Solid State Physics and Atomic and Molecular Physics

Recapitulations of crystal structures, brief overview of quasi crystals and liquid crystals:
1. Identify different crystal structures and their properties
2. Compare and contrast crystalline, quasi-crystalline, and liquid crystal structures

Band theory of solids:
1. Explain the Bloch equation and its significance in the band theory of solids
2. Analyze the concept of band structure and band gap in solid materials
3. Apply the tight binding approximation and Slater-Koster LCAO approach to study electronic properties of solids
4. Classify materials as metals, semiconductors, and insulators based on their band structure
5. Discuss the concept of effective mass and holes in a band structure
6. Evaluate the electronic properties of 2D materials and Landau levels

Dielectric properties of solids:
1. Define complex dielectric constant and dielectric losses in solids
2. Explain the classical theory of electronic polarization and optical absorption in dielectric materials
3. Describe the phenomenon of ferroelectricity and its applications in solid-state physics

Electronic & Thermal properties of solids:
1. Formulate the Boltzmann transport equation and its implications on electrical and thermal conductivity
2. Analyze the Wiedemann-Franz law and its relation to thermal conduction in metals
3. Evaluate the electrical and thermal conductivities of materials using relaxation time concept
4. Investigate Magnetoresistance and Hall effect in solid materials

Magnetic properties of solids:
1. Interpret quantum theory of paramagnetism and spin paramagnetism in solid-state physics
2. Define and apply Stoner's criterion and Curie-Weiss law in studying ferromagnetism
3. Analyze the temperature dependence of saturation magnetization and factors influencing magnetic properties
4. Explain Heisenberg's exchange interaction and its role in ferromagnetic materials
5. Discuss different types of magnetic ordering such as Ferrimagnetism and Antiferromagnetism
6. Investigate the Longitudinal and Transverse relaxation times in magnetic materials

Imperfections in solids:
1. Classify different types of lattice imperfections in solids
2. Describe the formation and effects of vacancies, interstitial defects, and dislocations in crystal structures
3. Analyze the role of colour-centres, photoconductivity, and luminescence in imperfections in solids
4. Evaluate the Order-disorder phenomena in binary alloys using Bragg-Williams theory

Superconductivity:
1. Define superconductivity and describe its phenomenological aspects
2. Explain the formation of Cooper pairs and their role in superconducting materials
3. Understand the BCS theory and its expression for energy gap in superconductors
4. Discuss the Josephson effect and its implications on superconducting devices
5. Analyze the characteristics of high-Tc superconductors and their potential applications