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# UNIVERSITI SAINS MALAYSIA

First Semester Examination  
Academic Session 2007/2008

October/November 2007

## **EBP 202/3 - Polymer Structure** **[Struktur Polimer]**

Duration : 3 hours  
[Masa : 3 jam]

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

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

This paper contains SEVEN questions.

*[Kertas soalan ini mengandungi TUJUH soalan.]*

**Instructions:** Answer any FIVE questions. If a candidate answers more than five questions, only the first five answers will be examined and awarded marks.

**[Arahan:** Jawab LIMA soalan. 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.]*

1. [a] For a linear molecule of polyethylene of molecular weight  $1.4 \times 10^5$ , calculate the following:

*Satu polietilena linear mempunyai berat molekul  $1.4 \times 10^5$ . Hitungkan*

- (i) contour length

*panjang kontur*

(10 marks/markah)

- (ii) RMS end-to-end distance according to freely-jointed chain model

*punca purata kuasa jarak hujung-ke-hujung berdasarkan model rantai bersambung bebas*

(15 marks/markah)

- (iii) RMS end-to-end distance according to valence angle model

*punca purata kuasa jarak hujung-ke-hujung berdasarkan model sudut valensi*

(15 marks/markah)

Given that:

length of each bond = 0.154 nm

bond angle =  $109.5^\circ$

*Diberikan:*

*Panjang setiap ikatan = 0.154 nm*

*sudut ikatan =  $109.5^\circ$*

- [b] Comment on the values obtained from 1(a), indicating which one is a more realistic estimate of polymer chain dimensions.

*Berikan komen bagi nilai yang didapatkan dari 1(a) serta tunjukkan yang mana satu nilai dapat memberikan anggaran dimensi rantai polimer dengan lebih realistik.*

(10 marks/markah)

- [c] Discuss on Free Volume Theory and WLF equation.

*Bincangkan teori isipadu bebas dan persamaan WLF.*

(50 marks/markah)

2. [a] Discuss how X-ray can be used to determine polymer crystal structure, giving emphasis on the derivation of the Bragg's equation.

*Bincangkan bagaimana sinar-X boleh digunakan untuk menentukan struktur hablur polimer. dengan memberikan penekanan kepada penerbitan persamaan Bragg.*

(40 marks/markah)

- [b] Flat film X-ray diffraction patterns obtained using  $\text{CuK}\alpha$  beam (Ni filter) for an isotropic polyethylene yielded 3 sharp rings with each having radius of 19.7, 22.2 and 36.6 nm, respectively. With the assumption that molecular chain arrangement of polyethylene as orthorombic (i.e.  $\alpha = \beta = \gamma = 90^\circ$ );

*Satu pola pembelauan sinar-X filem rata diperolehi menggunakan alur cahaya  $\text{CuK}\alpha$  (penapis Ni) bagi suatu polietilena isotropik yang menghasilkan 3 gelang cahaya berkeamatan tinggi dengan jejari masing-masing berukuran 19.7, 22.2 dan 36.6 nm. Dengan anggapan bahawa penyusunan molekul polietilena adalah secara ortorombik (i.e.  $\alpha = \beta = \gamma = 90^\circ$ );*

- (i) Calculate the spacing of molecule planes distance,  $d$ , that produce the diffraction patterns.

*Kirakan jarak pemisahan satah molekul,  $d$ , yang menghasilkan pola pembelauan tersebut.*

- (ii) Show that the diffraction rings were produced by these planes; (1 1 0), (2 0 0) and (3 0 0).

*Tunjukkan bahawa gelang pembelauan dihasilkan oleh satah-satah berikut; (1 1 0), (2 0 0) and (3 0 0).*

- (iii) If the polyethylene sample is subjected to extension, what kind of diffraction pattern would you expect?

*Sekiranya sampel polietilena tersebut diregangkan, apakah jenis pola pembelauan yang anda jangkakan akan terhasil?*

Given,

- Specimen distance from film = 5.0 cm
- X-ray wavelength = 0.154 nm
- Unit cell dimension and  $d_{hkl}$  for polyethylene is:  
 $a = 0.742 \text{ nm}$        $b = 0.494 \text{ nm}$        $c = 0.255 \text{ nm}$

Diberi,

*Jarak spesimen dari filem = 5.0 cm*

*Jarak gelombang sinar-X = 0.154 nm*

*Dimensi sel unit dan  $d_{hkl}$  bagi polietilena ialah:*

*$a = 0.742 \text{ nm}$        $b = 0.494 \text{ nm}$        $c = 0.255 \text{ nm}$*

$$d_{hkl} = \left( \frac{h^2}{a^2} + \frac{k^2}{b^2} + \frac{l^2}{c^2} \right)^{-\frac{1}{2}}$$

(60 marks/markah)

3. [a] A new linear amorphous polymer has a  $T_g$  of  $+10^\circ\text{C}$ . At  $25^\circ\text{C}$  it has a melt viscosity of  $4 \times 10^8$  poises. Estimate its melt viscosity at  $50^\circ\text{C}$ .

