

**FINAL  
ALTERNATIVE ASSESSMENT**

(COVER PAGE)

Session : August 2020

Programme : Diploma in Electrical & Electronic Engineering (DEEI)  
Diploma in Mechanical Engineering (DMEN)

Course : **EGM1182/EGM1184/: Structures and Properties of Materials  
EGM1185: Materials Science**

Date of Examination : 17 December 2020 (Thursday)

Time : 8.00am – 10.15am Reading Time : Nil

Duration : 2 Hours 15 Minutes

**Special Instructions :**

This paper consists of **FOUR (4)** questions. Answer all **FOUR (4)** questions.

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Material permitted : Non-Programmable Scientific Calculator

Materials provided : Periodic Table

Examiner(s) : **Johnny Wong Kee Hui**

Chief Moderator : Teow Hsien Loong

*This paper consists of 7 printed pages, including the cover page*

DIPLOMA IN ELECTRICAL & ELECTRONICS ENGINEERING PROGRAMME (DEEI)  
 DIPLOMA IN MECHANICAL ENGINEERING PROGRAMME (DMEN)  
 EGM1182/EGM1184: STRUCTURES AND PROPERTIES OF MATERIALS  
 EGM1185: MATERIALS SCIENCE  
 FINAL ALTERNATIVE ASSESSMENT: AUGUST 2020 SESSION

**Instructions:** This paper consists of **FOUR (4)** questions. Answer all **FOUR (4)** questions.

**Question 1**

a) State the 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 a, b, and c lattice parameters are 0.481 nm, 0.720 nm, and 0.981 nm, respectively.

- i. If the atomic packing factor and atomic radius are 0.547 and 0.177 nm, respectively, find the number of atoms in each unit cell. (a simple orthorhombic structure shown in Figure 1(b).

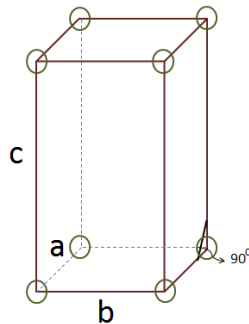


Figure 1(b)

(5 marks)

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

(4 marks)

c) Find the composition, in atomic percentage of an alloy that contains 218 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)

**Question 2**

- a) Draw the following. Clearly label the axes of interception in a cubic unit cells.

- i. (020)
- ii.  $[\bar{2}12]$
- iii.  $(\bar{3}2\bar{1})$

(9 marks)

- b) Define the difference between crystalline material and amorphous materials. Give one example for each type of the materials.

(4 marks)

- c) Consider a HCP crystal structure where the atoms in the crystal structure are packed as close together as possible.

- (i) State is the total number of complete atom in the unit cell of HCP

(1 mark)

- (ii) Find the volume of pure zinc unit cell that has the HCP crystal structure, with lattice constant  $a = 0.2665$  nm and  $c = 0.4947$  nm. Show the derivation required to calculate the volume.

(6 marks)

- (iii) Find its atomic packing factor (APF)

(5 marks)

**Question 3**

- a) The lead-tin phase diagram are given in Figure Q3(a) below. For a 40 wt% Sn–60 wt% Pb alloy at 150 °C (300 °F).

- (i) State down the phase(s) is (are) present.

(1 mark)

- (ii) Find the composition(s) of the phase(s).

(2 marks)

- (iii) Indicate 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/cm<sup>3</sup> respectively.

(9 marks)

