1. Give three low-index planes of a zone axis [112]. (6%)

2. Prove that van der Waals energy between two inert-gas atoms due to dipole interaction varies as the square of the dipole moment and the inverse sixth power of their distance of seperation. (6%)

3. How could an Auger electron be emitted after a beam electron knocks an atom? With what kind of materials analysis could Auger electrons provide us? (10%)

4. Derive the force acting on a unit length of edge dislocation on which a shear stress is applied in a direction parallel to its Burgers vector. (8%)

5. When three boundaries meet in a line, a force balance equation relating boundary energy and the dihedral angle between boundaries would exist in equilibrium condition. Derive this equation assuming all boundary energies are independent of orientation. (10%)

6. What is the double cross-slip mechanism of a dislocation? How could this relate with the slip-band formation. (10%)

7. Given $r_C = 0.077A$, $r_{\alpha-Fe} = 0.1241A$, and $r_{\gamma-Fe} = 0.1269A$, calculate the maximum widths of octahedral sites for α-Fe and γ-Fe, respectively. Can carbon dissolve in both lattices without causing distortion of the iron atoms? Based on the calculation, predict in which lattice the solubility of carbon is higher? (6%)

8. Explain the origin of electrical resistivity in metals. How does resistivity vary with (1) temperature, (2) concentration of vacancies, (3) concentration of interstitial solutes, and (4) concentration of smaller substitutional solute atoms? (10%)

9. Estimate the magnitudes of activation enthalpies for the following reactions. Write the choices directly on your answer sheet. (6%)
　　(1) Formation of vacancies in Cu
　　　　(a) 10 eV (b) 1 eV (c) 0.1 eV (d) 0.01 eV
　　(2) Diffusion of C in α-Fe.
　　　　(a) 10 eV (b) 1 eV (c) 0.1 eV (d) 0.01 eV
　　(3) Solubility of C in α-Fe
　　　　(a) 10 eV (b) 1 eV (c) 0.1 eV (d) 0.01 eV

10. Fig.1 shows the isothermal recrystallization curves for pure Cu cold-rolled 98%. Estimate the activation energy (in kJ/mol) for recrystallization. (R=8.314J/mol.K) (10%)

11. Refer to the Cu-Zn phase diagram shown in Fig. 2.
    (1)　Write all the possible peritectic reactions. (4%)
    (2)　Write all the possible eutectoid reactions. (2%)
    (3)　On the right hand side of the phase diagram, redraw an enlarged version for the
portion for Zn=90% to 100% so that the transition of $Zn_{(s)}$ to $Zn_{(l)}$ and η to L+ε can be
seen more clearly. (4%)

