

Syllabus for Level-10 Post Code: NCB/CME-01

Process Calculations and Thermodynamics

Steady and unsteady state mass and energy balances including multiphase, multi-component, reacting and non-reacting systems. Use of tie components; recycle, bypass and purge calculations; Gibb's phase rule and degree of freedom analysis.

First and Second laws of thermodynamics. Applications of first law to close and open systems. Second law and Entropy. Thermodynamic properties of pure substances: Equation of State and residual properties, properties of mixtures: partial molar properties, fugacity, excess properties and activity coefficients; phase equilibria: predicting VLE of systems; chemical reaction equilibrium.

Fluid Mechanics and Mechanical Operations

Fluid statics, surface tension, Newtonian and non-Newtonian fluids, transport properties, shell-balances including differential form of Bernoulli equation and energy balance, equation of continuity, equation of motion, equation of mechanical energy, Macroscopic friction factors, dimensional analysis and similitude, flow through pipeline systems, velocity profiles, flow meters, pumps and compressors, elementary boundary layer theory, flow past immersed bodies including packed and fluidized beds, Turbulent flow: fluctuating velocity, universal velocity profile and pressure drop. Particle size and shape, particle size distribution, size reduction and classification of solid particles; free and hindered settling; centrifuge and cyclones; thickening and classification, filtration, agitation and mixing; conveying of solids.

Heat Transfer

Equation of energy, steady and unsteady heat conduction, convection and radiation, thermal boundary layer and heat transfer coefficients, boiling, condensation and evaporation; types of heat exchangers and evaporators and their process calculations; design of double pipe, shell and tube heat exchangers, and single and multiple effect evaporators.

Chemical Reaction Engineering

Theories of reaction rates; kinetics of homogeneous reactions, interpretation of kinetic data, single and multiple reactions in ideal reactors, kinetics of enzyme reactions (Michaelis-Menten and Monod models), non-ideal reactors; residence time distribution, single parameter model; non-isothermal reactors; kinetics of heterogeneous catalytic reactions; diffusion effects in catalysis; rate and performance equations for catalyst deactivation.

Instrumentation and Process Control

Measurement of process variables; sensors and transducers; PCID equipment symbols; process modeling and linearization, transfer functions and dynamic responses of various systems, systems with inverse response, process reaction curve, controller modes (P, PI, and PID); control valves; transducer dynamics; analysis of closed loop systems including stability, frequency response, controller tuning, cascade and feed forward control.

Syllabus for Level-10 Post Code: NCB/CME-02

Electric circuits

Network Elements: Ideal voltage and current sources, dependent sources, R, L, C, M elements; Network solution methods: KCL, KVL, Node and Mesh analysis; Network Theorems: Thevenin's, Norton's, Superposition and Maximum Power Transfer theorem; Transient response of DC and AC networks, sinusoidal steady-state analysis, resonance, two port networks, balanced three phase circuits, star-delta transformation, complex power and power factor in AC circuits.

Signals and Systems

Representation of continuous and discrete time signals, shifting and scaling properties, linear time invariant and causal systems, Fourier series representation of continuous and discrete time periodic signals, sampling theorem, Applications of Fourier Transform for continuous and discrete time signals, Laplace Transform and Z transform. R.M.S. value, average value calculation for any general periodic waveform.

Electrical Machines

Single phase transformer: equivalent circuit, phasor diagram, open circuit and short circuit tests, regulation and efficiency; Three-phase transformers: connections, vector groups, parallel operation; Auto-transformer, Electromechanical energy conversion principles; DC machines: separately excited, series and shunt, motoring and generating mode of operation and their characteristics, speed control of dc motors; Three-phase induction machines: principle of operation, types, performance, torque-speed characteristics, no-load and blocked-rotor tests, equivalent circuit, starting and speed control; Operating principle of single-phase induction motors; Synchronous machines: cylindrical and salient pole machines, performance and characteristics, regulation and parallel operation of generators, starting of synchronous motors; Types of losses and efficiency calculations of electric machines.

Power Systems

Basic concepts of electrical power generation, AC and DC transmission concepts, Models and performance of transmission lines and cables, Economic Load Dispatch (with and without considering transmission losses), Series and shunt compensation, Electric field distribution and insulators, Distribution systems, Per-unit quantities, Bus admittance matrix, Gauss-Seidel and Newton-Raphson load flow methods, Voltage and

Frequency control, Power factor correction, Symmetrical components, Symmetrical and unsymmetrical fault analysis, Principles of over-current, differential, directional and distance protection; Circuit breakers, System stability concepts, Equal area criterion.

