tcg crest

(Deemed to be University u/s 3 of UGC Act, 1956)

Distinct Category - Research

TCG CREST

School of Natural Sciences

Ph.D. Programme

Academic Session: August 2026

Focused Research Areas & Detailed Syllabus

Focused Broad Research Areas:

- Quantum Computing, Quantum Information & Communication, Quantum Sensing
- Sustainable Energy Solutions
- Food Science and Technology

Quantum Computing, Quantum Information & Communication, Quantum Sensing

The test will consist of two sections. Section A will have limited or no choice. Section B will have a significant choice.

Section A:

Quantum Mechanics and Linear Algebra: Basic linear algebra relevant to quantum mechanics (for example: vector spaces, direct sum, tensor product, Hermitian and unitary operators, etc), postulates of quantum mechanics, Schrodinger equation

and its applications, quantum harmonic oscillator, symmetries, angular momentum, variational principle, and approximation methods.

Section B:

Atomic and Molecular Physics: Hydrogen atom, helium atom, H2+ molecular ion, Zeeman effect, and Stark effect.

Thermodynamics and Statistical Mechanics: Microcanonical, canonical, and grand canonical ensembles, partition function, laws of thermodynamics, Maxwell-Boltzmann, Fermi-Dirac, and Bose-Einstein statistics.

Electricity and Magnetism: Electrostatics, magnetostatics, electrodynamics, Maxwell's equations, electromagnetic waves.

Analog and Digital Electronics: Basic electronics, digital electronics, analog and digital modulation, microprocessors.

Condensed Matter Physics: Symmetry in solids, X-ray diffraction methods, free electron theory of metals, thermal conductivity of metals, theory of specific heat, lattice vibrations, dielectrics, magnetism, superconductivity, energy bands in solids, semiconductors, defects in solids.

Embedded Systems: Embedded System Design, Microprocessors & Microcontrollers, Real-Time Systems & RTOS, Software for Embedded Systems, Hardware–Software Co-Design, Microcontrollers & Interfacing, Communication Protocols, FPGA Based System Design, Embedded Linux / Operating Systems.

Digital Signal Processing: Signals and Systems-Continuous & Discrete Time Signals, LTI Systems and their frequency response, Convolution (CT & DT), Fourier Series, Fourier Transform (CTFT, DTFT), Laplace Transform, Z-Transform, Sampling Theorem, Stability & Causality, Discrete-Time Signal Processing, Parseval's Theorem, IIR and FIR filters, Random Signal Processing, Random variable, Power Spectral density, Auto correlation, Cross-correlation

Numerical Methods: Floating-point errors and stability, root-finding algorithms, interpolation and numerical integration, direct and iterative methods for linear systems, eigenvalue problems, convergence analysis, conditioning, error estimation, finite-difference schemes, finite-element methods, spectral methods, random number generation, discretization techniques.

Sustainable Energy Solutions

Chemistry Syllabus for RISE Admission Test 2026

- **Inorganic Chemistry**: Periodic Properties, Structure and Bonding, Acids & Bases, Main Group Elements and Transition metals, Co-ordination Chemistry, Organometallic Compounds, Bioinorganic Chemistry, Characterisation of Inorganic Compounds by Spectroscopic techniques, EPR and Mössbauer Spectroscopy, Electrochemical Analysis, Organometallic Chemistry and Catalysis, Introduction of Nanomaterials.

- **Physical Chemistry:** Basic Quantum Mechanics, Chemical Bonding Theory, Thermodynamics, Chemical Thermodynamics, Atomic structure & Term Symbols, Group Theory and Symmetry, Chemical Kinetics & Catalysis, Statistical Thermodynamics, Molecular spectroscopy, Photochemistry, Absorption and Emission Spectroscopy, Electrochemistry, Solid state & Crystal structure, Colloids and Surfaces.

- **Organic Chemistry:** IUPAC nomenclature of organic molecules, Stereochemistry, Aromaticity, Organic reaction mechanisms, Common named reactions and rearrangements, Asymmetric synthesis, Pericyclic reactions, Organic transformations and reagents, Structural determination of organic compounds, NMR spectroscopy, IR spectroscopy, Mass Spectroscopy.

- **Analytical Chemistry**: Conventional Analytical Procedures, Risks and Hazards of Chemicals and Procedures, Errors in Chemical Analysis, Sampling, Solvent

Extraction and Concept of Chromatography, Advanced Inorganic Spectroscopy, Kinetics in Analytical Chemistry, Sensing of Analytes, Materials Chemistry and Nanochemistry, Bioanalyical Chemistry, Green Chemistry, Atmospheric Chemistry.

