1. Determine the crystal structure for the following:
   (a) a metal with a_0= 4.9489 Å, r =1.75 Å and one atom per lattice point; (5%) and
   (b) a metal with a_0= 0.42906 nm, r= 0.1858 nm and one atom per lattice point. (5%)
   a_0 is the lattice constant and r is the atomic radius.

2. (a) How many equivalent $\{111\}\langle 1\bar{1}0\rangle$ slip systems are there in the FCC lattice?
   (b) Identify each system by writing out its slip plane and slip direction indices. (10%)

3. Determine the degrees of freedom under the following conditions: (10%)
   (a) Mg-5wt% Al at 400°C;
   (b) Mg-20wt% Al at 400°C;
   (c) Mg-32.3wt% Al at 437°C.

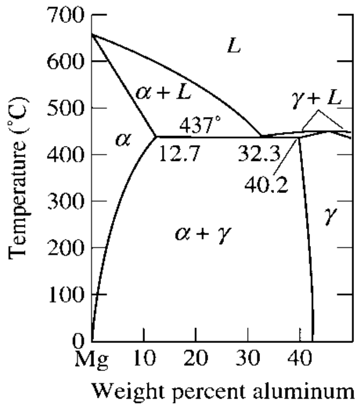

Figure 1 A portion of the magnesium-aluminum phase diagram

4. Among BCC, FCC, and HCP metals, which one is often recommended for use at low temperatures, particularly when any sudden loading of the part is expected? Please explain. (10%)

5. Figure 2 shows a cooling curve for a Pb–Sn alloy. Determine (a) the superheat, (b) the liquidus temperature, (c) the eutectic temperature, (d) the freezing range, and (e) the local solidification time. (10%)

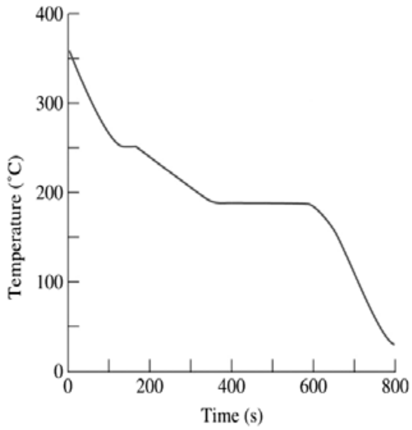

Figure 2 Cooling curve for a Pb-Sn alloy

6. Draw (a) the $[1\ \bar{2}\ 1]$ direction and (b) the $(\bar{1}10)$ plane in a cubic unit cell. (10%)

7. (a) Convert the (010) and (101) planes into the four-index Miller–Bravais scheme for hexagonal unit cells. (b) Cite the relative Burgers vector–dislocation line orientations for edge, screw, and mixed dislocations. (10%)

8. (a) Briefly cite the main differences between ionic, covalent, and metallic bonding.
   (b) Cite two reasons why interstitial diffusion is normally more rapid than vacancy diffusion. (10%)

9. Describe (a) the steps to determine the **0.2% offset yield strength** in typical alloys, and (b) the **yield point** phenomenon in low carbon steels. (10%)

10. Write down the **eutectic** reaction and the **eutectoid** reaction in the binary Fe-C (or Fe-Fe_3C) system. (the name of each phase should be included) (10%)