nano Chemistry**

Elementary idea on nano materials. Basic chemical strategy for making nanomaterials. Nanoclusters, Nanowires and Carbon Nanotubes. Applications.

6. **Colloidal State**

General classification, general methods of preparation of lyophobic colloids and general properties of colloids, ideas of coagulation, peptization, protective colloids, dialysis, gold number, isoelectric point, Brownian motion

7. **Macromolecular Chemistry**

Introduction, definition of macromolecules, natural and synthetic polymers, monomers, polymers, degree of polymerization, simple idea of polymer structure: homopolymer (linear, branched, cross-linked) and copolymer (random, block, graft), polymerization reaction step (growth, addition, ring opening), importance of polymers both natural and synthetic

Number and weight average molecular weights of polymers – significance, structure and use of natural rubber, synthetic rubber (neoprene), synthetic fibres (Nylon 66, poly ester), plastics like polyethylene and PVC, macromolecules and environment

## Practical

**Paper V** Full Marks: 35

### Inorganic Quantitative

a. Titration of $Na_2CO_3$ + $NaHCO_3$ mixture vs HCl using phenolphthalein and methyl orange indicators
b. To find the total hardness of water by EDTA titration
c. To find the pH of an unknown solution by comparing colour of a series of (HCl solutions + 1 drop of methyl orange) and a similar series of (NaOH solutions + 1 drop of phenolphthalein)
d. Estimation of saponification equivalent of a supplied ester/oil
e. Titration of ferrous iron by $KMnO_4$/$K_2Cr_2O_7$
f. Titration of ferric iron by $KMnO_4$/$K_2Cr_2O_7$ using $SnCl_2$ reduction

Notes: Duration of the examination will be 3 hours (for any one of the above experiments). Marks will be divided as follows: Experiment = 25 (Theory = 5, Presentation = 5, Correct calculation = 5, Results = 10); Viva-voce = 5, Note book = 5

Accurate weighing by the students should be avoided. Standard solutions will be supplied. Teachers need not disclose exact strengths of supplied solution to students, but encourage them to perform required calculations by assuming a factor in each case. Examiners will set more than one experiments in the examination and students will perform one drawing card. Properly signed laboratory note book should be a must for the examinee to the practical laboratory where examination will be conducted.

**Tentative list of Recommended Books**

**Paper I**


1. Advanced Organic Chemistry, Vol. 1, Aditi Sangal, Krishna Prakashan Media (P) Ltd, Meerut, India, 2012
2. Elementary Physical Chemistry, S.R. Palit, 30th Edn, Book Syndicate Private Limited
3. Physical Chemistry; P.C. Rakshit, 7th Edn, Sarat Book Distributers, 2004.
4. Degree Bhouto O Sadharan Rasayan; Dr. A. K. Mondal: Sarat Book Distributers.
5. Sadharan O Bhouto Rasayan; Amalendu Ghoshal: Books and Allied (P) Ltd.
6. General Chemistry, S. Ekambaram, 1st Edn, Pearson, 2006.
7. Inorganic Chemistry, R. L. Dutta and G. S. De, Part – I, The New Book Stall, 7th Edn, 2013
8. Inorganic Chemistry, R. L. Dutta, Part –II, The New Book Stall, 5th Edn, 2006
9. General and Inorganic Chemistry, P. K. Dutt, 15th Edn, Levant Books, 2003.
10. Organic Chemistry, S. Sengupta, M/s Subrata Sengupta.
11. Organic Chemistry, B. S. Bahl and A. Bahl, 21st Edn, S. Chand, 2012.
12. Organic Chemistry, R. K. Bansal, 5th Edn, New Age International, 2007.
13. B. M. Mahan and R. J. Meyers, University Chemistry, 4th Edn, Pearson, 2009


