UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2007/2008

October/November 2007

EBP 201/3 - Polymer Synthesis
[Sintesis Polimer]

Duration : 3 hours
[Masa : 3 jam]

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

This paper contains SEVEN questions.
[Kertas soalan ini mengandungi TUJUH soalan.]

Instructions: Answer any **FIVE** questions. If a candidate answers more than five questions, only the first five answers will be examined and awarded marks.
*[**Arahan:** Jawab **LIMA** soalan. Jika calon menjawab lebih daripada lima soalan hanya lima soalan pertama mengikut susunan dalam skrip jawapan akan diberi markah.]*

Answer to any question must start on a new page.
[Mulakan jawapan anda untuk setiap 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.]

1. [a] What is meant by living polymerisation?

Apakah yang dimaksudkan dengan pempolimeran hidup?
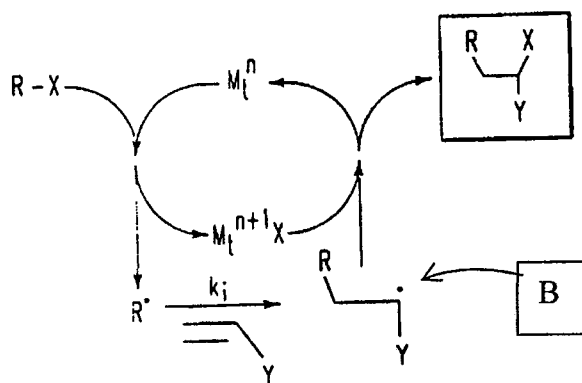
(15 marks/*markah*)

[b] Discuss the conditions required for living anionic polymerization.

Bincangkan keadaan yang sesuai bagi berlakunya pempolimeran anionik hidup.

(25 marks/*markah*)

[c] Atomic transfer radical polymerisation (ATRP) is a system to produce a living radical polymerisation. Based on the reaction scheme of ATRP illustrated as follows, answer the following:

Pempolimeran radikal pemindahan atom (ATRP) adalah suatu sistem untuk menghasilkan pempolimeran radikal hidup. Berdasarkan skema tindakbalas di bawah, jawab soalan yang berikut:

(i)   What does M^n and M^{n+1} represent?

Apakah yang diwakili oleh M^n dan M^{n+1}?

(ii)   How is the radical R● formed?

Bagaimana radikal R● terbentuk?

(iii)   Why is the active radical intermediate B less likely to undergoes termination?

Kenapa radikal perantara teraktif B kurang kecenderungan mengalami penamatan?

(60 marks/*markah*)

2.   During radical polymerisation:

Bagi pempolimeran radikal:

(a)   Explain what is ceiling temperature.

Jelaskan maksud suhu terhad.

(20 marks/*markah*)

(b)   Discuss 3 methods to control the average molecular weight.

Bincangkan 3 cara bagi mengawal purata berat molekul.

(30 marks/*markah*)

(c)   Determine the final temperature required to bring about a 2 fold decrease in the degree of radical polymerisation if the initial temperature is 50°C. (Given E_p = 34 kJmol⁻¹, E_t = 10 kJmol⁻¹, E_i = 126 kJmol⁻¹ and R = 8.314Jmol⁻¹K⁻¹)

Tentukan suhu akhir yang diperlukan bagi mengurangkan 2 kali ganda darjah pempolimeran radikal jika suhu awal ialah 50°C. (Diberi E_p = 34 kJmol⁻¹, E_t = 10 kJmol⁻¹, E^i = 126 kJmol⁻¹ dan R = 8.314kJmol⁻¹K⁻¹)
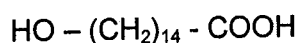
(50 marks/*markah*)

3.   [a]   Derive the Carothers equation.

Terbitkan persamaan Carothers.

(15 marks/*markah*)

[b]   The following data are given for the polycondensation of an acid,

Data berikut diberi bagi polikondensasi suatu asid,

$$HO - (CH_2)_{14} - COOH$$

where the concentration of the acid was measured at different times by titration:

di mana kepekatan asid itu ditentukan pada masa tertentu menggunakan kaedah pentitratan:

t (hours) / *t (jam)*	0	0.5	1.0	1.5
Acid [M] / *Asid [M]*	3.10	1.30	0.83	0.61

Determine the rate constant and order of reaction. Calculate the extent of reaction, P after 1 hour.

Tentukan pemalar kadar serta tertib tindakbalas. Hitung jangkauan tindakbalas P selepas 1 jam.

(40 marks/*markah*)

[c]   Ignore end-group effects, calculate the extent of reaction, P to reach $M_n = 24\ 000$ for the monomer $HO - (CH_2)_{14} - COOH$.

Abaikan kesan kumpulan hujung, kirakan jangkauan tindakbalas P untuk menghasilkan $M_n = 24000$ bagi monomer $HO - (CH_2)_{14} - COOH$.

(45 marks/*markah*)

4.   Answer all of the the followings:

Jawab kesemua yang berikut:

(a)   Why polyacrylonitrile cannot be prepared by bulk polymerisation?

Kenapa poliakrilonitril tidak boleh disediakan secara pempolimeran pukal?

(25 marks/*markah*)

(b)   Why "head-to-tail" addition dominates in chain polymerisation of a vinyl polymer?

