CONFIDENTIAL

SET A

UNIVERSITI KUALA LUMPUR
Malaysia France Institute

FINAL EXAMINATION
JANUARY 2014 SESSION

SUBJECT CODE	:	**FTD 11403**
SUBJECT TITLE	:	**MATERIALS SCIENCE**
LEVEL	:	**DIPLOMA**
DURATION	:	**2 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 TWO (2) 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: 50 marks)

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

Question 1

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

(3 Marks)

(b) Composite is one of the engineering materials. Describe the general properties of composite material and its applications in our daily lives.

(9 Marks)

Question 2

(a) In the atomic and ionic arrangements, there are seven unique arrangements, known as Crystal Systems and a total of 14 distinct arrangements of lattice points, known as the Bravais Lattices.

i. Sketch Body Center Cubic (BCC) structure.

(4 Marks)

ii. Determine the coordination number for Face Centered Cubic (FCC).

(6 marks)

(b) Calculate the number of vacancies per cubic meter in iron at $850^{o}C$. The energy for vacancy formation is 1.08 eV/ atom. Its density is 7.65 g/cm^3. Given k is 8.62×10^{-5} eV/ atom. K and atomic weight of iron is 55.85 g/mol.

(8 marks)

Question 3

(a) State **THREE** (**3**) differences between covalent and ionic bonding.

(6 Marks)

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

i. Zinc (Atomic No. = 30)

ii. Phosphorus (Atomic No. = 15)

iii. Fluorine (Atomic No. = 9)

(9 Marks)

(c) Describe how the vacancy mechanism of diffusion occurs in materials.

(5 Marks)

SECTION B (Total: 50 marks)

INSTRUCTION: Answer TWO (2) questions only.
Please use answer booklet provided.

Question 1

(a) Describe the mechanism of heat conduction in solid material. Explain why heat conduction in metal is faster than non-metal.

(9 Marks)

(b) Refer to phase diagram (Lead-Tin Alloy) below:

i. Determine the maximum solubility of Pb in Sn and Sn in Pb.

(4 Marks)

ii. Calculate the amount of α and L at 184 ^{O}C for 38%Sn-62% Pb.

(6 marks)

iii. Calculate the amount of α and β at 182 ^{O}C for 38%Sn-62%Pb

(6 Marks)

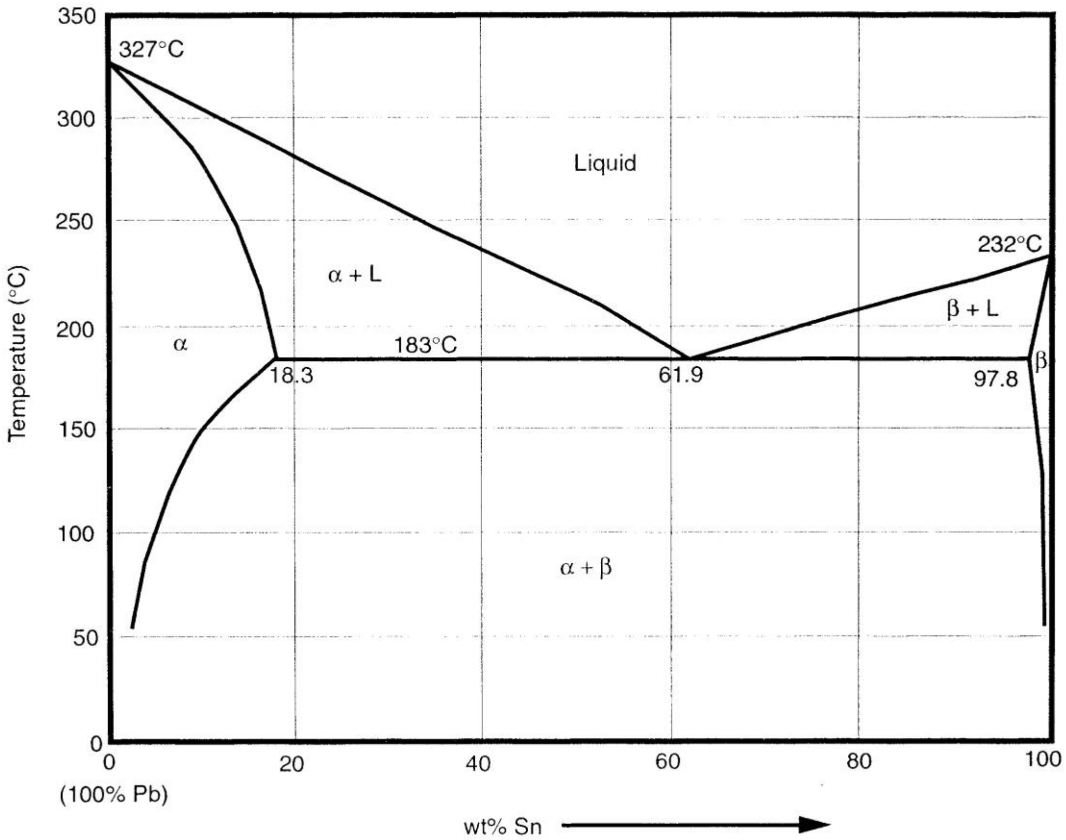

Figure 1: Lead – tin alloy phase diagram

Question 2

The following data have been obtained in a tensile test of a stainless steel specimen:

Stress (Mpa)	Strain
91	0.0006
490	0.0010
675	0.0016
730	0.0020
815	0.0030
855	0.0040
895	0.0050
910	0.0060
893	0.0070
860	0.0080
820	0.0090
795	0.0100

(a) Plot a stress-strain curve.

