UNIVERSITI SAINS MALAYSIA

Second Semester Examination
Academic Session 2010/2011

April/May 2011

EBB 220/3 – Engineering Polymer
[Polimer Kejuruteraan]

Duration : 3 hours
[Masa : 3 jam]

Please ensure that this examination paper contains FOURTEEN printed pages before you begin the examination.
[Sila pastikan bahawa kertas peperiksaan ini mengandungi EMPAT 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 **ALL** 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 **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.]*

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] For each of the following pairs (a-c) of polymers listed in Table 1, comment on each of them based on the ability to crystallize and outline the reason for your answer.

Bagi setiap pasangan polimer (a-c) yang disenaraikan di dalam Jadual 1 berikut, berikan komen berdasarkan kebolehan untuk menghablur dan berikan alasan bagi jawapan anda.

Group / *Kumpulan*	Polymer pair / *Pasangan Polimer*
a	Isotactic Polypropylene (PP) and atactic Polyvinyl Chloride (PVC) / *Polipropilina Isotaktik dan Polivinil Klorida ataktik*
b	Syndiotactic Polypropylene (PP) and Crosslinked Cis-Isoprene / *Polipropilina Sindiotaktik dan Cis-Isoprina tertaut silang*
c	Isotactic Polystyrene and network phenol-formaldehyde / *Polistirena Isotaktik network Fenol-formaldehida*

Table 1 / *Jadual 1*

(40 marks/*markah*)

[b] Chain entanglement, summation of intermolecular forces and time scale motion in polymer make polymer unique in comparison with other materials. Discuss how these factors influence the behavior of polymers.

Penggumpalan rantaian, jumlah daya antara molekul dan skala pergerakan di dalam polimer menjadikan polimer unik berbanding bahan lain. Bincangkan bagaimana faktor-faktor tersebut mempengaruhi kelakuan polimer.

(40 marks/*markah*)

[c] Figure 1 shows the geometrical isomerism of polyisoprene. Outline the reasons why cis-polyisoprene is more popular than trans-polyisoprene.

Rajah 1 menunjukkan geometri isomer bagi poliisoprena. Berikan alasan-alasan mengapa cis-poliisoprena adalah lebih popular berbanding trans-poliisoprena.

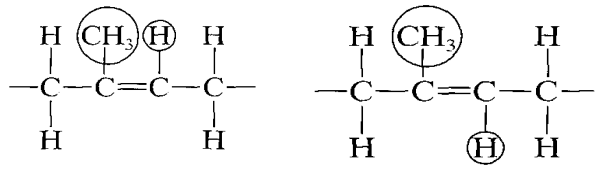

Figure 1: Chemical structure Cis-polyisoprene and trans-polyisoprene

Rajah 1: Struktur kimia Cis-poliisoprena dan trans-poliisoprena

(20 marks/*markah*)

2. [a] A tensile experiment was done on a plastic sample and the following data was noted on the plot of the experiment; Ultimate tensile strength = 62 MPa, Yield strength = 34.5 MPa, Proportional limit = 27.6 MPa, Strain-to-failure = 0.025, Strain at yield = 0.020, Strain at proportional limit = 0.015. The original length was 11 cm. Calculate the modulus of the samples.

Ujian tegangan telah dijalankan ke atas sampel plastik dan data berikut telah dicatatkan bagi ujikaji ini; kekuatan tegangan maksimum = 62 MPa, Kekuatan pada alah = 34.5 MPa, had perkadaran = 27.6 MPa, terikan kegagalan = 0.025, terikan pada alah = 0.020, terikan pada had perkadaran = 0.015. Panjang asal adalah 11 sm. Hitungkan modulus bagi sampel ini.

(30 marks/*markah*)

[b] Explain the effect of crystallinity on the tensile strength, toughness, glass transition (T_g), density and elastic modulus of a polymer?

Terangkan kesan kehabluran ke atas kekuatan tensil, keliatan, peralihan kaca (T_g), ketumpatan dan modulus elastik polimer.

(30 marks/*markah*)

[c] Figure 2 shows a tensile load vs. extension curves for various types of polymers. Assumption: Temperature for $T_1 < T_2 < T_3 < T_4$.

(i) Name type of fracture for T_1, T_2, T_3 and T_4.

