

FAROOK COLLEGE (AUTONOMOUS), KOZHIKODE

First Semester M.Sc Chemistry Degree Examination, November 2025

MCH1C01 – Quantum Mechanics & Group Theory

(2022 Admission onwards)

Time: 3 hours

Max. Weightage : 30

Section A Short Answer
Answer 8 Questions out of 12.**Each question carries a weightage of 1 (8 X 1 = 8)**

- 1) Evaluate the integral $\int x \ln x$
- 2) Distinguish between cyclic groups and abelian groups. Prove that every cyclic group is abelian.
- 3) Find out the point groups of a) 1,4-dichlorobenzene b) ethane (eclipsed), c) cis-1,3-butadiene, d) CHCl_3 and e) ethylene
- 4) Draw the molecular orbital diagram of H_2O , clearly indicating the symmetry labels of each orbital according to the C_{2v} point group.
- 5) Explain Laporte selection rule using group theory.
- 6) With reference to a particle in a three-dimensional box, illustrate the concept of degeneracy using a suitable example.
- 7) Calculate the expectation value of position for a particle in 1D box with infinite potential walls.
- 8) Calculate the expectation value for angular momentum in particle on a ring.
- 9) Explain space quantization of angular momentum.
- 10) Calculate the associated Legendre polynomials $P_1^2(x)$ and $P_2^1(x)$
- 11) Evaluate the commutator $[\widehat{L}_+, \widehat{L}_z]$
- 12) What are spin orbitals?

Section B Short Essay
Answer 4 Questions out of 7.**Each question carries a weightage of 3 (4 X 3 = 12)**

- 13) Using differential calculus, find the local maximum and local minimum values of the function $f(x) = x^3 - 3x^2 + 2$
- 14) Demonstrate that molecular wavefunctions can be used to construct representations of symmetry point groups.
- 15) Use group theoretical methods to determine the vibrational modes of NH_3 and predict which are IR- and Raman-active.
- 16) What is transition moment integral? How is it used to analyze spectral transition probabilities?

- 17) Write the wave equation for particle on a sphere. Separate the variables to obtain in Φ and θ equations.
- 18) Describe the origin and theoretical justification of electron spin.
- 19) Plot the radial wavefunction and the radial distribution function of the 2s orbital. Explain the significance of the radial distribution function.

Section B Essay

Answer 2 Questions out of 4.

Each question carries a weightage of 5 (2 X 5 = 10)

- 20) State and explain the fundamental postulates of quantum mechanics in detail.
- 21) Using GOT, derive the character table of C_{2v} point group. Explain the Mulliken symbols used in the nomenclature of irreducible representations.
- 22) Construct the SALCs for the hybrid orbitals of BF_3 and obtain hybrid orbitals using inverse transformation method.
- 23) Give the quantum mechanical treatment of the one-dimensional harmonic oscillator to obtain its eigenfunctions and eigenvalues. Illustrate the vibrational energy levels diagrammatically.

C _{3v}	E	2C ₃	3 σ _v					
A1	1	1	1	z	x ² + y ² , z ²			
A2	1	1	-1	R _z				
B1	2	-1	0	(x,y) (R _x , R _y)	(x ² - y ² , xy) (xz, yz)			
D _{3h}	E	2C ₃	3C ₂	σ _h	2S ₃	3σ _v		
A' ₁	1	1	1	1	1	1		X ² + y ² , z ²
A' ₂	1	1	-1	1	1	-1	R _z	
E'	2	-1	0	2	-1	0	(x, y)	(x ² -y ² , xy)
A'' ₁	1	1	1	-1	-1	-1		
A'' ₂	1	1	-1	-1	-1	1	z	
E''	2	-1	0	-2	1	0	(R _x , R _y)	(xz, yz)

Name:

FAROOK COLLEGE (AUTONOMOUS), KOZHIKODE

First Semester M.Sc Chemistry Degree Examination, November 2025

MCH1C02 – Chemistry of Elements

(2022 Admission onwards)

Time: 3 hours

Max. Weightage : 30

Section A Short Answer

Answer 8 Questions out of 12.

