SET A

UNIVERSITI KUALA LUMPUR
Malaysia France Institute

FINAL EXAMINATION
SEPTEMBER 2013 SESSION

SUBJECT CODE	:	FTB 11203
SUBJECT TITLE	:	MATERIAL SCIENCE
LEVEL	:	BACHELOR
DURATION	:	2.5 HOURS
DATE / TIME	:	

INSTRUCTIONS TO CANDIDATES

1. Please read the instructions given in the question paper CAREFULLY.
2. This question paper is printed on both sides of the paper.
3. Please write your answers on the answer booklet provided.
4. Answer should be written in blue or black ink except for sketching, graphic and illustration.
5. This question paper consists of TWO (2) sections only. Answer ALL questions in SECTION A and THREE (3) questions only in SECTION B.
6. Answer all questions in English.

THERE ARE 4 PRINTED PAGES OF QUESTIONS AND 3 PAGES OF APPENDICES EXCLUDING THIS PAGE.

SECTION A (Total: 40 marks)

INSTRUCTION: Answer ALL questions. Please use answer booklet provided.

Question 1

(a) List **THREE (3)** types of basic materials.

(3 marks)

(b) Explain briefly **ONE (1)** of the above basic materials regarding its characteristic and applications.

(8 marks)

(c) Using the abbreviated quantum number notation (s, p, d, f), write the electronic configurations of the following ions:

(i) S^{2-} (Atomic number for sulfur = 16)

(ii) Ba^{2+} (Atomic number for barium = 56)

(iii) Sr^{2+} (Atomic number for strontium = 38)

(9 marks)

Question 2

(a) Show for the body-centered cubic crystal structure that the lattice parameter, *a* and the atomic radius, *r* are related through $a = \frac{4r}{\sqrt{3}}$.

(8 marks)

(b) Rhodium has an atomic radius of 0.1345 nm and a density of 12.41 g/cm^3. Verify whether it has an FCC or BCC crystal structure. Given, atomic weight of rhodium is 102.9 g/mol.

(8 marks)

(c) Sketch the **Schottky** and **Frenkel** defects.

(4 marks)

SECTION B (Total: 60 marks)

INSTRUCTION: Answer THREE (3) questions only.
Please use answer booklet provided.

Question 1

(a) Describe the **THREE (3)** categories in solubility.

(9 marks)

(b) By referring lead-tin alloy phase diagram in Figure 1 below, for 55% wt Pb-45% wt Sn at temperature 200°C,

(i) Determine the phases present.

(2 marks)

(ii) Determine the composition of Sn in the phases in Question 1b (i).

(4 marks)

(iii) Calculate the percentage of phases present.

(5 marks)

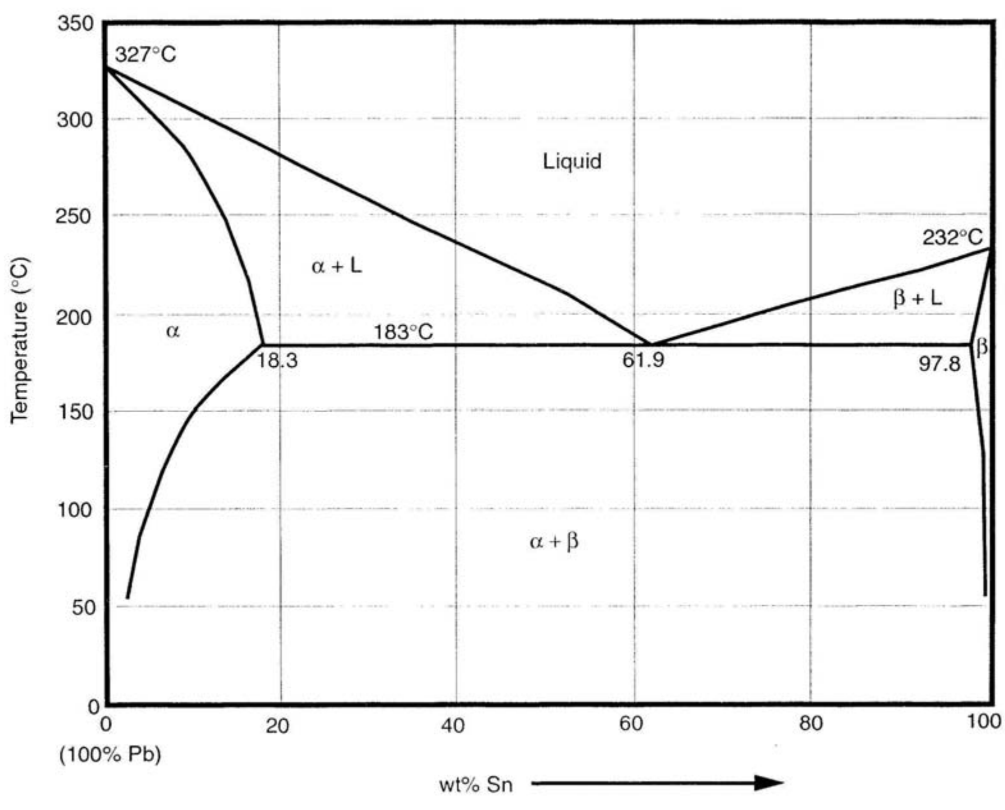

Figure 1: Lead – tin alloy phase diagram

Question 2

(a) Describe the bainite and martensite microstructure.

