Examination Period 3: 2017/18

ENG100718N

Module Title          Materials Science
Level                Four
Time Allowed         Two hours

Instructions to students:

• Enter your student number not your name on all answer books.
• Answer all questions.
• Begin each question on a separate page; label each page clearly with the number of the question you are answering.
• The use of an electronic non-programmable calculator is permitted.
• paper remains the property of the University of Northampton.

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Answer **all** questions.

**Question 1**

**a.** State the **two** types of primary bond that are found in engineering ceramic materials. Identify **two** important properties of ceramics and relate these to the type of bonding.  

(5 marks)

**b.** Indicate on **two** sketches, stress-strain curves for a low carbon steel in the normalised condition and another drawing (using the same scale) the stress-strain curve of the same metal after cold working.

- Identify on each sketch the yield point and the ultimate tensile strength.
- Also show, on one of the curves, how you would calculate the plastic ductility from the stress-strain curve.
- What is the advantage of using a stress-strain diagram compared to the load-extension graph of the same test?  

(14 marks)

**c.** Describe (or show using sketches) how the grain structure of a metal arises as a result of cooling from the melt.  

(6 marks)

**Total:** 25 marks

**Question 2**

**a.** Draw (sketch) and label the phases as seen under an optical microscope at approximately 400x magnification for a 0.35% carbon steel, a 0.8% carbon steel and a 1.2% carbon steel in the normalised condition. How would the structure of the 0.35% carbon steel be altered if it had been hot-worked?  

(10 marks)

**b.** Sketch the equilibrium diagram for the steel system for the range up to 1000°C and up to 1.5% Carbon. Name the phase areas.  

(10 marks)

**c.**

i. What non-equilibrium phase would be formed if a 0.35% carbon steel was to be quenched in oil or water from the austenitic state to 25 Deg-C?

ii. Why does this phase not appear on the diagram?

iii. What are the two main (extreme) properties associated with this phase?

iv. What heat treatment process can be carried out on the material to alter these two properties?  

(5 marks)

**Total:** 25 marks
Question 3

a. Produce a sketch for a corrosion cell showing an anode and cathode and the rest of the circuit. Indicate the direction of electron flow. What similar and relatively inexpensive alloy could replace mild steel in this circuit to prevent or reduce corrosion? (6 marks)

b. Calculate the maximum force required to produce a washer of diameter 35mm, simultaneously with a 20mm dia hole from a steel sheet of thickness 2.0mm with a shear strength of 410 MPa (or MN m⁻²). (12 marks)

c. What effect does metal ductility have on the appearance of the sheared edge of a component? (2 marks)

d. To determine hardness, tests can be carried out using hardened steel balls or an industrial diamond indenter. Give advantages and disadvantages for both types. (5 marks)

Total: 25 marks

Question 4

a. What important point or characteristic of some steels can be determined by an Impact (Charpy or Izod) test? What is the variable in this test? Using a sketch graph showing axis labels, mark using a circle or cross where this point is observed. Why is this situation dangerous in safety critical components? (8 marks)

b. Name and describe the procedure for how a test could be carried out to determine the impact toughness of a metal. Give any potential advantages or disadvantages of the technique you choose. (8 marks)

c. Name the two types of secondary bond. Will polyvinyl chloride have a higher MPt (or softening point) than polyethylene? Justify your answer in terms of the type of bonding. (3 marks)

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Question 4 continues overleaf
d. In metallography;

i. Why is it important to have a very flat polished surface on the sample?

ii. Why does this surface usually require etching before it can be viewed under an optical microscope?

iii. What would be a typical magnification for initially viewing a steel sample under a light or optical microscope?

iv. Why do we use incident illumination and not transmitted light to view thick metal samples?

(6 marks)

Total: 25 marks