Jyoti Nivas College Autonomous
Bangalore 560095
III Semester B.Sc.
Chemistry Paper–III (SEP Syllabus)
Integrated Principles of Chemistry I

COURSE TITLE	**Integrated Principles of Chemistry I**
COURSE CODE	**24IIICH3T**
COURSE CREDITS	**3**
TOTAL CONTACT HOURS	**56 HOURS**
DURATION OF ESA	**3 HOURS**
FORMATIVE ASSESSMENT MARKS	**20 MARKS**
SUMMATIVE ASSESSMENT MARKS	**80 MARKS**

Course Objectives

1. **Understanding Core Concepts**
   To develop a foundational understanding of core physical, inorganic, and organic chemistry principles including kinetics, nuclear chemistry, thermodynamics, metallurgy, and functional group chemistry.
2. **Analytical Skills**
   To enable students to derive, manipulate, and apply theoretical expressions for chemical kinetics, thermodynamic systems, and reaction mechanisms.
3. **Practical Applications**
   To familiarize students with real-world applications such as radioisotope usage, metallurgy processes, and synthetic strategies in organic chemistry.
4. **Critical Thinking**
   To cultivate the ability to critically assess and analyze chemical phenomena, experimental methods, and industrial applications for informed decision-making.

Course Learning Outcomes (CLOs)

1. **Understanding Core Concepts**
   - Grasp fundamental principles of chemical kinetics, thermodynamics, nuclear chemistry and organic reactions.
2. **Analytical Skills**
   - Derive and apply equations related to reaction rates, thermodynamic processes, and nuclear decay.
3. **Practical Applications**
   - Utilize theoretical knowledge in real-world scenarios like metallurgy, radioisotope applications, and organic synthesis.
4. **Critical Thinking**
   - Evaluate chemical phenomena and experimental methods to make informed decisions.

Programme Outcomes (POs) for B.Sc. Programmes

The general Programme Outcomes for B.Sc. programmes with Chemistry at Jyoti Nivas College include:

1. **Core Competency**: Develop a strong foundation in the respective disciplines, enabling students to pursue higher education and research.
2. **Critical Thinking**: Enhance analytical and problem-solving skills to address scientific queries effectively.
3. **Analytical Reasoning**: Apply logical reasoning and quantitative analysis in scientific investigations.
4. **Research Skills**: Acquire the ability to design experiments, collect and interpret data, and present findings.
5. **Team Work**: Foster collaborative skills to work effectively in diverse teams.

These outcomes are designed to prepare students for advanced studies, research, and professional careers in science and related fields.

Based on the provided course objectives and learning outcomes, and aligning them with the Programme Outcomes (POs) of the B.Sc. programmes at Jyoti Nivas College Autonomous, Bangalore, here is a mapping for the B.Sc. CBZ (Chemistry, Botany, Zoology), BCZ (Biotechnology, Chemistry, Zoology), BCB (Biotechnology, Chemistry, Botany), BCG (Biotechnology, Chemistry and Genetics) and PCM (Physics, Chemistry, Mathematics) streams.

Mapping of Course Learning Outcomes (CLOs) with Programme Outcomes (POs)

Course Learning Outcomes (CLOs)	PO1	PO2	PO3	PO4	PO5
1. Understanding Core Concepts - Grasp fundamental principles of chemical kinetics, thermodynamics, nuclear chemistry, and organic reactions.	✓				
2. Analytical Skills - Derive and apply equations related to reaction rates, thermodynamic processes, and nuclear decay.		✓	✓		
3. Practical Applications - Utilize theoretical knowledge in real-world scenarios like metallurgy, radioisotope applications, and organic synthesis.	✓		✓	✓	✓
4. Critical Thinking - Evaluate chemical phenomena and experimental methods to make informed decisions.		✓	✓	✓	✓

This mapping ensures that the course content not only imparts essential knowledge but also aligns with the broader educational goals of the B.Sc. programmes at Jyoti Nivas College. It prepares students for higher studies, research, and professional careers in science and related fields.

Syllabus

UNIT – I — 14 Hours

Chapter 1: Chemical Kinetics — 8 hours

Review: Rate, Order and Molecularity. First-order reactions, half-life period

1.1 Second-order reactions: definition with examples. Derivation of expression for the rate constant of a second-order reaction with a = b and a ≠ b. Derivation of the expression for half-life of a second-order reaction with a = b. The mean life period of a reaction -definition, expression for

mean life period of a II order reaction (a=b). Problems on rate constant (a=b).

