UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2012/2013

COURSE NAME	:	MATERIAL SCIENCE
COURSE CODE	:	BNJ 10602
PROGRAMME	:	1 BNL/1BNK
EXAMINATION DATE	:	JUNE 2013
DURATION	:	2 HOURS
INSTRUCTION	:	1. ANSWER **FIVE** (5) QUESTIONS ONLY FROM **SIX** (6) QUESTIONS PROVIDED 2. ATTACH **FIGURE Q3, FIGURE Q4 (a) AND FIGURE Q4 (b)** WITH YOUR ANSWER BOOKLET

THIS QUESTIONS PAPER CONSISTS OF **TEN** (10) PAGES

Q1 (a) By applying W. Pollack's formula, determine the distribution of electron in shell and subshell of Ti with atomic number 22. .

(10 marks)

(b) An x-ray diffractometer recorder chart for an element that has either the BCC or the FCC crystal structure showed diffraction peaks at the following 2θ angles: 36.191^0, 51.794^0, 64.982^0, and 76.663^0 (The wavelength λ of the incoming radiation was 0.15405 nm). (Using **Table Q1 (a), Q1(b) and Q1(c)** , if necessary). Determine:

(i) The crystal structure of the element.
(ii) The lattice constant of the element and identify the element.

(10 marks)

Q2 Data molecular weights for a polyethylene material are tabulated in Table 1:

Table 1: Data molecular weight.

Molecular weight Range (g/mol)	x_i	w_i
15,000-30,000	0.04	0.01
30,000-45,000	0.07	0.04
45,000-60,000	0.16	0.11
60,000-75,000	0.26	0.24
75,000-90,000	0.24	0.27
90,000-105,000	0.12	0.16
105,000-120,000	0.08	0.12
120,000-135,000	0.03	0.15

Mer Structure of polyethylene is in **Figure Q2**, The atomic weight of C and H are 12.01 g/mol and 1.01 g/mol respectively.

Calculate:

(a) The number –average molecular weight.

(8 marks)

(b) The weight average molecular weight.

(8 marks)

(c) The degree of polymerization.

(4 marks)

Q3 An alloy of 80 wt% Sn-20 wt% Pb at the temperature of 200^0C (see **Figure Q3**). The density at 200^0C takes the densities of Pb and Sn to be 11.23 and 7.24 g/cm^3 respectively:

(a) Describe what phase (s) is (are) present?

(2 marks)

(b) Determine the compositions of the phases?

(4 marks)

(c) Calculate the relative amount of each phase present in terms of mass fraction.

(6 marks)

(d) Calculate the relative amount of each phase present in terms of volume fraction.

(8 marks)

Q4 (a) Plot the radial hardness profile (center, ½ R, ¾ R and surface) for a 50 mm diameter cylindrical specimen of 8640 steel that has been quenched in moderately agitated water (Using data of **Figure Q4 (a) and Q4 (b)**). Please provide/submit your answer with the **Figure Q4 (a) and Q4 (b)**).

(12 marks)

(b) A 0.505 in. in diameter aluminium alloy test bar is subjected to a load of 25,000 lb. If the diameter of the bar is 0.490 in. at this load, determine:

(i) The engineering stress and strain.

(ii) The true stress and strain at this load.

(8 marks)

Q5 (a) Determine the elastic modulus of unidirectional epoxy-glass fiber composite in the longitudinal and transversal direction given the following data: E_{matrix} = 3.0 GPa , E_{fiber} = 70 GPa and V_{fiber} = 0.6

(6 marks)

(b) Calculate the reflectivity of ordinary light from a smooth, flat upper surface of a borosilicate (n=1.47) and polyethylene (n=1.53).

(5 marks)

(c) Using Table Q5, select the material for a conducting wire of diameter 40 mm that carries a current of 30 A and the maximum power dissipation is 5 W/m .

(5 marks)

(d) The modulus of elasticity for titanium carbide (TiC) having 5 vol % porosity is 310 GPa. Calculate

(i) The modulus elasticity for non porous material.
(ii) The modulus of elasticity for 15% porosity.

