Syllabus for Material Science and Nanotechnology (PGQP55)

Crystal structure, Different types of bonding: ionic, covalent, metallic and van der Wall's. Lattice energy - Madelung constants – Born Haber cycle – cohesive energy. Quantum states- binding energy-interatomic spacing - variation in bonding characteristics - Single crystals – polycrystalline - Non crystalline solids - Imperfection in solids – Vacancies – Interstitials. Equilibrium thermodynamics, Phase equilibria, Phase transformations,

Crystalline and amorphous solids, primitive and unit cells, Bravais lattices, crystal structure, lattice and basis. Packing factors – cubic, hexagonal, diamond structures Lattice translation operation. Elementary idea of point symmetry operations (inversion centre, rotation and reflection symmetry). Primitive translation vectors, lattice planes – Miller indices for designating crystal planes. Inter-planar distances – directions. Reciprocal lattice. Volume of a primitive cell in the reciprocal space. Geometrical interpretation of the Bragg equation in the reciprocal space. Structural characterization Basic principles of X-ray diffraction spectroscopy.

Law of thermodynamics and related applications, Concepts of free energy and entropy,

Mechanical properties - Stress, Strain, Elastic properties Optical properties - refraction, reflection, Absorption, Transmission, Insulators, luminescence - Magnetic properties – para-magnetism - ferromagnetism - domain theory - magnetic hysteresis, – anti-ferromagnetism.

Free electron gas in one and three dimensions. Thermionic emission, work function, electrical conductivity of the free electron gas: Drude Lorentz Model, Sommerfield's quantum theory. The heat-capacity of the conduction electrons (Electron Specific heat) Widemann - Franz law and its validity. Metallic conduction, Energy bands, Brillouin zones, Temperature dependence of metallic conductivity - carrier concentrations in intrinsic, extrinsic semiconductors – Impurity contributions, Doping effects, Law of mass action. Fermi level - variation of conductivity, mobility with temperature

Electrons in periodic potential, Origin of energy bands in solids, classification of solids as metals, insulators and semiconductors on the basis of the band picture, Origin of the energy gap (qualitative discussions). Bloch's theorem in one dimension, nearly free electron approximation - formation of energy bands and gaps - Brillouin zones and boundaries - the Kronig-Penney model. E-K diagram, Reduced zone representation, Brillouin zone, concept of effective mass and holes, Fermi- Dirac distribution function, Density of states for electrons in band. Temperature dependence of Fermi energy.

Nanoscale Science and Technology- Implications for Physics, Chemistry, Biology and Engineering- Classification of nanostructures, nanoscale architecture – Effects of the nanometre length scale - surface to volume ratio – Effect of nanoscale dimensions on various properties – Structural, thermal, chemical, mechanical, magnetic, optical and electronic properties – effect of nanoscale dimensions on biological systems. Structure of nanomaterials - comparison with conventional materials.

Top down and bottom up synthesis approach, physical and chemical techniques for nanomaterial synthesis.

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