UNIVERSITI SAINS MALAYSIA

Second Semester Examination
Academic Session 2009/2010

April/May 2010

EBB 220/3 – Engineering Polymer
[Polimer Kejuruteraan]

Duration : 3 hours
[Masa : 3 jam]

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

This paper consists of TWO questions from PART A and FIVE questions from PART B.
[Kertas soalan ini mengandungi DUA soalan dari BAHAGIAN A dan LIMA soalan dari BAHAGIAN B.]

Instruction: Answer **TWO** questions from PART A and **THREE** questions from PART B. If candidate answers more than five questions only the first five questions answered in the answer script would be examined.
*[**Arahan**: Jawab **DUA** 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.]*

The answers to all question 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 must be used.
[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai.]

PART A / *BAHAGIAN A*

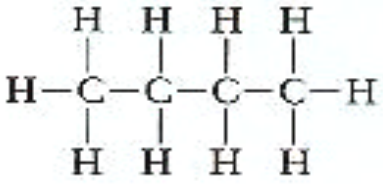
1. [a] Properties of polymers are highly influenced by its molecular structure. Based on this statement, list and discuss various types of polymer structures and how does these backbone structures affect their properties.

Sifat-sifat polimer amat dipengaruhi oleh struktur polimer tersebut. Berdasarkan kenyataan ini, senarai dan bincangkan pelbagai struktur polimer dan bagaimana struktur tulang belakang ini mempengaruhi sifat-sifatnya.

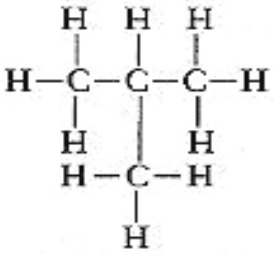
(30 marks/*markah*)

[b] Figure 1 shows butane (C_4H_{10}) and isobutene (C_4H_{10}) structures. Based on their atomic arrangements, comment and compare the physical properties of each structure which arise as a result from the differences in their atomic arrangement.

Rajah 1 menunjukkan struktur-struktur butana (C_4H_{10}) dan isobutana (C_4H_{10}). Berdasarkan susunan atom, komen dan bandingkan sifat-sifat fizikal setiap struktur yang anda jangkakan hasil daripada perbezaan susunan atom yang terhasil.



(a) Butane / B*utana*



(b) Isobutene / *Isobutana*

Figure 1: Molecular structures / *Rajah 1: Struktur molekul*

(20 marks/*markah*)

[c] Degree of crystallinity of polymers is determined by several factors. List the factors and discuss each of them with suitable examples. Subsequently, based on the stereoregularity, comment on how the atactic, syndiotactic and isotactic configurations influence the level of crystallinity in polymers.

Darjah penghabluran sesuatu polimer ditentukan oleh beberapa faktor. Senarai dan bincangkan setiap faktor tersebut berserta contoh yang sesuai. Seterusnya, berdasarkan kepada stereoregulariti, berikan komen bagaimana konfigurasi ataktik, sindiotatik dan isotaktik mempengaruhi tahap penghabluran dalam polimer.

(50 marks/*markah*)

2. [a] Compared to simple liquids, polymers are very different and have extremely high viscosity with special flow characteristics, which is termed "Non-Newtonian". List and differentiate 3 types of non-Newtonian liquids. Explain how the behavior of these liquids differ from those of Newtonian liquids.

Jika dibandingkan dengan cecair mudah, polimer adalah berbeza dan mempunyai kelikatan yang sangat tinggi dengan ciri aliran yang istimewa, yang dirujuk sebagai non-Newton. Senaraikan dan bezakan 3 jenis cecair non-Newton. Terangkan bagaimana kelakuan cecair ini yang berbeza daripada cecair Newton tersebut.

(40 marks/*markah*)

[b] Define rheology in polymer. State 2 benefits related to polymer processing that can be obtained from the study of polymer rheology.

Takrifkan reologi dalam polimer. Berikan 2 faedah berkaitan pemprosesan polimer yang boleh diperolehi daripada kajian reologi polimer.

(20 marks/*markah*)

[c] Briefly discuss how volume fraction of filler, temperature, pressure and molecular structure affect viscosity of polymer melt.

Bincangkan dengan ringkas bagaimana pecahan isipadu pengisi, suhu, tekanan dan struktur molekul mempengaruhi kelikatan leburan polimer.

(40 marks/*markah*)

PART B / *BAHAGIAN B*

3. [a] Figure 2 shows a typical tensile stress-strain curves for an engineering polymer, i.e. polyester. Briefly explain the effect of temperature on stress-strain behaviour of the material.

Rajah 2 menunjukkan kurva tegasan-terikan bagi polimer kejuruteraan, iaitu poliester. Terangkan dengan ringkas kesan suhu ke atas kelakuan tegasan-terikan bahan ini.

Figure 2 / *Rajah 2*

(30 marks/*markah*)

[b] The stress on a rubber disk is seen to relax from 0.75 to 0.5 MPa in 100 days.

(i) What is the relaxation time, ζ for this material.

