National Exams December 2016

10-Met-B7: Physical Metallurgy of Non-Ferrous Metals and Alloys

3 hours duration

Notes:

1. If doubt exists 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. Candidates may use one of two calculators, the Casio or Sharp approved models. This is a closed book exam.

3. Any five (5) questions constitute a complete paper (100 marks total). Only the first five questions as they appear in your answer book will be marked.

4. Each question is of equal value.

5. Most questions require an answer in essay format. Clarity and organization of the answer are important.

Question 1:

(a) Describe in general how wrought Al-alloys are classified. How are Al casting alloys classified? ***(10 marks)***

(b) List the four (4) basic temper designations for Al-alloys and describe the alloy condition for each case? ***(10 marks)***

Question 2:

(a) The heat treatment of hardenable aluminum alloys normally involves a three-stage procedure. Briefly describe the nature of the three stages and the microstructures that result following each stage. ***(10 marks)***

(b) The production of sheet material for structural applications requires careful control of annealing-induced transformations, either during rolling (i.e. hot working) or after cold rolling. Discuss two factors that control grain growth (i.e. ultimate grain size) during the annealing of aluminum alloy deformed to a specific strain. ***(10 marks)***

Question 3:

The microstructure of as-cast copper-based alloys can be modified using one of several heat treatments. Briefly describe each of the following treatments. (Note: Your answer should consider the heat treatment procedure and the resulting microstructural changes that develop).

(a) precipitation hardening ***(5 marks)***

(b) spinodal decompositon ***(5 marks)***

(c) homogenizing ***(5 marks)***

(d) stress-relieving ***(5 marks)***

Question 4:

(a) What are the major alloying elements added to magnesium to make magnesium alloys for engineering applications? ***(4 marks)***

(b) Why is grain refining not necessary for die-cast magnesium alloys? ***(4 marks)***

(c) What is the precipitation sequence in Mg-Al alloys, which are solution-heat-treated, quenched and aged? Is the precipitation hardening effect large or small? Explain. ***(8 marks)***

(d) Why can't magnesium alloys be directly connected to metals like steel and copper in most engineering designs? ***(4 marks)***

Question 5:

(a) What alloying elements are used to make the alloy brasses? ***(4 marks)***

(b) What is the dezincification of brasses? What is the mechanism for this type of corrosion? ***(6 marks)***

(c) Why is phosphorus added to the tin bronzes? What is the chief disadvantage of these alloys when compared to the brasses? ***(6 marks)***

(d) What special property does aluminum provide to the alumimum bronzes to make them useful engineering alloys? ***(4 marks)***

Question 6:

(a) What are the principal solid-solution strengthening elements added to nickel-based superalloys? ***(4 marks)***

(b) How do carbides strengthen cobalt-base superalloys? ***(5 marks)***

(c) How does the precipitation strenghtening of the cobalt-base superalloys differ from the nickel-base superalloys? ***(6 marks)***

(d) What is hot corrosion of superalloys? What is one way in which hot corrosion resistance can be increased? ***(5 marks)***

Question 7:

(a) What are the three types of alloy phase stabilizing systems formed in binary titanium alloys? ***(6 marks)***

(b) Why are beta titanium alloys more cold-formable than the alpha-titanium alloys? ***(5 marks)***

(c) Why must the amount of aluminum alloyed with titanium be limited to about 8%? ***(4 marks)***

(d) Why do transformed or partly transformed microstructures in titanium alloys have, in general, higher fracture toughness than equiaxed microstructures? ***(5 marks)***

Question 8:

(a) Give the distinctive features, limitations, and applications of: (i) refractory metals and (ii) noble metals. ***(10 marks)***

(b) Using a schematic phase diagram describe the difference between stoichiometric and non-stoichiometric intermetallic compounds. Choose one example of a structural intermetallic compound and explain the primary strengthening mechanism responsible for good high temperature creep resistance. ***(10 marks)***