

PART A / BAHAGIAN A

- (1). (a). What are the differences between isotactic and syndiotactic polystyrene? The answer must be supported by the drawing of the tacticity of the polystyrene.

Apakah perbezaan antara polistirena isotaktik dan sindiotaktik? Jawapannya mesti disokong dengan lukisan ketaktikan polistirena.

(6 marks/markah)

- (b). Describe helical conformation and random coil conformation.

Huraikan konformasi heliks dan konformasi gegelung rawak.

(4 marks/markah)

- (c). Two polymer samples, one is thermoplastic and the other is thermoset, need to be prepared using surface replication technique for Transmission Electron Microscopy (TEM). Differentiate sample preparation for each case and explain the existence of such difference in preparing each sample.

Dua sampel polimer, satu adalah termoplastik dan satu lagi bersifat termoset, perlu disediakan menggunakan teknik peniruan permukaan bagi Mikroskopi Transmisi Elektron (TEM). Bezakan teknik penyediaan sampel bagi setiap kes dan terangkan perbezaan yang wujud dalam menyediakan setiap sampel.

(10 marks/markah)

...3/-

PART B / BAHAGIAN B

- (2). (a). Explain how the backbone chain and side group influence the flexibility of the polymer chain.

Terangkan bagaimana rantai tulang belakang dan kumpulan sisi mempengaruhi kelenturan rantai polimer.

(10 marks/markah)

- (b). Calculate the polydispersity index for a polymer consisting of three fractions with molecular weights: 1.6×10^5 , 2.7×10^5 , and 3.5×10^5 . The mole fractions of each of these fractions were found to be 0.24, 0.33, and 0.43, respectively.

Kira indeks polidispersiti bagi polimer yang terdiri daripada tiga pecahan dengan berat molekul: 1.6×10^5 , 2.7×10^5 , dan 3.5×10^5 . Pecahan mol bagi setiap pecahan ini didapati masing-masing 0.24, 0.33, dan 0.43.

(10 marks/markah)

- (3). (a). A polymer has a glass transition temperature of 60°C and a melting temperature of 150°C . Four testing instruments are available in the laboratory, i.e., a dilatometer, scanning electron microscope, thermogravimetric analyzer, and differential scanning calorimeter.

Suatu polimer mempunyai suhu peralihan kaca 60°C dan suhu lebur 150°C . Empat instrumen ujian tersedia di makmal, iaitu, dilatometer, mikroskop elektron pengimbasan, penganalisis termogravimetrik, dan kalorimeter pengimbasan pembezaan.

...4/-

- (i). Select two testing instruments as mentioned above for the determination of the thermal transition of the polymer.

Pilih dua instrumen ujian seperti yang dinyatakan di atas untuk penentuan peralihan haba polimer.

(2 marks/markah)

- (ii). Draw analytical graphs of the thermal transition of the polymer using the two methods you selected.

Lukis graf analitik peralihan haba polimer menggunakan dua kaedah yang anda pilih.

(4 marks/markah)

- (iii). Why is the thermal transition information important?

Mengapakah maklumat peralihan haba penting?

(4 marks/markah)

- (b). The dynamic mechanical thermal analysis and differential scanning calorimetry were done on polymer Z. The thermal characteristics of the polymer Z are shown in Table 1.

Analisis haba mekanikal dinamik dan kalorimetri pengimbasan pembezaan telah dilakukan pada polimer Z. Ciri-ciri haba polimer Z ditunjukkan dalam Jadual 1.

...5/-

Table 1: Thermal characteristics of polymer Z and its composites.

Jadual 1: Ciri terma polimer Z dan komposit.