Control Systems

Mathematical modelling and representation of systems, Feedback principle, transfer function, Block diagrams and Signal flow graphs, Transient and Steady-state analysis of linear time invariant systems, Stability analysis using Routh-Hurwitz and Nyquist criteria, Bode plots, Root loci, Lag, Lead and Lead-Lag compensators; P, PI and PID controllers; State space model, Solution of state equations of LTI systems.

Electrical and Electronic Measurements

Bridges and Potentiometers, Measurement of voltage, current, power, energy and power factor; Instrument transformers, Digital voltmeters and multi-meters, Phase, Time and Frequency measurement; Oscilloscopes, Error analysis.

Syllabus for Level-10 Post Code: NCB/CME-03

Air and Noise Pollution

Structure of the atmosphere; Natural and anthropogenic sources of pollution; Atmospheric sources, sinks, transport; Indoor air pollution; Effects on health and environment; Air pollution: gases and particulate matter; Air quality standards; Primary and secondary pollutants; Criteria pollutants, ambient and source standards, air quality indices, visibility.

Particulate Pollutants: Measurement and control methods; Control of particulate air pollutants using gravitational settling chambers, cyclone separators, wet collectors, fabric filters (Bag-house filter), electrostatic precipitators (ESP).

Gaseous Pollutants: Measurement and control methods; Control of gaseous contaminants: absorption, adsorption, condensation and combustion; Control of sulphur oxides, nitrogen oxides, carbon monoxide, and hydrocarbons; Vapour-liquid and vapour-solid equilibria; Diffusion, Fick's law and interfacial mass transfer. Automotive emission controls, fuel quality, diesel particulate filters, catalytic convertors.

Air Quality Management: Point, line and area sources; Inventory; Influence of meteorology - wind rose diagrams, stability, mixing height, topography, dispersion modelling, monitoring.

Noise Pollution: Sources; Health effects; Standards; Measurement and control methods.

Solid and Hazardous Waste Management

Integrated solid waste management; Waste hierarchy; Rules and regulations for solid waste management in India.

Municipal solid waste management: Sources, generation, characteristics, collection and transportation, waste processing and disposal (including reuse options, biological methods, energy recovery processes and landfilling).

Hazardous waste management: Characteristics, generation, fate of materials in the environment, treatment and disposal. Soil contamination and leaching of contaminants into groundwater.

Management of biomedical waste, plastic waste and E-waste: Sources, generation and characteristics; Waste management practices including storage, collection and transfer.

Global and Regional Environmental Issues

Global effects of air pollution: Greenhouse gases, global warming, climate change, urban heat islands, acid rain, ozone hole.

Ecology and various ecosystems; Biodiversity; Factors influencing increase in population, energy consumption, and environmental degradation.

Environmental Management and Sustainable Development

Environmental Management Systems; ISO14000 series; Environmental Auditing: Environmental Impact Assessment; Life cycle assessment; Human health risk assessment.

Environmental Law and Policy: Objectives; Polluter pays principle, Precautionary principle; The Water and Air Acts with amendments; The Environment (Protection) Act (EPA) 1986; National Green Tribunal Act, 2010; National Environment Policy; Principles of International Law and International treaties.

Energy and Environment: Energy Sources: Overview of resources and reserves; Renewable and non-renewable energy sources; Energy-Environment nexus.

Sustainable Development: Definition and concepts of sustainable development; Sustainable development goals; Hurdles to sustainability; Environment and economics.

Syllabus for Level-10 Post Code: NCB/CME-04

Common Section

Basic structural geology - stress, strain and material response; brittle and ductile deformation; nomenclature and classification of folds and faults.

Crystallography – basic crystal symmetry and concept of point groups. Mineralogy – silicate crystal structure and determinative mineralogy of common rock forming minerals.

Petrology of common igneous, sedimentary and metamorphic rocks.

Geological time scale; Geochronology and absolute time. Stratigraphic principles; major stratigraphic divisions of India.

Mineral, coal and petroleum resources of India.

Introduction to remote sensing. Engineering properties of rocks and soils. Elements of hydrogeology.

Principles and applications of gravity, magnetic, electrical, electromagnetic, seismic and radiometric methods of prospecting for oil, mineral and ground water; introductory well logging.

Geology

Crystallography and Mineralogy: Elements of crystal symmetry, form and twinning; crystallographic projection; crystal chemistry; classification of minerals, physical and optical properties of rock-forming minerals.

Geochemistry: Cosmic abundance of elements; meteorites; geochemical evolution of the earth; geochemical cycles; distribution of major, minor and trace elements in crust and mantle; elements of high temperature and low temperature geochemical thermodynamics; isotopic evolution of the crust and the mantle, mantle reservoirs; geochemistry of water and water-rock interaction.

