UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2011/2012

COURSE NAME	:	ENGINEERING TECHNOLOGY MATERIALS
COURSE CODE	:	BDU 10603
PROGRAMME	:	BACHELOR OF AERONAUTICAL ENGINEERING TECHNOLOGY WITH HONOURS
EXAMINATION DATE	:	JUNE 2012
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER FIVE (5) OF THE SIX (6) QUESTIONS.

THIS PAPER CONSISTS OF NINE (9) PRINTED PAGES

Q1 (a) Define the following terms:

(i) Crystal structure
(ii) Unit cell
(iii) Lattice point

(5 marks)

(b) Calculate the radius of a palladium (Pd) atom, given that it has an FCC crystal structure, a density of 12.0 g/cm^3, and an atomic weight of 106.4 g/mol.

(7 marks)

(c) In cubic unit cells, sketch the following direction vectors and crystal planes.

(i) $(10\bar{3})$

(ii) $[10\bar{3}]$

(iii) (212)

(iv) $[122]$

(8 marks)

Q2 (a) A sheet of steel 2.5mm thick has nitrogen atmospheres on both sides and is permitted to achieve a steady-state diffusion condition. The diffusion coefficient for nitrogen in steel is 1.2 x 10^{-10} m^2/s, and the diffusion flux is found to be 1.0 x 10^{-7} kg/m^{2}s. It is known that the concentration of nitrogen in the steel at the surface is 2 kg/m^3. Determine how far into the sheet from the surface side, for the concentration to be 0.5 kg/m^3. Assume a linear concentration profile.

(4 marks)

(b) The diffusion coefficients for carbon in nickel are given at two temperatures; 5.5 x 10^{-14} m^2/s at 600°C and 3.9 x 10^{-13} m^2/s at 700°C. Calculate:

(i) Activation energy, Q_d
(ii) Pre-exponential, D_o for diffusion at 600°C
(iii) Diffusion coefficient at 850°C
(iv) Temperature at which the diffusion coefficient is 6.0 x 10^{-15} m^2/s

(12 marks)

(c) Describe the gas-carburizing process for steel parts and explain why the carburization of steel parts is carried out?

(4 marks)

Q3 (a) Steel alloys are commonly used for both rotating and static engine components such as compressor turbine blades, wheels, stator vanes and structural members. Figure Q3(a) shows the tensile engineering stress-strain curve for the steel alloy. Based on the figure, determine:

(i) Modulus of elasticity
(ii) Stress at the proportional limit
(iii) Yield strength
(iv) Tensile strength
(v) Fracture strain

(6 marks)

(b) A bar of a steel alloy that exhibits the stress–strain behavior shown in Figure Q3(a) is subjected to a tensile load; the specimen is 380 mm long and has square cross section side length of 5.5 mm on each side.

(i) Compute the magnitude of the load necessary to produce an elongation of 1.9 mm
(ii) What will be the deformation after the load has been released?

(7 marks)

(c) Define creep in metals and describe **one (1)** example of creep of metals in aerospace industry.

(3 marks)

(d) Explain **two (2)** methods to improve fatigue strength in a metal.

(4 marks)

Q4 (a) Heat treatment is a controlled heating and cooling of metals intended to adjust microstructure/physical and mechanical properties of a material for a specific purpose. Choose **two (2)** types of heat treatment and explain briefly how the processes are done.

(4 marks)

(b) Consider the binary eutectic copper-silver phase diagram in Figure Q4(b). Make phase analysis of 30 wt% Ag–70 wt% Cu alloy at 800°C.
In the phase analysis, include:

(i) the phases present
(ii) the chemical compositions of the phases
(iii) the amounts of each phase

(8 marks)

(c) Using the isothermal transformation curve shown in Figure Q4(c) for the Fe-C system, determine the final structure of the Fe-C alloy for the following cooling processes. Assume all processes start as homogeneous austenite above the eutectoid temperature.

(i) Rapidly cool to 400°C, hold for 1 second, rapidly cool to room temperature
(ii) Rapidly cool to 600°C, hold for 3 seconds, rapidly cool to room temperature
(iii) Rapidly cool to 600°C, hold for 1 second, rapidly cool to 450°C hold for 1000 seconds, rapidly cool to room temperature

(6 marks)

(d) Identify and name the invariant reaction occurred at point c in Figure Q4(d). Write the equation for this reaction. Determine chemical composition at this point.

(2 marks)

Q5 (a) Compare mechanical characteristics of material phase and fiber phase for polymer-matrix fiber reinforced composite.

