Universidad Carlos III de Madrid

EXAM

June 2013

Aerospace Materials I (2nd Year)

Surname: **Name:** **Group:**

Information:

- Read the questions carefully before answering.
- You have 2h 30min to complete the exam.
- The marks assigned to each of the questions are given at the beginning of the question.
- To pass the exam you need a minimum mark of 4 over 10.

1. (**1 point**) Explain the dependence that exists between diffusion phenomena in solids and:
   a) The point defects
   b) The packing factor

2. **(2 points)** Iron undergoes a polymorphic change from BCC to FCC when it reaches 912°C. At 911°C, iron is BCC, with a planar density in the plane (111) of 7.04×10^{14} at/cm^2. At 913°C, iron is FCC, with a the interplanar spacing d_{114} of 0.846 Å. Determine:
   a. Volume of the unit cell of BCC iron;
   b. Volume of the unit cell of FCC iron;
   c. Change in volume during transformation of 1 cm^3 iron cube;
   d. Density of BCC iron.

DATA: $N_A = 6.023 * 10^{23}$ at/mol ; M_{Fe} = 55.84 g/mol

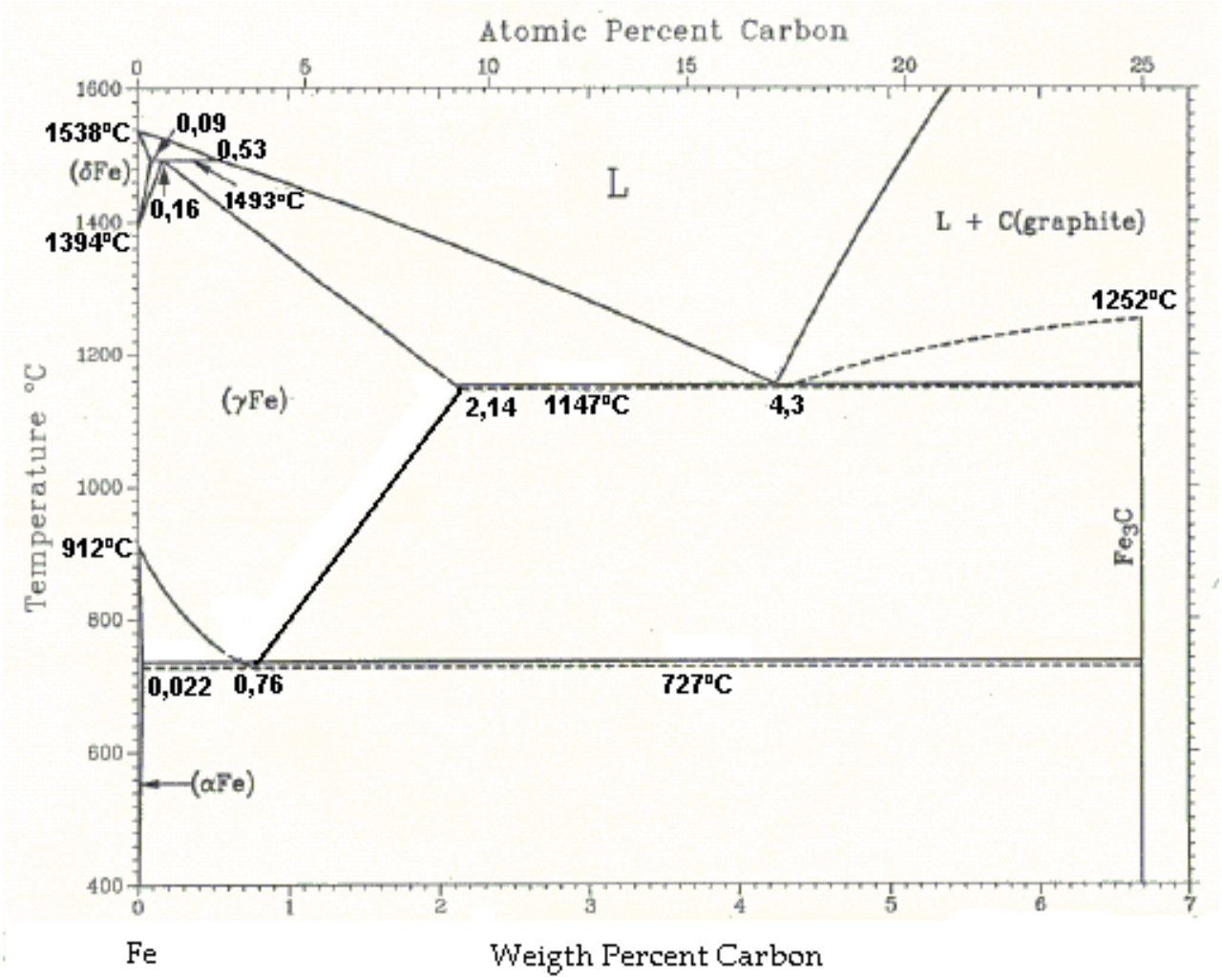
Note: It is important to draw the planes in the cubic cell to justify your answers.

3. **(2 points)** A composite material is composed of an epoxy matrix and 68% in volume of unidirectional continuous carbon fibers. Calculate:
   a. The average density of the composite material.
   b. The weight percentage of the carbon fibers and the epoxy resin in the composite.
   c. The young's modulus of the composite material in the longitudinal and transverse directions.
   d. If a cylindrical rod 20 mm in diameter of this composite is stressed in the longitudinal direction to 90 MPa, determine the forces in the fibre and matrix phases, respectively assuming isostrain conditions.
   e. Estimate the tensile strength of the composite.

Material	Density (g/cm^3)	E (GPa)	σ (MPa)
Epoxy resin	1.2	3.0	70
Carbon fibre	1.79	220	2500

4. **(1 point)** A 10 mm diameter, 204 mm long titanium bar has a yield strength of 345 MPa, a modulus of elasticity of 110 GPa, and Poisson´s ratio of 0.30.
   a) Determine whether the bar will plastically deform when 2.2 KN load is applied.
   b) Determine the length and diameter of the bar when 2.2 KN load is applied.

5. **(2 points)** Consider the metastable Fe-C diagram of the figure. Answer the following questions:
   a. Name and fully describe the invariant reactions of the diagram.
   b. Indicate the maximum solubility of carbon in austenite at 1300 ºC, 1000 ºC, 730 ºC and 400ºC,
   c. At 1300 ºC, 1000 ºC, 730 ºC and 400 ºC, for an alloy of 4.1 (wt.)%C
      i. Indicate the phases present, their mass fraction in the alloy and their chemical composition.
      ii. Indicate the microconstituents present, their mass fraction in the alloy and their chemical composition.
   d. At 730 ºC, consider 100g of the alloy and calculate the amount of pre-eutectic austenite (γ') and the amount of austenite inside the ledeburite (γ_{ledeb}).
   e. If we add 12% of Cr to the alloy: how will the eutectoid temperature change with respect to the studied alloy? How much carbon will the pearlite have? Justify your answers.



6. (1 point)

A. (0.5 points) In adhesive bonding explain why surface preparation is important. List some of the objectives of applying a primer prior to the application of an adhesive.

B. (0.5 points) Explain the relationship between superconducting materials and magnetism. Define the T_c (critical temperature in a superconductor). What is the Meissner effect?

7. (1 point)

a) Explain how does chain branching influence the following properties in polyethylene: (i) amount of crystallinity (ii) strength and (iii) elongation.

b) In general, explain how does processing of thermoplastic polymers into the desired shape differ from the processing of thermosetting polymers?.