Igneous Petrology: Classification, forms, textures and genesis of common igneous rocks; magmatic differentiation; binary and ternary phase diagrams; major and trace elements as monitors of partial melting and magma evolutionary processes. Mantle plumes, hotspots and large igneous provinces.

Sedimentology: Texture, structure and sedimentary processes; petrology of common sedimentary rocks; Sedimentary facies and environments, cyclicities in sedimentary succession; provenance and basin analysis. Important sedimentary basins of India.

Metamorphic Petrology: Structures and textures of metamorphic rocks. Physico-chemical conditions of metamorphism and concept of metamorphic facies, grade and baric types; chemographic projections; metamorphism of pelitic, mafic and impure carbonate rocks; role of

bulk composition including fluids in metamorphism; thermobarometry and metamorphic P- T-t paths, and their tectonic significance.

Stratigraphy: Principles of stratigraphy and concepts of correlation; Lithostratigraphy, biostratigraphy and chronostratigraphy. Principles of sequence stratigraphy and applications. Stratigraphy of peninsular and extra-peninsular India. Boundary problems in Indian stratigraphy.

Resource Geology: Ore-mineralogy; ore forming processes vis-à-vis ore-rock association (magmatic, hydrothermal, sedimentary, supergene and metamorphogenic ores); fluid inclusions as ore genetic tools. Coal and petroleum geology; marine mineral resources. Prospecting and exploration of economic mineral deposits - sampling, ore reserve estimation, geostatistics, mining methods. Ore dressing and mineral economics. Distribution of mineral, fossil and nuclear fuel deposits in India.

Applied Geology: Physico-mechanical properties of rocks and soils; rock index tests; Rock failure criteria (Mohr-Coulomb, Griffith and Hoek-Brown criteria); shear strength of rock discontinuities; rock mass classifications (RMR and Q Systems); in-situ stresses; rocks as construction materials; geological factors in the construction of engineering structures including dams, tunnels and excavation sites. Analysis of slope stability.

Natural hazards (landslide, volcanic, seismogenic, coastal) and mitigation. Principles of climate change.

Hydrogeology: Groundwater flow and exploration, well hydraulics and water quality.

Basic Principles of Remote Sensing: energy sources and radiation principles, atmospheric absorption, interaction of energy with earth's surface, aerial-photo interpretation, multispectral remote sensing in visible, infrared, thermal IR and microwave regions, digital processing of satellite images. GIS – basic concepts, raster and vector mode operations.

Methods of Geological Prospecting and Exploration

Principles and concepts of mineral exploration, methods of Prospecting and Exploration. Different stages of mineral exploration. Radiometric survey. Remote sensing in mineral exploration.

Sampling and Subsurface Exploration

Sampling theory, objectives and methods. Exploration drilling technique, planning, drill core logging and sampling. Planning of geological plans and sections for ore body evaluation.

Reserve Estimation

Cut-off grade concepts and applications, reserve estimation—principles, practices and different

conventional methods.

Principles of Geochemical Exploration

Geochemical cycle, geochemical mobility and association of elements. Primary and secondary dispersions of elements; determination of background and geochemical anomalies; pathfinder and target elements for geochemical exploration.

Geochemical Methods of Mineral Exploration

Methods of geochemical explorations, procedures for geochemical sampling; interpretation of geochemical surveys.

Mineral Economics: World resources of minerals

Classification of mineral resources with special reference to UNFC and JORC schemes. Mineral markets, import-export policies and international trade. Demand analysis of minerals, royalty and taxes. India's status in mineral production.

Mineral Policies and Regulations:

International and national mineral policies. Mines and Mineral policies. Mines and Minerals (Development and Regulation) Act. Marine and mineral resources and laws of sea.

Economics of Deposit:

Economic evaluation of mineral deposit.

Mineral Conservation:

Methods of mineral conservation and substitution.

Syllabus for Level-10 Post Code: NCB/CDR-01

Solid Mechanics: Bending moment and shear force in statically determinate beams; Simple stress and strain relationships; Simple bending theory, flexural and shear stresses, shear center; Uniform torsion, Transformation of stress; buckling of column, combined and direct bending stresses.

Structural Analysis: Statically determinate and indeterminate structures by force/ energy methods; Method of superposition; Analysis of trusses, arches, beams, cables and frames; Displacement methods: Slope deflection and moment distribution methods; Influence lines; Stiffness and flexibility methods of structural analysis.

Construction Materials and Management: Construction Materials: Concrete - Constituents, mix design, short-term and long-term properties. Construction Management: Types of construction projects; Project planning and network analysis - PERT and CPM.

