

National Examination,  
December 2009

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

3-Hour Duration

NOTES:

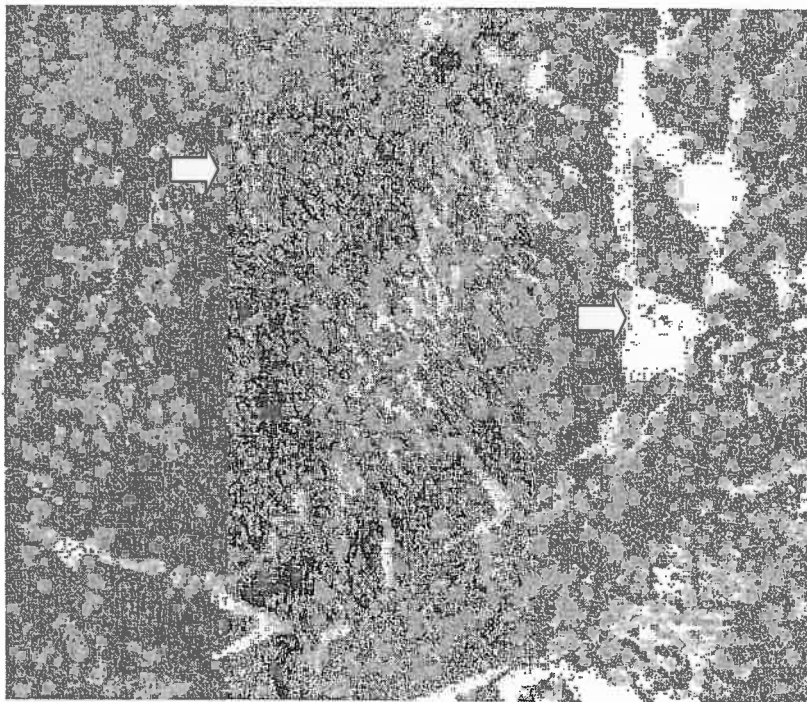
1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with a clear statement of any assumptions made in the answer paper.
2. Candidates may use one of two calculators, the Casio or Sharpe approved models. This is a *Closed Book* exam.
3. There are totally 6 questions. 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 arrows in the micrograph below. The micrograph was taken from a steel sample with C content less than the eutectoid composition.

(ii) Describing 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 austenite in the material heated to and held for a long time at a temperature slightly higher than the eutectoid temperature.



- II. (i) 10 marks. (ii) 10 marks.
- (i) Describe step by step how you would experimentally construct a CCT curve for a given steel. Draw a schematic CCT 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. (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) 7 marks, (ii) 8 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. 15 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 gray 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 irons so that the ductility of cast irons could be considerably improved.