National Examination, 2010

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 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.

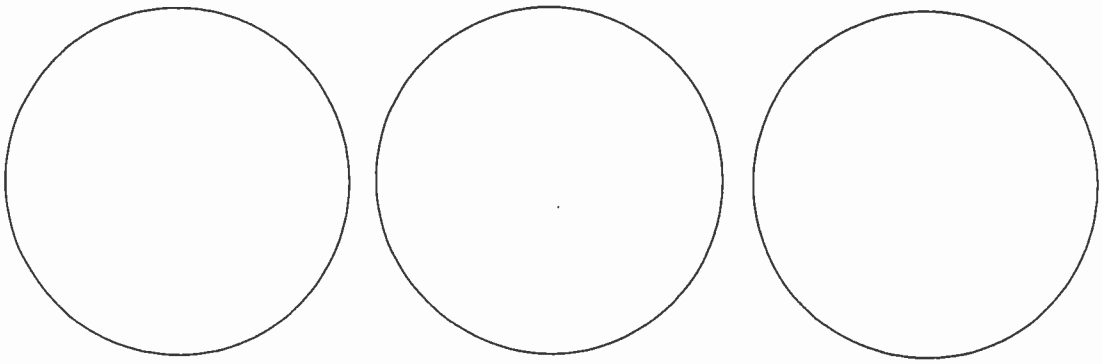
3. There are totally 7 questions. You must answer all of them.

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

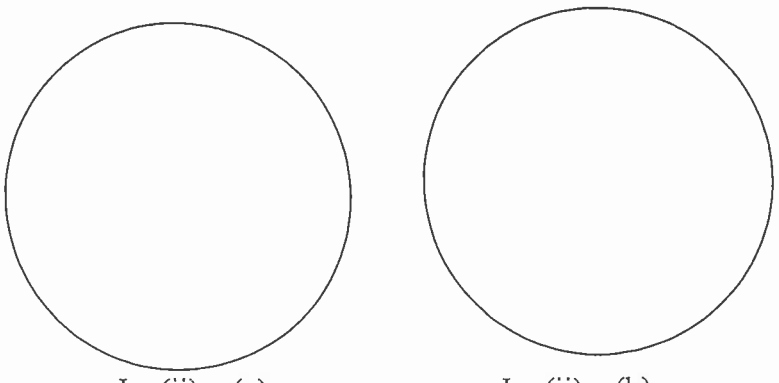
In the circles provided below,

(i) Draw schematically the microstructure of 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 730°C and (c) the microstructure at 20°C after it is slowly cooled down from 730°C.

(ii) Draw schematically the microstructure of 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) 7 marks. (ii) 8 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. (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?
(iii) Why does the hardness of martensite increase with increasing C content for most structural steels?

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

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

Chemical Composition of T1 in weight percent:
C(0.65–0.80), Cr(3.75-4.00), Mo(0.2-0.5), W(17.25-18.75), V(0.9-1.3), Mn(0.1-0.4), Co(0.1-0.15), Si(0.2-0.4)

the austenization temperature for a quenching operation is very high, such as 1250 to 1280 ^{0}C for T1 steel. Explain the reason.

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

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

V. (i) 3 marks, (ii) 3 marks, (iii) 3 marks, (iv) 3 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) What are the contributing or determining factors for the chemical form and morphology of carbon in these two types of cast irons?
(iv) How would you produce a spheroidal cast iron? Why?

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

In the modern manufacturing, especially auto-manufacturing, industry, the following newly developed steels are being used more and more frequently for their respective special properties.
Please provide the full names for these steels, and briefly explain the technical meaning of these names, respectively.

(i) TRIP steels,
(ii) DP steels,
(iii) IF steels,
(iv) HSLA steels.

VII. (i) 4 marks, (ii) 4 marks

Upon quenching, from austenite to martensite, there is usually a volumetric change in the steel. Assume that, for a plain carbon steel with 1 percent of C, the volume of austenite unit cell is 0.0233 nm^3 and that of matersite unit cell is 0.0234 nm^3.

(i) Estimate the lattice strain caused by such a transformation in this steel.

(Hint: Based upon calculus, a small isotropic length change is approximately equal to 1/3 of the corresponding volume change)

(ii) Would the lattice strain be different if the steel has a different C content?