KABARAK UNIVERSITY

UNIVERSITY EXAMINATIONS

2010/2011 ACADEMIC YEAR

FOR THE DEGREE OF BACHELOR OF SCIENCE IN TELECOMMUNICATIONS

COURSE CODE: **TLCM 313**

COURSE TITLE: **MATERIALS & TECHNOLOGIES**

STREAM: **Y3S1**

DAY: **FRIDAY**

TIME: **9.00 – 12.00 P.M.**

DATE: **18/03/2011**

INSTRUCTIONS:

- *Answer question 1 and any other THREE*
- *Use a graph paper for question 2*

PLEASE TURN OVER

Question 1 (20 marks

a) Define material science (½ mark)

b) Distinguish between atomic mass and atomic weight of an element (1 marks)

c) State the purpose of conduction electrons in atoms (½ mark)

d) Explain the mechanisms responsible for thermal conductivity (1 mark)

e) i) Define isotropy with regard materials (1 mark)

ii) Explain why the properties of polycrystalline materials are most often isotropic. (1 mark)

f) Give the electron configurations for the following ions: Sn^{4+}, Se^{2-} *(you may refer to periodic table in Appendix 1)*. (½,½ mark)

g) With reference to materials, explain the term "stone age". (1 mark)

h) Explain 4 properties of materials commonly investigated when studying materials (2 marks)

j) Explain 4 types of defects in solids (2 marks)

k) Illustrate graphically concentration profile resulting from inter-diffusion in a two specie system (Cu/Ni). (1 mark)

l) i) Explain any two types of point defect (2 marks)

ii Explain any two cases where defects are introduced to improve material properties. (2 marks)

m) Show that Ohm's law can be rewritten as

$$\mathbf{J} = \sigma \mathbf{E}$$

where, J is the current density, σ electrical conductivity and E the electric field. (2 marks)

n) Below is the data for silicon at 300 K. Calculate carrier concentration of Si at the said temperature. (Take: electron charge = 1.6×10^{-19} C). (2 marks)

Material	*Band Gap (eV)*	*Electrical Conductivity* $[(\Omega \cdot m)^{-1}]$	*Electron Mobility* $(m^2/V \cdot s)$	*Hole Mobility* $(m^2/V \cdot s)$
		Elemental		
Si	1.11	4×10^{-4}	0.14	0.05

Question 2 (10 marks)

a) Define
   i) Engineering stress (½ mark)
   ii) Engineering strain (½ mark)

b) Use diagrams to illustrate 4 different loadings and the resulting strain. (2 marks)

c) A specimen of magnesium having a rectangular cross-section of dimensions 3.2 mm x 19.1 mm is deformed in tension. Using the load-elongation data tabulated as follows, answer parts a-f

Load (N)	Length (mm)
0	63.5
1380	63.53
2780	63.56
5630	63.62
7430	63.7
8140	63.75
9870	64.14
12850	65.41
14100	66.68
14340	67.95
13830	69.22
12500	70.49

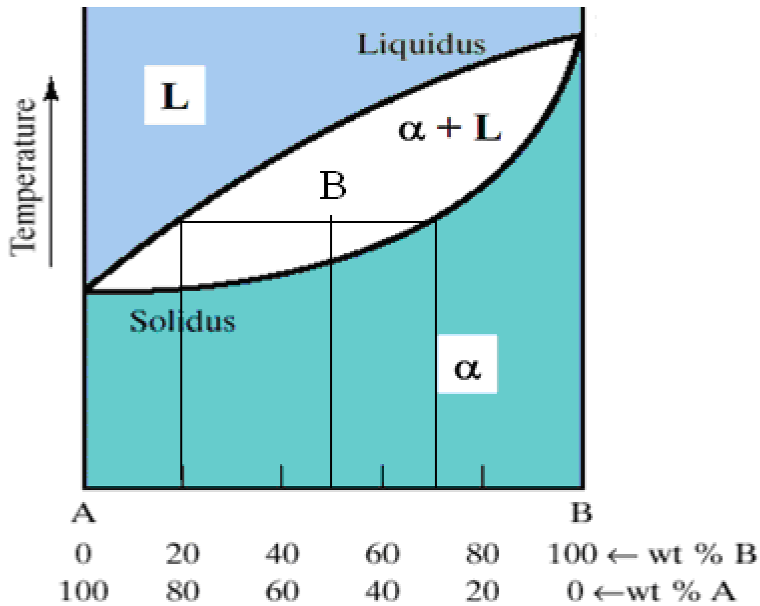
   i) Plot the data as engineering stress versus engineering strain (3 marks)
   ii) Compute the modulus of elasticity (1 mark)
   iii) Determine the yield strength at a strain offset of 0.002 (2 mark)
   iv) Determine the tensile strength of this alloy (1 mark)

