

FINAL
Examination Paper

(COVER PAGE)

Session : April 2019

Programme : Diploma In Mechanical Engineering (DMEN)

Course : **EGM1184 : Structures and Properties of Materials**

Date of Examination : July 29, 2019 (Monday)

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 : Calculator

Materials provided : Periodic Table and List of Formula

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Moderator : Mr Abdolreza Toudehdeghan

DIPLOMA IN MECHANICAL ENGINEERING PROGRAMME (DMEN)
EGM 1184: STRUCTURES AND PROPERTIES OF MATERIALS
FINAL EXAMINATION: APRIL 2019 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) How many atoms are there in 5 g of gold? (3 marks)
- (b) A solder contains 52 wt % tin and 48 wt % lead. What are the atomic percentages of Sn and Pb in the solder? (8 marks)
- (c) Potassium iodide (KI) exhibits predominantly ionic bonding. Which inert gases have identical electron structures to each of the K^+ and I^- ions? Explain your reason with the electron configuration. (6 marks)
- (d) Material selection is an important part of design and manufacturing processes of any product.
- (i) State five selection criteria for a flexible PVC hose pipe. (5 marks)
- (ii) Suggest an alternative material to PVC that can be used to manufacture hose pipes and provide two reasons to justify your answer. (3 marks)

Question 2

- (a) Distinguish between homogeneous and heterogeneous nucleation for solidification of a pure metal. (4 marks)
- (b) The solidification process of a pure metal liquid involves 3 stages. Describe and illustrate these 3 process. (6 marks)
- (c) Crystal lattice imperfections are classified according to their geometry and shape and one of the imperfections is point defect. Describe the following defects.
- (i) Vacancy
- (ii) Interstitially (6 marks)

- (d) If there are 60 grains per square inch on a photomicrograph of a metal at 200x, what is the ASTM grain-size number of metal. (4 marks)
- (e) Determine the ASTM grain size number if 25 grains per square inch are measured at a magnification of 75. (5 marks)

Question 3

- (a) Consider a BCC crystal structure where the central atom is surrounded by eight nearest neighbours.
- Derive the relation between the length of the side a of the BCC unit cell and the radius of its atom.
 - Calculate its atomic packing factor (APF).
 - 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. (10 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/cm³. (5 marks)
- (c) Draw the following direction vectors in cubic unit cells.
- $[\bar{1}10]$
 - $[\bar{3}2\bar{1}]$ (4 marks)
- (d) Annealing is a heat treatment process to soften metals. Describe **THREE (3)** factors that affect the recrystallization process of metal during annealing. (6 marks)

Question 4

- (a) Briefly describe a solid solution in an alloy. State two (2) examples. (4 marks)
- (b) The lead-tin phase diagram are given in Figure 4.1. For a 40 wt% Sn–60 wt% Pb alloy at 150°C (300°F). Determine the following.
- What phases are present for the alloy at this temperature?
 - What are the compositions of the phases?
 - Calculate the relative amount of each phase present in terms of mass fraction and volume fraction. At 150 °C take the densities of Pb and Sn to be 11.23 and 7.24 g/cm³ respectively.

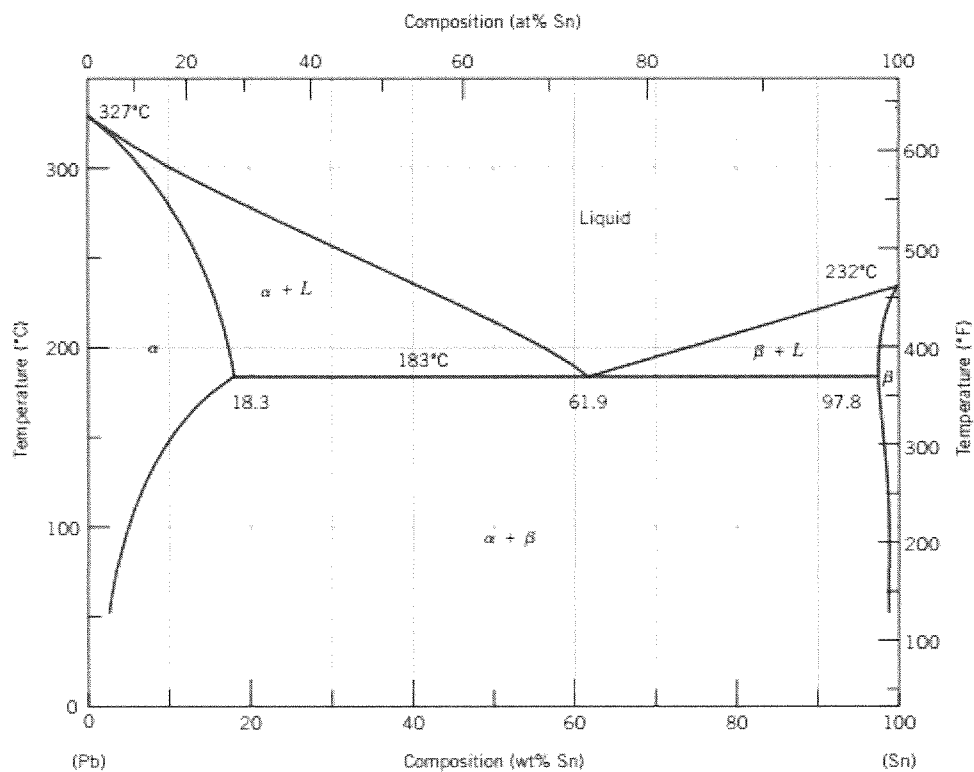


Figure 4.1

(14 marks)

(c) The iron-iron carbide diagram are given in the Figure 4.2. 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.
- (ii) The fractions of the pearlite and proeutectoid ferrite.
- (iii) The fraction of eutectoid ferrite.

(7 marks)

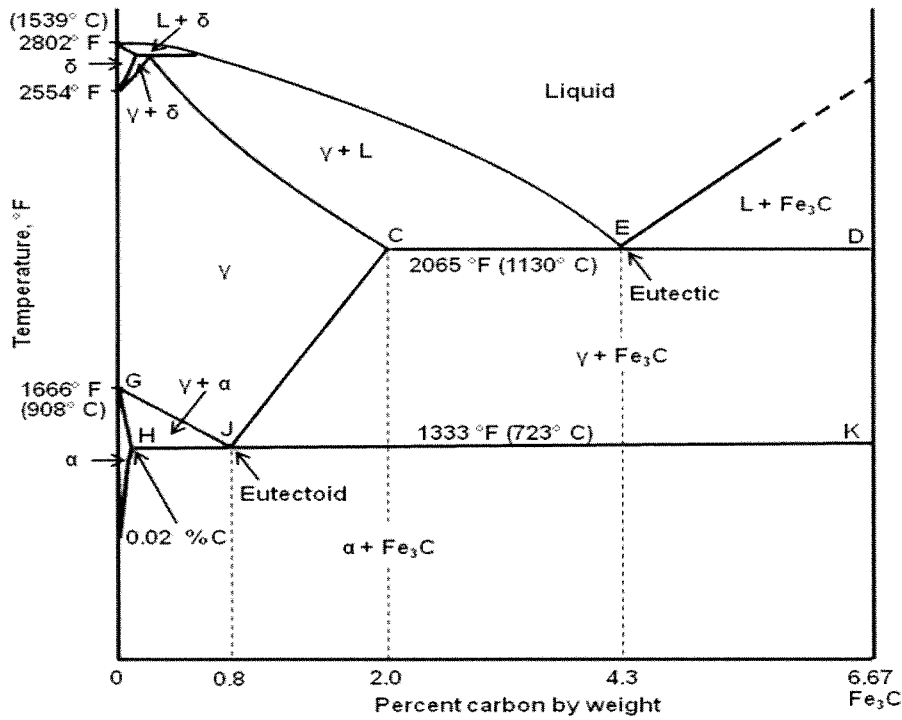


Figure 4.2

Question 5

(a) Twenty-cm-long rod with a diameter of 0.250 cm is loaded with a 5000 N weight. If the diameter decreases to 0.210 cm, determine:

- (i) the engineering stress and strain at this load.
- (ii) the true stress and strain at this load.

