UNIVERSITY COLLEGE TATI

UNIVERSITY COLLEGE TATI (UC TATI)

FINAL EXAMINATION QUESTION BOOKLET	
COURSE CODE	: BGE 2253
COURSE	: MATERIALS SCIENCE
SEMESTER/SESSION	: 1 - 2022/2023
DURATION	: 3 HOURS

Instructions:

1. This booklet contains 4 questions. Answer all questions.
2. All answers should be written in answer booklet.
3. Write legibly and draw sketches wherever required.
4. If in doubt, raise your hands and ask the invigilator.

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO

THIS BOOKLET CONTAINS 7 PRINTED PAGES INCLUDING COVER PAGE

QUESTION 1

a) Materials could be divided into metals and non-metals, identify the sub-class of metal and non-metal groups. (4 marks)

b) Atom is built by electrons orbiting the nucleus and the orbiting electrons has their own energy states. Express the electronic configuration for element below:

i. Boron, B^5 (2 marks)

ii. Kalium, K^{19} (2 marks)

iii. Ferum, Fe^{26} (2 marks)

c) Crystalline in solid shows the repeated arrangement of atoms. Illustrate the Face-Centre Cubic (FCC) crystal structure and the total number of atoms in the cell. (4 marks)

QUESTION 2

a) Define crystal defect. (4 marks)

b) Describe the two (2) common point defect occur in solid. (6 marks)

c) Diffusion in solid is represented by Fick's Law. Express the two types of diffusion in solid

i. Steady state (3 marks)

ii. Non-steady state (3 marks)

d) A sheet of steel 2.5 mm thick has nitrogen atmosphere on both sides at 900°C and is permitted to achieve a steady state diffusion condition. The diffusion coefficient for nitrogen in steel at this temperature is 1.2×10^{-10} m^2/s and the diffusion flux is found to be 1.0×10^{-7} kg/m^2-s. Also, it is known that the concentration of nitrogen in the steel at the high pressure surface is 2 kg/m^3. Calculate how far into the sheet from this high-pressure side will the concentration be 0.5 kg/m^3. Assume that it is a steady state diffusion. (8 marks)

QUESTION 3

a) Define corrosion in metals and list two (2) types of corrosion. (4 marks)

b) Corrosion is normally an electrochemical process.

i. Describe the electrochemical reaction at the anode and cathode. (4 marks)

ii. Explain which are reduction and oxidation reactions. (4 marks)

c) A piece of corroded metal alloy plate was found in a submerged ocean vessel. It was estimated that the original area of the plate was 165 in^2 and that approximately 15.6 kg has corroded away during the submersion. Assuming a corrosion penetration rate of 4 mpy for this alloy in seawater, estimate the time of submersion in years. The density of the alloy is 7.8 g/cm^3. (15 marks)

d) Degradation is a process of losing materials in polymers. Compare the process of

i. Swelling & dissolution (5 marks)

ii. Bond rupture (5 marks)

iii. Weathering (5 marks)

QUESTION 4

a) The most common phase diagram in metals is binary phase diagram. Give 4 factors affecting the phase of the materials. (4 marks)

b) A 98.8 wt% Fe – 1.2 wt%C alloy in Figure 1 is heated to 1000°C and is cooling down to room temperature. Illustrate

i. the phase or phases present at 1000°C, 800°C and 600°C. (4 marks)

ii. composition and amount of γ and Fe_3C at 800°C. (4 marks)

