NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

Faculty of Industrial Technology

Department of Industrial & Manufacturing Engineering

BEng. Degree in Industrial and Manufacturing Engineering

Materials Technology II -TIE2204

2ND SEMESTER EXAMINATIONS - AUGUST 2009

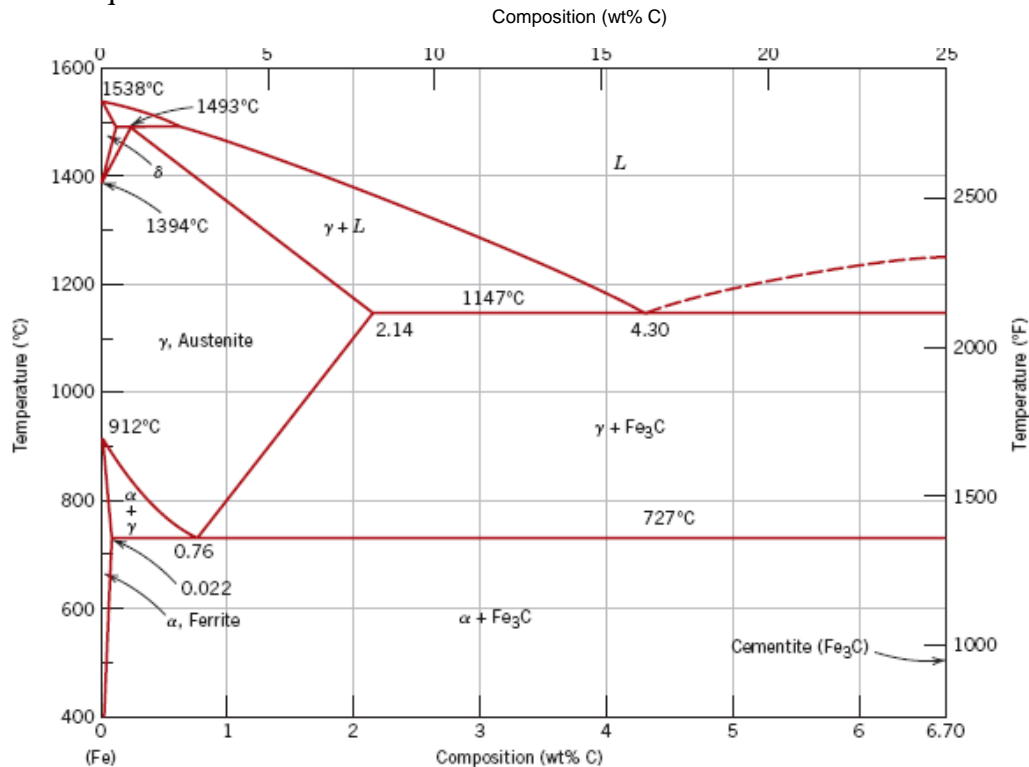*Instructions To Candidates*
1. Examination length is **3hrs**.
2. Each question carries twenty (**20**) marks and there are six (**6**) questions in total.
3. Attempt the whole of Section A and three questions from Section B.

Section A

Question 1

a)   Below is the Iron–Iron Carbide (Fe–Fe$_3$C) Phase Diagram. Use it to answer the questions that follow.

i)   What is the name given to the eutectic?   [1]
ii)   What is the name given to the eutectoid?   [1]
iii)   What is the distinction between hypoeutectoid and hypereutectoid steels?   [2]
iv)   In a hypoeutectoid steel, both eutectoid and proeutectoid ferrite exist. Explain the difference between them and give the carbon concentration in each?   [4]
v)   Distinguish between steels and cast iron.   [3]