(ii) Explain in detail the molecular changes in T_3 and relate with its properties.

Rajah 2 menunjukkan beban melawan pemanjangan bagi beberapa jenis polimer. Anggapkan suhu bagi $T_1 < T_2 < T_3 < T_4$.

(i) Namakan jenis kegagalan bagi T_1, T_2, T_3 dan T_4.

(ii) Terangkan dengan lengkap perubahan molekul dalam T_3, cuba kaitkan dengan sifat polimer tersebut.

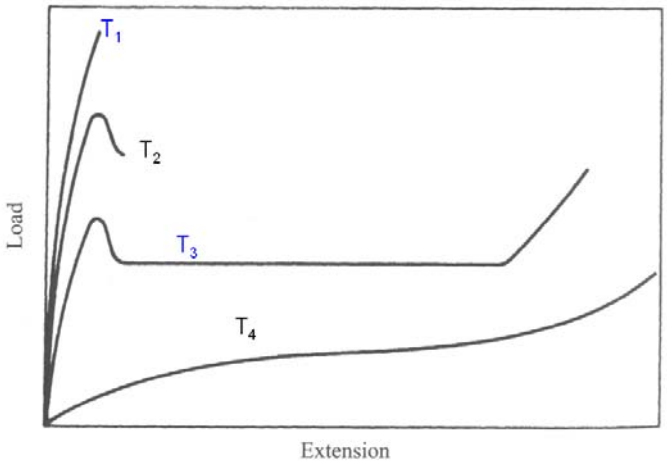

Figure 2: Load vs. extension of various types of polymers

Rajah 2: Beban melawan pemanjangan bagi pelbagai jenis polimer

(40 marks/*markah*)

PART B / *BAHAGIAN B*

3. [a] Figure 3 shows the effect of temperature and strain rate on the stress-strain response of polymers. Discuss with a suitable example why mechanical behaviors of polymer are affected by the strain rate and temperature.

Rajah 3 menunjukkan kesan suhu dan kadar terikan terhadap tindakan tegasan-terikan bagi polimer. Bincangkan dengan contoh yang sesuai bagaimana kelakuan mekanikal polimer dipengaruhi oleh kadar terikan dan suhu.

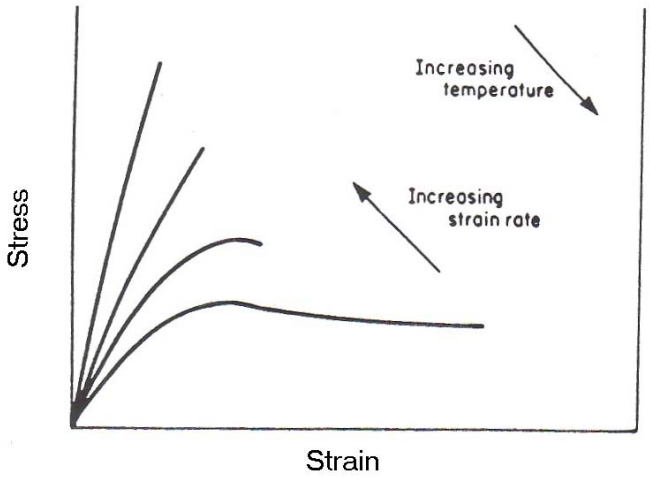

Figure 3: Effect of strain rate and temperature on the stress-strain response of polymers

Rajah 3: Kesan kadar terikan dan suhu terhadap tindakan tegasan-terikan bagi polimer

(30 marks/*markah*)

[b] List down and briefly discuss all factors affecting melting temperature (T_m) and glass transition temperature (T_g) of polymers.

Senaraikan faktor-faktor yang mempengaruhi suhu peleburan (T_m) dan suhu peralihan kaca (T_g) bagi polimer.

(40 marks/*markah*)

...7/-

[c] Crystallinity in polymers is affected by many factors such as polymer structure and intermolecular forces. Illustrate with a suitable example and discuss how the structure and intermolecular forces affect the degree of crystallinity in polymers.

Kehabluran di dalam polimer dipengaruhi oleh beberapa faktor seperti struktur polimer dan daya antara molekul. Ilustrasikan dengan contoh yang sesuai dan bincangkan bagaimana struktur dan daya antara molekul mempengaruhi kehabluran dalam polimer.

