
UNIVERSITI SAINS MALAYSIA

Second Semester Examination
Academic Session 2007/2008

April 2008

EBB 220/3 - Engineering Polymer **[Polimer Kejuruteraan]**

Duration : 3 hours
[Masa : 3 jam]

Please ensure that this examination paper contains NINE printed pages before you begin the examination.

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

This paper contains SEVEN questions. TWO questions in PART A and FIVE questions in PART B.

[Kertas soalan ini mengandungi TUJUH soalan. DUA soalan di BAHAGIAN A dan LIMA soalan di BAHAGIAN B.]

Instructions: Answer **FIVE** questions. Answer **ALL** questions from PART A and **THREE** questions from PART B. If a candidate answers more than five questions only the first five questions in the answer sheet will be graded.

[Arahan: Jawab **LIMA** soalan. Jawab **SEMUA** soalan dari BAHAGIAN A dan **TIGA** soalan dari BAHAGIAN B. Jika calon menjawab lebih daripada lima soalan hanya lima soalan pertama mengikut susunan dalam skrip jawapan akan diberi markah.]

Answer to any question must start on a new page.

[Mulakan jawapan anda untuk setiap soalan pada muka surat yang baru.]

You may answer a question either in Bahasa Malaysia or in English.

[Anda dibenarkan menjawab soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.]

PART A**BAHAGIAN A**

1. [a] Using suitable diagrams explain the structural differences between linear, branched, cross-linked and network polymers. Based on structural aspects, comment on mechanical and thermal properties of these polymers.

Bezakan dengan jelas struktur polimer linear, bercabang, tersambung silang dan jaringan dengan menggunakan diagram yang sesuai. Berdasarkan aspek struktur, komen mengenai sifat-sifat mekanikal dan terma bagi polimer linear, bercabang, tersambung silang dan jaringan.

(35 marks/markah)

- [b] Figure 1 shows the dependence of melting temperatures (T_m) on molecular weight (M_w) of polymer. Describe the significance of the M_w in terms of T_m for low and high M_w polymer.

Rajah 1 menunjukkan kebergantungan takat lebur (T_m) terhadap berat molekul (M_w) polimer. Terangkan kesan berat molekul (M_w) suhu peleburan (T_m) bagi polimer ynag mempunyai berat molekul tinggi dan rendah.

(35 marks/markah)

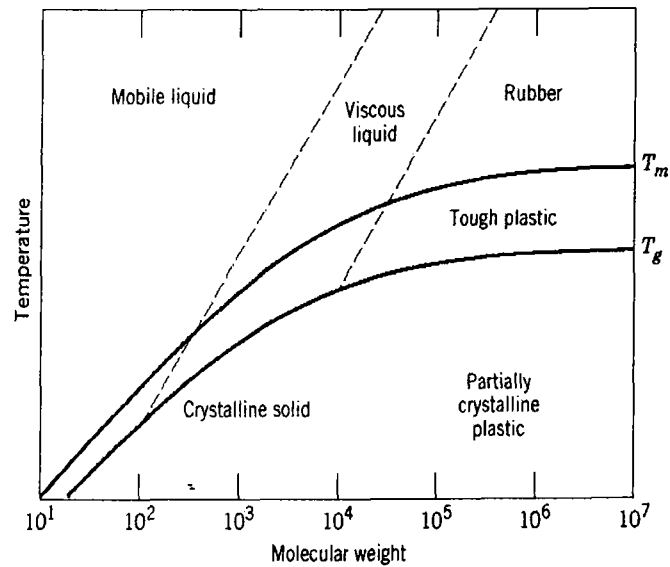


Figure 1 - Dependence of melting temperatures (T_m) on molecular weight (M_w) of polymer.

Rajah 1 - Kebergantungan takat lebur (T_m) terhadap jisim molekul (M_w) relatif polimer.

- [c] Mechanical properties of polymers include strength, modulus and toughness. Define these properties and explain them with respect to tensile stress and strain curve.

Sifat-sifat mekanikal polimer termasuklah kekuatan, modulus dan kemuluran. Jelaskan dan terangkan sifat-sifat tersebut dengan merujuk kepada graf tegasan melawan terikan.

(30 marks/markah)

2. [a] What is a viscoelastic material? Using suitable models relate its response to applied stresses and compare it with elastic solid and viscous liquid materials.

Terangkan apakah yang dimaksudkan dengan bahan viskoelastik. Dengan menggunakan model-model yang bersesuaian kaitkan tindakbalas bahan ini terhadap tegasan yang dikenakan dan bandingkan dengan bahan pepejal elastik dan cecair likat.

(50 marks/markah)

- [b] A polymer melt behaves according to the following flow equation $\tau = \dot{\gamma}^{1.5}$:

- (i) What type of liquid is it?
- (ii) Express the apparent viscosity as a function of shear rate ($\dot{\gamma}$) for the chosen liquid
- (iii) Express the shear stress (τ) as a function of shear rate ($\dot{\gamma}$) for the chosen liquid

Leburan polimer bersifat seperti persamaan aliran berikut $\tau = \dot{\gamma}^{1.5}$:

- (i) *Apakah jenis cecair ini?*
- (ii) *Tunjukkan kelikatan ketara dengan fungsi kadar ricih ($\dot{\gamma}$) bagi cecair tersebut*
- (iii) *Tunjukkan tegasan ricih (τ) dengan fungsi kadar ricih ($\dot{\gamma}$) bagi cecair tersebut*

(50 marks/markah)

PART B**BAHAGIAN B**

3. [a] Draw the possible tacticity of each polymer listed below (i – vi) and name them accordingly. Some of these polymers may have more than one form of tacticity.

Lukiskan ketaktikan bagi setiap polimer (i – vi) dan namakan ketaktikan yang bersesuaian. Sebahagian daripada polimer-polimer berikut mempunyai lebih daripada satu ketaktikan.

- (i) $\text{CH}_2 = \text{CH} (\text{C}_2\text{H}_5)$
- (ii) $\text{CH}_2 = \text{CH} (\text{OH})$
- (iii) $\text{CH}_2 = \text{CH} (\text{CH}_3)$
- (iv) $\text{CH}_2 = \text{CHF}$
- (v) $\text{CH}_2 = \text{CCl}_2$
- (vi) $\text{CH}_2 = \text{C}(\text{CH}_3)_2$

(40 marks/markah)

- [b] Draw alternative polymer structures that can be formed from the isoprene molecule (Figure 2) and describe the geometrical isomerism by referring to a suitable example of polymeric material.

Lakarkan dengan jelas struktur alternatif polimer bagi molekul isoprene (Rajah 2) dan terangkan keisomeran geometri dengan merujuk kepada contoh polimer yang sesuai.

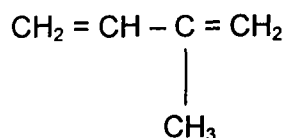


Figure 2 - Isoprene molecule

Rajah 2 - Molekul isoprena

(30 marks/markah)

- [c] Tensile deformation of semi crystalline polymers involved a series of mechanisms and stages. Explain the mechanism and stages of the tensile deformation.

Deformation polimer separa hablur melibatkan beberapa siri mekanisma dan peringkat. Terangkan setiap peringkat dan mekanisma pembentukan polimer separa hablur.

(30 marks/markah)

4. [a] The stress-strain curve of polymer provides significance information pertaining to its mechanical behaviour. Referring to tensile stress-strain curve summarized in Figure 3, describe the characteristics of polymers (a, b and c) by taking into account their mechanical properties and microstructural features.

Graf tegasan melawan terikan polimer memberikan banyak maklumat mengenai sifat-sifat mekanikal polimer. Berdasarkan lakaran kurva tegasan terikan ujian tegangan yang di dalam Rajah 3, terangkan sifat-sifat polimer-polimer (a, b dan c) dengan memberikan penekanan terhadap sifat-sifat mekanikal dan mikrostrukturnya.

(40 marks/markah)

- [b] State the differences between melting temperature (T_m) and glass transition temperature (T_g) of polymers.

Berikan perbezaan-perbezaan di antara suhu peleburan (T_m) dan suhu peralihan kaca (T_g) bagi polimer.