Concrete Structures: Working stress and Limit state design concepts; Design of beams, slabs, columns; Bond and development length; Prestressed concrete beams.

Condition Assessment of Concrete Structures: Methods of Non Destructive Testing, assessment methods, load testing.

Municipal Solid Wastes: Characteristics, generation, collection and transportation of solid wastes, engineered systems for solid waste management (reuse/ recycle, energy recovery, treatment and disposal).

Highway Pavements: Highway materials - desirable properties and tests; Desirable properties of bituminous paving mixes; Design factors for flexible and rigid pavements; Design of flexible and rigid pavement using IRC codes.

Syllabus for Level-10 Post Code: NCB/CQC-01

Probability and Statistics

Sampling theorems, conditional probability, mean, median, mode, standard deviation and variance; random variables: discrete and continuous distributions: normal, Poisson and binomial distributions.

Electrical Circuits and Machines

Voltage and Current Sources: Independent, dependent, ideal and practical; v-i relationships of resistor, inductor, mutual inductance and capacitor; transient analysis of RLC circuits with dc excitation.

Kirchoff's laws, mesh and nodal analysis, superposition, Thevenin, Norton, maximum power transfer and reciprocity theorems.

Peak-, average- and rms values of AC quantities; apparent-, active- and reactive powers; phasor analysis, impedance and admittance; series and parallel resonance, locus diagrams, realization of basic filters with R, L and C elements. transient analysis of RLC circuits with ac excitation.

One-port and two-port networks, driving point impedance and admittance, open-, and short circuit parameters.

Single Phase Transformer: Equivalent circuit, phasor diagram, open circuit and short circuit tests, regulation and efficiency; Three phase induction motors: principle of operation, types, performance, torque-speed characteristics, no-load and blocked rotor tests, equivalent circuit, starting and speed control; Types of losses and efficiency calculations of electric machines.

Control Systems

Feedback principles, signal flow graphs, transient response, steady-state-errors, Bode plot, phase and gain margins, Routh and Nyquist criteria, root loci, design of lead, lag and lead-lag compensators, state-space representation of systems; time-delay systems; mechanical, hydraulic and pneumatic system components, synchro pair, servo and stepper motors, servo valves; on-off, P, PI, PID, cascade, feed forward, and ratio controllers, tuning of PID controllers and sizing of control valves.

Analog Electronics

Characteristics and applications of diode, Zener diode, BJT and MOSFET; small signal analysis of transistor circuits, feedback amplifiers. Characteristics of ideal and practical operational amplifiers; applications of opamps: adder, subtractor, integrator, differentiator, difference amplifier, instrumentation amplifier, precision rectifier, active filters, oscillators, signal generators, voltage controlled oscillators and phase locked loop, sources and effects of noise and interference in electronic circuits.

Digital Electronics

Combinational logic circuits, minimization of Boolean functions. IC families: TTL and CMOS. Arithmetic circuits, comparators, Schmitt trigger, multi-vibrators, sequential circuits, flipflops, shift registers, timers and counters; sample-and-hold circuit, multiplexer, analog-to-digital (successive approximation, integrating, flash and sigma-delta) and digital-to-analog converters (weighted R, R-2R ladder and current steering logic). Characteristics of ADC and DAC (resolution, quantization, significant bits, conversion/settling time); basics of number systems, Embedded Systems: Microprocessor and microcontroller applications, memory and input-output interfacing; basics of data acquisition systems, basics of distributed control systems (DCS) and programmable logic controllers (PLC).

Measurements

SI units, standards (R, L, C, voltage, current and frequency), systematic and random errors in measurement, expression of uncertainty - accuracy and precision, propagation of errors, linear and weighted regression. Bridges: Wheatstone, Kelvin, Megohm, Maxwell, Anderson, Schering and Wien for measurement of R, L, C and frequency, Q-meter. Measurement of voltage, current and power in single and three phase circuits; ac and dc current probes; true rms meters, voltage and current scaling, instrument transformers, timer/counter, time, phase and frequency measurements, digital voltmeter, digital multimeter; oscilloscope, shielding and grounding.

Sensors and Industrial Instrumentation

Resistive-, capacitive-, inductive-, piezoelectric-, Hall effect sensors and associated signal conditioning circuits; transducers for industrial instrumentation: displacement (linear and angular), velocity, acceleration, force, torque, vibration, shock, pressure (including low pressure), flow (variable head, variable area, electromagnetic, ultrasonic, turbine and open channel flow meters) temperature (thermocouple, bolometer, RTD (3/4 wire), thermistor, pyrometer and semiconductor); liquid level, pH, conductivity and viscosity measurement. 4- 20 mA two-wire transmitter.

