Please answer in order.

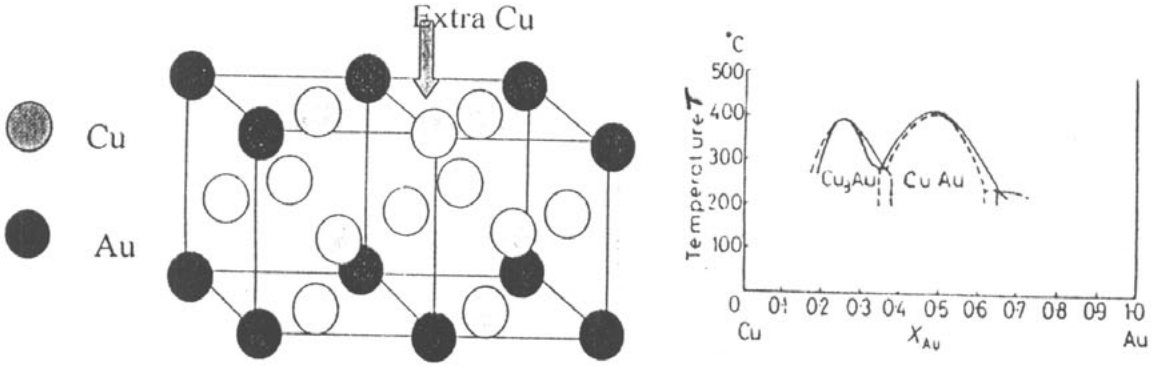
1. Please describe the types of bonds of crystalline solid and explain how they form in detail. (15%)
2. Second-phase inclusions are known to put an upper limit on the grain size of a metal during grain growth. Please derive the Zener's relationship of $(r/R) = (3/4)f$, where r is the radius of the inclusions, R is the radius of curvature of the average grain, and f is the volume fraction of inclusions. Please also discuss the assumptions made in deriving this relationship and the effects of the morphology of inclusions on the grain growth. (15%)
3. Please plot and discuss the free energy as a function of the number of the impurity in an equilibrium state. Based on this plot, please plot and discuss the solubility curve of the impurity in a material. (5%)

(背面仍有題目,請繼續作答)

4.

(a) Please calculate the composition of the alloy with the lattice shown in the figure below and specify its location in the phase diagram. Please note that there is an Au site lattice substituted by the Cu atom. (5%)

(b) What type of the crystal structure would be if the temperature is at 500 ^{o}C. Please use a figure to assist your answer. (5%)



5.

(a) Please explain what is a homogenization heat treatment. (5%)

(b) Which of the following equation should be used to estimate the time and temperature of the homogenization? Explain why. What parameters you need? (5%)

$$v = B\left(\frac{\Delta\mu}{\lambda}\right)^{m} = \frac{D_b}{kT}\cdot\left(\frac{V\,2\gamma/\gamma}{\lambda}\right)^{m}$$

$$C(Z,t) = C_0\left[1-\left(1-\frac{C_1}{C_2}\right)\operatorname{erf} Z/2\sqrt{Dt}\right]$$

$$C = C + \beta_0 \sin\left(\frac{\pi x}{l}\right)\exp\frac{-t}{\tau} \qquad \tau = \frac{l^2}{\pi^2 D_B}$$

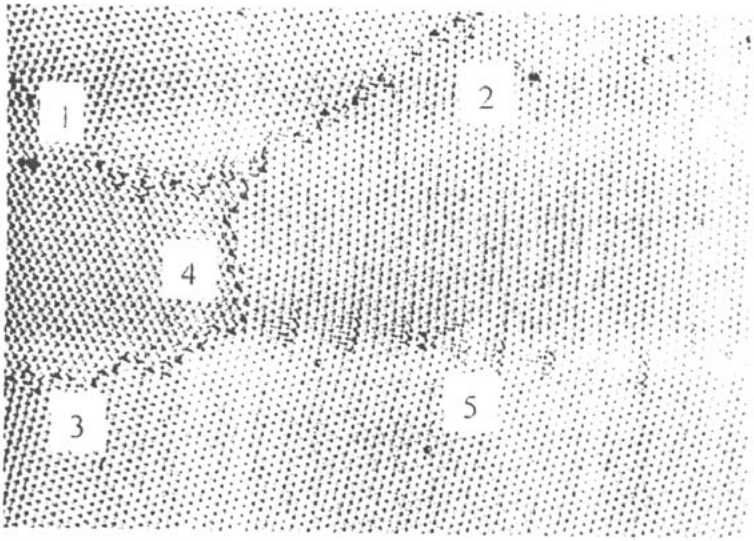
6.

There are 5 interfaces between four grains in the attached picture below, which shows a layer of many soap bubbles with the same size. This picture can be used to illustrate the mis-orientation between grains, i.e. grain boundaries.

(a) Please identify which boundary can be classified as a low angle grain boundary. Explain why. (5%)

(b) Estimate the angle of the low angle grain boundary. Discuss how you obtain the angle. (5%)

(c) Please estimates what is the sequence (from large to small) of the surface energy of the following interface: (1) coherent twin boundary, (2) vapor/solid interface, (3) high angle grain boundary, and (4) semi-coherent boundary. Please describe the reason. (5%)



7. (a) What is the purpose of the Orowan equation. (5 points)
   (b) Please derive the Orowan equation. Be sure to use illustration figures to explain the derivation. (10 points)

8. Please derive the theoretical fracture stress for isotropic elastic solid in terms of surface energy, Young's modulus and mean interatomic distance. (15 points)