(4 marks)

Q6 (a) A silicon wafer is doped with 10^{21} phosporus atoms/m^3. Calculate :
(i) The majority – carrier concentration
(ii) The minority –carrier concentration
(iii) The electrical resistivity of the doped silicon at room temperature (300 K). Assume complete inozation of the dopant atoms; $n_i(Si) = 1.5 \times 10^{16}$ m^{-3}, μ_n = 0.135 m^2/V.s), and μ_p = 0.048 m^2/(V.s)

(10 marks)

(b) Calculate the number of silicon atoms per cubic meter. The density of silicon is 2.33 Mg/m^3 (2.33 g/cm^3), and its atomic mass is 28.08 g/mol. Avogadro's number =6.023 x 10^{23} atoms/mol.

(4 marks)

(c) A phosphorus-doped silicon wafer has an electrical resistivity of 8.33 x 10-5 Ωm at 27^{0}C. Assume mobilities of charge carriers to be the constants 0.135 m^2/(V.s) for electrons and 0.048 m^2/(V.s) for holes.
(i) Calculate its majority-carrier concentration (carriers per cubic meter) if complete ionization is assumed?
(ii) Determine the ratio of phosphorus to silicon atoms in this material?

(6 marks)

- END OF QUESTION -

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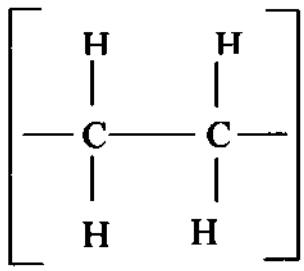

FIGURE Q2

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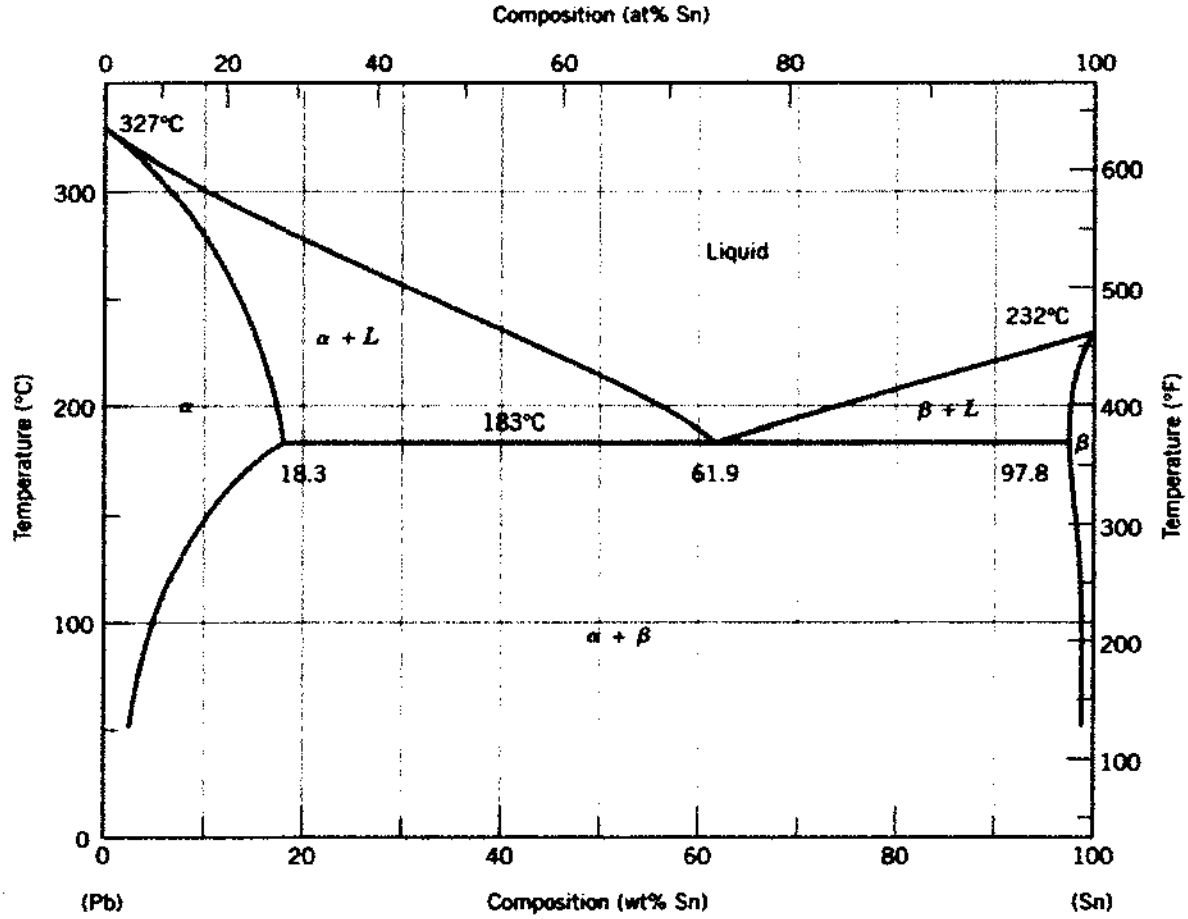

