Universidad Carlos III de Madrid

EXAM

January 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 5 over 10.

1. **(1 mark)** a) Indicate the differences between covalent, ionic and metallic bonding in terms of: strength and directionality. b) Explain why metals are ductile and ceramics are brittle taking into account the atomic bonding.

2. **(2 marks)** Aluminium has an FCC structure and its atomic weight is 26.98 g/mol. Given that its linear density in the direction [111] is $1.43 \cdot 10^7$ at/cm, determine:
   a. The lattice parameter and the atomic radius for Aluminium.
   b. Its density in (g/cm^3).
   c. The planar density in the plane (101) in (at/cm^2).
   d. The linear density in [110] direction in (at/cm).

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

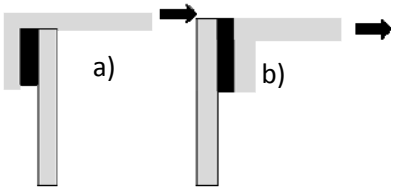
3. **(1 mark)**
   a) What are the most common types of fibre reinforcements in polymer matrix composites? Describe one method of processing a continuous fibre polymer matrix composite material.
   b) How do the properties of continuous fibre reinforced polymer matrix composites change with the direction of applied load (parallel and perpendicular to alignment direction)?

4. **(1 mark)**

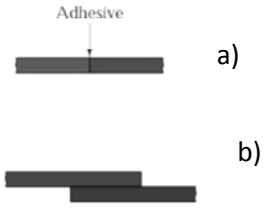
A. (0.5 marks) Draw energy-band diagrams showing donor or acceptor levels for the following:
   a) p-type silicon extrinsic semiconductor doped with boron impurity atoms.
   b) n-type silicon extrinsic semiconductor doped with phosphorus impurity atoms.

B. (0.5 marks) Indicate which of the following joint designs in adhesive joining is more appropriate and explain in each case why.

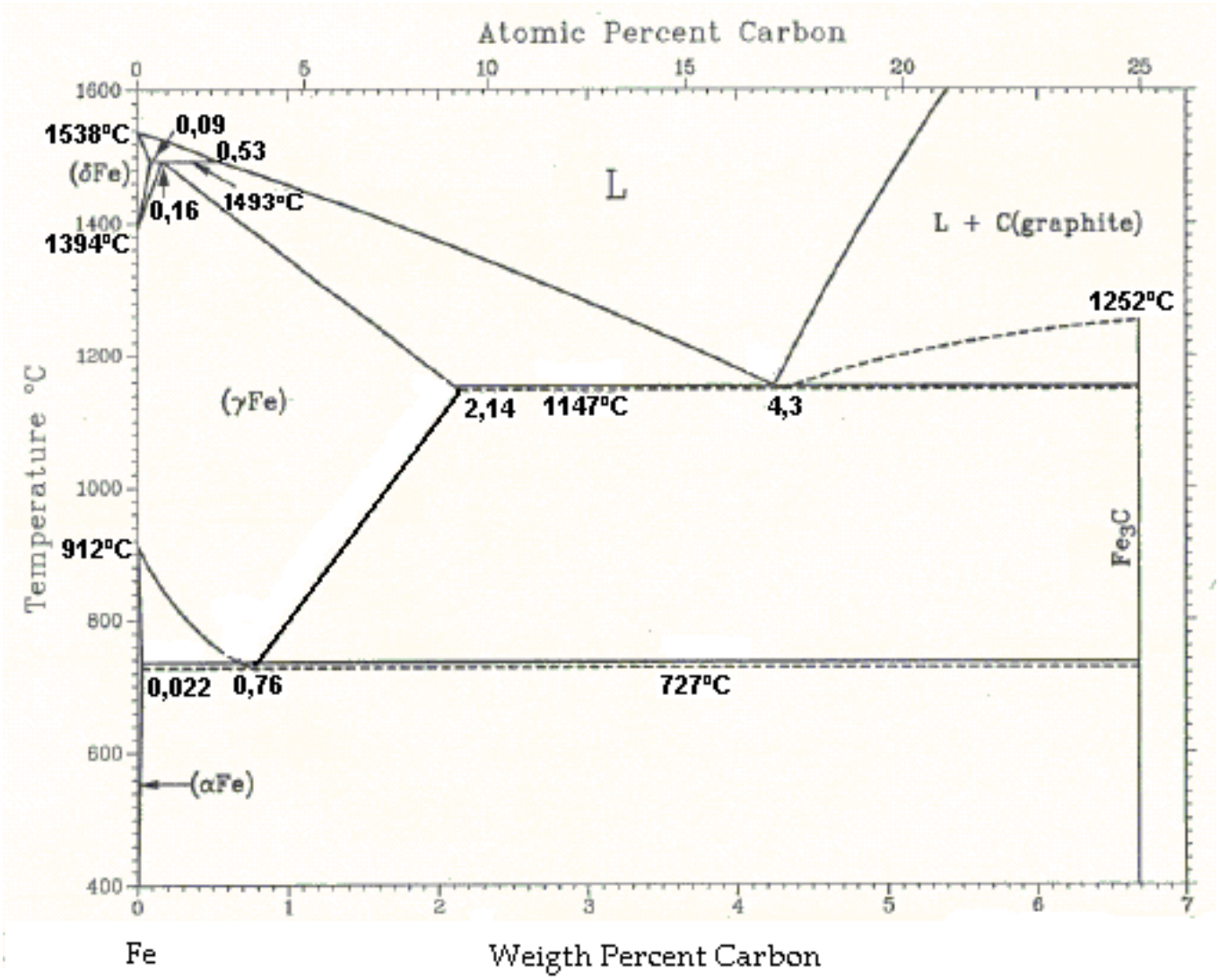
Case 1



Case 2



5. **(2 marks)** 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 0.3 (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 400 ºC, consider 100g of the alloy and calculate the amount of pre-eutectoid ferrite (α') and the amount of ferrite inside the pearlite ($\alpha_{pearlite}$).
    e. If we add 8% of Ni 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 mark)

a) In ionic solids, explain what two main factors affect the packing of ions? Describe and draw the sodium chloride structure.

b) What are the basic steps in processing of ceramic products?

7. (2 marks) The following data was collected from a 12mm diameter test specimen of magnesium. After fracture, the gage length is 32.61 mm and the diameter is 11.74 mm.

a. Calculate the engineering stress and strain values and draw the stress-strain curve.
b. Calculate the yield strength and the tensile strength.
c. Calculate the modulus of elasticity and the modulus of resilience.
d. Calculate the % elongation and % reduction in area.
e. Calculate the engineering stress at fracture and the true stress at fracture.

Load (N)	**Gage length (mm)**	**Engineering stress**	**Engineering strain**
0	30.0000		
5000	30.0296		
10000	30.0592		
15000	30.0888		
20000	30.15		
25000	30.51		
26500	30.90		
27000 (maximum load)	31.50		
26500	32.10		
25000 (point of fracture)	32.79		

