University of Ruhuna- Faculty of Technology

Bachelor of Engineering Technology

Level II (Semester I) Examination, November 2019.

COURSE UNIT: ENT2152 PROPERTIES OF MATERIALS AND APPLICATIONS

Time Allowed 2 hours

Answer ALL (04) Questions.

All symbols have their usual meaning.

1) Deformation of a metal under an applied longitudinal stress is depicted in the following figure (Figure 1).

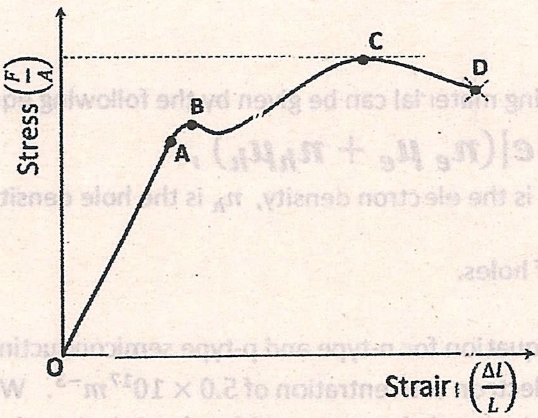

Figure 1 Graph of Stress Vs Strain.

(I) Briefly explain the terms **elastic deformation** and the **plastic deformation**. In the above figure, identify these two regions.

(II) Identify the yield point, ultimate tensile strength, and fracture point on the above figure.

(III) A carbon steel rod with circular cross section is used to lift vehicles. The rod is 10 mm in diameter and 3 m long. What is the maximum load that can be lifted without plastic deformation?

(Modulus of elasticity of carbon steel is 203 GPa and the Yield strength is 415 $GPa.$)

(IV) A cylindrical specimen of carbon steel having an original diameter of 15.4 mm is tensile tested to fracture and found to have an engineering fracture strength of 490 MPa. If its cross-sectional diameter at fracture is 12.6 mm, determine:

a. The ductility in terms of percent reduction in area.

b. The true stress at fracture.

2) Steel is made by mixing iron(Fe) with carbon(C). This mixing produces an interstitial solid solution as the carbon atom is much smaller than the Fe atom. Answer the following questions referring to the attached phase diagram (Figure 2 attached separately).

(I) Describe the crystal structures of α-Ferrite, γ-Austenite and δ-Ferrite phases.

(II) What is the maximum solubility of carbon in α-Ferrite and γ-Austenite phases?

(III) An iron-carbon alloy at 0.76 wt% of carbon composition is slowly cooled down from a temperature 800 °C.

a) Sketch the equilibrium microstructure of the austenite phase at temperature 800 °C.

b) Sketch the equilibrium microstructure of the pearlite structure below the temperature 727 °C.

c) If the system is cooled rapidly(quenched) at the above composition a martensite phase is formed at low temperatures. What major change of physical property would be observed in the martensite phase compared to the pearlite?

3) (I) Electrical conductivity of a semiconducting material can be given by the following equation,

$$\sigma = |e|(n_e \mu_e + n_h \mu_h),$$

where e is the charge of an electron, n_e is the electron density, n_h is the hole density, μ_e is the mobility of electrons and μ_h is the mobility of holes.

a) How would you modify the above equation for n-type and p-type semiconducting materials?

b) An n-type semiconductor have an electron concentration of $5.0 \times 10^{17} m^{-3}$. When an electric field of $1000\ V/m$ is applied, the drift velocity of electrons is $420\ m/s$. Calculate the conductivity of the semiconductor?

(II) A Cylindrical metal wire of $3.0 \times 10^{-3} m$ in diameter is used to carry a current of $12A$. The expected minimum voltage drop of the wire is $0.03\ V/m$. Which of the materials listed in the following table are suitable for the application?

Metal	Electrical conductivity $(\Omega.m)^{-1}$
Silver	6.8×10^7
Copper	6.0×10^7
Gold	4.3×10^7
Aluminum	3.8×10^7
Brass	1.6×10^7
Iron	1.0×10^7
Platinum	0.94×10^7
Stainless Steel	0.2×10^7

4) Metal Oxide Semiconductor Field Effect Transitor (*MOSFET*) is the basic building block of modern electronics.
This is the solid state analogue of the mechanical switch which can be switched at a very high frequency.

(I) Write the two main advantages of a MOSFET compared to a Bipolar Junction Transistor (BJT).