Syllabus for Level-10 Post Code: NCB/CRT-01

INORGANIC CHEMISTRY

Periodicity of elements: Periodicity of Elements: 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-blocks. (a) Effective nuclear charge, shielding or screening effect, 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 energy, Successive ionization enthalpies and factors affecting ionization energy. (f) Electron gain enthalpy; trends of electron gain enthalpy. (g) Electronegativity, Variation of electronegativity with bond order, partial charge, hybridization.

Chemical bonding:

Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of Ions in crystals. Born-Landé equation, Born-Haber cycle and its application, Lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds, polarizing power and polarizability. Fajan's rules and its applications.

Covalent bond: Valence Bond theory. Hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements, equivalent and non-equivalent hybrid orbitals, Concept of resonance and resonating structures in various Inorganic and organic compounds.

MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules (N_2 , O_2) and heteronuclear diatomic molecules (CO, NO).

Comparison of VB and MO approaches.

VSEPR theory, shapes of simple molecules and ions containing lone and bond pairs of electrons, multiple bonding (σ and π 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.

Metallic Bond: Qualitative idea of valence bond and band theories. Semiconductors and insulators. 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.

Oxidation-reduction: Redox equations, standard electrode potential and its applications to inorganic reactions. Principles involved in some volumetric analyses (iron and copper).

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

Chemistry of s and p Block Elements I: Periodicity in s- and p-block elements with respect to electronic configuration, atomic and ionic size, ionization enthalpy, electronegativity (Pauling & Mulliken scales). Allotropy in C, S, and P.

Oxidation states with reference to elements in unusual and rare oxidation states like carbides and nitrides), inert pair effect, diagonal relationship and anomalous behaviour of first member of each group.

Chemistry of s and p Block Elements II: Hydrides and their classification (ionic, covalent and interstitial), structure and properties with respect to stability of hydrides of p- block elements. Concept of multicentre bonding (diborane).

Structure, bonding and their important properties like oxidation/reduction, acidic/basic nature of the following compounds and their applications in industrial, organic and environmental chemistry.

Hydrides of nitrogen (NH_3 , N_2H_4 , N_3H , NH_2OH); Oxoacids of P, S and Cl; Halides and oxohalides: PCl_3 , PCl_5 , SOCl_2 .

Chemistry of 3d metals

Oxidation states displayed by Cr, Fe, Co, Ni and Cu.

A study of the following compounds (including preparation and important properties): Peroxo compounds of Cr, $\text{K}_2\text{Cr}_2\text{O}_7$, KMnO_4 , $\text{K}_4[\text{Fe}(\text{CN})_6]$, sodium nitroprusside, $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$, $\text{Na}_3[\text{Co}(\text{NO}_2)_6]$.

Transition Elements

Chemistry of Ti, V, Cr Mn, Fe and Co in various oxidation states.

Inorganic Materials of Industrial Importance

Glass: Glassy state and its properties, classification (silicate and nonsilicate glasses). Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armoured 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.

PHYSICAL CHEMISTRY

Gaseous State

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 σ from η ; 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 behaviour. van der Waal's equation of state, its derivation and application in explaining real gas behaviour. 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.

Solid state

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, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analyses of powder diffraction patterns of NaCl, CsCl and KCl. Defects in crystals (stoichiometric and non-stoichiometric). Glasses and liquid crystals.

Chemical thermodynamics

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.

Carnot cycle, efficiency of heat engine, Carnot theorem.

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.

Chemical equilibrium

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 (van't Hoff's reaction). 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) and its applications.

Phase Equilibria

Concept of phases, components and degrees of freedom, 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 (H_2O and sulphur system).

Phase diagrams for systems of solid-liquid equilibria involving eutectic (Pb-Ag system, desilverisation of lead), congruent (ferric chloride-water) and incongruent (sodium sulphate-water) melting points, completely miscible solid solutions (intermediate, medium, maximum freezing points).

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

Chemical Kinetics

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 orders.

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

ANALYTICAL METHODS IN CHEMISTRY

UV-Visible Spectrometry: Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law. Instrumentation (choice of source, monochromator and detector) for single and double beam instrument.

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

Qualitative and quantitative aspects of analysis.

Flame Atomic Absorption 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.

Thermal and electro-analytical methods of analysis

Theory of thermo-gravimetry (TG), basic principle of instrumentation. Classification of electro-analytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points.

