Syllabus for Materials Science and Engineering

1: Classification and Structure of Materials

Classification of materials: metals, ceramics, polymers and composites.

Nature of bonding in materials: metallic, ionic, covalent and mixed bonding; structure of materials: fundamentals of crystallography, symmetry operations, crystal systems, Bravais lattices, unit cells, primitive cells, crystallographic planes and directions; structures of metals, ceramics, polymers, amorphous materials and glasses.

Defects in crystalline materials: 0-D, 1-D and 2-D defects; vacancies, interstitials, solid solutions in metals and ceramics, Frenkel and Schottky defects; dislocations; grain boundaries, twins, stacking faults; surfaces and interfaces.

2: Thermodynamics, Kinetics and Phase Transformations

Extensive and intensive thermodynamic properties, laws of thermodynamics, phase equilibria, phase rule, phase diagrams (unary and binary), basic electrochemistry. Reaction kinetics, fundamentals of diffusion, Fick's laws, their solutions and applications.Solidification of pure metals and alloys, nucleation and growth, diffusional solid-state phase transformations (precipitation and eutectoid), martensitic transformation.

3: Properties and Applications of Materials

Mechanical properties:Mechanical properties of metals, ceramics, polymers and composites at room temperature; stress-strain response (elastic, anelastic and plastic deformation).

Electronic properties: free electron theory, Fermi energy, density of states, elements of band theory, semiconductors, Hall effect, dielectric behaviour, piezo- and ferro-electric behaviour. **Magnetic properties:** Origin of magnetism in materials, para-, dia-, ferro- and ferri-magnetism.

Thermal properties: Specific heat, heat conduction, thermal diffusivity, thermal expansion, and thermoelectricity.

Optical properties: Refractive index, absorption and transmission of electromagnetic radiation.

Examples of materials exhibiting above properties, and their typical/common applications.

4: Characterization and Measurements of Properties: X-ray diffraction; spectroscopic techniques such as UV-Vis, IR, Fluorescence and Raman; optical microscopy, electron microscopy, composition analysis in electron microscopes.

Tensile test, hardness measurement.

Electrical conductivity, carrier mobility and concentrations.

Thermal analysis techniques: thermogravimetry and calorimetry.

5: Processing of Materials

Heat treatment of ferrous and aluminium alloys; preparation of ceramic powders, sintering; thinfilm deposition: evaporation and sputtering techniques, and chemical vapour deposition, thin film growth phenomena.

6: Nanostructured Materials:

Top down and bottom up synthesis, Classification of nanomaterials, optical, thermal, magnetic and electronic properties of nanomaterials, Metallic and Carbon nanostructures, Applications of nanomaterials.

Model questions:

S. No.	Question	Correct option
1.	Among the defects listed below, which defect is an equilibrium defect? (a) Dislocation (b) Twin Boundaries (c) Stacking Faults (d) Point defects	(d)
2.	How many bravais lattices and crystal structures exist? (a) 14 and 7 (b) 7 and 14 (c) 12 and 7 (d) 7 and 12	(a)
3.	Ice in water is an example of (a) One component- one phase system (b) One component- Two phase system (c) Two component- Two phase system (d) Two component- One phase system	(b)
4.	Which of the following is true for FTIR spectrum of nitrogen (N_2)? (a) It is similar to that of methanol (b) It has a complicated pattern (c) $N_2$is IR inactive (d) Shows two peaks at 1710 and 1650 cm^{-1}.	(c)
5.	A semiconductor when cooled to absolute zero temperature behaves like a (a) Conductor (b) Semiconductor (c) Insulator (d) All of the above	(c)