1.2 Determination of order of reaction: differential method, method of integration, method of half-life period and isolation method.

1.3 Theories of reaction rates: Arrhenius Theory – Arrhenius Equation, concept of activation energy, threshold energy definitions with energy profile diagram. Effect of temperature on rate of reaction – temperature coefficient and probability distribution curve of effective molecules with rise in temperature of 10^{o}C; Problems on Arrhenius equation in calculating energy of activation and rate constants. Collision theory - The collision theory of bimolecular gaseous reactions. Simple collisions theory based on hard sphere model, ACT - Activated complex theory of bimolecular reactions transition state theory (equilibrium hypothesis). Expression for the rate constant based on equilibrium constant and thermodynamic aspects. Limitations of collision theory. Steady state approximation statement and Lindemann's theory of unimolecular reactions hypothesis- postulates. Explanation of the hypothesis using concentration dependence in deciding the order of a reaction.

1.4 Experimental determination of kinetics: (i) inversion of cane sugar by polarimetric method (ii) spectrophotometric method for the reaction between potassium per sulphate and potassium iodide.

Chapter 2: Nuclear and Radiochemistry **6 hours**

Review: Property of radioactivity, types of radiations and their properties, atomic number and mass number, isotopes and isobars. Nucleus – nucleons.

2.1 Nuclear force: Definition, density, stability - explanation using meson theory, n/p ratio, n versus p graph. Mass defect; Binding energy - definition, graph, calculation of binding energy to show that 1 amu =931 MeV. Explanation of the instability of the nuclei. Problems.

2.2 Radioactive decay law: derivation of $N=N_0\, e^{-\lambda t}$, half-life period of a radioisotope, relationship between half-life and decay constant, numerical problems. Radioactive equilibrium - explanation, introduction of the terms parent and daughter elements. Group displacement law - statement and explanation taking examples; radioactive series - U, Th, Ac and Np series (mention of the first and last stable elements, number of α and β particles. Type of series namely 4n, (4n+1), (4n+2) and (4n+3).

2.3 Artificial radioactivity: Rutherford's first artificial transmutation, induced radioactivity; nuclear reactions – differences between chemical and nuclear reactions; reason for the large amount of Q value; symbolic representation of a nuclear reaction, introduction of the term projectile, comparison of neutron, proton, α, γ and deuteron as projectiles. Examples of nuclear reaction induced by γ-radiation, α, n, p and deuteron.

2.4 Self-Study: Applications of radio isotopes: Use of radio isotopes in tracer technique - agriculture (phosphorous in agriculture research), medicine (phosphorous to check crack in bones, sodium/ iodine to detect clots in blood vessels), food preservation. Carbon dating - formation of radioactive carbon in the atmosphere. Explanation of the determination of age of wood or peat or fossil. Numerical problems on carbon dating.

UNIT – II **14 Hours**

Chapter 3 Thermodynamics -I **8 hours**

Review: State functions and path functions, exact and inexact differentials, I law of Thermodynamics – statement.

3.1First Law of Thermodynamics: Mathematical expression with explanation of the terms:

Derivation of expressions for work done in isothermal and adiabatic expansion and compression of an ideal gas (IUPAC sign conventions to be used). Numerical problems. Heat capacity of a gas at

constant pressure and constant volume, derivation of the relationship between C_p and C_v. Relation between P, V and T in an adiabatic process to be derived. Derivation of Kirchhoff's equation. Numerical problems on Kirchhoff's equation, C_p and C_v.

3.2 Second Law of Thermodynamics: Spontaneous and non-spontaneous processes: definitions with suitable examples. Second law of thermodynamics: Limitations of First law of thermodynamics with illustrations. Need for Second law of thermodynamics, different ways of stating Second law with respect to heat and spontaneity. Other forms of Second law of thermodynamics. Concept of entropy and its physical significance- illustrations with order, disorder, physical and chemical processes and probability.

Review: Heat engine-Carnot's cycle and derivation of the expression for its efficiency based on entropy concept.

Second law in terms of efficiency (η). Change in entropy in reversible and irreversible processes (derivations required). Calculation of entropy changes in reversible isothermal and reversible adiabatic processes. Limitations of the entropy concept of spontaneity.

