UNIVERSITI SAINS MALAYSIA

First Semester Examination
2014/2015 Academic Session

December 2014 / January 2015

EBP 103/3 – Polymer Organic Chemistry
[Kimia Organik Polimer]

Duration : 3 hours
[Masa : 3 jam]

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

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

<u>Instruction:</u> Answer <u>FIVE</u> questions. Answer <u>ALL</u> questions from PART A, <u>TWO</u> questions from PART B and <u>TWO</u> questions from PART C. If a candidate answers more than five questions only the first five questions answered in the answer script would be examined.
[<u>Arahan</u>: Jawab <u>LIMA</u> soalan. Jawab <u>SEMUA</u> soalan dari BAHAGIAN A, <u>DUA</u> soalan dari BAHAGIAN B dan <u>DUA</u> 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 in the examination questions, the English version shall be used.
[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah digunapakai.]
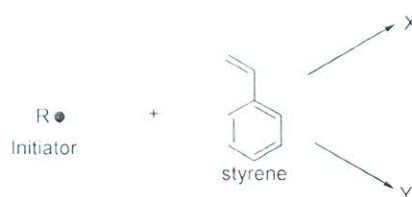
PART A / *BAHAGIAN A*

1. [a] Compare the difference between chain-growth polymerization and step-growth polymerization.

Bandingkan perbezaan antara pempolimeran rantai dan pempolimeran langkah.

(50 marks/*markah*)

[b] Define with example a free radical species. Reaction of a radical initiator with a styrene monomer could produce two type of radical intermediates X and Y as shown in the following reaction scheme 1. State these intermediates henceforth determine which is major and minor.

Berikan definisi berserta satu contoh spesies radikal bebas. Tindakbalas satu pemula radikal dengan monomer stirena boleh menghasilkan dua jenis perantara radikal X dan Y seperti ditunjukkan dalam skema tindakbalas 1 berikut. Nyatakan bahan perantara ini dan seterusnya nyatakan hasil major dan minor.

Scheme 1

Skema 1

(20 marks/*markah*)

[c] Define nucleophile and electrophile. Predict with reasons whether the followings are nucleophile, electrophile or both:
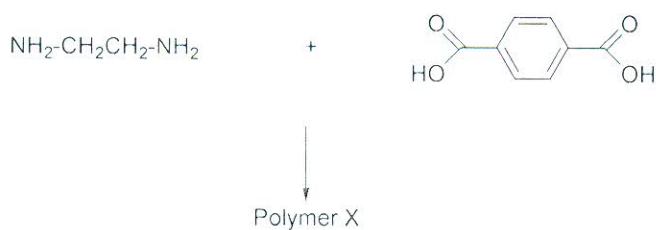
Berikan definisi nukleofil dan elektrofil. Ramalkan serta berikan alasan samada yang berikut merupakan nukleofil, elektrofil atau kedua-duanya sekali:

$$-NH_2 \qquad -OH^- \qquad AlCl_3 \qquad H^+ \qquad \diagdown C=O \qquad -SH$$

(15 marks/*markah*)

[d]   Identify the nucleophilic and the electrophilic centre of the following monomers used during polycondensation of polymer X (scheme 2). Predict the structure of polymer X:

Tentukan pusat nukleofil dan elektrofil bagi monomer berikut yang digunakan bagi tindakbalas polikondensasi untuk polimer X (skema 2). Cadangkan struktur polimer X:

Polymer X

Scheme 2

Skema 2

(15 marks/*markah*)

PART B / *BAHAGIAN B*

2.   [a]   Write and explain the following free radical polymerization mechanism of styrene:

(i)   initiation by benzoyl peroxide

(ii)   propagation

(iii)   termination by combination

Tuliskan dan jelaskan mekanisma pempolimeran radikal bebas bagi stirena seperti berikut:

(i)   permulaan dengan benzoil peroksida

(ii)   perambatan

(iii)   penamatan secara penggabungan

(60 marks/*markah*)

[b]   Calculate the solubility parameter of polystyrene. Given that the group molar attraction constant (G) of $-CH_3$, $-CH<$ and phenyl group is 133, 28 and 735, respectively. The density of polystyrene is 1.05 g/cm^3 and the monomer molecular weight is 104 g/mol.

Hitungkan parameter kebolehlarutan polistirena. Diberikan pemalar tarikan molar kumpulan (G) bagi $-CH_3$, $-CH<$ dan kumpulan fenil ialah 133, 28 dan 735, masing-masing. Ketumpatan polistirena ialah 1.05 g/cm^3 dan berat molekul monomer bernilai 104 g/mol.

(40 marks/*markah*)

3. [a] Describe the ionic polymerizability of monomers.

    Huraikan keboleh-pempolimeran ionik bagi monomer.

    (40 marks/*markah*)

    [b] Discuss on ring opening polymerization. Answer must be supported by THREE examples.

    Bincangkan pempolimeran pembukaan-gelang. Jawapan mesti disokong dengan TIGA contoh.

    (60 marks/*markah*)

4. [a] Discuss on living polymerization. Write the initiation and propagation mechanism for the polymerization of styrene with sodium naphthalene.

    Bincangkan pempolimeran hidup. Tuliskan mekanisme permulaan dan perambatan bagi pempolimeran stirena dengan natrium naftalena.

    (60 marks/*markah*)

    [b] Give ONE example of polymer that synthesized using polyaddition-type step growth polymerization. Answer must be supported by chemical reaction.

    Berikan SATU contoh polimer yang disintesis melalui pempolimeran langkah jenis poli-penambahan. Jawapan mesti disokong dengan tindakbalas kimia.

    (20 marks/*markah*)

    [c] Give ONE example of polymer that synthesized using polycondensation-type step growth polymerization. Answer must be supported by chemical reaction.

    Berikan SATU contoh polimer yang disintesis melalui pempolimeran langkah jenis poli-kondensasi. Jawapan mesti disokong dengan tindakbalas kimia.

    (20 marks/*markah*)

PART C / *BAHAGIAN C*

5.   [a]   Chitosan is a biodegradable polymer found in sea animals which display good mechanical properties. Show any intermolecular forces that exist between the chitosan chains based on the given structure in Figure 1 below:

Kitosan adalah polimer bio-terurai yang didapati dalam haiwan laut yang mempamerkan sifat mekanik yang baik. Tunjukkan sebarang daya antara-ikatan yang wujud dalam molekul kitosan berdasarkan struktur dalam Rajah 1 berikut:
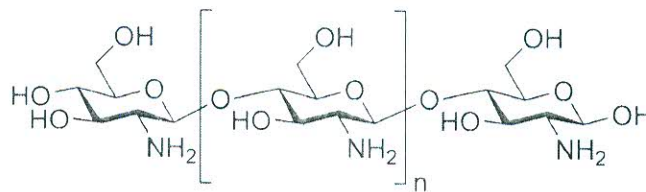

Figure 1 - Structure of Chitosan

Rajah 1 - Struktur Kitosan

(40 marks/*markah*)

[b]   The structures of epoxy resin and graphene is shown in Figure 2. Answer the followings:

(i)   Predict the distribution of graphene in the epoxy resin matrix. Explain your prediction.

(ii)   Suggest with reasons what happen to the level of distribution of modified graphene in epoxy resin if the number of oxygen in the graphene is increased.

Struktur bagi resin epoksi dan grafin adalah ditunjukkan dalam Rajah 2. Jawab soalan yang berikut:

(i)   Ramalkan taburan grafin dalam matrik gaulan resin grafit. Jelaskan ramalan anda.

(ii)   Cadangkan dengan alasan apa akan berlaku terhadap tahap taburan grafin dalam resin epoksi sekiranya bilangan oksigen dalam grafin meningkat.

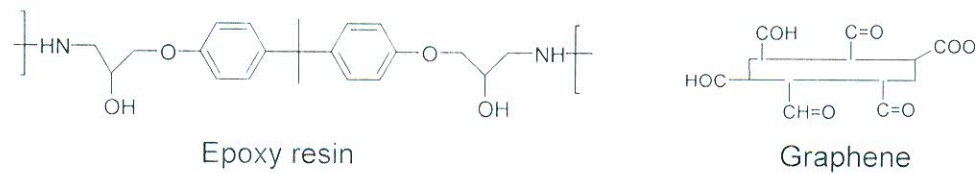Epoxy resin   Graphene

Figure 2

Rajah 2

(60 marks/*markah*)

6. [a] Give differences between aliphatic and aromatic structures in terms of thermal stability, conformation and reactivity.

