

**Syllabus for  
Bachelor of Science in Chemistry (Honours)  
Under Choice Based Credit System**

**Academic Session:  
w.e.f. 2020-2023**



*for*  
***All Constituent/Affiliated Colleges Under***  
**Binod Bihari Mahto Koyalanchal University,**  
**Dhanbad**

**Members of Board of Studies for Bachelor of Science in Chemistry (Honours) Under Choice Based Credit System as per Guidelines of the Binod Bihari Mahto Koyalanchal University, Dhanbad, Jharkhand.**

|    |   |                               |                           |
|----|---|-------------------------------|---------------------------|
| 1. | <b>Dr. B. Kumar</b><br>Associate Professor<br>Dean, Faculty of Science & Head,<br>University Department of Chemistry,<br>BBMKU, Dhanbad | <b>Chairman</b>               | B. Kumar<br>21-09-2020    |
| 2. | <b>Dr. Sanjoy Mishra</b><br>Professor<br>University Department of Chemistry<br>Ranchi University, Ranchi                                | <b>External Expert Member</b> |                           |
| 3. | <b>Dr. L. P. Mishra</b><br>Associate Professor<br>University Department of Chemistry<br>VBU, Hazaribag                                  | <b>External Expert Member</b> |                           |
| 4. | <b>Dr. Leelawati Kumari</b><br>Assistant Professor<br>University Department of Chemistry,<br>BBMKU, Dhanbad                             | <b>Internal Members</b>       | Kumari<br>21.09.2020      |
| 5. | <b>Sri R. P. Singh</b><br>Assistant Professor<br>University Department of Chemistry,<br>BBMKU, Dhanbad                                  | <b>Internal Members</b>       | R. P. Singh<br>21/09/2020 |
| 6. | <b>Dr. Dharmendra Kumar Singh</b><br>Assistant Professor<br>University Department of Chemistry,<br>BBMKU, Dhanbad                       | <b>Internal Members</b>       | D. K. Singh<br>21.09.2020 |
| 7. | <b>Dr. Rajeev Pradhan</b><br>Assistant Professor<br>Department of Chemistry<br>P. K. Roy Memorial College, Dhanbad                      | <b>Internal Members</b>       | R. Pradhan<br>21/9/2020   |
| 8. | <b>Dr. P. K. Jha</b><br>Assistant Professor<br>Department of Chemistry<br>B. S. City College, Bokaro                                    | <b>Internal Members</b>       | P. K. Jha<br>21/09/2020   |

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To

Dated 17/09/2020

The Registrar,  
BBMK University,  
Dhanbad

Ref: BBMKU/CCDC/R/724/2020 Dated 14/08/2020 received on Whatsapp on  
04/09/2020

Subject: Board of Studies for UG/ syllabus (Chemistry)

Sir,

Thanks for nominating me in the Board of Studies for assessment of syllabus of  
UG/GEN Choice based Credit System.

I have gone through the syllabus for Bachelor of Science (Chemistry Honours/  
Generic/ General) provided to me on my mail and have found the syllabus  
appropriate for the UG courses in Chemistry.

I recommend the implementation of this syllabus.

Regards

Yours sincerely

*S. Misra*  
17/9/20  
(Sanjoy Misra)



# JAGANNATH JAIN COLLEGE

(A CONSTITUENT UNIT OF VINOBA BHAVE UNIVERSITY)

NAAC Accredited 'B'

Estd. 1980

JHUMRI TELAIYA - 825402, DIST. - KODERMA (JHARKHAND) PIN - (06504) 223540 (X) 224871 (M)

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OFFICE OF THE PRINCIPAL

Ref. No. J.J.C./

Date

To,

Dated 21.09.2020

The Registrar,

B.B.M.K. UNIVERSITY

DHANBAD

REF. - BBM/KU/CCDC/R/724/2020, Dated 14/08/2020 received on Whatsapp

Sub :- Board of studies for UG/Gen syllabus ( Chemistry)

Sir,

Thanks for nominating me in the board of studies for assessment of syllabus of UG/Gen, Choice Based Credit System.

I have gone through the syllabus for B.Sc. ( Chemistry Hons / Generic /General ) provided to me on my mail and have found the syllabus appropriate for the UG courses in Chemistry.

I recommend the implementation of this syllabus.

With regards,

Yours sincerely,

  
(Lalan Pd. Mishra)

Principal

J.J. College, Jhumri Telaiya

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| 1.    | <b>Semester - I</b>  |               |
|       | I. Ability Enhancement Compulsory Course<br>Language (English/Hindi/NH+MB)                                 | 01            |
|       | II. Inorganic Chemistry-I  | 02-04         |
|       | III. Physical Chemistry  | 05-06         |
|       | IV. Chemistry Lab (Practical)  | 07-08         |
|       | V. Generic Elective-01   | 09            |
| 2.    | <b>Semester - II</b>   |               |
|       | I. Ability Enhancement Compulsory Course<br>Environmental Science  | 10            |
|       | II. Organic Chemistry –I   | 11-13         |
|       | III. Physical Chemistry-II   | 14-15         |
|       | IV. Chemistry Lab  | 16-17         |
|       | V. Generic Elective-02   | 18            |
| 3.    | <b>Semester - III</b>  |               |
|       | I. Inorganic Chemistry-II  | 19-20         |
|       | II. Organic Chemistry-II   | 21-22         |
|       | III. Physical Chemistry –III   | 23-24         |
|       | IV. Chemistry Lab  | 25-27         |
|       | V. Skill Enhancement Course (SEC-01)   | 28            |
|       | VI. Generic Elective-03  | 29            |
| 4.    | <b>Semester - IV</b>   |               |
|       | I. Inorganic Chemistry –III,   | 30-31         |
|       | II. Organic Chemistry –III   | 32-33         |
|       | III. Physical Chemistry-IV   | 34-35         |
|       | IV. Chemistry Lab  | 36-38         |
|       | V. Skill Enhancement Course (SEC-02)   | 39            |
|       | VI. Generic Elective -04   | 40            |
| 5.    | <b>Semester - V</b>  |               |
|       | I. Organic Chemistry –IV   | 41-42         |
|       | II. Physical Chemistry-V   | 43-45         |
|       | III. Chemistry Lab   | 46-47         |
|       | <b>IV: Discipline Specific Elective (DSE-01):</b>  |               |
|       | A1. Analytical Methods in Chemistry (DSE-01A)  | 48-49         |

|    |   |       |
|----|---|-------|
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|    | B1. Applications of Computers in Chemistry (DSE-01B)                  | 52-53 |
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|    | C2. Practical – DSE Lab: Nanoscale Materials and Their Applications   | 57    |
|    | <b>V: Discipline Specific Elective (DSE-02):</b>                      |       |
|    | A1. Instrumental Methods of Chemical Analysis (DSE-02A)               | 58-59 |
|    | A2. Practicals –DSE Lab: Instrumental Methods of Chemical Analysis    | 60-61 |
|    | B1. Polymer Chemistry (DSE-02B)                                       | 62-63 |
|    | B2. Practical – DSE Lab: Polymer Chemistry                            | 64-65 |
|    | C1. Inorganic Materials of Industrial Importance (DSE-02C)            | 66-67 |
|    | C2. Practical – DSE Lab: Inorganic Materials of Industrial Importance | 68    |
| 6. | <b>Semester - VI</b>  |       |
|    | I. Inorganic Chemistry –IV  | 69-70 |
|    | II. Organic Chemistry-V   | 71-73 |
|    | III. Chemistry Lab  | 74-75 |
|    | <b>IV: Discipline Specific Elective (DSE-03):</b>                     |       |
|    | A1. Green Chemistry (DSE-03A)   | 76-77 |
|    | A2. Practicals –DSE Lab: Green Chemistry                              | 78-79 |
|    | B1. Molecular Modelling and Drug Design (DSE-03B)                     | 80-81 |
|    | B2. Practical – DSE Lab: Molecular Modelling and Drug Design          | 82    |
|    | <b>V: Discipline Specific Elective (DSE-04):</b>                      |       |
|    | A1. Industrial Chemical and Environment (DSE-04A)                     | 83-84 |
|    | A2. Practical – DSE Lab: Industrial Chemical and Environment          | 85    |
|    | B1. Novel Inorganic Solids (DSE-04B)                                  | 86-87 |
|    | B2. Practical – DSE Lab: Novel Inorganic Solids                       | 88    |
|    | C1. Research Methodology for Chemistry                                | 89-90 |
|    |   |       |

## **Course Structure (Chemistry-Major)**

### **Details of courses under B.Sc. (Honours)**

**TABLE-01**

| <b>Course</b>   | <b>Credits</b>            |                          |
|---|---------------------------|--------------------------|
|   | <b>Theory + Practical</b> | <b>Theory + Tutorial</b> |
| <b>I. Core Course</b>   |                           |                          |
| i. Core Course Theory<br>(14 Papers)  | <b>14 × 4 = 56</b>        | <b>14 × 5 = 70</b>       |
| ii. Core Course Practical / Tutorial*<br>(14 Papers)  | <b>14 × 2 = 28</b>        | <b>14 × 1 = 14</b>       |
| <b>II. Elective Course (8 Papers)</b>   |                           |                          |
| A.I. Discipline Specific Elective<br>( Theory: 4 Paper)   | <b>4 × 4 = 16</b>         | <b>4 × 5 = 20</b>        |
| A.II. Discipline Specific Elective<br>(Practical/Tutorial* : 4 Papers)  | <b>4 × 2 = 08</b>         | <b>4 × 1 = 04</b>        |
| B.I Generic Elective/ Interdisciplinary<br>(Theory: 4 Papers)   | <b>4 × 4 = 16</b>         | <b>4 × 5 = 20</b>        |
| B.II Generic Elective<br>(Practical/ Tutorial* : 4 Papers)  | <b>4 × 2 = 08</b>         | <b>4 × 1 = 04</b>        |
| <b>III. Ability Enhancement Courses</b>   |                           |                          |
| 1. Ability Enhancement Compulsory<br>(2 Papers of 2 credit each)<br>Environmental Science<br>English/MIL Communication                      | <b>2 × 2 = 04</b>         | <b>2 × 2 = 04</b>        |
| 2. <b>Ability Enhancement Elective</b><br>Skill Enhancement Course of the Core<br>Course opted (SEC 1& SEC 2=2 Papers<br>of 2 credits each) | <b>2 × 2 = 04</b>         | <b>2 × 2 = 04</b>        |
| <b>Total Credits</b>  | <b>140</b>                | <b>140</b>               |

\* Wherever there is a practical there will be no tutorial and vice-versa

**PROPOSED SCHEME FOR CHOICE BASED CREDIT SYSTEM IN**

**B.Sc Chemistry Honours**

**TABLE - 02**

| SE<br>M. | CORE COURSE<br>(14)   | Ability<br>Enhancement<br>Compulsory<br>Course<br>(AECC) (2) | Ability<br>Enhancement<br>Elective<br>Course<br>(AEEC) (2)<br>(Skill Based) | Elective:<br>Discipline<br>Specific<br>DSE<br>(4) | Generic<br>(GE) (4) |
|----------|---|--|---|---|---------------------|
| I        | Inorganic Chemistry- I<br>Physical Chemistry –I                             | Language<br>(English/Hindi)                                  |   |   | GE-1<br>(TABLE-03)  |
| II       | Organic Chemistry-I<br>Physical Chemistry –II                               | Environmental<br>Science                                     |   |   | GE-2                |
| III      | Inorganic Chemistry- II<br>Organic Chemistry-II<br>Physical Chemistry –III  |  | SEC-I<br>ANNEXTURE - 01   |   | GE-3                |
| IV       | Inorganic Chemistry- III<br>Organic Chemistry-III<br>Physical Chemistry –IV |  | SEC-2<br>ANNEXTURE - 01   |   | GE-4                |
| V        | Organic Chemistry-IV<br>Physical Chemistry –V                               |  |   | DSE-1<br>DSE-2                                    |                     |
| VI       | Inorganic Chemistry- IV<br>Organic Chemistry-V                              |  |   | DSE-3<br>DSE-4                                    |                     |

The following subjects, depending upon the requirement of the core subject, may be chosen as the Generic Elective.

**TABLE - 03**

| Sl. No. | Honours<br>Programme<br>(Core Subject) | Generic Elective (GE): Any <u>ONE</u> subject to be chosen                  |
|---------|--|---|
| 1.      | Physics                                | Mathematics, Chemistry, Geology, Statistics                                 |
| 2.      | Chemistry                              | Mathematics, Physics, Geology, Statistics,<br>Botany, Zoology, Anthropology |
| 3.      | Geology                                | Mathematics, Chemistry, Botany, Zoology,<br>Physics, Anthropology           |
| 4.      | Mathematics                            | Chemistry, Geology, Physics, Anthropology                                   |
| 5.      | Botany                                 | Chemistry, Geology, Zoology, Anthropology                                   |
| 6.      | Zoology                                | Chemistry, Geology, Botany, Anthropology                                    |
| 7.      | Statistics                             | Mathematics, Physics, Geology, Statistics,<br>Botany, Zoology, Anthropology |



## **Skill Enhancement Courses (Common for All Programmes)**

### **For Honours Degree**

#### **ANNEXTURE-01**

**I. Third Semester:** Compulsory for All Disciplines

**Any one of the following three in a particular college depending upon the facility available:**

1. Constitution of India and Human Rights
2. Environment and Public Health
3. Computer Applications and Information Technology

**II. Fourth semester:**

One from the following may be chosen may be common for a faculty. The courses may include the following:

1. Entrepreneurship
2. Life Skills and Personality Development
3. Human Resource Development
4. Legal Aid and Awareness
5. Indian History, Culture and Diversity
6. Science and Life
7. Banking and Finance
8. Building Mathematical Ability
9. Capital and Stock Market
10. Any other subject to be decided by the Academic Council.

**SEMESTERWISE COURSE OPTED, COURSE NAME, CODE AND  
DISTRIBUTION OF CREDITS OF B.SC. CHEMISTRY HONOURS**

**TABLE - 04**

| SEM | COURSE OPTED                             | COURSE NAME   | CODE             | Credits |
|-----|--|---|------------------|---------|
| I   | Ability Enhancement Compulsory Course-I  | Language (English/Hindi)<br>Language<br>(English/Hindi/NH+MB) | CHE-H-AECC-101-T | 2       |
|     | Core Course-I                            | Inorganic Chemistry-I   | CHE-H-C-101-T    | 4       |
|     | Core Course-I Practical                  | Inorganic Chemistry-I Lab                                     | CHE-H-C-101-P    | 2       |
|     | Core Course-II                           | Physical Chemistry-I  | CHE-H-C-102-T    | 4       |
|     | Core Course-II Practical                 | Physical Chemistry-I Lab                                      | CHE-H-C-102-P    | 2       |
|     | Generic Elective -1                      | GE-1  | XYZ-H-GE-101-T   | 4/5     |
|     | Generic Elective -1 Practical/Tutorial   |   | XYZ-H-GE-101-P   | 2/1     |
| II  | Ability Enhancement Compulsory Course-II | Environmental Science   | CHE-H-AECC-202-T | 2       |
|     | Core Course-III                          | Organic Chemistry-I   | CHE-H-C-203-T    | 4       |
|     | Core Course-III Practical/Tutorial       | Organic Chemistry-I Lab                                       | CHE-H-C-203-P    | 2       |
|     | Core Course-IV                           | Physical Chemistry-II   | CHE-H-C-204-T    | 4       |
|     | Core Course-IV Practical/Tutorial        | Physical Chemistry-II Lab                                     | CHE-H-C-204-P    | 2       |
|     | Generic Elective -2                      | GE-02   | XYZ-H-GE-202-T   | 4/5     |
|     | Generic Elective -2 Practical/Tutorial   |   | XYZ-H-GE-202-P   | 2/1     |
| III | Core Course-V                            | Inorganic Chemistry-II  | CHE-H-C-305-T    | 4       |
|     | Core Course-V Practical/Tutorial         | Inorganic Chemistry-II Lab                                    | CHE-H-C-305-P    | 2       |
|     | Core Course-VI                           | Organic Chemistry-II  | CHE-H-C-306-T    | 4       |
|     | Core Course-VI Practical/Tutorial        | Organic Chemistry-II Lab                                      | CHE-H-C-306-P    | 2       |
|     | Core Course-VII                          | Physical Chemistry-III  | CHE-H-C-307-T    | 4       |
|     | Core Course-VII Practical/Tutorial       | Physical Chemistry-III Lab                                    | CHE-H-C-307-P    | 2       |
|     | Skill Enhancement Course -1              | SEC-01  | CHE-H-SEC-301-T  | 2       |
|     | Generic Elective -3                      | GE-03   | XYZ-H-GE-303-T   | 4/5     |
|     | Generic Elective -3 Practical/Tutorial   |   | XYZ-H-GE-303-P   | 2/1     |
| IV  | Core Course-VIII                         | Inorganic Chemistry-III                                       | CHE-H-C-408-T    | 4       |
|     | Course-VIII Practical/Tutorial           | Inorganic Chemistry-III Lab                                   | CHE-H-C-408-P    | 2       |
|     | Core Course-IX                           | Organic Chemistry-III   | CHE-H-C-409-T    | 4       |
|     | Course-IX Practical/Tutorial             | Organic Chemistry-III Lab                                     | CHE-H-C-409-P    | 2       |
|     | Core Course-X                            | Physical Chemistry-IV   | CHE-H-C-410-T    | 4       |
|     | Course-X Practical/Tutorial              | Physical Chemistry-IV Lab                                     | CHE-H-C-410-P    | 2       |
|     | Skill Enhancement Course -2              | SEC -02   | CHE-H-SEC-402-T  | 2       |
|     | Generic Elective -3                      | GE-04   | XYZ-H-GE-404-T   | 4/5     |
|     | Generic Elective -3 Practical/Tutorial   |   | XYZ-H-GE-404-P   | 2/1     |
|     | Core Course-XI                           | Organic Chemistry-IV  | CHE-H-C-511-T    | 4       |
|     | Core Course-XI Practical/Tutorial        | Organic Chemistry-IV Lab                                      | CHE-H-C-511-P    | 2       |
|     | Core Course-XII                          | Physical Chemistry-V  | CHE-H-C-512-T    | 4       |

|   |  |   |                    |   |
|---|--|---|--------------------|---|
| V   | Core Course-XII Practical/Tutorial   | Physical Chemistry-V Lab  | CHE-H-C-512-P      | 2 |
|   | Discipline Specific Elective(DSE) -01<br>(Choice to choose any one paper)  | <b>DSE-1A:</b> Analytical Methods in Chemistry  | CHE-H-DSE-501 A –T | 4 |
|   |  | <b>DSE-1B:</b> Application of Computers in Chemistry  | CHE-H-DSE-501 B –T |   |
|   |  | <b>DSE-1C:</b> Nanoscale Materials and Their Applications                                   | CHE-H-DSE-501 C –T |   |
|   | Discipline Specific Elective (DSE)-01<br>Practical/Tutorial (Any one subject) according to theory paper chosen.  | <b>DSE-1A Lab:</b> Chemistry Practicals DSE LAB: Analytical Methods in Chemistry            | CHE-H-DSE-501 A –P | 2 |
|   |  | <b>DSE-1B Lab:</b> Chemistry Practicals DSE LAB: Application of Computers in Chemistry      | CHE-H-DSE-501 B –P |   |
|   |  | <b>DSE-1C Lab:</b> Chemistry Practicals-DSE LAB: Nanoscale Materials and Their Applications | CHE-H-DSE-501 C –P |   |
|   | Discipline Specific Elective(DSE)-02<br>Theory<br>(Choice to Choose any one paper)                               | <b>DSE-2A:</b> Instrumental Methods of Chemical Analysis                                    | CHE-H-DSE-502 A –T | 4 |
|   |  | <b>DSE-2B:</b> Polymer Chemistry  | CHE-H-DSE-502 B –T |   |
|   |  | <b>DSE-2C:</b> Inorganic Materials of Industrial Importance                                 | CHE-H-DSE-502 C –T |   |
|   | Discipline Specific Elective (DSE)-0 2<br>Practical/Tutorial<br>(Any one paper according to theory paper chosen) | <b>DSE-2A:</b> - Chemistry Practicals-DSE LAB: Instrumental Methods of Chemical Analysis    | CHE-H-DSE-502 A –P | 2 |
| <b>DSE-2B:</b> Chemistry Practicals DSE LAB: Polymer Chemistry                            |  | CHE-H-DSE-502 B –P  |                    |   |
| <b>DSE-2C:</b> Chemistry Practicals DSE LAB: Inorganic Materials of Industrial Importance |  | CHE-H-DSE-502 C –P  |                    |   |
| VI  | Core Course-XIII   | Inorganic Chemistry-IV  | CHE-H-C-613-T      | 4 |
|   | Core Course-XIII Practical/Tutorial  | Inorganic Chemistry-IV Lab  | CHE-H-C-613-P      | 2 |
|   | Core Course-XIV  | Organic Chemistry-V   | CHE-H-C-614-T      | 4 |
|   | Core Course-XIV Practical/Tutorial   | Organic Chemistry-V Lab   | CHE-H-C-614-P      | 2 |
|   | Discipline Specific Elective(DSE) -03<br>(Choice to Choose any one paper)  | <b>DSE-3A:</b> Green Chemistry  | CHE-H-DSE-603 A –T | 4 |
|   |  | <b>DSE-3B:</b> Molecular Modelling & Drug Design  | CHE-H-DSE-603 B –T |   |
|   | Discipline Specific Elective (DSE) -3<br>Practical/Tutorial<br>(Any one paper according to theory paper chosen)  | <b>DSE-3A Lab</b><br>Chemistry Practicals DSE LAB: Green Chemistry                          | CHE-H-DSE-603 A –P | 2 |
| <b>DSE-3B Lab</b><br>Chemistry Practicals DSE LAB: Molecular Modelling & Drug Design      |  | CHE-H-DSE-603 B –P  |                    |   |
| Discipline Specific Elective (DSE)-4  | <b>DSE-4A:</b><br>Industrial Chemical & Environment  | CHE-H-DSE-604 A –T  |                    |   |

|  |   |                    |            |
|--|---|--------------------|------------|
| Theory (Any one subject)   | <b>DSE-4B:</b><br>Novel Inorganic Solids  | CHE-H-DSE-604 B –T | <b>4/5</b> |
|  | <b>DSE-4C:</b><br>Research Methodology for chemistry                                  | CHE-H-DSE-604 C –T |            |
| Discipline Specific Elective(DSE) -4<br>Practical/Tutorial<br>Any one according to theory paper chosen | <b>DSE-4A Lab:</b><br>Chemistry Practicals -DSE:<br>Industrial Chemical & Environment | CHE-H-DSE-604 A –P | <b>2/1</b> |
|  | <b>DSE-4B Lab:</b><br>Chemistry Practicals -DSE:<br>Novel Inorganic Solids            | CHE-H-DSE-604 B –P |            |
|  | <b>DSC-4C:</b><br>Research Methodology for chemistry <b>Tutorial</b>                  |                    |            |