Question 3 (10 marks)

a) i) Define a phase diagram (½ mark)

   ii) State the information that can be determined from a temperature – component phase diagram. (1 ½ marks)

   iii) For the diagram below, explain the three phase regions shown (α, L and L+ α). (1 ½ marks)



iv) Calculate the mass fraction of L and α at point marked B (shown by the intersection of the lines). (2 ½ marks)

b) i) Explain why the valence electrons of atoms form wide electron energy bands when they form a solid (1 marks)

ii) Explain the various contributions electrical resistivity in metals. (3 marks)

<u>Question 4 (10 marks)</u>

a) i) Illustrate the three steps of polymerization process (1 ½ marks)

ii) Draw a stress-strain graph describing the behaviour of brittle plastic, plastics polymer and elastomer. (1 ½ marks)

iii) Explain factors that influence mechanical properties of polymers (1 ½ marks)

b) i) Explain diffusion mechanisms in materials (2 marks)

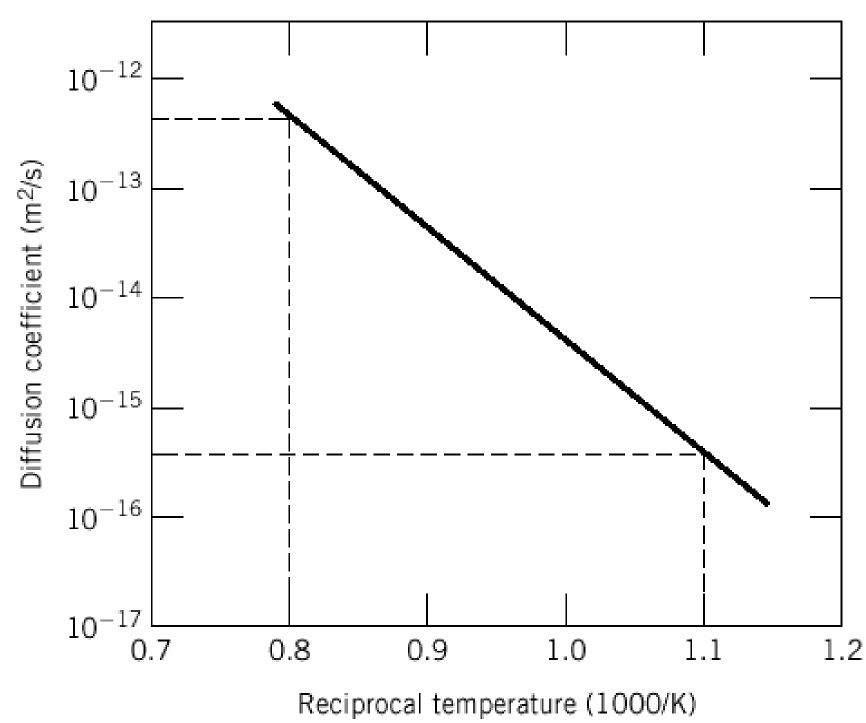
ii) Temperature dependence of the diffusion coefficient follows the Arrhenius dependence

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

where, D_0 – temperature-independent preexponential (m2/s); Q_d – the activation energy for diffusion (J/mol or eV/atom); R – the gas constant (8.31 J/mol-K or 8.62×10-5 eV/atom-K); T – absolute temperature (K).

I. State the significance of Q_d (½ mark)

II. Use the plotted data below to determine Q_d (3 marks)



Question 5 (10 marks)

a) With reference to crystal structures, define

i) Coordination number (½ mark)
ii) Unit cell (½ mark)
iii) Atomic packing factor (APF) (½ mark)

b) Compare FCC and BCC crystal structures (3 marks)

c) Show that the APF for BCC crystal structure is 0.68 (2 ½ marks)

d) i) Define **atomic mass unit** (amu). (½ mark)

ii) Some hypothetical metal has a simple cubic crystal structure. If its atomic weight is 74.5 grams/mol and its atomic radius is 0.145 nanometres, calculate its density. (*take* $1\ amu = 1.66 \times 10^{-27} kg$) (2 ½ marks)

Appendix 1

IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII	VIII	VIII	IB	IIB	IIIA	IVA	VA	VIA	VIIA	0
1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	Rare earth series	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	Acti-nide series	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds								