UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2010/2011

November 2010

EBB 427/3 – Technology & Application of Engineering Polymer
[Teknologi & Penggunaan 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 **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 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.]

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PART A / *BAHAGIAN A*:-

1. [a] A side group or a pendant group will influence the properties of a polymer. By using polyethylene (PE), polyvinyl chloride (PVC), polypropylene (PP) and polystyrene (PS) as examples, evaluate how the side group influences the glass transition temperature (T_g) and crystallinity of the polymers.

Kumpulan sisi atau kumpulan pendan akan mempengaruhi sifat polimer. Dengan menggunakan polietilena (PE), polivinil klorida (PVC), polipropilena (PP) dan polistirena (PS) sebagai contoh, kenal pasti bagaimana kumpulan sisi mempengaruhi suhu peralihan kaca (T_g) dan kehabluran polimer tersebut.

(40 marks/*markah*)

[b] Table 1 shows a comparison of the typical properties of polyethylenes; low density polyethylene (LDPE), high density polyethylene (HDPE) and linear low density polyethylene (LLDPE). Predict the molecular weight, opacity and yield strength of these three polyethylenes, and give suitable reasons for your answers.

Table 1: Comparisons of typical properties of polyethylenes

Property	LDPE	HDPE	LLDPE
MFI (190°C/2.16 kg)	1.1	1.1	0.85
Density (g/cm^3)	0.924	0.961	0.922
Crystallinity (%)	40	67	40

Jadual 1 menunjukkan perbezaan sifat lazim polietilena; polietilena berketumpatan rendah (LDPE), polietilena berketumpatan tinggi (HDPE) dan polietilena berketumpatan rendah linear (LLDPE). Ramalkan berat molekul, kelegapan dan kekuatan alah bagi tiga jenis polietilena ini, dan berikan alasan yang sesuai untuk jawapan anda.

Jadual 1: Perbandingan sifat tipikal polietilena

Sifat	*LDPE*	*HDPE*	*LLDPE*
MFI (190°C/2.16 kg)	*1.1*	*1.1*	*0.85*
Ketumpatan (g/cm^3)	*0.924*	*0.961*	*0.922*
Kehabluran (%)	*40*	*67*	*40*

(30 marks/*markah*)

[c] An injection molded poly(methyl methacrylate**)** (PMMA) part was found to crack when dropped. The virgin resin had a melt flow index (MFI) of 28.5 g/10min. A sample from a known "good" lot of parts was ground up and tested in a melt indexer. It had a MFI of 27, well within established tolerances of $\pm$30% but a "problem" part showed a MFI of 90. Justify TWO reasons related to the differences in the MFI values.

*Komponen Poli(metil metakrilat**)** (PMMA) didapati retak apabila jatuh. Resin yang baru mempunyai indeks aliran lebur (MFI) sebanyak 28.5 g/10min. Sampel daripada lot yang 'baik' telah dihancurkan dan diuji dengan indeks leburan. Didapati nilai MFI adalah 27, iaitu dalam toleren yang boleh diterima* $\pm$30% *tetapi komponen "bermasalah" menunjukkan MFI sebanyak 90. Berikan DUA alasan yang mengaitkan perbezaan nilai MFI ini.*

(30 marks/*markah*)

2. [a] Concrete and fibre reinforced polymers (FRP's) are used widely in construction particularly for footbridge applications. List and discuss the main advantages and disadvantages of using FRP's in place of concrete in constructing a footbridge.

Konkrit dan polimer diperkuat gentian (FRP) digunakan secara meluas di dalam pembinaan jambatan pejalan kaki. Senarai dan bincangkan kelebihan dan kelemahan FRP di dalam pembinaan jambatan pejalan kaki berbanding konkrit.

(20 marks/*markah*)

[b] Table 2 shows the typical values for various properties of unfilled castings prepared from a liquid bisphenol A-based epoxy resin and various curing agents. Based on the values given, comment on how the type and structure of the curing agent influence the properties of the cured epoxy resin with respect to the properties listed.

