FINAL
Examination Paper

(COVER PAGE)

Session : **April 2017**

Programme : Diploma In Electrical And Electronic Engineering (DEEI)

Course : **EGM1182 : Structures and Properties of Materials**

Date of Examination : August 3, 2017 (Thursday)

Time : 8:00 am – 10:00 am Reading Time: Nil

Duration : 2 Hours

Special Instructions :

This paper consists of **SIX (6)** questions. Answer any **FOUR (4)** questions in the answer booklet provided. All questions carry equal marks.

Materials permitted : Non-programmable calculator

Materials provided : Graph paper, Appendix A and B

Examiner (s) : **Ms Jaisatia Varthani a/p Appalanaidu,** Ms Iylia Elena Abdul Jamil

Moderator : Dr How Ho Cheng

*This paper consists of **10** printed pages, including the cover page.*

DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING PROGRAMME (DEEI)
EGM 1182: STRUCTURES AND PROPERTIES OF MATERIALS
FINAL EXAMINATION : APRIL 2017 SESSION

Instructions: This paper consists of **SIX (6)** questions. Answer any **FOUR (4)** questions in the answer booklet provided. All questions carry equal marks.

Question 1

(a) Briefly cite the main differences between ionic, covalent, and metallic bonding.
(6 marks)

(b) A monel alloy consists 70 wt % Ni and 30 wt % Cu. What are the atom percentages of Ni and Cu in this alloy.
(10 marks)

(c) Write down the electron configuration for Se, Se^{6+} and Se^{2-} by using the *spdf* notation.
(4 marks)

(d) The melting temperature of Li (180°C) is significantly lower than the melting temperature of its neighbor Be (1287°C). Please explain this in terms of the differences in electronic structure?
(5 marks)

Question 2

(a) Consider a BCC crystal structure where the central atom is surrounded by eight nearest neighbours

(i) What is the total number of complete atom in the unit cell of BCC?

(1 mark)

(ii) Derive the relation between the length of the side *a* of the BCC unit cell and the radius of its atom.

(2 marks)

(iii) Calculate its atomic packing factor (APF).

(4 marks)

(iv) Iron at 20°C is BCC with atoms of atomic radius 0.124 nm. Calculate the lattice constant *a* for the cube edges of the iron unit cell.

(5 marks)

(b) Copper has an atomic radius of 0.128 nm, an FCC crystal structure, and an atomic weight of 63.5 g/mol. Assuming the atoms to be hard spheres that touch each other along the face diagonals of the FCC unit cell, calculate the density of copper in g/cm^3.

(4 marks)

(c) Draw the following direction vectors in cubic unit cells.

(i) $[100]$

(ii) $[\bar{1}10]$

(iii) $[\bar{3}2\bar{1}]$

(9 marks)

Question 3

(a) Describe and illustrate the following imperfections that can exist in crystal lattices:

(i) Frenkel imperfection and

(ii) Schottky imperfection.

(5 marks)

(b) What factors affect the diffusion rate in solid metal crystals?

(5 marks)

(c) Describe and illustrate the solidification process of a pure metal.

(5 marks)

(d) When a cold-worked metal is heated into the temperature range where recrystallization take place, how are the following factors affected:

(i) internal residual stresses
(ii) strength
(iii) ductility
(iv) hardness

(4 marks)

(e) An undeformed specimen of some alloy has an average grain diameter of 0.045 mm. You are asked to reduce its average grain diameter to 0.010 mm. Is this possible? If so, explain the procedures you would use and name the processes involved. If it is not possible, explain why?

(6 marks)

Question 4

(a) What is the difference between the states of phase equilibrium and metastability?

(4 marks)

(b) The lead-tin phase diagram are given in Figure Q4.1 below. For a 40 wt% Sn–60 wt% Pb alloy at 150C°C (300F). Determine

(i) What phase(s) is (are) present?

(1 mark)

(ii) What is (are) the composition(s) of the phase(s)?

(2 marks)

(iii) Calculate the relative amount of each phase present in terms of (a) mass fraction and (b) volume fraction. At 150 °C take the densities of Pb and Sn to be 11.23 and 7.24 g/cm^3 respectively.