Syllabus for Level-11 Post Code: NCB/CME-05

Material & Energy Balance: Steady state and unsteady state balances, Heat and mass balance calculations in cement plant

Fluid mechanics: Fluid flow through pipes and ducts, Pumps, fans, blowers and compressors, Pressure drop calculations, Flow measurement techniques

Heat transfer: Conduction, convection and radiation, Heat exchangers, Thermal efficiency concepts considering cement plants, Waste heat recovery principles

Mechanical Operations: Crushing, grinding and size reduction, Screening and classification, Mixing and blending, Separation processes

Energy management and energy audits: Types and methodology of energy audits, Data collection and analysis, Energy balance preparation, Identification of energy saving opportunities, ISO 50001 concepts, Monitoring and targeting, Key Performance Indicators (KPIs)

Alternative fuels and renewable energy: Co-processing of RDF, biomass and other waste in cement plants, co-processing guidelines

Process optimization in cement plants: Process diagnostics including troubleshooting cement plant operation, mills performance optimization, optimization of fuel consumption, Reduction of false air, Quality & Productivity Improvement

Digitalization & Advanced Process Control: Expert systems, AI/ML applications in cement plants, Industry 4.0 concepts

Carbon emission reduction and decarbonisation strategies

Plant Design and Economics

Principles of process economics and cost estimation including depreciation and total annualized cost, cost indices, rate of return, payback period, discounted cash flow, optimization in process design and sizing of chemical engineering equipments such as heat exchangers and multistage contactors.

Syllabus for Level-11 Post Code: NCB/CME-06

Cement Plant Operation: Cement manufacturing process from quarry to dispatch, Operation of crushers, stacker reclaimers and material handling systems, Operation of raw mills, coal mills and cement mills, Operation and maintenance aspects of rotary kiln, preheater and clinker cooler, Cement grinding systems including Ball Mill, VRM and Roller Press

Project Engineering in Cement Plants: Basic and detailed engineering concepts, Equipment selection and technical specifications, Preparation and interpretation of PFDs, P&IDs and layout drawings, Tendering, bid evaluation and vendor management, Inspection, testing and quality assurance, Erection, commissioning and performance testing

Project Management: Project planning, scheduling and monitoring (PERT/CPM/MS Project/Primavera basics), Cost estimation, budgeting and project control, Resource planning and contractor management, Procurement procedures and contract management, Risk management and mitigation strategies, Preparation of project reports and documentation

Energy Efficiency & Utility Systems: Energy efficient operation of cement plant equipment, Waste Heat Recovery (WHR) systems, Fans, pumps, compressors and utility optimisation, Reduction of specific power and heat consumption, Energy conservation opportunities in cement plants

Mechanical Equipment & Maintenance: Mechanical systems used in cement plants, Preventive, predictive and breakdown maintenance practices, Lubrication systems and condition monitoring, Alignment, balancing and vibration analysis, Troubleshooting of mills, kilns, coolers, fans, conveyors and pumps, Shutdown and turnaround maintenance planning

Fluid Mechanics and Thermal Sciences

Fluid Mechanics: Fluid properties; fluid statics, forces on submerged bodies, stability of floating bodies; control-volume analysis of mass, momentum and energy; fluid acceleration; differential equations of continuity and momentum; Bernoulli's equation; dimensional analysis; viscous flow of incompressible fluids, boundary layer, elementary turbulent flow, flow through pipes, head losses in pipes, bends and fittings; basics of compressible fluid flow.

Heat Transfer: Modes of heat transfer; one dimensional heat conduction, resistance concept and electrical analogy, heat transfer through fins; unsteady heat conduction, lumped parameter system, Heisler's charts; thermal boundary layer, dimensionless parameters in free and forced convective heat transfer, heat transfer correlations for flow over flat plates and through pipes, effect of turbulence; heat exchanger performance, LMTD and NTU methods; radiative heat transfer, Stefan- Boltzmann law, Wien's displacement law, black and grey surfaces, view factors, radiation network analysis.

Syllabus for Level-11 Post Code: NCB/CME-07

Probability and Statistics:

Counting (permutation and combinations), probability axioms, Sample space, events, independent events, mutually exclusive events, marginal, conditional and joint probability, Bayes Theorem, conditional expectation and variance, mean, median, mode and standard deviation, correlation, and covariance, random variables, discrete random variables and probability mass functions, uniform, Bernoulli, binomial distribution, Continuous random variables and probability distribution function, uniform, exponential, Poisson, normal, standard normal, t-distribution, chi-squared distributions, cumulative distribution function, Conditional PDF, Central limit theorem, confidence interval, z-test, t-test, chi-squared test.

Programming, Data Structures and Algorithms:

Programming in Python, basic data structures: stacks, queues, linked lists, trees, hash tables; Search algorithms: linear search and binary search, basic sorting algorithms: selection sort, bubble sort and insertion sort; divide and conquer: mergesort, quicksort; introduction to graph theory; basic graph algorithms: traversals and shortest path.

