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FINAL
Examination Paper

(COVER PAGE)

Session	:	**August 2017**
Programme	:	Diploma in Electrical & Electronic Engineering (DEEI) Diploma in Mechanical Engineering (DMEN)
Course	:	**EGM1182/EGM1184 : Structures and Properties of Materials**
Date of Examination	:	December 12, 2017 (Tuesday)
Time	:	2:00 pm – 4:00 pm 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 : Calculator

Materials provided : List of Formulas, Periodic Table

Examiner (s) : **Phua Chin Lai,** Iylia Elena Abdul Jamil

Moderator : Dr How Ho Cheng

This paper consists of 8 printed pages, including the cover page.

DIPLOMA IN ELECTRICAL & ELECTRONIC ENGINEERING PROGRAMME (DEEI)
DIPLOMA IN MECHANICAL ENGINEERING PROGRAMME (DMEN)
EGM1182/EGM1184: STRUCTURES AND PROPERTIES OF MATERIAL
FINAL EXAMINATION: AUGUST 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) Aluminum foil used for storing food weighs about 0.3 grams per square inch. **How many atoms** of aluminum are contained in one cm^2 of foil? (Note: 1 inch = 2.54 cm, $N_A = 6.022 \times 10^{23}$ atoms/mol)

(6 marks)

(b) **Determine Miller indices** for the planes in the cubic unit cell shown in Figure Q1.

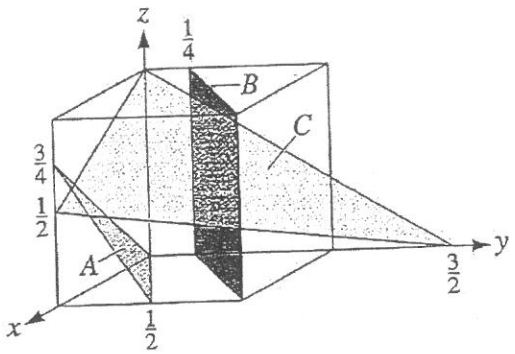

Figure Q1

(6 marks)

(c) **Briefly describe the following terms** that related to mechanical test.

(i) Ductility

(3 marks)

(ii) Modulus of elasticity

(3 marks)

(iii) Impact test and name an impact test.

(3 marks)

(d) State the **electronic configuration** of Sc and Ni^{2+}.

(4 marks)

Question 2

(a) Tin substitutional atoms are introduced into a FCC copper crystal, producing an alloy with a lattice parameter of 3.7589×10^{-8} cm and a density of 8.772 g/cm^3. **Calculate the atomic percentage** of tin present in the alloy. ($N_A = 6.022 \times 10^{23}$ atoms/mol)

(8 marks)

(b) **Briefly describe the following terms** that related to fatigue test of materials.

(i) Endurance limit

(3 marks)

(ii) Fracture surface of fatigue failure

(3 marks)

(c) Consider the binary eutectic copper-silver phase diagram in Figure Q2. Make phase analyses of an 88 wt % Ag–12 wt % Cu alloy at the temperatures

(i) 1000°C,

(ii) 800°C,

(iii) $780°C + \Delta T$, and

(iv) $780°C - \Delta T$.

Note: In the phase analyses, **include the phases present, chemical compositions of the Phases the amounts of each phase.**

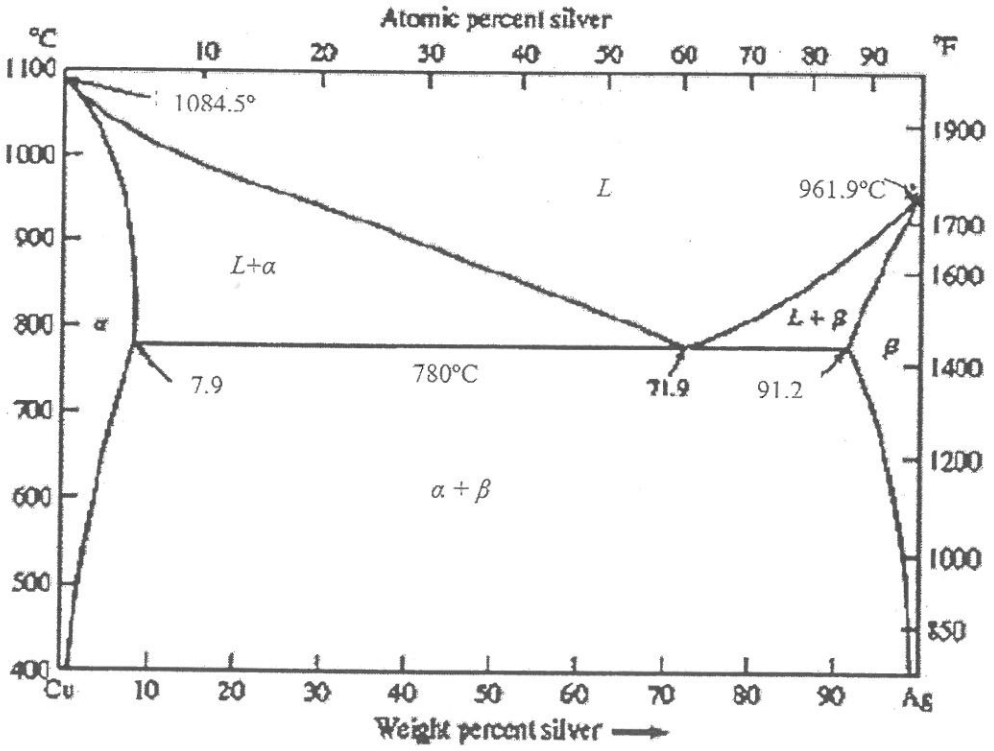

Figure Q2

(10 marks)

