Universidad Carlos III de Madrid

EXAM

January 2014

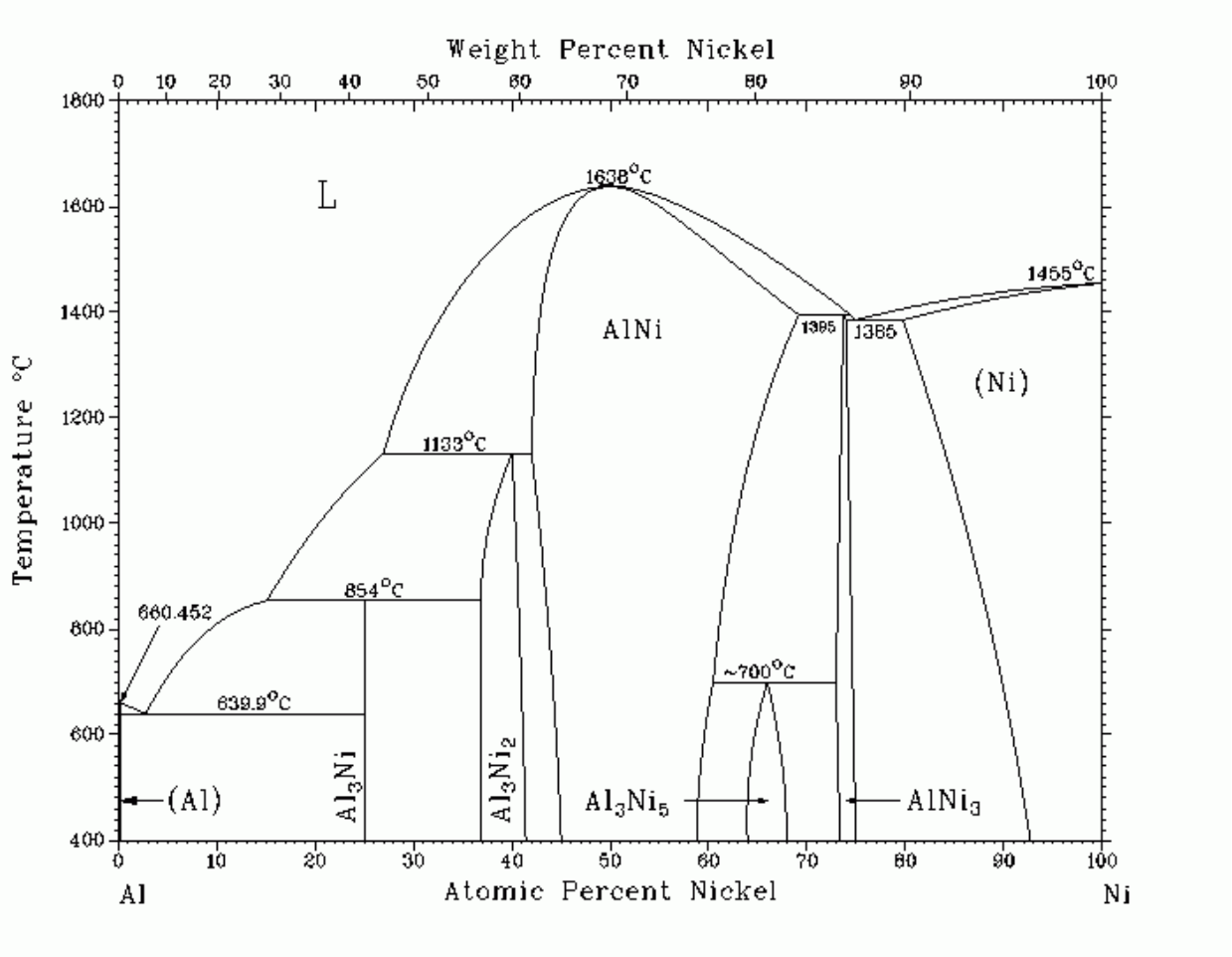
Aerospace Materials I (2nd Year)

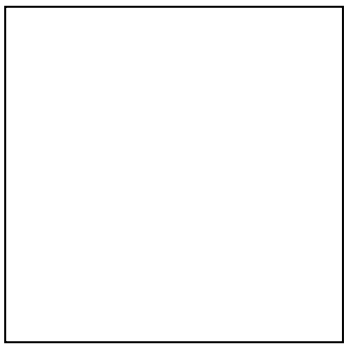
Surname: **Name:** **Group:**

Information:

- Read the questions carefully before answering. Use the space given for answering each question.
- 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.

