



Final Examination  
2018/2019 Academic Session

June 2019

**JIF419 – Materials Science  
(Sains Bahan)**

Time : 3 hours  
(Masa : 3 jam)

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Please check that this examination paper consists of **NINE (9)** pages of printed material before you begin the examination.

*[Sila pastikan bahawa kertas peperiksaan ini mengandungi **SEMBILAN (9)** muka surat yang bercetak sebelum anda memulakan peperiksaan ini].*

**Instructions** : Answer **ALL** questions. You may answer **either** in Bahasa Malaysia or in English.

**Arahan** : Jawab **SEMUA** soalan. Anda dibenarkan menjawab soalan **sama ada** dalam Bahasa Malaysia atau Bahasa Inggeris].

In the event of any discrepancies, the English version shall be used.

*[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah digunapakai].*

**Useful Information:**

Avogadro's number,  $N_A = 6.022 \times 10^{23}$  molecules mol<sup>-1</sup>

Gas constant,  $R = 8.31$  J mol<sup>-1</sup> K<sup>-1</sup>

Gravitational acceleration,  $g = 9.81$  m s<sup>-2</sup>

Table 1

## A Tabulation of Diffusion Data

<i>Diffusing Species</i>	<i>Host Metal</i>	$D_0$ (m <sup>2</sup> / s)	$Q_d$ (J / mol)
<b>Interstitial Diffusion</b>			
C <sup>b</sup>	Fe( $\alpha$ or BCC) <sup>a</sup>	$1.1 \times 10^{-6}$	87,400
C <sup>c</sup>	Fe( $\gamma$ or FCC) <sup>a</sup>	$12.3 \times 10^{-5}$	148,000
N <sup>b</sup>	Fe( $\alpha$ or BCC) <sup>a</sup>	$5.0 \times 10^{-7}$	77,000
N <sup>c</sup>	Fe( $\gamma$ or FCC) <sup>a</sup>	$9.1 \times 10^{-5}$	168,000
<b>Self-Diffusion</b>			
Fe <sup>c</sup>	Fe( $\alpha$ or BCC) <sup>a</sup>	$2.8 \times 10^{-4}$	251,000
Fe <sup>c</sup>	Fe( $\gamma$ or FCC) <sup>a</sup>	$5.0 \times 10^{-5}$	284,000
Cu <sup>d</sup>	Cu(FCC)	$2.5 \times 10^{-5}$	200,000
Al <sup>c</sup>	Al(FCC)	$2.3 \times 10^{-4}$	144,000
Mg <sup>c</sup>	Mg(HCP)	$1.5 \times 10^{-4}$	136,000
Zn <sup>c</sup>	Zn(HCP)	$1.5 \times 10^{-5}$	94,000
Mo <sup>d</sup>	Mo(BCC)	$1.8 \times 10^{-4}$	461,000
Ni <sup>d</sup>	Ni(FCC)	$1.9 \times 10^{-4}$	285,000
<b>Interdiffusion (Vacancy)</b>			
Zn <sup>c</sup>	Cu(FCC)	$2.4 \times 10^{-5}$	189,000
Cu <sup>c</sup>	Zn(HCP)	$2.1 \times 10^{-4}$	124,000
Cu <sup>c</sup>	Al(FCC)	$6.5 \times 10^{-5}$	136,000
Mg <sup>c</sup>	Al(FCC)	$1.2 \times 10^{-4}$	130,000
Cu <sup>c</sup>	Ni(FCC)	$2.7 \times 10^{-5}$	256,000
Ni <sup>d</sup>	Cu(FCC)	$1.9 \times 10^{-4}$	230,000

Table 2

Table of room-temperature elastic and shear moduli and poisson ratio for various metal alloys

<b>Metal Alloy</b>	<b>Modulus of Elasticity</b>		<b>Shear Modulus</b>		<b>Poisson's Ratio</b>
	<b>GPa</b>	<b>10<sup>6</sup> psi</b>	<b>GPa</b>	<b>10<sup>6</sup> psi</b>	
Aluminum	69	10	25	3.6	0.33
Brass	97	14	37	5.4	0.34
Copper	110	16	46	6.7	0.34
Magnesium	45	6.5	17	2.5	0.29
Nickel	207	30	76	11.0	0.31
Steel	207	30	83	12.0	0.30
Titanium	107	15.5	45	6.5	0.34
Tungsten	407	59	160	23.2	0.28

Answer **ALL** Questions.

1. (a). (i). Define a unit cell and list four from all the seven crystal systems.  
*Takrifkan sel unit dan senaraikan empat daripada kesemua tujuh sistem kristal.*

(6 marks/markah)

- (ii). List all the body centered lattice type and face centered lattice type for the crystal systems.

*Senaraikan semua jenis kekisi berpusat jasad dan kekisi berpusat muka untuk sistem kristal tersebut.*

(4 marks/markah)

- (b). (i). Describe the differences between the face centered cubic (FCC) and hexagonal closed packed (HCP) in term of stacking sequence.