(4 marks)

(b) A continuous and aligned fiber-reinforced composite is to be produced consisting of 30 vol% of aramid fibers and 70vol% of a polycarbonate matrix. Given that the modulus of elasticity of these materials are 131GPa and 2.4GPa respectively. This composite has a cross-sectional area of 320mm^2 and is subjected to a longitudinal load of 44,500N. Calculate:

(i) The fiber-matrix load ratio
(ii) Actual load carried by both fiber and matrix phases
(iii) Stress on each of the fiber and matrix phases
(iv) Strain experienced by the composite

(14 marks)

(c) The material standards of aerospace engineering are far more stringent and the quality of composite used is much higher than automotive industry. However, automotive industry is ahead of aerospace in the volume of production. Provide **two (2)** examples of automotive part which use composite material.

(2 marks)

Q6 (a) Define **two (2)** types of extrinsic semiconductor and explain their differences.

(6 marks)

(b) Calculate the minimum allowable electrical conductivity of a wire in $(\Omega.m)^{-1}$ given that the wire diameter is 0.5cm and must carry 20A current. The maximum power dissipation along the wire is 4W/m.

(6 marks)

(c) There are **two (2)** types of magnetic materials. Name each of them together with their application.

(4 marks)

(d) Explain briefly **two (2)** types of application of optical phenomena.

(4 marks)

FINAL EXAMINATION

SEMESTER / SESSION: SEM 2 / 2011/2012
COURSE: ENGINEERING TECHNOLOGY MATERIALS

PROGRAMME: BDC / BDM
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EQUATIONS

$$J = -D\frac{dC}{dx}$$

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

$$D = D_o \exp\left(-\frac{Q_d}{RT}\right)$$

R = 8.314 J/mol.K

$N_A = 6.023 \times 10^{23}$ atoms/mol

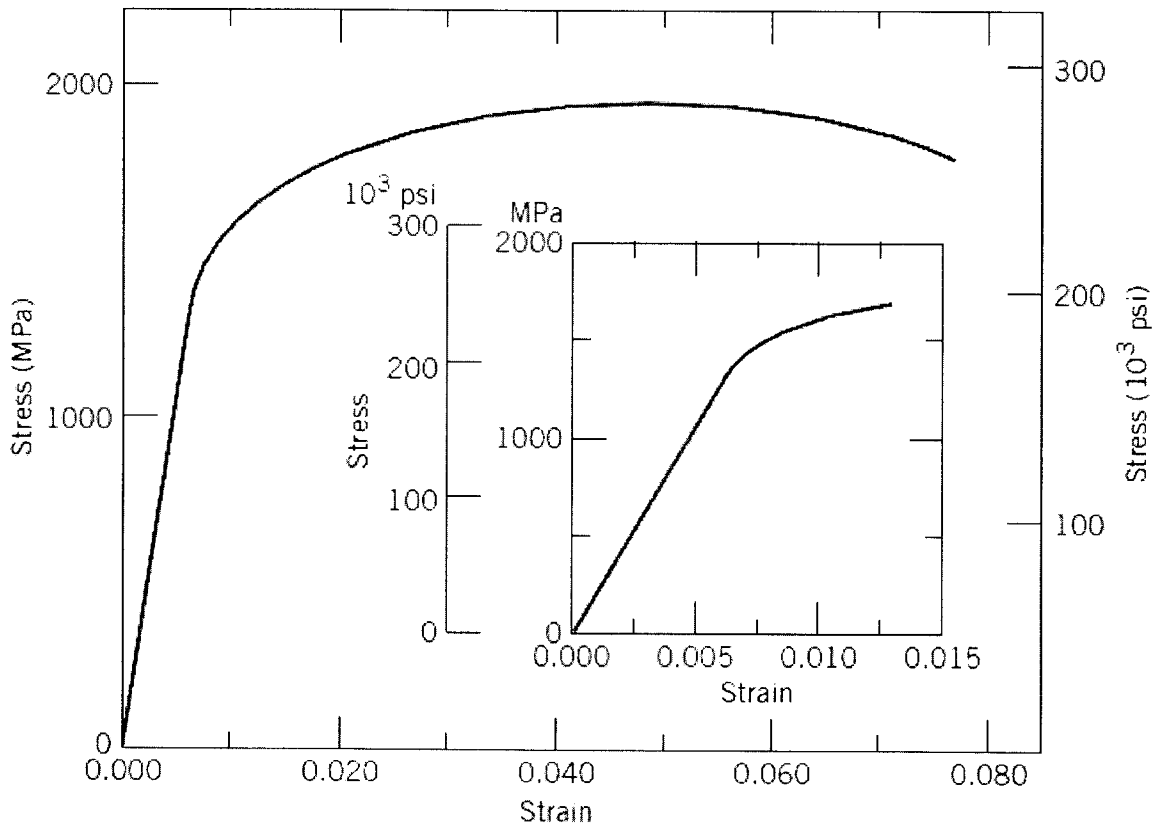

FIGURE Q3(a)

