Syllabus for the Post of Assistant Professor in Physical Science in Collegiate Education(Cat.No:565/2022)

Part I : Science Education

I) Basics of Science Education (10)

Science- Meaning – Evolution of Science as a discipline – Vocabulary of Science-SAPA- Science A Process Approach- Process skills in Science- its relevance. Aims and objectives of Science Education- Blooms Taxonomy of Educational Objectives- Revised Taxonomy- Mc Cormack and Yager Taxonomy of Science Education- Technology Integrated Taxonomy (Peck and Wilson).

II) Approaches, methods and strategies in Science Learning (15)

Guided Discovery approach, Enquiry approach, Inductive- deductive approach, issue based approach, Scientific method, Project based learning, Problem based learning, Experiential learning, Brain based learning, Cooperative and collaborative learning, Concept mapping, Mind mapping, Programmed learning, Personalised System of Instruction. Models of Teaching- Concept Attainment Model, Advanced Organiser Model, Inquiry Training Model.

ICT integrated pedagogy, ICT based resources for science education, Learning Management System(LMS), MOODLE, Web 2.0 tools, Augmented Reality, Virtual Reality, Artificial Intelligence tools.

Implications of the theory of Piaget, Bruner, Gagne, Vygotsky, Gardner and Sternberg. Critical pedagogy by Freire.

III) Curriculum and Assessment in Science Education (10)

Curriculum- types of curriculum, different approaches of curriculum (discipline wise, interdisciplinary, Unified, Integrated, Correlated and Hidden curriculum. Principles of curriculum construction, Curricular vision suggested by NCF (2005) and KCF (2007). Study of various curricular projects- PSSC, CHEM study, CBA, BSCS, Nuffield Sciences.

Assessment, Evaluation -- significance- various types- internal/external, formative/summative, achievement test, diagnostic test, standardized test, criterion referenced and norm referenced tests. Ongoing and future trends in evaluation- multi dimensional, individual/group, learning outcome based and performance based. Important tools and techniques to assess outcomes of various domains- Rubrics, portfolios, Online assessment.

IV) Professional development of Science Teacher (5)

Changing roles and responsibilities of Science teachers/ Teacher educators, Teacher as a Reflective practitioner- Reflective practices to be adopted, extension activities for Science teachers, Professionalism of Science teacher, networking (types and merits), Need for developing research attitude in teachers, science education journals and Impact factor of a journal.

V) Research in Education (10)

Meaning of Research-Qualities of good research, Types of Research, Classification based on Purpose (Basic/Applied), Method (Experimental- different designs/ descriptive/ Historical), Type (Qualitative/Quantitative/ Eclectic) and Action Research, Case study, Mixed method. Objectives, Hypotheses (types- directional, non-directional, null, and alternative), Sources and Characteristics, Types of Variables (independent, dependent, extraneous, confounding, intervening). Research designs- Experimental designs, Correlational designs, Action Research, Survey design. Steps of Research proposal.

Part II - Physics

Module1

Mathematical Physics (3 Marks)

Dimensional analysis, Vector algebra and vector calculus, Circular, cylindrical and spherical polar coordinates, Linear algebra, Matrices, Eigen values and eigen vectors, Linear ordinary differential equations of first and second order, Special functions – gamma, beta, Hermite, Bessel and Legendre functions, Fourier series and Laplace transforms, Tensors, Introductory group theory, Elementary probability theory.

Module 2

Classical Mechanics (3 Marks)

Newton’s laws, Lagrange and Hamilton formalism, Central force motion, Two body collisions – scattering in laboratory and center of mass frame, Rigid body dynamics and moment of inertia tensor, Non-inertial frames and pseudoforces, Variational principle, Generalized coordinates, Conservation laws and cyclic coordinates, Periodic motion and small oscillations, Special theory of relativity – Lorentz transformations, relativistic kinematics and mass energy equivalence.

Module 3

Electromagnetic theory (3 Marks)

Electrostatics - Gauss' law and applications, Laplace and Poisson equations, boundary value problems, Magnetostatics – Biot -Savart law, and Ampere's theorem, Electromagnetic induction, Maxwell's equations in free space and linear isotropic media, Boundary conditions on the fields at interfaces, Scalar and vector potential, Gauge invariance, Dielectrics and conductors, Dynamics of charged particles in static and uniform electromagnetic fields, Transmission lines and waveguides.

Module 4

Quantum Mechanics (3 Marks)

Wave particle duality, Fundamental postulates of quantum mechanics, Schrodinger equation (time dependent and time independent), Eigen value problem – particle in a box and harmonic oscillator, Tunnelling through a barrier, Heisenberg uncertainty principle and commutators, Dirac notation for state vectors, Angular momentum algebra (spin and addition of angular momenta), WKB approximation, Elementary theory of scattering – phase shift and partial waves, Born approximation.

Module 5

Thermodynamics and statistical physics (6 Marks)

Laws of thermodynamics and their consequences, Thermodynamic potentials, Maxwell's relations, Chemical potentials, Phase equilibria, Phase space, Micro and macro states, micro-canonical, canonical and grand-canonical ensembles, partition function, Classical and Quantum statistics, Ideal Bose and Fermi gas, Black body radiation and Planck's distribution law, First and second order phase transitions, Diamagnetism, Para magnetism and Ferromagnetism.

