

National Examination, 2011

**98-Met-B6, Physical Metallurgy of Iron and Steel
3-Hour Duration**

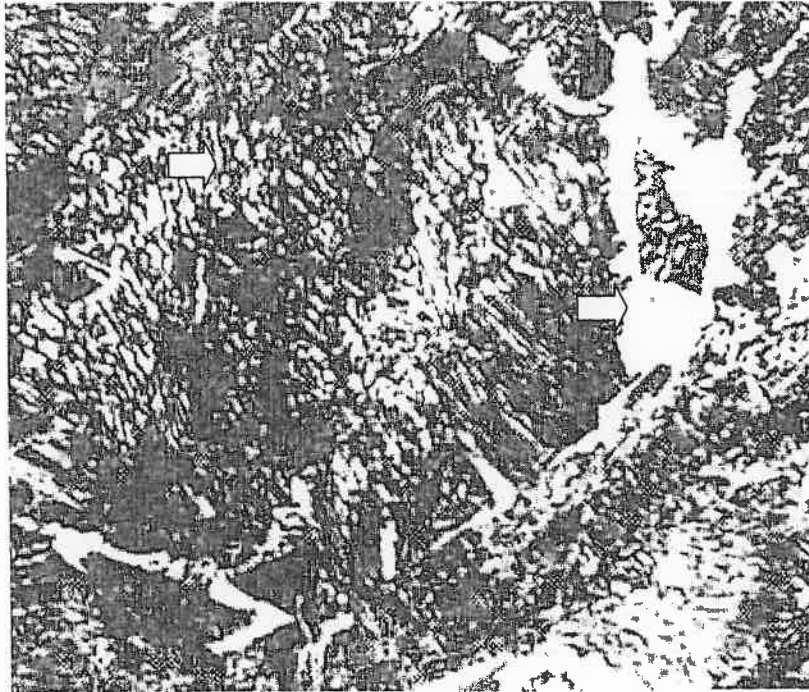
NOTES:

- 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 7 questions. You must answer all of them.**

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

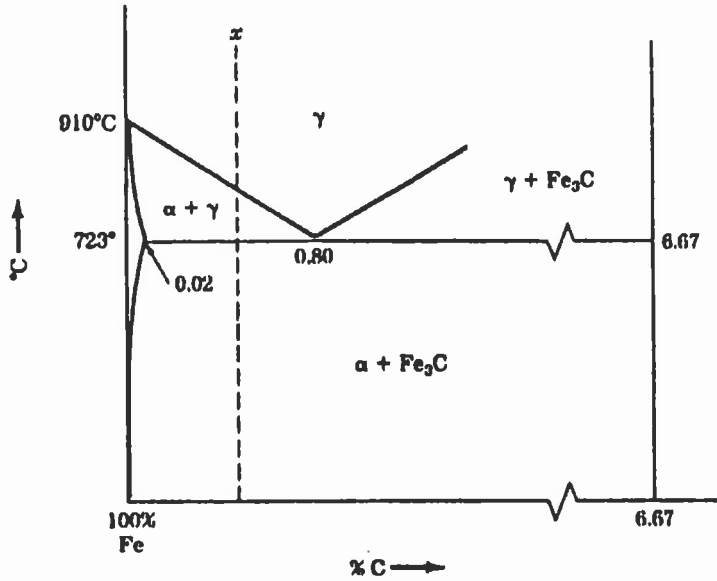
(i) Verify/indicate the phase and/or the structure as pointed by the arrows in the micrograph below. The micrograph was taken from a steel sample with C content less than the eutectoid composition.

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



II. 10 marks

A hypoeutectoid plain carbon steel which was slow-cooled from the austenitic region to room temperature contains 10.5% eutectoid ferrite. Assuming no change in structure upon cooling from just below the eutectoid temperature to room temperature, what is the carbon content of the steel?



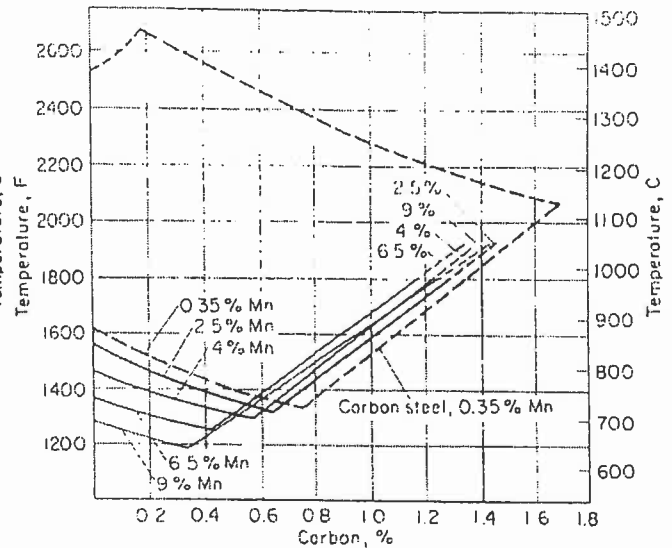
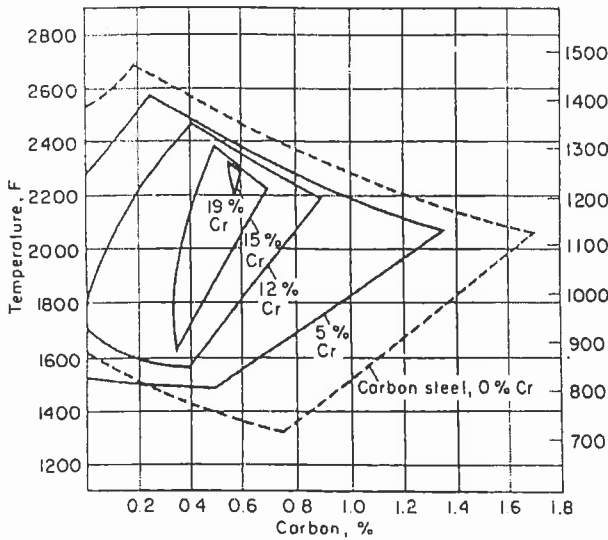
- III. (i) 10 marks. (ii) 10 marks.**
- (i) Describe step by step how you would experimentally construct a CCT curve for a given steel. Draw a schematic CCT plot to show your steps.**
- (ii) Explain the reason(s) qualitatively behind the “C” shape of a typical TTT curve, i.e. explain why a typical TTT curve has a “C” shape.**

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

(i) State the significance of “Hardenability”.

(ii) The two plots below show the effect of alloying element, Mn and Cr, respectively, on the stability of austenite in a carbon steel. By analyzing the two plots, can you indicate which of the two will increase hardenability of the steel considerably? Briefly explain the reason for your answer.

(iii) Continued from (ii) above, however, the hardness of martensite in most structure steels mainly depends on the carbon concentration in the steel? Why?



(a)

V (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?

VI. 15 marks

What are the four major reactions or microstructure changes in a mid-carbon steel, say SAE1045, during tempering? Assume that the steel was fully austenitized, at 860°C, and then quickly cold-water-quenched.

VII. (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.