FINAL EXAMINATION

SEMESTER / SESSION: SEM 2 / 2011/2012 PROGRAMME: BDC / BDM
COURSE: ENGINEERING TECHNOLOGY MATERIALS COURSE CODE: BDU 10603

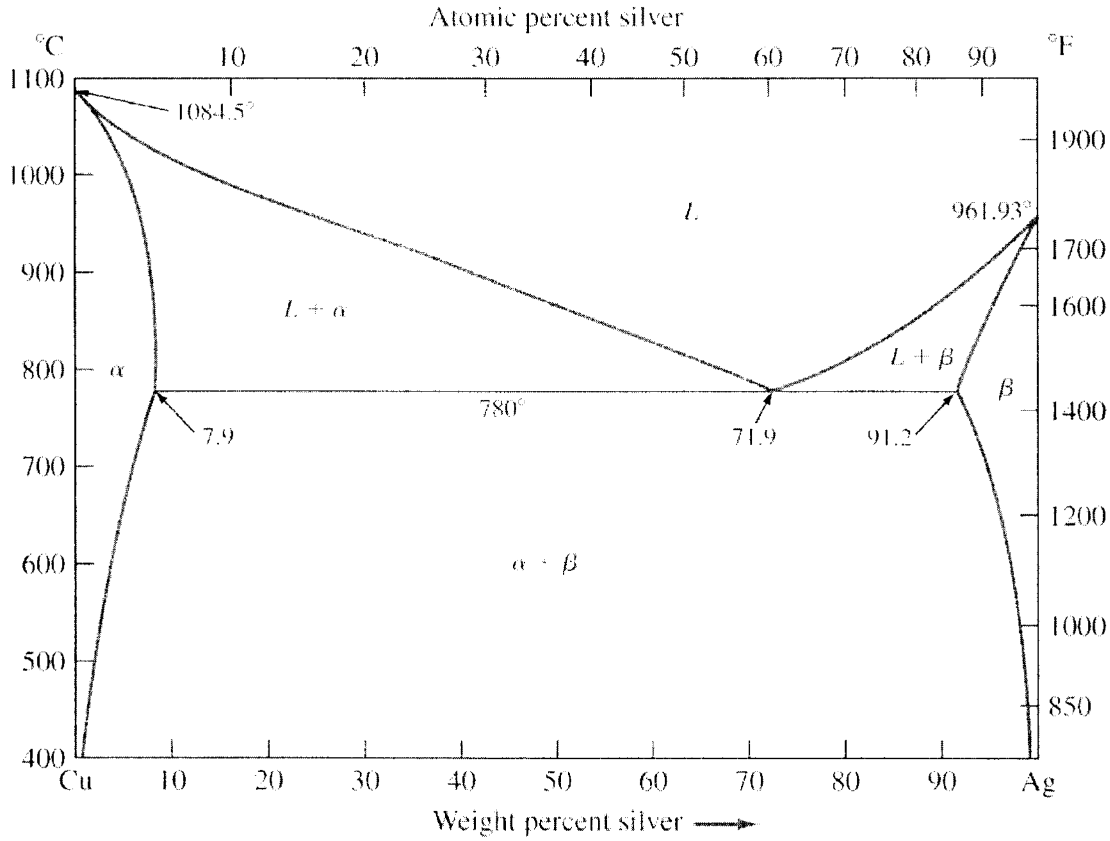

FIGURE Q4(b)

FINAL EXAMINATION	
SEMESTER / SESSION: SEM 2 / 2011/2012 COURSE: ENGINEERING TECHNOLOGY MATERIALS	PROGRAMME: BDC / BDM COURSE CODE: BDU 10603

