Summer Examinations 2016

ENG100716N

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 in a separate answer book; label each answer book clearly with the number of the question you are answering.
- Neither books nor notes may be taken into the examination.
- The use of a non-programmable calculator is permitted.
- Students are permitted to remove this examination paper at the end of the examination.

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Answer **all** questions.

**Question 1**

a. Describe using sketches how the grain structure of a metal arises as result of cooling from the melt. Indicate how the grain structure is changed by cold working.  

   **(7 marks)**

b. 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)**

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)**

   **Total: 25 marks**

**Question 2**

a. Calculate the maximum force required to produce a washer of diameter 30 mm, simultaneously with a 15mm dia hole from a steel sheet of thickness 2.0 mm with a shear strength of 430 MPa (or MN m~2).

   **(10 marks)**

b. What effect does metal ductility have on the appearance of the sheared edge of a component?

   **(2 marks)**

c. Name the two types of secondary bond. Indicate the strength of these bonds compared with primary bonds. Will polyvinyl chloride have a higher MPT (or softening point) than polyethylene? Justify your answer in terms of the type of bonding.

   **(5 marks)**

d. State the type of primary bond that is most commonly found in an engineering ceramic materials. Three important properties are MPT, corrosion (oxidation) resistance and maximum tensile strength. Suggest values for each of these for a chosen ceramic and state how they arise as a result of the type of bonding.

   **(8 marks)**

   **Total: 25 marks**
Question 3

a. 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)

b. 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)

c. What non-equilibrium phase would be formed if a 0.4% carbon steel above 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)

Total: 25 marks

Question 4

a. 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)

b. What important point or characteristic of some steels can be determined by the type of test described in your answer above. 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)

c. 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)

d. 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?

(4 marks)

Total: 25 marks

End of Paper