Kenapa penambahan "kepala-ke-ekor" banyak berlaku di dalam pempolimeran rantai polimer vinil?

(25 marks/*markah*)

(c)   Why is copolymerization of styrene and maleic anhydride would form alternating copolymer but that of styrene and vinyl acetate form block copolymer?

Kenapa kopolimeran stirena dan malik anhidrida membentuk kopolimer selang-seli manakala kopolimeran stirena dengan vinil asetat membentuk kopolimer blok?

(25 marks/*markah*)

(d)   How is high density polyethylene produced using Ziegler-Natta catalyst?

Bagaimana polietilena berketumpatan berat dihasilkan menggunakan mangkin Ziegler-Natta?

(25 marks/*markah*)

5. [a] Why is the copolymerization of styrene with methyl methacrylate preferably performed under radical condition compared to ionic condition?

Kenapa kopolimeran stirena dengan metil metakrilat banyak menggunakan mekanisme radikal berbanding mekanisme ionik?

(20 marks/*markah*)

[b] Given the reactivity of styrene and propylene as in the table:

Diberi kereaktifan stirena dan propilena seperti dalam jadual berikut:

monomer	Q	e
styrene	1.00	-0.80
Propylene	0.002	-0.78

Verify that the copolymerization of the two monomer would give a block copolymer and hence explain the verification based on the Q and e values.

Sahkan bahawa pengkopolimeran antara dua monomer tersebut menghasilkan kopolimer blok serta jelaskan pemerhatian ini berdasarkan nilai Q dan e yang diberi.
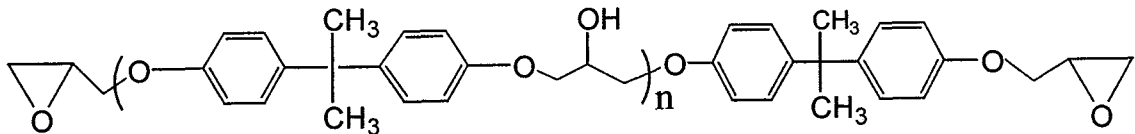
(40 marks/*markah*)

[c] Calculate the composition of the initial copolymer produced under radical polymerization of a solution containing styrene (r = 55) and vinyl acetate (r = 0.01) at initial feed composition of styrene f_1 = 0.2, 0.4, 0.6 and 0.8.

Kirakan komposisi awal kopolimer yang terhasil secara pempolimeran radikal bagi suatu campuran stirena (r = 55) dan vinil asetat (r = 0.01) pada komposisi muatan awal stirena dengan f_1 = 0.2, 0.4, 0.6, 0.8.

(40 marks/*markah*)

6. The table below describe several parameters for glycidyl ether–bisphenol A epoxy resins as shown:

Jadual di bawah menunjukkan beberapa parameter memerikan resin glisidil eter-bisfenol A seperti yang ditunjukkan dalam gambarajah berikut:

Based on the table, answer all the questions given below:

Berdasarkan jadual ini, jawab soalan yang berikut:

	A	B	C
Epoxy value/100g *Nilai epoksi/100g*	0.2	0.1	0.5
Epoxy group/molecule *Kumpulan epoksi/molekul*	I	II	III
Equivalent weight *Berat setara*	IV	V	VI
n *n*	VII	VIII	IX
Molecular weight *Berat molekul*	900	1400	370

(a) What is meant by epoxy equivalent weight?

Apakah yang dimaksudkan dengan berat setara epoksi?

(10 marks/*markah*)

(b) Estimate the unknown values I, II, III, IV, V, VI, VII, VIII, IX.

Tentukan nilai yang tak diketahui I, II, III, IV, V, VI, VII, VIII, IX

(27 marks/*markah*)

...8/-

(c)   Suggest a synthetic procedure to obtain A, B and C resin with different molecular weight.

Cadangkan satu kaedah sintesis bagi menghasilkan resin A, B dan C yang berbeza berat molekul.

(15 marks/*markah*)

(d)   If 4 mole of curing agent required to cure 1 mole epoxy group, how much is needed, in grams, for resin A to be cured by 0.1 mole of the curing agent?

Jika 4 mol agen pematangan diperlukan untuk mematangkan 1 mol kumpulan epoksi, berapa banyak yang diperlukan, dalam gram, bagi resin A untuk dimatangkan oleh 0.1 mol agen pematangan itu?
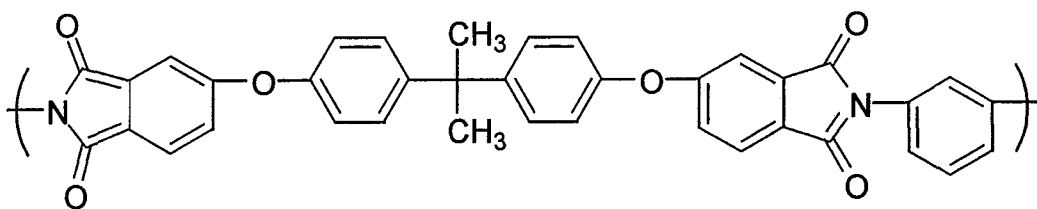
(48 marks/*markah*)

7.   Predict the monomers required to synthesis the following polymers:

Jangkakan monomer-monomer yang digunakan bagi menghasilkan polimer-polimer berikut:

(100 marks/*markah*)

(a)

(b)