Berikan perbezaan antara struktur alifatik dan aromatik berdasarkan kestabilan termal, konformasi dan kereaktifan.

(20 marks/*markah*)

[b] Arrange in increasing order for the melting point of the followings. Verify your answer.
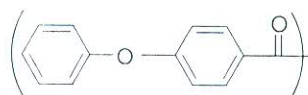
Susun secara menaik turutan takat lebur bagi struktur yang berikut. Tentusahkan jawapan anda.

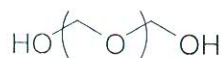| Polyethylene | Polypropylene | Polyetherketone | Polystyrene |

(50 marks/*markah*)

[c] Polyethylene oxide is soluble in water but polyethylene is not. Suggest a reason.

Polietilena oksida larut dalam air manakala polietilena tidak. Berikan satu alasan.

Polyethylene   Polyethylene oxide

(30 marks/*markah*)

7.   [a]   The range of FTIR spectroscopy is measured within wavenumber 4000 – 400 cm⁻¹. Indicate the range of occurrence for the followings functional groups in the following table:

Pengukuran dalam spektroskopi FTIR adalah dalam julat 4000 – 400 cm⁻¹ nombor gelombang. Tentukan julat ukuran bagi kumpulan berfungsi yang diberikan dalam jadual berikut:

Group *Kumpulan*	Wavenumber (cm⁻¹) *Nombor gelombang (cm⁻¹)*
-C-C	
-C=O	
-C=C	
-N-H	

(50 marks/*markah*)

[b]   Predict the identity of polymer based on the following FTIR spectrum in Figure 3 given that it only contains carbon and hydrogen. Justify your prediction.

Ramalkan identiti polimer berdasarkan spektrum dalam Rajah 3 di mana ianya hanya mengandungi unsur karbon dan hidrogen. Berikan ulasan anda.
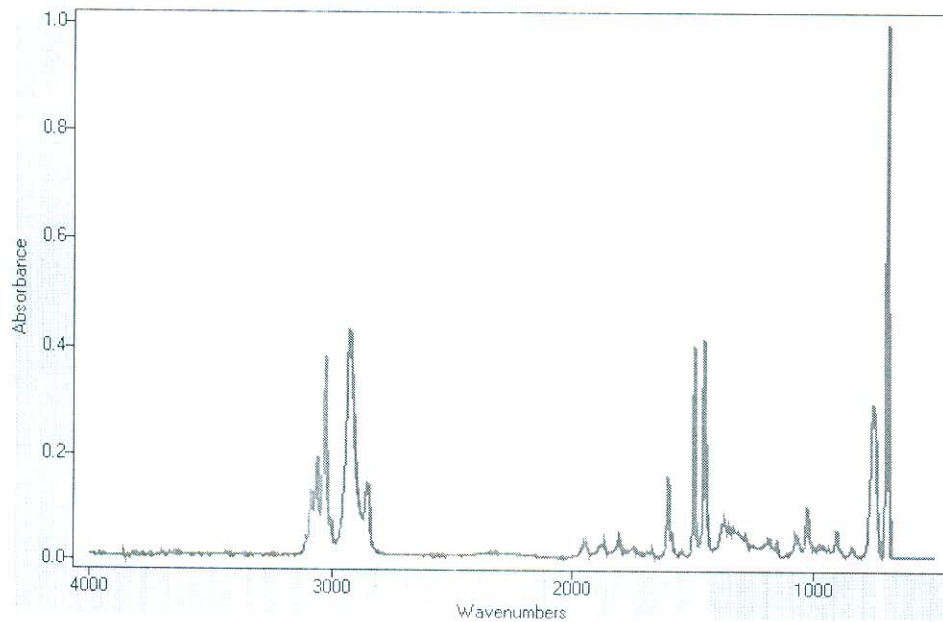

Figure 3

Rajah 3

(50 marks/*markah*)

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