(12 marks)

(b) When a cold-worked metal is heated into the temperature range where recovery takes place, how are the following affected:

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

(4 marks)

- (c) A brass wire is cold-drawn 25 percent to a diameter of 1.10 mm. It is then further cold-drawn to 0.900 mm. What is the total percent cold reduction?
(5 marks)
- (d) An iron wire is to conduct a 6.5 A current with a maximum voltage drop of 0.005 V/cm. What must be the minimum diameter of the wire in meters at (20°C)? (Resistivity for iron at 0°C = $9.0 \times 10^{-6} \Omega \text{ cm}$, coefficient of resistivity = $0.0045^\circ\text{C}^{-1}$)
(4 marks)

Question 6

- (a) Explain the difference between the characteristics of thermoplastic and thermosetting plastics.
(4 marks)
- (b) Briefly explain the definition of the following polymeric materials and give examples of item made from it :
- (i) Plastics.
(2 marks)
- (ii) Elastomers.
(2 marks)
- (c) A 5.0 mm diameter, 50 mm long cylindrical silicon specimen has a current of 0.1 A passing in axial direction. A voltage of 12.5 V is measured across two probes that are separated by 38 mm.
- (i) Find the electrical conductivity of the specimen.
- (ii) Compute the resistance over the entire 50 mm of the specimen.
(6 marks)
- (d) At what temperature will an iron wire have the same electrical resistivity as an aluminum one has at 35°C? (Resistivity for iron at 0°C = $9.0 \times 10^{-6} \Omega \text{ cm}$, coefficient of resistivity = $0.0045^\circ\text{C}^{-1}$; Resistivity for aluminum at 0°C = $2.7 \times 10^{-6} \Omega \text{ cm}$, coefficient of resistivity = $0.0039^\circ\text{C}^{-1}$)
(5 marks)
- (e) A fatigue test is made with a mean stress 120 MPa and a stress amplitude of 165 MPa. Calculate:
- (i) the maximum and minimum stresses
- (ii) the stress ratio
- (iii) the stress range
(6 marks)

-THE END-

EGM 1184

LIST OF FORMULA

1. Avogadro's constant = $6.02 \times 10^{23} \text{ atoms/mol}$
2. Atomic packing factor, $APF = \frac{\text{volume of atoms in a cell}}{\text{volume of cubic cell}}$
3. Number of grains in 100x magnification, $N = 2^{n-1}$
4. Volume density, $\rho_v = \frac{\text{mass/unit cell}}{\text{volume/unit cell}}$
5. Engineering Stress, $\sigma = \frac{F_o}{A}$
6. Engineering Strain, $\varepsilon = \frac{\Delta l}{l_o}$
7. Modulus of elasticity, $E = \frac{\sigma}{\varepsilon}$
8. Resistivity, $\rho = \frac{VA}{Il}$
9. Resistivity at specified temperature, $\rho_T = \rho_{0^\circ\text{C}}(1 + \alpha_T T)$
10. Conductivity, $\sigma = \frac{1}{\rho}$
11. Resistance, $R = \frac{\rho l}{A}$
12. Lever Rule:
 - a. Weight fraction of Phase A, $X_A = \frac{w_B - w_O}{w_B - w_A}$
 - b. Weight fraction of Phase B, $X_B = \frac{w_O - w_A}{w_B - w_A}$
13. Mass and volume fraction fraction
 - a. Mass fraction, phase a, = $\frac{100}{\frac{w_{a,1}}{\text{density}_1} + \frac{w_{a,2}}{\text{density}_2}}$, phase b, = $\frac{100}{\frac{w_{b,1}}{\text{density}_1} + \frac{w_{b,2}}{\text{density}_2}}$
 - b. Volume fraction, phase a, = $\frac{\frac{X_a}{\rho_a}}{\frac{X_a}{\rho_a} + \frac{X_b}{\rho_b}}$, phase b, = $\frac{\frac{X_b}{\rho_b}}{\frac{X_a}{\rho_a} + \frac{X_b}{\rho_b}}$