Database Management and Warehousing:

ER-model, relational model: relational algebra, tuple calculus, SQL, integrity constraints, normal form, file organization, indexing, data types, data transformation such as normalization, discretization, sampling, compression; data warehouse modelling: schema for multidimensional data models, concept hierarchies, measures: categorization and computations.

Machine Learning:

(i) Supervised Learning: regression and classification problems, simple linear regression, multiple linear regression, ridge regression, logistic regression, k-nearest neighbour, naive Bayes classifier, linear discriminant analysis, support vector machine, decision trees, bias-variance trade-off, cross-validation methods such as leave-one-out (LOO) cross-validation, k-folds cross-validation, multi-layer perceptron, feed-forward neural network; (ii) Unsupervised Learning: clustering algorithms, k-means/k-medoid, hierarchical clustering, top-down, bottom-up: single-linkage, multiple-linkage, dimensionality reduction, principal component analysis.

Artificial Intelligence:

Search: informed, uninformed, adversarial; logic, propositional, predicate; reasoning under uncertainty topics — conditional independence representation, exact inference through variable elimination, and approximate inference through sampling.

Syllabus for Level-11 Post Code: NCB/CDR-02

Solid Mechanics:

Stress–strain behaviour, bending, shear, torsion, combined stresses, buckling, fatigue, creep and fracture mechanics.

Structural Analysis, Design and Optimization:

Analysis of determinate/indeterminate structures; matrix, stiffness and flexibility methods; RC design; structural optimization for strength, serviceability, durability and material efficiency.

Concrete Technology and Advanced Concrete Composites:

Cement chemistry; SCMs; admixtures; mix design; rheology; fresh, hardened and durability properties; HPC, UHPC, SCC, fibre reinforced concrete, alkali-activated/geopolymer concrete, lightweight, mass and repair concretes.

Mechanical and Durability Performance of Concrete:

Strength, stiffness, creep, shrinkage, permeability, chloride ingress, carbonation, sulphate attack, corrosion, service life prediction and durability design.

Structural Assessment, NDT and Rehabilitation:

Condition assessment; NDT/semi-destructive testing; load testing; structural health monitoring; residual life assessment; forensic investigation; repair, retrofitting and strengthening.

Construction Technology, Technical Audit and Project Management:

Modern construction methods; precast/mechanized construction; QA/QC; third-party technical audit; project planning (PERT/CPM); cost, contract, risk and safety management.

Sustainable Construction Materials and Circular Construction:

Low-carbon binders; recycled materials; industrial by-products; construction & demolition waste utilization; sustainable concrete technologies.

Pavement and Infrastructure Materials:

Concrete and pavement materials; rigid/flexible pavements; evaluation, rehabilitation and IRC-based design concepts.

Standards and Guidelines (National & International):

BIS/IS Codes, ACI, ASTM, EN/Eurocodes, ISO, fib Model Code, RILEM, JSCE and related standards/guidelines for cement, concrete, advanced concrete composites, structural design, durability, testing, pavements, quality assurance, repair, rehabilitation and structural performance evaluation.

Syllabus for Level-11 Post Code-NCB/CRT-02

Introduction to Cement and cement manufacturing process in General:

What is cement, its brief history and importance in construction, Cement manufacturing process, material and chemical composition of cement, various unit operations in cement manufacturing, present status and future of cement industry in India.

Types of Cement:

Characteristics and use of OPC Clinker and various type of Cement such as, Ordinary Portland Cement, Blended Cements (PPC, PSC and PCC), Special Cements (Sulphate Resisting Cement, White Portland Cement, Low Heat Cement, Masonry Cement, Oil Well Cement, High Alumina Cement, Supersulphated Cement, Rapid hardening Cement and Hydrophobic Cement). Awareness of standard Indian (BIS) Codes for cement specifications.

Cement raw Materials:

Calcareous Raw Materials: Various Source of Lime (Limestone, Chalk, Marl, Industrial waste) Awareness of geological distribution of limestone deposits in India. Awareness of specifications of grades of limestone. Assessment of physiochemical characteristics of limestone for Cement manufacturing using different methods/techniques.

Argillaceous Raw Materials: Source of silica, Alumina, Iron Oxide, Shale and effect of coal ash and additives use as corrective materials, Fly Ash, Slag, Lime sludge as cement raw materials. Assessment of materials for cement manufacturing through different methods/techniques.

Additives: Characteristics, types and use of various additive materials like Fly ash and slag. Relevant Indian Standards.