b)   With reference to the diagram in (a) above describe the cooling of the following
        alloys:
(i)   3.40% C   [3]
(ii)   1.50% C   [3]
(iii)   0.26% C   [3]
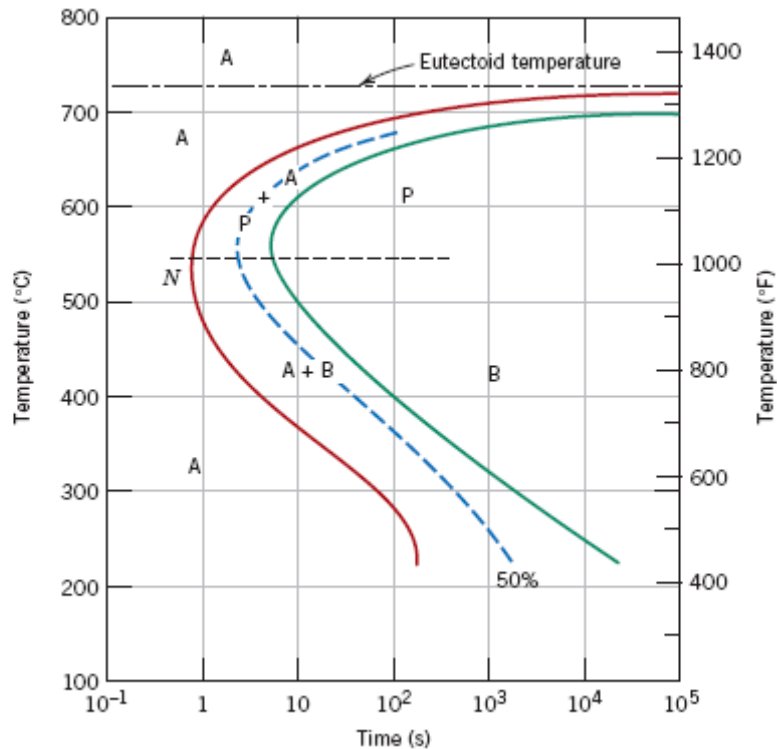
Question 2

Figure Q2

Figure Q2 is an isothermal transformation diagram for a steel of eutectoid
composition. Using it as a reference, describe the following heat treatment
processes.

a)   Normalising anneal.   [4]
b)   Ausforming   [4]
c)   Martensitic hardening   [4]
d)   Tempering   [4]
e)   Austempering   [4]

Section B

Question 3
a)   Give typical compositions, mechanical properties and applications of low-carbon
        steels.   [10]
b)   Low-carbon steels are non-hardenable unlike high-carbon steels.
(i)   Define hardenability.   [2]
(ii)   Describe in detail, the standard test employed to measure hardenability.   [8]

Question 4

a)   Martensitic hardening can only be used for allotropic metals and alloys. Metals like copper and aluminium together with their alloys have to be age hardened. Explain why this is the case.   [4]

b)   Using a suitable example outline the process of age hardening.   [15]

Question 5

a)   Define the term corrosion in relation to metals.   [4]

b)   Discuss some of the measures used to prevent or minimise general corrosion.
                                                                              [6]

c)   One-half of an electrochemical cell consists of a pure nickel electrode in a solution of Ni^{2+} ions; the other half is a cadmium electrode immersed in a Cd^{2+} solution.

(i)   If the cell is a standard one, write the spontaneous overall reaction and calculate the voltage that is generated.   [5]

(ii)   Compute the cell potential if the Cd^{2+} and Ni^{2+} concentrations are 0.5 and 10^{-3} M respectively. Is the spontaneous reaction direction still the same as for the standard cell?   [5]

Question 6

a)   Briefly describe the steps that are used to ascertain whether or not a particular metal alloy is suitable for use in an automobile valve spring.   [6]

b)   A continuous and aligned glass fiber-reinforced composite consists of 40 volume % of glass fibers having a modulus of elasticity of 69 GPa and 60 volume % of a polyester resin that, when hardened, displays a modulus of 3.4 GPa.

(i)   Compute the modulus of elasticity of this composite in the longitudinal direction.   [3]

(ii)   If the cross-sectional area is 250 mm^2 and a stress of 50 MPa is applied in this longitudinal direction, compute the magnitude of the load carried by each of the fibre and matrix phases.   [5]

(iii) Determine the strain that is sustained by each phase when the stress in part (b) is applied.   [6]

End of exam