(30 marks/markah)

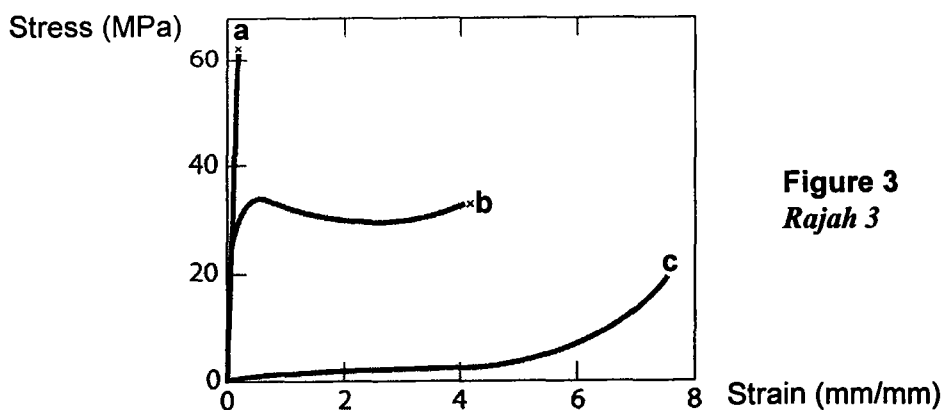


Figure 3
Rajah 3

- [c] Outline typical example of addition and condensation polymerizations of polyethylene (PE) and Nylon-6,6 respectively.

Berikan masing-masing contoh tipikal bagi pempolimeran tambahan dan kondensasi bagi polyetilena PE dan Nilon-6,6.

(30 marks/markah)

5. [a] Briefly describe how creep test and stress relaxation test are performed.

Terangkan secara ringkas bagaimana untuk menjalankan ujian rayapan dan ujian santaian tegasan dijalankan.

(30 marks/markah)

- [b] Discuss the effect of temperature on creep properties of a polymer.

Bincangkan kesan suhu ke atas sifat-sifat rayapan polimer.

(30 marks/markah)

- [c] Explain why rheological studies are important in the polymer processing?

Terangkan mengapa kajian reologi penting dalam pemprosesan bahan polimer?

(20 marks/markah)

- [d] Define the meaning of thermoplastic elastomer and cite ONE advantage of this material.

Terangkan maksud elastomer termoplastik dan nyatakan SATU kelebihan bahan ini.

(20 marks/markah)

6. [a] Briefly compare compression, injection and transfer molding techniques that are used to form plastic materials.

Bandungkan secara ringkas teknik-teknik pengacuanan mampatan, suntikan acuan dan pengacuanan pindah yang digunakan bagi penghasilan bahan plastik.

(40 marks/markah)

- [b] What are plasticizers? Why are they used in some polymeric materials? How do plasticizers usually affect the strength and flexibility of polymeric materials?

Apakah pemplastikan? Mengapakah bahan ini digunakan di dalam sesetengah bahan-bahan polimer? Bagaimana pemplastikan mempengaruhi kekuatan dan kebolehlenturan bahan-bahan polimer?

(40 marks/markah)

- [c] What is the distinction between dye and colorants pigment?

Apakah perbezaan di antara dai dan pewarna pigmen?

(20 marks/markah)

7. [a] What are the functions of resin in a long fiber composites at high fiber concentrations?

Apakah tujuan resin di dalam komposit gentian panjang pada kandungan gentian yang tinggi?

(30 marks/markah)

- [b] List TWO important advantages of hybrid composites over normal fiber composites.

Senaraikan DUA kelebihan komposit hibrid jika dibandingkan dengan komposit gentian yang normal.

(20 marks/markah)

- [c] Write short notes on the following topics:
- (i) Weight average molecular weight
 - (ii) Number average molecular weight
 - (iii) Viscosity average molecular weight
 - (iv) Molecular weight distribution

Tuliskan nota ringkas mengenai tajuk-tajuk di bawah:

- (i) *Berat molekul purata berat*
- (ii) *Berat molekul purata nombor*
- (iii) *Berat molekul purata kelikatan*
- (iv) *Taburan berat molekul*

(50 marks/markah)