**Total Numbers of Papers and Marks semester wise for B.Sc Chemistry Hon.  
with Practical/ Without Practical**

**TABLE - 05**

| SEM.       | COURSE CODE   | FULL MARKS      | END SEMESTER MARKS | MID SEMESTER MARKS |
|------------|---|-----------------|--------------------|--------------------|
| <b>I</b>   | <b>CHE-H-AECC-101-T</b><br>Language (English/Hindi/NH+MB)<br>(02 Credits, 30 Lectures)  | 50              | 40                 | 10                 |
|            | <b>CHE-H-C-101-T</b><br>(04 Credits, 60 Lectures)   | 75              | 60                 | 15                 |
|            | <b>CHE-H-C-102-T</b><br>(04 Credits, 60 Lectures)   | 75              | 60                 | 15                 |
|            | <b>CHE-H-C-101 &amp; 102-P</b><br>(02+02=04 Credits, 60x2 Lectures)   | 50              | 40                 | 10                 |
|            | <b>XYZ-H-GE-101-T</b><br>(06 Credits, 60 Lectures & 15 Tutorials)<br>or<br><b>XYZ-H-GE-101-T</b><br>(04 Credits, 60 Lectures)<br><b>XYZ-H-GE-101-P</b><br>(02 Credits, 30 Lectures)<br>Choice to choose from other disciplines<br>(Table-3) | 100<br>75<br>25 | 80<br>60<br>20     | 20<br>15<br>05     |
|            | <b>TOTAL</b>  | <b>350</b>      | <b>280</b>         | <b>70</b>          |
|            |   |                 |                    |                    |
| <b>II</b>  | <b>CHE-H-AECC-202-T</b><br>Environmental Science<br>(02 Credits, 30 Lectures)   | 50              | 40                 | 10                 |
|            | <b>CHE-H-C-203-T</b><br>(04 Credits, 60 Lectures)   | 75              | 60                 | 15                 |
|            | <b>CHE-H-C-204-T</b><br>(04 Credits, 60 Lectures)   | 75              | 60                 | 15                 |
|            | <b>CHE-H-C-203 &amp; 204-P</b><br>(02+02=04 Credits, 60x2 Lectures)   | 50              | 40                 | 10                 |
|            | <b>XYZ-H-GE-202-T</b><br>(06 Credits, 60 Lectures & 15 Tutorials)<br>or<br><b>XYZ-H-GE-202-T</b><br>(04 Credits, 60 Lectures)<br><b>XYZ-H-GE-202-P</b><br>(02 Credits, 30 Lectures)<br>Choice to choose from other disciplines<br>(Table-3) | 100<br>75<br>25 | 80<br>60<br>20     | 20<br>15<br>05     |
|            | <b>TOTAL</b>  | <b>350</b>      | <b>280</b>         | <b>70</b>          |
|            |   |                 |                    |                    |
| <b>III</b> | <b>CHE-H-C-305-T</b><br>(04 Credits, 60 Lectures)   | 75              | 60                 | 15                 |
|            | <b>CHE-H-C-306-T</b><br>(04Credits, 60 Lectures)  | 75              | 60                 | 15                 |
|            | <b>CHE-H-C-307-T</b><br>(04 Credits, 60 Lectures)   | 75              | 60                 | 15                 |
|            | <b>CHE-H-C-305 &amp; 306 &amp; 307-P</b><br>(02+02+02=06 Credits, 60x3 Lectures)  | 75              | 60                 | 15                 |
|            | <b>CHE-H-SEC-301-T</b><br>(Annexure-1)<br>(02 Credits, 30 Lectures)   | 50              | 40                 | 10                 |
|            | <b>XYZ-H-GE-303-T</b>   | 100             | 80                 | 20                 |

|           |  |            |            |           |
|-----------|--|------------|------------|-----------|
|           | (06 Credits, 60 Lectures & 15 Tutorials)<br><b>Or</b><br><b>XYZ-H-GE-303-T</b><br>04 credits, 60 Lectures<br><b>XYZ-H-GE-303-P</b><br>(02 Credits, 30 Lectures)<br>Choice to choose from other disciplines<br>(Table-3)                          | 75         | 60         | 15        |
|           |  | 25         | 20         | 05        |
|           | <b>Total</b>   | <b>450</b> | <b>360</b> | <b>90</b> |
| <b>IV</b> | <b>CHE-H-C-408-T</b><br>(04 Credits, 60 Lectures)  | 75         | 60         | 15        |
|           | <b>CHE-H-C-409-T</b><br>(04 Credits, 60 Lectures)  | 75         | 60         | 15        |
|           | <b>CHE-H-C-410-T</b><br>(04 Credits, 60 Lectures)  | 75         | 60         | 15        |
|           | <b>CHE-H-C- 408 &amp; 409 &amp; 410-P</b><br>(02+02+02=06 Credits, 60x3 Lectures)  | 75         | 60         | 15        |
|           | <b>CHE-H-SEC-402-T</b><br>(Annexure-1)<br>(02 Credits, 30 Lectures)  | 50         | 40         | 10        |
|           | <b>XYZ-H-GE-404-T</b><br>(06 Credits, 60 Lectures & 15 Tutorials)<br><b>Or</b><br><b>XYZ-H-GE-404-T</b><br>04 credits, 60 Lectures<br><b>XYZ-H-GE-404-P</b><br>(02 Credits, 30 Lectures)<br>Choice to choose from other disciplines<br>(Table-3) | 100        | 80         | 20        |
|           |  | 75         | 60         | 15        |
|           |  | 25         | 20         | 05        |
|           | <b>TOTAL</b>   | <b>450</b> | <b>360</b> | <b>90</b> |
| <b>V</b>  | <b>CHE-H-C-511-T</b><br>(04 Credits, 60 Lectures)  | 75         | 60         | 15        |
|           | <b>CHE-H-C-512-T</b><br>(04 Credits, 60 Lectures)  | 75         | 60         | 15        |
|           | <b>CHE-H-C-511 &amp; 512-P</b><br>(02+02=04 Credits, 60x2 Lectures)  | 50         | 40         | 10        |
|           | <b>CHE-H-DSE-501A-T/</b><br><b>CHE-H-DSE-501B-T/</b><br><b>CHE-H-DSE-501C-T</b><br>(04 Credits, 60 Lectures)<br>(Choice to choose any one paper)   | 75         | 60         | 15        |
|           | <b>CHE-H-DSE-502A-T/</b><br><b>CHE-H-DSE-502B-T/</b><br><b>CHE-H-DSE-502C-T</b><br>(04 Credits, 60 Lectures)<br>(Choice to choose any one paper)   | 75         | 60         | 15        |
|           | <b>CHE-H-DSE-501A/B/C-P &amp; 502A/B/C-P</b><br>(02+02=04 Credits, 60x2 Lectures)  | 50         | 40         | 10        |
|           | <b>TOTAL</b>   | <b>400</b> | <b>320</b> | <b>80</b> |
|           | <b>CHE-H-C-613-T</b><br>(04 Credits, 60 Lectures)  | 75         | 60         | 15        |
|           | <b>CHE-H-C-614-T</b><br>(04 Credits, 60 Lectures)  | 75         | 60         | 15        |
|           | <b>CHE-H-C-613 &amp; 614-P</b><br>(02+02=04 Credits, 60x2 Lectures)  | 50         | 40         | 10        |
|           | <b>CHE-H-DSE-603A-T/</b><br><b>CHE-H-DSE-603B-T/</b><br><b>CHE-H-DSE-603C-T</b><br>(04 Credits, 60 Lectures)   | 75         | 60         | 15        |

|  |  |             |             |            |
|--|--|-------------|-------------|------------|
|  | (Choice to choose any one paper)   |             |             |            |
|  | <b>CHE-H-DSE-604A-T/<br/>CHE-H-DSE-604B-T/<br/>CHE-H-DSE-604C-T</b><br>(04 Credits, 60 Lectures)<br>(Choice to choose any one paper) | 75          | 60          | 15         |
|  | <b>CHE-H-DSE-603A/B/C-P &amp; 604A/B/C-P</b><br>(02+02=04 Credits, 60x2 Lectures)  | 50          | 40          | 10         |
|  | <b>TOTAL</b>   | <b>400</b>  | <b>320</b>  | <b>80</b>  |
|  |  |             |             |            |
|  | <b>TOTAL<br/>(SEM I+II+III+IV+V+VI)</b>  | <b>2400</b> | <b>1920</b> | <b>480</b> |

**Note:**

**Symbol of Paper: XYZ-H-C-101-T:** The first three symbols in Roman capital letters indicate the subject; the next symbol H or G indicate Honours or General course; the next symbol(s) denotes Core (C), Generic Elective (GE), Discipline Specific Elective (DSE), AECC, SEC, etc. Out of the next three digits, the first digit indicates the semester e.g. 1,2,3,4,5,6 for semester I, II, III, IV, V, VI respectively, and the next two digits indicate paper number. The last letter T or P indicates Theory or Practical.

## Grades and Grade Points Conversion for Undergraduate Programme

**TABLE - 06**

| Class interval of<br>Marks % | Grade<br>Point | Letter Grade      | Conventional Equivalent      |
|------------------------------|----------------|-------------------|------------------------------|
| 90 and above                 | 10             | O (Outstanding)   | First Class with Exemplary   |
| 75 to less than 90           | 9              | A+ (Excellent)    | First Class with Distinction |
| 60 to less than 75           | 8              | A (Very Good)     | First Class                  |
| 55 to less than 60           | 7              | B+ (Good)         | Second Class                 |
| 50 to less than 55           | 6              | B (Above Average) |                              |
| 45 to less than 50           | 5              | C (Average)       |                              |
| 40 to less than 45           | 4              | P (Pass)          | Pass                         |
| Below 40                     | 0              | #F (Fail)         | Fail                         |
| Absent                       | 0              | Ab (Absent)       |                              |

- In case of fractional marks, 0.5 will be considered as higher whole number.
- A student obtaining Grade F shall be considered failed and will be required to reappear in the examination.

### Computation of SGPA and CGPA

#### Calculation of Semester Grade Point (SGPA)

(A) The SGPA is the ratio of sum of the product of the number of credits with the grade points scored by a student in all the courses taken by a student and the sum of the number of credits of all the courses undergone by a student, i.e.

$$\text{SGPA (S}_i\text{)} = \sum(\text{C}_i \times \text{G}_i) / \sum \text{C}_i$$

where  $\text{C}_i$  is the number of credits of the  $i^{\text{th}}$  course and  $\text{G}_i$  is the grade point scored by the student in the  $i^{\text{th}}$  course.

(B) The CGPA is also calculated in the same manner taking into account all the courses undergone by a student over all the semesters of a programme i.e.

$$\text{CGPA} = \sum(\text{C}_i \times \text{S}_i) / \sum \text{C}_i$$

where  $\text{S}_j$  is the SGPA of the  $j^{\text{th}}$  semester and  $\text{C}_j$  is the total number of credits in that semester.

(C) The SGPA and CGPA shall be rounded off to 2 decimal points and reported in the transcript.

(D) Illustration of Computation of SGPA and CGPA and Format for Transcripts



### **Illustration for SGPA Calculation**

**TABLE-07**

| Course   | Credit | Grade Letter | Grade Point | Credit Point       |
|----------|--------|--------------|-------------|--------------------|
| Course 1 | 3      | A            | 8           | $3 \times 8 = 24$  |
| Course 2 | 4      | B+           | 7           | $4 \times 7 = 28$  |
| Course 3 | 3      | B            | 6           | $3 \times 6 = 18$  |
| Course 4 | 3      | O            | 10          | $3 \times 10 = 30$ |
| Course 5 | 3      | C            | 5           | $3 \times 5 = 15$  |
| Course 6 | 4      | B            | 6           | $4 \times 6 = 24$  |
|          | 20     |              |             | $= 139$            |

Thus,  $SGPA = 139/20 = 6.95$

### **Illustration for CGPA Calculation**

**TABLLE -08**

|                         |                         |                         |                         |                         |                         |
|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| Semester1               | Semester2               | Semester3               | Semester4               | Semester5               | Semester6               |
| Credit: 20<br>SGPA: 6.9 | Credit: 22<br>SGPA: 7.8 | Credit: 25<br>SGPA: 5.6 | Credit: 26<br>SGPA: 6.0 | Credit: 26<br>SGPA: 6.3 | Credit: 25<br>SGPA: 8.0 |

$$\text{Thus, CGPA} = \frac{20 \times 6.9 + 22 \times 7.8 + 25 \times 5.6 + 26 \times 6.0 + 26 \times 6.3 + 25 \times 8.0}{140} = 6.9$$

**SEMESTER -1**  
**Bachelor of Science in Chemistry (Honours)**

**ABILITY ENHANCEMENT COMPULSORY COURSE (AECC)**  
**PAPER: CHE-H-AECC-101-T**

**Credits: 02**

**30 Lectures.**

**Marks: 10 (MSE) + 40 (ESE) = 50**

**Pass Marks: (MSE: 04 +ESE: 16) = 40**

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Any One Compulsory Language Communication Prescribed by Ranchi University:

English Communication/ Hindi Communication / NH + MB Communication

**(Refer AECC Curriculum of Binod Bihari Mahto Koyalanchal University, Dhanbad)**

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**CORE COURSE (HONOURS IN CHEMISTRY)**

**PAPER: CHE-H-C-101-T**

**INORGANIC CHEMISTRY-I**

**Credits: Theory-04**

**Theory: 60 Lectures.**

**Marks: 15 (MSE) + 60 (ESE) =75**

**Pass Marks: (MSE: 06 +ESE: 24) = 30**

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*Instruction to Question Setter for*

*Mid Semester Examination (MSE):  $1\frac{1}{2}$  Hrs.*

*The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks. There will be three questions of 5 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 5 marks.*

*(Attendance: Upto 75% = 1 mark; 75-80% = 2 marks; 80.-85% = 3 marks; 85-90% = 4 marks; >90% = 5 marks)*

*End Semester Examination (ESE): 3 Hrs.*

*There will be two groups of questions. Group A is compulsory and will contain two questions. Q. No. 1(A) will be multiple type six questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 3 marks. Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to be answered.*

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**INORGANIC CHEMISTRY-**

**Theory: 60 Lectures**

**UNIT: 1 Atomic Structure**

**14 Lectures**

Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of  $\psi$  and  $\psi^2$ . Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and

Angular distribution curves. Shapes of *s*, *p*, *d* and *f* orbitals. Contour boundary and Probability diagrams.

Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number.

**UNIT 2: Periodicity of Elements:**

**16 Lectures**

*s*, *p*, *d*, *f* block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to *s* & *p*-block.

(a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table.

(b) Atomic radii (van der Waals)

(c) Ionic and crystal radii.

- (d) Covalent radii (octahedral and tetrahedral)
- (e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy.
- (f) Electron gain enthalpy, trends of electron gain enthalpy.
- (g) Electronegativity, Pauling's/ Mulliken's/ Allred Rachow's/ and Mulliken-Jaffé's electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity. Sanderson's electron density ratio.

### **UNIT 3: Chemical Bonding:**

**26 Lectures**

**(i) Ionic bond:** General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy.

**(ii) Covalent bond:** Lewis structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N<sub>2</sub>, O<sub>2</sub>, C<sub>2</sub>, B<sub>2</sub>, F<sub>2</sub>, CO, NO, and their ions; HCl, BeF<sub>2</sub>, CO<sub>2</sub>, (idea of s-p mixing and orbital interaction to be given). Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding ( $\sigma$  and  $\pi$  bond approach) and bond lengths.

Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization.

Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference.

**(iii) Metallic Bond:** Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids.

**(iv) Weak Chemical Forces:** Van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions.

Repulsive forces, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment) Effects of chemical force, melting and boiling points, solubility energetics of dissolution process.

### **UNIT 4: Oxidation-Reduction**

**4 Lectures**

Redox equations, Standard Electrode Potential and its application to inorganic reactions.

Principles involved in volumetric analysis to be carried out in class.

**Reference Books:**

1. Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
2. Douglas, B.E. and Mc Daniel, D.H., Concepts & Models of Inorganic Chemistry, Oxford, 1970
3. Atkins, P.W. & Paula, J. Physical Chemistry, Oxford Press, 2006.
4. Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publication.

**CORE COURSE (HONOURS IN CHEMISTRY)**

**PAPER: CHE-H-C-102-T**

**PHYSICAL CHEMISTRY-I**

**Credits: Theory-04**

**Theory: 60 Lectures**

**Marks: 15 (MSE) + 60 (ESE) =75**

**Pass Marks: (MSE: 06 +ESE: 24) = 30**

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*Instruction to Question Setter for*

*Mid Semester Examination (MSE):  $1\frac{1}{2}$  Hrs.*

*The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks. There will be three questions of 5 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 5 marks.*

*(Attendance: Upto 75% = 1 mark; 75-80% = 2 marks; 80-85% = 3 marks; 85-90% = 4 marks; >90% = 5 marks)*

*End Semester Examination (ESE): 3 Hrs.*

*There will be two groups of questions. Group A is compulsory and will contain two questions. Q. No. 1(A) will be multiple type six questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 3 marks. Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to be answered.*

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**UNIT 1: Gaseous state:**

**18 Lectures**

Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of  $\sigma$  from  $\eta$ ; variation of viscosity with temperature and pressure. Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities. Behaviour of real gases: Deviations from ideal gas behaviour, compressibility factor, Z, and its variation with pressure for different gases. Causes of deviation from ideal behavior. Vander Waals equation of state, its derivation and application in explaining real gas behaviour, mention of other equations of state (Berthelot, Dietrici); virial equation of state; van der Waals equation expressed in virial form and calculation of Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states.

**UNIT 2: Liquid state**

**6 Lectures**

Qualitative treatment of the structure of the liquid state; Radial distribution function; physical

properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases. Qualitative discussion of structure of water.

### **UNIT 3: Solid state**

**16 Lectures**

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Defects in crystals. Glasses and liquid crystals.

### **UNIT 4: Ionic equilibria**

**20 Lectures**

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di- and triprotic acids (exact treatment). Salt hydrolysis- calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications; buffer capacity, buffer range, buffer action and applications of buffers in analytical chemistry and biochemical processes in the human body. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of acid–base indicators; selection of indicators and their limitations. Multistage equilibria in polyelectrolyte systems; hydrolysis and hydrolysis constants.

### **Reference Books:**

1. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry Ed., Oxford University Press 13 (2006).
2. Ball, D. W. Physical Chemistry Thomson Press, India (2007).
3. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
4. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).