Each question carries a weightage of 1 (8 X 1 = 8)

- 1) What are super bases ? Give examples.
- 2) Discuss Wade's rule as applied to boranes.
- 3) Calculate the styx number of B_6H_{10} .
- 4) How do boron cluster compounds exhibit unusual stability and reactivity?.
- 5) What are Zeolites? Mention their applications.
- 6) Describe the synthesis of Anderson-type heteropoly anions (e.g., $[TeMo_6O_{24}]^{6-}$).
- 7) How does the magnetic moment of a transition metal complex change when the ligand field strength is varied?
- 8) What are photonuclear reactions? Give examples
- 9) What are the major products formed during the radiolysis of water.
- 10) Define Curie – Weiss Law.
- 11) Discuss the applications of uranyl compounds in Nuclear fuel cycles and energy production.
- 12) Outline the methods used to synthesize metal borides,

Section B Short Essay

Answer 4 Questions out of 7.

Each question carries a weightage of 3 ($4 \times 3 = 12$)

- 13) Illustrate the chemistry and use of NH_3 as a non-aqueous solvent.
- 14) Draw and discuss the structure and bonding in B_5H_9 and B_5H_{11} .
- 15) How many B-B and B-H-B bonds are present in $\text{B}_{10}\text{H}_{14}$ cluster.
- 16) Explain the synthesis and structure of phosphazene polymers.
- 17) Discuss the importance of term symbols in atomic spectroscopy and magnetic properties.
- 18) Describe the construction and interpretation of Pourbaix diagrams. Explain how Pourbaix diagrams can be used to predict the stability of different oxidation states in aqueous solutions
- 19) Write a note on isopolyanions of V.

Section C Essay

Answer 2 Questions out of 4.

Each question carries a weightage of 5 ($2 \times 5 = 10$)

- 20) Describe the different types of non-aqueous solvents, including polar aprotic solvents, non-polar solvents, and protic solvents. Explain their characteristics and applications..
- 21) Explain the structure, bonding and uses of Phosphorous-Nitrogen compounds.
- 22) Compare and contrast nuclear fission and nuclear fusion, including their underlying principles, advantages, and challenges. Discuss the potential of these two nuclear reactions to provide energy in the future.
- 23) Write short note on the following:
 - a) Latimer diagrams
 - b) Gouy method
 - c) Wade's rule
 - d) Chevrel Phases
 - e) Quenching of orbital magnetic moment.

FAROOK COLLEGE (AUTONOMOUS), KOZHIKODE

First Semester M.Sc Chemistry Degree Examination, November 2025

MCH1C03 – Structure & Reactivity of Organic Compounds

(2022 Admission onwards)

Time: 3 hours

Max. Weightage : 30

Section A Short Answer**Answer 8 Questions out of 12.****Each question carries a weightage of 1 (8 X 1 = 8)**

1. Explain why [10]-annulene does not show aromaticity, but its oxygen-bridged analogue does.
2. Which has a larger pK_a value, cyclopentadiene or cycloheptatriene? Justify your answer.
3. What are ylides? Explain the nature of bonding in a sulfur ylide.
4. Illustrate a reaction where an OH group acts as a neighbouring group to form an epoxide.
5. *exo-norbornyl* derivatives undergo solvolysis faster than their *endo* isomers. Explain.
6. Predict the product when *meso*-2,3-dibromobutane is treated with magnesium metal.
7. Draw the Newman projection of the least stable conformer of butane.
8. Define enantiomeric excess. How is it calculated from optical rotation data?
9. Explain the concept of topicity exists for –CH₂– protons in ethanol.
10. Draw the structure of a molecule that is chiral due to a nitrogen center.
11. What is a CBS catalyst? Draw its structure.

Section B Short Essay**Answer 4 Questions out of 7.****Each question carries a weightage of 3 (4 X 3 = 12)**

12. Azulene has a significant dipole moment of ~1.08 D. Account for its aromaticity and the direction of its dipole moment using resonance structures.
13. Define a conformationally biased molecule and the anchoring role of a *tert*-butyl group on cyclohexane.
14. Draw the preferred conformations of the ethyl esters of *cis* and *trans*-4-(*tert*-butyl)cyclohexane carboxylic acid. Which among them will undergo base-catalyzed hydrolysis faster, and why?