FIGURE Q3

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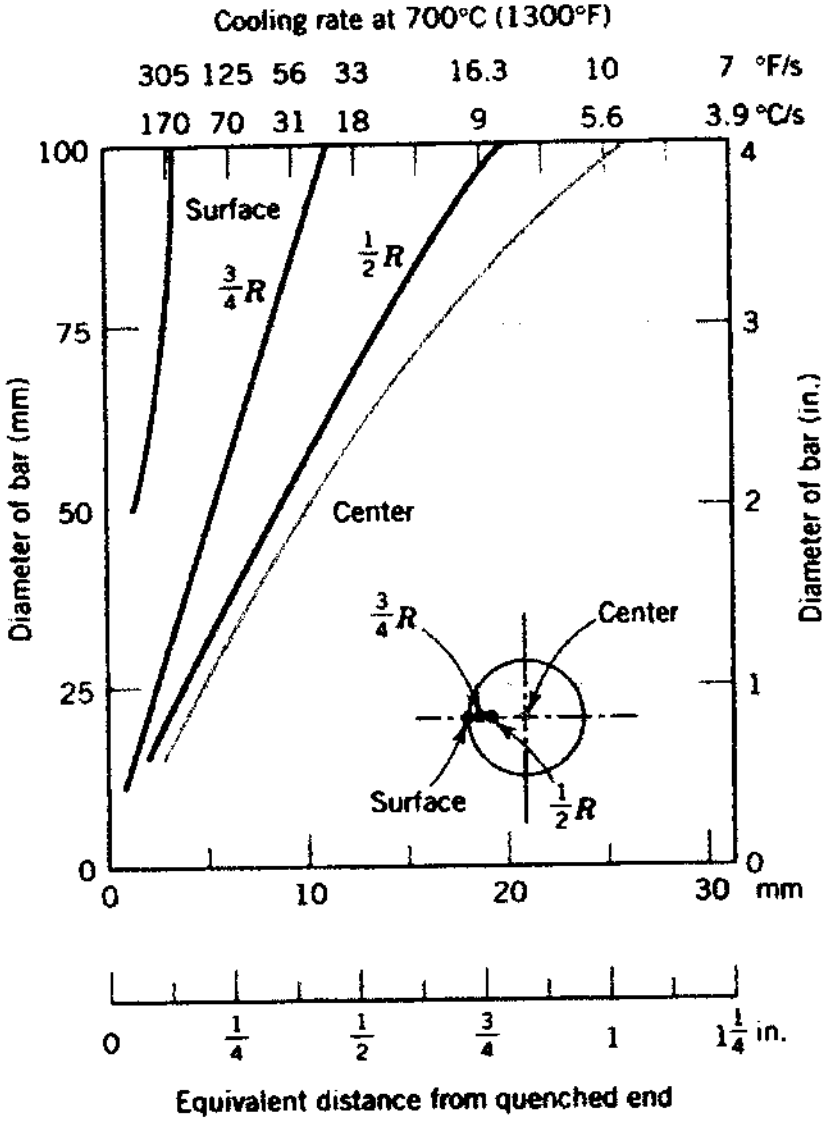

FIGURE Q4 (a)

