

**INTI**INTERNATIONAL COLLEGE PENANG (507232-U)
LAUREATE INTERNATIONAL UNIVERSITIESFINAL
Examination Paper

(COVER PAGE)

Session	:	<u>April 2013</u>
Programme	:	<u>Diploma in Electrical and Electronic Engineering Programme</u>
Course	:	<u>EGM1182 : Structures and Properties of Materials</u>
Date of Examination	:	<u>2 August 2013</u>
Time	:	<u>8a.m. – 10a.m.</u> Reading Time : <u>Nil</u>
Duration	:	<u>2 Hours</u>
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 : Nil

Materials provided : Periodic Table

Examiner(s) : **Phua Chin Lai**

Moderator : **Hemalatha**

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

INTI INTERNATIONAL COLLEGE PENANG

DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING PROGRAMME (DEEI)
 EGM 1182: STRUCTURES AND PROPERTIES OF MATERIAL
 FINAL EXAMINATION: APRIL 2013 SESSION

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

Question 1

(a) Give the electron configurations for the Cl^- ion and Zn^{2+} ion. (4 marks)

(b) In a metal-oxide-semiconductor (MOS) device, a thin layer of SiO_2 (density = 2.20 Mg/m^3) is grown on a single crystal chip of silicon. How many Si atoms and O atoms are present per square millimeter layer with the layer thickness of 100 nm? (5 marks)

(c) Calculate the atomic packing factor for pure silicon semiconductor, which exhibits diamond cubic structure as shown in Figure Q1. There are 4 interior atoms, 6 face-centered atoms and 8 atoms at the lattice position of unit cell. (8 marks)

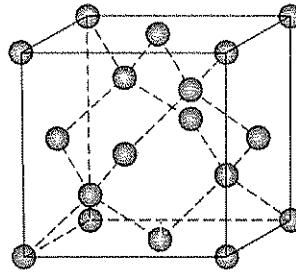


Figure Q1

(d) Briefly explain the following:

- (i) Phase diagram
- (ii) Eutectic
- (iii) Annealing of steels
- (iv) Tempering of steels

(8 marks)

Question 2

(a) The density of silver is 10.49 g/cm^3 . Calculate the number of electrons capable of conducting an electrical charge in 10 cm^3 of silver. (6 marks)

(b) The structural formulae of three monomers are shown in Figure Q2(b). For each of the compounds, name the type of reaction involved in the manufacture of a polymer and show how the polymerization occurred using simple equations (9 marks)

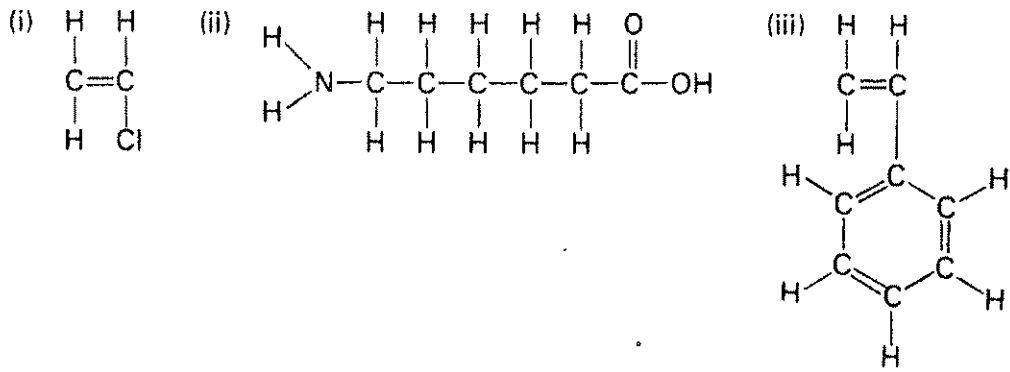


Figure Q2(b)

(9 marks)

(c) Determine the Miller indices for the planes as shown in Figure Q2(c).

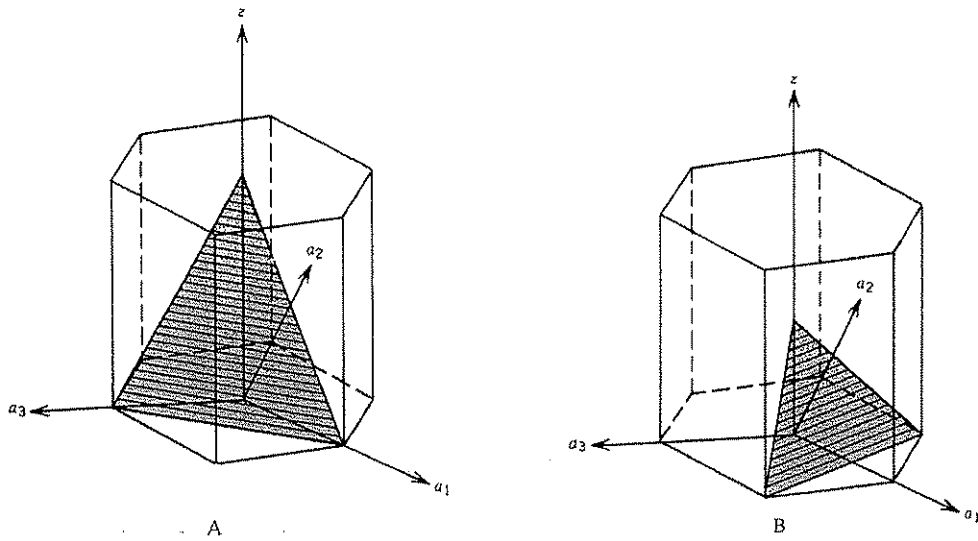


Figure Q2(c)

(5 marks)

(d) Cadmium at 20°C has a HCP structure with atoms of radius of 0.148 nm. Calculate the volume of unit cell of cadmium. Assume that the atomic packing factor for HCP crystal structure is 0.74

(5 marks)

Question 3

- (a) Consider the 1040 carbon steel listed in Table Q3.
- (i) A 20-mm diameter bar of this alloy is used as a structural member in an engineering design. The unstressed length of the bar is precisely 1 m. The structural load on the bar is $9 \times 10^4 \text{ N}$ in tension. What will be the length of the bar under this structural load?
- (ii) A design engineer is considering a structural change that will increase the tensile load on this member. What is the maximum tensile load that can be permitted without producing extensive plastic deformation of the bar?

(8 marks)

Tensile Test Data for Some Typical Metal Alloys				
Alloy*	E [GPa (psi)]	Y.S. [MPa (ksi)]	TS. [MPa (ksi)]	Percent elongation at failure
1. 1040 carbon steel	200 (29×10^6)	600 (87)	750 (109)	17
2. 8630 low-alloy steel		680 (99)	800 (116)	22
3. a. 304 stainless steel	193 (28×10^6)	205 (30)	515 (75)	40
b. 410 stainless steel	200 (29×10^6)	700 (102)	800 (116)	22
4. L2 tool steel		1,380 (200)	1,550 (225)	12

*Alloy designations and associated properties cited in this table and Tables 6.3 and 6.10 are from *Metals Handbook*, 8th ed., Vol. 1, and 9th ed., Vols. 1-3, American Society for Metals, Metals Park, OH, 1961, 1978, 1979, and 1980.

Table Q3

- (b) Assuming that all the valence electrons contribute to the current flow in copper (FCC structure):
- (i) Calculate the mobility of an electron in copper
- (ii) Calculate the average drift velocity for electrons in a 100cm copper wire when 10V are applied

Calculate the above with the given resistivity of copper at 0°C is $1.67 \times 10^{-6} \Omega \cdot \text{cm}$, charge of electron at $1.6 \times 10^{-19} \text{ C}$, lattice constant for copper is $3.62 \times 10^{-8} \text{ cm}$.

(10 marks)

- (c) Define the polymeric materials listed below:

- (i) plastics
- (ii) elastomers.

(7 marks)

Question 4

- (a) For cubic crystals, as values of the planar indices h , k , and l increase, does the distance between adjacent and parallel planes (i.e., the interplanar spacing) increase or decrease? Why?

(4 marks)

(b) Of those materials listed in Table Q4,

Material	Yield Strength (MPa)	Tensile Strength (MPa)	Strain at Fracture	Fracture Strength (MPa)	Elastic Modulus (GPa)
A	310	340	0.23	265	210
B	100	120	0.40	105	150
C	415	550	0.15	500	310
D	700	850	0.14	720	210
E	Fractures before yielding			650	350

Table Q4

- (i) Which material will exhibit brittle failure? Why?
 (ii) Which material has the highest limit of elastic deformation before experiencing extensive plastic deformation? Why?
 (iii) Which material is the stiffest? Why? (6 marks)

(c) Show that the minimum cation-to-anion radius ratio for a coordination number of 4 is 0.225, given the supporting diagram in Figure Q4.

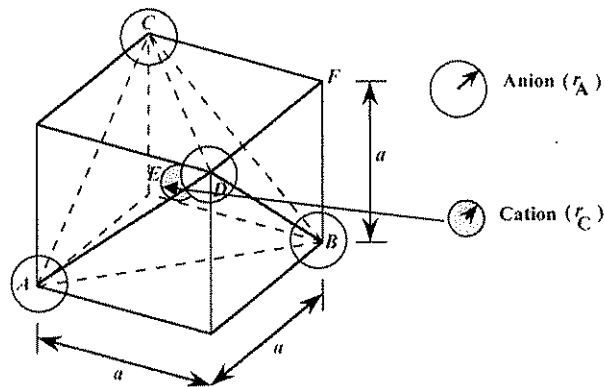


Figure Q4

(10 marks)

(d) Describe the surface of fatigue failure obtained from fatigue testing of materials.

(5 marks)

Question 5

(a) Between 1975 and 1985, the volume of all steel in a given automobile model decreased from 0.162 m^3 to 0.116 m^3 . In the same time frame, the volume of all aluminum alloys increased from 0.012 m^3 to 0.023 m^3 . Given the densities of steel 7.87 Mg/m^3 and Al 2.70 Mg/m^3 , determine the total mass reduction resulting from this trend of materials substitution.

(7 marks)

(b) See Figure Q5, describe qualitatively the microstructural development during the slow cooling of a melt composed of

- (i) 10 wt % Pb-90 wt% Sn,
- (ii) 40 wt % Pb-60 wt% Sn, and
- (iii) 50 wt % Pb-50 wt% Sn,

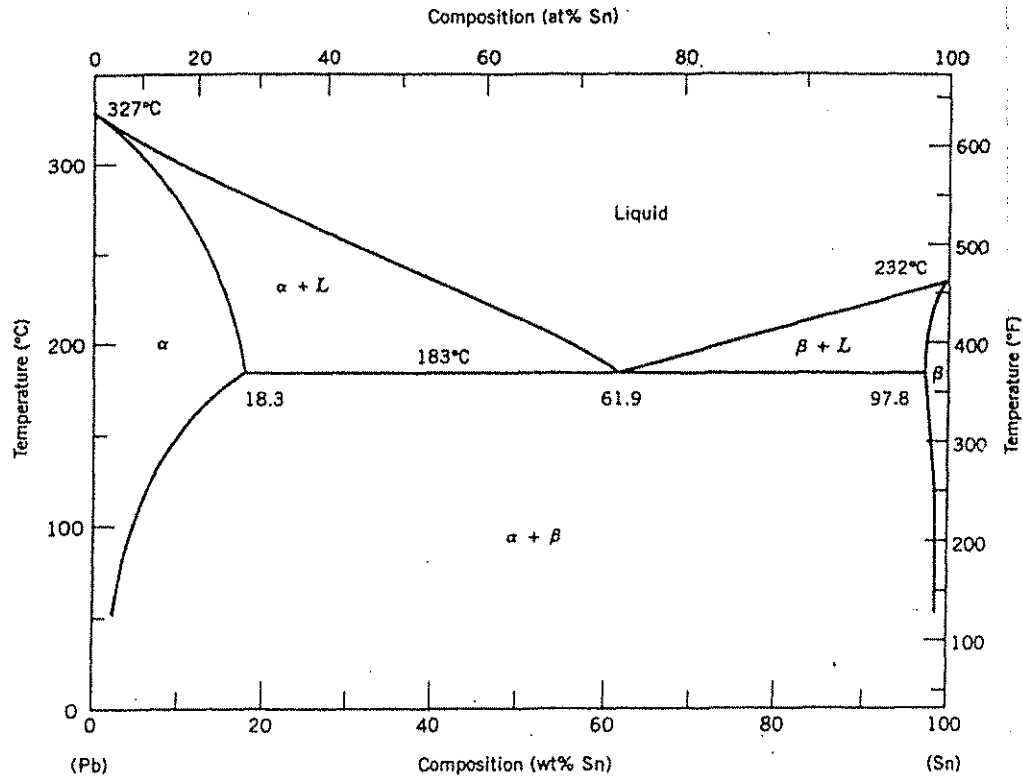


Figure Q5

(12 marks)

(c) A tungsten lightbulb filament is 10 mm long and 100 μm in diameter. What is the current in the filament when operating at 1000 $^{\circ}\text{C}$ with a line voltage of 110V? Given the resistivity at 20 $^{\circ}\text{C}$ is $55.1 \times 10^{-9} \Omega\text{m}$ and temperature coefficient of resistivity at 20 $^{\circ}\text{C}$ is $0.0045 \text{ }^{\circ}\text{C}^{-1}$.

(6 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 Q6)

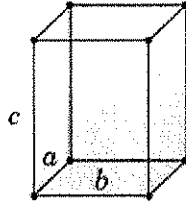


Figure Q6

(8 marks)

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

(4 marks)

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

(3 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)

--THE END--

EGM 1182(F)APR 13/CL PHUA/16/07/13

PERIODIC TABLE

2	He 4-003 Helium	10	Ne 20-18 Neon	18	Ar 39-95 Argon	36	Kr 83-80 Krypton	54	Xe 131-3 Xenon	86	Rn — Radon
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
11	Li 6-941 Lithium	12	Mg 24-31 Magnesium	13	Al 26-98 Aluminium	14	Si 28-09 Silicon	15	P 30-97 Phosphorus	16	S 32-07 Sulfur
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
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
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
87	Fr — Francium	88	Ra 226-0 Radium	89	Ac — Actinium	104	Rf — Rutherfordium	105	Db — Dubnium	106	Lr — Lawrencium
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
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
81	Tl 204-4 Thallium	82	Pb 207-2 Lead	83	Bi 209-0 Bismuth	84	Po — Polonium	85	At — Astatine	86	Rn — Radon
29	Cu 63-55 Copper	28	Ni 58-69 Nickel	27	Co 58-93 Cobalt	26	Fe 55-85 Iron	25	Mn 54-94 Manganese	24	Cr 52-00 Chromium
47	Ag 107-9 Silver	46	Pd 106-4 Palladium	45	Rh 102-9 Rhodium	44	Ru 101-1 Ruthenium	43	Tc 98-91 Technetium	42	Mo 95-94 Molybdenum
79	Au 197-0 Gold	78	Pt 195-1 Platinum	77	Ir 192-2 Iridium	76	Os 190-2 Osmium	75	Re 186-2 Rhenium	74	W 183-9 Tungsten
65	Tb 158-9 Terbium	64	Gd 157-3 Gadolinium	63	Eu 152-0 Europium	62	Sm 150-4 Samarium	61	Pm — Promethium	60	Nd 144-2 Neodymium
97	Bk — Berkelium	96	Cm — Curium	95	Am — Americium	94	Pu — Plutonium	93	Np 237-0 Neptunium	92	U 238-0 Uranium
101	Md — Mendelevium	100	Fm — Fermium	99	Es — Einsteinium	98	Cf — Californium	97	Bk — Berkelium	96	Cm — Curium
102	No — Nobelium	101	Md — Mendelevium	100	Fm — Fermium	99	Es — Einsteinium	98	Cf — Californium	97	Bk — Berkelium
103	Lr — Lawrencium	102	No — Nobelium	101	Md — Mendelevium	100	Fm — Fermium	99	Es — Einsteinium	98	Cf — Californium
71	Lu 175-0 Lutetium	70	Yb 173-0 Ytterbium	69	Tm 168-9 Thulium	68	Er 167-3 Erbium	67	Ho 164-9 Holmium	66	Dy 162-5 Dysprosium

KEY

1	H 1-008 Hydrogen
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79	Au 197-0 Gold
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Atomic Number

Symbol of element

Atomic Mass

Name of element

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