Table 2: Typical values for various properties of unfilled castings prepared from a liquid bisphenol A-based epoxy resin and various curing agents

Properties	Curing agents			
	Aliphatic amines	Aromatic amines	Fatty polymides	Anhydrides
Tensile strength (MPa)	48-69	69-90	31-45	83-90
Compressive strength (MPa)	83-100	120-130	48-62	120-130
Flexural strength (MPa)	83-100	120	48-62	120-130
Impact strength (J/m)	21-27	27-32	53-64	21
Heat deflection temperature (^{o}C)	70-110	145-150	40-60	125-135

Jadual 2 menunjukkan nilai-nilai sifat cecair epoksi resin bisphenol A di matang menggunakan pelbagai agent pematangan. Berdasarkan kepada nilai-nilai tersebut, komen bagaimana struktur dan jenis agen pematangan mempengaruhi sifat-sifat epoksi berdasarkan kepada sifat-sifat yang disenaraikan.

Jadual 2: Nilai-nilai tipikal sifat-sifat epoksi resin bisfenol A dimatangkan dengan pelbagai agen pematangan

Sifat	*Agen pematangan*			
	Amina alifatik	*Amina aromatiks*	*Poliamida lemak*	*Anhidrida*
Kekuatan tensil (MPa)	*48-69*	*69-90*	*31-45*	*83-90*
Kekuatan mampatan (MPa)	*83-100*	*120-130*	*48-62*	*120-130*
Kekuatan lenturan (MPa)	*83-100*	*120*	*48-62*	*120-130*
Kekuatan hentaman (J/m)	*21-27*	*27-32*	*53-64*	*21*
Suhu pesongan haba (^oC)	*70-110*	*145-150*	*40-60*	*125-135*

(40 marks/*markah*)

[c] Prepregs (pre-impregnated sheet materials) are fibrous materials impregnated with reactive resin materials and are the ideal starting material for lightweight yet high-strength constructional parts. Discuss and compare the main advantages and disadvantages of prepreg and hand lay-up techniques in preparing structural composites by taking into account the aspects of materials cost, handling of materials, health and safety, waste generation and surface finish.

Prapreg adalah bahan gentian yang di isitepu resin reaktif dan merupakan bahan pemula yang ideal untuk menghasilkan bahan struktur yang ringan dan berkekuatan tinggi. Bincang dan bandingkan kelebihan dan kekurangan utama kaedah prapreg dan hand-layup dengan mengambilkira aspek kos bahan, pengurusan bahan, keselamatan dan kesihatan, jumlah buangan dan keadaan permukaan.

(40 marks/*markah*)

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PART B / *BAHAGIAN B*:-

3. [a] Differentiate between a blending and a compounding process. State TWO equipments involved in each of the process.

Bezakan proses pencampuran dan penyebatian. Nyatakan DUA peralatan yang terlibat dalam setiap proses tersebut.

(30 marks/*markah*)

[b] A hollow part with a finished dimension of 100 x 50 x 10 cm and thickness of 3 mm is to be formed by a fundamental vacuum thermoforming. Determine the size and thickness of a blank sheet needed to make the part. Assume 2 cm per side are required for clamping.

Komponen lompang dengan dimensi akhir bersaiz 100 x 50 x 10 sm dan ketebalan 3 mm akan dihasilkan dengan kaedah pembentukan haba vakum asas. Kenalpasti saiz dan ketebalan kepingan kosong untuk menghasilkan komponen tersebut. Anggapkan 2 sm bagi setiap belah diperlukan untuk pengapitan.

(40 marks/*markah*)

[c] Poly(ethylene terephthalate) (PET) film is being cast using a 4 inch diameter single screw extruder running at 150 rpm. Substandard physical properties of the film product indicate that thermal degradation occurred during the processing operation. However, process temperature measurements are well below the threshold at which thermal degradation is known to occur. Specifically, careful laboratory measurements have shown that thermal degradation does not occur with this formulation unless the temperature exceeds 350ºC. The extruder has five temperature zones set as follows:

(Feed Section) 200ºC, 275ºC, 285ºC, 285ºC, 285ºC (Die).

The melt thermocouple at the die reads a stedy temperature of 290ºC. As a check, a sample of the extrudate was collected in an insulated bucket and its temperature was directly measured at 293ºC using a thermocouple.

Provide TWO possible reasons how thermal degradation of the PET film can occur despite the fact that all process temperatures are well below the degradation thereshold?

Filem poli(ethilena tereptalate) (PET) telah di acuankan dengan menggunakan 4 inci diameter penyemperitan skru tunggal berkelajuan 150 rpm. Sifat fizikal filem yang tidak menepati standard menunjukkan bahawa degradasi haba telah berlaku sewaktu pemprosesan. Bagaimanapun, pengukuran suhu menunjukkan suhu adalah di bawah suhu ambang. Melepasi suhu ambang degradasi akan berlaku. Secara khusus, pengukuran mendapati degradasi haba bagi formulasi ini tidak akan berlaku melainkan suhu mencapai 350ºC. Penyemperitan ini mempunyai lima zon suhu iaitu:

(Bahagian Masukan) 200ºC, 275ºC, 285ºC, 285ºC, 285ºC (Dai).

