Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION

SEMESTER I

SESSION 2013/2014

COURSE NAME	:	MATERIAL SCIENCE
COURSE CODE	:	BNR 10102
PROGRAMME	:	1 BND/1 BNF
EXAMINATION DATE	:	DECEMBER 2013/JANUARY 2014
DURATION	:	2 HOURS
INSTRUCTION	:	ANSWER **FIVE (5)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

Q1 (a) Coordinate A (1 0 0), B (0 1 0), C (1 1 1), D (1/2 0 0), E (0 1/3), F(½ 0 1) and G (0 1/3 1). Identify miller index for plane ABC and DEFG.

(5 marks)

(b) The metal rhodium gas an FCC (Face Centered Cubic) crystal structure. If the angle of diffraction for the (311) set of planes occurs at 36.120 (and order of reflection is taken) when monochromatic x-radiation having a wavelength of 0.0711 nm is used, compute:

(i) The interplanar spacing for this set of planes, and

(5 marks)

(ii) The atomic radius for the rhodium atom.

(5 marks)

(c) A specimen of copper having a rectangular cross section 15.2 mm x 19.1 mm and its modulus of elasticity 110 GPa is pulled in tension with 44,500 N force, producing only elastic deformation. Calculate the resulting strain.

(5 marks)

Q2 (a) A continuous and aligned fiber – reinforced composite is to be produced consisting of 45 % aramid fibers and 55 %vol of polycarbonate matrix. Mechanical properties of these materials are shown in Table **Q2**.

The stress on polycarbonate matrix when the aramid fiber fails is 35 MPa.

Calculate:

(i) The longitudinal tensile strength and
(ii) The longitudinal modulus of elasticity.

(10 marks)

(b) A three –point bending test is performed on a spinel ($MgAl_2O_4$) specimen having a rectangular cross section of height d 3.8 mm and width b 9 mm; the distance between support points is 25 mm. Compute the flexural strength if the load at fracture is 350 N.

(5 marks)

(c) The point of maximum deflection $\Delta_y = \dfrac{FL^3}{48EI}$ of question Q2 (b), where E is the modulus elasticity (260 GPa) and I is the cross sectional moment of inertia. Compute Δ_y at a load of 310 N.

(5 marks)

Q3 The molecular data for polytetrafluoroethylene (PTFE) (Figure **Q3**) are tabulated in Table **Q3**.

Atomic weight of C and F are respectively 12.01 and 19 g/mol.

Compute:

(a) The number of molecular weight

(7 marks)

(b) The weight –average molecular weight

(7 marks)

(c) Degree of polymerization

(6 marks)

Q4 (a) A wire whose diameter is 30 cm must carry a 20 A current. The maximum power dissipation along the wire is 5 W/m (Watt per meter).

(i) Calculate the minimum allowable conductivity of the wire $(\text{ohm–meters})^{-1}$

(5 marks)

(ii) Resistivity

(5 marks)

(b) A simple parallel –plate capacitor, with mica of d= 0.02 cm and A= 1 cm^2. as the dielectric, is subjected to an alternating electric field of magnitude 120 V and frequency 60 Hz. Calculate the power loss for this capacitor. tan $\delta = 0.0016, \kappa = 7$ $\varepsilon_0 = 8.85x10^{-12}\,F/m$. Use Formula **Q4 (b)** if necessary.

(10 marks)

Q5 Describe the transformation of the micro structure (in terms of just microconstituents present) of a small specimen that has been subjected to the following time-temperature treatments using the isothermal transformation diagram (Figure **Q5**) for a 1.13 wt % C steel alloy. In each case assume that the specimen begins at 920^0C and that is has been held at this temperature long enough to have achieved a complete and homogeneous austenitic structure.

(a) Rapidly cool to 250^0C, hold for 10^3 s, then quench to room temperature.
(5 marks)

(b) Rapidly cool to 775^0C, hold for 500 s, then quench to room temperature.
(5 marks)

(c) Rapidly cool to 650^0C, hold at this temperature for 3 s, rapidly cool to 400^0C, hold for 25 s, then quench to room temperature.
(5 marks)

(d) Rapidly cool to 600^0C, hold at this temperature for 7 s, rapidly cool to 450^0C, hold at this temperature for 4 s, the quench to room temperature.
(5 marks)