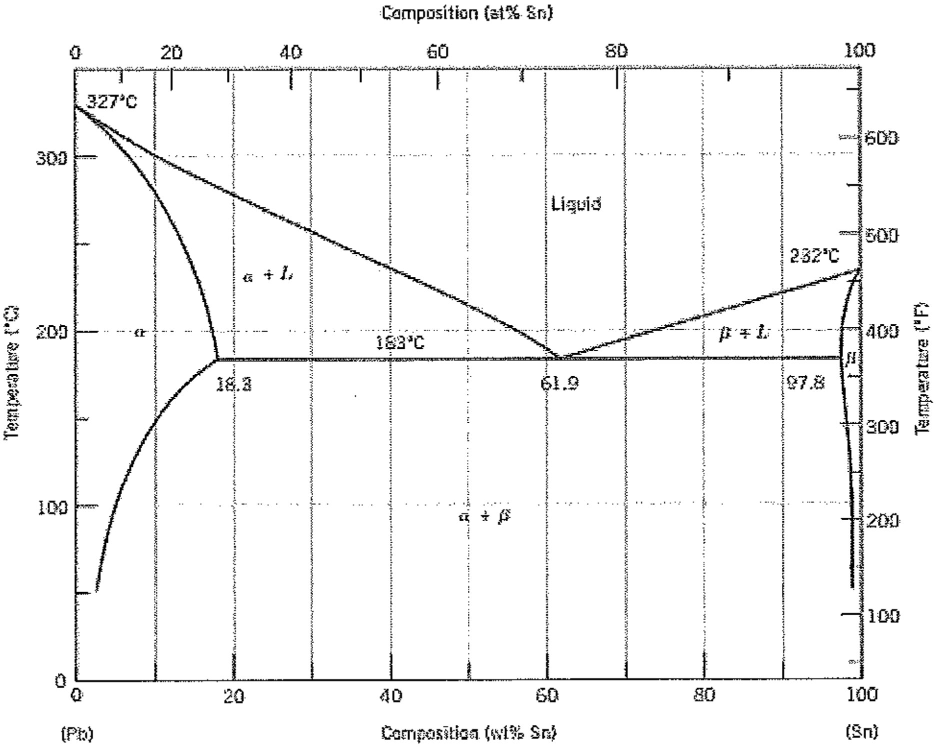


Figure Q 4.1

(11 marks)

(c) The iron-iron carbide diagram are given in the Figure Q4.2 below. For a 99.65 wt% Fe–0.35 wt% C alloy at a temperature just below the eutectoid, determine the following:

(i) The fractions of total ferrite and cementite phases.

(3 marks)

(ii) The fractions of the pearlite and proeutectoid ferrite.

(3 marks)

(iii) The fraction of eutectoid ferrite.

(1 mark)