Termokupel dai pada bahagian lebur menunjukkan bacaan yang mantap pada 290ºC. Sebagai pemeriksaan, sample penyemperitan telah dikutip dalam bahagian berpenebat dan suhu sebanyak 293ºC di ukur secara terus menggunakan termokupel.

Cadangkan DUA penyebab kenapa berlakunya degradasi haba ke atas PET, walhal suhu pemprosesan adalah di bawah suhu ambang?

(30 marks/*markah*)

4. [a] The structure of silicone is very different from that of other organic polymers. Referring to the structure of the silicone, convince why silicones are stronger and more flexible than carbon-based molecules.

Struktur silikon adalah berbeza daripada polimer organik yang lain. Merujuk kepada struktur silikon ini, jelaskan kenapa silikon ini lebih kuat dan lebih fleksibel daripada molekul yang berasaskan karbon.

(30 marks/*markah*)

[b] Due to the uniqueness of elastomers, some aspects of the processing methods are quite different from other plastic processing methods. Compare the processing of elastomer and thermoplastic elastomer in term of additives, machinery, curing agent and scrap. State THREE advantages of a thermoplastic elastomer.

Disebabkan keunikan elastomer, beberapa aspek kaedah pemprosesannya adalah daripada kaedah pemprosesan plastik yang lain. Bandingkan pemprosesan elastomer dan elastomer termoplastik dari segi bahan tambah, mesin, agen sambung silang dan skrap. Nyatakan TIGA kelebihan elastomer termoplastik.

(30 marks/*markah*)

[c] What is the importance of the curing characteristic test for a rubber compound? With appropriate diagram, discuss three stages of curing characteristics of a rubber compound

Apakah kepentingan ujian kelakuan pematangan sebatian getah? Dengan gambarajah yang sesuai, bincangkan tiga peringkat kelakuan pematangan sebatian getah.

(40 marks/*markah*)

5. [a] In the case where mechanical joint is not applicable, a structural adhesive plays an important role in joining similar or dissimilar faces. Discuss the nature of structural adhesive and outline the main specification of typical structural adhesive. In your discussion, please include also the way of improving the strength of the bonding with respect to the surface preparation.

Di dalam keadaan di mana sambungan mekanikal tidak berkaitan, perekat struktur memainkan peranan yang penting untuk menyambungkan dua permukaan yang sama atau berlainan. Bincangkan keadaan semulajadi perekat struktur dan senaraikan spesifikasi utama untuk sesuatu perekat lazim. Di dalam perbincangan anda, jelaskan kaedah-kaedah untuk menambah kekuatan rekatan dengan menekankan kepada aspek penyediaan permukaan.

(40 marks/*markah*)

[b] Discuss two important aspects of processing thermosetting resins.

Bincangkan dua aspek-aspek penting dalam pemprosesan resin termoset.

(20 marks/*markah*)

[c] Table 3 shows typical values for various properties of unfilled and filled cured phenol-formaldehyde polymers. Using the information in Table 3, state the main advantages and disadvantages of reinforcing phenol-formaldehyde with wood flour, cotton fabric and paper in comparison with the unfilled resin. Consequently, suggest the reason(s) why the properties of the resin are affected in one way or another by the filled materials.

Table 3: Typical values for various properties of cured phenol-formaldehyde polymers, unfilled and filled

Properties	Unfilled casting	Moulding, wood flour filled	Moulding, cotton fabric filled	Laminate, paper filled
Specific gravity	1.3	1.3 - 1.4	1.3 - 1.4	1.3 - 1.4
Tensile strength (MPa)	21-69	34-55	34-55	55-170
Bending strength (MPa)	48-100	55-100	55-100	100-210
Compression strength (MPa)	69-210	100-280	140-240	140-280
Impact strength (J/m)	5.3-27	5.3-27	16-160	11-110
Water absorption (mg)	2-20	70-150	200-400	15-300

Jadual 3 menunjukkan nilai-nilai tipikal phenol-formaldehyde yang dimatangkan pada keadaan terisi dan tidak terisi. Menggunakan maklumat di dalam Jadual 3, nyatakan kelebihan dan kekurangan menggunakan abuk kayu, fabrik kapas dan kertas sebagai pengisi berbanding dengan resin tak terisi. Seterusnya, cadangkan alasan-alasan yang sesuai bagaimana pengisi memberi kesan terhadap sifat-sifat resin.