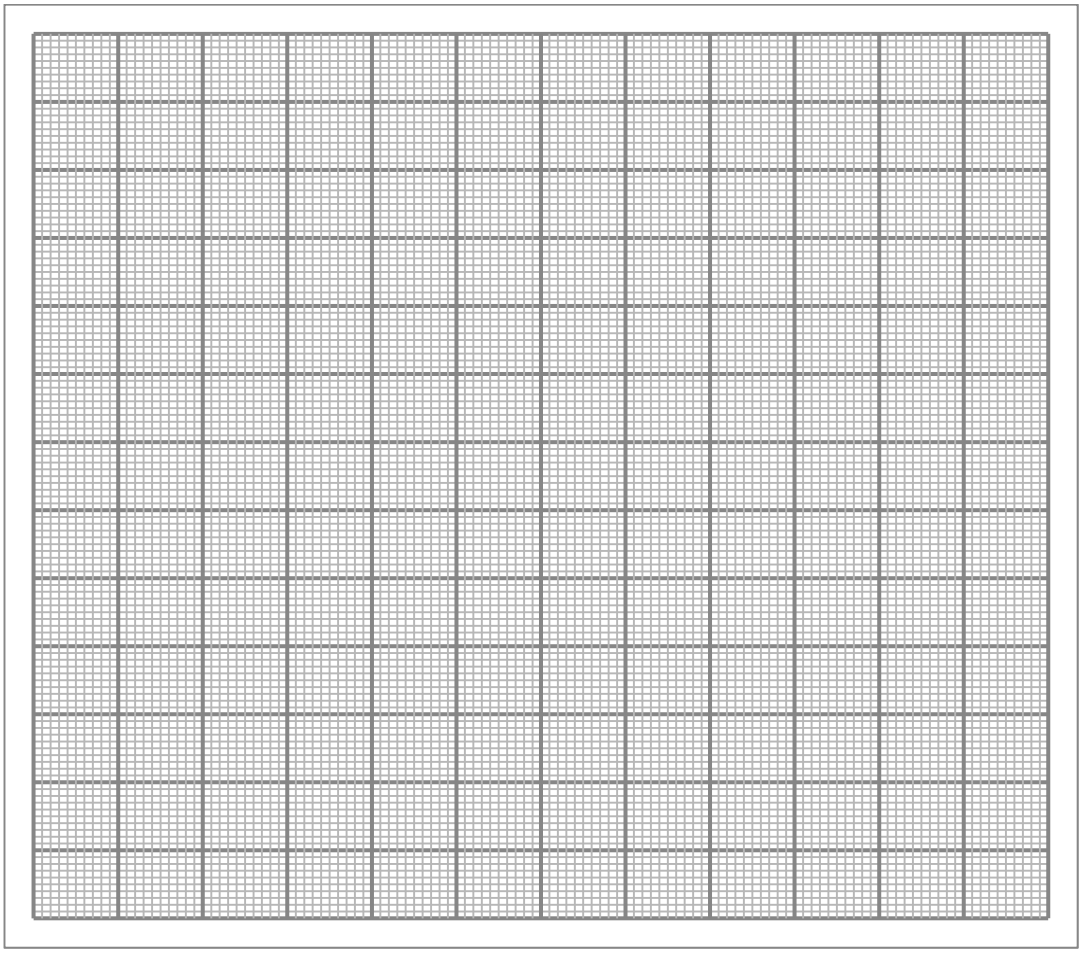
1. **(2 marks)** Use the following Al-Ni phase diagram to answer the questions.
   a) Determine the invariant reactions that take place at the following temperatures: 639.9ºC, 700ºC, 1133ºC, 1385ºC. For each reaction state its name, temperature and composition (in at% of Ni) of all phases involved in the reaction.
   b) For an alloy that has a 10 at% of Ni draw in the squre provided a schematic sketch of the microstructure that would be observed at a temperature of 638ºC.
   c) For an alloy that has a 10 at% Ni indicate the quantity and composition of the phases present and the quantity of the microconstituents present at a temperature of 638ºC.
   d) Indicate which intermetallic compounds have congruent and incongruent melting.
   e) What is the maximum solubility of Al in Nickel and at what temperature is it observed.





