**CONFIDENTIAL**

**SET A**

# UNIVERSITI KUALA LUMPUR
## Malaysia France Institute

# FINAL EXAMINATION
# SEPTEMBER 2014 SESSION

| | | |
|---|---|---|
| **SUBJECT CODE** | : | **FTD11403** |
| **SUBJECT TITLE** | : | **MATERIALS SCIENCE** |
| **LEVEL** | : | **DIPLOMA** |
| **TIME / DURATION** | : | **12.45 PM – 2.45 PM<br>(2 HOURS)** |
| **DATE** | : | **31 DECEMBER 2014** |

## 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 3 PRINTED PAGES OF QUESTIONS AND 2 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 composite material based on reinforcement types. Sketch the structure of the composites that you have listed.

(9 Marks)

(b) Ceramic is one of the basic materials. Describe the general properties of ceramic material and its applications in our daily lives.

(11 Marks)

### Question 2

(a) In the atomic and ionic arrangements, there are 14 distinct arrangements of lattice points, known as the Bravais Lattices. Cubic system is the one of the crystal system. Sketch Face Centered Cubic (FCC) structure.

(4 Marks)

(b) Nickel forms a FCC structure and has an atomic radius of 1.246Å. Calculate the volume if its unit cell.

(6 marks)

### Question 3

(a) State **THREE** (**3**) types of imperfection in crystal structure.

(3 Marks)

(b) Calculate the energy for vacancy formation in silver, given that the equilibrium number of vacancies at 800$^{o}$C is 3.6 x $10^{23}$ $m^{-3}$. The atomic weight and density (at 800$^{o}$C) for silver are, respectively, 107.9 g/ mol and 9.5 g/$cm^3$. Assume the gas constant is 8.62 x $10^{-5}$ eV/atom.K.

(9 Marks)

(c) Describe the interstitial mechanism of diffusion.

(8 Marks)

## SECTION B (Total: 50 marks)

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

**Question 1**

(a) Refer to Figure 1 below, state the type of phase diagram for Pb-Sn alloy. Define the solidus and liquidus line.

(6 marks)

(b) Determine the phases present at 200$^{o}$C for an 70Pb-30Sn alloy. Predict the percentage amount of each phase present at 200$^{o}$C.

(12 marks)

(c) Define a eutectic point. Determine the eutectic composition and eutectic temperature for Pb-Sn alloy.

(7 marks)

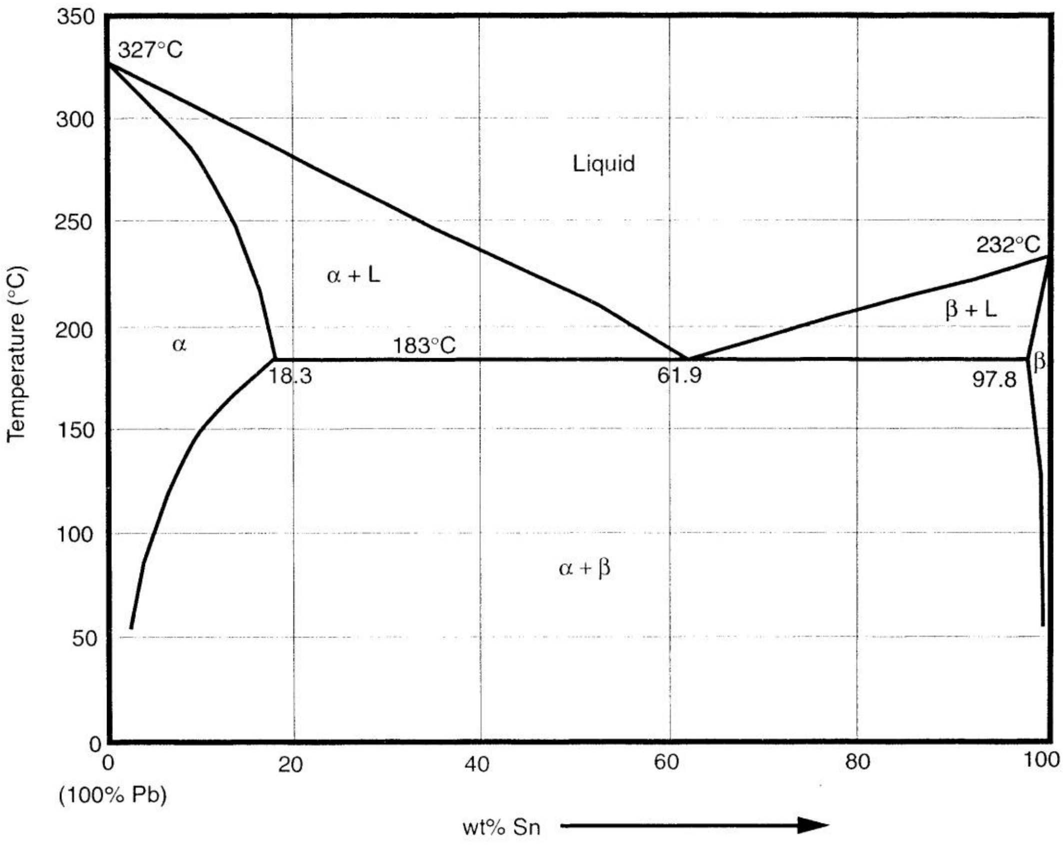


Figure 1: Pb-Sn alloy phase diagram

**Question 2**

(a) When a metal is heated its density decreases. There are two sources that give rise to this diminishment of: the thermal expansion of the solid, and the formation of vacancies. Consider a specimen of copper at room temperature ($20^{o}C$) that has a density of 8.940 $g/cm^3$. Determine its density upon heating to $1000^{o}C$ when only thermal expansion is considered.

(7 marks)

(b) By using the aid of sketch, explain the mechanism of heat transfer and thermal conduction of a heated rod metal.

(10 marks)

(c) Describe the differences between bainite and pearlite microstructure.

(8 marks)

**Question 3**

(a) A flat mild steel specimen having an original thickness of 6 mm, width of 25.4 mm and gauge length of 50.80 mm is pulled in tension until fracture occurs. The area at the point of fracture is 101.50 $mm^2$, and the fractured gauge length is 72.14 mm. Calculate the ductility in terms of percent reduction in area and percent elongation.

(8 Marks)

(b) If the specimen in Question 3(a) above is deformed elastically with the amount of elongation is 0.5 mm when the tension load of 48 kN is applied, determine modulus of elasticity.

(9 Marks)

(c) A Vickers hardness measurement, using 500 g load, produces an indentation of 68 µm on a sample.

i. Determine the Vickers hardness number (HV) of the sample.

(3 marks)

ii. Sketch the top view the shape of indentation.

(5 marks)

**END OF QUESTION**

# APPENDIX A

## Tabulation of the Thermal Properties for a Variety of Materials

| Material | $C_p$ (J/kg.K) | $\alpha_l$ [$(^oC)^{-1} \times 10^{-6}$] | 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

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

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

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

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

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

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

$$a_{sc} = 2r$$

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

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

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

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

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

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

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

$$\Delta L = L_o \alpha_l \Delta T$$

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

$$\Delta V = \alpha_v V_o \Delta T$$

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

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

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

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

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

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

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

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

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

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

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

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

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