(30 marks/*markah*)

4. [a] Polydimethylsiloxane and poly(phenylene sulfone) have a very distinctive different in terms of their glass transition temperature (T_g) value. Discuss why the differences exist between them with respect to their molecular structure. Consequently, poly(phenylene sulfone) (PPS) is known to have a serious processing problem and polymer scientist has introduced ether linkages into the backbone of poly(phenylene sulfone) which is then known as poly(ether sulfone) with a chemical structure as shown in Figure 4. Introduction of ether linkages has reduced the T_g of PPS from 500°C to 190°C. Explain the function of ether linkages in reducing the T_g of poly(phenylene sulfone).

Polidimetilsiloksana dan poli(phenilina sulfon) mempunyai perbezaan yang ketara terutamanya dari segi nilai suhu peralihan kaca (T_g). Bincangkan mengapa perbezaan ini wujud berdasarkan struktur molekulnya. Seterusnya poli(phenilina sulfon) PPS diketahui mempunyai masalah pemprosesan yang serius dan saintis polimer telah memperkenalkan sambungan eter kepada tulang belakang PPS dan kemudiannya dikenali sebagai poli(eter sulfon) dengan struktur kimia seperti ditunjukkan dalam Rajah 4. Pengenalan kepada sambungan eter telah menurunkan suhu peralihan kaca PPS dari 500^oC kepada 190^oC. Terangkan fungsi sambungan eter di dalam menurunkan suhu peralihan kaca bagi T_g PPS.

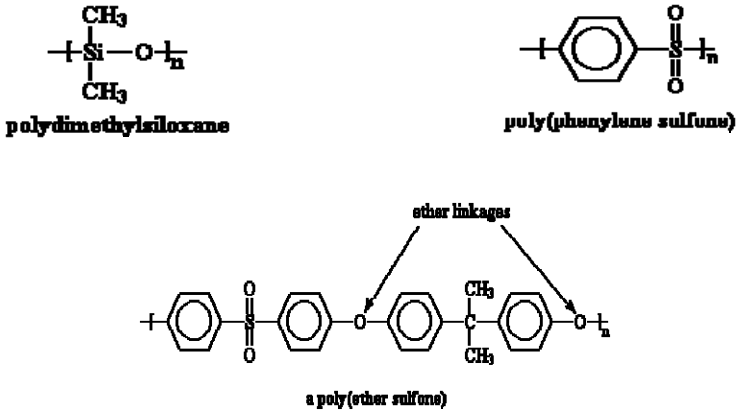

Figure 4: Structural formula of polydimethylsiloxane, poly(phenylene sulfone) and poly(ether sulfone)

Rajah 4: Formula struktur bagi polidimetilsiloksina, poli(finilin sulfon) dan poli(eter sulfon)

(35 marks/*markah*)

[b] Explain how a plasticizer could modify the properties of polyvinyl chloride (PVC) by comparing the properties of unplasticized PVC with plasticized PVC.

Terangkan bagaimana bahan pemplastik boleh mengubahsuai sifat-sifat polivinilklorida dengan membandingkan sifat-sifat PVC tak terplastik dan PVC terplastik..

(25 marks/*markah*)

[c] Figure 5 shows the variation of specific volume with temperature for amorphous polymer (glass), semi-crystalline polymer and pure crystalline materials. Discuss why the change in volume at glass transition temperature (T_g) and melting temperature (T_m) is the highest for amorphous followed by semi-crystalline and crystalline materials. Consequently, comment on why the change in specific volume is always higher at melting temperature (T_m) than at glass transition temperature (T_g).

Rajah 5 menunjukkan variasi isipadu spesifik terhadap suhu bagi polimer amorfus (kaca), polimer separa hablur dan bahan terhablur tulen. Bincangkan mengapa perubahan isipadu pada suhu peralihan kaca (T_g) dan suhu peleburan (T_m) adalah tertinggi bagi polimer amorfus diikuti separa hablur dengan bahan terhablur. Seterusnya komen mengapa perubahan isipadu lebih tinggi pada suhu peleburan (T_m) berbanding suhu peralihan kaca (T_g).

