UNIVERSITI SAINS MALAYSIA

First Semester Examination
2014/2015 Academic Session

December 2014 / January 2015

EBP 201/3 – Polymer Synthesis
[Sintesis Polimer]

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 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.]

Instruction: Answer **FIVE** questions. Answer **ALL** questions from PART A, **TWO** questions from PART B and **TWO** 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.
*[**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 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] Consider a hypothetical polymer sample composed of chains of four distinct molecular weights, 100 000, 200 000, 500 000 and 1 000 000 g/mol in the ratio 1:5:3:1. Calculate Mn, Mw and polydispersity of the polymer sample.

Pertimbangkan suatu sampel polimer hipotetik yang mengandungi rantai dengan empat berat molekul yang berbeza, 100 000, 200 000, 500 000 dan 1 000 000 pada nisbah 1:5:3:1. Kirakan Mn, Mw dan polisebaran bagi sampel polimer tersebut.

(30 marks/*markah*)

[b] List 5 important requirements for the successful synthesis of a high molecular weight polymer via step-growth polymerization.

Senaraikan 5 keperluan utama bagi memastikan sintesis polimer berberat molekul tinggi berjaya dihasilkan melalui pempolimeran pertumbuhan berlangkah.

(20 marks/*markah*)

[c] Consider the values of cross-propagation rate constant k_{12} for radical centre-monomer reaction during radical copolymerization as given in the Table 1 below:

Pertimbangkan nilai pemalar kadar perambatan-silang k_{12} bagi tindakbalas pusat radikal-monomer semasa pengkopolimeran radikal yang diberi dalam Jadual 1 di bawah.

Table 1 - Cross-propagation rate constant k_{12}
Jadual 1 - Pemalar kadar perambatan silang k_{12}

	Polymer radicals			
Monomers	Butadiene	Styrene	Methyl methacrylate	Vinyl acetate
Butadiene	100	280	2060	
Styrene	70	165	1130	230000
Methyl methacrylate	130	314	515	154000
Vinyl acetate		3.4	26	2300

...3/-

(i) Why do the k_{12} values of butadiene and styrene polymer radicals are mostly lower compared to that of methyl methacrylate and vinyl acetate.

Mengapakah nilai k_{12} bagi polimer radikal butadiena dan stirena lebih rendah berbanding radikal metil metakrilat dan vinil asetat.

(ii) Based on the k_{12} values above, explain why styrene will form ideal copolymer with butadiene.

Berdasarkan nilai k_{12} di atas, jelaskan mengapa stirena membentuk kopolimer unggul dengan butadiena.

(iii) Choose a polymer radicals-monomer pair which would give a block copolymer. Explain your choice.

Padankan pasangan radikal polimer-monomer yang akan membentuk kopolimer blok. Jelaskan jawapan anda.

(50 marks/*markah*)

PART B / *BAHAGIAN B*

2. [a] Define each of the following terms:

(i) Polymer

(ii) Monomer

(iii) Degree of polymerization

(iv) Homopolymer

(v) Copolymer

(vi) Functionality

Takrifkan setiap istilah yang berikut:

(i) Polimer

(ii) Monomer

(iii) Darjah pempolimeran

(iv) Homopolimer

(v) Kopolimer

(vi) Kebolehan berfungsi

(30 marks/*markah*)

[b] Calculate the number average molecular weight (Mn) for poly(butylenes terephthalate) prepared under optimum conditions to 97.5% conversion.

Kirakan nombor purata berat molekul (Mn) bagi poli(butilena tereftalat) yang disediakan di bawah keadaan optima kepada penukaran 97.5%.

(15 marks/*markah*)

[c] Karl Ziegler and Giulio Natta are jointly attributed with the discovery of transition metal catalysts which polymerize hydrocarbon monomers such as ethylene and propylene.

Karl Ziegler dan Giulio Natta bersama-sama telah menyumbang kepada penemuan pemangkin logam peralihan yang boleh mempolimerkan monomer hidrokarbon seperti etilena dan propilena.

(i) Provide an example of a Ziegler-Natta catalyst system.

Berikan satu contoh sistem pemangkin Ziegler-Natta.

(5 marks/*markah*)

(ii) Using chemical equations, describe the general mechanism for Ziegler-Natta catalyzed polymerization.

Menggunakan persamaan kimia, terangkan secara umum mekanisme bagi pempolimeran dengan pemangkin Ziegler-Natta.

(50 marks/*markah*)