National Exams May 2018

16-Mec-B8 Engineering Materials

3 Hours Duration

NOTES:

1. If doubts exist as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. Any non-communicating calculator is permitted. This is an open book exam.

3. Any **five** of the **eight** problems given constitute a complete paper.

4. All problems are of equal value.

1- Advanced fiber-reinforced plastic composites are now commonly used in aircraft structural design for both primary and secondary load bearing applications.

a- Present four different processing methods that may be used to consolidate those composites
b- Discuss the main advantages and disadvantages of each method in relationship to mechanical properties, geometrical aspects, processing speeds, size, and cost.

2- A box is to be placed on a bracket attached to the engine in an automobile. Two polymeric materials have been short-listed as primary candidates for this application, namely ABS and hardened PVC.

a- Compare the two materials in terms of strength, impact resistance, manufacturing methods, chemical resistance, heat resistance and cost.
b- What material would you select and why?

3- Discuss the following two applications where corrosion is an issue:

a- A brass faucet is connected to an iron pipe. Discuss this coupling from a corrosion viewpoint and explain which metal is likely to corrode and why?
b- Steel screws used as fasteners on aluminum siding experienced severe corrosion. Would you have expected this, why or why not? Explain why this might have occurred.

4- Floor beams of a transport airplane have been designed using an aluminum alloy containing 5.5 wt% Cu, 1.8 wt% Mg, and 1.2 wt% Mn for a total mass of 10500 kg. A customer has ordered the airplane but requested that its total mass be reduced by 1500 kg for fuel saving purposes. It is proposed that the weight saving objective can be entirely met by replacing the aluminum alloy of the floor beams with an aluminum-lithium one containing 5 wt% Li and 0.5 wt% Cu. Determine whether this is true or not by calculating the mass savings obtained using the new alloy. Assume weighted averages of density for each alloy and use the following densities for the mentioned materials:

Al = 2.70 g/cm^3 Cu = 8.92 g/cm^3 Mg = 1.74 g/cm^3 Mn = 7.47 g/cm^3 Li = 0.53 g/cm^3

5- Describe the heat treatment scheme that would provide the following property changes to 1080 steel: (refer your treatments to the appropriate time-temperature-transformation curve)

a- Pearlite to bainite
b- Martensite to fine pearlite
c- Pearlite to martensite
d- 100% pearlite to a mixture of 50% pearlite and 50% martensite
e- Mixture of 75% pearlite and 25% martensite to 100% tempered martensite

6- During heat treatment, carbon can diffuse into the face centered cubic (FCC) and the body centered cubic (BCC) iron. If the diffusion coefficients are $1x10^{-7}$ centimeters squared per second for FCC iron and $4x10^{-5}$ centimeters squared per second for BCC iron, how many carbon atoms diffuse through each lattice arrangement given that the concentration gradient of $5x10^{20}$ atoms per cubic centimeter is the same in each case?

7- A 0.9 kg magnesium sacrificial anode in a hot water heater is used up in 14 years.

a- What is the anode reaction?
b- What is the average corrosion current supplied by the anode?

Use an electromechanical valence of 2 and an atomic mass of 24.3 amu for Mg.

8- An aluminum cylindrical sample having a diameter of 12.8 mm and a length of 50.8 mm is tested in tension. It starts to yield at 31,000 Newtons and reaches its maximum load at 40,000 Newtons. Its final length after breaking is measured as being 63.5 mm. If the Young's modulus of elasticity E is obtained as equal to 69 GPa, determine:

a- The material's yield strength
b- The tensile strength
c- The elastic strain at the yield point
d- The total elongation
