AML 120
March 22, 2014

Q1

(a) Define a dislocation in a crystal in terms of slip. [1]
(b) Give two definitions of Burgers vector in terms of: (i) slip, and (ii) Burgers circuit [2]
(c) Define the line vector of a dislocation [1]
(d) Define three types of dislocations in terms of relation between the burgers vector and the line vector [3]
(e) Draw a schematic 2D diagram of arrangement of atoms in the (100) plane in a simple cubic crystal around an edge dislocation lying in [100] direction. Show the location of the dislocation line by appropriate symbol. Show the Burgers vector of the dislocation line by drawing a Burgers circuit (also indicate your choice of the positive sense of the line vector) [4]
(f) A dislocation line in a cubic crystal lies along [110] with its Burgers vector along [011]. Determine the nature (edge, screw or mixed) of the dislocation line and the Miller indices of its slip plane. Is crystal lattice is SC, BCC or FCC? Why? [4]

Q2.

(a) Draw a (110) plane in a CCP crystal. [3]
(b) Determine the number of atoms per unit area on this plane in terms of the lattice parameter a. [3]
(c) If this plane is the external surface of a crystal then determine the number of bonds broken per surface atom. [2]
(d) Determine the surface energy of the crystal in terms of bond energy (per bond) ε and the lattice parameter a.[4]
(e) Suppose, for a cubic crystal {100} free surfaces have minimum energy? What shape would you expect for the equilibrium single crystal? What if {111] faces have the minimum energy? [3]

Q3.

Fe-C phase diagram is provided with this exam:

(i) Draw the representative microstructure at locations A and B shown in the phase diagram. Marks will be awarded for a true representation/schematic of the microstructure. [6]
(ii) Calculate the amount of cementite (Fe_3C) phase in the pearlite at eutectoid composition? Clearly mark the tie line in the phase diagram to show your calculation. [3]
(iii) Compute the degree(s) of freedom (F) at locations marked 1 and 2 in Fe-C phase diagram. [3]
(iv) Compute the degree(s) of freedom (F) at locations I and II in the attached phase diagram for H_2O? [3]

<u>Note</u>: Credit will be awarded if detailed process to arrive at the final answer is shown. A correct final answer without relevant procedure will fetch ZERO credit.

PLEASE RETURN FE-C PHASE DIAGRAM WITH YOUR ANSWER SCRIPTS. WRITE YOUR NAME ON THE PHASE DIAGRAM.

Q4.

Aluminum (Al) matrix is reinforced with SiC particulates (volume fraction = 0.2). Elastic modulus of Al is 70 GPa whereas SiC has elastic modulus of 450 GPa.

(i) Calculate effective elastic modulus of above listed Al-SiC composite [3]
(ii) Draw schematic stress-strain curve for resulting composite and compare with pure Al and SiC. [6]
(iii) Assume that Aluminum matrix is reinforced with continuous long SiC fibers and is loaded in the direction perpendicular to the fiber orientation. Compute effective elastic modulus of this composite. Assume elastic modulus of long SiC fibers to be same as SiC particulates. [3]
(iv) Comment on the properties of a particulate vs. continuous fiber reinforced composite of the same composition [3].