UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2012/2013

January 2013

EBP 202/3 – Polymer Structure
[Struktur Polimer]

Duration : 3 hours
[Masa : 3 jam]

Please ensure that this examination paper contains <u>NINE</u> printed pages before you begin the examination.
[Sila pastikan bahawa kertas peperiksaan ini mengandungi <u>SEMBILAN</u> muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]

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

PART A / *BAHAGIAN A*

1.   [a]   Discuss the glass transition temperature of polymer.

Bincangkan suhu peralihan kaca bagi polimer.

(50 marks/*markah*)

[b]   (i)   Two polypropylene (PP) samples from a same grade were analysed using Differential Scanning Calorimetry (DSC) technique. It was found that 12.600 mg of the PP sample gave a melting enthalpy, ΔH_m, of 0.7940 Joule. Where as, another PP sample, which has gone through an extrusion process yielded a melting enthalpy, ΔH_m of 0.9835 Joule for 13.400 mg sample. Given that melting enthalpy of a 100% PP crsytal, ΔH^o_m is 207.1 Joule/g, calculate the degree of crystallinity of both PP samples.

(ii)   Why there is a difference of melting enthalpy between these samples?

(i)   *Dua sampel polipropilena (PP) dari gred yang sama dianalisa menggunakan teknik Kalorimetri Penskanan Pembezaan (DSC). Didapati bahawa 12.600 mg sampel PP tersebut memberikan entalpi peleburan, ΔH_m, pada 0.7940 Joule. Manakala, satu lagi sampel PP yang telah menjalani proses pengekstrudan memberikan entalpi peleburan ΔH_m pada 0.9835 Joule bagi sampel seberat 13.400 mg. Diberi bahawa entalpi peleburan bagi 100% hablur PP ialah 207.1 Joule/g, kirakan darjah keterhabluran kedua-dua sampel PP tersebut.*

(ii)   *Mengapakah wujud perbezaan dalam entalpi peleburan di antara sampel-sampel tersebut?*

(50 marks/*markah*)

PART B / *BAHAGIAN B***:**

2. [a] Discuss the following subjects:

   (i)   Freely-jointed chain model.

   (ii) Valence angle model.

   Bincangkan perkara-perkara berikut:

   (i)   Model rantai bersambung bebas.

   (ii) Model sudut valensi.

   (50 marks/*markah*)

   [b] Table 1 shows the mean molecular weight and weight fraction of a polystyrene sample. Calculate the polydispersity index of the polystyrene.

   Jadual 1 menunjukkan berat molekul purata dan pecahan berat bagi satu sampel polistirena. Hitungkan indeks polidispersiti bagi polistirena.

Table 1: Mean molecular weight and weight fraction of a polystyrene sample.

Jadual 1: Berat molekul purata dan pecahan berat bagi satu sampel polistirena.

Weight fraction, w_i *Pecahan berat, w_i*	Mean molecular weight, M_i *Berat molekul purata, M_i*
0.05	5,000
0.15	10,000
0.35	15,000
0.25	20,000
0.15	32,000
0.05	38,000

   (50 marks/*markah*)

3.   [a]   Discuss the free volume theory and Williams-Lendel-Ferry equation.

Bincangkan teori isipadu bebas dan persamaan Williams-Lendel-Ferry.

(50 marks/*markah*)

[b]   A new linear amorphous polymer has a T_g of $+10^oC$. At 25^oC it has a melt viscosity of 3×10^8 poises. Estimate its melt viscosity at 55^oC.

Satu polimer amorfus linear mempunyai T_g $+10^oC$. Pada suhu 25^oC, polimer tersebut mempunyai kelikatan leburan sebanyak 3×10^8 poises. Anggarkan kelikatan leburan bagi polimer itu pada suhu 55^oC.

(50 marks/*markah*)

4.   [a]   A linear polyethylene has average molecular weight of 8×10^5 g/mol. Given that the bond length of C-C and bond angle are 0.154 nm and 109.5^o respectively. The bond rotation is 60°. Calculate the following:
        (i)   root mean square (RMS) end-to-end distance according to valence angle model.
        (ii)   root mean square (RMS) end-to-end distance according to freely jointed chain model.

Satu polietilena linear mempunyai berat molekul purata 8×10^5 g/mol. Diberikan panjang ikatan C-C dan sudut ikatan ialah 0.154 nm dan 109.5^o masing-masing. Sudut putaran ikatan ialah 60°. Hitungkan yang berikut:
        (i)   punca purata kuasa jarak hujung-ke-hujung berdasarkan model sudut valensi.
        (ii)   punca purata kuasa jarak hujung-ke-hujung berdasarkan model rantai bersambung bebas.

