CONFIDENTIAL

SET A

UNIVERSITI KUALA LUMPUR
Malaysia France Institute

FINAL EXAMINATION
JANUARY 2014 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) Describe **ONE** (**1**) type of primary atomic bonding.

(5 Marks)

(b) Determine whether each of the electron configurations given below is an inert gas, a halogen, an alkali metal, an alkaline earth metal, or a transition metal. Justify your choices.

i. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^7$

ii. $1s^2 2s^2 2p^5$

(6 Marks)

(c) Polymer is one of the basic materials. Describe the general properties of polymer material and its applications in our daily lives.

(9 Marks)

Question 2

(a) Uranium has an orthorhombic unit cell, with a, b and c lattice parameters of 0.286, 0.587 and 0.495 nm, respectively.

Density: 19.05 g/cm^3 , Atomic Weight: 238.03 g/mol , Atomic radius: 0.1385 nm

Based on this information, calculate the atomic packing factor and compare that APF quantitatively with that of a BCC metal.

(9 marks)

(b) Describe the point defect that occurs in ceramic materials.

(5 marks)

(c) Explain the differences between interstitial and vacancy diffusion.

(6 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)

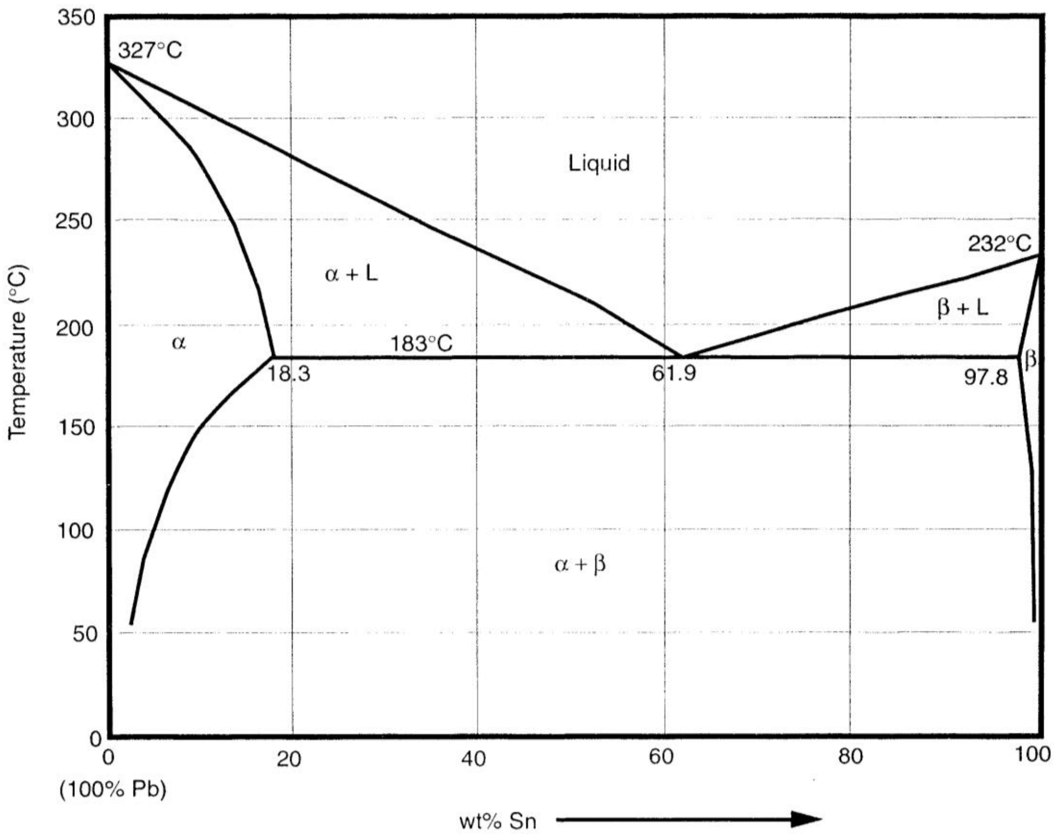

Figure 1: Lead – tin alloy phase diagram

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^{o}C within 1 second.

(3 marks)

(ii) Rapidly cooling from the γ region to 150^{o}C and held for 10 seconds, then reheat to 300^{o}C within 10 seconds.

(3 marks)

(iii) If the resulting microstructure in Question 2b (ii) above is heated for 1 hour, then rapidly quench to room temperature.

(3 marks)

(iv) Sketch the thermal history from Question 2b (ii) to (iii) on a TTT.

(5 marks)

Question 3

(a) Define:

i) ultimate tensile strength
ii) breaking strength
iii) elastic limit

(6 Marks)

(b) Show ALL points in Question 3(a) in a typical stress-strain curve.

