National Examination, May 2007

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 any non-programmable calculator.

3. This is a *Closed Book* exam.

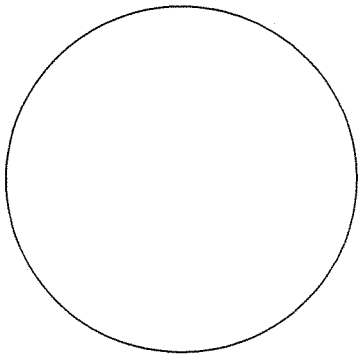
3. There are totally 6 questions. You must answer all of them.

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

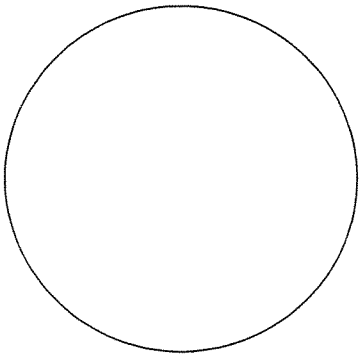
In the circles provided below,

(i) Draw schematically the microstructure of the SAE 1080 steel held at the following temperatures, respectively, for a relatively long period of time: (a) the microstructure at 750°C, (b) the microstructure at 700°C and (c) the microstructure at 20°C after it is slowly cooled down from 750°C.

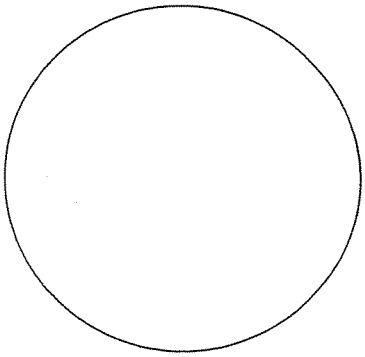
(ii) Draw schematically the microstructure of the SAE 1010 steel held at the following temperatures, respectively, for a relatively long period of time: (a) the microstructure at 800°C, (b) the microstructure at 20°C after it is slowly cooled down from 700°C.



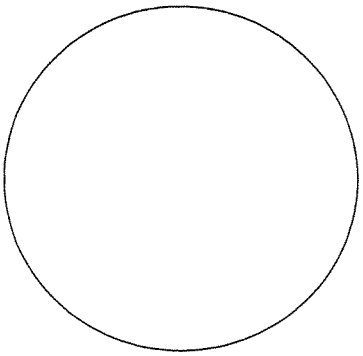
I – (i) – (a)



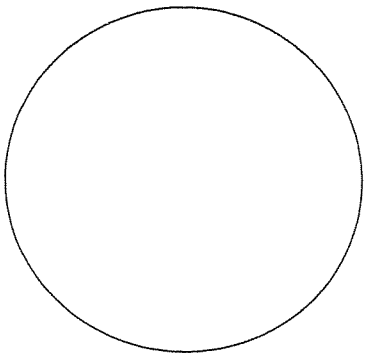
I – (i) – (b)



I – (i) – (c)



I – (ii) – (a)



I – (ii) – (b)

II. (i) 7 marks. (ii) 8 marks. (iii) 5 marks.

Answer the following questions:

(i) Explain why a typical TTT curve has a "C" shape?

(ii) Explain why the addition of some alloying elements such as Cr in a carbon steel, say SAE1045, can move its TTT curve towards right-hand, i.e. increase the "gap" between the C-curve nose and the vertical axis.

(iii) Explain why the addition of a relatively large amount of some alloying elements such as Cr in a steel can change its TTT curve from a single "C" curve to two "C" curves?

III. (i) 10 marks, (ii) 10 marks.

When manufacturing heavy duty steel strapping, the strapping, made of SAE1032 steel, needs to be heat-treated with a procedure whereby the strapping, on a continuous processing line, is heated to its austenitization temperature and then quenched very quickly into a molten lead bath of 380^0c and then kept at this temperature for a while before it is cooled down to the ambient temperature.

(i) What kind of microstructure should be expected after such treatment? Why?

(ii) In one case, many long-stringer-shaped ferrite grains were detected by metallographic investigation after the above processing (i). Such a structure is detrimental to the applications of the strapping. Can you figure out the reason for the formation of such a stringer ferrite structure?

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

(i) Define hardenability for steels?

(ii) John says when the carbon content in plain carbon steel is increased, say from 0.1wt% to 0.6wt%, the hardenability of the steel is also increased; but Jeffrey says, with such an increase in carbon, only hardness of the steel would be increased after quenching. By your understanding, what is the correct answer?

V. (i) 6 marks, (ii) 4 marks.

(i) Briefly describe the process of microstructure evolution upon increasing the tempering temperatur in SAE1045 steel after it is quenched to a full martensite structure.
(ii) What is the driving force for such evolution?

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

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

(iv)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.