(ii) What will be the stress on the disk after 50 days and 200 days.

Tegasan di atas cakera getah di dapati rehat daripada 0.75 ke 0.5 MPa dalam masa 100 hari.

(i) Apakah masa perehatan, ζ bagi bahan ini.

(ii) Apakah tegasan ke atas cakera selepas 50 hari dan 200 hari.

(30 marks/*markah*)

[c] (i) Given data on the modulus of elasticity (in tension) and tensile strength for various thermoplastic polymers in Table 1. Select the polymers that would meet the following design specifications for a mechanical gear application:

Modulus of elasticity, E: 2000 MPa < E < 3000 MPa

And tensile strength (T.S.): > 50 MPa

(ii) Define modulus of elasticity and tensile strength.

(i) Di beri data modulus keelastikan (tegangan) dan kekuatan tegangan untuk pelbagai jenis polimer termoplastik dalam Jadual 1. Pilih polimer yang akan memenuhi spesifikasi rekabentuk berikut untuk aplikasi gear mekanikal:

Modulus keelastikan, E: 2000 MPa < E < 3000 MPa

Dan kekuatan tegangan (T.S.): > 50 MPa

(ii) Berikan definasi bagi Modulus keelastikan dan kekuatan tegangan

Table 1 / *Jadual 1*

(40 marks/*markah*)

4. [a] There are a number of ways in which polymeric materials may degrade over a period of time. Explain three (3) of the of any of polymer degradation below:

(i) Oxidative degradation

(ii) Radiation degradation

(iii) Mechanical degradation

(iv) Microbiological degradation

Terdapat pelbagai cara bagaimana suatu bahan polimer boleh terdegradasi dalam jangkamasa penggunaannya. Jelaskan tiga (3) daripada degradasi polimer dibawah:

(i) Degradasi oksidatif

(ii) Degradasi radiasi

(iii) Degradasi mekanikal

(iv) Degradasi Mikrobiologi

(40 marks/*markah*)

[b] Additives are added in a plastic formulation to obtain desired properties. Explain 2 functions of flame retardant additive.

Bahan tambah telah dicampurkan ke dalam formulasi plastik bagi memprolehi sifat-sifat yang diingini. Terangkan 2 fungsi bahan tambah perencat nyalaan.

(20 marks/*markah*)

[c] Thermoplastics products can be produced using variety of polymer processing methods. Discuss the processing techniques below in terms of processing parts, processing methods and types of product. Use suitable diagrams if necessary:

(i) Extrusion

(ii) Injection moulding

Produk termoplastik boleh dihasilkan melalui pelbagai teknik pemprosesan. Bincangkan kaedah-kaedah pemprosesan di bawah dari segi peralatan pemprosesan, kaedah pemprosesan, dan jenis produk yang dihasilkan. Gunakan gambarajah yang sesuai jika perlu:

(i) Penyemperitan

(ii) Pengacuanan suntikan

(40 marks/*markah*)

5. [a] Define the following terms:

(i) Glass transition temperature (T_g) of polymers.

(ii) Melting temperature (T_m) of polymers.

(iii) First order transition of polymers.

(iv) Second order transition of polymers.

Takrifkan istilah-istilah berikut:

(i) Suhu peralihan kaca (T_g) polimer.

(ii) Suhu peleburan (T_m) polimer.

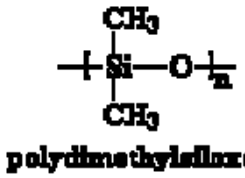
(iii) Peralihan tertib pertama polimer.

(iv) Peralihan tertib kedua polimer.

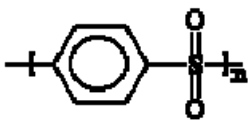
(30 marks/*markah*)

[b] Glass transition temperature (T_g) of polymers are strongly influenced by the mobility of polymer chains. Based on the structure of polydimethylsiloxane and polyphenylene sulfone provided in Figure 3, comment, compare and discuss on the aspects of chain mobility and flexibility of the chains and your expectation of their T_g values.

Suhu peralihan kaca (T_g) polimer amat dipengaruhi oleh kelincahan rantaian polimer. Berdasarkan struktur polidimetilsiloksana dan polifinolin yang diberi dalam Rajah 3, komen, bezakan dan bincangkan dari aspek kelincahan rantaian dan fleksibiliti rantaian dan jangkaan anda terhadap nilai-nilai T_g polimer tersebut.



polydimethylsiloxane



poly(phenylene sulfone)

Figure 3 / *Rajah 3*

(30 marks/*markah*)

[c] Figure 4 (a-d) shows various types of methacrylate-based polymers. Based on the structures provided, discuss how each of the structure influences the T_g of each polymer.

Rajah 4 (a-d) menunjukkan pelbagai jenis polimer berasaskan metakrilat. Berdasarkan struktur yang ditunjukkan, bincangkan bagaimana setiap struktur mempengaruhi T_g bagi setiap polimer.

