

## Study Guide for Midterm (ver. 1.0, Oct. 27, 2005)

Bravais lattices, sc, fcc, bcc, hex

Basis and its impact on structure factor and other probes of lattice periodicity

Diamond, hcp, graphene/graphite

NaCl, CsCl, ZnS, wurzite, perovskite

Reciprocal lattice, structure factor, form factor

Relation to families of [real-space] planes; Miller indices

Bonding types (metallic, covalent, ionic, van der Waals)

Electron distribution; radii: covalent, ionic, critical; packing

Cohesive energy: Madelung constant, Evjen method

Lennard-Jones, Morse, universal-binding potentials

Order-of-magnitude QM arguments for binding energies

Harmonic lattice theory

Approximations, symmetries

Lattice vibrations: # distinct  $\mathbf{k}$ 's, # branches, longitudinal, transverse, acoustic, optical

Depicting lattice displacements for particular modes

Phonons, quantizing SHO, Bose distribution

Crystal momentum vs. actual momentum; phonon velocity

Interpreting actual (measured or computed) phonon dispersion curves

Density of states  $g(\omega)$ , dependence on parameters, Van Hove singularities

Debye and Einstein models

Gaps, impurity modes, surface modes

Energy, specific heat,

Anharmonic lattice

Grüneisen parameter

Thermal expansion

Role of Umklapp in scattering

Transport theory and lattice thermal conductivity: assumptions, results, thermal regimes

Scattering time  $\tau$ , mean free path

Phonons (non-conserved) vs. electrons (conserved)

Role of dimensionality:  $D=1$  or  $2$  rather than  $3$

Experimental probes: neutrons, x-rays, photons, electrons

Drude theory of metals

Assumptions, conductivity, collision time, mean free path

Hall effect, plasmons, surface plasmons

Conductivity: thermal, electrical

Sommerfeld model

Fermi-Dirac distribution, periodic boundary conditions

Quasicontinuum of  $\mathbf{k}$  states, density of states, signatures of dimension

Fermi wavevector, energy

Use (but not derivation) of Sommerfeld expansion

Chemical potential vs. Fermi energy

Comparison of Debye and Fermi parameters:  $\varepsilon$ ,  $k$ ,  $T$ , ...

Units, orders of magnitude