**CORE COURSE (HONOURS IN CHEMISTRY)**  
**PAPER: CHE-H-C-101 & 102 -P**  
**CHEMISTRY LAB (PRACTICAL)**

**Credits: 02+ 02 = 04 Credits**

**Full Marks: 10 (MSE) + 40 (ESE) = 50**

**Pass Marks: (MSE: 04 + ESE: 16) = 20**

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*Instruction to Question Setter for*

*Mid Semester Examination (MSE): 3 Hrs.*

*The Mid Semester Examination shall have one components: One Semester Internal Assessment Test (SIA) of 10 Marks.*

*Distribution of Marks: One experiment = 06 marks, Practical record/note book = 02 marks, Viva-voce = 02 marks*

*End Semester Examination (ESE): 3 Hrs.*

*Two experiments (questions) will be set (one from each group) each of 24 marks out of which one is to be answered.*

*Evaluation of Practical Examination may be as per the following guidelines:*

*Experiment = 24 marks*

*Practical record notebook = 08 marks*

*Viva-voce = 08 marks*

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**GROUP “A”**  
**PAPER: CHE-H-C-101-P**  
**INORGANIC CHEMISTRY-I LAB**  
**(60 Lectures)**

**(A) Titrimetric Analysis**

- (i) Calibration and use of apparatus
- (ii) Preparation of solutions of different Molarity/Normality of titrants

**(B) Acid-Base Titrations**

- (i) Estimation of carbonate and hydroxide present together in mixture.
- (ii) Estimation of carbonate and bicarbonate present together in a mixture.
- (iii) Estimation of free alkali present in different soaps/detergents

**(C) Oxidation-Reduction Titrimetry**

- (i) Estimation of Fe(II) and oxalic acid using standardized KMnO<sub>4</sub> solution.
- (ii) Estimation of oxalic acid and sodium oxalate in a given mixture.
- (iii) Estimation of Fe(II) with K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> using internal (diphenylamine, anthranilic acid) and external indicator.



**GROUP “B”**  
**PAPER: CHE-H-C-102-P**  
**PHYSICAL CHEMISTRY-I LAB**  
**(60 Lectures)**

**1. Surface tension measurements.**

- a. Determine the surface tension by (i) drop number (ii) drop weight method.
- b. Study the variation of surface tension of detergent solutions with concentration.

**2. Viscosity measurement using Ostwald’s viscometer.**

- a. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) Sugar at room temperature.
- b. Study the variation of viscosity of sucrose solution with the concentration of solute.

**3. Indexing of a given powder diffraction pattern of a cubic crystalline system.**

**4. pH metry**

- a. Study the effect on pH of addition of HCl/ NaOH to solutions of acetic acid, sodium acetate and their mixtures.
- b. Preparation of buffer solutions of different pH
  - i. Sodium acetate-acetic acid
  - ii. Ammonium chloride-ammonium hydroxide
- c. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
- d. Determination of dissociation constant of a weak acid.

**Reference text:**

- 1. Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS.
- 2. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: N.Delhi (2011).
- 3. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8<sup>th</sup> Ed.*; McGraw-Hill: New York (2003).
- 4. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3<sup>rd</sup> Ed.*; W.H. Freeman & Co.: New York (2003).

**GENERIC ELECTIVE-01**  
(For Non Practical Subject)

**PAPER: XYZ-H-GE-101-T**

**Credits: Theory-06**

**60 Lectures & 15 Tutorials)**

**Marks: 20 (MSE) + 80 (ESE) = 100**

**Pass Marks: (MSE: 08 +ESE: 32) = 40**

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**For Practical Subject**

**PAPER: XYZ-H-GE-101-T**

**Credits: Theory-04**

**60 Lectures**

**Marks: 20 (MSE) + 80 (ESE) =75**

**Pass Marks: (MSE: 08 +ESE: 32) = 40**

**&**

**Credits: Practical -02**

**30 Lectures**

**Marks: 05 (MSE) + 20 (ESE) =25**

**Pass Marks: (MSE: 02 +ESE: 08) = 10**

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**One Subject to be opted other than the Honours Subject. Refer Table A-03 and for Content in detail refer the Syllabus of Opted Generic Elective Subject.**

**SEMESTER -II**  
**Bachelor of Science in Chemistry (Honours)**

**ABILITY ENHANCEMENT COMPULSORY COURSE (AECC)**

**PAPER: CHE-H-AECC-202-T**

**Environmental Science**

**Credits: 02**

**30 Lectures.**

**Marks: 10 (MSE) + 40 (ESE) = 50**

**Pass Marks: (MSE: 04 +ESE: 16) = 40**

---

**(Refer AECC Curriculum of Binod Bihari Mahto Koyalanchal University, Dhanbad)**

**CORE COURSE (HONOURS IN CHEMISTRY)**

**PAPER: CHE-H-C-203-T  
ORGANIC CHEMISTRY-I**

**Credits: Theory-04, Practical- 02**

**Theory: 60 Lectures.**

**Marks: 15 (MSE) + 60 (ESE) =75**

**Pass Marks: (MSE: 06 +ESE: 24) = 30**

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*Instruction to Question Setter for*

*Mid Semester Examination (MSE):  $1\frac{1}{2}$  Hrs.*

*The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks. There will be three questions of 5 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 5 marks.*

*(Attendance: Upto 75% = 1 mark; 75-80% = 2 marks; 80.-85% = 3 marks; 85-90% = 4 marks; >90% = 5 marks)*

*End Semester Examination (ESE): 3 Hrs.*

*There will be two groups of questions. Group A is compulsory and will contain two questions. Q. No. 1(A) will be multiple type six questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 3 marks. Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to be answered.*

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**ORGANIC CHEMISTRY I**

**Theory: 60 Lectures**

**UNIT 1: Basics of Organic Chemistry**

**06 Lectures**

*Organic Compounds:* Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties. *Electronic Displacements:* Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength.

Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophilicity and basicity; Types, shape and their relative stability of Carbocations, Carbanions, Free radicals and Carbenes.

Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

**UNIT 2: Stereochemistry:**

**18 Lectures**

Fischer Projection, Newman and Sawhorse Projection formulae and their interconversions; Geometrical isomerism: cis-trans and, syn-anti isomerism E/Z notations with C.I.P rules.

**Optical Isomerism:** Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures, racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations.

### **UNIT 3: Chemistry of Aliphatic Hydrocarbons**

**24 Lectures**

#### **A. Carbon-Carbon sigma bonds**

Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity.

#### **B. Carbon-Carbon pi bonds:**

Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations.

**Reactions of alkenes:** Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2-and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene.

**Reactions of alkynes:** Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.

#### **C. Cycloalkanes and Conformational Analysis**

Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of alkanes: Relative stability: Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy diagrams.

### **UNIT 4: Aromatic Hydrocarbons**

**12 Lectures**

*Aromaticity:* Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the groups.

#### **Reference Books:**

1. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural

Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

4. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds; Wiley: London, 1994.

5. Kalsi, P. S. Stereochemistry Conformation and Mechanism; New Age International, 2005.

**CORE COURSE (HONOURS IN CHEMISTRY)**

**PAPER: CHE-H-C-204-T  
PHYSICAL CHEMISTRY-II**

**Credits: Theory-04, Practical – 02**

**Theory: 60 Lectures.**

**Marks: 15 (MSE: 1Hr) + 60 (ESE: 3Hrs) = 75**

**Pass Marks: (MSE: 06 +ESE: 24) = 30**

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*Instruction to Question Setter for*

*Mid Semester Examination (MSE):  $1\frac{1}{2}$  Hrs.*

*The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks. There will be three questions of 5 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 5 marks.*

*(Attendance: Upto 75% = 1 mark; 75-80% = 2 marks; 80-85% = 3 marks; 85-90% = 4 marks; >90% = 5 marks)*

*End Semester Examination (ESE): 3 Hrs.*

*There will be two groups of questions. Group A is compulsory and will contain two questions. Q. No. 1(A) will be multiple type six questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 3 marks. Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to be answered.*

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**PHYSICAL CHEMISTRY II**

**Theory: 60 Lectures**

**UNIT 1: Chemical Thermodynamics:**

**36 Lectures**

Intensive and extensive variables; state and path functions; isolated, closed and open systems; Zeroth law of thermodynamics.

**First law:** Concept of heat,  $q$ , work,  $w$ , internal energy,  $U$ , and statement of first law; enthalpy,  $H$ , relation between heat capacities, calculations of  $q$ ,  $w$ ,  $U$  and  $H$  for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions.

**Thermochemistry:** Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations) and pressure on enthalpy of reactions. Adiabatic flame temperature, explosion temperature.

**Second Law:** Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes.

**Third Law:** Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules.

**Free Energy Functions:** Gibbs and Helmholtz energy; variation of  $S$ ,  $G$ ,  $A$  with  $T$ ,  $V$ ,  $P$ ; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.

**Free Energy Functions:** Gibbs and Helmholtz energy; variation of  $S$ ,  $G$ ,  $A$  with  $T$ ,  $V$ ,  $P$ ; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.

**UNIT 2: Systems of Variable Composition**

**8 Lectures**

Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs- Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases.

**UNIT 3: Chemical Equilibrium**

**8 Lectures**

Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases, concept of fugacity. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient. Coupling of exoergic and endoergic reactions. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Free energy of mixing and spontaneity; thermodynamic derivation of relations between the various equilibrium constants  $K_p$ ,  $K_c$  and  $K_x$ . Le Chatelier principle (quantitative treatment); equilibrium between ideal gases and a pure condensed phase.

**UNIT 4: Solutions and Colligative Properties**

**8 Lectures**

Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Excess thermodynamic functions.

Thermodynamic derivation using chemical potential to derive relations between the four colligative properties [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure] and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.

**Reference Books**

1. Peter, A. & Paula, J. de. Physical Chemistry 9<sup>th</sup> Ed., Oxford University Press (2011).
2. Castellan, G. W. Physical Chemistry 4<sup>th</sup> Ed., Narosa (2004).
3. Engel, T. & Reid, P. Physical Chemistry 3<sup>rd</sup> Ed., Prentice-Hall (2012).
4. McQuarrie, D. A. & Simon, J. D. Molecular Thermodynamics Viva Books Pvt. Ltd.: New Delhi (2004).
5. Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. Commonly Asked Questions in Thermodynamics. CRC Press: NY (2011).
6. Levine, I. N. Physical Chemistry 6<sup>th</sup> Ed., Tata Mc Graw Hill (2010).
7. Metz, C.R. 2000 solved problems in chemistry, Schaum Series (2006)



**CORE COURSE (HONOURS IN CHEMISTRY)**

**PAPER: CHE-H-C-203 & 204 -P**

**CHEMISTRY LAB (PRACTICAL)**

**Credits: 4 Credits**

**Full Marks: 10 (MSE: 1Hr) + 40 (ESE: 3Hrs) = 50**

**Pass Marks: (MSE: 04 + ESE: 16) = 20**

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*Instruction to Question Setter for*

*Mid Semester Examination (MSE): 3 Hrs.*

*The Mid Semester Examination shall have one components: One Semester Internal Assessment Test (SIA) of 10 Marks.*

*Distribution of Marks: One experiment = 06 marks, Practical record/note book = 02 marks, Viva-voce = 02 marks*

*End Semester Examination (ESE): 3 Hrs.*

*Two experiments (questions) will be set (one from each group) each of 24 marks out of which one is to be answered.*

*Evaluation of Practical Examination may be as per the following guidelines:*

*Experiment = 24 marks*

*Practical record notebook = 08 marks*

*Viva-voce = 08 marks*

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**GROUP “A”**

**PAPER: CHE-H-C-203-P**

**ORGANIC CHEMISTRY-I LAB**

**(60 Lectures)**

1. Checking the calibration of the thermometer
2. Purification of organic compounds by crystallization using the following solvents:
  - a. Water
  - b. Alcohol
  - c. Alcohol-Water
3. Determination of the melting points of above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus).
4. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds
5. Determination of boiling point of liquid compounds. (Boiling point lower than and more than 100 °C by distillation and capillary method)
6. Chromatography
  - a. Separation of a mixture of two amino acids by ascending and horizontal paper

chromatography

- b. Separation of a mixture of two sugars by ascending paper chromatography
- c. Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC)

**GROUP “B”**  
**PAPER: CHE-H-C-204-P**  
**PHYSICAL CHEMISTRY-II LAB**  
**(60 Lectures)**

**Thermochemistry**

- a) Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization).
- b) Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
- c) Calculation of the enthalpy of ionization of ethanoic acid.
- d) Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.
- e) Determination of basicity/proticity of a polyprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.
- f) Determination of enthalpy of hydration of copper sulphate.
- g) Study of the solubility of benzoic acid in water and determination of  $\Delta H$ .

**Reference Books:**

- 1. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
- 2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5<sup>th</sup> Ed., Pearson (2012)
- 3. Khosla, B.D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
- 4. Athawale, V. D. & Mathur, P. Experimental Physical Chemistry New Age International: New Delhi (2001).

**GENERIC ELECTIVE-02**

**(For Non Practical Subject)**

**PAPER: XYZ-H-GE-202-T**

**Credits: Theory-06**

**60 Lectures & 15 Tutorials)**

**Marks: 20 (MSE) + 80 (ESE) = 100**

**Pass Marks: (MSE: 08 +ESE: 32) = 40**

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**For Practical Subject**

**PAPER: XYZ-H-GE-202-T**

**Credits: Theory-04**

**60 Lectures**

**Marks: 20 (MSE) + 80 (ESE) =75**

**Pass Marks: (MSE: 08 +ESE: 32) = 40**

**&**

**Credits: Practical -02**

**30 Lectures**

**Marks: 05 (MSE) + 20 (ESE) =25**

**Pass Marks: (MSE: 02 +ESE: 08) = 10**

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**One Subject to be opted other than the Honours Subject. Refer Table A-03 and for Content in detail refer the Syllabus of Opted Generic Elective Subject.**

**SEMESTER-III**  
**CORE COURSE (HONOURS IN CHEMISTRY)**  
**PAPER: CHE-H-C-305-T**  
**INORGANIC CHEMISTRY-II**

**Credits: Theory-04, Practical – 02**

**Theory: 60 Lectures.**

**Marks: 15 (MSE: 1Hr) + 60 (ESE: 3Hrs) = 75**

**Pass Marks: (MSE: 06 +ESE: 24) = 30**

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*Instruction to Question Setter for*

*Mid Semester Examination (MSE):  $1\frac{1}{2}$  Hrs.*

*The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks. There will be three questions of 5 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 5 marks.*

*(Attendance: Upto 75% = 1 mark; 75-80% = 2 marks; 80.-85% = 3 marks; 85-90% = 4 marks; >90% = 5 marks)*

*End Semester Examination (ESE): 3 Hrs.*

*There will be two groups of questions. Group A is compulsory and will contain two questions. Q. No. 1(A) will be multiple type six questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 3 marks. Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to be answered.*

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**UNIT 1: General Principles of Metallurgy**

**06 Lectures**

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy. Methods of purification of metals: Electrolytic Kroll process, Parting process, van Arkel-de Boer process and Mond's process, Zone refining.

**UNIT 2: Acids and Bases**

**08 Lectures**

Brönsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, levelling solvents, Lewis acid-base concept, Classification of Lewis acids, Hard and Soft Acids and Bases (HSAB) Application of HSAB principle.

**UNIT 3: Chemistry of *s* and *p* Block Elements**

**30 Lectures**

Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Allotropy and catenation. Complex formation tendency of *s* and *p* block elements.

Hydrides and their classification: Ionic, Covalent and Interstitial. Basic beryllium acetate and nitrate. Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses.

Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine. Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens.

**UNIT 4: Noble Gases:****08 Lectures**

Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF<sub>2</sub>, XeF<sub>4</sub> and XeF<sub>6</sub>; Nature of bonding in noble gas compounds (Valence bond treatment and MO treatment for XeF<sub>2</sub>). Molecular shapes of noble gas compounds (VSEPR theory).

**UNIT 5: Inorganic Polymers:****08 Lectures**

Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes. Borazines, silicates and phosphazenes and polysulphates.

**Reference Books:**

1. Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991
2. Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. Concepts & Models of Inorganic Chemistry 3<sup>rd</sup> Ed., John Wiley Sons, N.Y. 1994.
3. Greenwood, N.N. & Earnshaw. Chemistry of the Elements, Butterworth- Heinemann. 1997.
4. Cotton, F.A. & Wilkinson, G. Advanced Inorganic Chemistry, Wiley, VCH, 1999.

**SEMESTER-III**  
**CORE COURSE (HONOURS IN CHEMISTRY)**  
**PAPER: CHE-H-C-306-T**  
**ORGANIC CHEMISTRY-II**

**Credits: Theory-04, Practical – 02**

**Theory: 60 Lectures.**

**Marks: 15 (MSE) + 60 (ESE) = 75**

**Pass Marks: (MSE: 06 +ESE: 24) = 30**

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*Instruction to Question Setter for*

*Mid Semester Examination (MSE): 1  $\frac{1}{2}$  Hrs.*

*The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks. There will be three questions of 5 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 5 marks.*

*(Attendance: Upto 75% = 1 mark; 75-80% = 2 marks; 80-85% = 3 marks; 85-90% = 4 marks; >90% = 5 marks)*

*End Semester Examination (ESE): 3 Hrs.*

*There will be two groups of questions. Group A is compulsory and will contain two questions. Q. No. 1(A) will be multiple type six questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 3 marks. Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to be answered.*

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**UNIT 1: Chemistry of Halogenated Hydrocarbons**

**16 Lectures**

**Alkyl halides:** Methods of preparation, nucleophilic substitution reactions – SN1, SN2 and SNi mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination.

**Aryl halides:** Preparation, including preparation from diazonium salts. Nucleophilic aromatic substitution; SNAr, Benzyne mechanism.

Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.

Organometallic compounds of Mg and Li – Use in synthesis of organic compounds.

**UNIT 2: Alcohols, Phenols, Ethers and Epoxides**

**16 Lectures**

**Alcohols:** preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement;

**Phenols:** Preparation and properties; Acidity and factors effecting acidity, Ring substitution

reactions, Reimer–Tiemann and Kolbe’s–Schmidt Reactions, Fries and Claisen rearrangements with mechanism;

**Ethers and Epoxides:** Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and  $\text{LiAlH}_4$ .

### **UNIT 3: Carbonyls Compounds**

**(14 Lectures)**

Structure, reactivity and preparation:

Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation,  $\alpha$ -substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner,  $\text{LiAlH}_4$ ,  $\text{NaBH}_4$ , MPV, PDC and PGC);

Addition reactions of unsaturated carbonyl compounds: Michael addition.

Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.

### **UNIT 3: Carboxylic Acids and their derivatives**

**(10 Lectures)**

Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids;

Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic substitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmann- bromamide degradation and Curtius rearrangement.

### **UNIT 4: Sulphur containing compounds**

**(04 Lecture)**

Preparation and reactions of thiols, thioethers and sulphonic acids.

### **Reference Books:**

1. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. *Organic Chemistry (Volume I)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Graham Solomons, T.W. *Organic Chemistry*, John Wiley & Sons, Inc.

**SEMESTER-III**  
**CORE COURSE (HONOURS IN CHEMISTRY)**  
**PAPER: CHE-H-C-307-T**  
**PHYSICAL CHEMISTRY-III**

**Credits: Theory-04, Practical – 02**

**Theory: 60 Lectures.**

**Marks: 15 (MSE) + 60 (ESE) = 75**

**Pass Marks: (MSE: 06 +ESE: 24) = 30**

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*Instruction to Question Setter for*

*Mid Semester Examination (MSE): 1  $\frac{1}{2}$  Hrs.*

*The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks. There will be three questions of 5 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 5 marks.*

*(Attendance: Upto 75% = 1 mark; 75-80% = 2 marks; 80-85% = 3 marks; 85-90% = 4 marks; >90% = 5 marks)*

*End Semester Examination (ESE): 3 Hrs.*

*There will be two groups of questions. Group A is compulsory and will contain two questions. Q. No. 1(A) will be multiple type six questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 3 marks. Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to be answered.*

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**UNIT 1: Phase Equilibria**

**28 Lectures**

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid- liquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems, with applications.

Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions.

Three component systems, water-chloroform-acetic acid system, triangular plots.

*Binary solutions:* Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and nonideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation.

Nernst distribution law: its derivation and applications.

**UNIT 2: Chemical Kinetics**

**18 Lectures**

Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated form of rate expressions up to second order reactions, experimental



methods of the determination of rate laws, kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions.

Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates.

**UNIT 3: Catalysis:****08 Lectures**

Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

**UNIT 4: Surface chemistry:****06 Lectures**

Physical adsorption, chemisorption, adsorption isotherms. Nature of adsorbed state.