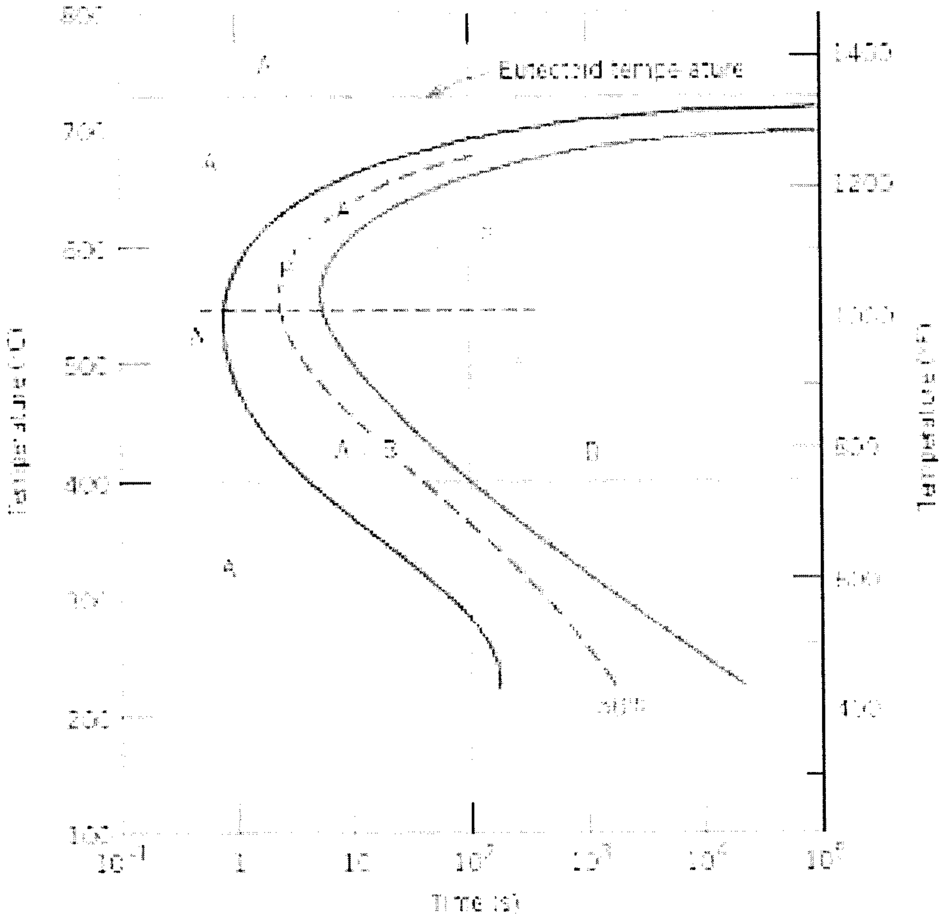

FIGURE Q4(c)

FINAL EXAMINATION

SEMESTER / SESSION: SEM 2 / 2011/2012 PROGRAMME: BDC / BDM
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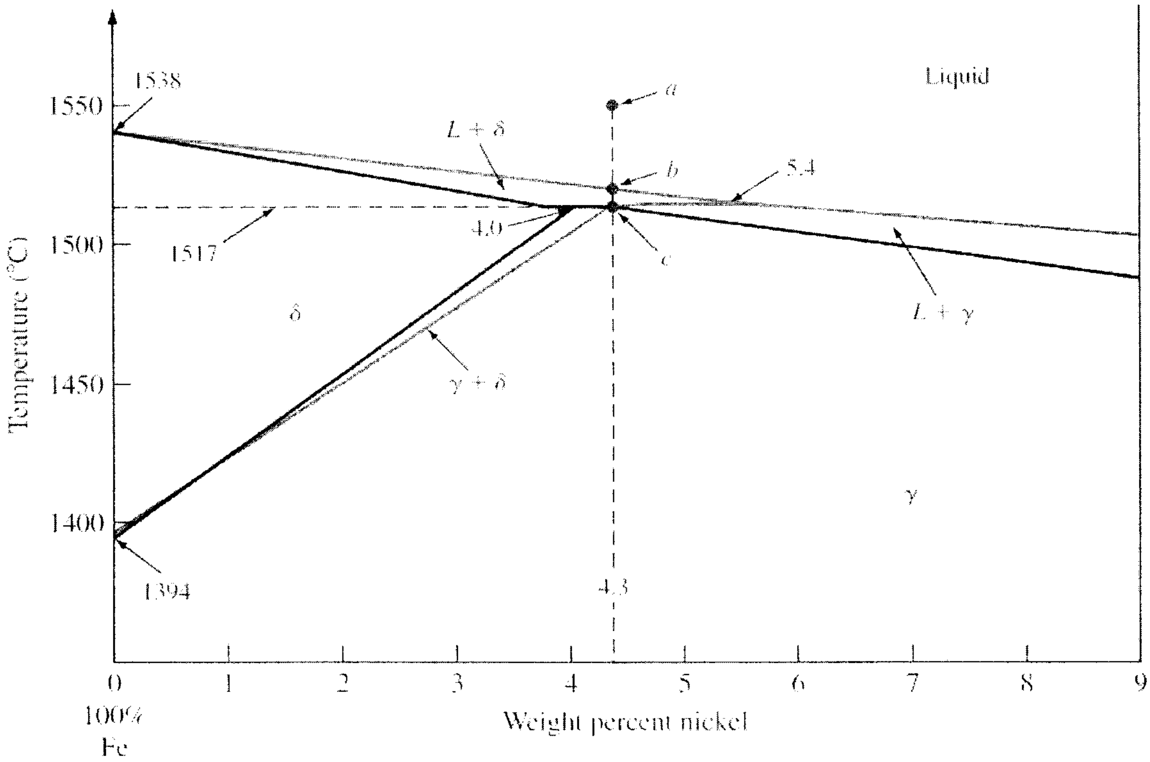

FIGURE Q4(d)