Q6 (a) Camera and microscope lenses are several glasses cemented together. Consider reflection from these lenses. Light travels through silica glass into a high – lead silica glass at normal incidence. How much light is reflected at the internal surfaces? Refractive indices silica glass is 1.51 and high – lead silica glass is 2.5.
(5 marks)

(b) Calculate the magnetic field strength to create an induction equal to that of the earth in an aluminum sample. The magnetic susceptibility of Al is 16.5 x 10^{-6}., magnetic induction of earth B= 6 x 10^{-5} T. The permeability of a vacuum $\mu_0 = 4\pi\, x 10^7 T - m/$A
(5 marks)

(c) Estimate the maximum saturation magnetization and saturation induction of Fe.Atomic mass 55.85 amu. Density of Fe at 7.87 g/cm^3. Avogadro number = 6.02 x 10^{23} atoms/mol. $\mu_B = 9.27 x 10^{-24}\ A - m^2$. The permeability of a vacuum $\mu_0 = 4\pi\, x 10^7 T - m/$A, N_s for Fe=4
(10 marks)

- END OF QUESTION -

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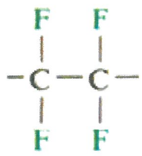

FIGURE Q3

Isothermal transformation diagram for a 1.13 wt% C iron–carbon alloy: A, austenite; B, bainite; C, proeutectoid cementite; M, martensite; P, pearlite. [Adapted from H. Boyer (Editor), *Atlas of Isothermal Transformation and Cooling Transformation Diagrams*, American Society for Metals, 1977, p. 33.]

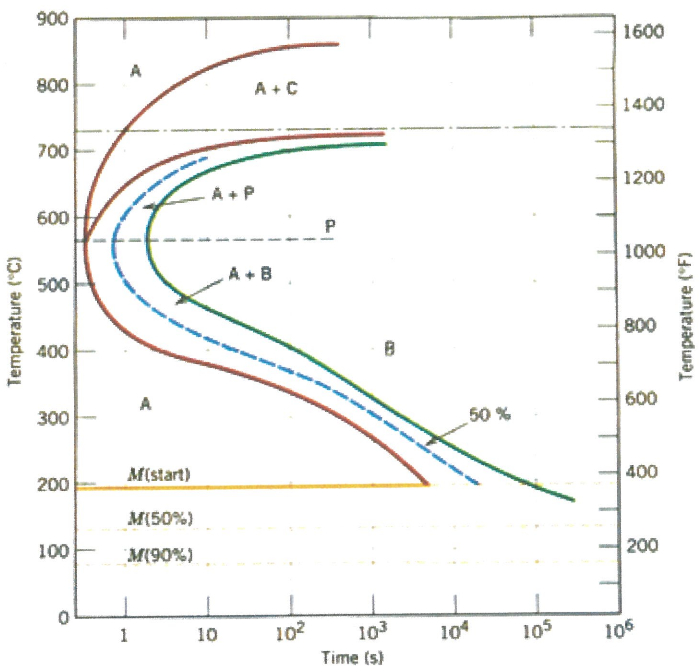

FIGURE Q5

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Table Q2 Modulus of Elasticity and Tensile Strength of Aramid Fiber and Polycarbonate

	Modulus of Elasticity (GPa)	Tensile Strength (MPa)
Aramid Fiber	131	3600
Polycarbonate	2.4	65

Table Q3 Polytetrafluoroethylene data

Molecular Weight Range (g/mol)	x_i	w_i
8,000-20,000	0.05	0.02
20,000-32,000	0.15	0.08
32,000-44,000	0.21	0.17
44,000-56,000	0.28	0.29
56,000-68,000	0.18	0.23
68,000-80,000	0.10	0.16
80,000-92,000	0.03	0.5

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FORMULAS MAY BE REQUIRED

No	
1	$\kappa = \frac{\varepsilon}{\varepsilon_0}; \xi = \frac{V}{d}$ $W = \pi\varepsilon f \xi^2 \tan\delta$
2	$B = \mu_o(1+\chi)H; B = magnetic\ induction$
3	$B_s = \mu_0 M_s; H = field\ strenght; M = magnetic\ vector$
4	$M_s = N_v N_s \mu_B; N_v = the\ number\ of\ atom\ per\ unit\ volume$
5	$N_s = the\ number\ of\ unpaired\ spins\ per\ atoms;$ $\mu_B = magnetic\ moment\ associated\ with\ the \cdots spin\ of\ an\ electron.$