(II) Briefly explain the basic structure of a MOSFET. (Diagrams or a sketch can be used to explain.)

(III) Describe the working principle of a n-channel and a p-channel MOSFETs (n-MOSFET, p-MOSFET).

(IV) Using a circuit diagram explain how would you use a n-MOSFET and a p-MOSFET to construct a CMOS (Complementary Metal Oxide Semiconductor) inverter and explain its working principle.

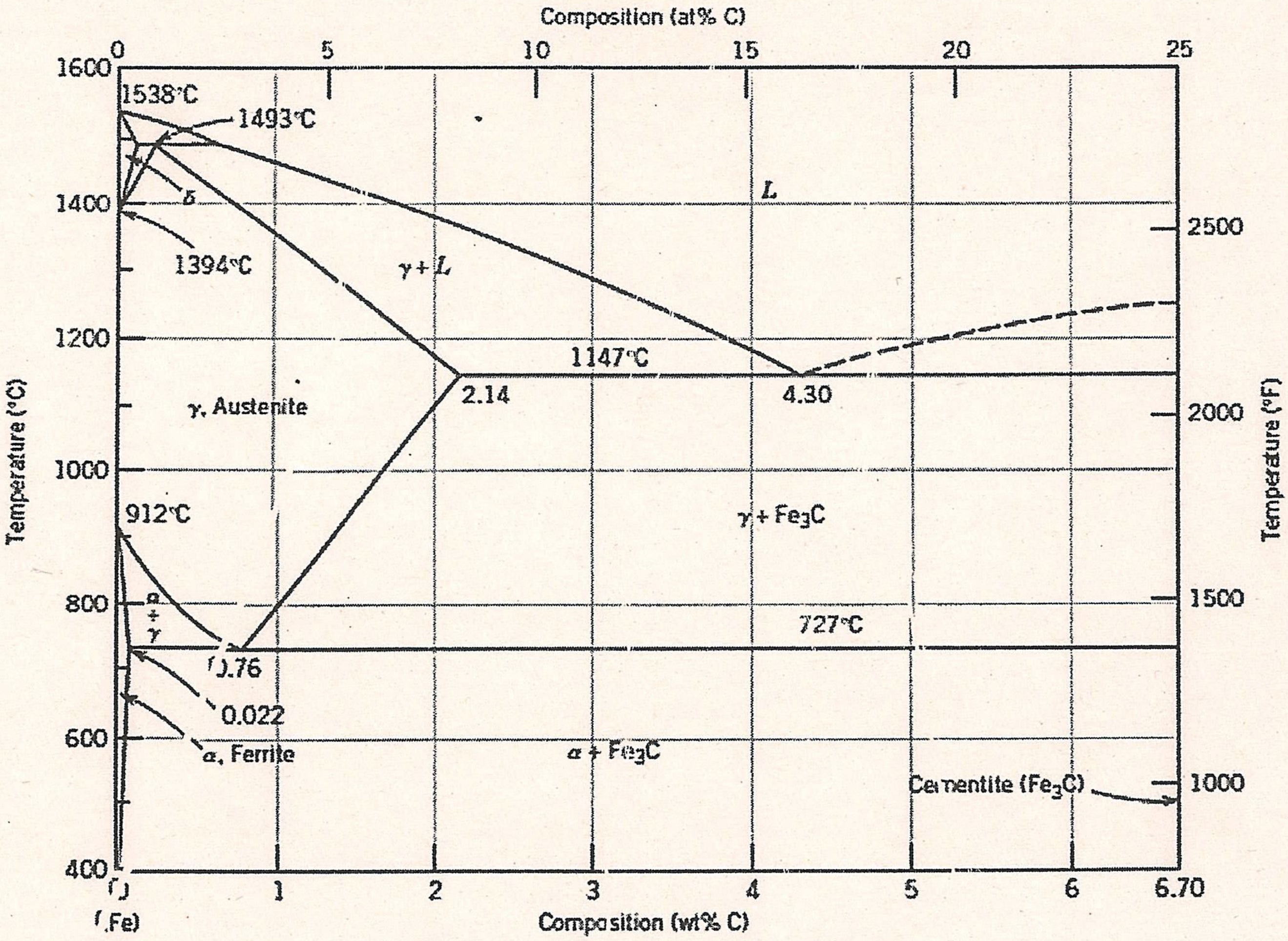

Figure 2 Iron (Fe)- Carbon(C) Phase Diagram.