(5 Marks)

(c) A cylindrical specimen of aluminum having a diameter of 19 mm and length of 200 mm is deformed elastically in tension with a force of 48,800 N. The modulus of elasticity is 69 GPa. Determine the amount of elongation in the direction of the applied stress.

(9 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.

(5 marks)

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

(5 marks)

(c) Explain why a brass lid ring on a glass canning jar will loosen when heated. Suppose the ring is made of tungsten instead of brass. Discuss the effect of heating the lid and jar.

(10 marks)

END OF QUESTION

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APPENDIX A

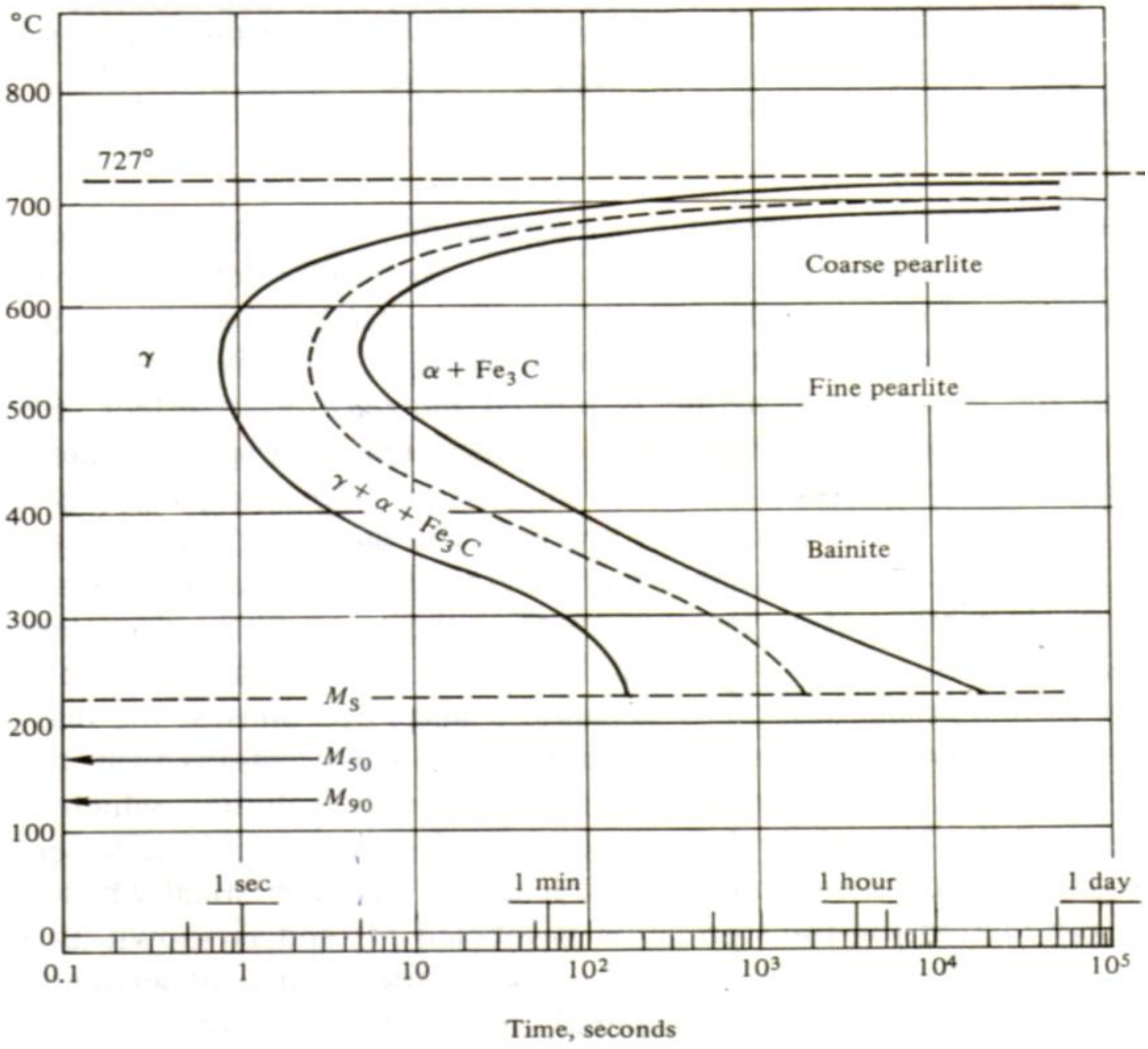

Figure 1: TTT diagram for 0.8% Carbon

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

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

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

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

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

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

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

$$a_{sc} = 2r$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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