*Tentukan perbezaan antara kekisi berpusatkan muka (FCC) dan heksagon terpadat rapat (HCP) dari segi jujukan susunan.*

(6 marks/markah)

- (ii). Illustrate a stacking fault in the FCC crystal structures using the stacking sequence notation, (e.g. for a region of perfect FCC crystal: ABCABCABC).

*Gambarkan kesilapan susunan dalam struktur hablur kristal FCC menggunakan notasi jujukan susunan, (contohnya untuk kawasan hablur kristal FCC yang sempurna: ABCABCABC).*

(4 marks/markah)

2. (a). (i). With the help of a diagram, describe the mechanism of diffusion.  
*Dengan bantuan satu gambar rajah, perihalkan mekanisma peresapan.*
- (6 marks/markah)
- (ii). Briefly explain the most important factor that influence diffusion.  
*Terangkan secara ringkas faktor paling penting yang mempengaruhi peresapan.*
- (4 marks/markah)
- (b). Determine the values of the diffusion coefficients for the inter-diffusion of carbon in both  $\alpha$ -iron (BCC) and  $\gamma$ -iron (FCC) at 900 °C. Which one is larger? Explain why this is the case.  
*Tentukan nilai pekali peresapan untuk peresapan karbon antara kedua-dua  $\alpha$ -besi (BCC) and  $\gamma$ -besi (FCC) pada 900 °C. Yang mana satukah yang lebih besar? Terangkan mengapa ini berlaku.*
- (10 marks/markah)
3. (a). A cylindrical specimen of aluminum having diameter of 20 mm and length 210 mm is deformed elastically in tension with a force 48 800 N.  
Calculate the:  
*spesimen silinder aluminium dengan diameter 20 mm dan panjang 210 mm berubah mengalami canggaaan elastik dalam tegangan oleh daya 48 800 N. Hitung:*
- (i). elongation in the direction of the applied stress.  
*Nilai pemanjangan spesimen mengikut arah tegasan.*
- (ii). change in diameter of the specimen.  
*perubahan diameter spesimen.*
- (10 marks/markah)

- (b). Stress-strain curves are shown in Figure 1. Which is the safest material and explain why?

*Keluk tegasan-terikan ditunjukkan pada Rajah 1. Bahan manakah yang paling selamat dan terangkan mengapa?*

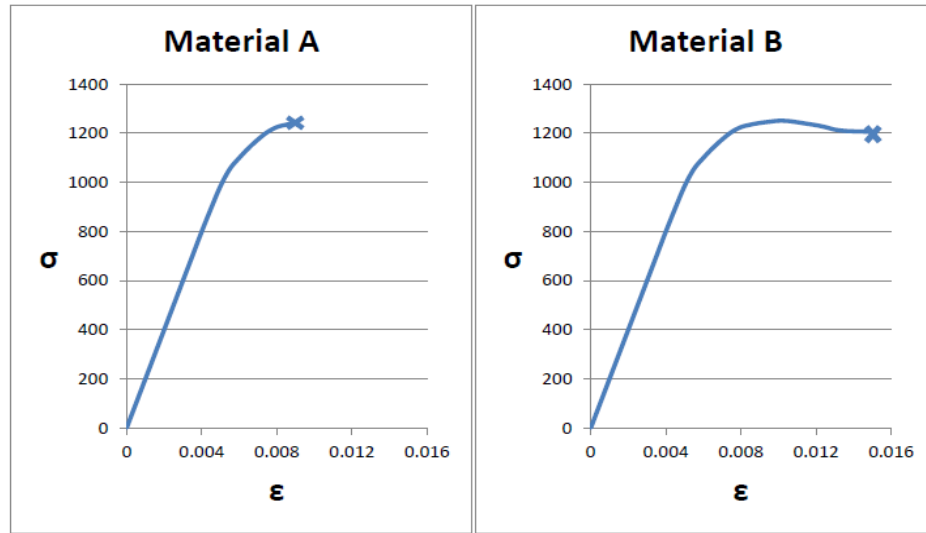


Figure 1  
Rajah 1

(5 marks/markah)

- (c). Label the stress strain curve in Figure 2.

*Labelkan keluk tegasan-terikan pada Rajah 2.*

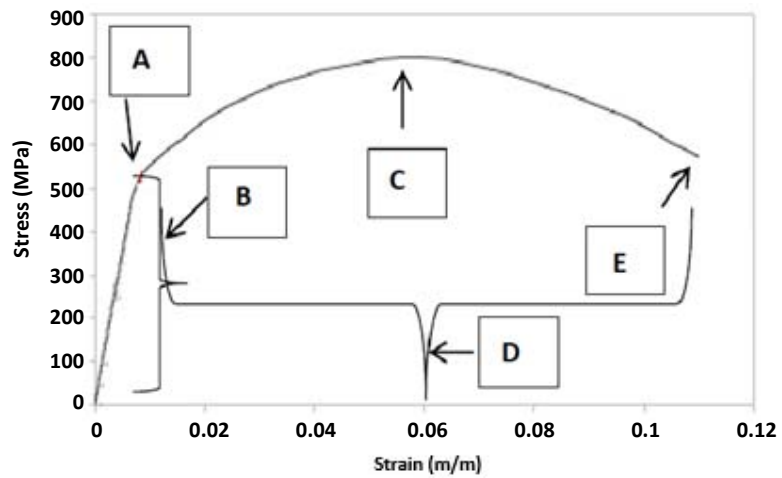


Figure 2  
Rajah 2

(5 marks/markah)

...7/-

4. (a). Explain the development of microstructure during the equilibrium solidification of a 35 wt% Ni-65 wt% Cu alloy as shown in Figure 3.