(50 marks/*markah*)

[b]   Discuss the following subjects:

    (i)   Schatzki crankshaft rotation model.

    (ii)   Conformation of polymer chains.

Bincangkan perkara-perkara berikut:

(i)   Model putaran aci engkol Schatzki.

(ii)   Konformasi bagi rantai-rantai polimer.

(50 marks/*markah*)

PART C / *BAHAGIAN C*

5. [a] (i) What do you understand about spherulite?

    (iii) Compare formation and growth of spherulite in homogenous and heterogenous crystallization process.

    (i) Apakah yang anda faham mengenai sferulit?

    (ii) Bandingkan pembentukan dan pertumbuhan sferulit dalam proses penghabluran homogenus dan heterogenus.

    (30 marks/*markah*)

    [b] (i) Elaborate the method used in studying polymer crystallization using an optical microscope.

    (ii) State the effect of temperature on the crystallization rate.

    (i) Huraikan kaedah eksperimen yang digunakan dalam mengkaji penghabluran polimer menggunakan suatu mikroskop optik.

    (ii) Nyatakan kesan suhu ke atas kadar penghabluran.

    (40 marks/*markah*)

    [c] "In most polymer processing techniques, molecular orientation is almost unavoidable".

    Support the above statement using a suitable diagram or example.

    "Dalam kebanyakan teknik-teknik pemprosesan polimer, orientasi molekul adalah hampir tidak boleh dielakkan".

    Sokong kenyataan di atas dengan menggunakan rajah atau contoh yang sesuai.

    (30 marks/*markah*)

6. [a] Explain the main principle used in pycnometry technique for the determination of polymer materials density. Also, give related mathematical equation involved in the density calculation.

Terangkan prinsip utama yang digunakan dalam teknik piknometri bagi menentukan ketumpatan bahan polimer. Berikan juga persamaan matematik berkaitan yang terlibat dalam pengiraan ketumpatan tersebut.

(30 marks/*markah*)

[b] The following information was obtained from a pycnometry experiment:
- Weight of empty pycnometer bottle = 25.407 g
- Weight of pycnometer bottle + polymer sample = 26.863 g
- Weight of pycnometer bottle filled with water = 48.890 g (ρ_{water} = 0.998 g/cm^3)
- Weight of pycnometer bottle filled water + polymer sample = 48.703 g

Determine the polymer sample density and list down factors that could affect the obtained results.

Maklumat berikut telah diperoleh daripada suatu eksperimen piknometri:
- *Berat botol piknometer kosong = 25.407 g*
- *Berat botol piknometer + sampel polimer = 26.863 g*
- *Berat botol piknometer yang diisi dengan air = 48.890 g (ρ_{air} = 0.998 g/cm^3)*
- *Berat botol piknometer yang diisi dengan air + sampel polimer = 48.703 g*

Tentukan ketumpatan sampel polimer tersebut dan senaraikan faktor-faktor yang boleh mempengaruhi keputusan yang diperoleh.

(30 marks/*markah*)

[c] Describe the relationship between density and crystallinity in polymer samples. You are required to use these polymer samples: i.e. LDPE, LLDPE and HDPE as examples in your answer.

Jelaskan hubungkait antara ketumpatan dan keterhabluran dalam sampel-sampel polimer. Anda dikehendaki menggunakan sampel-sampel polimer berikut: iaitu LDPE, LLDPE dan HDPE sebagai contoh dalam jawapan anda.

(40 marks/*markah*)

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

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

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

Use suitable diagrams to assist your answer.

Gunakan rajah-rajah yang sesuai untuk membantu jawapan anda.

(40 marks/*markah*)

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

Terbitkan persamaan berikut yang menghubungkan teknik dilatometri dengan persamaan Avrami.

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

…9/-

where:

h_t = mercury height at time, t

h_o = mercury height at the beginning of the experiment

h_∞ = mercury height after the crystallization has completed

z, n = Avrami's equation constants

dimana:

h_t = *tinggi merkuri pada masa, t*

h_o = *tinggi merkuri pada permulaan eksperimen*

h_∞ = *tinggi merkuri setelah penghabluran selesai*

z, n = *pemalar-pemalar persamaan Avrami*

(60 marks/*markah*)

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