Examination Period 3: 2018/19

**ENG100719N**

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<th>Module Title</th>
<th>Materials Science</th>
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<tr>
<td>Level</td>
<td>Four</td>
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<td>Time Allowed</td>
<td>Two hours</td>
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Instructions to students:
- Enter your student number **not** your name on all answer books.
- Answer **all** questions.
- The use of a calculator **is** permitted.

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Answer all questions.

Question 1

a. Name and describe the procedure for a test to determine the tensile strength of a metal. Give any potential advantages or disadvantages of the technique you choose.  

(10 marks)

b. Indicate important points or characteristics on a sketch graph for low carbon normalised steel typical of that produced by the type of test described in your answer above. Show axis labels. If we calculate the UTS from the original (pre-test) diameter of the specimen, is this Engineering stress or True stress? Is Engineering stress higher or lower than True stress?  

(9 marks)

c. To determine hardness, a test can be carried out using hardened steel balls or an industrial diamond indenter. Give advantages and disadvantages for both types.  

(6 marks)

Total: 25 marks

Question 2

a. Name the two types of secondary bond. Indicate the strength of these bonds compared with primary bonds. Will polyvinyl chloride have a higher Melting Point (or softening point) than polyethylene?  

(2 marks)

b. Using a sketch of dendrites show how the grain boundaries in a metal arise. Indicate in a sketch showing rolling direction how the grain structure is changed by cold working.  

(5 marks)

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

(12 marks)

d. Calculate the number of atoms in a Face Centre Cubic (FCC) unit cell and in a body centre cubic unit cell (BCC) (show all working).  

(6 marks)

Total: 25 marks

Question 3

a. What non-equilibrium phase would be formed if a 0.4% carbon steel were quenched from the austenitic (FCC) state. Why does it not appear on an equilibrium phase diagram? What are the two main (extreme) properties associated with this phase? What heat treatment process can be carried out on the material to alter these two properties?  

(5 marks)

Question 3 continues overleaf
b. Describe using a diagram for a composite material the long and short fibre model to determine the critical fibre length. In your description relate to the common failure mechanism of composites. (10 marks)

c. Draw (sketch) and label the phase or metallurgical structures for a 0.35% carbon steel, a 0.8% carbon steel and a 1.2% carbon steel in the normalised condition as viewed under an optical microscope. How would the structure of the 0.4% carbon steel be altered if it had been hot-worked? (10 marks)

Total: 25 marks

Question 4

a. In metallography, why is it important to have a very flat polished surface on the sample? Why does this surface usually require etching before it can be viewed under an optical microscope? What is a typical magnification for initial observation of a mounted steel sample under an optical microscope? (5 marks)

b. This part is about expansion/contraction of a steel measuring tool. The following information may be of use in answering the question:

Linear temperature coefficients $\alpha$ - aluminium: 0.000023 (m/m°C), steel: 0.000016 (m/m°C), copper/alloy: 0.000017 (m/m°C)

A cutting machine has a bed of length 5 metres. This incorporates a steel rule which is 5 metres along its length when assembled at 20°C. Construction is designed for temperatures ranging from -40°C to +40°C.

i. What is the shortest length of the rule at minimum temperature -40°C? (5 marks)

ii. What is the length of the rule at +40°C? (5 marks)

iii. Suggest, with a reason, which of copper or aluminium would be the better alternative to steel for this application? (4 marks)

iv. What happens when mild steel is exposed to water and air? Make a sketch showing an anode and cathode and the rest of the circuit. Give the equations that govern the reaction of the metal with this environment. (6 marks)

Total: 25 marks

End of Paper