APL102 Major Test, May 06, 2015

Time 2 hrs   Maximum Marks 120

There are 8 questions each carrying 15 marks. Q1 is objective. Answer the objective questions in the box provided on the question paper itself.

1. Objective (provided separately)

2. You only need to give properly labeled sketches in the answer to following questions. There is no need for any description.

(a) Sketch the variation of free energy of a crystal as function of number of vacancies and indicate the equilibrium number of vacancies. Add to your sketch the separate enthalpic and entropic contribution of vacancies to the free energy.

(b) Draw the surface energy, volume free energy and the total energy of formation of a spherical homogeneous nucleus in an undercooled melt as a function of its radius. Indicate the critical radius.

(c) Draw the surface energy change, strain energy change, and total energy change for presence of a crack in a uniaxially loaded plate as a function of crack size. Indicate the critical crack size.

(d) Draw the strength of a polycrystal as a function of grain size to get a straight line assuming the material follows Hall-Petch relation.

(e) Draw a typical creep curve and indicate the stages. Superimpose on the drawing another curve for a testing at a higher stress.

3. With help of neat sketches show a tetrahedral and an octahedral void in a monatomic BCC crystal. Determine the size of the largest sphere that can fit into the octahedral void.

4. During a grain growth process, the average grain diameter increases from 0.01 mm to 0.1 mm. Calculate the change in energy per unit volume of the specimen if the grain boundary energy is 0.5 J m^{-2}.

5. In a CCP crystal the tensile axis along [123] direction. Determine the slip system which will activate at the beginning of yielding.

6. (a) What was the cause of Comet disaster? How was it established?

(b) A sheet of glass, with Young's modulus = 70 GPa and surface energy = 0.5 J m^{-2}, has an internal crack of length equal to 2 µm. A surface scratch is introduced by scratching the surface with a sharp tool. Adsorption at the surface lowers the surface energy by 50%. Determine which crack will propagate first, on increasing the applied stress and at what value of the stress?

7. (a) Draw a schematic heat treatment curve used to produce glass ceramic. Give the significance of each stage.

(b) Draw a schematic TTT diagram for eutectoid steel. Clearly lablel all axes, boundaries and phase fields. Superimpose on this diagram cooling curves for quenching, and austempering and indicate the final microstructure obtained by these heat treatments.

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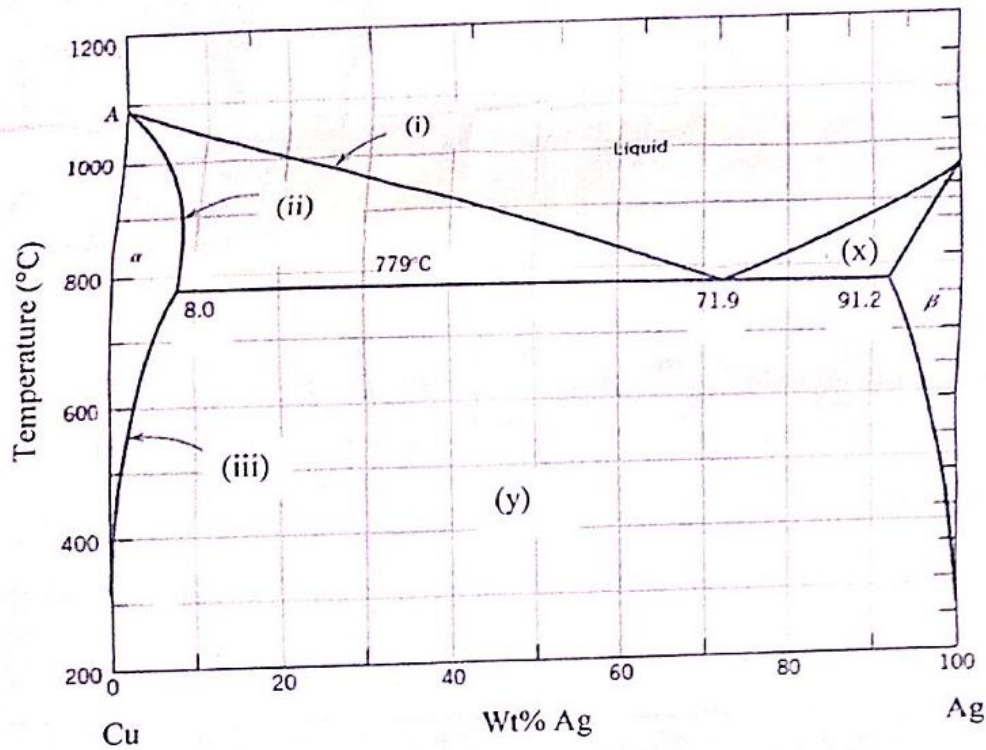
A phase diagram of the binary Cu-Ag system is provided. Answer the following questions based on this diagram.

(a) Three boundaries are labeled (i), (ii) and (iii). Give the names of these boundaries.

(b) Two phase fields are labeled (x) and (y). Name them.

(c) Write down the invariant reaction occurring in this phase diagram giving the composition of the phases and the temperature. Give the name of the reaction.

(d) Determine the degrees of freedom in the phase field labeled (x).

(e) If an alloy of 20 wt. % Ag is heated at what temperature the first liquid appears. At what temperature the melting completes. What is the composition of final solid in equilibrium with the liquid.

(f) Determine the composition and relative amounts of phases present in an alloy of 20 wt. % Ag held in equilibrium just below 779°C.