**Reference Books:**

1. Peter Atkins & Julio De Paula, Physical Chemistry 9<sup>th</sup> Ed., Oxford University Press (2010).
2. Castellan, G. W. Physical Chemistry, 4<sup>th</sup> Ed., Narosa (2004).
3. McQuarrie, D. A. & Simon, J. D., Molecular Thermodynamics, Viva Books Pvt. Ltd.: New Delhi (2004).
4. Engel, T. & Reid, P. Physical Chemistry 3<sup>rd</sup> Ed., Prentice-Hall (2012).
5. Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. Commonly Asked Questions in Thermodynamics. CRC Press: NY (2011).
6. Zundhal, S.S. Chemistry concepts and applications Cengage India (2011).
7. Ball, D. W. Physical Chemistry Cengage India (2012).
8. Mortimer, R. G. Physical Chemistry 3<sup>rd</sup> Ed., Elsevier: NOIDA, UP (2009).
9. Levine, I. N. Physical Chemistry 6<sup>th</sup> Ed., Tata McGraw-Hill (2011).
10. Metz, C. R. Physical Chemistry 2<sup>nd</sup> Ed., Tata McGraw-Hill (2009).

## SEMESTER - III

### CORE COURSE (HONOURS IN CHEMISTRY)

#### PAPER: CHE-H-C-305 & 306 & 307-P

#### CHEMISTRY LAB (PRACTICAL)

**Credits:** 02+02+02 =06

**Full Marks:** 15 (MSE) + 60 (ESE) = 75

**Pass Marks:** (MSE: 06 + ESE: 24) = 30

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*Instruction to Question Setter for*

*Mid Semester Examination (MSE): 03 Hrs.*

*The Mid Semester Examination shall have one components: One Semester Internal Assessment Test (SIA).*

*Distribution of Marks: Two experiments = 10 marks, Practical record/note book = 2.5 marks, Viva-voce = 2.5 marks*

*End Semester Examination (ESE): 03 Hrs.*

*Three experiments (questions) will be set (one from each group) each of 20 marks out of which one is to be answered.*

*Evaluation of Practical Examination may be as per the following guidelines:*

*Experiment = 40 marks*

*Practical record notebook = 10 marks*

*Viva-voce = 10 marks*

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#### GROUP “A”

#### PAPER: CHE-H-C-305-P

#### INORGANIC CHEMISTRY-II LAB

(60 Lectures)

##### (A) Iodo / Iodimetric Titrations

- I. Estimation of Cu(II) and  $K_2Cr_2O_7$  using sodium thiosulphate solution (Iodometrically).
- II. Estimation of (i) arsenite and (ii) antimony in tartar-emetic iodometrically
- III. Estimation of available chlorine in bleaching powder iodometrically

##### B) Inorganic preparations

- I. Cuprous Chloride,  $Cu_2Cl_2$
- II. Preparation of Manganese(III) phosphate,  $MnPO_4 \cdot H_2O$ .
- III. Preparation of Aluminium potassium sulphate  $KAl(SO_4)_2 \cdot 12H_2O$  (Potash alum) or Chrome alum.

#### GROUP “B”

#### PAPER: CHE-H-C-306-P

#### ORGANIC CHEMISTRY-II LAB

(60 Lectures)

1. Functional group tests for alcohols, phenols, carbonyl and carboxylic acid group.
2. Organic preparations:

- (i) Acetylation of one of the following compounds: amines (aniline, *o*-, *m*-, *p*- toluidines and *o*-, *m*-, *p*-anisidine) and phenols ( $\beta$ -naphthol, vanillin, salicylic acid) by any one method:
  - (a) Using conventional method.
  - (b) Using green approach
- (ii) Benzoylation of one of the following amines (aniline, *o*-, *m*-, *p*- toluidines and *o*-, *m*-, *p*-anisidine) and one of the following phenols ( $\beta$ -naphthol, resorcinol, *p*- cresol) by Schotten-Baumann reaction.
- (iii) Oxidation of ethanol/ isopropanol (Iodoform reaction).
- (iv) Bromination of any one of the following:
  - (a) Acetanilide by conventional methods
  - (b) Acetanilide using green approach (Bromate-bromide method)
- (v) Nitration of any one of the following:
  - (a) Acetanilide/nitrobenzene by conventional method
  - (b) Salicylic acid by green approach (using ceric ammonium nitrate).
- (vi) Selective reduction of *meta* dinitrobenzene to *m*-nitroaniline.
- (vii) Reduction of *p*-nitrobenzaldehyde by sodium borohydride.
- (viii) Hydrolysis of amides and esters.
- (ix) Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone, benzaldehyde.
- (x) *S*-Benzyliothiuronium salt of one each of water soluble and water insoluble acids (benzoic acid, oxalic acid, phenyl acetic acid and phthalic acid).
- (xi) Aldol condensation using either conventional or green method.
- (xii) Benzil-Benzilic acid rearrangement.

**GROUP “C”**

**PAPER: CHE-H-C-307-P**

**PHYSICAL CHEMISTRY-I LAB**

**(60 Lectures)**

- I. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.
- II. Phase equilibria: Construction of the phase diagram using cooling curves or ignition tube method:
  - a. simple eutectic and
  - b. Congruently melting systems.
- III. Distribution of acetic/ benzoic acid between water and cyclohexane.
- IV. Study the kinetics of the following reactions.

1. Initial rate method: Iodide-persulphate reaction
2. Integrated rate method:
  - a. Acid hydrolysis of methyl acetate with hydrochloric acid.
  - b. Saponification of ethyl acetate.
3. Compare the strengths of HCl and H<sub>2</sub>SO<sub>4</sub> by studying kinetics of hydrolysis of methyl acetate.

**V. Adsorption**

Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal.

**Reference Books:**

1. Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS. 1978.
2. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
3. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5<sup>th</sup> Ed., Pearson (2012)
4. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
5. Ahluwalia, V.K. & Dhingra, S. Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press (2000).
6. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

**SEMESTER-III**  
**CORE COURSE (HONOURS IN CHEMISTRY)**  
**PAPER: CHE-H-SEC-301-T**  
**Skill Enhancement Course-01**

**Credits: 02**

**Theory: 30 Lectures.**

**Marks: 10 (MSE :) + 40 (ESE) = 50**

**Pass Marks: (MSE: 04 +ESE: 16) = 20**

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***Instruction to Question Setter for***

***Mid Semester Examination (MSE):  $1\frac{1}{2}$  Hrs.***

*The Mid Semester Examination shall have one components: One Semester Internal Assessment Test (SIA) of 10 Marks.*

***End Semester Examination (ESE): 3 Hrs.***

*There will be two groups of questions. Five Questions to be answered out of Nine Questions. Group A is compulsory and will contain two questions. Question No.1 (A) will be MCQ of 1 mark each (four questions). Question No.1 (B) will be short answer type to be answered in about 50 words of 2 marks (2 Questions). Group B will contain descriptive type eight questions of eight marks each, out of which any four are to answer. Each question carries 08 marks.*

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**One Subject to be opted other than the Honours and Generic Elective Subject. Refer Annexure-01 and for Content in detail refer the University website of BBM KU, Dhanbad, Jharkhand.**

**GENERIC ELECTIVE-03**  
(For Non Practical Subject)

**PAPER: XYZ-H-GE-303-T**

**Credits: Theory-06**

**60 Lectures & 15 Tutorials)**

**Marks: 20 (MSE) + 80 (ESE) = 100**

**Pass Marks: (MSE: 08 +ESE: 32) = 40**

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**For Practical Subject**

**PAPER: XYZ-H-GE-303-T**

**Credits: Theory-04**

**60 Lectures**

**Marks: 20 (MSE) + 80 (ESE) =75**

**Pass Marks: (MSE: 08 +ESE: 32) = 40**

**&**

**Credits: Practical -02**

**30 Lectures**

**Marks: 05 (MSE) + 20 (ESE) =25**

**Pass Marks: (MSE: 02 +ESE: 08) = 10**

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**One Subject to be opted other than the Honours Subject. Refer Table A-03 and for Content in detail refer the Syllabus of Opted Generic Elective Subject.**

**SEMESTER-IV**  
**CORE COURSE (HONOURS IN CHEMISTRY)**  
**PAPER: CHE-H-C-408-T**  
**INORGANIC CHEMISTRY-III**

**Credits: Theory-04, Practical – 02**  
**Lectures.**

**Theory: 60 Lectures**

**Marks: 15 (MSE) + 60 (ESE) = 75**

**Pass Marks: (MSE: 06 +ESE: 24) = 30**

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*Instruction to Question Setter for*

*Mid Semester Examination (MSE):  $1\frac{1}{2}$  Hrs.*

*The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks. There will be three questions of 5 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 05 marks.*

*(Attendance: Upto 75% = 1 mark; 75-80% = 1.5 marks; 80.-85% = 2 marks; 85-90% = 2.5 marks; >90% = 3 marks)*

*End Semester Examination (ESE): 3 Hrs.*

*There will be two groups of questions. Group A is compulsory and will contain two questions. Q. No. 1(A) will be multiple type six questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 3 marks. Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to be answered.*

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**UNIT 1: Coordination Chemistry:**

**(26 Lectures)**

Werner's theory, valence bond theory (inner and outer orbital complexes), electro neutrality principle and back bonding. Crystal field theory, measurement of  $10 Dq$  ( $\Delta_o$ ), CFSE in weak and strong fields, pairing energies, factors affecting the magnitude of  $10 Dq$  ( $\Delta_o$ ,  $\Delta_t$ ). Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar geometry. Qualitative aspect of Ligand field and MO Theory.

IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with 4 and 6 coordination numbers. Chelate effect, polynuclear complexes, Labile and inert complexes.

**UNIT 2: Transition Elements:**

**(18 Lectures)**

General group trends with special reference to electronic configuration, colour, variable valency, magnetic, catalytic properties, and ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer & Bsworth diagrams). Difference between the first, second and third transition series. Chemistry of Ti, V, Cr Mn, Fe and Co in various oxidation states (excluding their metallurgy)

**UNIT 3: Lanthanoids and Actinoids:**

**(06 Lectures)**

Electronic configuration, oxidation states, colour, spectral and magnetic properties, lanthanide contraction, separation of lanthanides (ion-exchange method only).

**UNIT 4: Bioinorganic Chemistry:**

**(10 Lectures)**

Metal ions present in biological systems, classification of elements according to their action in biological system. Geochemical effect on the distribution of metals. Sodium/ K-pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace metals.

Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, Use of chelating agents in medicine. Iron and its application in bio-systems, Haemoglobin; Storage and transfer of iron.



**SEMESTER-IV**  
**CORE COURSE (HONOURS IN CHEMISTRY)**  
**PAPER: CHE-H-C-409-T**  
**ORGANIC CHEMISTRY-III**

**Credits: Theory-04, Practical – 02**

**Theory: 60 Lectures.**

**Marks: 15 (MSE) + 60 (ESE) = 75**

**Pass Marks: (MSE: 06 +ESE: 24) = 30**

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*Instruction to Question Setter for*

*Mid Semester Examination (MSE):  $1\frac{1}{2}$  Hrs.*

*The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks. There will be three questions of 5 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 05 marks.*

*(Attendance: Upto 75% = 1 mark; 75-80% = 1.5 marks; 80.-85% = 2 marks; 85-90% = 2.5 marks; >90% = 3 marks)*

*End Semester Examination (ESE): 3 Hrs.*

*There will be two groups of questions. Group A is compulsory and will contain two questions. Q. No. 1(A) will be multiple type six questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 3 marks. Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to be answered.*

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**UNIT 1: Nitrogen Containing Functional Groups**

**(18 Lectures)**

Preparation and important reactions of nitro and compounds, nitriles and isonitriles.

Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction; Distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid.

Diazonium Salts: Preparation and their synthetic applications.

**UNIT 2: Polynuclear Hydrocarbons**

**(08 Lectures)**

Reactions of naphthalene phenanthrene and anthracene Structure, Preparation and structure elucidation and important derivatives of naphthalene and anthracene; Polynuclear hydrocarbons.

**UNIT 3: Heterocyclic Compounds**

**(22 Lectures)**

Classification and nomenclature, Structure, aromaticity in 5-membered and 6-membered rings containing one heteroatom; Synthesis, reactions and mechanism of substitution reactions of: Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine

(Hantzsch synthesis), Pyrimidine, Structure elucidation of indole, Fischer indole synthesis and Madelung synthesis), Structure elucidation of quinoline and isoquinoline, Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner- Miller synthesis, Bischler-Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch reaction. Derivatives of furan: Furfural and furoic acid.

#### **UNIT 4: Alkaloids**

**(06 Lectures)**

Natural occurrence, General structural features, Isolation and their physiological action.

Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation and synthesis of Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine.

#### **UNIT 5: Terpenes**

**(06 Lectures)**

Occurrence, classification, isoprene rule; Elucidation of structure and synthesis of Citral, Neral and  $\alpha$ -terpineol.

#### **Reference Books:**

1. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. *Organic Chemistry (Volume 1)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar, I. L. *Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Acheson, R.M. *Introduction to the Chemistry of Heterocyclic compounds*, John Welly & Sons (1976).
5. Graham Solomons, T.W. *Organic Chemistry*, John Wiley & Sons, Inc.
6. Kalsi, P. S. *Textbook of Organic Chemistry 1<sup>st</sup> Ed.*, New Age International (P) Ltd. Pub.
7. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry*, Oxford University Press.
8. Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, Prajati Parakashan (2010).

**SEMESTER-IV**  
**CORE COURSE (HONOURS IN CHEMISTRY)**  
**PAPER: CHE-H-C-410-T**  
**PHYSICAL CHEMISTRY-IV**

**Credits: Theory-04, Practical – 02**

**Theory: 60 Lectures.**

**Marks: 15 (MSE) + 60 (ESE) = 75**

**Pass Marks: (MSE: 06 +ESE: 24) = 30**

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*Instruction to Question Setter for*

*Mid Semester Examination (MSE):  $1\frac{1}{2}$  Hrs.*

*The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks. There will be three questions of 5 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 05 marks.*

*(Attendance: Upto 75% = 1 mark; 75-80% = 1.5 marks; 80-85% = 2 marks; 85-90% = 2.5 marks; >90% = 3 marks)*

*End Semester Examination (ESE): 3 Hrs.*

*There will be two groups of questions. Group A is compulsory and will contain two questions. Q. No. 1(A) will be multiple type six questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 3 marks. Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to be answered.*

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**UNIT 1: Conductance**

**(20 Lectures)**

Arrhenius theory of electrolytic dissociation. Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Kohlrausch law of independent migration of ions. Debye-Hückel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rules.

Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants of salts.

**UNIT 2: Electrochemistry**

**(28 Lectures)**

Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry.

Chemical cells, reversible and irreversible cells with examples. Electromotive force of a cell and its

measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF measurements in determining

(i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone, glass and  $\text{SbO/Sb}_2\text{O}_3$  electrodes.

Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation).

### **UNIT 3: Electrical & Magnetic Properties of Atoms and Molecules**

**12 Lecture**

Basic ideas of electrostatics, Electrostatics of dielectric media, Clausius-Mosotti equation, Lorenz-Laurentz equation, Dipole moment and molecular polarizabilities and their measurements. Diamagnetism, paramagnetism, magnetic susceptibility and its measurement, molecular interpretation.

#### **Reference Books:**

1. Atkins, P.W & Paula, J.D. Physical Chemistry, 9<sup>th</sup> Ed., Oxford University Press (2011).
2. Castellan, G. W. Physical Chemistry 4<sup>th</sup> Ed., Narosa (2004).
3. Mortimer, R. G. Physical Chemistry 3<sup>rd</sup> Ed., Elsevier: NOIDA, UP (2009).
4. Barrow, G. M., Physical Chemistry 5<sup>th</sup> Ed., Tata McGraw Hill: New Delhi (2006).
5. Engel, T. & Reid, P. Physical Chemistry 3<sup>rd</sup> Ed., Prentice-Hall (2012).
6. Rogers, D. W. Concise Physical Chemistry Wiley (2010).
7. Silbey, R. J.; Alberty, R. A. & Bawendi, M. G. Physical Chemistry 4<sup>th</sup> Ed., John Wiley & Sons, Inc. (2005).

**SEMESTER - IV**  
**CORE COURSE (HONOURS IN CHEMISTRY)**  
**PAPER: CHE-H-C-408 & 409 & 410-P**  
**CHEMISTRY LAB (PRACTICAL)**

**Credits:** 02+02+02 = 06 Credits

**Full Marks:** 15 (MSE) + 60 (ESE) = 75

**Pass Marks:** (MSE: 06 + ESE: 24) = 30

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*Instruction to Question Setter for*

*Mid Semester Examination (MSE): 03 Hrs.*

*The Mid Semester Examination shall have one components: One Semester Internal Assessment Test (SIA).*

*Distribution of Marks: Two experiments = 10 marks, Practical record/note book = 2.5 marks, Viva-voce = 2.5 marks*

*End Semester Examination (ESE): 03 Hrs.*

*Three experiments (questions) will be set (one from each group) each of 40 marks out of which one is to be answered.*

*Evaluation of Practical Examination may be as per the following guidelines:*

*Experiment = 40 marks*

*Practical record notebook = 10 marks*

*Viva-voce = 10 marks*

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**GROUP “A”**  
**PAPER: CHE-H-C-408-P**  
**INORGANIC CHEMISTRY-III LAB**  
**(60 Lectures)**

**Gravimetric Analysis:**

- i. Estimation of nickel (II) using Dimethylglyoxime (DMG).
- ii. Estimation of copper as CuSCN
- iii. Estimation of iron as Fe<sub>2</sub>O<sub>3</sub> by precipitating iron as Fe(OH)<sub>3</sub>.
- iv. Estimation of Al (III) by precipitating with oxine and weighing as Al(oxine)<sub>3</sub> (aluminium oxinate).

**Inorganic Preparations:**

- i. Tetraamminecopper (II) sulphate, [Cu(NH<sub>3</sub>)<sub>4</sub>]SO<sub>4</sub>.H<sub>2</sub>O
- ii. *Cis* and *trans* K[Cr(C<sub>2</sub>O<sub>4</sub>)<sub>2</sub>. (H<sub>2</sub>O)<sub>2</sub>] Potassium dioxalatodiaquachromate (III)
- iii. Tetraamminecarbonatocobalt (III) ion
- iv. Potassium tris(oxalate)ferrate(III)

**Chromatography of metal ions**

Principles involved in chromatographic separations. Paper chromatographic

separation of following metal ions:

- i. Ni (II) and Co (II)
- ii. Fe (III) and Al (III)

**GROUP “B”**

**PAPER: CHE-H-C-409-P**

**ORGANIC CHEMISTRY-III LAB**

**(60 Lectures)**

1. Detection of extra elements.
2. Functional group test for nitro, amine and amide groups.
3. Qualitative analysis of unknown organic compounds containing simple functional groups (alcohols, carboxylic acids, phenols and carbonyl compounds)

**GROUP “C”**

**PAPER: CHE-H-C-410-P**

**PHYSICAL CHEMISTRY-III LAB**

**(60 Lectures)**

**Conductometry**

- I. Determination of cell constant
- II. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
- III. Perform the following conductometric titrations:
  - i. Strong acid vs. strong base
  - ii. Weak acid vs. strong base
  - iii. Mixture of strong acid and weak acid vs. strong base
  - iv. Strong acid vs. weak base

**Potentiometry**

- I perform the following potentiometric titrations:
  - i. Strong acid vs. strong base
  - ii. Weak acid vs. strong base
  - iii. Dibasic acid vs. strong base
  - iv. Potassium dichromate vs. Mohr's salt

**Reference Book:**

1. Vogel, A.I. A text book of Quantitative Analysis, ELBS 1986.

2. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2011).
3. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8<sup>th</sup> Ed.*; McGraw-Hill: New York (2003).
4. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3<sup>rd</sup> Ed.*; W.H. Freeman & Co.: New York (2003).