	Polymer Z <i>Polimer Z</i>	Carbon nanotube reinforced polymer Z <i>Polimer Z diperkuatkan tiub nano karbon</i>
Storage modulus (MPa) <i>Modulus simpanan (MPa)</i>	3000	4500
tan δ peak <i>Puncak tan δ</i>	65	70
Melting temperature ($^{\circ}$ C) <i>Suhu lebur ($^{\circ}$C)</i>	170	185

It was found that the melt viscosity of the pure polymer Z at 40 $^{\circ}$ C is 4.8×10^8 poises. Estimate the melt viscosity of the pure polymer Z at 95 $^{\circ}$ C.

Didapati bahawa kelikatan leburan polimer tulen Z pada 40 $^{\circ}$ C ialah 4.8×10^8 poise. Anggarkan kelikatan leburan polimer tulen Z pada 95 $^{\circ}$ C.

(10 marks/markah)

...6/-

- (4). (a). (i). What happens if a sample of an amorphous polymer is heated to a temperature above its glass transition temperature (T_g) and then subjected to tensile stress?

Apakah yang berlaku jika sampel polimer amorfus dipanaskan pada suhu melebihi suhu peralihan kacanya (T_g) dan kemudian dikenakan tegasan tegangan?

(3 marks/markah)

- (ii). What happens if the sample is then cooled below its T_g while the molecular chain is still under stress?

Apakah yang berlaku jika sampel itu kemudiannya disejukkan di bawah T_g semasa rantai molekul masih di bawah tegasan?

(3 marks/markah)

- (iii). What is the significance of the above findings and how can they be related to the structure-properties-processing relationship of the polymer?

Apakah kepentingan penemuan di atas dan bagaimana ia boleh dikaitkan dengan hubungan struktur-sifat-pemprosesan polimer?

(4 marks/markah)

...7/-

- (b). The glass transition temperature (T_g) of acrylonitrile butadiene styrene (ABS) is 105°C . Suggest two methods to increase the T_g of ABS to 120°C . The answer must be supported using suitable calculations.

Suhu peralihan kaca (T_g) akrilonitril butadiena stirena (ABS) ialah 105°C . Cadangkan dua kaedah untuk meningkatkan T_g ABS ke 120°C . Jawapan mesti disokong menggunakan pengiraan yang sesuai.

(10 marks/markah)

...8/-

PART C / BAHAGIAN C

- (5). (a). Discuss FOUR (4) factors that can affect degree of crystallinity for a polymer.

Bincangkan EMPAT (4) faktor yang mempengaruhi darjah keterhabluran bagi suatu polimer.

(8 marks/markah)

- (b). One of the important parameters in the degree of crystallinity determination is the density of 100% polymer crystal. The following equation presented a way calculating volume of a given polymer crystal unit cell.

Salah satu parameter penting dalam penentuan darjah keterhabluran ialah ketumpatan hablur polimer 100%. Persamaan berikut memberikan cara untuk mengira isipadu suatu sel unit hablur polimer.

$$V = abc(1 + 2 \cos \alpha \cdot \cos \beta \cdot \cos \gamma - \cos^2 \alpha - \cos^2 \beta - \cos^2 \gamma)^{1/2}$$

Using the above equation, determine the density of crystals for these polymers;

Menggunakan persamaan di atas, tentukan ketumpatan hablur-hablur polimer berikut;

...9/-

- (i). Isotactic polystyrene $[-CH_2-CHC_6H_5-]_n$ has a hexagonal unit cell with 18 chemical repeat units in the unit cell. Given that the unit cell has these dimensions.

Polistirena isotaktik $[-CH_2-CHC_6H_5-]_n$ mempunyai sel unit trigonal dengan 18 unit ulangan kimia dalam sel unit tersebut. Diberi bahawa sel unit itu mempunyai dimensi-dimensi berikut;

$$a = 2.19 \text{ nm}, b = 2.19 \text{ nm}, c = 0.665 \text{ nm and } \alpha = 120^\circ$$

- (ii). Poly(vinyl alcohol) $[-CH_2-CHOH-]$ has a monoclinic unit cell of dimensions; $a = 0.551 \text{ nm}$, $b = 0.781 \text{ nm}$, and $c = 0.251 \text{ nm}$ with 2 chemical repeat units per unit cell. The angle β is 91.7° and all the other angles are 90° .