Question 3

(a) A part produced from the acetal polymer to survive for a million cycles under conditions that of equal compressive and tensile stresses. From Figure 3, **determine**

(i) The stress amplitude,

(1 mark)

(ii) The mean stress, tensile stress and compressive stress.

(6 marks)

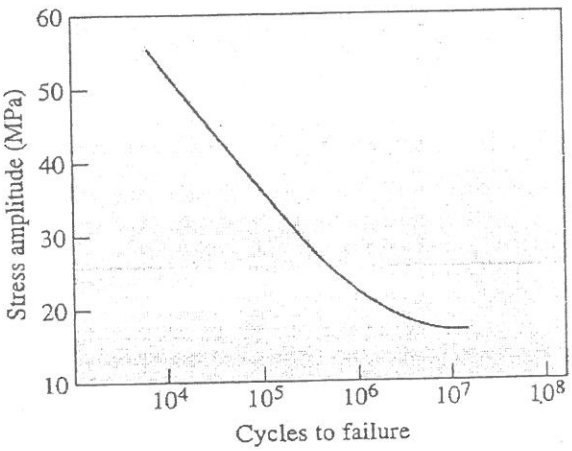

Figure Q3, S/N graph of acetal polymer

(b) **Briefly describe** the following terms that related to solidification of metal.

(i) Dendrite

(ii) Embryo

(iii) Heterogeneous nucleation

(9 marks)

(c) The mobility of electrons in silver is 75 $cm^2/V.s$ and the lattice constant of FCC silver is 4.0862×10^{-8} cm. **Determine**

(i) **the number of charge carrier** if the conductivity of silver is 680000 $(ohm.cm)^{-1}$ and absolute value of electron charge, 1.602×10^{-19} C.

(2 marks)

(ii) **the total number of valence electrons per unit cell,** and consequently **find the fraction of the valence electrons that are carrying an electrical charge.**

(7 marks)

Question 4

(a) The degree of polymerization of polytetrafluoroethylene $-[C_2F_4]_n-$ is 7500. If all of the polymer chains are the same length, **calculate the molecular weight** of the chains.

(3 marks)

(b) **Briefly describe** the following terms that related to electrical properties of materials.

(i) Energy gap

(3 marks)

(ii) Valence band

(3 marks)

(iii) Hole

(2 marks)

(c) If we wish to double the electrical conductivity of cobalt from the electrical conductivity at 0 °C. To **what temperature** must we cool the metal?(Given the coefficient of resistivity α is 0.006 Ω/°C)

(5 marks)

(d) **Calculate the linear atomic** density in atoms per millimeter for the following directions in FCC iridium, which has a lattice constant of 0.38389 nm:

(i) [100]

(ii) [110]

(iii) [111]

(9 marks)

Question 5

(a) **Briefly describe** the following terms that related to polymeric materials.

(i) Monomer

(ii) Thermosetting plastic

(6 marks)

(b) **Compute the atomic packing factor** for the cesium chloride structure in which $r_C/r_A = 0.735$. (r_C denotes radius of cation and r_A denotes radius of anion)

(9 marks)

(c) A cylindrical rod of copper (E = 110 GPa) having a yield strength of 240 MPa is to be subjected to a load of 6660 N. If the length of the rod is 380 mm, **what must be the diameter** to allow an elongation of 0.50 mm?

(6 marks)

(d) For a ceramic compound, what are the two characteristics of the component ions that **determine the crystal structure**?

(4 marks)

Question 6

(a) What **type(s) of bonding** would be expected for each of the following materials:

(i) brass (copper-zinc alloy),

(ii) rubber,

(iii) barium sulfide (BaS),

(iv) solid xenon.

(4 marks)

(b) Iodine has an orthorhombic unit cell for which the a, b, and c lattice parameters are 0.481, 0.720, and 0.981 nm, respectively.

(i) If the atomic packing factor and atomic radius are 0.547 and 0.177 nm, respectively, **determine the number of atoms** in each unit cell. (a simple orthorhombic structure shown in Figure 6)

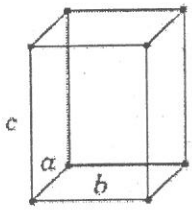

Figure 6

(5 marks)

(ii) The atomic weight of iodine is 126.91 g/mol; **compute its theoretical density.**

(4 marks)

(c) **Calculate the composition**, in atomic percentage of an alloy that contains 218.0 kg titanium, 15 kg of aluminum, and 10 kg of vanadium.