Periodic Table of the Elements

Atomic Number		Symbol		Name		Atomic Mass	
1	IA	1A	H	Hydrogen	1.00784(1)	1	
2	IIA	2A	He	Helium	4.002602(2)	2	
3			Li	Lithium	6.941(1)	3	
4			Be	Beryllium	9.0121831(5)	4	
5	VB	5B	B	Boron	10.806(1)	5	
6	VIB	6B	C	Carbon	12.0107(8)	6	
7	VII	7B	N	Nitrogen	14.00643(4)	7	
8	VIII	8	O	Oxygen	15.999(4)	8	
9	VIII	9	F	Fluorine	18.998403163(6)	9	
10	VIII	10	Ne	Neon	20.1797(6)	10	
11	IB	11B	Na	Sodium	22.98976928(2)	11	
12	IB	12B	Mg	Magnesium	24.304(2)	12	
13	IIIA	3A	Al	Aluminum	26.9815386(8)	13	
14	IVA	4A	Si	Silicon	28.0855(8)	14	
15	VA	5A	P	Phosphorus	30.973761998(5)	15	
16	VIA	6A	S	Sulfur	32.059(5)	16	
17	VIIA	7A	Cl	Chlorine	35.448(5)	17	
18	VIIIA	8A	Ar	Argon	39.948(1)	18	
19			K	Potassium	39.0983(1)	19	
20			Ca	Calcium	40.078(4)	20	
21	IIIB	3B	Sc	Scandium	44.955908(5)	21	
22	IVB	4B	Ti	Titanium	47.88(7)	22	
23			V	Vanadium	50.9415(1)	23	
24			Cr	Chromium	51.9961(6)	24	
25			Mn	Manganese	54.938045(5)	25	
26			Fe	Iron	55.845(2)	26	
27			Co	Cobalt	58.933194(4)	27	
28			Ni	Nickel	58.933194(4)	28	
29			Cu	Copper	63.546(3)	29	
30			Zn	Zinc	65.38(3)	30	
31			Ga	Gallium	69.723(1)	31	
32			Ge	Germanium	72.630(8)	32	
33			As	Arsenic	74.921595(5)	33	
34			Se	Selenium	78.9718(8)	34	
35			Br	Bromine	79.904(3)	35	
36			Kr	Krypton	83.798(2)	36	
37			Rb	Rubidium	85.4678(3)	37	
38			Sr	Strontium	87.62(1)	38	
39			Y	Yttrium	88.90584(3)	39	
40			Zr	Zirconium	91.224(2)	40	
41			Nb	Niobium	92.90638(2)	41	
42			Mo	Molybdenum	95.94(1)	42	
43			Tc	Technetium	-98>	43	
44			Ru	Ruthenium	101.07(2)	44	
45			Rh	Rhodium	102.90550(2)	45	
46			Pd	Palladium	106.42(1)	46	
47			Ag	Silver	107.8682(2)	47	
48			Cd	Cadmium	112.411(4)	48	
49			In	Indium	114.818(1)	49	
50			Sn	Tin	118.710(7)	50	
51			Sb	Antimony	121.760(1)	51	
52			Te	Tellurium	127.60(3)	52	
53			I	Iodine	126.90447(3)	53	
54			Xe	Xenon	131.29(4)	54	
55			Cs	Cesium	132.90545196(6)	55	
56			Ba	Barium	137.327(7)	56	
57			La	Lanthanum	138.90547(7)	57	
58			Ce	Cerium	140.116(1)	58	
59			Pr	Praseodymium	140.90768(2)	59	
60			Nd	Neodymium	144.242(3)	60	
61			Pm	Promethium	-145>	61	
62			Sm	Samarium	150.36(2)	62	
63			Eu	Europium	151.964(1)	63	
64			Gd	Gadolinium	157.25(3)	64	
65			Tb	Terbium	158.92535(2)	65	