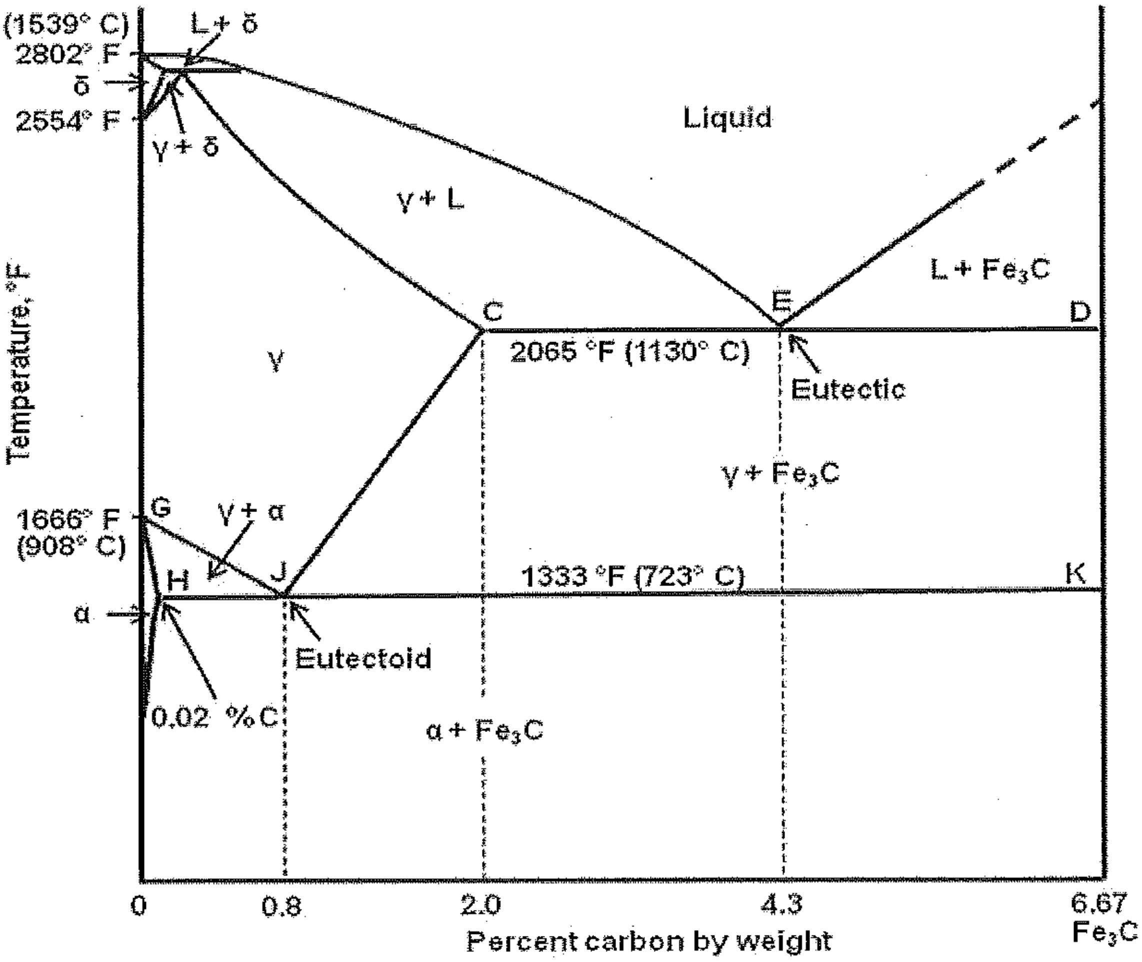


Figure Q 4.2

Question 5

(a) Define and differentiate between polymers and elastomers.

(6 marks)

(b) Define a composite material with respect to a materials system, and name three main types of synthetic fibers used to produce fiber-reinforced-plastic composite materials.

(6 marks)

(c) A stress of 9.0 MPa is applied to an elastomeric materials at a constant stress at 20°C. After 25 days, the stress decreases to 6.0 MPa.

(i) What is the relaxation time τ for this material?

(ii) What will be the stress after 50 days?

(10 marks)

(d) A partially stabilized zirconia advanced ceramic has a strength of 352MPa and a fracture toughness of 7.5 MPa.$\sqrt{\text{m}}$. What is the largest-sized internal flaw (expressed in micrometers) that this material can support? $(Use\ Y = \sqrt{\pi})$

(3 marks)

Question 6

(a) In terms of electron energy band structure, discuss reasons for the difference in electrical conductivity between metals, semiconductors, and insulators.

(5 marks)

(b) At room temperature the electrical conductivity and the electron mobility for copper are 6.0 x 107 $(\Omega.m)^{-1}$ and 0.0030 $m^2/V.s$, respectively.

(i) Compute the number of free electrons per cubic meter for copper at room temperature.

(ii) What is the number of free electrons per copper atom? Assume a density of 8.9 g/cm^3.

(5 marks)

(c) A specimen of magnesium having a rectangular cross section of dimension (3.2 mm x 20.2 mm) is deformed in tension. Using the load-elongation data tabulated as follows, answer the following question:

Table 1

Load (N)	Length (mm)	Load (N)	Length (mm)
0	50.800	44800	52.832
55.7330	50.851	46200	53.848
15100	50.902	47300	54.864
23100	50.952	47500	55.880
30400	51.003	46100	56.896
34400	51.054	44800	57.658
38400	51.308	42600	58.420
41300	51.816	36400	59.182

(i) Plot the data as engineering stress versus engineering strain in graph paper.