**SEMESTER-III**  
**CORE COURSE (HONOURS IN CHEMISTRY)**  
**PAPER: CHE-H-SEC-402-T**  
**Skill Enhancement Course-2**

**Credits: 02**

**Theory: 30 Lectures.**

**Marks: 10 (MSE :) + 40 (ESE) = 50**

**Pass Marks: (MSE: 04 +ESE: 16) = 20**

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*Instruction to Question Setter for*

*Mid Semester Examination (MSE):  $1\frac{1}{2}$  Hrs.*

*The Mid Semester Examination shall have one components: One Semester Internal Assessment Test (SIA) of 10 Marks.*

*End Semester Examination (ESE): 3 Hrs.*

*There will be two groups of questions. Five Questions to be answered out of Nine Questions. Group A is compulsory and will contain two questions. Question No.1 (A) will be MCQ of 1 mark each (four questions). Question No.1 (B) will be short answer type to be answered in about 50 words of 2 marks (2 Questions). Group B will contain descriptive type eight questions of eight marks each, out of which any four are to answer. Each question carries 08 marks.*

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**One Subject to be opted other than the Honours and Generic Elective Subject. Refer Annexure-01 and for Content in detail refer the University website of BBMKU, Dhanbad, Jharkhand.**



**GENERIC ELECTIVE-04  
PAPER: XYZ-H-GE-404-T**

**(For Non Practical Subject)**

**Credits: Theory-06**

**60 Lectures & 15 Tutorials)**

**Marks: 20 (MSE) + 80 (ESE) = 100**

**Pass Marks: (MSE: 08 +ESE: 32) = 40**

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**For Practical Subject**

**PAPER: XYZ-H-GE-404-T**

**Credits: Theory-04**

**60 Lectures**

**Marks: 20 (MSE) + 80 (ESE) =75**

**Pass Marks: (MSE: 08 +ESE: 32) = 40**

**&**

**Credits: Practical -02**

**30 Lectures**

**Marks: 05 (MSE) + 20 (ESE) =25**

**Pass Marks: (MSE: 02 +ESE: 08) = 10**

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**One Subject to be opted other than the Honours Subject. Refer Table A-03 and for Content in detail refer the Syllabus of Opted Generic Elective Subject.**

**SEMESTER-V**  
**CORE COURSE (HONOURS IN CHEMISTRY)**  
**PAPER: CHE-H-C-511-T**  
**ORGANIC CHEMISTRY-IV**

**Credits: Theory-04, Practical – 02**

**Theory: 60 Lectures.**

**Marks: 15 (MSE) + 60 (ESE) = 75**

**Pass Marks: (MSE: 06 +ESE: 24) = 30**

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*Instruction to Question Setter for*

*Mid Semester Examination (MSE): 1  $\frac{1}{2}$  Hrs.*

*The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks. There will be three short types' questions of 5 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 05 marks.*

*(Attendance: Upto 75% = 1 mark; 75-80% = 2 marks; 80-85% = 3 marks; 85-90% = 4 marks; >90% = 5 marks)*

*End Semester Examination (ESE): 3 Hrs.*

*There will be two groups of questions. Group A is compulsory and will contain two questions. Q. No. 1(A) will be multiple type six questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 3 marks. Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to be answered.*

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**UNIT 1: Nucleic Acids**

**(12 Lectures)**

Components of nucleic acids, Nucleosides and Nucleotides; Structure, synthesis and reactions of: Adenine, Guanine, Cytosine, Uracil and Thymine; Structure of polynucleotides.

**UNIT 2: Amino Acids, Peptides and Proteins**

**(14 Lectures)**

Amino acids, Peptides and their classification.

$\alpha$ -Amino Acids - Synthesis, ionic properties and reactions. Zwitterions,  $pK_a$  values, isoelectric point and electrophoresis;

Study of peptides: determination of their primary structures-end group analysis, methods of peptide synthesis. Synthesis of peptides using N-protecting, C-protecting and C-activating groups -Solid-phase synthesis

**UNIT 3: Enzymes**

**(12 Lectures)**

Introduction, classification and characteristics of enzymes. Salient features of active site of enzymes.

Mechanism of enzyme action (taking trypsin as example), factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, specificity of enzyme action

(including stereospecificity), enzyme inhibitors and their importance, phenomenon of inhibition (competitive, uncompetitive and non-competitive inhibition including allosteric inhibition).

**UNIT 4: Lipids**

**(10 Lectures)**

Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenation of fats and oils, Saponification value, acid value, iodine number. Reversion and rancidity.

**UNIT 5: Pharmaceutical Compounds: Structure and Importance**

**(12 Lectures)**

Classification, structure and therapeutic uses of antipyretics: Paracetamol (with synthesis), Analgesics: Ibuprofen (with synthesis), Antimalarial: Chloroquine (with synthesis). An elementary treatment of Antibiotics and detailed study of chloramphenicol, Medicinal values of curcumin (haldi), azadirachtin (neem), vitamin C and antacid (ranitidine).

**Reference Books:**

1. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2006) Biochemistry. VIth Edition. W.H. Freeman and Co.
2. Nelson, D.L., Cox, M.M. and Lehninger, A.L. (2009) Principles of Biochemistry. IV Edition. W.H. Freeman and Co.
3. Murray, R.K., Granner, D.K., Mayes, P.A. and Rodwell, V.W. (2009) Harper's Illustrated Biochemistry. XXVIII edition. Lange Medical Books/ McGraw-Hill.

**SEMESTER-V**  
**CORE COURSE (HONOURS IN CHEMISTRY)**  
**PAPER: CHE-H-C-512-T**  
**PHYSICAL CHEMISTRY-V**

**Credits: Theory-04, Practical – 02**

**Theory: 60 Lectures.**

**Marks: 15 (MSE) + 60 (ESE) = 75**

**Pass Marks: (MSE: 06 +ESE: 24) = 30**

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*Instruction to Question Setter for*

*Mid Semester Examination (MSE):  $1\frac{1}{2}$  Hrs.*

*The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks. There will be three short types' questions of 5 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 03 marks.*

*(Attendance: Upto 75% = 1 mark; 75-80% = 2 marks; 80-85% = 3 marks; 85-90% = 4 marks; >90% = 5 marks)*

*End Semester Examination (ESE): 3 Hrs.*

*There will be two groups of questions. Group A is compulsory and will contain two questions. Q. No. 1(A) will be multiple type six questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 3 marks. Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to be answered.*

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**UNIT 1: Quantum Chemistry**

**(24 Lectures)**

Postulates of quantum mechanics, quantum mechanical operators, Schrödinger equation and its application to free particle and "particle-in-a-box" (rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wave functions, probability distribution functions, nodal properties, Extension to two and three dimensional boxes, separation of variables, degeneracy.

Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrödinger equation and discussion of solution and wave functions. Vibrational energy of diatomic molecules and zero-point energy.

Angular momentum: Commutation rules, quantization of square of total angular momentum and z- component.

Rigid rotator model of rotation of diatomic molecule. Schrödinger equation, transformation to spherical polar coordinates. Separation of variables. Spherical harmonics. Discussion of solution.

Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of schrödinger equation in spherical polar coordinates, radial part, and quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus.

Setting up of Schrödinger equation for many-electron atoms (He, Li). Need for approximation methods. Statement of variation theorem and application to simple systems (particle-in-a-box, harmonic oscillator, hydrogen atom).

Chemical bonding: Covalent bonding, valence bond and molecular orbital approaches, LCAO-MO treatment of  $\text{H}_2^+$ . Bonding and antibonding orbitals. Qualitative extension to  $\text{H}_2$ . Comparison of LCAO-MO and VB treatments of  $\text{H}_2$  (only wave functions, detailed solution not required) and their limitations. Refinements of the two approaches (Configuration Interaction for MO, ionic terms in VB). Qualitative description of LCAO-MO treatment of mononuclear and heteronuclear diatomic molecules (HF, LiH). Localized and non-localized molecular orbitals treatment of triatomic ( $\text{BeH}_2$ ,  $\text{H}_2\text{O}$ ) molecules. Qualitative MO theory and its application to  $\text{AH}_2$  type molecules.

## **UNIT 2: Molecular Spectroscopy**

**(24 Lectures)**

Interaction of electromagnetic radiation with molecules and various types of spectra; Born-Oppenheimer approximation.

Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.

Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies. Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches.

Raman spectroscopy: Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.

Electronic spectroscopy: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation, calculation of electronic transitions of polyenes using free electron model.

Nuclear Magnetic Resonance (NMR) spectroscopy: Principles of NMR spectroscopy, Larmor precession, chemical shift and low resolution spectra, different scales, spin-spin coupling and high resolution spectra, interpretation of PMR spectra of organic molecules.

Electron Spin Resonance (ESR) spectroscopy: Its principle, hyperfine structure, ESR of simple

radicals.

### **UNIT 3: Photochemistry**

**(12 Lectures)**

Characteristics of electromagnetic radiation, Lambert-Beer's law and its limitations, physical significance of absorption coefficients. Laws, of photochemistry, quantum yield, actinometry, examples of low and high quantum yields, photochemical equilibrium and the differential rate of photochemical reactions, photosensitised reactions, quenching. Role of photochemical reactions in biochemical processes, photostationary states, chemiluminescence.

#### **Reference Books:**

1. Banwell, C. N. & McCash, E. M. Fundamentals of Molecular Spectroscopy 4<sup>th</sup> Ed. Tata McGraw- Hill: New Delhi (2006).
2. Chandra, A. K. Introductory Quantum Chemistry Tata McGraw-Hill (2001).
3. House, J. E. Fundamentals of Quantum Chemistry 2<sup>nd</sup>Ed. Elsevier: USA (2004).
4. Lowe, J. P. & Peterson, K. Quantum Chemistry, Academic Press (2005).
5. Kakkar, R. Atomic & Molecular Spectroscopy, Cambridge University Press (2015).

**SEMESTER - V**  
**CORE COURSE (HONOURS IN CHEMISTRY)**  
**PAPER: CHE-H-C-511 & 512-P**  
**CHEMISTRY LAB (PRACTICAL)**

**Credits: (02+02) = 04**

**60×2=120 Lectures**

**Marks: 10 (MSE) + 40 (ESE) = 50**

**Pass Marks: (MSE: 04 +ESE: 16) = 20**

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*Instruction to Question Setter for*

*Mid Semester Examination (MSE): 3 Hrs.*

*The Mid Semester Examination shall have one components: One Semester Internal Assessment Test (SIA) of 10 Marks.*

*Distribution of Marks: One experiment = 06 marks, Practical record/note book = 2 marks, Viva-voce = 02 marks*

*End Semester Examination (ESE): 3 Hrs.*

*Two experiments (questions) will be set (one from each group) each of 24 marks out of which one is to be answered.*

*Evaluation of Practical Examination may be as per the following guidelines:*

*Experiment = 24 marks*

*Practical record notebook = 08 marks*

*Viva-voce = 08 marks*

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**GROUP "A"**  
**PAPER: CHE-H-C-511-P**  
**ORGANIC CHEMISTRY-IV LAB**  
**(60 Lectures)**

1. Estimation of glycine by Sorenson's formalin method.
2. Study of the titration curve of glycine.
3. Estimation of proteins by Lowry's method.
4. Study of the action of salivary amylase on starch at optimum conditions.
5. Effect of temperature on the action of salivary amylase.
6. Saponification value of an oil or a fat.
7. Determination of Iodine number of an oil/ fat.
8. Isolation and characterization of DNA from onion/ cauliflower/peas.

**GROUP "B"**  
**PAPER: CHE-H-C-512-P**  
**ORGANIC CHEMISTRY-IV LAB**  
**(60 Lectures)**

**UV/Visible spectroscopy**

- I. Study the 200-500 nm absorbance spectra of KMnO<sub>4</sub> and K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> (in 0.1 M H<sub>2</sub>SO<sub>4</sub>) and

determine the  $\lambda_{\text{max}}$  values. Calculate the energies of the two transitions in different units ( $\text{J molecule}^{-1}$ ,  $\text{kJ mol}^{-1}$ ,  $\text{cm}^{-1}$ ,  $\text{eV}$ ).

- II. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of  $\text{K}_2\text{Cr}_2\text{O}_7$ .
- III. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.

### **Colourimetry**

- I. Verify Lambert-Beer's law and determine the concentration of  $\text{CuSO}_4/\text{KMnO}_4/\text{K}_2\text{Cr}_2\text{O}_7$  in a solution of unknown concentration
- II. Determine the concentrations of  $\text{KMnO}_4$  and  $\text{K}_2\text{Cr}_2\text{O}_7$  in a mixture.
- III. Study the kinetics of iodination of propanone in acidic medium.
- IV. Determine the amount of iron present in a sample using 1,10-phenanthroline.
- V. Determine the dissociation constant of an indicator (phenolphthalein).
- VI. Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium hydroxide.
- VII. Analysis of the given vibration-rotation spectrum of  $\text{HCl(g)}$

### **Reference Books:**

- 1. Manual of Biochemistry Workshop, 2012, Department of Chemistry, University of Delhi.
- 2. Arthur, I. V. *Quantitative Organic Analysis*, Pearson.
- 3. Khosla, B. D.; Garg, V. C. & Gulati, A., *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2011).
- 4. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry* 8<sup>th</sup> Ed.; McGraw-Hill: New York (2003).
- 5. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry* 3<sup>rd</sup> Ed.; W.H. Freeman & Co.: New York (2003).



**SEMESTER-V**  
**(DSE-01A)**  
**PAPER: CHE-H-DSE-501 A –T**  
**ANALYTICAL METHODS IN CHEMISTRY**

**Credits: Theory-04, Practical – 02**

**Theory: 60 Lectures.**

**Marks: 15 (MSE) + 60 (ESE) = 75**

**Pass Marks: (MSE: 06 +ESE: 24) = 30**

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*Instruction to Question Setter for*

*Mid Semester Examination (MSE): 1  $\frac{1}{2}$  Hrs.*

*The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks. There will be three questions of 5 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 05 marks.*

*(Attendance: Upto 75% = 1 mark; 75-80% = 2 marks; 80.-85% = 3 marks; 85-90% = 4 marks; >90% = 5 marks)*

*End Semester Examination (ESE): 3 Hrs.*

*There will be two groups of questions. **Group A is compulsory** and will contain two questions. Q. No. 1(A) will be multiple type six questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 3 marks. **Group B will contain descriptive type eight** questions of twelve marks each, out of which any four are to be answered.*

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**UNIT 1: Qualitative and quantitative aspects of analysis**

**(05 Lectures)**

Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution of indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals.

**UNIT 2: Optical methods of analysis**

**(25 Lectures)**

Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law.

**UV-Visible Spectrometry:** Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument.

**Basic principles of quantitative analysis:** estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers. Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method.

**Infrared Spectrometry:** Basic principles of instrumentation (choice of source, monochromator & detector) for single and double beam instrument; sampling techniques.

Structural illustration through interpretation of data, Effect and importance of isotope substitution.

**Flame Atomic Absorption and Emission Spectrometry:** Basic principles of instrumentation (choice of source, monochromator, detector, choice of flame and Burner designs. Techniques of atomization and sample introduction; Method of background correction, sources of chemical interferences and their method of removal. Techniques for the quantitative estimation of trace

level of metal ions from water samples.

**UNIT 3: Thermal methods of analysis:**

**(05 Lectures)**

Theory of thermogravimetry (TG), basic principle of instrumentation. Techniques for quantitative estimation of Ca and Mg from their mixture.

**UNIT 4: Electroanalytical method**

**(10 Lectures)**

Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Techniques used for the determination of pK<sub>a</sub> values.

**UNIT 5: Separation techniques**

**(15 Lectures)**

Solvent extraction: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation.

Technique of extraction: batch, continuous and counter current extractions.

Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and nonaqueous media.

Chromatography: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange.

Development of chromatograms: frontal, elution and displacement methods.

Qualitative and quantitative aspects of chromatographic methods of analysis: IC, GLC, GPC, TLC and HPLC.

Stereoisomeric separation and analysis: Measurement of optical rotation, calculation of Enantiomeric excess (ee)/ diastereomeric excess (de) ratios and determination of enantiomeric composition using NMR, Chiral solvents and chiral shift reagents. Chiral chromatographic techniques using chiral columns (GC and HPLC).

Role of computers in instrumental methods of analysis.

**Reference Books:**

1. Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G.H. Jeffery and others) 5<sup>th</sup> Ed. The English Language Book Society of Longman .
2. Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7<sup>th</sup> Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
3. Christian, Gary D; Analytical Chemistry, 6<sup>th</sup> Ed. John Wiley & Sons, New York, 2004.
4. Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.
5. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.
6. Skoog, D.A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Thomson Asia Pvt. Ltd. Singapore.

**SEMESTER-V**  
**(DSE-01A: PRACTICAL)**

**PAPER: CHE-H-DSE-501 A-P**

**PRACTICALS- DSE LAB: ANALYTICAL METHODS IN CHEMISTRY**

**Credits: 02 Credits**

**60 Lectures**

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**I. Separation Techniques**

**1. Chromatography:**

**(a) Separation of mixtures**

(i) Paper chromatographic separation of  $\text{Fe}^{3+}$ ,  $\text{Al}^{3+}$ , and  $\text{Cr}^{3+}$ .

(ii) Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the  $R_f$  values.

(b) Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their  $R_f$  values.

(c) Chromatographic separation of the active ingredients of plants, flowers and juices by TLC

**II. Solvent Extractions:**

(i) To separate a mixture of  $\text{Ni}^{2+}$  &  $\text{Fe}^{2+}$  by complexation with DMG and extracting the  $\text{Ni}^{2+}$ - DMG complex in chloroform, and determine its concentration by spectrophotometry.

(ii) Solvent extraction of zirconium with amberlite LA-1, separation from a mixture of irons and gallium.

3. Determine the pH of the given aerated drinks fruit juices, shampoos and soaps.

4. Determination of Na, Ca, and Li in cola drinks and fruit juices using flame photometric techniques.

**5. Analysis of soil:**

(i) Determination of pH of soil.

(ii) Total soluble salt

(iii) Estimation of calcium, magnesium, phosphate, nitrate

**6. Ion exchange:**

(i) Determination of exchange capacity of cation exchange resins and anion exchange resins.

(ii) Separation of metal ions from their binary mixture.

(iii) Separation of amino acids from organic acids by ion exchange chromatography.

### **III Spectrophotometry**

1. Determination of  $pK_a$  values of indicator using spectrophotometry.
2. Structural characterization of compounds by infrared spectroscopy.
3. Determination of dissolved oxygen in water.
4. Determination of chemical oxygen demand (COD).
5. Determination of Biological oxygen demand (BOD).
6. Determine the composition of the Ferric-salicylate/ ferric-thiocyanate complex by Job's method.

#### **Reference Books:**

- 1 Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G.H. Jeffery and others) 5<sup>th</sup> Ed. The English Language Book Society of Longman.
2. Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7<sup>th</sup> Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
3. Christian, Gary D; Analytical Chemistry, 6<sup>th</sup> Ed. John Wiley & Sons, New York, 2004.
4. Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.
5. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.

## SEMESTER-V

### (DSE-01B)

#### PAPER: CHE-H-DSE-501 B –T

#### APPLICATIONS OF COMPUTERS IN CHEMISTRY

**Credits: Theory-04, Practical – 02**

**Theory: 60 Lectures.**

**Marks: 15 (MSE) + 60 (ESE) = 75**

**Pass Marks: (MSE: 06 +ESE: 24) = 30**

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##### *Instruction to Question Setter for*

**Mid Semester Examination (MSE):  $1\frac{1}{2}$  Hrs.**

The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks. There will be three questions of 5 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 05 marks.

(Attendance: Upto 75% = 1 mark; 75-80% = 2 marks; 80.-85% = 3 marks; 85-90% = 4 marks; >90% = 5 marks)

**End Semester Examination (ESE): 3 Hrs.**

There will be two groups of questions. **Group A is compulsory** and will contain two questions. Q. No. 1(A) will be multiple type six questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 3 marks. **Group B will contain descriptive type eight** questions of twelve marks each, out of which any four are to be answered.

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##### **Basics:**

Constants, variables, bits, bytes, binary and ASCII formats, arithmetic expressions, hierarchy of operations, inbuilt functions. Elements of the BASIC language. BASIC keywords and commands. Logical and relative operators. Strings and graphics. Compiled versus interpreted languages. Debugging. Simple programs using these concepts. Matrix addition and multiplication. Statistical analysis.

##### **Numerical methods:**

*Roots of equations:* Numerical methods for roots of equations: Quadratic formula, iterative method, Newton-Raphson method, Binary bisection and Regula-Falsi.

*Differential calculus:* Numerical differentiation.

*Integral calculus:* Numerical integration (Trapezoidal and Simpson's rule), probability distributions and mean values.

*Simultaneous equations:* Matrix manipulation: addition, multiplication. Gauss-Siedal method.

*Interpolation, extrapolation and curve fitting:* Handling of experimental data.

*Conceptual background of molecular modelling:* Potential energy surfaces. Elementary ideas of molecular mechanics and practical MO methods.

##### **Reference Books:**

1. Harris, D. C. *Quantitative Chemical Analysis*. 6<sup>th</sup> Ed., Freeman (2007) Chapters 3-5.
2. Levie, R. de, *How to use Excel in analytical chemistry and in general scientific data*

*analysis*, Cambridge Univ. Press (2001) 487 pages.