Chapter 4: Thermodynamics –II **6 hours**

4.1 Gibb's free energy: Work function, Chemical potential definitions, and physical significance. Relationship between free energy and work function. Criteria for equilibrium, spontaneous and non-spontaneous processes based on free energy. Derivation of Gibb's-Helmholtz equation. Change of free energy with respect to temperature and pressure. Mention of temperature coefficient.

$\Delta G_o = -RT \ln K_p$ Problems. Derivation of van't Hoff isotherm, van't Hoff reaction isochore and Clausius-Clapeyron equation. The applications of Clausius-Clapeyron equation to ΔT_b and ΔT_f determination (thermodynamic derivation not required).

4.2 Third Law of Thermodynamics: Qualitative treatment of Nernst heat theorem. Statements of third and zeroth law of thermodynamics. Elementary concept of residual entropy.

UNIT – III 14 Hours

Chapter 5: Metallurgy **5 hours**

5.1 Principles Ellingham's diagrams - principle, salient features, Curves corresponding to formation of CO, CO_2 and oxides of Cr, Al, Mg, Ca, Hg and Ag. Applications with reference to selection of reducing agents using Carbon for ZnO and Al for Cr_2O_3.

5.2 Applications Extraction of the following metals: (i) Nickel from pentlandite ore (ii) Thorium from monazite sand (iii) Uranium from pitch blende (iv) Plutonium from nuclear waste.

Chapter 6: Powder Metallurgy **2 hours**

Advantages of powder metallurgy- and its applications. Methods of production of metal powders: Production of tungsten powder from wolframite.

Chapter 7: Steel **5 hours**

7.1 Alloy steels: Influence of Si, Mn, Cr, Ni, Ti and W on the properties of steel and their applications. Ferro alloys: production of ferro chrome, ferro manganese and ferro silicon: diagram, equation and manufacture. Applications of alloy steels. Grades of steel.

7.2 Carbon steel: Classification based on carbon content. Heat treatment of steels: hardening, case hardening, carbiding, nitriding, tempering and annealing - definition with applications of each type.

Chapter 8: Non-aqueous solvents **2 hours**

Introduction Classification of Solvents Physical Properties of Solvents and their Role in Chemical Reactions: Acid-Base Behaviour in Non-Aqueous Solvents Examples Liquid Ammonia Liquid Sulfur Dioxide.

UNIT – IV 14 Hours

Chapter 9: Alcohols and thiols **7 hours**

9.1 Alcohols: Introduction and classification: monohydric, dihydric and trihydric alcohols with an example each. 1°, 2° and 3° alcohols with an example each. Methods of preparation: (i) from carbonyl compounds –by the reduction of aldehydes and ketones (by Meerwin-Pondorff-Verley reaction) (ii) from acids and esters (by reduction with $LiAlH_4$) (iii) hydroboration-oxidation of alkenes and (iv) hydration of alkenes. Reactions of alcohols: acidic nature-reaction with sodium, esterification, oxidation of alcohols with $KMnO_4$. Comparison of the 1°, 2° and 3° alcohols - Lucas test, reactivity and oxidation with $K_2Cr_2O_7$ with equations.

9.2 Glycols: Preparation from alkenes using OsO_4, $KMnO_4$ and epoxides. Oxidation of glycols by periodic acid and lead tetraacetate with mechanisms. Pinacol-pinacolone re-arrangement.
Glycerol: Preparation from propene and oils/fats. Reactions of glycerol (i) nitration, (ii) action of concentrated H_2SO_4, and (iii) oxidation by periodic acid. Uses of glycerol.

9.3 Thiols: Nomenclature. Methods of preparation (Ex: methanethiol). Chemical reactions of methanethiol with (i) sodium, (ii) NaOH, (iii) metal oxides, (iv) formation of thioesters and (v) oxidation with mild oxidising agent (H_2O_2) and strong oxidising agent (HNO_3 or HIO_4). Uses of dithanes. Introduction of umpolung character (reversal of polarity) in carbonyl compounds, taking 1,3-dithane as an example.

