

Introduction to Solid State Physics 2017

- (a) Please describe the two examples, electron and phonon, in Solid State, which have the physical properties of Band Dispersion and Energy Gap. (10%)
 - (b) Please conceptually describe their physical origins of the existence of Energy Gap, respectively, by drawing the corresponding scheme of band structure. (10%)
 - (c) Please briefly describe the similarity and difference in both examples. (10%)
 - (d) Please show how to construct the Brillouin Zones in the band structure for both examples. Are all of Brillouin Zones are physically meaningful for both examples? Why? (10%)
 - (e) Please use a schematic energy band and band gap to describe the different materials of insulator, metal, semimetal, n-type and p-type semiconductor. (15%)
- (a) Please use the form of Newton's second law to define/derive the **effective mass** m^* in semiconductor. (20%)
 - (b) Can the effective mass be negative? If yes, please give a brief explanation. (10%)
- (a) In the ground state of a three-dimensional system of N free electrons at 0 K, the occupied orbitals may be represented as points inside a sphere in \mathbf{k} space. Please derive

$$k_F = \left(\frac{3\pi^2 N}{V} \right)^{\frac{1}{3}},$$

where k_F is the wave vector at the Fermi surface and V is volume. (15%)