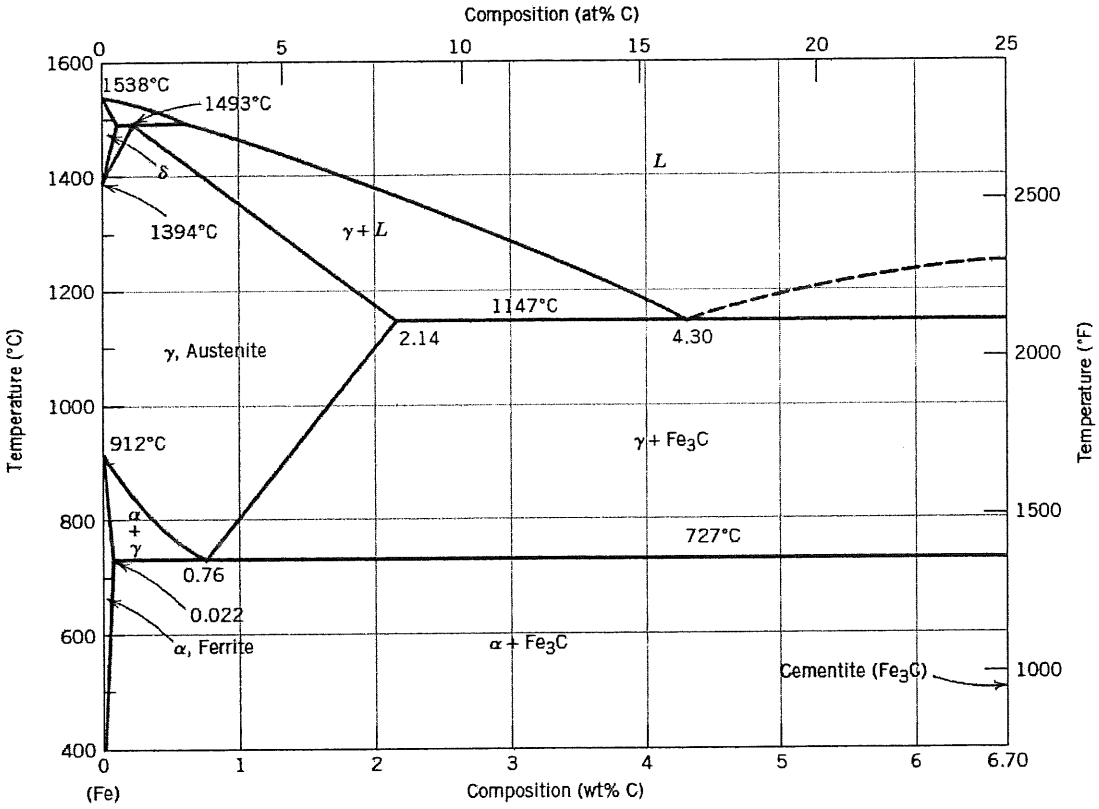

Figure 1: Phase diagram of iron-carbon system

c) Using the isothermal transformation diagram (Figure 2) for 0.45 wt%C steel alloy, illustrate the final microstructure present of a small specimen that has been subjected to the following time-temperature treatments. In each case assume that the specimen begins at 800°C, and that is has been held at this temperature long enough to have achieved a complete and homogeneous austenitic structure.

i. Rapidly cool to 250°C, hold for 10s, then quench to room temperature. (2 marks)

ii. Rapidly cool to 700°C, hold for 30s, then quench to room temperature. (3 marks)

iii. Rapidly cool to 400°C, hold for 500s, then quench to room temperature (3 marks)

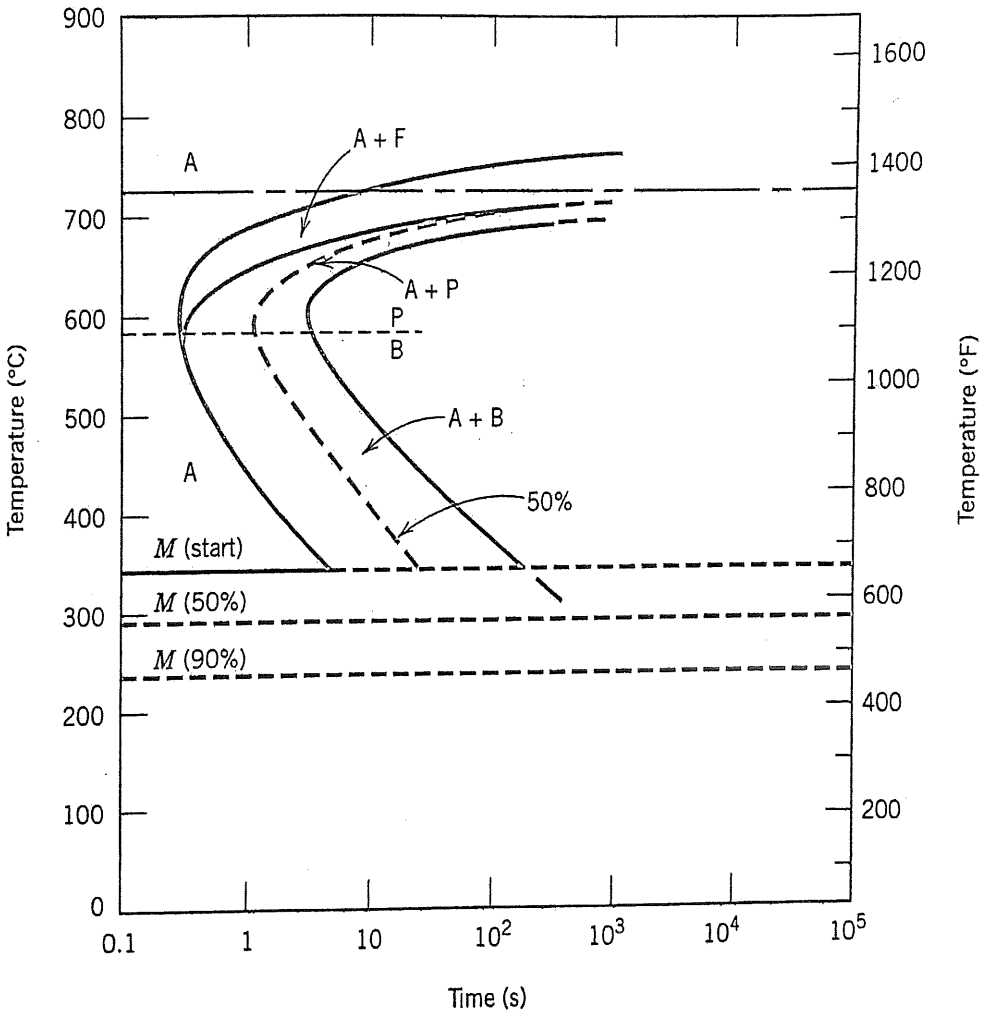

Figure 2: TTT diagram for 0.45 wt%C steel alloy

----------End of question----------

Useful Formulae

$$J = -D\left(\frac{C_A - C_B}{X_A - X_B}\right)$$

$$\frac{C_x - C_o}{C_s - C_o} = 1 - \text{erf}\left(\frac{x}{2\sqrt{Dt}}\right)$$

$$CPR = \frac{KW}{\rho At} \quad K = 534 \text{ for mpy or } 87.6 \text{ for mmyr}$$

$$W_s = \frac{R}{R+S}$$

$$W_r = \frac{S}{R+S}$$