National Examination, 2016

Met-B6, Physical Metallurgy of Iron ands 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.

3. This is a *Closed Book* exam.

3. There are a total of 7 questions with a total of 100 marks possible.

I. (i) 12 marks, (ii) 8 marks.

In the circles provided below,

(i) Draw schematically the microstructure of the SAE 1040 steel held at the following temperatures, respectively, for a relatively long period of time: (a) the microstructure at 1000°C, (b) the microstructure at 750°C and (c) the microstructure at 20°C after it is slowly cooled down from 750°C.

(ii) Draw schematically the microstructure of the SAE 1090 steel held at the following temperatures, respectively, for a relatively long period of time: (a) the microstructure at 730°C, (b) the microstructure at 20°C after it is slowly cooled down from 730°C.

I – (i) – (a)   I – (i) – (b)   I – (i) – (c)

I – (ii) – (a)   I – (ii) – (b)

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

(i) Suggest an operation procedure (i.e. a process) for a thermomechanical treatment of a steel? Why is such treatment recommended for some applications?
(Hint: Use a double-nosed TTT curve to demonstrate your discussion)

(ii) What is an austempering procedure? In general, what kind of microstructure is obtained?
(Hint: Use a single-nosed TTT curve to demonstrate your discussion)

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

(i) Describe step by step how you would experimentally construct a *CCT* 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) What is the reason, for some steels, the TTT curve has a double-nosed shape?

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

(i) What is the driving force for a martensitic transformation in steel?
(ii) What is the phase-transformation micro-mechanism of martensite formation in steel? Does it only exist in steels?
(iii) Why does the hardness of martensite increase with increasing C content for most structural steels?

V. (i) 5 marks, (ii) 5 marks, (iii) 5 marks (iv) 5 marks.

(i) For many tool steels, such as high speed steel T1, see its chemistry in the table below

Grade	C	Cr	Ni	W	V	Cu	Mn	S	P
T1	0.65–0.80	3.75–4.00	0.3	17.25–18.75	0.9–1.3	0.25	0.1–0.4	0.03	0.03

for austenization the heating temperature must be as high as 1250°C(+/-). Explain the reason.

(ii) For this kind of steels, often the cooling for the quenching operation can be done either in still air or simply by a slow fan cooling in air. Why is such a processing procedure recommended and workable?

(iii) In addition, for these steels, especially for T1 steel, there is a general requirement to temper the steel after quenching a minimum of three times. Why?

(iv) What is the micro-mechanism that gives the steel very high hardness after the aforementioned treatment?

VI. (i) 3 marks, (ii) 3 marks, (iii) 4 marks.

(i) What is the chemical form and morphology of carbon in conventional gray cast irons?
(ii) What is the chemical form and morphology of carbon in white cast irons?
(iii) How would you produce white cast irons?

VII. 10 marks

Name three surface hardening approaches that are commonly employed by modern manufacturing industry and explain briefly the hardening mechanism(s) of each approach, respectively.