(15 Marks)

(b) From the plot, determine ultimate tensile strength and breaking strength.

(4 Marks)

(c) Determine modulus of elasticity.

(6 Marks)

Question 3

(a) Calculate the heat flux through a sheet of aluminum 12 mm thick if the temperatures at the two faces are 400 and 150^{o}C; assume steady-state heat flow.

(5 marks)

(b) Determine the heat loss per hour if the area of the sheet is 0.75 m^2.

(5 marks)

(c) 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 5 seconds.

(3 marks)

(ii) Rapidly cooling to 180^{o}C and held for 100 seconds, then reheat to 250^{o}C within 10 seconds.

(3 marks)

(iii) If the resulting microstructure in Question 3c (ii) above is heated for 1000 seconds, then rapidly quench to room temperature.

(3 marks)

(iv) Sketch the thermal history from Question 3c (i) to (iii) on a TTT.

(6 marks)

END OF QUESTION

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APPENDIX A

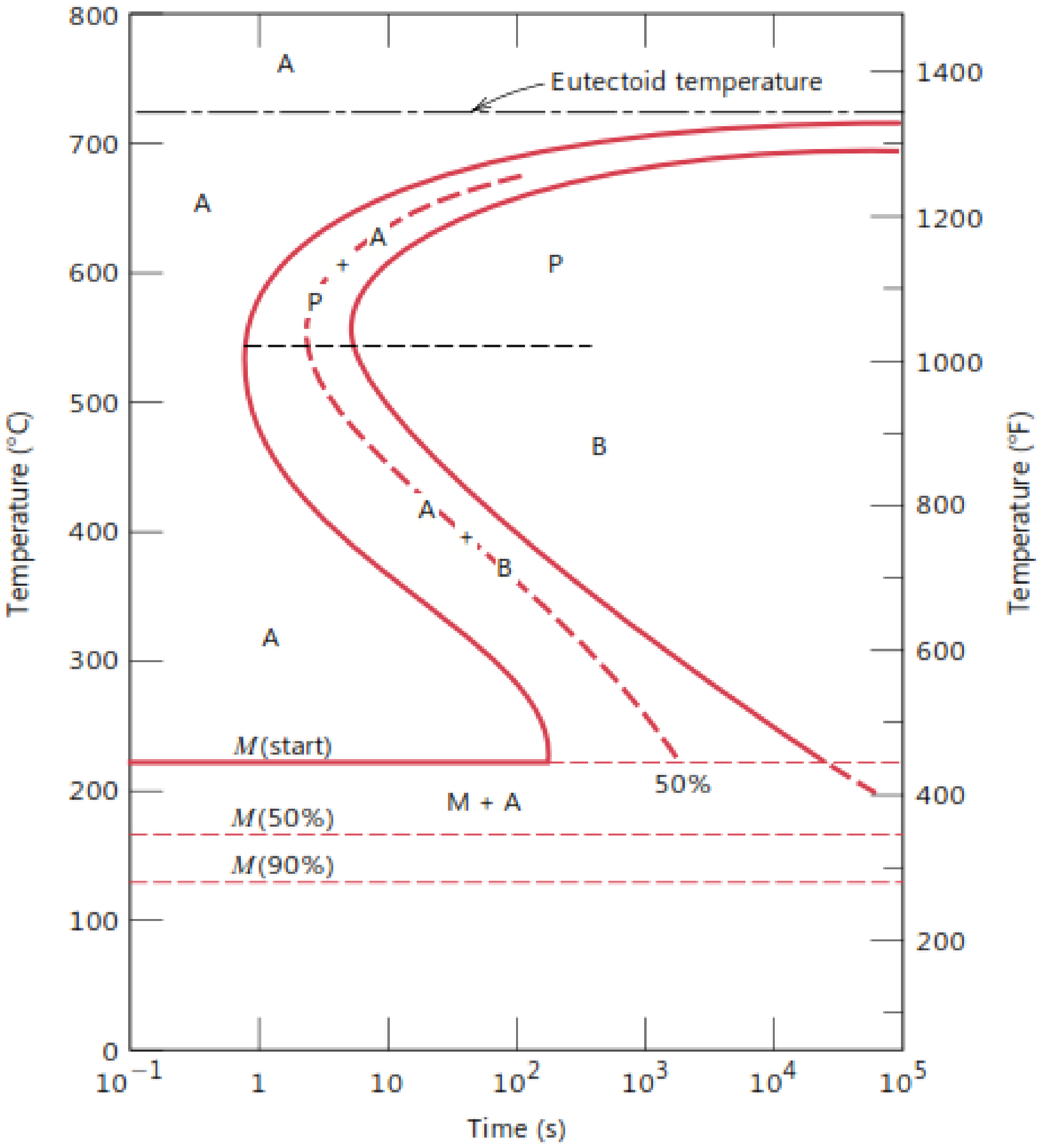

Figure 1: TTT diagram for 0.8% Carbon

APPENDIX B

Tabulation of the Thermal Properties for a Variety of Materials

Material	C_p (J/kg.K)	α_l $[(^oC)^{-1} \times 10^{-5})$	k (W/m.K)	L $[\Omega.W/(K)^2 \times 10^{-8}]$
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

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

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

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

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

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

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

$$a_{sc} = 2r$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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