*Jelaskan perkembangan mikrostruktur semasa pemejalan keseimbangan aloi 35 wt% Ni-65 wt% Cu seperti pada Rajah 3.*

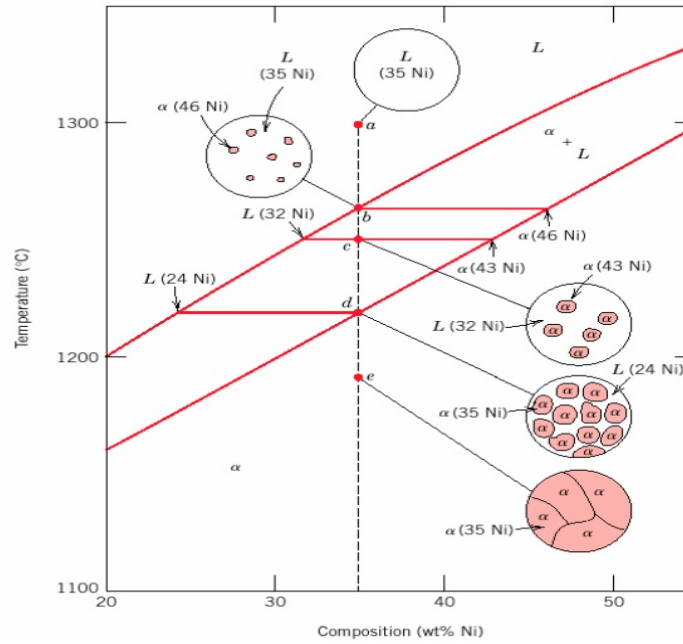


Figure 3  
Rajah 3

(10 marks/markah)

- (b). The Pb-Sn eutectic system is shown in Figure 4. Consider a 40 wt% Sn-60 wt% Pb alloy on the Pb-Sn eutectic system at 150 °C:

*Sistem eutektik Pb-Sn ditunjukkan pada Rajah 4. Pertimbangkan aloi 40 wt% Sn-60 wt% Pb terhadap sistem eutektik Pb-Sn pada 150 °C:*

- (i). What phase(s) is (are) present?

*Apakah fasa yang wujud?*

- (ii). What is (are) the composition(s) of the phase(s)?

*Apakah komposisi fasa?*

- (iii). What is the relative amount of each phase present?

*Berapakah jumlah relatif setiap fasa yang wujud?*

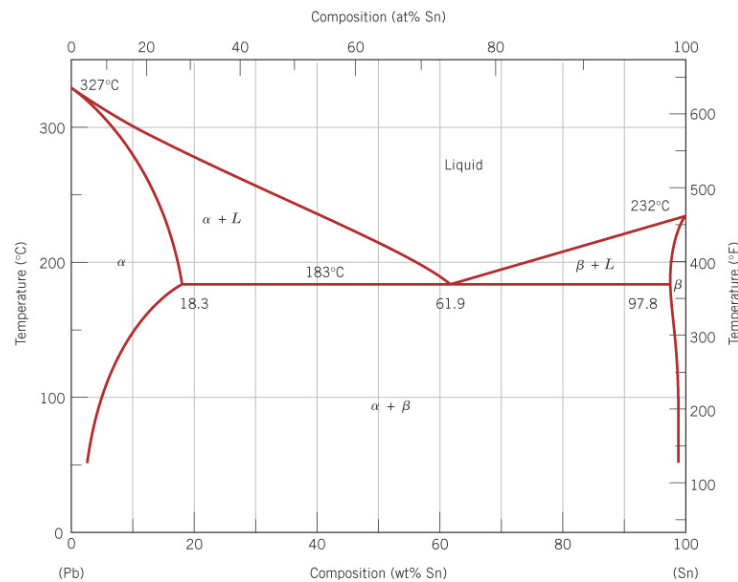


Figure 4  
Rajah 4

(10 marks/markah)

...9/-



5. (a). Describe the differences between paramagnetic and ferromagnetic substance. (Please answer in a table format)

*Terangkan perbezaan di antara bahan paramagnet dan ferromagnet. (Sila jawab dalam format jadual)*

(10 marks/markah)

- (b). With the help of a diagram, describe the behavior of magnetic field lines in (i). paramagnetism and (ii). diamagnetism. Explain the distinguishing feature.

*Dengan bantuan satu gambar rajah, jelaskan kelakuan garis medan magnet dalam (i). paramagnetisma dan (ii). diamagnetisma. Terangkan sifat yang membezakannya.*

(10 marks/markah)

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