(6 marks)

(b) Time-temperature-transformation (TTT) diagram is normally used to predict microstructure during heat treatment. Based on the TTT diagram given in Appendix A, determine the resulting microstructure for 0.8% carbon steel if following heat treatment process is given to carbon steel in (i) to (iii).

(i) Cooling from the γ region to 180^oC within 1 second.

(3 marks)

(ii) Cooling within 10 seconds, then reheat to 250^oC within 30 seconds.

(3 marks)

(iii) If the resulting microstructure in Question (ii) above is reheated for 1 hour, then rapidly quench to room temperature.

(3 marks)

(iv) Sketch the thermal history from (i) to (iii) on a TTT.

(5 marks)

Question 3

(a) (i) Draw a typical stress-strain curve for brittle and ductile materials.

(4 marks)

(i) Compare these **TWO (2)** types of materials in terms of their toughness, hardness and strength.

(6 marks)

(b) For a bronze alloy, the stress at which plastic deformation begins is 275 MPa, and the modulus of elasticity is 115 GPa.

(i) Calculate the maximum load that may be applied to a specimen with a cross-sectional area of 325 mm^2 without plastic deformation.

(5 marks)

(ii) If the original specimen length is 115 mm, determine the maximum length to which it may be stretched without causing plastic deformation.

(5 marks)

Question 4

(a) Calculate the heat flux through a sheet of aluminum 10 mm thick if the temperatures at the two faces are 300 and 100^{o}C; assume steady-state heat flow.

(6 marks)

(b) Determine the heat loss per hour if the area of the sheet is 0.25 m^2.

(6 marks)

(c) Explain why, on a cold day, the metal door handle of an automobile feels colder to the touch than a plastic steering wheel, even though both are at the same temperature.

(8 marks)

