UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2010/2011

November 2010

EBP 202/3 - Polymer Structure
[Struktur Polimer]

Duration : 3 hours
[Masa : 3 jam]

Please ensure that this examination paper contains TEN printed pages before you begin the examination.
[Sila pastikan bahawa kertas peperiksaan ini mengandungi SEPULUH muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]

This paper consists of SEVEN questions. ONE question in PART A, THREE questions in PART B and THREE questions in PART C.
[Kertas soalan ini mengandungi TUJUH soalan. SATU soalan di BAHAGIAN A, TIGA soalan di BAHAGIAN B dan TIGA soalan di BAHAGIAN C.]

Instruction: Answer **FIVE** questions. Answer **ALL** questions from PART A, **TWO** questions from PART B and **TWO** questions from PART C. If candidate answers more than five questions only the first five questions answered in the answer script would be examined.
*[**Arahan**: Jawab **LIMA** soalan. Jawab **SEMUA** soalan dari BAHAGIAN A, **DUA** soalan dari BAHAGIAN B dan **DUA** soalan dari BAHAGIAN C. Jika calon menjawab lebih daripada lima soalan hanya lima soalan pertama mengikut susunan dalam skrip jawapan akan diberi markah.]*

The answers to all questions must start on a new page.
[Mulakan jawapan anda untuk semua 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.]

In the event of any discrepancies, the English version shall be used.
[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai.]

…2/-

PART A

BAHAGIAN A

1. [a] Discuss the five regions of viscoelastic behavior of polystyrene based on a log storage modulus (E')-temperature (T) plot.

Bincangkan lima kawasan kelakuan kelikatkenyalan bagi polistirena berdasarkan satu plot log modulus simpanan (E')-suhu (T).

(50 marks/*markah*)

[b] Imagine that you are conducting tensile test for a Low Density Polyethylene (LDPE) sample using a dumbbell shape specimen. At certain extent of your experiment, you observed that the sample starts to become whitish as the sample is pulled further. The phenomenon continues until the sample breaks completely.

With the aid of an expected stress-strain curve, explain what actually happens when the sample become whitish. Also, discuss the importance of this phenomenon in developing an enhanced polymer structure.

Bayangkan anda sedang menjalankan ujian tensil bagi suatu sampel Polietilena Berketumpatan Rendah (LDPE) menggunakan spesimen berbentuk "dumbbell". Selepas beberapa ketika, anda dapati sampel tersebut mula menjadi keputih-putihan semasa sampel itu ditarik dengan lebih lanjut. Fenomena tersebut berterusan sehingga sampel tersebut putus sepenuhnya.

Dengan bantuan lengkungan tegasan-terikan yang dijangka, terangkan apakah yang sebenarnya berlaku apabila sampel menjadi keputih-putihan. Juga, bincangkan kepentingan fenomena itu dalam menghasilkan suatu peningkatan dalam struktur polimer.

(50 marks/*markah*)

PART B

BAHAGIAN B

2. [a] Draw the following configuration of polystyrene in zig-zag planar.

(i) isotactic

(ii) atactic

(iii) syndiotactic

Lukiskan konfigurasi bagi polistirena dalam satah zig-zag seperti yang berikut:

(i) isotaktik

(ii) ataktik

(iii) sindiotaktik

(30 marks/*markah*)

[b] A linear polyethylene has a weight average molecular weight (M_w) of 6×10^5 and polydispersity index of 1.5. Given that the bond length of C-C and bond angle is 0.154 nm and 109.5^o respectively. The bond rotation is 60^o. Calculate the following.

(i) root mean square (RMS) end-to-end distance according to freely jointed chain model

(ii) root mean square (RMS) end-to-end distance according to valence angle model

Satu polietilena linear mempunyai berat molekul purata berat (M_w) 6×10^5 dan indeks polidispersiti bernilai 1.5. Diberikan panjang ikatan C-C dan sudut ikatan ialah 0.154 nm dan 109.5^o masing-masing. Sudut putaran ikatan ialah 60^o. Hitungkan yang berikut:

(i) punca purata kuasa jarak hujung-ke-hujung berdasarkan model rantai bersambung bebas

(ii) punca purata kuasa jarak hujung-ke-hujung berdasarkan model sudut valens

(70 marks/*markah*)

3. [a] Write short note on the following subjects:

(i) freely jointed chain model

(ii) free volume theory

(iii) Schatzki crankshaft rotation model

Tuliskan nota ringkas bagi perkara-perkara berikut:

(i) model rantai bersambung bebas

(ii) teori isipadu bebas

(iii) model putaran aci engkol Schatzki

(60 marks/*markah*)

[b] Polybutadiene has a T_g of -90°C, and polystyrene homopolymer has a T_g of +105°C. Estimate the T_g of a 60/40 w/w poly(styrene-stat-butadiene) copolymer.