Chapter 10 Phenols **4 hours**

Classification. Acidic nature - Comparison of acidic strength of phenol with alcohols and monocarboxylic acids. Aphoteric nature. Effect of electron-withdrawing group ($-NO_2$) and electron donating group ($-CH_3$) on the acidity of phenols at o-,m-,p- positions. Pechmann reaction. Mechanisms of Reimer-Tiemann and Kolbe-Schmidt reactions. Industrial applications of phenols: Conversion of phenol to (i) aspirin (ii) methyl salicylate (iii) salol (iv) salicyl salicylic acid - reactions with conditions.

Chapter 11 Ethers and Epoxides **3 hours**

Ethers: Methods of preparation - (i) dehydration of alcohols (ii) Williamson's ether synthesis with diethyl ether as an example. Reactions - Ethers as Lewis bases (complexation with metal ions), cleavage and auto-oxidation. Zeisel's method. Epoxides: Definition, Preparation using per acids, Darzen's reaction. Reactions of mono and 1,2-disubstituted epoxides with (i) carbon nucleophiles (Ex: CH_3MgI) (ii) nitrogen nucleophiles (Ex: NH_3) (iii) reduction with $LiAlH_4$.

Recommended Books

1. Puri B.R., Sharma L.R. and Pathania M.S., Principles of Physical Chemistry, 46 th Edition, Vishal Publishing Co. 2013.
2. Bahl B.S., Bahl A., Tuli G.D., Essentials of Physical Chemistry, S. Chand Publ., 2008.3.
3. Atkins P.W. and DePaula J., Physical Chemistry, 7 th Edition, Oxford University Press, 2008.
4. Laidler K J, Chemical Kinetics, 2023, 3rd Edition, Pearson Publication
5. Gurdeep Raj., Chemical Kinetics, GOEL Publishing House,2002.
6. Madan R.D., Sathyaprakash's Modern Inorganic Chemistry, 3 rd Edition, S. Chand Publishing Co., 1987
7. Puri B.R., Sharma L.R. and Pathania M.S., Principles of Inorganic Chemistry, 40th Edition, Vishal Publishing Co. 2013
8. Atkins P.W. and Shriver, Inorganic Chemistry, Oxford University Press, 2012.
9. Morrison R.T., Boyd R.N. and Bhattacharjee S.K., Organic Chemistry, 7 th Edition, Pearson Publication., 2011.
10. Solomon G. And Fryhle C.B., Organic Chemistry, 10 th Edition., Wiley Publication, 2014
11. Finar I.L., Organic Chemistry – Volume 1., Pearson Publishing Co., 2013

12. Finar I.L., Organic Chemistry – Volume 2., Pearson Publishing Co., 2013
13. Clayden J, Greeves N, Organic Chemistry, 2014, Oxford Publication.
14. Sanyal S.N., Reactions, Rearrangements and Reagents, Harati Bhawan Publishers and distributors, 2013.
15. Norman R.O.C and Coxon J.M, Principles of Organic Synthesis, 3rd Edition, CPP Publishers, 2017.

Blueprint

The question paper consists of three parts:

- Part A: Two-mark questions, there will be nine questions of which the student answers any five.
- Part B: Ten-mark questions, there shall be nine questions of which the student answers any six questions, each ten-mark question can be divided as 5 + 5, 6 + 4 or 7+ 3.
- Part C: Ten-mark question which is compulsory and thought provoking. can be divided further as 2 + 2 + 2 + 2 + 2 or any suitable division.

Sl. No.	Chapter Name	No. of Hours	Marks	No of questions		
				Part A	Part B	Part C
1	Chemical Kinetics	8	17	1	1.5	
2	Nuclear and Radiochemistry	6	12	1	1	
3	Thermodynamics I	8	17	1	1.5	
4	Thermodynamics II	6	12	1	1	
5	Metallurgy	5	10		1	
6	Powder Metallurgy	2	6	1		1
7	Steel	5	10		1	
8	Non-Aqueous Solvents	2	6	1		2
9	Alcohols and Thiols	7	14		1	2
10	Phenols	4	8	1	1	
11	Ethers and Epoxides	3	6	2		
Total		**56**	**118**	**9**	**9**	**5**

Jyoti Nivas College Autonomous
Bangalore 560095
III Semester B.Sc.
Chemistry Paper–III
Integrated Principles of Chemistry I Practical

COURSE TITLE	**Integrated Principles of Chemistry I Practical**
COURSE CODE	**24IIICH3P**
COURSE CREDITS	**2**
TOTAL CONTACT HOURS	**48 HOURS (3 hours per week)**
DURATION OF ESA	**3 HOURS**
FORMATIVE ASSESSMENT MARKS	**10 MARKS**
SUMMATIVE ASSESSMENT MARKS	**40 MARKS**

Course Objectives

1. **To develop practical skills in purification techniques** for organic compounds, including solids and liquids, and the determination of their physical constants such as melting and boiling points.
2. **To provide hands-on experience in organic synthesis**, including both single-stage and multi-stage preparations, and to enable preliminary analysis of organic compounds through qualitative testing.