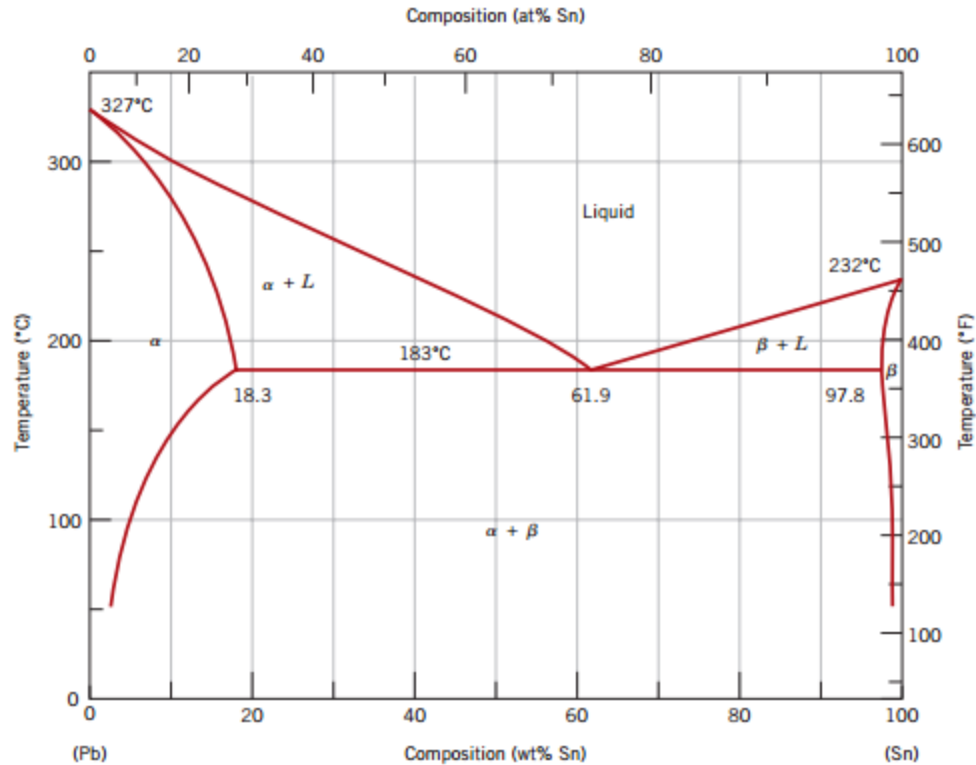


Figure Q3(a)

- b) (i) The transformation process of 0.4 wt% C hypoeutectoid plain-carbon steel with slow cooling are shown in sequence from *a* to *d* in the Figure Q3b below. Explain the process that takes place at point *b* and *d*. (4 marks)
- (ii) A 0.40 wt% C hypoeutectoid plain-carbon steel is slowly cooled from 940 °C to a temperature just slightly below 723°C . Find;
- I. The weight percent proeutectoid ferrite in the steel. (1 mark)
  - II. The weight percent eutectoid ferrite and weight percent eutectoid cementite present in the steel. (4 marks)

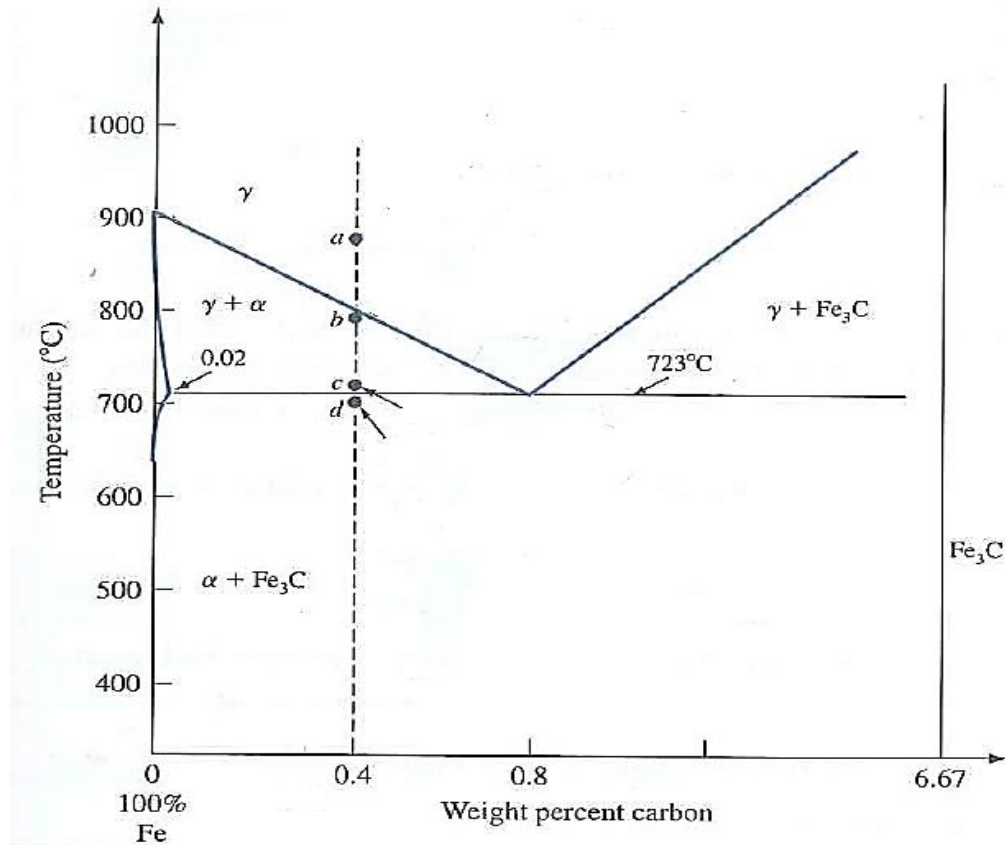


Figure Q3b: Hypoeutectoid plain-carbon steel phase diagram

- c) Define the process of annealing and normalizing of Plain-Carbon steels (4 marks)

#### Question 4

- a) State the difference between thermoplastic and thermoset. (4 marks)
- b) The average density of a carbon fibre-epoxy composite is  $1.615 \text{ g/cm}^3$ . The density of the epoxy resin is  $1.21 \text{ g/cm}^3$  and that of the carbon fibres is  $1.74 \text{ g/cm}^3$ .
- Indicate the volume percentage of carbon fibres in the composite? (6 marks)
  - Indicate the weight percentage of epoxy resin and carbon fibres in the composite? (4 marks)

c) A wire whose diameter is 3.5 mm must carry a 40A, current. The maximum power dissipation along the wire is 0.05 kW/m (kilowatts per meter). Find the minimum allowable conductivity of the wire in  $(\Omega \text{ m})^{-1}$  for this application.