Polibutadiena mempunyai T_g bernilai -90°C, dan homopolimer polistirena mempunyai T_g bernilai +105°C. Anggarkan T_g bagi 60/40 w/w kopolimer poli(stirena-stat-butadiena).

(40 marks/*markah*)

4. [a] A linear amorphous polymer has a T_g of +10°C. At 25°C, it has a melt viscosity of 3×10^8 poises. What is the difference between its melt viscosity at 60°C and 80°C?

Satu polimer amorfus linear mempunyai T_g bernilai +10°C. Pada suhu 25°C, polimer tersebut mempunyai kelikatan leburan sebanyak 3×10^8 poise. Apakah perbezaan kelikatan leburan pada suhu 60°C dan 80°C?

(60 marks/*markah*)

[b] Write short note on the following subject:

(i) Williams-Landel-Ferry equation

(ii) reptation model

Tuliskan nota ringkas bagi perkara-perkara berikut:

(i) persamaan Williams-Landel-Ferry

(ii) model reptasi

(40 marks/*markah*)

PART C

BAHAGIAN C

5. [a] Figure 1 displays changes of X-ray diffraction patterns for a certain polymer sample. Discuss what could have caused such changes.

Rajah 1 berikut mempamerkan perubahan yang berlaku kepada pola pembelauan sinar-X bagi suatu sampel polimer. Bincangkan apakah punca kepada perubahan tersebut.

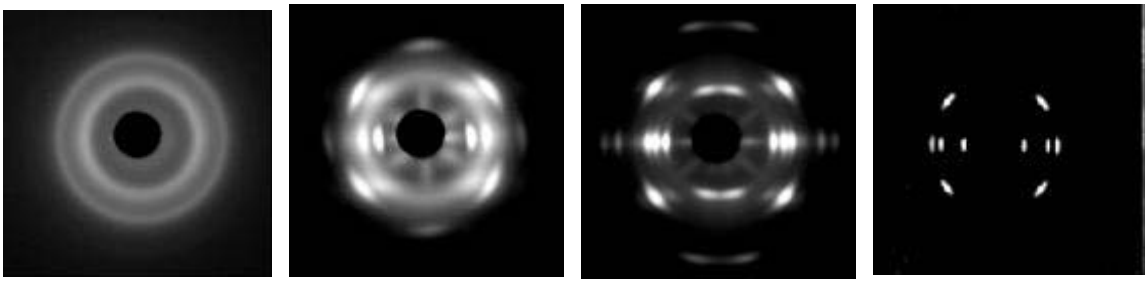

Figure 1 - Changes in X-ray diffraction patterns for a polymer sample

Rajah 1 - Perubahan pola pembelauan Sinar-X bagi suatu sampel polimer

Also give example of a polymer processing technique that exploits advantages of the above phenomenon.

Berikan juga satu contoh teknik pemprosesan polimer yang mengeksploit kelebihan fenomena di atas.

(40 marks/*markah*)

[b] One of the important parameters in the degree of crystallinity determination is the density of 100% polymer crystal. The following equation presented a way of calculating the volume of a given polymer crystal unit cell.