(6 marks)

(d) **Describe and illustrate with sketches** the solidification process of a pure metal in terms of the nucleation and growth of crystals.

(6 marks)

APPENDIX 1

PERIODIC TABLE

																	2 He 4·003 Helium
			1 H 1·008 Hydrogen									5 B 10·81 Boron	6 C 12·01 Carbon	7 N 14·01 Nitrogen	8 O 16·00 Oxygen	9 F 19·00 Fluorine	10 Ne 20·18 Neon
3 Li 6·941 Lithium	4 Be 9·012 Beryllium											13 Al 26·98 Aluminium	14 Si 28·09 Silicon	15 P 30·97 Phosphorus	16 S 32·07 Sulfur	17 Cl 35·45 Chlorine	18 Ar 39·95 Argon
11 Na 22·99 Sodium	12 Mg 24·31 Magnesium																
19 K 39·10 Potassium	20 Ca 40·08 Calcium	21 Sc 44·96 Scandium	22 Ti 47·88 Titanium	23 V 50·94 Vanadium	24 Cr 52·00 Chromium	25 Mn 54·94 Manganese	26 Fe 55·85 Iron	27 Co 58·93 Cobalt	28 Ni 58·69 Nickel	29 Cu 63·55 Copper	30 Zn 65·39 Zinc	31 Ga 69·72 Gallium	32 Ge 72·59 Germanium	33 As 74·92 Arsenic	34 Se 78·96 Selenium	35 Br 79·90 Bromine	36 Kr 83·80 Krypton
37 Rb 85·47 Rubidium	38 Sr 87·62 Strontium	39 Y 88·91 Yttrium	40 Zr 91·22 Zirconium	41 Nb 92·91 Niobium	42 Mo 95·94 Molybdenum	43 Tc 98·91 Technetium	44 Ru 101·1 Ruthenium	45 Rh 102·9 Rhodium	46 Pd 106·4 Palladium	47 Ag 107·9 Silver	48 Cd 112·4 Cadmium	49 In 114·8 Indium	50 Sn 118·7 Tin	51 Sb 121·8 Antimony	52 Te 127·6 Tellurium	53 I 126·9 Iodine	54 Xe 131·3 Xenon
55 Cs 132·9 Cesium	56 Ba 137·3 Barium	57 La 138·9 Lanthanum	72 Hf 178·5 Hafnium	73 Ta 180·9 Tantalum	74 W 183·9 Tungsten	75 Re 186·2 Rhenium	76 Os 190·2 Osmium	77 Ir 192·2 Iridium	78 Pt 195·1 Platinum	79 Au 197·0 Gold	80 Hg 200·6 Mercury	81 Tl 204·4 Thallium	82 Pb 207·2 Lead	83 Bi 209·0 Bismuth	84 Po — Polonium	85 At — Astatine	86 Rn — Radon
87 Fr — Francium	88 Ra 226·0 Radium	89 Ac — Actinium	104	105	106												

KEY

Atomic Number — 79 — Symbol of element
Atomic Mass — Au 197·0 — Name of element
Gold

58 Ce 140·1 Cerium	59 Pr 140·9 Praseodymium	60 Nd 144·2 Neodymium	61 Pm — Promethium	62 Sm 150·4 Samarium	63 Eu 152·0 Europium	64 Gd 157·3 Gadolinium	65 Tb 158·9 Terbium	66 Dy 162·5 Dysprosium	67 Ho 164·9 Holmium	68 Er 167·3 Erbium	69 Tm 168·9 Thulium	70 Yb 173·0 Ytterbium	71 Lu 175·0 Lutetium
90 Th 232·0 Thorium	91 Pa 231·0 Protactinium	92 U 238·0 Uranium	93 Np 237·0 Neptunium	94 Pu — Plutonium	95 Am — Americium	96 Cm — Curium	97 Bk — Berkelium	98 Cf — Californium	99 Es — Einsteinium	100 Fm — Fermium	101 Md — Mendelevium	102 No — Nobelium	103 Lr — Lawrencium

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LIST OF FORMULA

1. Density, $\rho = \frac{mass}{volume} = \frac{n_1 A_1 + n_2 A_2}{a^3 N_A}$

2. Linear atomic density, $\rho_l = \frac{no.\ of\ atom\ diameter}{linear\ length}$

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

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

5. Modulus of Elasticity, $E = \frac{stress}{strain} = \frac{\sigma}{\epsilon}$

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

7. Conductivity, $\sigma = nq\mu$
   $n = number\ of\ conduction\ electrons\ per\ unit\ volume$
   $q = electron\ charge = 1.602 \times 10^{-19}\ C$
   $\mu = electron\ mobility$

8. Conductivity, $\sigma_{n\,°C} = \frac{1}{\rho_{n\,°C}}$

9. Resistivity, $\rho_T = \rho_{0\,°C}(1 + \alpha \Delta T)$

-THE END-