



**FOUR-YEAR UNDER GRADUATE PROGRAMME
(CU-FYUGP)**

BSc CHEMISTRY

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|----------------|--|------------------|-------------------|--------------------|-------------|
| Programme | B.Sc Chemistry | | | | |
| Course Title | QUANTUM MECHANICS, SOLID STATE AND GASEOUS STATE | | | | |
| Type of Course | MINOR | | | | |
| Semester | II | | | | |
| Academic Level | 100 - 199 | | | | |
| Course Details | Credit | Lecture per week | Tutorial per week | Practical per week | Total Hours |
| | 4 | 3 | - | 2 | 75 |
| Pre-requisites | 1. Basic idea the structure of atom 2. Fundamentals of states of matter 3. Basic knowledge in analytical principles | | | | |
| Course Summary | 1. This course aims to introduce the failures of classical theories in explaining many experiments and the emergence of quantum theory. 2. This course also aims to realise the theories of different states of matter and their implications. 3. This course also aims to develop proficiency in qualitative analysis and to familiarize physical chemistry experiments | | | | |

Course Outcomes (CO):

| CO | CO Statement | Cognitive Level* | Knowledge Category# | Evaluation Tools used |
|-----|--|------------------|---------------------|---|
| CO1 | To understand the importance and the impact of quantum revolution in science. | U | F | Instructor-created exams / Quiz /Assignment |
| CO2 | To evaluate the properties of solids | E | C | Instructor-created exams / Quiz /Assignment |
| CO3 | To analyse the behaviour of gases | An | C | Instructor-created exams / Quiz /Assignment |
| CO4 | To understand the properties of gaseous state and how it links to thermodynamic systems. | U | C | Instructor-created exams / Quiz /Assignment |
| CO5 | To perform the cation analysis on a provided mixture containing two cations. | An | P | Lab work |

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|--|---|----|---|----------|
| CO6 | To enable the students to determine the physical properties (physical constants). | Ap | P | Lab work |
| * - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M) | | | | |

Detailed Syllabus:

| Module | Unit | Content | Hrs | Marks |
|------------|--|--|-----------|-----------|
| I | Introduction to Quantum mechanics | | 15 | 32 |
| | 1 | Postulates of quantum mechanics – derivation of time-independent Schrodinger equation | 2 | |
| | 2 | Particle in one dimensional box problem- Schrodinger equation, derivation for expression of energy, quantisation of energy levels, HOMO-LUMO transition in 1,3-butadiene Particle in three dimensional box (no derivation)- Concept of degeneracy of energy levels | 3 | |
| | 3 | Harmonic oscillator model, Schrodinger equation and Energy levels (basic idea only, no derivation) | 1 | |
| | 4 | Spherical polar coordinates and Rigid rotor model (no derivation, basic idea only), Expression for energy, Spherical harmonics, Angular momentum | 2 | |
| | 5 | Quantum mechanics of Hydrogen-like atoms - Hamiltonian operator of H-like systems, The Schrodinger equation in spherical polar coordinates, separation of variables | 3 | |
| | 6 | Wave functions or atomic orbitals, radial and angular parts of atomic orbitals. Quantum numbers (n, l, m). | 2 | |
| | 7 | The Stern - Gerlach experiment and the concept of electron spin, spin quantum number. | 2 | |
| II | Solid state | | 10 | 22 |
| | 8 | Classification of solids: Amorphous, Crystalline, Lattice points, lattice energy (general idea), unit cell, seven crystal systems. | 2 | |
| | 9 | Weiss and Miller indices - Bravais lattices, Close packing in crystals, examples of simple cubic, bcc and fcc lattices, | 1 | |
| | 10 | Explanation of electrical properties using concepts of bands, Explanation of conductors, semiconductors and insulators, Super conductors | 2 | |
| | 11 | Magnetic Properties: classification - diamagnetic, paramagnetic, antiferromagnetic, ferro and ferrimagnetic, permanent and temporary magnets. | 3 | |
| | 12 | Defects in crystals – stoichiometric and non-stoichiometric defects (Basic ideas only). | 2 | |
| III | Gaseous state - I | | 10 | 22 |