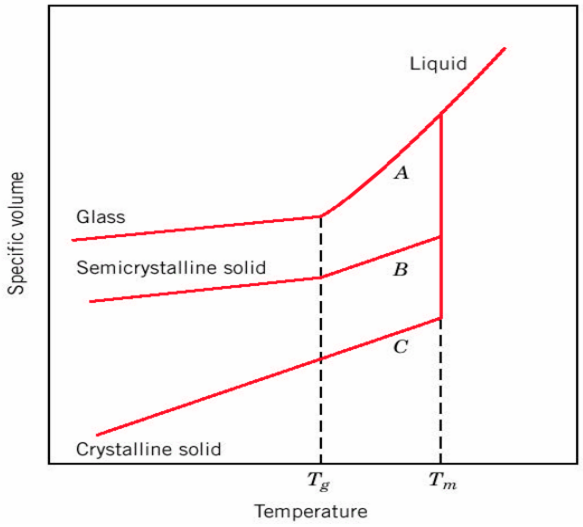

Figure 5: The variation of specific volume with temperature for amorphous polymer (glass), semi-crystalline polymer and pure crystalline materials

Rajah 5: Variasi bagi isipadu spesifik dengan suhu bagi polimer amorfus (kaca), polimer separa hablur dan bahan-bahan terhablur tulen

(40 marks/*markah*)

5. [a] Define viscoelastic property.

Definasikan sifat likat kenyal.

(10 marks/*markah*)

[b] Maxwell model can be used to predict stress relaxation phenomena and Voight model to predict the creep in polymeric materials. Give your comment and justification.

Model Maxwell boleh digunakan untuk meramalkan fenomena santaian tegasan dan model Voight untuk meramalkan rayapan bahan polimer. Berikan komen anda dan justifikasi.

(40 marks/*markah*)

[c] Creep phenomenon is a common behaviour for visco-elastic polymer. The creep data can be presented as isochronous curves, isometric curve and creep modulus. Using the data from creep curves in tension from Figure 6, sketch the curves for representation of creep data and how can it be used to predict the life time of polymers.

Fenomena rayapan merupakan kelakuan umum bagi bahan polimer yang bersifat likat-kenyal. Data rayapan boleh ditunjukkan semula dengan lengkungan isokronos, lengkungan isometrik dan lengkungan modulus rayapan. Menggunakan data daripada lengkungan rayapan dalam tegangan Rajah 6, lakarkan lengkungan untuk mewakili data rayapan dan bagaimanakah ia boleh digunakan untuk menentukan jangka hayat sesuatu bahan polimer.

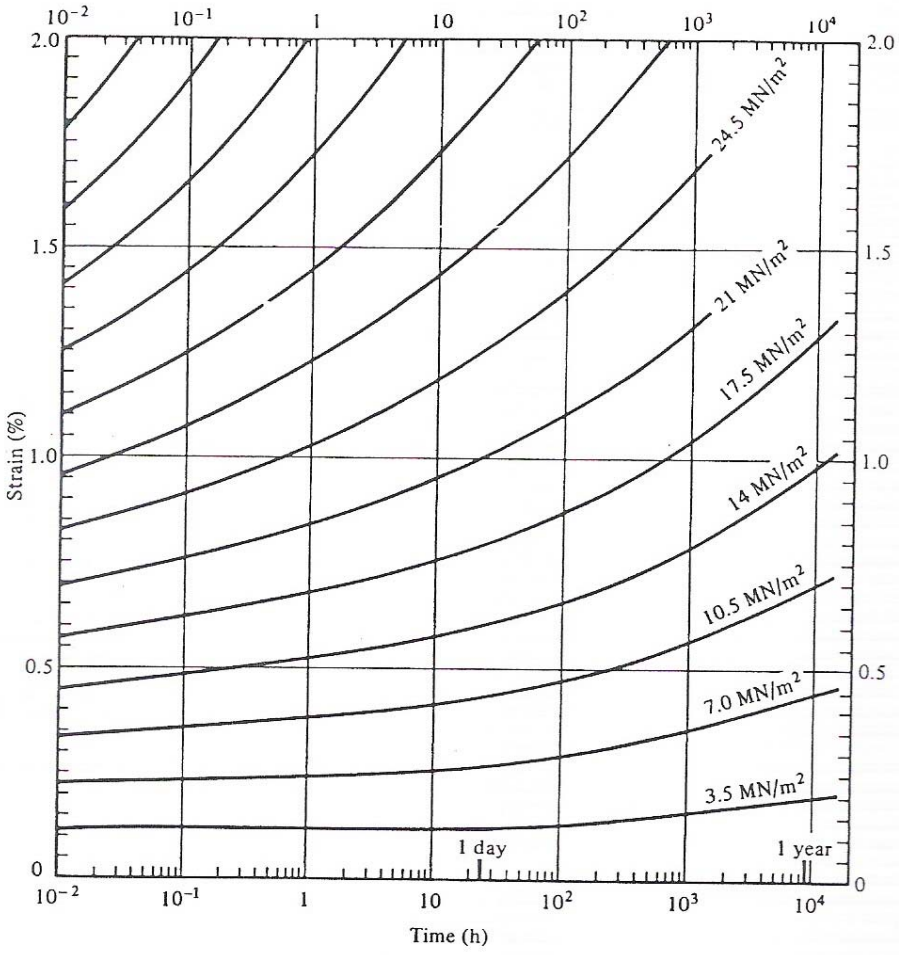

Figure 6: Creep curves in tension of cast acrylic sheet: 20°C and 65% relative humidity

Rajah 6: Keluk rayapan bagi tegangan bagi kepingan akrilik tuangan: 20°C dan 65% kelembapan relatif

(50 marks/*markah*)

6. [a] Thermoplastic sheet production is a significant sector of plastics processing. Select one processing method to produce the thermoplastic sheet, and with a schematic diagram outline the processing steps involve in this method.

Pengeluaran kepingan termoplastik merupakan sektor yang penting dalam pemprosesan plastik. Cadangkan satu kaedah pemprosesan bagi menghasilkan kepingan plastik dan dengan menggunakan gambarajah skematik, rangkakan langkah pemprosesan yang terlibat bagi kaedah ini.

(40 marks/*markah*)

[b] Polyethylene (PE) is a major group of thermoplastic polymers. Depending on the polymerization process used, various types of polyethylene with different properties can be obtained. They can be categorized based on their density, molecular weight, and branching structure. Differentiate between high density polyethylene (HDPE) and ultra high molecular weight polyethylene (UHMWPE) in term of their structure and properties.

Polietilena (PE) merupakan kumpulan utama bagi polimer termoplastik. Bergantung kepada jenis proses pempolimeran yang digunakan, PE dengan pelbagai sifat boleh diperolehi. PE ini dikategorikan berdasarkan ketumpatan, berat molekul dan struktur cabang. Bezakan polietilena berketumpatan tinggi (HDPE) dan polietilena berat molekul lampau tinggi (UHMWPE) dari segi struktur dan sifat.

(40 marks/*markah*)

[c] Polymer adhesives are used to join together the surfaces of two solid materials to produce a joint with a high shear strength, and they are available in different categories. Based on this statement, list and discuss those 3 categories of polymer adhesives.

Perekat polimer digunakan untuk mencantum bersama permukaan dua bahan pepejal bagi menghasilkan cantuman dengan kekuatan ricih yang tinggi, dan adhesif ini boleh diperolehi dalam beberapa kategori. Berdasarkan kenyataan ini senarai dan bincangkan 3 jenis kategori perekat.

(20 marks/*markah*)

7. [a] Discuss the role of three types of additives in rubber compounding.

Bincangkan fungsi tiga jenis pengisi yang digunakan dalam penyebatian getah.

(30 marks/*markah*)

[b] What is the likely affect on modulus when adding a filler? Give your comment.

Apakah kesan ke atas modulus dengan penambahan bahan pengisi. Berikan komen anda.

(30 marks/*markah*)

[c] There are a number of ways in which polymeric materials may degrade over a period of time. Explain two of any of polymer degradation below:

(i) Oxidative degradation.

(ii) Radiation degradation.

(iii) Mechanical degradation.

Terdapat pelbagai cara bagaimana suatu bahan polimer boleh terdegradasi dalam jangkamasa penggunaannya. Jelaskan dua daripada degradasi polimer dibawah:

(i) Degradasi oksidatif.

(ii) Degradasi radiasi.

(iii) Degradasi mekanikal.

(40 marks/*markah*)

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