Electronics

Semiconductor devices (diode, BJT and FET) – device structure, device characteristics, frequency dependence and applications, Optoelectronic devices – solar cell, photodetector and LED, Operational amplifier and their applications, Digital techniques and applications (registers, counters and comparators), A/D and D/A converters.

Experimental methods

Precision and accuracy, Error analysis, Propagation of errors.

Module 6

Atomic and Molecular Physics (7 Marks)

Atomic spectroscopy – LS and JJ coupling, Zeeman effect, Stark effect and Paschen Back effect, ESR and NMR spectroscopy, Chemical shift, Frank Condon principle, Born Oppenheimer approximation, Electronic, rotational, vibrational and Raman spectra of diatomic molecules and selection rules, Lasers – spontaneous and stimulated emission, Einstein coefficients, optical pumping, population inversion and rate equations.

Condensed Matter Physics

Bravais lattice, Reciprocal lattice, Diffraction and structure factor, Bonding of solids, elastic properties, phonons, Lattice specific heat, free electron theory and electronic specific heat, Drude model of electrical and thermal conductivity, Hall effect and thermoelectric power, Superconductivity, type I and type II superconductors, Josephson junction, BCS theory.

Nuclear and particle physics

Basic nuclear properties – size, shape, charge, spin and parity, Binding energy, Semiempirical mass formula, Liquid drop model, properties of nuclear forces, Elementary ideas of alpha, beta and gamma decay, nuclear fusion, nuclear fission, nuclear reactors, Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness), Quark model, Fundamental forces.

PART - III

CHEMISTRY

Module 1 **5 marks**

Analytical Chemistry:

Evaluation of analytical data: Accuracy and precision. Errors: Classification, distribution, propagation, causes and minimization of errors. Significant figures and computation rules.

Inorganic qualitative analysis- common ion effect- solubility product- precipitation of cations. Quantitative analytical methods: Principle of volumetric analysis –standard solution, primary standard, theory of acid - base titration, permanganometric, dichrometric and complexometric titrations, types of indicators, theory of acid – base and redox indicators. Gravimetric methods - precipitation from homogeneous solutions, Contamination of precipitates – Co-precipitation, Post precipitation.

Spectral methods –Atomic Absorption Spectroscopy (AAS) - principle, measurement, advantages, disadvantages, and applications. Flame Emission Spectroscopy (FES) principle, measurement(single beam method) and applications.

Thermal methods - Thermo gravimetric analysis (TG)-principle and method, factors affecting thermogravimetric analysis, application, Differential Thermal Analysis (DTA) - principle, method, factors affecting DTA Applications.

Chromatography - principle and applications of adsorption and partition chromatography, paper, thin layer, ion exchange, gas chromatography , HPLC - R_f and R_t value .

Module 2 **5 marks**

Inorganic Chemistry

Basic Concepts - Quantum numbers and their significance, Concept of orbitals. Energy sequence rule – Pauli’s principle, Hund’s rule, stability of filled and half-filled orbitals. Electronic configuration and classification of elements in to s, p, d and f blocks.

Periodic properties, Ionisation energy, Electronegativity and Electron affinity. Diagonal relationship. Important characteristics of representative elements - valency, oxidation states, ionic and covalent bond formation. Important compounds of p block elements- Sulphur-Nitrogen compounds, Sulphur-Phosphorus compounds, Phosphorous-Nitrogen compounds, Boron-Nitrogen compounds, Boranes, Carboranes, metalloboranes and metallocarboranes. Silicates and its classification. Interhalogen compounds, oxyhalides, Xenon compounds. Important characteristics of transition elements -

variable valency and oxidation states, formation of complex compounds. Lanthanides and actinides- electronic configuration. Lanthanide contraction and its consequences.

Coordination Chemistry- Ligands- Classification - Stability of chelates. Valence bond theory Crystal field theory - CFSE for d^1 to d^{10} systems. Magnetic properties.
Electronic spectra of metal complexes-Term symbols of d^n system, Racah parameters, splitting of terms in weak and strong octahedral and tetrahedral fields. Selection rules for electronic transition. Charge transfer spectra. Stability of complexes - Thermodynamic and kinetic stability.

Bioinorganic chemistry - Metalloporphyrins: Porphyrin ring system. Chlorophyll. Haemoglobin and Myoglobin. Sodium and Potassium transport.

Metallurgy - Ores and Minerals. Concentration of ores, General Methods of extracting metal from concentrated ore, examples. Electro metallurgy-Metallurgy of Aluminium, Sodium-Pyrometallurgy. Refining of crude metals: Distillation, Liquation, electrolytic and zone refining Chromatographic techniques and vapour phase refining (Mond's process and Van Arkel process).

Module 3 **5 marks**

Organic Chemistry

Classification of organic compounds, IUPAC nomenclature of organic compounds.