15. Explain the principle of resolution of racemates through diastereomeric salt formation. Illustrate its application by showing how S-brucine can resolve a racemic organic acid.
16. Draw the Felkin-Anh model for the nucleophilic addition by NaBH_4 to the carbonyl group in (S)-3-phenylbutan-2-one. Predict the major diastereomer and assign its configuration.
17. Illustrate the Sharpless Asymmetric Epoxidation reaction with a specific example, mentioning all reagents and conditions.
18. The hydroboration-oxidation of alkenes is stereospecific and regioselective. Explain the mechanism and stereochemistry with an example.

Section B Essay

Answer 2 Questions out of 4.

Each question carries a weightage of 5 (2 X 5 = 10)

19. a) Discuss LFER. The pK_a of p-methoxybenzoic acid is 4.49, and that of benzoic acid is 4.19. Calculate the Hammett substituent constant (σ) for the p-OMe group.
b) Discuss the limitations of the pH scale for strong acids and how the Hammett acidity function (H_0) addresses them.
20. a) "A molecule without a stereogenic center can still be chiral." Justify this statement with three distinct examples.
b) The tertiary amines like EtMePhN are achiral, whereas properly substituted quaternary ammonium salts are chiral. Comment.
21. a) Write a comprehensive note on the major factors affecting the conformational stability of organic molecules.
b) How does hydrogen bonding affect the preferred conformation of 1,2-ethanediol and 1,2-cyclohexanediol?
22. a) Explain the term 1,4-asymmetric induction. How does *Prelog's rule* predict the stereoselectivity of nucleophilic addition to certain chiral ketones?
b) Explain the Zimmerman-Traxler model for the asymmetric aldol reaction.

FAROOK COLLEGE (AUTONOMOUS), KOZHIKODE

First Semester M.Sc Chemistry Degree Examination, November 2025

MCH1C04 – Thermodynamic Kinetics & Catalysis

(2022 Admission onwards)

Time: 3 hours

Max. Weightage : 30

Section A Short Answer**Answer 8 Questions out of 12.****Each question carries a weightage of 1 (8 X 1 = 8)**

- 1) Write down Gibbs-Duhem equation? State its significance.
- 2) What are excess functions?
- 3) Explain residual entropy, with suitable example.
- 4) Define Onsager reciprocal relations.
- 5) What is steady-state approximation?
- 6) What is the primary salt effect in solution kinetics?
- 7) Define diffusion-controlled reactions.
- 8) Write down the Eyring equation and explain the term.
- 9) What is mercury intrusion porosimetry?
- 10) Mention the significance of the BET equation.
- 11) Give two methods used to prepare zeolites.
- 12) Define autocatalysis with an example.

Section B Short Essay**Answer 4 Questions out of 7.****Each question carries a weightage of 3 (4 X 3 = 12)**

- 13) Discuss the four electro kinetic effects.
- 14) Derive rate of entropy production in a system involving only heat flow.
- 15) Describe the Rice-Herzfeld mechanism for the decomposition of organic molecules.
- 16) What is flash photolysis? Describe its principle and application in kinetic studies.

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- 16) What is flash photolysis? Describe its principle and application in kinetic studies.

- 17) Explain the concept of potential energy surfaces and their significance in reaction mechanisms.
- 18) Discuss the assumptions and limitations of Langmuir's adsorption isotherm.
- 19) What are oscillating reactions? Briefly explain the Lotka–Volterra and Brusselator models.

Section B Essay

Answer 2 Questions out of 4.

Each question carries a weightage of 5 (2 X 5 = 10)

- 20) a) Explain partial molar quantities and chemical potential. Derive the expression for the variation of chemical potential with temperature and pressure. (3 marks)
- b) Derive Duhem Margules equation (2 marks)
- 21) Compare and contrast the Collision Theory and Activated Complex Theory of reaction rates. Highlight their assumptions, strengths, and limitations.
- 22) Discuss the different techniques used to determine surface acidity. Explain the TPD (Temperature Programmed Desorption) method in detail.
- 23) Describe the Michaelis–Menten mechanism of enzyme catalysis. Derive the Michaelis–Menten equation and explain the significance of the Michaelis constant (K_m) and maximum velocity (V_{max}).