Physics Syllabus for RISE Admission Test 2026

- **Mathematical methods of Physics:**
  Dimensional analysis, Vector algebra and vector calculus, Linear algebra, matrices, Eigenvalues and eigenvectors, Fourier series, Fourier and Laplace transformations, ordinary differential equations.
- **Classical mechanics:**
  Phase space dynamics. Central force motions. Two body collisions, Rigid body dynamics, Non-inertial frames, Variational principle. Generalized coordinates, Lagrangian and Hamiltonian formalism, Caley-Hamilton theorem
- **Electromagnetic theory:**
  Electrostatics, Maxwell's equations, Scalar and vector potentials, gauge invariance, Dielectrics and conductors.
- **Quantum Mechanics:**
  Wave-particle duality. Schrödinger equation. Tunnelling through a barrier. Heisenberg uncertainty principle. Hydrogen atom. Time independent perturbation theory and applications. Pauli exclusion principle, Variational method. Spin-orbit coupling, fine structure.
- **Thermodynamic and Statistical Physics:**
  Laws of thermodynamics and their consequences. Thermodynamic potentials, Maxwell relations. Micro-canonical, canonical and grand-canonical ensembles and partition functions. Blackbody radiation and Planck's distribution law, Landau theory of first- and second-order phase transitions. Ising model.
- **Electronics and Experimental Methods:**
  Semiconductor devices, Operational amplifiers. Data interpretation and analysis. Precision and accuracy. Error analysis, propagation of errors. Least squares fitting, Linear and nonlinear curve fitting, chi-square test.
- **Atomic & Molecular Physics:**

Quantum states of an electron. Spectrum of alkali atom, hyperfine structure and isotopic shift, LS & JJ couplings. Zeeman, Paschen-Bach & Stark effects.

- **Condensed Matter Physics:**
  Bravais lattices. Reciprocal lattice. Diffraction and the structure factor. Bonding of solids. Free electron theory and electronic specific heat, electron motion in a periodic potential, metal, insulators and semiconductors.
- **Nuclear and Particle Physics:**
  Basic nuclear properties, Binding energy, liquid drop model. Classification of fundamental forces. Elementary particles
  # There may also be a few questions from general sciences of XII standards.

  # The examination will include questions on research methodology designed to assess the candidate's research aptitude, reasoning ability, divergent thinking, and general awareness of research methodology.

*** Research in this area is interdisciplinary, and we invite student applications from* ***both Chemistry and Physics backgrounds.*** *The Question paper for the admission test will have separate sections for Chemistry and Physics questions, and students are required to attempt questions from only one section, depending on their PG degree.*

Food Science and Technology

The topics include basic questions on Research Methodology, Food Technology, Biochemistry, Molecular Biology, and Industrial Biotechnology, especially from the topics that are relevant to Food Product Design. In addition, there are some advanced biology questions that include advanced Enzymology, Fermentation, protein Chemistry and Food Engineering topics. The detailed topics of each subject are given below.

Food Technology:

Reference: Textbook of Food Science and Technology, Sharma A

- Basic Concepts: Nutrition, balanced diet, energy, macronutrients and micronutrients.
- Principles of Food Science: Understanding the physical, chemical, and microbiological changes in food caused by various factors like heat, enzymes, and pH changes.
- Food Safety: HACCP (Hazard Analysis and Critical Control Points) and food safety management tools.
- Food Processing and Preservation: Understanding the significance of food processing, its impact on food quality, and different methods of preservation.
- Food Components:
  - Carbohydrates: Structure, function, and metabolism of carbohydrates in food, including monosaccharides, disaccharides, and polysaccharides.
  - Lipids: Chemistry and function of lipids in food, including fatty acids, fats, and oils.
  - Proteins: Structure, function, and metabolism of proteins in food, including amino acids and peptide sequencing.
  - Nucleic Acids: Structure and biochemical roles of DNA and RNA in food.

Biochemistry:

Reference: Principles of Biochemistry, Lehninger.

- Quantitative Analysis: Quantitative analysis of food components.
- Enzyme Assays: Methods for determining enzyme activity.
- Microbial Analysis: Isolation, identification, and enumeration of microorganisms in food samples.
- Physical Chemistry: Atomic structure and

reaction kinetics.

Molecular Biology:

Reference: Molecular Biology by Verma and Agarwal

- Enzymology: Structure of enzymes, their mechanisms, and role in biological processes.

- Bioinformatics: Deals with the analysis of biological data, including DNA and protein sequences, using computational tools.
- Molecular biology techniques: DNA extraction, PCR, gel electrophoresis, and other relevant methods.

Industrial Biotechnology:

Reference: Industrial Biotechnology: Current Progress and Novel Technologies, “Industrial Biotechnology: Principles and Applications” and “Industrial Biotechnology: Products and Processes (Advanced Biotechnology)"

- Enzyme Technology: Focuses on enzymes, their applications in industrial processes, and enzyme engineering.
- Bioprocess Technology and Downstream Processing: Covers the design, optimization, and scale-up of industrial bioprocesses, as well as techniques for product isolation and purification.
- Food Biotechnology: The role of biotechnology in food production, processing, and quality control.
- Fermentation Biology: Production of enzymes and other bioactive molecules, Bioreactors, Downstream processing, Inoculum preparation and Process optimization.

Research Methodology:

- Statistical techniques, Data collection and analysis, Ethics in research and Report generation will be the focus.