Gypsum: Types and Chemical properties of gypsum, Awareness of BIS Codes for gypsum. Influence of Raw Materials on unit operations

Raw mix proportioning, processing and burnability:

Raw material selection and proportioning method (Raw Mix Design), Quality (Stoichiometric) Requirements in terms of oxides, phases, and moduli (Silica Modules, Alumina Modulus, Hydraulic Modulus, Lime Saturation Factor), Liquid Content, Impact of moduli values on cement manufacturing process and quality of clinker, potential phase calculation by Bogue equations, Coal ash absorption, Factors affecting burnability of raw meal like fineness, homogeneity, chemical and mineral characteristics, minor constituents, reactivity, Mineralizer, Role of additive in clinker formation, various mineralizer and fluxes, their role in manufacture of clinker.

Clinkerization reactions, sequence of reactions and reaction products, calculation of potential phase composition and liquid phase temperature, Bogue's calculation, formation of clinker minerals, absorption of constituents in clinker phase, phase diagram, Role of minor constituents in clinkerization, Thermo-chemistry of clinker formation.

Hydration of Portland cement:

Hydration of clinker minerals, role of gypsum in cement hydration process, hydration and strength of Portland cement.

Instrumental Methods of Analysis:

Principles, working and applications of UV-VIS spectrophotometer, pH meter, conductivity meter, ion selective electrodes, flame photometer, Atomic Absorption Spectrophotometer, Induction Coupled Plasma (ICP) Spectrophotometer, Isothermal Conduction Calorimeter, TG/DTA, TGA, DSC, XRF, XRD and SEM. Applications of advanced instrumental techniques in cement R&D.

Alternate Fuels and Raw Materials (AFR) Co-processing in Cement manufacturing:

Traditional and alternate fuels and raw materials (AFR) in cement manufacturing, Types (based on source) and characteristics (hazardous and non-hazardous) of AFR, Assessment of AFR characteristics and effect on clinkerization CO-processing of wastes as AFR materials in cement manufacturing, CPCB guidelines for co-processing.

Clinker Grinding:

Clinker Grindability, factors affecting clinker grindability.

Quality Management and Quality Control Systems:

Awareness about Quality Control and Quality Assurance, Product Quality management, ISO 9001:2015 and ISO/IEC 17025:2017.

Syllabus for Level-6 Post Code: DGO/SEC-01

PART-1: Skill Test

A hands on practice session shall be conducted for eligible candidates covering skill for MS Office and computer work (related to post requirement)

PART-II : Written Test

Subject

- General Mental Ability, Quantitative Aptitude, Logical Reasoning and Analytical Skills
- General Awareness, Current Affairs
- Computer Knowledge (MS Office)
- General English Language Skills
- Drafting, Noting, Precise Writing and Paragraph Comprehension

परीक्षा पाठ्यक्रम लिखित तथा कौशल परीक्षा के लिए लेवल-3,
पोस्टकोड :- HRS/01

1. सामान्य हिंदी

हिंदी व्याकरण: संधि, समास, संज्ञा, सर्वनाम, विशेषण, क्रिया, काल, कारक।
शब्द भंडार: पर्यायवाची, विलोम, तत्सम-तद्भव, वाक्यांश के लिए एक शब्द।
वाक्य शुद्धि: व्याकरणिक अशुद्धियाँ, वाक्य सुधार।
मुहावरे और लोकोक्तियाँ।
हिंदी भाषा और लेखन क्षमता।

2. सामान्य ज्ञान और करंट अफेयर्स

राष्ट्रीय और अंतर्राष्ट्रीय महत्व की वर्तमान घटनाएँ।
भारत का संविधान और राजव्यवस्था।

3. तर्कशक्ति एवं गणितीय क्षमता

तार्किक क्षमता (Reasoning): कोडिंग-डिकोडिंग, दिशा-निर्देश, रिश्ते, पहेली।
बुनियादी गणित: संख्या प्रणाली, प्रतिशत, अनुपात, औसत, लाभ-हानि।

4. बुनियादी कंप्यूटर ज्ञान

कंप्यूटर के मूल सिद्धांत (हार्डवेयर/सॉफ्टवेयर)।
MS Office (Word, Excel, Power Point)
इंटरनेट, ईमेल और सोशल नेटवर्किंग।

Syllabus for Level-3 Post Code: HRS/02

PART-1: Skill Test

- Noting and Drafting in a computerized set-up using MS-Word
- Database preparation using MS-Excel
- Presentation using MS-Power point

PART-II: Written Test

- Office Management and General Administration like office records and filling system
- Transport Management
- Canteen Management
- Maintenance of office equipment
- Security Management
- Mechanizing Office Systems