National Examination, **December 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.

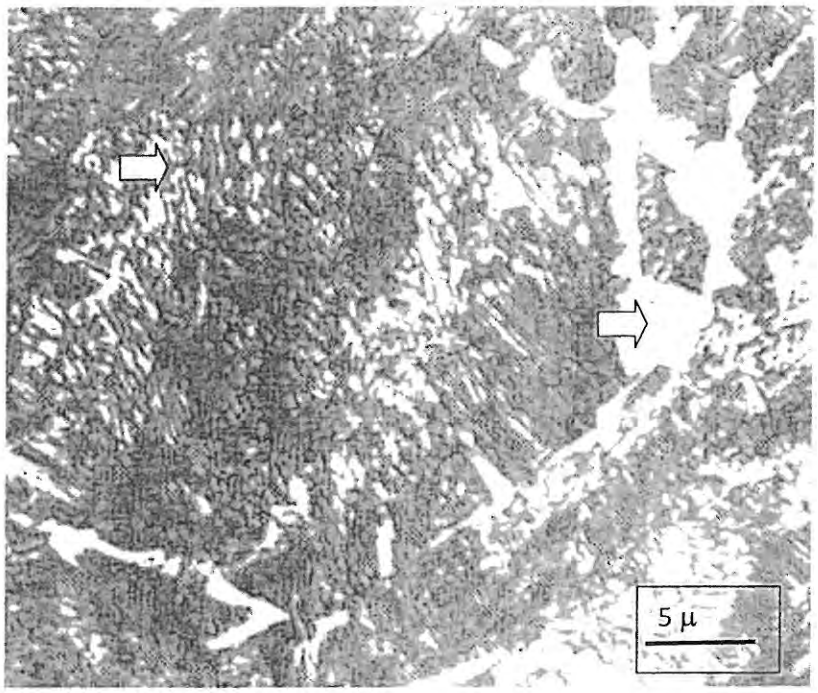
I. (i) 4 marks, (ii) 4 marks, (iii) 4 marks, (iv) 8 marks.

(i) Verify/indicate the phase and/or the structure as pointed by the arrows in the micrograph below. The micrograph was taken from a hypo-eutectoid steel sample.

(ii) Estimate the C concentration of the steel with the microstructure shown in the micrograph

(iii)Describe the process through which the microstructure in the micrograph was obtained.

(iv)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 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) 8 marks, (ii) 7 marks

(i) It has been established and well accepted* that the comprehensive relation to describe the yield strength of lath martensite steel is

$$\sigma_{ys} = \sigma_i + k(c)^{1/2} + k_y(d)^{-1/2} + \alpha G b(\rho)^{1/2}$$

Describe very briefly the mechanism behind each of the four terms on the right hand side of the expression.

*L. A. Norstrom, Scand. J. Metall., 5, 159, 1976, and R. W. Hertzberg, <<Deformation and Fracture Mechanics of Engineering Materials>>, 4 ed., John Wiley and Sons, Inc., P146

(ii) Tool steels usually contain rather high alloying elements. As an example, the alloying composition of T1 high speed cutting steel is given in the table below

Alloying compositions of T1 high speed steel (by %wt)

Grade	C[8]	Cr	Mo	W	V	Co	Mn	Si
T1	0.65–0.80	4.00	-	18	1	-	0.1–0.4	0.2–0.4

Note that impurity limits are not included

State the major role of the three major alloying elements in this steel, C, Cr and W.

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

(i) State the significance of "Hardenability".
(ii) Why do some alloying elements such as Mn and Cr would increase the hardenability of steels?
(iii) Continued from (ii) above, however, the hardness of martensite in most structural steels mainly depends on the carbon concentration in the steel? 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) 5 marks, (ii) 5 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.

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

In the modern manufacturing industries, especially auto-manufacturing industry, newly developed steels, such as TRIP steel and DP steel, are employed for their respective superior properties.

(i) Provide the full names and their significance of these two steel, respectively.

(ii) Describe the major feature of their microstructure, respectively.