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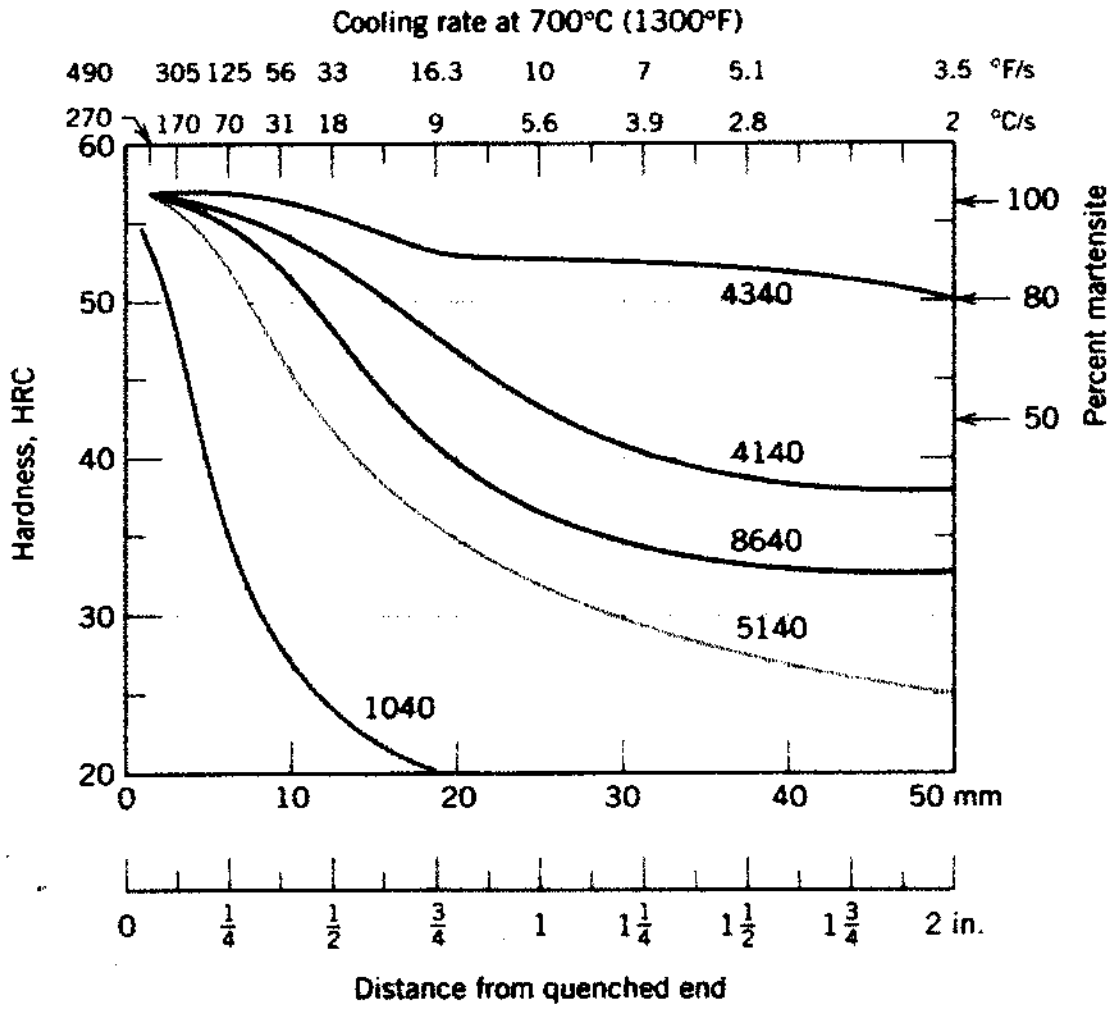

FIGURE Q4 (b)

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Table Q1 (a)
Miller indices of diffracting planes for BCC and FCC lattice

Cubic planes {hkl}	Cubic diffracting planes {hkl}	
	FCC	BCC
{100}		
{110}	...	110
{111}	111	
{200}	200	200
{210}		
{211}	...	211

Table Q1 (b)
Selected metals that have BCC crystal structure at room temperature (200^0C) and their lattice constants

No.	Material	Lattice Constant a (nm)
1	Chromium	0.289
2	Iron	0.287
3	Molybdenum	0.315
4	Potassium	0.533
5	Sodium	0.429
6	Tungsten	0.316
7	Tantalum	0.338
8	Vanadium	0.304

Table Q1 (c)
Selected metals that have FCC crystal structure at room temperature (200^0C) and their lattice constants

No.	Material	Lattice Constant a (nm)
1	Aluminium	0.405
2	Copper	0.3615
3	Gold	0.408
4	Lead	0.495
5	Nickel	0.352
6	Platinum	0.393
7	Silver	0.409

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Table Q5
Electrical conductivities of some metals and non metals at room temperature

Metal and alloy	$\sigma(\Omega.m)^{-1}$	Non Metal	$\sigma\ (\Omega.m)^{-1}$
Silver	6.3×10^7	Graphite	10^5
Copper, commercial purity	5.8×10^7	Germanium	2.2
Gold	4.2×10^7	Silicon	4.3×10^{-4}
Aluminium, commercial purity	3.4×10^7	Polyethylene	10^{-4}
		Polystyrene	10^{-4}
		Diamond	10^{-4}