    (4)　Name the reaction for β to β'. How can you distinguish these two phases by
means of x-ray diffraction? Design an experiment to measure the transition temperature for
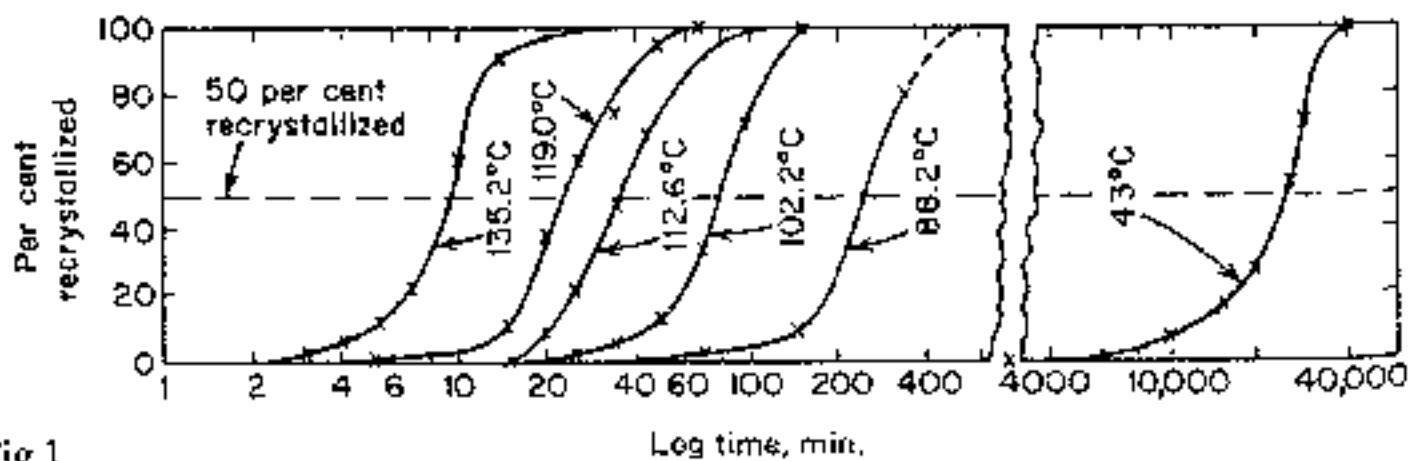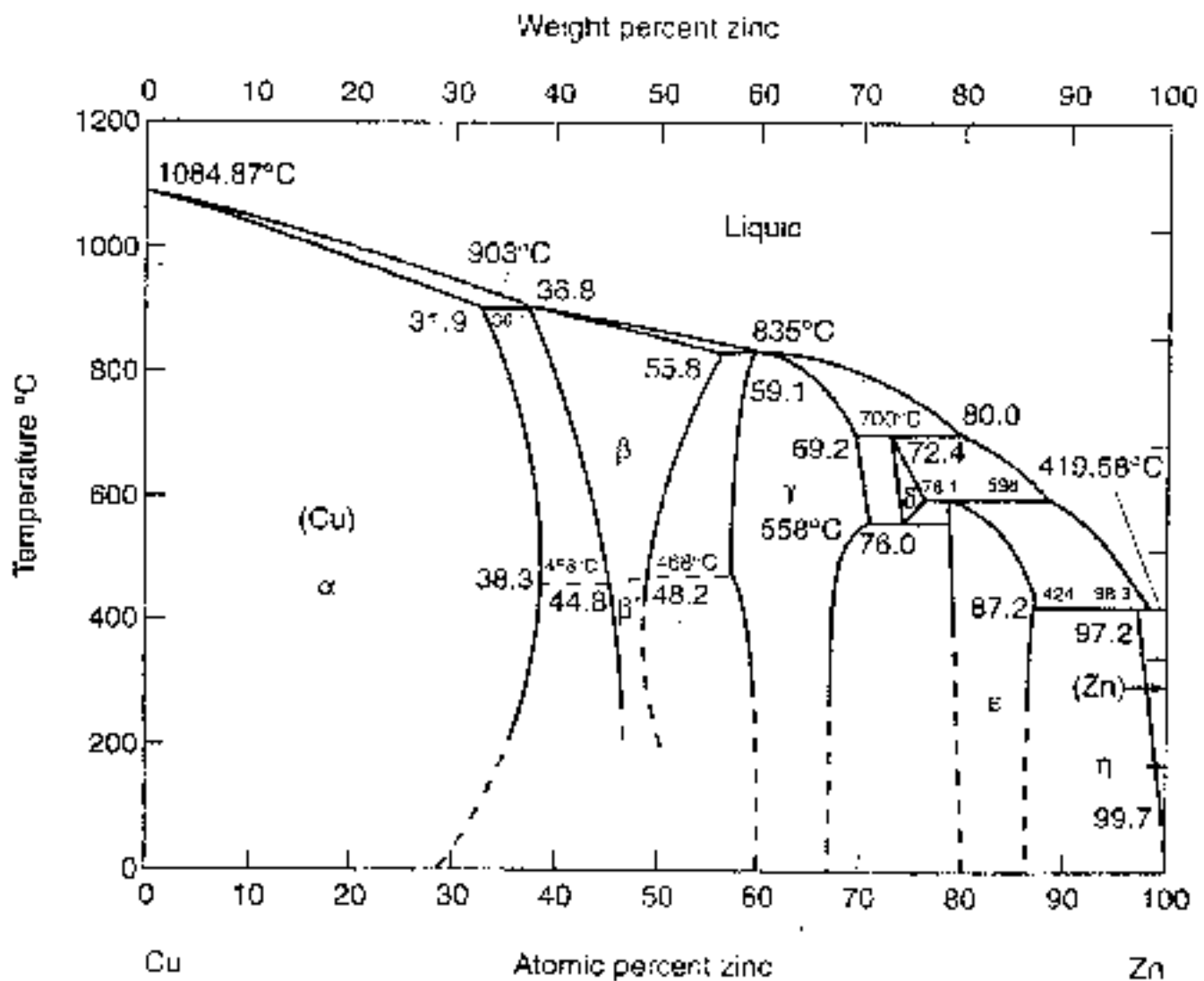this reaction. (8%)

Fig.1

Weight percent zinc

Fig. 2　　Cu　　　　　Atomic percent zinc　　　　Zn