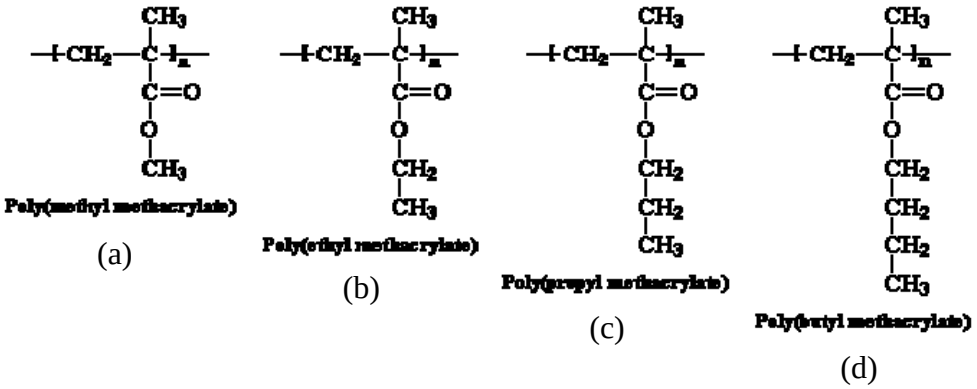


Figure 4 / *Rajah 4*

(40 marks/*markah*)

6. [a] Define:

(i) Weight average molecular weight (M_w).

(ii) Number average molecular weight (M_n).

(iii) Viscosity average molecular weight (M_v).

Takrifkan:

(i) Berat molekul purata berat (M_w).

(ii) Berat molekul purata nombor (M_n).

(iii) Berat molekul purata kelikatan (M_v).

(10 marks/*markah*)

[b] Based on the data provided in Table 2, compute:

(i) Weight average molecular weight (M_w).

(ii) Number average molecular weight (M_n).

(iii) Polydispersity Index(DPI).

Berdasarkan data di dalam Jadual 2, kirakan:

(i) Berat molekul purata berat (M_w).

(ii) Berat molekul purata nombor (M_n).

(iii) Indeks polidispersiti (DPI).

Molecular weight range / *Jarak berat molekul*	x_i	w_i
8,000 – 20,000	0.05	0.02
20,000 – 32,000	0.15	0.08
32,000 – 44,000	0.21	0.17
44,000 – 56,000	0.28	0.29
56,000 – 68,000	0.18	0.23
68,000 – 80,000	0.10	0.16
80,000 – 92,000	0.03	0.05

Table 2 / *Jadual 2*

(60 marks/*markah*)

…13/-

[c] Using suitable diagrams and explanation, differentiate between the following polymers:

(i) Linear polymer.

(ii) Branched polymer.

(iii) Cross-linked polymer.

(iv) Network polymer.

(v) Dendrimer.

(vi) Star polymer.

Menggunakan lakaran dan penerangan yang sesuai, bezakan di antara polimer-polimer berikut:

(i) Polimer linear.

(ii) Polimer bercabang.

(iii) Polimer sambung silang.

(iv) Polimer rangkaian.

(v) Dendrimer.

(vi) Polimer bintang.

(30 marks/*markah*)

7. [a] Define composite materials and give 2 advantage of this material.

Takrifkan definasi bahan komposit dan berikan 2 kelebihan bahan ini.

(20 marks/*markah*)

[b] A continuous and aligned glass reinforced composite consists of 30% of glass fibres having a modulus of elasticity of 55 GPa and 70% of a polyester resin that displays a modulus of 4.5 GPa. With information given, calculate:

(i) Longitudinal modulus of composite

(ii) Transverse modulus of composite

Suatu polimer komposit bergentian kaca secara berterusan dan tersusun mengandungi 30% gentian kaca dengan modulus keelastikan 55 GPa dan 70% resin poliester yang mempamerkan modulus 4.5 GPa. Dengan maklumat yang diberi, kirakan

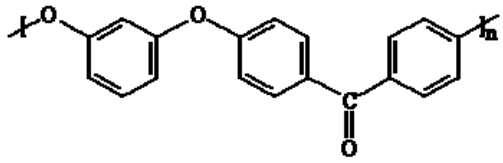
(i) Modulus membujur bagi komposit

(ii) Modulus melintang bagi komposit

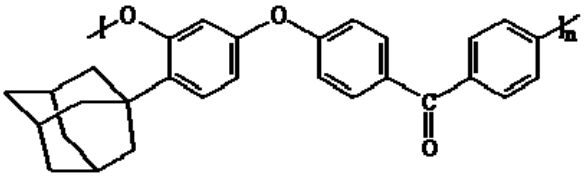
(30 marks/*markah*)

[c] Figure 5 shows two different types of poly (ether ketone). Based on the structures provided, comment, discuss and compare on the expected glass transition temperature and mechanical properties of both polymers.

Rajah 5 menunjukkan dua polieter ketona yang berlainan. Berdasarkan struktur tersebut, komen, bincangkan dan bandingkan suhu peralihan kaca dan sifat-sifat mekanikal yang dijangkakan bagi kedua-dua polimer tersebut.



(a)



(b)

Figure 5: Structures of two different polyether ketone

Rajah 5: Dua struktur polieter keton yang berbeza

(50 marks/*markah*)