66			Dy	Dysprosium	162.500(1)	66	
67			Ho	Holmium	164.93032(2)	67	
68			Er	Erbium	167.259(3)	68	
69			Tm	Thulium	168.93422(2)	69	
70			Yb	Ytterbium	173.054(5)	70	
71			Lu	Lutetium	174.967(1)	71	
72			Hf	Hafnium	178.49(2)	72	
73			Ta	Tantalum	180.94788(2)	73	
74			W	Tungsten	183.84(1)	74	
75			Re	Rhenium	186.207(1)	75	
76			Os	Osmium	190.23(3)	76	
77			Ir	Iridium	192.222(3)	77	
78			Pt	Platinum	195.084(9)	78	
79			Au	Gold	196.966569(5)	79	
80			Hg	Mercury	200.59(2)	80	
81			Tl	Thallium	204.382(2)	81	
82			Pb	Lead	207.2(1)	82	
83			Bi	Bismuth	208.98040(1)	83	
84			Po	Polonium	-209>	84	
85			At	Astatine	-210>	85	
86			Rn	Radon	-222>	86	
87			Fr	Francium	-223>	87	
88			Ra	Radium	-226>	88	
89			Ac	Actinium	-227>	89	
90			Th	Thorium	232.037(4)	90	
91			Pa	Protactinium	231.03688(8)	91	
92			U	Uranium	238.02891(3)	92	
93			Np	Neptunium	-237>	93	
94			Pu	Plutonium	-244>	94	
95			Am	Americium	-243>	95	
96			Cm	Curium	-247>	96	
97			Bk	Berkelium	-247>	97	
98			Cf	Californium	-251>	98	
99			Es	Einsteinium	-252>	99	
100			Fm	Fermium	-257>	100	
101			Md	Mendelevium	-258>	101	
102			No	Nobelium	-259>	102	
103			Lr	Lawrencium	-260>	103	
104			Rf	Rutherfordium	-261>	104	
105			Db	Dubnium	-262>	105	
106			Sg	Seaborgium	-263>	106	
107			Bh	Bohrium	-264>	107	
108			Hs	Hassium	-265>	108	
109			Mt	Mitlerium	-266>	109	
110			Ds	Darmstadtium	-271>	110	
111			Rg	Roentgenium	-272>	111	
112			Cn	Copernicium	-285>	112	
113			Uut	Ununtrium	-286>	113	
114			Fl	Flerovium	-289>	114	
115			Uup	Ununpentium	-289>	115	
116			Lv	Livermorium	-293>	116	
117			Uus	Ununseptium	-294>	117	
118			Uuo	Ununoctium	-294>	118	

Atomic masses reflect the IUPAC accepted values as of 09/2013. Masses enclosed in [] format show the lower and upper limit of atomic mass depending on the physical and chemical history of the element. Masses enclosed in < > format are the most numbers of the longest-lived isotopes for elements with no stable nucleus.

57	La	58	Ce	59	Pr	60	Nd	61	Pm	62	Sm	63	Eu	64	Gd	65	Tb	66	Dy	67	Ho	68	Er	69	Tm	70	Yb	71	Lu
89	Ac	90	Th	91	Pa	92	U	93	Np	94	Pu	95	Am	96	Cm	97	Bk	98	Cf	99	Es	100	Fm	101	Md	102	No	103	Lr

Lanthanide Series

Actinide Series

196 986588(5)