National Examination, May 2015

10-Met-B6, Physical Metallurgy of Iron and Steel

3-Hour 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 Sharpe approved models. This is a *Closed Book* exam.

3. There are 7 questions in total. You must answer all of them.

1. (i) 4 marks, (ii) 4 marks, (iii) 4 marks

After being cooled down from the austenite temperature region, a simple iron-carbon steel exhibits a microstructure consisting of 40% pearlite and 60% ferrite.

(i) Estimate the C concentration of the steel;

(ii) Describe in a sketch the equilibrium structure of the steel that would be obtained if the steel were heated to 730°C and held there for a long period of time;

(iii) What would be the equilibrium structure if the steel were heated to 900°C?

II. 10 marks

In a slowly cooled hypereutectoid Fe-C steel, the pearlite colonies are normally separated from each other by a more or less continuous boundary layer of cementite. Explain how it is that this microstructure develops.
(Use simple sketches to illustrate your answer)

III. (i) 5 marks; (ii) 5 marks; (iii) 5 marks

(i)Determine the relative volume change when a carbon steel containing 0.6% of C is quenched to from 100% martensite.

(ii)What is the corresponding change in a linear dimension?

(iii)Assuming that Young's modulus of the steel is 206GPa, what is the tensile stress that would have to be applied to this steel in order to obtain a strain equivalent to that found in (ii) of this problem?

IV. (i) 10 marks. (ii) 10 marks.

(i) Describe step by step how you would experimentally construct a CCT curve for a given steel.

(ii) Explain the reason(s) qualitatively why, unlike the TTT curves, the lower part of the CCT curves are usually 'disappeared', i.e. why the shape of CCT curves usually is incomplete, missing the lower portion of the "C" shape?

V. (i) 5 marks, (ii) 5 marks, (iii) 5 marks.

(i) Define "Hardenability".

(ii) What is the phenomenon of Temper Embrittlement (TE)? What is the most commonly accepted mechanism for TE?

(iii) Why does the hardness of martensite increases with increasing C content for most structural steels?

VI. (i) 4 marks, (ii) 3 marks, (iii) 3 marks, (iv) 3 marks.

In modern manufacturing, especially the auto-manufacturing industry, the following newly developed steels are being used more and more frequently for their respective special properties.

Please provide the full names for these steels, and briefly explain the significance of these names, respectively.

a. TRIP steels,
b. DP steels,
c. IF steels,
d. HSLA steels.

VII. (i) 5marks; (ii) 4 marks; (iii) 3 marks; (iv) 3 marks

(i) What is the meaning of ***Carbon Equivalent*** (C.E.) for analyzing the chemistry of cast iron? Usually C.E. is given as C.E. = %C + (1/3)%Si. For example, a C.E. of 4.3 indicates that the alloy is of eutectic composition.

(ii) A cast iron has carbon concentration of 2.5% and silicon concentration of 2.8%. What is the C. E. number? Is it a hypoeutectic or a hypereutectic alloy?

(iii) Certain types of elements promote graphite formation, and others may tend to decrease the graphitization of carbon in cast iron. Name at least one for each case.

(iv) Conventional gray cast irons are generally considered to be brittle materials as they have very limited potential for plastic deformation. Why?