Poli(vinil alkohol) $[-CH_2-CHOH-]_n$ mempunyai sel unit monoklinik dengan dimensi-dimensi; $a = 0.551 \text{ nm}$, $b = 0.781 \text{ nm}$, and $c = 0.251 \text{ nm}$. Sudut β bersamaan dengan 91.7° dan sudut-sudut lain adalah 90° .

Also given are:

- Relative atomic mass of hydrogen, carbon and oxygen;
 $H = 1 \quad C = 12 \quad O = 16$
- Avogadro number, $N_A, = 6.023 \times 10^{23} \text{ mol}^{-1}$

Juga diberi:

- *Jisim atom relatif bagi hidrogen, karbon dan oksigen;*
 $H = 1 \quad C = 12 \quad O = 16$
- *Nombor Avogadro, $N_A, = 6.023 \times 10^{23} \text{ mol}^{-1}$*

(12 marks/markah)

...10/-

- (6). (a). What do you understand about spherulite? State the differences between homogenous and heterogenous crystallization process.

Apakah yang anda fahami dengan sferulit? Nyatakan perbezaan penukleusan homogenous dan penukleusan heterogenous.

(8 marks/markah)

- (b). Two polypropylene (PP) samples from a same grade were analysed using Differential Scanning Calorimetry (DSC) technique. It was found that 11.300 mg of the PP sample gave a melting enthalpy, ΔH_m , of 0.7845 Joule. Whereas, another PP sample, which has gone through an extrusion process yielded a melting enthalpy, ΔH_m of 0.9835 Joule for 12.700 mg sample. Given that melting enthalpy of a 100% PP crystal, ΔH_m^0 is 207.1 Joule/g, calculate the degree of crystallinity of both PP samples.

Why there is a difference of melting enthalpy between these samples?

Dua sampel polipropilena (PP) dari gred yang sama menjalani ujian Kalorimetri Penskanan Pembezaan (Differential Scanning Calorimetry – DSC). Didapati 11.300 mg sampel PP memberikan entalpi peleburan, $\Delta H_m = 0.7845$ Joule. Manakala, satu lagi sampel PP yang telah mengalami proses pengestrudan memberikan entalpi peleburan, $\Delta H_m = 0.9835$ Joule bagi 12.700 mg sampel. Diberi maklumat entalpi peleburan untuk 100% hablur PP, ΔH_m^0 ialah 207.1 Joule/g, kirakan darjah keterhabluran bagi kedua-dua sampel PP tersebut.

Mengapakah terdapat perbezaan entalpi peleburan di antara sampel-sampel PP itu?

(12 marks/markah)

...11/-

- (7). (a). Explain how molecular orientation that occurred during polymer processing can affect degree of crystallinity.

Terangkan bagaimana orientasi molekul yang berlaku semasa pemprosesan polimer boleh mempengaruhi darjah keterhabluran.

(6 marks/markah)

- (b). Elaborate the method used in studying polymer crystallization using an optical microscope. State the effect of temperature on the rate of crystallization.

Huraikan kaedah eksperimen yang digunakan dalam mengkaji penghabluran polimer menggunakan suatu mikroskop optik. Nyatakan kesan suhu ke atas kadar penghabluran.

(8 marks/markah)

- (c). If you are requested to evaluate molecular orientation in a polymer sample using a birefringence technique, describe the experimental setup you need to assemble.

Can this technique be used on any type of polymer samples?

Jika anda diminta menilai orientasi molekul dalam suatu sampel polimer menggunakan teknik birefringens, jelaskan susun atur eksperimen yang perlu anda sediakan.

Bolehkah teknik ini digunakan pada sebarang jenis polimer?

(6 marks/markah)