Jadual 3: Nilai-nilai tipikal sifat polimer fenolfomadihida terisi dan tak terisi

Sifat	*Resin tak terisi*	*Resin terisi serbuk kayu*	*Resin terisi fabrik kapas*	*Laminat terisi kertas*
Graviti spesifik	*1.3*	*1.3 - 1.4*	*1.3 - 1.4*	*1.3 - 1.4*
Kekuatan regangan (MPa)	*21-69*	*34-55*	*34-55*	*55-170*
Kekuatan lenturan (MPa)	*48-100*	*55-100*	*55-100*	*100-210*
Kekuatan mampatan (MPa)	*69-210*	*100-280*	*140-240*	*140-280*
Kekuatan hentaman (J/m)	*5.3-27*	*5.3-27*	*16-160*	*11-110*
Penyerapan air (mg)	*2-20*	*70-150*	*200-400*	*15-300*

(40 marks/*markah*)

6. [a] Describe the process of manufacturing unidirectional composites using a pultrusion technique. In your description, provide information pertaining to the resin and fibre preparations, requirements including the resin:fibre ratio, vital additives and speed in order to ensure a smooth operation.

Terangkan proses penghasilan komposit sejajar menggunakan kaedah pultrusi. Di dalam keterangan anda, gariskan aspek penyediaan resin dan fiber serta keperluannya termasuklah nisbah resin: fiber, bahan tambah penting dan kelajuan mesin untuk memastikan proses berjalan lancar.

(40 marks/*markah*)

[b] Linear unsaturated polyesters are prepared commercially by the reaction between a saturated diol with a mixture of an unsaturated dibasic acid and the corresponding anhydrides. Outline the procedure of preparing the linear unsaturated polyesters commercially and recommend a typical ratio of saturated diol and anhydride.

Poliester linear tak tepu dihasilkan secara komersil melalui tindakbalas antara campuran diol tepu dan dibasic asid tak tepu berserta anhydride yang sesuai. Perincikan kaedah penghasilan poliester linear tak tepu secara komersil dan cadangkan ratio tipikal antara dibasic asid tak tepu dan anhydride.

(30 marks/*markah*)

[c] Autoclave curing is always recommended when a high quality composite is required especially for aircraft and automotive components. Explain why autcolave curing is capable of producing high quality composites and compare your answer with ordinary curing method such as compression moulding.

Pematangan autoclav adalah kaedah pilihan apabila komposit berkualiti tinggi diperlukan terutamanya untuk komponen-komponen kapal terbang dan automotif. Terangkan mengapa kaedah pematangan autoclav mampu menghasilkan komposit berkualiti tinggi dan bandingkan jawapan anda dengan kaedah pematangan biasa seperti acuan mampatan.

(30 marks/*markah*)

7. [a] Briefly explain TWO issues related to environmental impact of plastic and paper grocery bags.

Terangkan secara ringkas DUA isu berkenaan dengan kesan persekitaran bagi beg plastik dan beg kertas.

(20 marks/*markah*)

[b] The number of motorcar waste tyres generated annually in Malaysia was estimated to be 8.2 million or approximately 57,391 tonnes. Instead of using landfill as the easiest and a legal avenue to dispose waste tyres, recommend TWO alternative ways to reduce the accumulation of waste tyre.

Bilangan tayar kereta terbuang di Malaysia meningkat setiap tahun sebanyak 8.2 juta atau anggaran sebanyak 57,391 ton. Selain daripada tapak pelupusan sebagai kaedah yang termudah dan sah dari segi undang-undang untuk melupuskan tayar yang terbuang ini, cadangkan DUA kaedah alternatif untuk mengurangkan timbunan tayar terbuang ini.

(30 marks/*markah*)

[c] You are required to produce a long and continuous profile of a fibre reinforced unsaturated polyester composite in a large quantity within a reasonable time. Recommend a suitable manufacturing technique for the profile and discuss your choice. Hence, outline the main reason of your selection.

Anda diminta untuk menghasilkan profil komposit terkuat fiber poliester tak tepu di dalam kuantiti yang besar dan jangkamasa yang singkat. Cadangkan kaedah yang sesuai untuk menghasilkan profil tersebut dan bincangkan pilihan anda beserta dengan alasan yang sesuai.

(50 marks/*markah*)

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