END OF QUESTION

SUBJECT CODE: ______________________

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APPENDIX A

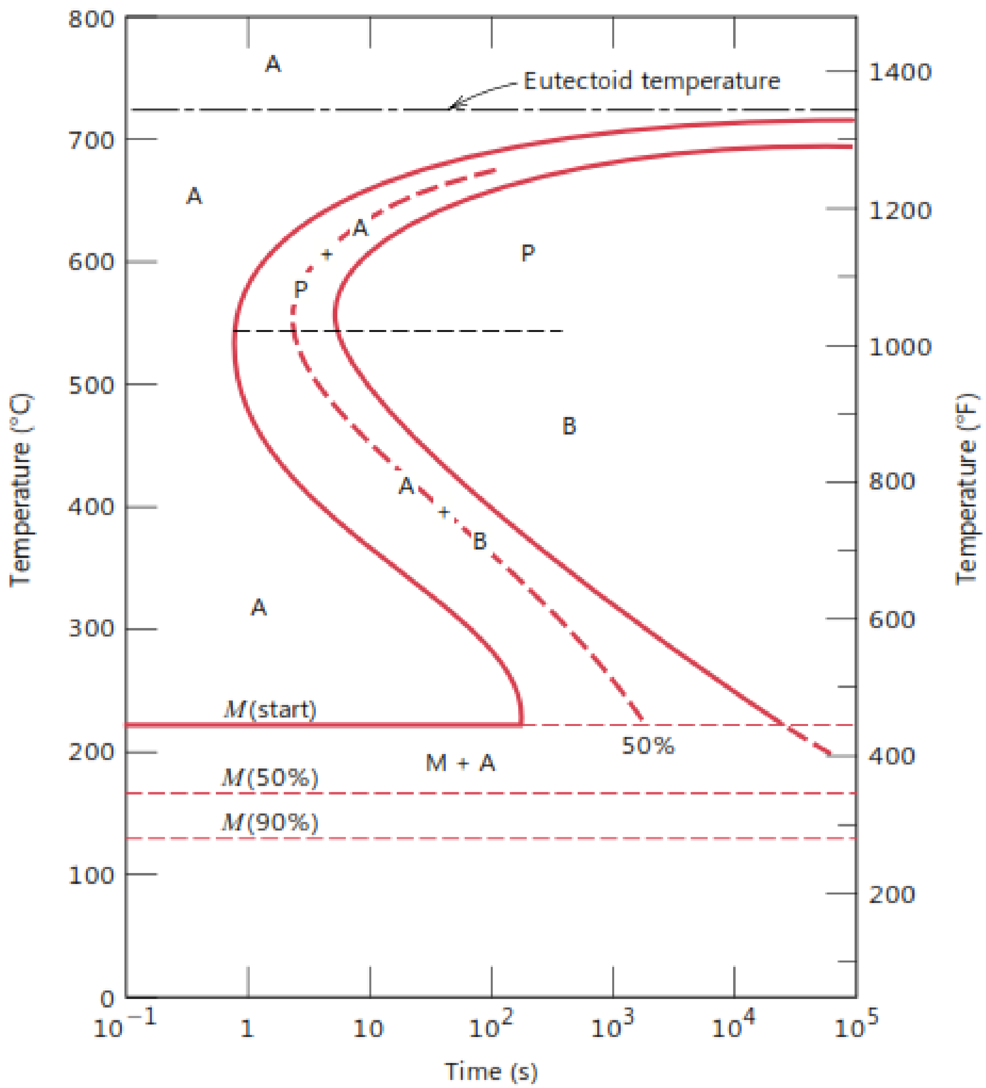

Figure 1: TTT diagram for 0.8% Carbon

APPENDIX B

Tabulation of the Thermal Properties for a Variety of Materials

Material	C_p (J/kg.K)	α_l [$(^oC)^{-1}$ x 10^{-5})	k (W/m.K)	L [Ω.W/(K)^2 x 10^{-8}]
		Metals		
Aluminum	900	23.6	247	2.20
Copper	386	17.0	398	2.25
Gold	128	14.2	315	2.50
Iron	448	11.8	80	2.71
Nickel	443	13.3	90	2.08
Silver	235	19.7	428	2.13
Tungsten	138	4.5	178	3.20
1025 Steel	486	12.0	51.9	-
316 Stainless Steel	502	16.0	15.9	-
Brass (70Cu-30Zn)	375	20.0	120	-
Kovar (54Fe-29Ni-17Co)	460	5.1	17	2.80
Invar (64Fe-36Ni)	500	1.6	10	2.75
Super Invar (63Fe-32Ni-5Co)	500	0.72	10	2.68
		Ceramics		
Alumina (Al_2O_3)	775	7.6	39	-
Magnesia (MgO)	940	13.5	37.7	-
Spinel ($MgAl_2O_4$)	790	7.6	15.0	-
Fused Silica (SiO_2)	740	0.4	1.4	-
Soda-lime Glass	840	9.0	1.7	-
Borosilicate (Pyrex) glass	850	3.3	1.4	-
		Polymers		
Polyethylene high density (HDPE)	1850	106-198	0.46-0.50	-
Polypropylene	1925	145-180	0.12	-
Polystyrene	1170	90-150	0.13	-
Polytetrafluoroethylene (Teflon)	1050	126-216	0.25	-
Phenol-formaldehyde, phenolic (Bakelite)	1590-1760	122	0.15	-
Nylon 6,6	1670	144	0.24	-
Polyisoprene	-	220	0.14	-

FORMULAE

$$APF = (n)(\frac{4\pi r^3}{3})(\frac{1}{a^3})$$

$$\rho = \frac{nA}{V_c N_A}$$

$$N = \frac{N_A \rho}{A}$$

$$N_v = Ne^{(\frac{-Q}{kT})}$$

$$a_{fcc} = \frac{4r}{\sqrt{2}}$$

$$a_{bcc} = \frac{4r}{\sqrt{3}}$$

$$a_{sc} = 2r$$

$$D = D_o e^{(\frac{-Q_d}{RT})}$$

$$m_\alpha\ phase = \frac{m_\beta - m_x}{m_\beta - m_\alpha} x Total\ Mass$$

$$m_\beta\ phase = \frac{m_x - m_\alpha}{m_\beta - m_\alpha} x Total\ Mass$$

$$m_L\ phase\% = \frac{m_s\% - m_x\%}{m_s\% - m_{L\%}} x100$$

$$m_s\ phase\% = \frac{m_x\% - m_L\%}{m_s\% - m_{L\%}} x100$$

$$\rho_\alpha = \frac{100}{\frac{C_{A(\alpha)}}{\rho_A} + \frac{C_{B(\alpha)}}{\rho_B}}$$

$$\rho_\beta = \frac{100}{\frac{C_{A(\beta)}}{\rho_A} + \frac{C_{B(\beta)}}{\rho_B}}$$

$$\Delta L = L_o \alpha_1 \Delta T$$

$$\Delta V = 3\alpha_1 V_o \Delta T$$

$$V_\alpha = \frac{\frac{m_\alpha}{\rho_\alpha}}{\frac{m_\alpha}{\rho_\alpha} + \frac{m_\beta}{\rho_\beta}}$$

$$V_\beta = \frac{\frac{m_\beta}{\rho_\beta}}{\frac{m_\alpha}{\rho_\alpha} + \frac{m_\beta}{\rho_\beta}}$$

$$\sigma = \frac{F}{A_o}$$

$$\varepsilon = \frac{\Delta l}{l_o}$$

$$E = \frac{\sigma}{\varepsilon}$$

$$\%elongation = \frac{\Delta l}{l_o} x100\%$$

$$\%\ area\ reduction = \frac{\Delta A}{A_o} x100\%$$

$$BHN = \frac{F}{\frac{\pi D}{2}(D - \sqrt{D^2 - d^2})}$$

$$VHN = \frac{1.85F}{d^2}$$

$$Q = \mathrm{mC}\theta$$

$$C = \frac{dQ}{dT}$$

$$q = -k\frac{dT}{dx}$$

$$Q = q\mathrm{At}$$