3. Noggle, J. H. *Physical chemistry on a Microcomputer*. Little Brown & Co. (1985).

4. Venit, S.M. *Programming in BASIC: Problem solving with structure and style*. Jaico Publishing House: Delhi (1996).

**SEMESTER-V**  
**(DSE-01B: PRACTICAL)**

**PAPER: CHE-H-DSE-501 B-P**

**PRACTICAL-DSE LAB: APPLICATIONS OF COMPUTERS IN CHEMISTRY**

**Credits: 02 Credits**

**60 Lectures**

Computer programs based on numerical methods for

1. Roots of equations: (e.g. volume of van der Waals gas and comparison with ideal gas, pH of a weak acid).
2. Numerical differentiation (e.g., change in pressure for small change in volume of a van der Waals gas, potentiometric titrations).
3. Numerical integration (e.g. entropy/ enthalpy change from heat capacity data), probability distributions (gas kinetic theory) and mean values.
4. Matrix operations. Application of Gauss-Siedel method in colourimetry.
5. Simple exercises using molecular visualization software.

**Reference Books:**

1. McQuarrie, D. A. *Mathematics for Physical Chemistry* University Science Books (2008).
2. Mortimer, R. *Mathematics for Physical Chemistry*. 3<sup>rd</sup> Ed. Elsevier (2005).
3. Steiner, E. *The Chemical Maths Book* Oxford University Press (1996).
4. Yates, P. *Chemical Calculations*. 2<sup>nd</sup> Ed. CRC Press (2007).
5. Harris, D. C. *Quantitative Chemical Analysis*. 6<sup>th</sup> Ed., Freeman (2007) Chapters 3-5.
6. Levie, R. de, *How to use Excel in analytical chemistry and in general scientific data analysis*, Cambridge Univ. Press (2001) 487 pages.
7. Noggle, J. H. *Physical Chemistry on a Microcomputer*. Little Brown & Co. (1985).
8. Venit, S.M. *Programming in BASIC: Problem solving with structure and style*. Jaico Publishing House: Delhi (1996).

## SEMESTER-V

### (DSE-01C)

#### PAPER: CHE-H-DSE-501 C –T

#### Nanoscale Materials and Their Applications

**Credits: Theory-04, Practical – 02**

**Theory: 60 Lectures.**

**Marks: 15 (MSE) + 60 (ESE) = 75**

**Pass Marks: (MSE: 06 +ESE: 24) = 30**

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#### *Instruction to Question Setter for*

**Mid Semester Examination (MSE):  $1\frac{1}{2}$  Hrs.**

The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks. There will be three questions of 5 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 05 marks.

(Attendance: Upto 75% = 1 mark; 75-80% = 2 marks; 80.-85% = 3 marks; 85-90% = 4 marks; >90% = 5 marks)

**End Semester Examination (ESE): 3 Hrs.**

There will be **two** groups of questions. **Group A is compulsory** and will contain two questions. Q. No. 1(A) will be multiple type six questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 3 marks. **Group B will contain descriptive type eight** questions of twelve marks each, out of which any four are to be answered.

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#### **UNIT 1: Introduction to nanodimensions**

**(10 Lectures)**

0D, 1D, 2D nanomaterials, Quantum Dots, Nanoparticles, Nanostructures (nanowires, thin films, nanorods), carbon nanostructures (carbon nanotubes, carbon nanofibers, fullerenes), Size Effects in nano systems, Quantum confinement and its consequences, Semiconductors. Band structure and band gap.

#### **UNIT 2: Preparation of nanomaterials**

**(08 Lectures)**

Top down and Bottom up approach, Photolithography. Ball milling. Vacuum deposition. Physical vapor deposition (PVD), Chemical vapor deposition (CVD), Thermal decomposition, Chemical reduction, Sol- Gel synthesis, hydrothermal synthesis, Spray pyrolysis, Electrochemical deposition, Pulsed Laser deposition.

#### **UNIT 3: Characterization techniques (Basic working principles and interpretation of experimental data using these techniques need to be covered)**

**(14 Lectures)**

UV-visible spectroscopy, X-ray diffraction (Powder and Single Crystal), Raman Spectroscopy, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Energy Dispersive X-ray Spectroscopy (EDX), X-ray Photoelectron Spectroscopy (XPS), Atomic Force Microscopy (AFM), Scanning Tunneling Microscopy (STM), Dynamic light scattering (DLS), Brunauer-Emmett-Teller (BET) Surface area measurement and Thermogravimetric analysis (TG).



**UNIT 4: Optical Properties**

**(08 Lectures)**

Surface plasmon resonance, Excitons in direct and indirect band gap semiconductor nanocrystals. Radiative processes: General absorption, emission and luminescence (fluorescence and photoluminescence).

**UNIT 5: Conducting properties**

**(06 Lectures)**

Carrier transport in nanostructures. Tunneling and hopping conductivity. Defects and impurities: Deep level and surface defects.

**UNIT 6: Applications**

**(14 Lectures)**

Nanomaterials as Catalysts, semiconductor nanomaterials as photocatalysts, Nanocomposites as catalysts.

Carbon nanostructures as catalytic nanoreactors, metal and metal oxides confined inside carbon nanostructures, Nanowires and thin films for photonic devices (LEDs, solar cells, transistors).

**SEMESTER-V**  
**(DSE-1C: PRACTICAL)**

**PAPER: CHE-H-DSE-501 C-P**

**PRACTICAL-DSE LAB: Nanoscale Materials and Their Applications**

**Credits: 02 Credits**

**60 Lectures**

*At least 04 experiments from the following:*

1. Synthesis of metal nanoparticles by chemical reduction method.
2. Synthesis of semiconductor nanoparticles.
3. Surface Plasmon study of metal nanoparticles by UV-Visible spectrophotometer.
4. XRD pattern of nanomaterials and estimation of particle size. (Students can be provided with XRD patterns of known materials and asked to interpret the data.)
5. To study the effect of size on color of nanomaterials.
6. To prepare composite of CNTs with other materials.
7. Growth of quantum dots by thermal evaporation.
8. Prepare a disc of ceramic of a compound using ball milling, pressing and sintering, and study its XRD.
9. Fabricate a thin film of nanoparticles by spin coating (or chemical route) and study transmittance spectra in UV-Visible region.

**References:**

1. West, A. R.(2014),**Solid State Chemistry and Its Application**, Wiley
2. Smart, L. E.; Moore, E. A.(2012),**Solid State Chemistry An Introduction**, CRC Press  
Taylor & Francis.
3. Rao, C. N. R.; Gopalakrishnan, J.(1997),**New Direction in Solid State Chemistry**,  
Cambridge University Press.
4. Poole, Jr.; Charles P.; Owens, Frank J.:(2003), **Introduction to Nanotechnology**, John Wiley  
and Sons.
5. Chattopadhyay, K.K.; Banerjee, A. N.(2009),**Introduction to Nanoscience and Technology**,  
PHI.

## SEMESTER-V

### (DSE-02A)

#### PAPER: CHE-H-DSE-502 A –T

#### INSTRUMENTAL METHODS OF CHEMICAL ANALYSIS

**Credits: Theory-04, Practical – 02**

**Theory: 60 Lectures.**

**Marks: 15 (MSE) + 60 (ESE) = 75**

**Pass Marks: (MSE: 06 +ESE: 24) = 30**

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##### *Instruction to Question Setter for*

**Mid Semester Examination (MSE):  $1\frac{1}{2}$  Hrs.**

The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks. There will be three questions of 5 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 05 marks.

(Attendance: Upto 75% = 1 mark; 75-80% = 2 marks; 80-85% = 3 marks; 85-90% = 4 marks; >90% = 5 marks)

**End Semester Examination (ESE): 3 Hrs.**

There will be two groups of questions. **Group A is compulsory** and will contain two questions. Q. No. 1(A) will be multiple type six questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 3 marks. **Group B will contain descriptive type eight** questions of twelve marks each, out of which any four are to be answered.

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#### **UNIT 2: Introduction to spectroscopic methods of analysis**

**(04 Lectures)**

Recap of the spectroscopic methods covered in detail in the core chemistry syllabus: Treatment of analytical data, including error analysis. Classification of analytical methods and the types of instrumental methods. Consideration of electromagnetic radiation.

#### **UNIT 2: Molecular spectroscopy:**

**(16 Lecture)**

##### **Infrared spectroscopy:**

Interactions with molecules: absorption and scattering. Means of excitation (light sources), separation of spectrum (wavelength dispersion, time resolution), detection of the signal (heat, differential detection), interpretation of spectrum (qualitative, mixtures, resolution), advantages of Fourier Transform (FTIR). Samples and results expected. Applications: Issues of quality assurance and quality control, Special problems for portable instrumentation and rapid detection.

**UV-Visible/ Near IR** – emission, absorption, fluorescence and photoacoustic. Excitation sources (lasers, time resolution), wavelength dispersion (gratings, prisms, interference filters, laser, placement of sample relative to dispersion, resolution), Detection of signal (photocells, photomultipliers, diode arrays, sensitivity and S/N), Single and Double Beam instruments, Interpretation (quantification, mixtures, absorption vs. fluorescence and the use of time, photoacoustic, fluorescent tags).

#### **UNIT 3: Separation techniques**

**(16 Lectures)**

**Chromatography:** Gas chromatography, liquid chromatography, supercritical fluids, Importance

of column technology (packing, capillaries), Separation based on increasing number of factors (volatility, solubility, interactions with stationary phase, size, electrical field), Detection: simple vs. specific (gas and liquid), Detection as a means of further analysis (use of tags and coupling to IR and MS), Electrophoresis (plates and capillary) and use with DNA analysis.

### **Immunoassays and DNA techniques**

**Mass spectroscopy:** Making the gaseous molecule into an ion (electron impact, chemical ionization), Making liquids and solids into ions (electrospray, electrical discharge, laser desorption, fast atom bombardment), Separation of ions on basis of mass to charge ratio, Magnetic, Time of flight, Electric quadrupole. Resolution, time and multiple separations, Detection and interpretation (how this is linked to excitation).

### **UNIT 4: Elemental analysis**

**(08 Lectures)**

Mass spectrometry (electrical discharges).

Atomic spectroscopy: Atomic absorption, Atomic emission, and Atomic fluorescence

Excitation and getting sample into gas phase (flames, electrical discharges, plasmas), Wavelength separation and resolution (dependence on technique), Detection of radiation (simultaneous/scanning, signal noise), Interpretation (errors due to molecular and ionic species, matrix effects, other interferences).

### **UNT 5: NMR spectroscopy**

**(04 Lectures)**

Principle, Instrumentation, Factors affecting chemical shift, Spin- coupling, Applications.

### **UNIT 6: Electroanalytical Methods:**

**(04 Lectures)**

Potentiometry & Voltammetry

### **UNIT 7: Radiochemical Methods**

**(04 Lectures)**

### **UNIT 8: X-ray analysis and electron spectroscopy (surface analysis)**

**(04 Lectures)**

### **Reference books:**

1. Principles of Instrumental Analysis - 6th Edition by Douglas A. Skoog, F. James Holler, and Stanley Crouch (ISBN 0-495-01201-7).
2. Instrumental Methods of Analysis, 7th ed, Willard, Merritt, Dean, Settle.
3. P.W. Atkins: Physical Chemistry.
4. G.W. Castellan: Physical Chemistry.
5. C.N. Banwell: Fundamentals of Molecular Spectroscopy.
6. Brian Smith: Infrared Spectral Interpretations: A Systematic Approach.
7. W.J. Moore: Physical Chemistry.

**SEMESTER-V**  
**(DSE-02A: PRACTICAL)**

**PAPER: CHE-H-DSE-502 A-P**

**PRACTICALS-DSE LAB: INSTRUMENTAL METHODS OF CHEMICAL ANALYSIS**

**Credits: 02 Credits**

**60 Lectures**

1. Safety Practices in the Chemistry Laboratory
2. Determination of the isoelectric pH of a protein.
3. Titration curve of an amino acid.
4. Determination of the void volume of a gel filtration column.
5. Determination of a Mixture of Cobalt and Nickel (UV/Vis spec.)
6. Study of Electronic Transitions in Organic Molecules (i.e., acetone in water)
7. IR Absorption Spectra (Study of Aldehydes and Ketones)
8. Determination of Calcium, Iron, and Copper in Food by Atomic Absorption
9. Quantitative Analysis of Mixtures by Gas Chromatography (i.e., chloroform and carbon tetrachloride)
10. Separation of Carbohydrates by HPLC
11. Determination of Caffeine in Beverages by HPLC
12. Potentiometric Titration of a Chloride-Iodide Mixture
13. Cyclic Voltammetry of the Ferrocyanide/Ferricyanide Couple
14. Nuclear Magnetic Resonance
15. Use of fluorescence to do “presumptive tests” to identify blood or other body fluids.
16. Use of “presumptive tests” for anthrax or cocaine
17. Collection, preservation, and control of blood evidence being used for DNA testing
18. Use of capillary electrophoresis with laser fluorescence detection for nuclear DNA (Y chromosome only or multiple chromosome)
19. Use of sequencing for the analysis of mitochondrial DNA
20. Laboratory analysis to confirm anthrax or cocaine
21. Detection in the field and confirmation in the laboratory of flammable accelerants or explosives
22. Detection of illegal drugs or steroids in athletes
23. Detection of pollutants or illegal dumping
24. Fibre analysis

*At least 10 experiments to be performed.*

**Reference Books:**

1. Principles of Instrumental Analysis - 6th Edition by Douglas A. Skoog, F. James Holler, and Stanley Crouch (ISBN 0-495-01201-7).
2. Instrumental Methods of Analysis, 7th ed, Willard, Merritt, Dean, Settle.

## SEMESTER-V

### (DSE-02B)

#### PAPER: CHE-H-DSE-502 B –T

#### POLYMER CHEMISTRY

**Credits: Theory-04, Practical – 02**

**Theory: 60 Lectures.**

**Marks: 15 (MSE) + 60 (ESE) = 75**

**Pass Marks: (MSE: 06 +ESE: 24) = 30**

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*Instruction to Question Setter for*

*Mid Semester Examination (MSE): 1  $\frac{1}{2}$  Hrs.*

*The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks. There will be three questions of 5 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 05 marks.*

*(Attendance: Upto 75% = 1 mark; 75-80% = 2 marks; 80.-85% = 3 marks; 85-90% = 4 marks; >90% = 5 marks)*

*End Semester Examination (ESE): 3 Hrs.*

*There will be two groups of questions. Group A is compulsory and will contain two questions. Q. No. 1(A) will be multiple type six questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 3 marks. Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to be answered.*

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#### **UNIT 1: Introduction and history of polymeric materials**

**(04 Lectures)**

Different schemes of classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers, Texture of Polymers.

#### **UNIT 2: Functionality and its importance**

**(08 Lectures)**

Criteria for synthetic polymer formation, classification of polymerization processes, Relationships between functionality, extent of reaction and degree of polymerization. Bi- functional systems, Poly-functional systems.

#### **UNIT 3: Kinetics of Polymerization:**

**(08 Lectures)**

Mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations, Mechanism and kinetics of copolymerization, polymerization techniques.

#### **UNIT 4: Crystallization and crystallinity**

**(04 Lectures)**

Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point.

#### **UNIT 5: Nature and structure of polymers**

**(10 Lectures)**

Structure Property relationships.

**Determination of molecular weight of polymers ( $M_n$ ,  $M_w$ , etc) by end group analysis, viscometry, light scattering and osmotic pressure methods. Molecular weight distribution and its**

significance. Polydispersity index.

**UNIT 6: Glass transition temperature (T<sub>g</sub>) and determination of T<sub>g</sub> (08 Lectures)**

Free volume theory, WLF equation, Factors affecting glass transition temperature (T<sub>g</sub>).

**UNIT 7: Polymer Solution (08 Lectures)**

Criteria for polymer solubility, Solubility parameter, Thermodynamics of polymer solutions, entropy, enthalpy, and free energy change of mixing of polymers solutions, Flory- Huggins theory, Lower and Upper critical solution temperatures.

**UNIT 8: Properties of Polymers (10 Lectures)**

(Physical, thermal, Flow & Mechanical Properties).

Brief introduction to preparation, structure, properties and application of the following polymers: polyolefins, polystyrene and styrene copolymers, poly(vinyl chloride) and related polymers, poly(vinyl acetate) and related polymers, acrylic polymers, fluoro polymers, polyamides and related polymers. Phenol formaldehyde resins (Bakelite, Novalac), polyurethanes, silicone polymers, polydienes,

Polycarbonates, Conducting Polymers, [polyacetylene, polyaniline, poly(p-phenylene sulphide polypyrrole, polythiophene)].

**Reference Books:**

1. Seymour's Polymer Chemistry, Marcel Dekker, Inc.
2. G. Odian: Principles of Polymerization, John Wiley.
3. F.W. Billmeyer: Text Book of Polymer Science, John Wiley.
4. P. Ghosh: Polymer Science & Technology, Tata Mcgraw-Hill.
5. R.W. Lenz: Organic Chemistry of Synthetic High Polymers.



**SEMESTER-V**  
**(DSE-02B: PRACTICAL)**  
**PAPER: CHE-H-DSE-502 B-P**  
**CHEMISTRY PRACTICAL - DSE LAB: POLYMER CHEMISTRY**

**Credits: 02 Credits**

**60 Lectures**

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**Polymer synthesis**

1. Free radical solution polymerization of styrene (St) / Methyl Methacrylate (MMA) / Methyl Acrylate (MA) / Acrylic acid (AA).
  - a. Purification of monomer
  - b. Polymerization using benzoyl peroxide (BPO) / 2,2'-azo-bis-isobutyronitrile (AIBN)
2. Preparation of nylon 66/6
3. Redox polymerization of acrylamide
4. Precipitation polymerization of acrylonitrile
5. Preparation of urea-formaldehyde resin
6. Preparations of novalac resin/resold resin.
7. Microscale Emulsion Polymerization of Poly (methylacrylate).

**Polymer characterization**

1. Determination of molecular weight by viscometry:
  - (a) Polyacrylamide-aq.  $\text{NaNO}_2$  solution
  - (b) (Poly vinyl propylidene (PVP) in water
2. Determination of the viscosity-average molecular weight of poly(vinyl alcohol) (PVOH) and the fraction of "head-to-head" monomer linkages in the polymer.
3. Determination of molecular weight by end group analysis: Polyethylene glycol (PEG) (OH group).
4. Testing of mechanical properties of polymers.
5. Determination of hydroxyl number of a polymer using colorimetric method.

**Polymer analysis**

1. Estimation of the amount of HCHO in the given solution by sodium sulphite method
2. Instrumental Techniques
3. IR studies of polymers
4. DSE analysis of polymers
5. Preparation of polyacrylamide and its electrophoresis

\*at least 7 experiments to be carried out.

**Reference Books:**

1. Malcolm P. Stevens, Polymer Chemistry: An Introduction, 3<sup>rd</sup> Ed.
2. Harry R. Allcock, Frederick W. Lampe and James E. Mark, Contemporary Polymer Chemistry, 3<sup>rd</sup> ed. Prentice-Hall (2003)
3. Fred W. Billmeyer, Textbook of Polymer Science, 3<sup>rd</sup> ed. Wiley-Interscience (1984)
4. Joel R. Fried, Polymer Science and Technology, 2<sup>nd</sup> ed. Prentice-Hall (2003)
5. Petr Munk and Tejraj M. Aminabhavi, Introduction to Macromolecular Science, 2<sup>nd</sup> ed. John Wiley & Sons (2002)
6. L. H. Sperling, Introduction to Physical Polymer Science, 4<sup>th</sup> ed. John Wiley & Sons (2005)
7. Malcolm P. Stevens, Polymer Chemistry: An Introduction, 3<sup>rd</sup> ed. Oxford University Press

## SEMESTER-V

### (DSE-02C)

#### PAPER: CHE-H-DSE-502 C –T

#### INORGANIC MATERIALS OF INDUSTRIAL IMPORTANCE

**Credits: Theory-04, Practical – 02**

**Theory: 60 Lectures.**

**Marks: 15 (MSE) + 60 (ESE) = 75**

**Pass Marks: (MSE: 06 +ESE: 24) = 30**

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##### *Instruction to Question Setter for*

**Mid Semester Examination (MSE):  $1\frac{1}{2}$  Hrs.**

The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks. There will be three questions of 5 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 05 marks.

(Attendance: Upto 75% = 1 mark; 75-80% = 2 marks; 80-85% = 3 marks; 85-90% = 4 marks; >90% = 5 marks)

**End Semester Examination (ESE): 3 Hrs.**

There will be two groups of questions. **Group A is compulsory** and will contain two questions. Q. No. 1(A) will be multiple type six questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 3 marks. **Group B will contain descriptive type eight** questions of twelve marks each, out of which any four are to be answered.

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#### **UNIT 1: Silicate Industries**

**(16 Lectures)**

**Glass:** Glassy state and its properties, classification (silicate and non-silicate glasses). Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armored glass, safety glass, borosilicate glass, fluorosilicate, coloured glass, photosensitive glass.

**Ceramics:** Important clays and feldspar, ceramic, their types and manufacture. High technology ceramics and their applications, superconducting and semiconducting oxides, fullerenes carbon nanotubes and carbon fibre.

**Cements:** Classification of cement, ingredients and their role, Manufacture of cement and the setting process, quick setting cements.

#### **UNIT 2: Fertilizers**

**(08 Lectures)**

Different types of fertilizers. Manufacture of the following fertilizers: Urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates; polyphosphate, superphosphate, compound and mixed fertilizers, potassium chloride, potassium sulphate.

Different types of fertilizers. Manufacture of the following fertilizers: Urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates; polyphosphate, superphosphate, compound and mixed fertilizers, potassium chloride, potassium sulphate.

#### **UNIT 3: Surface Coatings**

**(10 Lectures)**

Objectives of coatings surfaces, preliminary treatment of surface, classification of surface

coatings. Paints and pigments-formulation, composition and related properties. Oil paint, Vehicle, modified oils, Pigments, toners and lakes pigments, Fillers, Thinners, Enamels, emulsifying agents. Special paints (Heat retardant, Fire retardant, Eco-friendly paint, Plastic paint), Dyes, Wax polishing, Water and Oil paints, additives, Metallic coatings (electrolytic and electroless), metal spraying and anodizing.

#### **UNIT 4: Batteries**

**(06 Lectures)**

Primary and secondary batteries, battery components and their role, Characteristics of Battery. Working of following batteries: Pb acid, Li-Battery, Solid state electrolyte battery. Fuel cells, Solar cell and polymer cell.

#### **UNIT 5: Alloys**

**(10 Lectures)**

Classification of alloys, ferrous and non-ferrous alloys, Specific properties of elements in alloys. Manufacture of Steel (removal of silicon decarbonization, demanganization, desulphurization dephosphorisation) and surface treatment (argon treatment, heat treatment, nitriding, carburizing). Composition and properties of different types of steels.

#### **UNIT 6: Catalysis**

**(06 Lectures)**

General principles and properties of catalysts, homogenous catalysis (catalytic steps and examples) and heterogenous catalysis (catalytic steps and examples) and their industrial applications, Deactivation or regeneration of catalysts. Phase transfer catalysts, application of zeolites as catalysts.

#### **UNIT 7: Chemical explosives**

**(04 Lectures)**

Origin of explosive properties in organic compounds, preparation and explosive properties of lead azide, PETN, cyclonite (RDX). Introduction to rocket propellants.

#### **Reference Books:**

1. E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
2. R. M. Felder, R. W. Rousseau: *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.
3. W. D. Kingery, H. K. Bowen, D. R. Uhlmann: *Introduction to Ceramics*, Wiley Publishers, New Delhi.
4. J. A. Kent: *Riegel's Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
5. P. C. Jain, M. Jain: *Engineering Chemistry*, Dhanpat Rai & Sons, Delhi.
6. R. Gopalan, D. Venkappayya, S. Nagarajan: *Engineering Chemistry*, Vikas Publications, New Delhi.

**SEMESTER-V**  
**(DSE-02C: PRACTICAL)**

**PAPER: CHE-H-DSE-502 C-P**

**CHEMISTRY PRACTICAL - DSE LAB: INORGANIC MATERIALS OF INDUSTRIAL IMPORTANCE**

**Credits: 02 Credits**

**60 Lectures**

1. Determination of free acidity in ammonium sulphate fertilizer.
2. Estimation of Calcium in Calcium ammonium nitrate fertilizer.
3. Estimation of phosphoric acid in superphosphate fertilizer.
4. Electroless metallic coatings on ceramic and plastic material.
5. Determination of composition of dolomite (by complexometric titration).
6. Analysis of (Cu, Ni); (Cu, Zn ) in alloy or synthetic samples.
7. Analysis of Cement.
8. Preparation of pigment (zinc oxide).

**Reference Books:**

1. E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
2. R. M. Felder, R. W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
3. W. D. Kingery, H. K. Bowen, D. R. Uhlmann: Introduction to Ceramics, Wiley Publishers, New Delhi.
4. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
5. P. C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
6. R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, New Delhi.
7. B. K. Sharma: Engineering Chemistry, Goel Publishing House, Meerut

**SEMESTER-VI**  
**CORE COURSE (HONOURS IN CHEMISTRY)**  
**PAPER: CHE-H-C-613-T**  
**INORGANIC CHEMISTRY-IV**

**Credits: Theory-04, Practical – 02**

**Theory: 60 Lectures.**

**Marks: 15 (MSE: 1Hr) + 60 (ESE: 3Hrs) = 75**

**Pass Marks: (MSE: 06 +ESE: 24) = 30**

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*Instruction to Question Setter for*

*Mid Semester Examination (MSE):  $1\frac{1}{2}$  Hrs.*

*The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 12 Marks. There will be three short types' questions of 5 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 03 marks.*

*(Attendance: Upto 75% = 1 mark; 75-80% = 1.5 marks; 80.-85% = 2 marks; 85-90% = 2.5 marks; >90% = 3 marks)*

*End Semester Examination (ESE): 3 Hrs.*

*There will be two groups of questions. Group A is compulsory and will contain two questions. Q. No. 1(A) will be multiple type six questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 3 marks. Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to be answered.*

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**UNIT 1: Theoretical Principles in Qualitative Analysis (H<sub>2</sub>S Scheme) (10 Lectures)**

Basic principles involved in analysis of cations and anions, solubility products and common ion effect. Principles involved in separation of cations into groups and choice of group reagents.

Interfering anions (fluoride, borate, oxalate and phosphate) and need to remove them after Group II.

**UNIT 2: Organometallic Compounds (22 Lectures)**

Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands.

Metal carbonyls: 18 electron rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT.  $\pi$ -acceptor behavior of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding.

Zeise's salt: Preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls.

Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler – Natta Catalyst). Species present in ether solution of Grignard reagent and their structures, Schlenk equilibrium.

Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene.

**UNIT 3: Reaction Kinetics and Mechanism (18 Lecture)**

Introduction to inorganic reaction mechanisms. Substitution reactions in square planar complexes, Trans- effect, theories of trans effect, Mechanism of nucleophilic substitution in square planar complexes, Thermodynamic and Kinetic stability, Kinetics of octahedral substitution, Ligand field effects and reaction rates, Mechanism of substitution in octahedral complexes.

**UNIT 4: Catalysis by Organometallic Compounds (10 Lectures)**

Study of the following industrial processes and their mechanism:

1. Alkene hydrogenation (Wilkinson's Catalyst)
2. Hydroformylation (Co salts)
3. Wacker Process
4. Synthetic gasoline (Fischer Tropsch reaction)
5. Synthesis gas by metal carbonyl complexes

**SEMESTER-VI**  
**CORE COURSE (HONOURS IN CHEMISTRY)**  
**PAPER: CHE-H-C-614-T**  
**ORGANIC CHEMISTRY-V**

**Credits: Theory-04, Practical – 02**

**Theory: 60 Lectures.**

**Marks: 15 (MSE: 1Hr) + 60 (ESE: 3Hrs) = 75**

**Pass Marks: (MSE: 06 +ESE: 24) = 30**

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*Instruction to Question Setter for*

**Mid Semester Examination (MSE):  $1\frac{1}{2}$  Hrs.**

*The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 12 Marks. There will be three short types' questions of 5 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 03 marks.*

*(Attendance: Upto 75% = 1 mark; 75-80% = 1.5 marks; 80.-85% = 2 marks; 85-90% = 2.5 marks; >90% = 3 marks)*

**End Semester Examination (ESE): 3 Hrs.**

*There will be two groups of questions. Group A is compulsory and will contain two questions. Q. No. 1(A) will be multiple type six questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 3 marks. Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to be answered.*

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**UNIT 1: Organic Spectroscopy**

**(24 Lectures)**

General principles Introduction to absorption and emission spectroscopy.

**UV Spectroscopy:** Types of electronic transitions,  $\lambda_{\max}$ , Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; Application of Woodward Rules for calculation of  $\lambda_{\max}$  for the following systems:  $\alpha, \beta$  unsaturated aldehydes, ketones, carboxylic acids and esters; Conjugated dienes: alicyclic, homoannular and heteroannular; Extended conjugated systems (aldehydes, ketones and dienes); distinction between Cis and Trans isomers.

**IR Spectroscopy:** Fundamental and non-fundamental molecular vibrations; IR absorption positions of O, N and S containing functional groups; Effect of H-bonding, conjugation, resonance and ring size on IR absorptions; Fingerprint region and its significance; application in functional group analysis.

**NMR Spectroscopy:** Basic principles of Proton Magnetic Resonance, chemical shift and factors influencing it; Spin – Spin coupling and coupling constant; Anisotropic effects in alkene, alkyne, aldehydes and aromatics, Interpretation of NMR spectra of simple compounds.

Applications of IR, UV and NMR for identification of simple organic molecules.

**UNIT 2: Carbohydrates**

**(16 Lectures)**

Occurrence, classification and their biological importance.

Monosaccharides: Constitution and absolute configuration of glucose and fructose, epimers and



anomers, mutarotation, determination of ring size of glucose and fructose, Haworth projections and conformational structures; Interconversions of aldoses and ketoses; Killiani- Fischer synthesis and Ruff degradation;

Disaccharides – Structure elucidation of maltose, lactose and sucrose. Polysaccharides – Elementary treatment of starch, cellulose and glycogen.

### **UNIT 3: Dyes**

**(08 Lectures)**

Classification, Colour and constitution; Mordant and Vat Dyes; Chemistry of dyeing; Synthesis and applications of: Azo dyes – Methyl Orange and Congo Red (mechanism of Diazo Coupling); Triphenyl Methane Dyes -Malachite Green, Rosaniline and Crystal Violet; Phthalein Dyes – Phenolphthalein and Fluorescein; Natural dyes –structure elucidation and synthesis of Alizarin and Indigotin; Edible Dyes with examples.

### **UNIT 4: Polymers**

**(12 Lectures)**

Introduction and classification including di-block, tri-block and amphiphilic polymers; Number average molecular weight, Weight average molecular weight, Degree of polymerization, Polydispersity Index.

Polymerisation reactions -Addition and condensation -Mechanism of cationic, anionic and free radical addition polymerization; Metallocene-based Ziegler-Natta polymerisation of alkenes; Preparation and applications of plastics – thermosetting (phenol-formaldehyde, Polyurethanes) and thermosoftening (PVC, polythene);

Fabrics – natural and synthetic (acrylic, polyamido, polyester); Rubbers – natural and synthetic: Buna-S, Chloroprene and Neoprene; Vulcanization; Polymer additives;

Introduction to liquid crystal polymers; Biodegradable and conducting polymers with examples.

### **Reference Books:**

1. Kalsi, P. S. Textbook of Organic Chemistry 1<sup>st</sup> Ed., New Age International (P) Ltd. Pub.
2. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Billmeyer, F. W. Textbook of Polymer Science, John Wiley & Sons, Inc.
4. Gowariker, V. R.; Viswanathan, N. V. & Sreedhar, J. Polymer Science, New Age International (P) Ltd. Pub.
5. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6. Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.
7. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; Organic Chemistry, Oxford University Press.

8. Singh, J.; Ali, S.M. & Singh, J. Natural Product Chemistry, Prajati Prakashan (2010).
9. Kemp, W. Organic Spectroscopy, Palgrave.

**SEMESTER - VI**  
**CORE COURSE (HONOURS IN CHEMISTRY)**  
**PAPER: CHE-H-C-613 & 614-P**  
**CHEMISTRY LAB (PRACTICAL)**

**Credits: 04 Credits**

**(60+60 = 120) Lectures**

**Full Marks: 10 (MSE) + 40 (ESE) = 50**

**Pass Marks: (MSE: 04 + ESE: 16) = 20**

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*Instruction to Question Setter for*

*Mid Semester Examination (MSE): 3 Hrs.*

*The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 8 Marks each. (b) Class Attendance Score (CAS) and Day to day assessment (DDA) of 2 marks.*

*(Attendance: Upto 75% = 1 mark; 75-80% = 2 marks; 80-85% = 3 marks; 85-90% = 4 marks; >90% = 5 marks)*

*End Semester Examination (ESE): 3 Hrs.*

*Two experiments (questions) will be set (one from each group) each of 24 marks out of which one is to be answered.*

*Evaluation of Practical Examination may be as per the following guidelines:*

*Experiment = 24 marks*

*Practical record notebook = 08 marks*

*Viva-voce = 08 marks*

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**GROUP "A"**  
**PAPER: CHE-H-C-613-P**  
**INORGANIC CHEMISTRY-IV LAB**  
**(60 Lectures)**

Qualitative semimicro analysis of mixtures containing 3 anions and 3 cations. Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested:

$\text{CO}_3^{2-}$ ,  $\text{NO}_2^-$ ,  $\text{S}^{2-}$ ,  $\text{SO}_3^{2-}$ ,  $\text{S}_2\text{O}_3^{2-}$ ,  $\text{CH}_3\text{COO}^-$ ,  $\text{F}^-$ ,  $\text{Cl}^-$ ,  $\text{Br}^-$ ,  $\text{I}^-$ ,  $\text{NO}_3^-$ ,  $\text{BO}_3^{3-}$ ,  $\text{C}_2\text{O}_4^{2-}$ ,  $\text{PO}_4^{3-}$ ,  $\text{NH}_4^+$ ,  $\text{K}^+$ ,  $\text{Pb}^{2+}$ ,  $\text{Cu}^{2+}$ ,  $\text{Cd}^{2+}$ ,  $\text{Bi}^{3+}$ ,  $\text{Sn}^{2+}$ ,  $\text{Sb}^{3+}$ ,  $\text{Fe}^{3+}$ ,  $\text{Al}^{3+}$ ,  $\text{Cr}^{3+}$ ,  $\text{Zn}^{2+}$ ,  $\text{Mn}^{2+}$ ,  $\text{Co}^{2+}$ ,  $\text{Ni}^{2+}$ ,  $\text{Ba}^{2+}$ ,  $\text{Sr}^{2+}$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$

Mixtures should preferably contain one interfering anion, or insoluble component ( $\text{BaSO}_4$ ,  $\text{SrSO}_4$ ,  $\text{PbSO}_4$ ,  $\text{CaF}_2$  or  $\text{Al}_2\text{O}_3$ ) or combination of anions e.g.  $\text{CO}_3^{2-}$  and  $\text{SO}_3^{2-}$ ,  $\text{NO}_2^-$  and  $\text{NO}_3^-$ ,  $\text{Cl}^-$  and  $\text{Br}^-$ ,  $\text{Cl}^-$  and  $\text{I}^-$ ,  $\text{Br}^-$  and  $\text{I}^-$ ,  $\text{NO}_3^-$  and  $\text{Br}^-$ ,  $\text{NO}_3^-$  and  $\text{I}^-$ .

Spot tests should be done whenever possible.

A. Measurement of 10 Dq by spectrophotometric method

B. Verification of spectrochemical series.

C. Controlled synthesis of two copper oxalate hydrate complexes: kinetic vs thermodynamic factors.

D. Preparation of acetylacetonato complexes of  $\text{Cu}^{2+}/\text{Fe}^{3+}$ . Find the  $\lambda_{\text{max}}$  of the complex.

E. Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentate ligands like acetylacetone, DMG, glycine) by substitution method

**GROUP “B”**  
**PAPER: CHE-H-C-614-P**  
**ORGANIC CHEMISTRY-IV LAB**  
**(60 Lectures)**

1. Extraction of caffeine from tea leaves.
2. Preparation of sodium polyacrylate.
3. Preparation of urea formaldehyde.
4. Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars.
5. Qualitative analysis of unknown organic compounds containing monofunctional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols etc.
6. Identification of simple organic compounds by IR spectroscopy and NMR spectroscopy (Spectra to be provided).
7. Qualitative analysis of unknown organic compounds containing monofunctional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols etc.
8. Identification of simple organic compounds by IR spectroscopy and NMR spectroscopy (Spectra to be provided).
7. Preparation of methyl orange.

**Reference Books:**

1. Vogel, A.I. *Quantitative Organic Analysis*, Part 3, Pearson (2012).
2. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education (2009)
3. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry*, 5<sup>th</sup> Ed., Pearson (2012)
4. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*, University Press (2000).
5. Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis*, University Press (2000).
6. Vogel's *Qualitative Inorganic Analysis*, Revised by G. Svehla.
7. Marr & Rockett *Inorganic Preparations*

## SEMESTER-VI (DSE-03A)

### PAPER: CHE-H-DSE-603 A –T GREEN CHEMISTRY

**Credits: Theory-04, Practical – 02**

**Theory: 60 Lectures.**

**Marks: 15 (MSE) + 60 (ESE) = 75**

**Pass Marks: (MSE: 06 +ESE: 24) = 30**

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*Instruction to Question Setter for*

*Mid Semester Examination (MSE): 1  $\frac{1}{2}$  Hrs.*

*The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks. There will be three questions of 5 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 05 marks.*

*(Attendance: Upto 75% = 1 mark; 75-80% = 2 marks; 80.-85% = 3 marks; 85-90% = 4 marks; >90% = 5 marks)*

*End Semester Examination (ESE): 3 Hrs.*

*There will be two groups of questions. Group A is compulsory and will contain two questions. Q. No. 1(A) will be multiple type six questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 3 marks. Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to be answered.*

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#### **UNIT 1: Introduction to Green Chemistry**

**(04 Lectures)**

What is Green Chemistry? Need for Green Chemistry. Goals of Green Chemistry. Limitations/Obstacles in the pursuit of the goals of Green Chemistry.

#### **UNIT 2: Principles of Green Chemistry and Designing a Chemical synthesis**

**(24 Lectures)**

Twelve principles of Green Chemistry with their explanations and examples; Designing a Green Synthesis using these principles; Prevention of Waste/ byproducts; maximum incorporation of the materials used in the process into the final products (Atom Economy); prevention/ minimization of hazardous/ toxic products; designing safer chemicals – different basic approaches to do so; selection of appropriate auxiliary substances (solvents, separation agents), green solvents, solventless processes, immobilized solvents and ionic liquids; energy requirements for reactions - use of microwaves, ultrasonic energy; selection of starting materials; avoidance of unnecessary derivatization – careful use of blocking/protecting groups; use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; designing of biodegradable products; prevention of chemical accidents; strengthening/ development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes.

#### **UNIT 3: Examples of Green Synthesis/ Reactions**

**(24 Lectures)**

**1.** Green Synthesis of the following compounds: adipic acid, catechol, BHT, methyl methacrylate, urethane, aromatic amines (4-aminodiphenylamine), benzyl bromide, acetaldehyde, disodium iminodiacetate (alternative to Strecker synthesis), citral, ibuprofen, paracetamol, furfural.

**2.** Microwave assisted reactions in water: Hofmann Elimination, Hydrolysis (of benzyl chloride, benzamide, n-phenyl benzamide, methylbenzoate to benzoic acid), Oxidation (of toluene, alcohols).

Microwave assisted reactions in organic solvents: Esterification, Fries rearrangement, Orthoester Claisen Rearrangement, Diels-Alder Reaction, and Decarboxylation.

Microwave assisted solid state reactions: Deacetylation, Deprotection. Saponification of esters, Alkylation of reactive methylene compounds, reductions, synthesis of nitriles from aldehydes; anhydrides from dicarboxylic acid; pyrimidine and pyridine derivatives; 1,2- dihydrotriazine derivatives; benzimidazoles.

**3.** Ultrasound assisted reactions: Esterification, saponification, substitution reactions, Alkylations, oxidation, reduction, coupling reaction, Cannizaro reaction, Strecker synthesis, Reformatsky reaction.

**4.** Selective methylation of active methylene group using dimethylcarbonate: Solid-state polymerization of amorphous polymers using diphenylcarbonate; Use of “Clayan”, a nonmetallic oxidative reagent for various reactions; Free Radical Bromination; Role of Tellurium in organic syntheses; Biocatalysis in organic syntheses.

#### **UNIT 4: Future Trends in Green Chemistry**

**(08 Lectures)**

Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; Non-covalent derivatization; Green chemistry in sustainable development.

#### **Reference Books:**

1. V.K. Ahluwalia & M.R. Kidwai: New Trends in Green Chemistry,
2. Anamalaya Publishers (2005).
3. P.T. Anastas & J.K. Warner: Oxford Green Chemistry- Theory and Practical, University Press (1998).
4. A.S. Matlack: Introduction to Green Chemistry, Marcel Dekker (2001).
5. M.C. Cann & M.E. Connely: Real-World cases in Green Chemistry, American Chemical Society, Washington (2000).
6. M.A. Ryan & M. Tinnesand, Introduction to Green Chemistry, American Chemical Society, Washington (2002).

