National Examination, 2013

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 with 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.

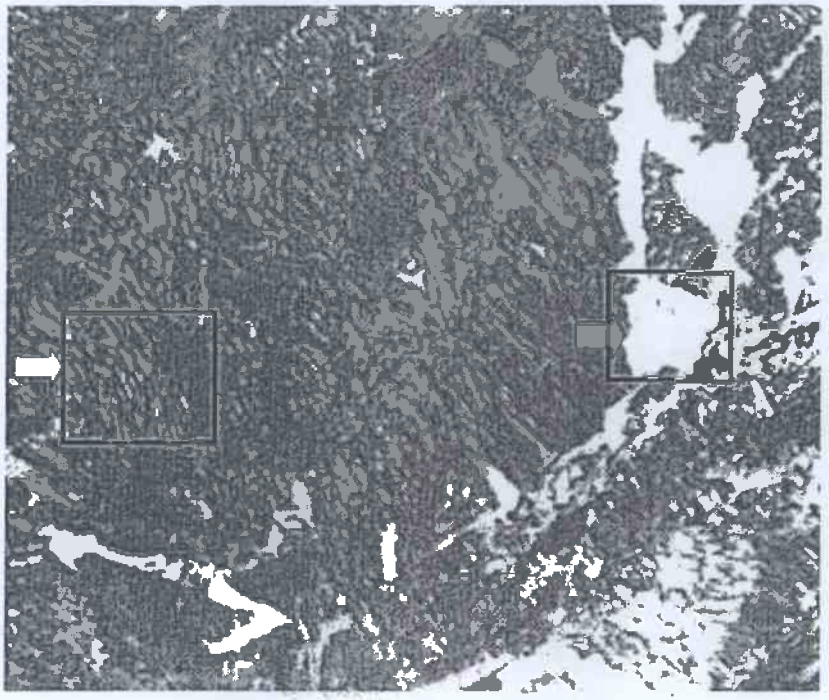
3. There are 7 questions in total. You must answer all of them.

I. (i) 4 marks, (ii) 4 marks, (iii) 2 marks

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

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

(iii) Can you conclude that the C concentration in this steel is higher or lower than 0.4wt%?



II. (i) 10 marks. (ii) 10 marks.

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

(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) Define "Hardenability".

(ii) When the C content in steel increases, so does the hardenability of the steel. Why?

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

IV. 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 before tempering.
(Hint: there are 3 stages.)

V. (i) 8 marks, (ii) 7 marks

(i) A block of SAE 1090 steel is heated to and then held for a long time at a temperature just above the eutectoid temperature. Calculate the weight fraction of cementite in the steel at this temperature.

(ii) Assuming that the sample is then very slowly cooled and held at a temperature just below the eutectoid temperature for a very lengthy period of time and then cooled down to room temperature slowly, what would be the most likely microstructure in the steel? (Draw a schematic micrograph to show your consideration.)

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

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

(ii) Provide a practical method for increasing the ductility of cast irons and explain the metallurgical mechanism(s) behind it.

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

(i) The high speed tool steel T1 has the following chemistry:

Grade	C	Cr	Mo	W	V	Co	Mn	Si
T1[III]	0.65–0.80	3.75–4.00	-	17.25–18.75	0.9–1.3	-	0.1–0.4	0.2–0.4

For austenization, the heating temperature must be as high as 1250 °C. Explain the reason.

(ii) The quenching operation for this kind of tool steel can often be done either in still air or by using a slow fan. Why is such a processing procedure recommended and workable?

(iii) There is a general requirement to temper these types of steels (especially a T1 steel) a minimum of three times after quenching. Why?