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|-----------|---|---|-----------|-----------|
| | 13 | Characteristics of gases | 1 | |
| | 14 | Postulates of kinetic theory of gases | 2 | |
| | 15 | Maxwell's distribution of molecular velocities – Root mean square, average and most probable velocities. | 3 | |
| | 16 | Collision number – Mean free path – Collision diameter | 1 | |
| | 17 | Viscosity of gases, including their temperature and pressure dependence, | 1 | |
| | 18 | Relation between mean free path and coefficient of viscosity, calculation of σ from η ; variation of viscosity with temperature and pressure. | 2 | |
| IV | Gaseous state -II | | 10 | 22 |
| | 19 | Behaviour of real gases - Deviation from ideal behaviour – Compressibility factor | 3 | |
| | 20 | Causes of deviation from ideal behaviour - van der Waals equation of state (derivation not required) – Expression of van der Waals equation in virial form and calculation of Boyle temperature | 4 | |
| | 21 | PV isotherms of real gases – Continuity of states – Isotherm of van der Waals equation | 1 | |
| | 22 | Critical phenomena (basic idea only) – Critical constants and their determination (derivation not required) – Relationship between critical constants and van der Waals constants. | 2 | |
| V | Practical | | 30 | |
| | A minimum of seven experiments must be done. Out of the seven experiments, one is to be open-ended which can be selected by the teacher | | | |
| | 1 | Inorganic Qualitative Analysis (semi – micro analysis) <ul style="list-style-type: none"> ● Reactions of Cations: Study of the reactions of the following cations with a view of their identification and confirmation. NH_4^+, Pb^{2+}, Cu^{2+}, Cd^{2+}, Al^{3+}, Ni^{2+}, Co^{2+}, Mn^{2+}, Zn^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, and Mg^{2+} ● Systematic qualitative analysis of a solution containing any two cations from the above list. (Minimum 6 mixtures) | 25 | |
| | 2 | Open ended experiments– Physical chemistry experiments. (Any one experiment) <p>Suggestions</p> <p>Determination of Physical Constants [Determination of colligative properties, Determination of viscosity of a binary liquid solution (Glycerol-water system) Refractometry experiments etc]</p> | 5 | |

Reference Books

1. P. W. Atkins, J. de Paula, Atkin's Physical Chemistry, 8th Edn., Oxford University Press, 2006.

- B. R. Puri, L. R. Sharma, M. S. Pathania, Principles of Physical Chemistry, 46th Edn., Vishal Publishing Company, New Delhi, 2013.
- Kapoor K. L., Text Book of Physical Chemistry, McGraw Hill, 3rd Edn. 2017.
- G. M. Barrow, Physical Chemistry, 5th Edn., Tata McGraw Hill Education, New Delhi, 2006.
- Anthony R. West, Solid State Chemistry and its Applications, 2nd Edn., Wiley-Blackwell, 2014.
- L. V. Azaroff, Introduction to Solids, Tata McGraw Hill Publishing Company, New Delhi, 1960.
- J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, Vogel's Textbook of Qualitative Chemical Analysis, 6th Edn., Pearson Education, Noida, 2013.
- V. V. Ramanujam, Inorganic Semi Micro Qualitative Analysis, 3rd Edn., The National Publishing Company, Chennai, 1974.
- A. Findlay, Findlay's Practical Physical Chemistry, 9th Edn., John Wiley and Sons, New York, 1972.
- J. B. Yadav, Advanced Practical Physical Chemistry, Goel Publications, Meerut, 2008.

Mapping of COs with PSOs and POs

| | PS O1 | PS O2 | PS O3 | PS O4 | PS O5 | PS O6 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 |
|------|-------|-------|-------|-------|-------|-------|-----|-----|-----|-----|-----|-----|-----|
| CO 1 | 2 | | | | 2 | | 1 | | | | | | |
| CO 2 | 2 | | | | 2 | | 1 | | | | | | |
| CO 3 | 2 | | | | 2 | | 1 | | | | | | |
| CO 4 | 2 | | | | 2 | | 1 | | | | | | |
| CO 5 | | | 2 | | 2 | | 1 | | | | 1 | | |
| CO 6 | | | 2 | | 2 | | 1 | | | | 1 | | |

Correlation Levels :

| Level | Correlation |
|-------|----------------|
| 0 | Nil |
| 1 | Slightly / Low |

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|---|--------------------|
| 2 | Moderate / Medium |
| 3 | Substantial / High |

Assessment Rubrics:

- Quiz / Discussion / Seminar
- Internal Theory / Practical exam
- Assignments / Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

| | Internal Theory / Practical Exam | Assignment / Viva | Practical Skill Evaluation | End Semester Examination |
|-----|-------------------------------------|----------------------|-------------------------------|-----------------------------|
| CO1 | ✓ | ✓ | | ✓ |
| CO2 | ✓ | ✓ | | ✓ |
| CO3 | ✓ | ✓ | | ✓ |
| CO4 | ✓ | ✓ | | ✓ |
| CO5 | ✓ | ✓ | ✓ | |
| CO6 | ✓ | ✓ | ✓ | |