## SEMESTER-VI (DSE-03A: PRACTICAL)

PAPER: CHE-H-DSE-603 A-P

CHEMISTRY PRACTICAL - DSE LAB: GREEN CHEMISTRY

Credits: 02 Credits

60 Lectures

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### 1. Safer starting materials

The Vitamin C clock reaction using Vitamin C tablets, tincture of iodine, hydrogen peroxide and liquid laundry starch.

- Effect of concentration on clock reaction
- Effect of temperature on clock reaction. (if possible)

### 2. Using renewable resources

Preparation of biodiesel from vegetable oil.

### 3. Avoiding waste

Principle of atom economy.

Use of molecular model kit to stimulate the reaction to investigate how the atom economy can illustrate Green Chemistry.

Preparation of propene by two methods can be studied

(I) Triethylamine ion +  $\text{OH}^- \rightarrow$  propene + trimethylpropene + water



(II) 1-propanol  $\longrightarrow$  propene + water

The other types of reactions, like addition, elimination, substitution and rearrangement should also be studied for the calculation of atom economy.

### 4. Use of enzymes as catalysts

Benzoin condensation using Thiamine Hydrochloride as a catalyst instead of cyanide

Alternative Green solvents

### 5. Diels Alder reaction in water

Reaction between furan and maleic acid in water and at room temperature rather than in benzene and reflux.

6. Extraction of D-limonene from orange peel using liquid  $\text{CO}_2$  prepared from dry ice.

7. Mechanochemical solvent free synthesis of azomethines

8. Co-crystal controlled solid state synthesis ( $C^2S^3$ ) of N-organophthalimide using phthalic anhydride and 3-aminobenzoic acid.

Alternative sources of energy

9. Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of copper (II).

10. Photoreduction of benzophenone to benzopinacol in the presence of sunlight.

**Reference Books:**

1. Anastas, P.T & Warner, J.C. *Green Chemistry: Theory and Practice*, Oxford University Press (1998).
2. Kirchoff, M. & Ryan, M.A. *Greener approaches to undergraduate chemistry experiment*. American Chemical Society, Washington DC (2002).
3. Ryan, M.A. *Introduction to Green Chemistry*, Tinnesand; (Ed), American Chemical Society, Washington DC (2002).
4. Sharma, R.K.; Sidhwani, I.T. & Chaudhari, M.K. I.K. *Green Chemistry Experiment: A monograph International Publishing House Pvt Ltd. New Delhi*. Bangalore C ISBN 978-93-81141-55-7 (2013).



## SEMESTER-VI (DSE - 03B)

### PAPER: CHE-H-DSE-603 B –T

#### CHEMISTRY-DSE: MOLECULAR MODELLING & DRUG DESIGN

**Credits: Theory-04, Practical – 02**

**Theory: 60 Lectures.**

**Marks: 15 (MSE) + 60 (ESE) = 75**

**Pass Marks: (MSE: 06 +ESE: 24) = 30**

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*Instruction to Question Setter for*

*Mid Semester Examination (MSE): 1  $\frac{1}{2}$  Hrs.*

*The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks. There will be three questions of 5 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 05 marks.*

*(Attendance: Upto 75% = 1 mark; 75-80% = 2 marks; 80.-85% = 3 marks; 85-90% = 4 marks; >90% = 5 marks)*

*End Semester Examination (ESE): 3 Hrs.*

*There will be two groups of questions. Group A is compulsory and will contain two questions. Q. No. 1(A) will be multiple type six questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 3 marks. Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to be answered.*

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#### UNIT 1: Introduction to Molecular Modelling

**(10 Lectures)**

Introduction. Useful Concepts in Molecular Modelling: Coordinate Systems. Potential Energy Surfaces. Molecular Graphics. Surfaces. Computer Hardware and Software. The Molecular Modelling Literature.

#### UNIT 2: Force Fields

**(14 Lectures)**

Fields. Bond Stretching. Angle Bending. Introduction to nonbonded interactions. Electrostatic interactions. van der Waals Interactions. Hydrogen bonding in Molecular Mechanics. Force Field Models for the Simulation of Liquid Water.

#### UNIT 3: Energy Minimization and Computer Simulation

**(12 Lectures)**

Minimization and related methods for exploring the energy surface. Non-derivative method, First and second order minimization methods. Computer simulation methods. Simple thermodynamic properties and Phase Space. Boundaries. Analyzing the results of a simulation and estimating Errors.

#### UNIT 4: Molecular Dynamics & Monte Carlo Simulation

**(12 Lectures)**

Molecular Dynamics Simulation Methods. Molecular Dynamics using simple models. Molecular Dynamics with continuous potentials. Molecular Dynamics at constant temperature and pressure. Metropolis method. Monte Carlo simulation of molecules. Models used in Monte Carlo simulations of polymers.

#### UNIT 5: Structure Prediction and Drug Design

**(12 Lectures)**

Structure prediction - Introduction to comparative Modeling. Sequence alignment. Constructing and evaluating a comparative model. Predicting protein structures by 'Threading', Molecular docking.

Structure based de novo ligand design,

Drug Discovery – Chemo informatics – QSA

**Reference Books:**

1. A.R. Leach, Molecular Modelling Principles and Application, Longman, 2001.
2. J.M. Haile, Molecular Dynamics Simulation Elementary Methods, John Wiley and Sons, 1997.
3. Satya Prakash Gupta, QSAR and Molecular Modeling, Springer - Anamaya Publishers, 2008

## SEMESTER-VI (DSE -03B: PRACTICAL)

PAPER: CHE-H-DSE-603 B –P

CHEMISTRY PRACTICAL -DSE: MOLECULAR MODELLING & DRUG DESIGN

Credits: 02

60 Lectures

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1. Compare the optimized C-C bond lengths in ethane, ethene, ethyne and benzene. Visualize the molecular orbitals of the ethane  $\sigma$  bonds and ethene, ethyne, benzene and pyridine  $\pi$  bonds.
2. (a) Perform a conformational analysis of butane. (b) Determine the enthalpy of isomerization of *cis* and *trans* 2-butene.
3. Visualize the electron density and electrostatic potential maps for LiH, HF, N<sub>2</sub>, NO and CO and comment. Relate to the dipole moments. Animate the vibrations of these molecules.
4. (a) Relate the charge on the hydrogen atom in hydrogen halides with their acid character. (b) Compare the basicities of the nitrogen atoms in ammonia, methylamine, dimethylamine and trimethylamine.
5. (a) Compare the shapes of the molecules: 1-butanol, 2-butanol, 2-methyl-1-propanol, and 2-methyl-2-propanol. Note the dipole moment of each molecule. (b) Show how the shapes affect the trend in boiling points: (118 °C, 100 °C, 108 °C, 82 °C, respectively).
6. Build and minimize organic compounds of your choice containing the following functional groups. Note the dipole moment of each compound: (a) alkyl halide (b) aldehyde (c) ketone (d) amine (e) ether (f) nitrile (g) thiol (h) carboxylic acid (i) ester
7. (a) Determine the heat of hydration of ethylene. (b) Compute the resonance energy of benzene by comparison of its enthalpy of hydrogenation with that of cyclohexene.
8. Arrange 1-hexene, 2-methyl-2-pentene, (*E*)-3-methyl-2-pentene, (*Z*)-3-methyl-2-pentene, and 2,3-dimethyl-2-butene in order of increasing stability.
9. (a) Compare the optimized bond angles H<sub>2</sub>O, H<sub>2</sub>S, H<sub>2</sub>Se. (b) Compare the HAH bond angles for the second row dihydrides and compare with the results from qualitative MO theory.

*Note:* Software: ChemSketch, ArgusLab ([www.planaria-software.com](http://www.planaria-software.com)), TINKER 6.2 ([dasher.wustl.edu/ffe](http://dasher.wustl.edu/ffe)), WebLab Viewer, Hyperchem, or any similar software.

### Reference Books:

1. A.R. Leach, Molecular Modelling Principles and Application, Longman, 2001.
2. J.M. Haile, Molecular Dynamics Simulation Elementary Methods, John Wiley and Sons, 1997.
3. Satya Prakash Gupta, QSAR and Molecular Modeling, Springer - Anamaya Publishers, 2008

## SEMESTER-VI (DSE-04A)

PAPER: CHE-H-DSE-604 A –T

### INDUSTRIAL CHEMICALS AND ENVIRONMENT

**Credits: Theory-04, Practical – 02**

**Theory: 60 Lectures.**

**Marks: 15 (MSE) + 60 (ESE) = 75**

**Pass Marks: (MSE: 06 +ESE: 24) = 30**

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*Instruction to Question Setter for*

*Mid Semester Examination (MSE): 1  $\frac{1}{2}$  Hrs.*

*The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks. There will be three questions of 5 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 05 marks.*

*(Attendance: Upto 75% = 1 mark; 75-80% = 2 marks; 80-85% = 3 marks; 85-90% = 4 marks; >90% = 5 marks)*

*End Semester Examination (ESE): 3 Hrs.*

*There will be two groups of questions. Group A is compulsory and will contain two questions. Q. No. 1(A) will be multiple type six questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 3 marks. Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to be answered.*

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#### UNIT 1: Industrial Gases and Inorganic Chemicals

(10 Lectures)

*Industrial Gases:* Large scale production, uses, storage and hazards in handling of the following gases: oxygen, nitrogen, argon, neon, helium, hydrogen, acetylene, carbon monoxide, chlorine, fluorine, sulphur dioxide and phosgene.

*Inorganic Chemicals:* Manufacture, application, analysis and hazards in handling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, caustic soda, common salt, borax, bleaching powder, sodium thiosulphate, hydrogen peroxide, potash alum, chrome alum, potassium dichromate and potassium permanganate.

#### UNIT 2: Industrial Metallurgy

(04 Lectures)

Preparation of metals (ferrous and nonferrous) and ultrapure metals for semiconductor technology.

#### UNIT 3: Environment and its segments

(30 Lectures)

Ecosystems. Biogeochemical cycles of carbon, nitrogen and Sulphur.

Air Pollution: Major regions of atmosphere. Chemical and photochemical reactions in atmosphere. Air pollutants: types, sources, particle size and chemical nature; Photochemical smog: its constituents and photochemistry. Environmental effects of ozone, Major sources of air pollution.

Pollution by SO<sub>2</sub>, CO<sub>2</sub>, CO, NO<sub>x</sub>, H<sub>2</sub>S and other foul smelling gases. Methods of estimation of CO, NO<sub>x</sub>, SO<sub>x</sub> and control procedures.

Effects of air pollution on living organisms and vegetation. Greenhouse effect and Global warming, Ozone depletion by oxides of nitrogen, chlorofluorocarbons and Halogens, removal of sulphur from coal. Control of particulates.

*Water Pollution:* Hydrological cycle, water resources, aquatic ecosystems, Sources and nature of water pollutants, Techniques for measuring water pollution, Impacts of water pollution on hydrological and ecosystems.

Water purification methods. Effluent treatment plants (primary, secondary and tertiary treatment). Industrial effluents from the following industries and their treatment: electroplating, textile, tannery, dairy, petroleum and petrochemicals, agro, fertilizer, etc. Sludge disposal.

Industrial waste management, incineration of waste. Water treatment and purification (reverse osmosis, electro dialysis, ion exchange). Water quality parameters for waste water, industrial water and domestic water.

#### **UNIT 4: Energy & Environment**

**(10 Lectures)**

Sources of energy: Coal, petrol and natural gas. Nuclear Fusion / Fission, Solar energy, Hydrogen, geothermal, Tidal and Hydel, etc.

Nuclear Pollution: Disposal of nuclear waste, nuclear disaster and its management.

#### **UNIT 5: Biocatalysis**

**(06 Lectures)**

Introduction to biocatalysis: Importance in “Green Chemistry” and Chemical Industry.

#### **Reference Books:**

1. E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
2. R.M. Felder, R.W. Rousseau: *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.
3. J. A. Kent: *Riegel's Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
4. S. S. Dara: *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. New Delhi.
5. K. De, *Environmental Chemistry*: New Age International Pvt., Ltd, New Delhi.
6. S. M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi.
7. S.E. Manahan, *Environmental Chemistry*, CRC Press (2005).
8. G.T. Miller, *Environmental Science* 11th edition. Brooks/ Cole (2006).
9. A. Mishra, *Environmental Studies*. Selective and Scientific Books, New Delhi (2005).

**SEMESTER-VI**  
**(DSE-04A: PRACTICAL)**

**PAPER: CHE-H-DSE-604 A –P**

**CHEMISTRY PRACTICAL -DSE: INDUSTRIAL CHEMICALS AND ENVIRONMENT**

**Credits: Practical – 02**

**60 Lectures.**

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1. Determination of dissolved oxygen in water.
2. Determination of Chemical Oxygen Demand (COD)
3. Determination of Biological Oxygen Demand (BOD)
4. Percentage of available chlorine in bleaching powder.
5. Measurement of chloride, sulphate and salinity of water samples by simple titration method ( $\text{AgNO}_3$  and potassium chromate).
6. Estimation of total alkalinity of water samples ( $\text{CO}_3^{2-}$ ,  $\text{HCO}_3^-$ ) using double titration method.
7. Measurement of dissolved  $\text{CO}_2$ .
8. Study of some of the common bio-indicators of pollution.
9. Estimation of SPM in air samples.
10. Preparation of borax/ boric acid.

**Reference Books:**

- E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
- R.M. Felder, R.W. Rousseau: *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.
- J. A. Kent: *Riegel's Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
- S. S. Dara: *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. New Delhi.
- K. De, *Environmental Chemistry*: New Age International Pvt., Ltd, New Delhi.  
S. M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi.

## SEMESTER-VI (DSE-04B)

PAPER: CHE-H-DSE-604 B –T

NOVEL INORGANIC SOLIDS

Credits: Theory-04, Practical – 02

Theory: 60 Lectures.

Marks: 15 (MSE) + 60 (ESE) = 75

Pass Marks: (MSE: 06 +ESE: 24) = 30

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*Instruction to Question Setter for*

*Mid Semester Examination (MSE): 1  $\frac{1}{2}$  Hrs.*

*The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks. There will be three questions of 5 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 05 marks.*

*(Attendance: Upto 75% = 1 mark; 75-80% = 2 marks; 80-85% = 3 marks; 85-90% = 4 marks; >90% = 5 marks)*

*End Semester Examination (ESE): 3 Hrs.*

*There will be two groups of questions. Group A is compulsory and will contain two questions. Q. No. 1(A) will be multiple type six questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 3 marks. Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to be answered.*

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### UNIT 1: Synthesis and modification of inorganic solids

(10 Lectures)

Conventional heat and beat methods, Co-precipitation method, Sol-gel methods, hydrothermal method, Ion-exchange and Intercalation methods.

### UNIT 2: Inorganic solids of technological importance

(10 Lectures)

Solid electrolytes – Cationic, anionic, mixed Inorganic pigments – coloured solids, white and black pigments.

Molecular material and fullerenes, molecular materials & chemistry – one-dimensional metals, molecular magnets, inorganic liquid crystals.

### UNIT 3: Nanomaterials

(10 Lectures)

Overview of nanostructures and nanomaterials: classification.

Preparation of gold and silver metallic nanoparticles, self-assembled nanostructures-control of nanoarchitecture-one dimensional control. Carbon nanotubes and inorganic nanowires. Bio-inorganic nanomaterials, DNA and nanomaterials, natural and antisocial nanomaterials, bionano composites.

### UNIT 4: Introduction to engineering materials for mechanical construction

(10 Lectures)

Composition, mechanical and fabricating characteristics and applications of various types of cast

irons, plain carbon and alloy steels, copper, aluminum and their alloys like duralumin, brasses and bronzes cutting tool materials, super alloys thermoplastics, thermosets and composite materials.

**UNIT 5: Composite materials**

**(10 Lectures)**

Introduction, limitations of conventional engineering materials, role of matrix in composites, classification, matrix materials, reinforcements, metal-matrix composites, polymer-matrix composites, fibre-reinforced composites, environmental effects on composites, applications of composites.

**UNIT 6: Speciality polymers**

**(10 Lectures)**

Conducting polymers - Introduction, conduction mechanism, polyacetylene, polyparaphenylene and polypyrrole, applications of conducting polymers, Ion-exchange resins and their applications. Ceramic & Refractory: Introduction, classification, properties, raw materials, manufacturing and applications.

**Reference Books:**

1. Shriver & Atkins. Inorganic Chemistry, Peter Atkins, Tina Overton, Jonathan Rourke, Mark Weller and Fraser Armstrong, 5<sup>th</sup> Edition, Oxford University Press (2011-2012)
2. Adam, D.M. Inorganic Solids: An introduction to concepts in solid-state structural chemistry.
3. Frank J. Owens, Introduction to Nanotechnology.



**SEMESTER-VI**  
**(DSE-04B: PRACTICAL)**

**PAPER: CHE-H-DSE-604 B –P**

**CHEMISTRY PRACTICAL -DSE: NOVEL INORGANIC SOLIDS**

**Credits: Practical – 02**

**60 Lectures.**

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1. Determination of cation exchange method
2. Determination of total difference of solids.
3. Synthesis of hydrogel by co-precipitation method.
4. Synthesis of silver and gold metal nanoparticles.

**Reference Book:**

1. Ahan, Materials Chemistry, Springer (2004).

## SEMESTER-VI (DSE-04C)

PAPER: CHE-H-DSE-604 C –T

### RESEARCH METHODOLOGY FOR CHEMISTRY

Credits: Theory-05, Tutorials – 01

60 Lectures & 15 Tutorials

Marks: 20 (MSE) + 80 (ESE) = 75

Pass Marks: (MSE: 08 +ESE: 32) = 40

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#### Instruction to Question Setter for

**Mid Semester Examination (MSE):**  $1\frac{1}{2}$  Hrs.

The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 15 Marks. There will be five questions of 5 marks each, out of which three are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 05 marks.

(Attendance: Upto 75% = 1 mark; 75-80% = 2 marks; 80-85% = 3 marks; 85-90% = 4 marks; >90% = 5 marks)

**End Semester Examination (ESE):** 3 Hrs.

There will be two groups of questions. **Group A is compulsory** and will contain two questions. Q. No. 1(A) will be multiple type eight questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 04 marks. **Group B will contain descriptive type eight** questions of sixteen marks each, out of which any four are to be answered.

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#### UNIT 1: Literature Survey

(20 Lectures)

**Print:** Sources of information: Primary, secondary, tertiary sources; Journals: Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples.

**Digital:** Web resources, E-journals, Journal access, TOC alerts, Hot articles, Citation index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups and communities, Blogs, Preprint servers, Search engines, Scirus, Google Scholar, ChemIndustry, Wiki- Databases, ChemSpider, Science Direct, SciFinder, Scopus.

#### Information Technology and Library Resources

The Internet and World Wide Web. Internet resources for chemistry. Finding and citing published information.

#### UNIT 2: Methods of Scientific Research and Writing Scientific Papers

(20 Lectures)

Reporting practical and project work. Writing literature surveys and reviews. Organizing a poster display. Giving an oral presentation.

Writing scientific papers – justification for scientific contributions, bibliography, description of

methods, conclusions, the need for illustration, style, publications of scientific work. Writing ethics. Avoiding plagiarism.

**UNIT 3: Chemical Safety and Ethical Handling of Chemicals (12 Lectures)**

Safe working procedure and protective environment, protective apparel, emergency procedure and first aid, laboratory ventilation. Safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric – safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals

**UNIT 4: Data Analysis (13 Lectures)**

*The Investigative Approach:* Making and Recording Measurements. SI Units and their use. Scientific method and design of experiments.

*Analysis and Presentation of Data:* Descriptive statistics. Choosing and using statistical tests. Chemometrics. Analysis of variance (ANOVA), Correlation and regression, Curve fitting, fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, General polynomial fitting, linearizing transformations, exponential function fit,  $r$  and its abuse. Basic aspects of multiple linear regression analysis.

**UNIT 5: Electronics (10 Lectures)**

Basic fundamentals of electronic circuits and their components used in circuits of common instruments like spectrophotometers, typical circuits involving operational amplifiers for electrochemical instruments. Elementary aspects of digital electronics.

**Reference Books:**

1. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J. & Jones, A. (2011) *Practical skills in chemistry*. 2<sup>nd</sup> Ed. Prentice-Hall, Harlow.
2. Hibbert, D. B. & Gooding, J. J. (2006) *Data analysis for chemistry*. Oxford University Press.
3. Topping, J. (1984) *Errors of observation and their treatment*. Fourth Ed., Chapman Hall, London.
4. Harris, D. C. *Quantitative chemical analysis*. 6<sup>th</sup> Ed., Freeman (2007) Chapters 3-5.
5. Levie, R. de, *How to use Excel in analytical chemistry and in general scientific data analysis*. Cambridge Univ. Press (2001) 487 pages.
6. Chemical safety matters – IUPAC – IPCS, Cambridge University Press, 1992