Stereochemistry - Molecular chirality, relative configuration, stereochemical nomenclature, R and S, E and Z. Racemic mixture, resolution, methods of resolution. Conformational analysis of alkanes, cycloalkanes and decalin.
Concept of aromaticity – Application of Huckel's rule to benzenoid and non-benzenoid compounds (naphathalene, anthracene, annulenes, cyclic carbocations and anions, five membered heterocylics, azulene, fulvene)

Electron displacement effects. Acidity and basicity of organic compounds based on electron displacement effects: Acid characters of alcohols, phenols and carboxylic acids and basic character of amines.

Reaction intermediates: Carbocations, carbanions, free radicals, carbenes and nitrenes - Structure, formation, stability and reactivity.

Aliphatic nucleophilic substitutions: S_N1 and S_N2 mechanisms, Effect of nature of substrate and solvent in substitution reactions, Stereochemistry of SN reactions, Stereospecificity and Stereoselecticity in SN reactions, Walden Inversion. Neighbouring group participation. Elimination reaction: 1,1 and 1,2 eliminations, mechanisms of E1 and E2 reactions, Regioselectivity in elimination reactions (Hoffmann and Saytzeff rule and Bredt's rule). Stereo chemical pathways of elimination: Syn and Anti eliminations. Addition reactions: mechanism of addition of bromine and hydrogen halides to double bonds, Regioselectivity in addition reaction (Markownikoff's rule and peroxide effect). Cis hydroxylation, Diels Alder addition, 1,2- and 1,4- additions in 1,3-butadiene.

Module 4 **5 marks**

Physical Chemistry

Solid state- Amorphous and Crystalline solids. Types of crystals. Crystal symmetry- Seven basic crystal systems, Space lattice and unit cell, Bravais lattices, close packing structures of cubic and orthorhombic space lattices. X-ray diffraction by crystals: Bragg's equation. Diffraction methods: Powder and rotating crystal. Crystal defects: Point, line and plane defects. Stoichiometric and Nonstoichiometric defects, Colour centers in alkali halide crystals.

Liquid state-Properties of liquids: vapour pressure, Surface tension, Viscosity.

Gaseous state- Kinetic Theory of gases: postulates, Types of molecular velocities, Maxwell Boltzmann distribution of molecular velocities. Collision properties. Collision diameter, Collision number, Collision frequency and mean free path. Behaviour of real gases,
Explanation for deviation from ideal behaviour, Compressibility factor– Boyle temperature, Law of corresponding states – reduced equation of state, Joule Thomson effect, liquefaction of gases

Electrochemistry- Electrochemical cells- definition, types. Electrodes-Types of electrodes. Electrode potential. Cell potential. Reference electrodes. Nernst equation. Relation between electrical energy, free energy, enthalpy and entropy. Applications of EMF measurements - determination of pH.

Chemical kinetics - Rates of reaction, various factors influencing rates of reactions – order and molecularity – Zero, first, second and third order reaction, derivation of integrated rate equation, fractional life time, units of rate constants, influence of temperature on reaction rates. Arrhenius equation, calculation of Arrhenius parameters – collision theory of reaction rates.

Thermodynamics - First law of thermodynamics, mathematical form, intrinsic energy, enthalpy, reversible process and maximum work, work of expansion of an ideal gas in reversible isothermal process. Second law of thermodynamics. Criteria of equilibrium, and spontaneity on the basis of entropy and free energy – Gibbs- Helmholtz equation.

Module 5 **3 marks**

Spectroscopy

Microwave spectroscopy- Rotation spectrum of diatomic molecules – expressions for rotational energy, selection rule – frequency separation and determination of bond length.
IR spectroscopy- harmonic oscillator, equation for frequency of vibration, expression for vibrational energy, selection rule, frequency separation, calculations of force constant.
Electronic spectroscopy – types of transition and regions of absorption. Beer-Lambert law - Principle of colorimetry.
Raman spectroscopy – stokes and anti-stokes lines, quantum theory of Raman spectrum – advantages and disadvantages of Raman spectrum, rotational Raman spectrum, selection rules and frequency separation. Mutual exclusion principle.
NMR spectroscopy- principle, chemical shift, spin – spin coupling, application of NMR to simple molecules.

Module 6 **2 marks**

Biomolecules and Chemistry in everyday life

Carbohydrates - Classification, Configuration of monosaccharides. Pyranoside structures of glucose and fructose, furanoside structure of fructose. Anomers and Mutarotation. Epimers and epimerization. Amino acids - Classification, structure and stereochemistry of amino acids.Oils and Fats-saponification value, iodine value and acid value. Proteins – classification and structure of proteins, denaturation and colour reactions. Nucleic acids - Classification and structure of DNA and RNA. Vitamins - Classification, functions and deficiency diseases

Food additives - preservatives, anti oxidants, artificial sweeteners. Cleansing agents. Cosmetics. Chemistry in the field of Medicine: Classification of drugs. Use of radio isotopes in medicine

NOTE: - It may be noted that apart from the topics detailed above, questions from other topics prescribed for the educational qualification of the post may also appear in the question paper. There is no undertaking that all the topics above may be covered in the question paper