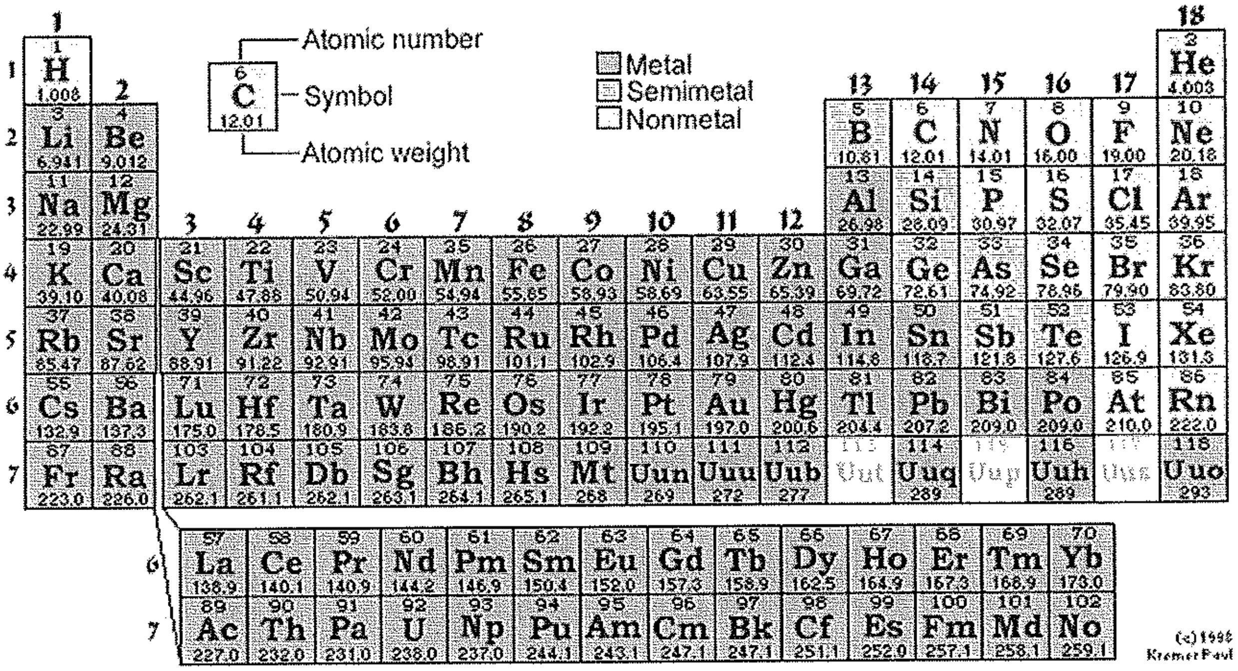
(ii) Compute the modulus of elasticity.

(iii) Determine the yield strength at strain offset of 0.002.

(15 marks)

-THE END-

APPENDIX A



6
C
12.01: Atomic number, Symbol, Atomic weight

▨ Metal
▤ Semimetal
☐ Nonmetal

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H 1.008																	2 He 4.003
2	3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
3	11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
4	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
5	37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc 98.91	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
6	55 Cs 132.9	56 Ba 137.3	71 Lu 175.0	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po 209.0	85 At 210.0	86 Rn 222.0
7	87 Fr 223.0	88 Ra 226.0	103 Lr 262.1	104 Rf 261.1	105 Db 262.1	106 Sg 263.1	107 Bh 264.1	108 Hs 265.1	109 Mt 268	110 Uun 269	111 Uuu 272	112 Uub 277	113 Uut	114 Uuq 289	115 Uup	116 Uuh 289	117 Uus	118 Uuo 293

6	57 La 138.9	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm 146.9	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0
7	89 Ac 227.0	90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np 237.0	94 Pu 244.1	95 Am 243.1	96 Cm 247.1	97 Bk 247.1	98 Cf 251.1	99 Es 252.0	100 Fm 257.1	101 Md 258.1	102 No 259.1

(c)1998
Kremer Paul

APPENDIX B: LIST OF FORMULA

1. Atomic packing factor, $APF = \frac{volume\ of\ atoms\ in\ unit\ cell}{volume\ of\ unit\ cell}$

2. Density, $\rho = \frac{mass}{volume}$

3. Cold work, % $CW = \frac{initial\ thickness - final\ thickness}{initial\ thickness} \times 100\%$

4. Engineering stress, $\sigma = \frac{tensile\ force}{cross\ sectional\ area}$

5. True stress, $\sigma_t = \frac{tensile\ force}{instatanious\ area}$

6. Engineering strain, $\varepsilon = \frac{change\ in\ length}{original\ length}$

7. Modulus of Elasticity, $E = \frac{stress}{strain}$

8. Lever rule, $x_s = \frac{w_0 - w_l}{w_s - w_l}$ and $x_l = \frac{w_s - w_0}{w_s - w_l}$

9. Free electrons in atom, $N_X = \frac{Avogadro's\ constant \times density}{atomic\ weight\ of\ element\ X}$

10. Free electrons in volume, $n = \frac{electron\ conductivity}{electron\ charge \times electron\ mobility}$

11. Fracture toughness, $K_{IC} = Y\sigma_f\sqrt{\pi a}$

12. Stress relaxation of polymers, $\sigma = \sigma_0 e^{-t/\tau}$