**Paper II**


1. Elementary Physical Chemistry, S.R. Palit, 30th Edn, Book Syndicate Private Limited
2. Physical Chemistry; P.C. Rakshit, 7th Edn, Sarat Book Distributers, 2004.
3. Degree Bhouto O Sadharan Rasayan; Dr. A. K. Mondal: Sarat Book Distributers.
4. Sadharan O Bhouto Rasayan; Amalendu Ghoshal: Books and Allied (P) Ltd.
5. General Chemistry, S. Ekambaram, 1st Edn, Pearson, 2006.
6. Inorganic Chemistry, R. L. Dutta and G. S. De, Part – I, The New Book Stall, 7th Edn, 2013
7. Inorganic Chemistry, R. L. Dutta, Part –II, The New Book Stall, 5th Edn, 2006
8. General and Inorganic Chemistry, P. K. Dutt, 15th Edn, Levant Books, 2003.
9. B. M. Mahan and R. J. Meyers, University Chemistry, 4th Edn, Pearson, 2009


**Paper III (Practical)**


1. A. K. Nad, B. Mahapatra and A. Ghosal, An Advanced Course in Practical Chemistry, New Central, 2007.
2. Vogel's Text Book of Practical Organic Chemistry (5th Edn).
3. Mann and Saunders, Practical Organic Chemistry.
4. S. C. Das, Advanced Practical Chemistry.


**Paper IV**


1. Advanced Organic Chemistry, Vol. 1, Aditi Sangal, Krishna Prakashan Media (P) Ltd, Meerut, India, 2012
2. Elementary Physical Chemistry, S.R. Palit, 30th Edn, Book Syndicate Private Limited
3. Physical Chemistry; P.C. Rakshit, 7th Edn, Sarat Book Distributers, 2004.
4. Degree Bhouto O Sadharan Rasayan; Dr. A. K. Mondal: Sarat Book Distributers.
5. Sadharan O Bhouto Rasayan; Amalendu Ghoshal: Books and Allied (P) Ltd.
6. General Chemistry, S. Ekambaram, 1st Edn, Pearson, 2006.
7. Inorganic Chemistry, R. L. Dutta and G. S. De, Part – I, The New Book Stall, 7th Edn, 2013

8. Inorganic Chemistry, R. L. Dutta, Part –II, The New Book Stall, 5th Edn, 2006.
9. General and Inorganic Chemistry, P. K. Dutt, 15th Edn, Levant Books, 2003.
10. Organic Chemistry, S. Sengupta, M/s Subrata Sengupta.
11. Organic Chemistry, B. S. Bahl and A. Bahl, 21st Edn, S. Chand, 2012.
12. Organic Chemistry, R. K. Bansal, 5th Edn, New Age International, 2007.
13. Environmental Chemistry With Green Chemistry, Asim Kr Das, Books & Allied (P) Ltd, 2004.
14. Medicinal Chemistry, A. Kar, 5th Edn, New Age International, 2011.
15. Medicinal Chemistry, D. Sriram and P. Yogeswari, 1st Edn, Pearson, 2006.
16. Nanochemistry: A Chemical Approach to Nanomaterials, G. A. Ozin, A. C. Arsenult, L. Cademartiri and C. A. Mirkin, 2nd Edn, Royal Society of Chemistry, 2009.
17. Nanomaterial Chemistry: Recent Development and New Directions, C. N. R. Rao, A. Muller and A. K. Cheetham, Wiley-VCH, 2007.
18. A. K. Nad, B. Mahapatra and A. Ghosal, An Advanced Course in Practical Chemistry, New Central, 2007.
19. B. M. Mahan and R. J. Meyers, University Chemistry, 4th Edn, Pearson, 2009.
20. S. M. Khopkar, Basic Concepts of Analytical Chemistry, Wiley Eastern Ltd., New Delhi, 1998.
21. A. L. Underwood and R. A. Day, Quantitative Analysis 6th Edn, Prentice-Hall, 2009.
22. J. Mendham, R.C. Denney, J.D. Barnes, M. Thomas and B. Sivasankar, Vogel's Text Book on Quantitative Chemical Analysis, 6/e, Pearson.

**Paper V (Practical)**

1. A. K. Nad, B. Mahapatra and A. Ghosal, An Advanced Course in Practical Chemistry, New Central, 2007.
2. M. J. K. Thomas, J. Mendham, R. C. Denney, J. D. Barnes, Vogel's Quantitative Chemical Analysis, 6th Edn, Pearson Higher Education, 2000.
3. Vogel's Text Book of Practical Organic Chemistry (5th Edn).
4. Mann and Saunders, Practical Organic Chemistry.
5. S. C. Das, Advanced Practical Chemistry.