2. **(2 marks)** The following data were collected from a 12 mm diameter test specimen of magnesium (l_o= 30.00 mm). After fracture, the gage length is 32.61 mm and the diameter is 11.74 mm. Poisson´s ratio for Mg is 0.29.
   a) Plot the engineering stress-strain curve. Determine the yield strength and the tensile strength.
   b) Calculate the modulus of elasticity and the modulus of resilience.
   c) Calculate the % elongation and the % reduction in area.
   d) Determine the engineering stress at fracture and the real stress at fracture. Calculate the real stress and the real strain for an engineering stress 176.8 MPa.
   e) Calculate the change in diameter when a tensile load of 10000 N is applied to this test specimen.

Load (N)	Gage Length (mm)	Stress (MPa)	Strain (mm/mm)
0	0000	0	0.0
5000	0.0296	44.2	0.000987
10000	0.0592	88.4	0.001973
15000	0.0888	132.6	0.00296
20000	0.15	176.8	0.005
25000	0.51	221.0	0.017
26500	0.90	234.3	0.030
27000	1.50 (max. load)	238.7	0.050
26500	2.10	234.3	0.070
25000	2.79 (fracture)	221.0	0.093



3. (1 mark)

a) What is the primary role of the matrix and the fibers, respectively, in a fiber reinforced composite?

b) What is the most common fiber product used in aeronautical technology for the fabrication of laminate structures? Describe briefly how it is manufactured.

4. (**1 mark)** What is the family of close packed directions for BCC and FCC structures respectively? How many octahedral and tetrahedral interstitial sites exist in the FCC structure? Determine de density of aluminum, which has and FCC structure, given that the interaplanar distance for planes (111) is 0.234 nm

DATA: M(Al)=26.98 g/mol ; N_A=6.022 x $10^{23}mol^{-1}$

5. (1 mark)

a) What are some common properties to most ceramic materials? What two main factors affect the packing of ions in ionic solids?

b) Describe briefly the basic steps in dry-pressing methods for producing such ceramic materials as technical ceramic compounds and structural refractories.

6. (1 mark) Polymers

Draw a characteristic stress-strain curve for a typical semi-crystalline polymer in the axis provided. Label the yield and tensile strengths on your curve. Does plastic deformation start in the crystalline or amorphous regions of a semicrystalline polymer? How does the amount of crystallinity affect the mechanical properties and the melting temperature of a polymer? Explain briefly.



7. **(1 mark)** Consider the following diffusion couples: (i) C in FCC Iron (ii) C in BCC Iron (iii) Fe in FCC Iron and (iv) Fe in BCC Iron.
    a) What will be the diffusion mechanism in each case?
    b) Where does C diffuse faster in FCC Iron or in BCC Iron? Explain your answer briefly.
    c) Will the activation energy for C diffusion in FCC Iron be higher or lower than that for Fe diffusion in iron?

8. (1 mark)

a) Explain what type of semiconductors are (i) silicon doped with 1ppm Boron and (ii) silicon doped with 1ppm Indium. Assuming that they are both at the same temperature, which semiconductor will have higher conductivity? Explain. (Boron- column III A of the periodic table; Indium- column III A of the periodic table; B ion size < In ion size).

b) Calculate the electrical conductivity of silicon doped with 4.5×10^{21} Boron atoms/m^3 assuming complete dopant ionization.

(DATA: μ_e=0.135 $m^2V^{-1}s^{-1}$; μ_h= 0.048 $m^2V^{-1}s^{-1}$; q_e=-1.6022x10^{-19}C)