National Examination, 2012

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 a clear statement of any assumptions made in the answer paper.**

2. **Candidates may use one of two calculators, the Casio or Sharpe approved models. This is a *Closed Book* exam.**

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

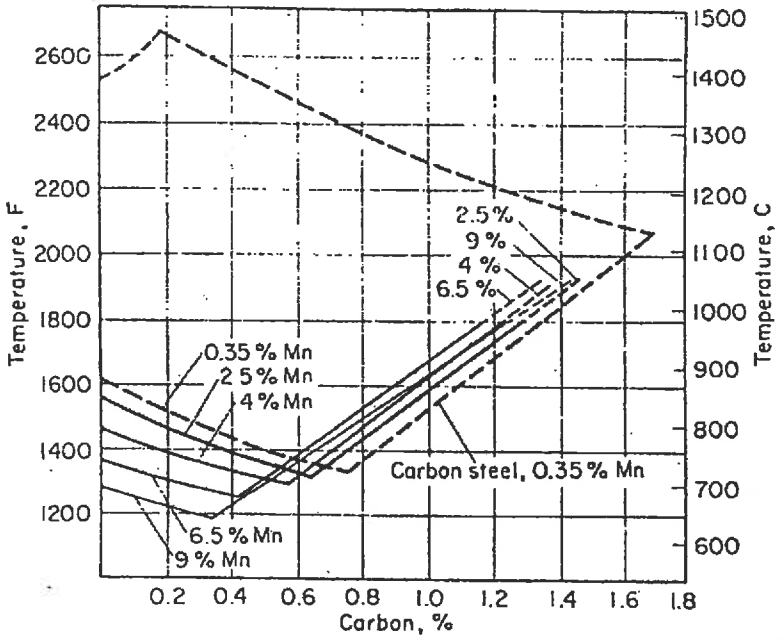
I. **(i) 5 marks, (ii) 5 marks, (iii) 5 marks, (iv) 5 marks.**

(i) Define the parameter - "Hardness".

(ii) Generally speaking, addition of certain alloying elements in carbon steel will improve the hardenability of the steel. Would it always increase the hardness of the steel as well after a quenching-to-martensite operation is carried out? Why?

(iii) The plot below show the effect of the alloying element, Mn, on the stability of austenite in carbon steel. By analyzing the plot, can you indicate whether the hardenability of the steel would be improved considerably? Briefly explain the reason for your answer.

(iv) Continued from (iii) above, if the carbon concentration in the steel is kept unchanged, would the addition of Mn increase the hardness of the martensite of the steel considerably? Why?



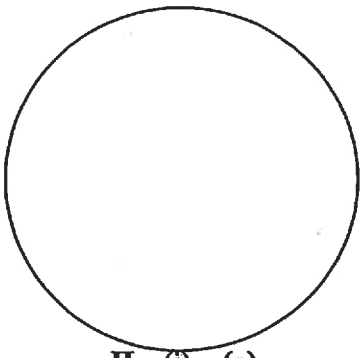
(a)

II. **(i) 12 marks, (ii) 8 marks.**

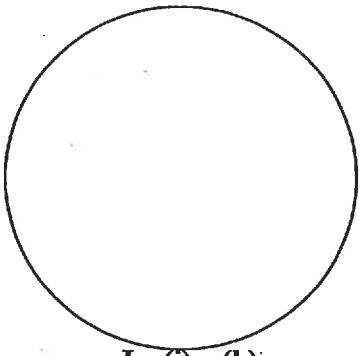
In the circles provided below,

(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.

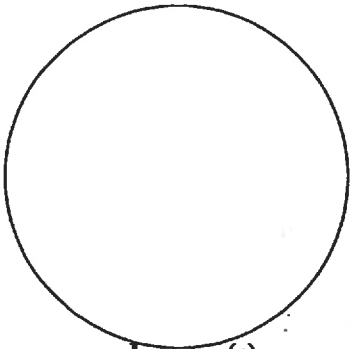
(ii) Draw schematically the microstructure of the SAE 1090 steel held at the following temperatures, respectively, for a relatively long period of time: (a) the microstructure at 730°C, (b) the microstructure at 20°C after it is slowly cooled down from 730°C.