Salah satu parameter penting dalam penentuan darjah keterhabluran ialah ketumpatan 100% hablur polimer. Persamaan berikut memberikan cara untuk mengira isipadu suatu sel unit hablur polimer.

$$V = abc(1 + 2\cos\alpha \cdot \cos\beta \cdot \cos\gamma - \cos^2\alpha - \cos^2\beta - \cos^2\gamma)^{1/2}$$

Using the above equation, determine the density of crystals for these polymers;

Menggunakan persamaan di atas, tentukan ketumpatan hablur-hablur polimer berikut;

(i) Isotactic polystyrene $[\text{-}CH_2\text{-}CHC_6H_5\text{-}]_n$ has a trigonal unit cell with 18 chemical repeat units in the unit cell. Given that the unit cell has these dimensions;

Polistirena isotaktik $[\text{-}CH_2\text{-}CHC_6H_5\text{-}]_n$ mempunyai sel unit trigonal dengan 18 unit ulangan kimia dalam sel unit tersebut. Diberi bahawa sel unit itu mempunyai dimensi-dimensi berikut;

a = 2.19 nm, b = 2.19 nm, c = 0.665 nm and $\alpha = 120^o$

(30 marks/*markah*)

(ii) Poly(vinyl alcohol) [-CH_2-CHOH-] has a monoclinic unit cell of dimensions; a = 0.551 nm, b = 0.781 nm, and c = 0.251 nm with two chemical repeat units per unit cell. The angle β is 91.7^o and all the other angles are 90^o.

Poli(vinil alkohol) [-CH_2-CHOH-] mempunyai sel unit monoklinik dengan dimensi-dimensi; a = 0.551 nm, b = 0.781 nm, dan c = 0.251 nm serta mempunyai 2 unit ulangan kimia per sel unit. Sudut β bersamaan dengan 91.7^o dan sudut-sudut lain adalah 90^o.

Also given are:

- Relative atomic mass of hydrogen, carbon and oxygen;
  H = 1 C = 12 O = 16
- Avogadro number, N_A, = 6.023×10^{23} mol^{-1}

Juga diberi:

- *Jisim atom relatif bagi hidrogen, karbon dan oksigen;*
  H = 1 C = 12 O = 16
- *Nombor Avogadro, N_A, = 6.023×10^{23} mol^{-1}*

(30 marks/*markah*)

6. [a] Consider the following statements;

"Degree of crystallinity of a semi-crystalline polymer is dependent of interchain bonding"

"The melting of a semi-crystalline polymer is related to the destruction of crystallite region"

Using polyamide as an example, comment on the relevance of both statements. Support your answer with suitable diagrams.

Pertimbangkan kenyataan-kenyataan berikut;

"Darjah keterhabluran suatu polimer separa-hablur adalah bergantung kepada ikatan antara-rantai"

"Peleburan suatu polimer separa-hablur boleh dikaitkan dengan pemusnahan kawasan berhablur"

Dengan menggunakan poliamida sebagai contoh, berikan komen kerelevanan kenyataan-kenyataan tersebut. Sokong jawapan anda dengan rajah-rajah bersesuaian.

(50 marks/*markah*)

[b] Using a schematic representation of the Laue technique in X-ray diffraction, derive the Bragg's equation as given below.

$$n\lambda = 2d \sin\theta$$

Use suitable diagrams to assist your answer.

Dengan menggunakan perwakilan skematik teknik Laue bagi pembelauan sinar X, terbitkan persamaan Bragg seperti yang diberikan di bawah.

$$n\lambda = 2d \sin\theta$$

Gunakan rajah-rajah yang bersesuaian untuk membantu jawapan anda.

(50 marks/*markah*)

7. [a] Elaborate the dilatometry technique in the study of polymer crystallization and explain the meaning of the $t_{1/2}$ term that can be obtained from the dilatometry experiment.

Huraikan teknik dilatometri dalam kajian penghabluran polimer dan terangkan maksud ungkapan $t_{1/2}$ yang boleh diperolehi daripada eksperimen dilatometri.

(40 marks/*markah*)

[b] Derive the following equation which relates the dilatometry technique with the Avrami's equation.

Terbitkan persamaan berikut yang menghubungkan teknik dilatometri dengan persamaan Avrami.

$$\frac{h_t - h_\infty}{h_o - h_\infty} = \mathbf{exp}\left(zt\right)^n$$

where,
di mana,

h_t = mercury height at time, t
h_t = *tinggi merkuri pada masa, t*

h_o = mercury height at the beginning of the experiment
h_o = *tinggi merkuri pada permulaan eksperimen*

h_∞ = mercury height after the crystallization has completed
h_∞ = *tinggi merkuri setelah penghabluran selesai*

z, n= Avrami's equation constants
z, n = pemalar-pemalar persamaan Avrami

(60 marks/*markah*)

- oooOooo -