(7 marks)

d) Describe some properties common to most ceramic materials.

(4 marks)

**~THE END~**

*EGM1182/EGM1184/EGM1185 (F)/ August 2020 Session/ formatted*

# PERIODIC TABLE OF ELEMENTS

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1	H	Hydrogen	1.0080	5	B	Boron	10.81	6	C	Carbon	12.011	7	N	Nitrogen	14.007	8	O	Oxygen	15.999	9	F	Fluorine	18.99840316	10	Ne	Neon	20.180	11	Na	Sodium	22.9897693	12	Mg	Magnesium	24.305	13	Al	Aluminum	26.981538	14	Si	Silicon	28.085	15	P	Phosphorus	30.97376200	16	S	Sulfur	32.07	17	Cl	Chlorine	35.45	18	Ar	Argon	39.9	19	K	Potassium	39.098	20	Ca	Calcium	40.08	21	Sc	Scandium	44.95591	22	Ti	Titanium	47.87	23	V	Vanadium	50.941	24	Cr	Chromium	51.996	25	Mn	Manganese	54.93804	26	Fe	Iron	55.84	27	Co	Cobalt	58.93319	28	Ni	Nickel	58.693	29	Cu	Copper	63.55	30	Zn	Zinc	65.4	31	Ga	Gallium	69.72	32	Ge	Germanium	72.63	33	As	Arsenic	74.92159	34	Se	Selenium	78.97	35	Br	Bromine	79.90	36	Kr	Krypton	83.80	37	Rb	Rubidium	85.468	38	Sr	Strontium	87.6	39	Y	Yttrium	88.9058	40	Zr	Zirconium	91.22	41	Nb	Niobium	92.9064	42	Mo	Molybdenum	96.0	43	Tc	Technetium	97.90721	44	Ru	Ruthenium	101.1	45	Rh	Rhodium	102.9055	46	Pd	Palladium	106.4	47	Ag	Silver	107.868	48	Cd	Cadmium	112.41	49	In	Indium	114.82	50	Sn	Tin	118.71	51	Sb	Antimony	121.76	52	Te	Tellurium	127.6	53	I	Iodine	126.9045	54	Xe	Xenon	131.29	55	Cs	Cesium	132.9054520	56	Ba	Barium	137.33	57	La	Lanthanum	138.9055	58	Ce	Cerium	140.12	59	Pr	Praseodymium	140.9077	60	Nd	Neodymium	144.24	61	Pm	Promethium	144.91276	62	Sm	Samarium	150.4	63	Eu	Europium	151.96	64	Gd	Gadolinium	157.2	65	Tb	Terbium	158.92535	66	Dy	Dysprosium	162.50	67	Ho	Holmium	164.93033	68	Er	Erbium	167.26	69	Tm	Thulium	168.93422	70	Yb	Ytterbium	173.04	71	Lu	Lutetium	174.967	72	Hf	Hafnium	178.5	73	Ta	Tantalum	180.9479	74	W	Tungsten	183.8	75	Re	Rhenium	186.21	76	Os	Osmium	190.2	77	Ir	Iridium	192.22	78	Pt	Platinum	195.08	79	Au	Gold	196.96657	80	Hg	Mercury	200.59	81	Tl	Thallium	204.383	82	Pb	Lead	207	83	Bi	Bismuth	208.9804	84	Po	Polonium	209	85	At	Astatine	209	86	Rn	Radon	222.01758	87	Fr	Francium	223.01973	88	Ra	Radium	226.02541	89	Ac	Actinium	227.02775	90	Th	Thorium	232.038	91	Pa	Protactinium	231.036	92	U	Uranium	238.0289	93	Np	Neptunium	237.04817	94	Pu	Plutonium	244.06420	95	Am	Americium	243.06138	96	Cm	Curium	247.07035	97	Bk	Berkelium	247.07031	98	Cf	Californium	251.07959	99	Es	Einsteinium	252.0830	100	Fm	Fermium	257.09511	101	Md	Mendelevium	258.09843	102	No	Nobelium	259.10100	103	Lr	Lawrencium	262.110