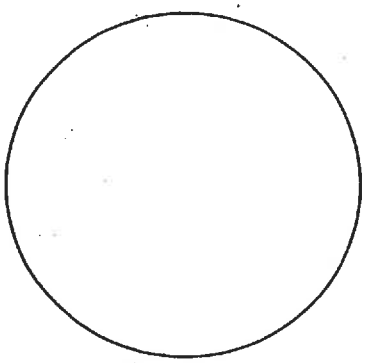
II – (i) – (a)



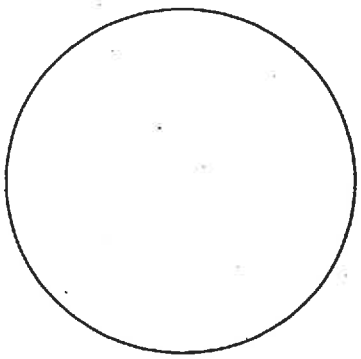
I – (i) – (b)



I – (i) – (c)



II – (ii) – (a)



II – (ii) – (b)

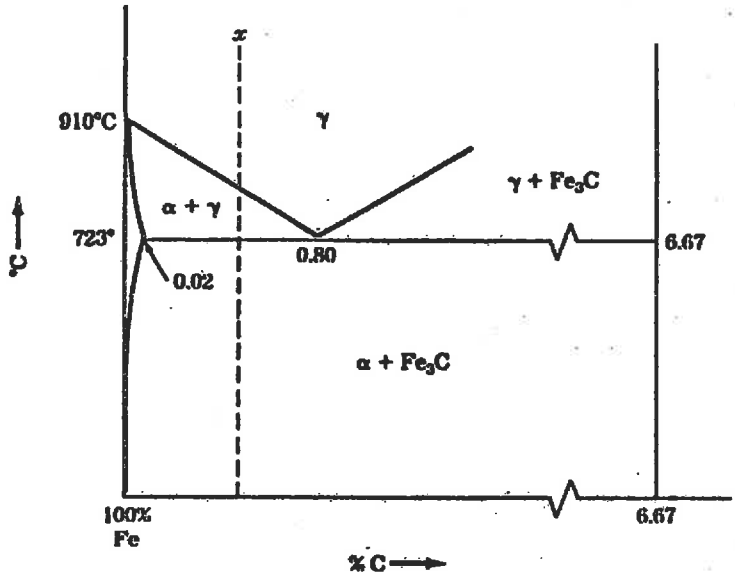
III. **(i) 5 marks. (ii) 5 marks.**

(i) **Describe step by step how you would experimentally construct a *CCT* curve for a specific steel.**

(ii) **Explain why a typical TTT curve has a "C" shape.**

IV. 10 marks

A hypoeutectoid plain carbon steel which was slow-cooled from the austenitic region to room temperature contains 15% proeutectoid ferrite. Assuming no change in structure upon cooling from just below the eutectoid temperature to room temperature, what is the carbon content of the steel?



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

Answer the following questions:

(i) **What is austempering process? What kind of microstructure will be obtained though such as process?**

(ii) **What is martempering? What kind of microstructure will be obtained though such as process?**

VI. (i) 5 marks, (ii) 10 marks.

In the manufacturing process of heavy duty steel strapping, the strapping (1 mm in thickness, 100 mm in width, and 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 along the longitudinal direction of the strapping by metallographic investigation after the above processing (i). Such a structure is known to be detrimental to the strength of the strapping. Can you suggest the reason for the formation of such a stringer ferrite structure?

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

(i) What is the most employed technique/ procedure in industry to make ductile cast iron?

(ii) Why do cast iron materials made with the technique/procedure you provided in (i) demonstrate good ductility, but conventional cast iron is usually rather brittle?

(iii) The micrograph given below is taken from a cast iron sample. Indicate all phases in the micrograph and describe the major feature of such microstructure.