*Satu polimer amorfus linear mempunyai  $T_g +10^\circ\text{C}$ . Pada suhu  $25^\circ\text{C}$ , polimer tersebut mempunyai kelikatan leburan sebanyak  $4 \times 10^8$  poises. Anggarkan kelikatan leburan bagi polimer tersebut pada suhu  $50^\circ\text{C}$ .*

(50 marks/markah)

- [b] Poly-Laboratory has synthesized three polymers based on styrene monomer. Predict and explain the viscoelastic behavior of the polymers. The discussion should be supported by a log E-temperature plot.

- (i) atactic polystyrene
- (ii) syndiotactic polystyrene
- (iii) cross-linked polystyrene

*Poly-Laboratory telah sintesis tiga polimer berdasarkan monomer stirena. Jangkakan dan jelaskan sifat-sifat kelikatkenyalan bagi polimer itu. Perbincangan perlu disokong dengan satu plot log E-suhu.*

- (i) polistirena ataktik
- (ii) polistirena sindiotaktik
- (iii) polistirena tersambung-silang

(50 marks/markah)

4. [a] Describe experimental procedure for polymer crystallisation study using polarized optical microscope.

*Terangkan kaedah eksperimen bagi kajian penghabluran polimer menggunakan mikroskop optik terpolar.*

(50 marks/markah)

- [b] Discuss **two** techniques that can be utilized in determining density of a polymer sample.

*Bincangkan dua teknik yang boleh digunakan dalam penentuan ketumpatan suatu sampel polimer.*

(50 marks/markah)

5. [a] Write short notes of the following:
- (i) configuration of polymer chain
  - (ii) conformation of polymer chain
  - (iii) glass transition temperature

*Tuliskan nota ringkas bagi berikut:*

- (i) konfigurasi bagi rantai polimer
- (ii) konformasi bagi rantai polimer
- (iii) suhu peralihan kaca

(60 marks/markah)

- [b] Polystyrene homopolymer has a  $T_g = 100^\circ\text{C}$ , and polybutadiene has a  $T_g = -90^\circ\text{C}$ . Estimate the  $T_g$  of a 50/50 w/w poly(styrene-stat-butadiene) copolymer.

*Homopolimer polistirena mempunyai  $T_g$  bernilai  $100^\circ\text{C}$ , dan polibutadiena mempunyai  $T_g$  bernilai  $-90^\circ\text{C}$ . Anggarkan  $T_g$  bagi 50/50 w/w kopolimer poli(stirena-stat-butadiena).*

(40 marks/markah)

6. [a] Explain why Chain Folding Model is preferable than Fringed Micelle Model in describing polymer crystal structure and list three types of chain folding proposed by the model.

*Terangkan mengapa Model Lipatan Rantai lebih digemari berbanding Model Misel Berambu dalam menjelaskan struktur hablur polimer dan senaraikan jenis-jenis lipatan rantai yang dicadangkan oleh model tersebut.*

(50 marks/markah)

- [b] Two polypropylene (PP) samples from a same grade were analysed using Differential Scanning Calorimetry (DSC) technique. It was found that 11.600 mg of the PP sample gave a melting enthalpy,  $\Delta H_m$ , of 0.7837 Joule. Whereas, another PP sample, which has gone through an extrusion process yielded a melting enthalpy,  $\Delta H_m$  of 0.9535 Joule for 12.400 mg sample. Given that melting enthalpy of a 100% PP crystal,  $\Delta H_m^\circ$  is 207.1 Joule/g, calculate the degree of crystallinity of both PP samples. Why there is a difference of melting enthalpy between these samples?

*Dua sampel polipropilena (PP) dari gred yang sama dianalisa menggunakan teknik Kalorimetri Penskanan Pembezaan (DSC). Didapati bahawa 11.600 mg sample PP tersebut memberikan entalpi peleburan,  $\Delta H_m$ , sebanyak 0.7967 Joule. Manakala, satu lagi sampel PP yang telah menjalani proses pengekstrudan memberikan entalpi peleburan  $\Delta H_m$  sebanyak 0.9725 Joule bagi sampel seberat 12.400 mg. Diberi bahawa entalpi peleburan bagi 100% hablur PP ialah 207.1 Joule/g, kirakan darjah kehabluran kedua-dua sampel PP tersebut. Mengapakah wujud perbezaan dalam entalpi peleburan di antara sampel-sampel tersebut?*

(50 marks/markah)

7. [a] Discuss procedures that can produce molecular orientation in polymers dan its importance in polymer studies.

*Bincangkan kaedah-kaedah yang mampu menghasilkan orientasi molekul dalam polimer dan kepentingannya dalam kajian polimer.*

(25 marks/markah)

- [b] State factors that can affect degree of crystallinity and its relationship with molecular orientation.

*Nyatakan faktor-faktor yang boleh mempengaruhi darjah kehabluran dan hubungannya dengan orientasi molekul.*

(25 marks/markah)

- [c] Discuss on Freely-Jointed Chain Model. Discussion should be supported by suitable equation.

*Bincangkan model rantai bersambung bebas. Perbincangan perlu disokong dengan persamaan yang sesuai.*

(50 marks/markah)