National Examination December 2016

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 a clear statement of any assumptions made in the answer paper.

2. Candidates may use one of two calculators, the Casio or Sharpe approved models. This is a *Closed Book* exam.

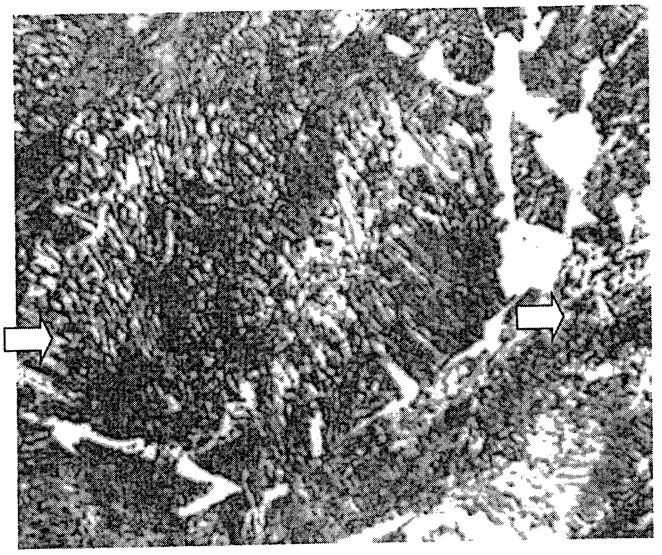
3. There are totally 7 questions. You must answer all of them.

I. (i) 5 marks, (ii) 5 marks, (iii) 10 marks.

(i) Verify/indicate the phase and/or the structure as pointed by the two arrows in the micrograph below. The micrograph was taken from a steel sample with C content less than the eutectoid composition.

(ii) Describe the process through which the microstructure in the micrograph could be obtained.

(iii) Assuming that there is another sample that has a carbon concentration of 0.85wt%, calculate the weight fraction of cementite in the material heated to and held for a long time at a temperature slightly higher than the eutectoid temperature.



II. (i) 8 marks. (ii) 6 marks. (iii) 6 marks.

(i)Describe step by step how you would experimentally construct a TTT curve for a given steel. Draw a schematic plot to show your steps.

(ii)Explain the reason(s) qualitatively behind the "C" shape of a typical TTT curve, i.e. explain why a typical TTT curve has a "C" shape.

(iii)What are the major differences in the experimental procedure for constructing a TTT curve and a CCT curve, respectively?

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

(i)State the significance of "Hardenability".
(ii)Why do some alloying elements such as Mn, Ni and Cr would increase the hardenability of steels?
(iii)Continued from (ii) above, however, the hardness of martensite in most structure steels mainly depends on the carbon concentration in the steel? Why?

IV. (i) 5 marks, (ii) 5 marks

(i) For many tool steels, such as D2, quenching can be done in air, i.e., for quenching operation, the work piece needs only to be taken out of the high temperature furnace and be put in air or through fan-cooling. Why is such a processing procedure recommended for quenching?
(ii) In addition, for these steels after quenching, there is a general requirement to temper the steel for multiple times, say sometimes three times. Why?

V. 10 marks
Describe the microstructural changes upon temperature increase during tempering in a mid-carbon steel, say SAE1045. Assume that the steel was fully austenitized, at 860°C, and quickly cold-water-quenched.
(Hint: there are 3 stages.)

VI. (i) 7 marks, (ii) 8 marks
(i)Conventional grey cast irons are generally considered brittle materials as they have very limited potential for plastic deformation. Why?
(ii) Provide a practical method and explain the mechanism(s) of your method for producing ductile cast iron that has comparable ductility to some annealed steels.

VII. (i) 5 marks, (ii) 5 marks.

When manufacturing heavy duty steel strapping, the strapping, made of SAE1032 steel, needs to be heat-treated with a procedure whereby the strapping, on a continuous processing line, is heated to its austenization temperature, then quenched very quickly into a molten lead bath of 380°c and kept at this temperature for a while before it is cooled down to the ambient temperature.

(i) What kind of microstructure should be expected after such treatment? Why?

(ii) In one case, many long-stringer-shaped ferrite grains were detected by metallographic investigation after the aforementioned processing. Such a structure is detrimental to the applications of the strapping as it reduces the strapping strength. Can you figure out the reason for the formation of such a stringer ferrite structure?