1. Please write out the electron configurations of H, Si, $Ti^{4+}$, Kr, and Er. (10%)

2. Figure 2 shows a sphere model of a unit cell of a face centered cubic (FCC) crystal structure.
(a) Calculate the number of atoms per unit cell.(3%)
(b) Derive the lattice constant ***a*** in terms of atomic radius R. (5%)
(c) The atomic packing factor (APF) is defined as: volume of atoms in a unit cell divided by the total unit cell volume. Determine the APF of an FCC structure. (5%)
(d) The atomic packing factor (APF) of the FCC crystal structure and of the hexagonal close-packed (HCP) crystal structure are exactly the same. Briefly explain the possible reasons. (5%)

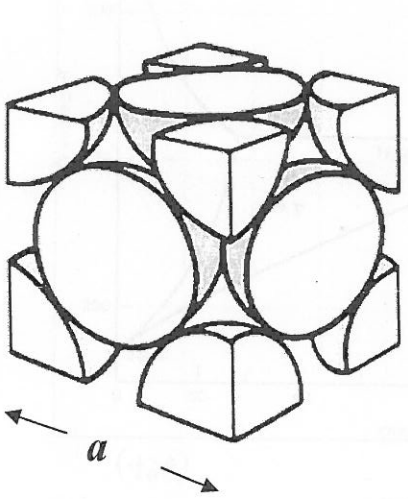



Figure 2

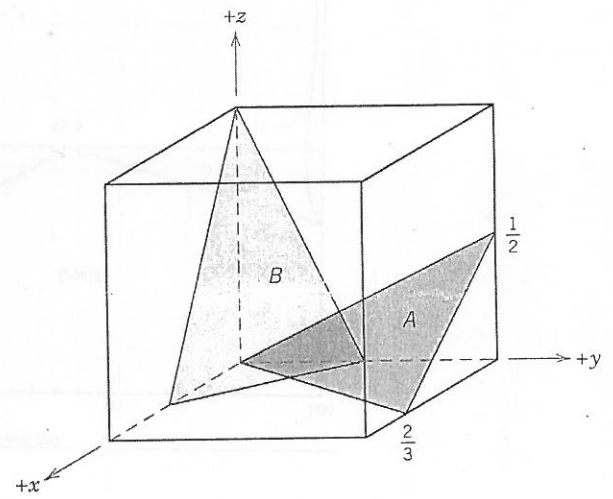
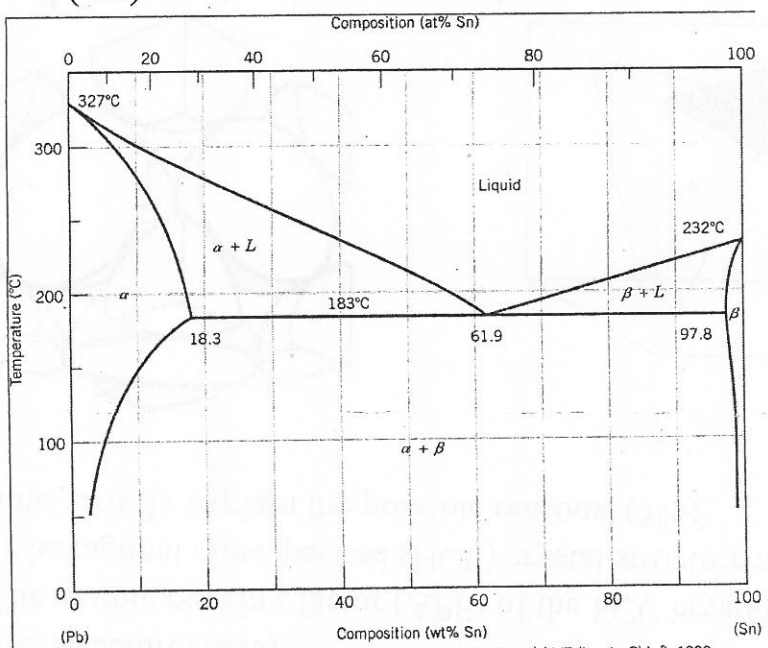



Figure 3

3. (a) Determine the Miller indices of the plane *A* in a cubic crystal system as shown in Figure 3. Plane A intersects z-axis and x-axis of an unit cell at 1/2 and at 2/3, respectively. (4%)
(b) Determine the interplanar spacing $d_{hkl}$ of parallel crystallographic planes (3 2 1), assume that the lattice constant of the crystal structure $a = 0.25$ nm. (6%)
(c) What is the meaning of *h, k* and *l* in the Miller indices (h k l) of a crystallographic plane or why we can use Miller indices to represent parallel crystallographic planes? (4%)

4. (a) Briefly cite the main differences between ionic, covalent, metallic bonding, and Van der Waals bonding. (6%)
(b) State the Pauli exclusion principle. (4%)

5. Figure 5 shows a lead-tin (Pb-Sn) phase diagram.
(a) What is the maximum solubility of Sn in Pb? (3%)
(b) What are the eutectic temperature and eutectic composition? (5%)
(c) Calculate the mass fraction of α-phase for a Pb-Sn alloy containing 60% Sn at temperature of 180°C. (6%)
(d) What is the main application of Pb-Sn alloy in the electronic industry? (4%)



Adapted from Binary Alloy Phase Diagrams, 2nd edition, Vol. 3, T. B. Massalski (Editor-in-Chief), 1990.
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Figure 5

6. (a) Please briefly describe the phenomenon of photoluminescence and photoconductivity. (10%)
(b) Would the semiconductor zinc selenide, which has a band gap of 2.58 eV, be photoconductive when exposed to 400-700 nm visible light radiation? (10%)

7. Calculate the equilibrium number of vacancies per cubic meter for copper at1000°C. The energy for vacancy formation is 1 eV/atom; the atomic weight and density (at 500°C) for copper are 50 g/mol and 10 g/cm$^3$, respectively. (10%)