Course Learning Outcomes

1. **Students will be able to perform purification procedures** for organic solids and liquids and accurately assess their purity using physical constant determination methods.
2. **Students will be able to synthesize and analyze organic compounds**, demonstrating proficiency in one-stage and two-stage organic preparations and identifying functional groups through systematic organic analysis.

Experiments:

1. Purification of organic solids and checking the purity by melting point — 1 Unit
2. Purification of organic liquids and determination of boiling point — 1 Unit
3. One stage preparations — 3 Units
   a) Preparation of aspirin
   b) Preparation of m- dinitrobenzene
   c) Preparation of benzoic acid from toluene
4. Two stage preparation — 2 Units
   a) Preparation of m-nitrobenzoic acid from methylbenzoate
   b)Preparation of methyl orange
5. Preliminary Organic Analysis — 5 Units
   a) Test for aliphatic and aromatic compounds
   b) Test for saturation and unsaturation

c) Detection of N, S and Halogens

d) Determination of physical constant

Repetition and Tests 2 Units

Recommended Books

1. P.K.Mani,A.O.Thomas, Text Bookof Practical Chemistry, 4thedition, 1976, Scientific Publications.
2. A.I.Vogel, Text Book of Practical Organic Chemistry 1998.
3. Arun Sethi, Practical Organic Chemistry 1999.

Jyoti Nivas College Autonomous

Bangalore 560095

III Semester B.Sc

Chemistry Paper – III Practical

Integrated Principles of Chemistry I

Scheme of Valuation

The practical paper is for a total of 50 marks of which ten marks is for internal assessment and forty marks is for the end-semester practical examination.

Part I: Continuous Internal Assessment (CIA)

The student will be assessed with viva on experiments. there will be a set of five viva of which the average marks are taken. The record of the student is also assessed a minimum of five times and the average marks is taken as the record component

Category	Marks
Viva Voce	5
Practical Record	5
Total	**10**

Part II: End-semester Practical Examination:

The examination will be for three hours duration and the student will be assigned a single step preparation along with one compound for preliminary analysis. A viva voce will be conducted on the experiments performed over the semester.

The distribution of marks is as follows:

<table>
<tr><th>Category</th><th>Marks</th></tr>
<tr><td>Aim, principle and procedure for single step preparation</td><td>5</td></tr>
<tr><td>Writing correct equation for the reaction</td><td>2</td></tr>
<tr><td>Calculation of theoretical yield</td><td>3</td></tr>
<tr><td>Presentation of crude sample</td><td>2</td></tr>
<tr><td>Presentation of recrystallised sample</td><td>3</td></tr>
<tr><td>Preliminary Tests</td><td>2</td></tr>
<tr><td>Determination of physical constant</td><td>5
<table>
<tr><td>Error</td><td>3^{o}C</td><td>5^{o}C</td><td>7^{o}C</td><td>Any other value</td></tr>
<tr><td>Marks</td><td>5</td><td>4</td><td>3</td><td>2</td></tr>
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<tr><td>Preparation of sodium fusion extract</td><td>5
<table>
<tr><th>Category</th><th>Marks</th></tr>
<tr><td>Writing the correct paragraph for preparation</td><td>2</td></tr>
<tr><td>Preparing the extract</td><td>3</td></tr>
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<tr><td>Elemental Analysis (Marks to be allotted for showing presence and absence of all three hetero-elements)</td><td>3
<table>
<tr><th>Test</th><th>Marks</th></tr>
<tr><td>N</td><td>1</td></tr>
<tr><td>S</td><td>1</td></tr>
<tr><td>X</td><td>1</td></tr>
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<tr><td>Viva Voce</td><td>5</td></tr>
<tr><td>Total</td><td>40</td></tr>
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