

PART A / BAHAGIAN A

- (1). Figure 1 shows the polymerization technique consisting of monomer and polymer that does not dissolve in a solvent.

Rajah 1 menunjukkan teknik pempolimeran yang merangkumi monomer dan polimer yang tidak larut dalam pelarut.

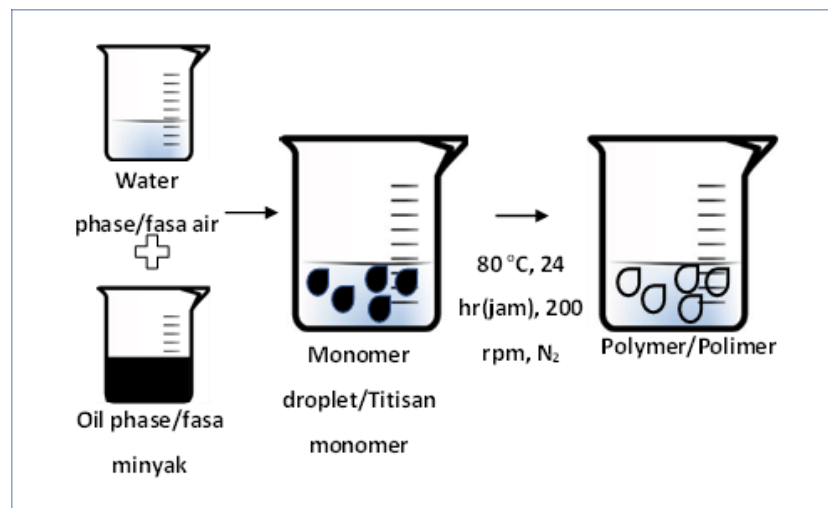


Figure 1: Polymerization technique
Gambar rajah 1: Teknik pempolimeran

- (a). State the polymerization technique in Figure 1. Describe the advantages and disadvantages of the polymerization technique.

Nyatakan teknik pempolimeran dalam Rajah 1. Jelaskan kebaikan dan keburukan teknik pempolimeran tersebut.

(8 marks/markah)

- (b). Explain why the product purity obtained using the polymerization technique in Figure 1 is low.

Jelaskan mengapa produk ketulenan yang diperolehi menggunakan teknik pempolimeran dalam Rajah 1 adalah rendah.

(4 marks/markah)

- (c). Suggest ONE type of reactor that is suitable for conducting the polymerization technique in Figure 1. Explain the reason for your suggestion.

Cadangkan SATU jenis reaktor yang sesuai untuk menjalankan teknik pempolimeran dalam gambarajah 1. Jelaskan sebab bagi cadangan anda.

(8 marks/markah)

- (2). Figure 2 illustrates the formation of polymer X repeat unit through a polymerization reaction.

Rajah 2 menggambarkan pembentukan unit ulangan polimer X melalui tindak balas pempolimeran.

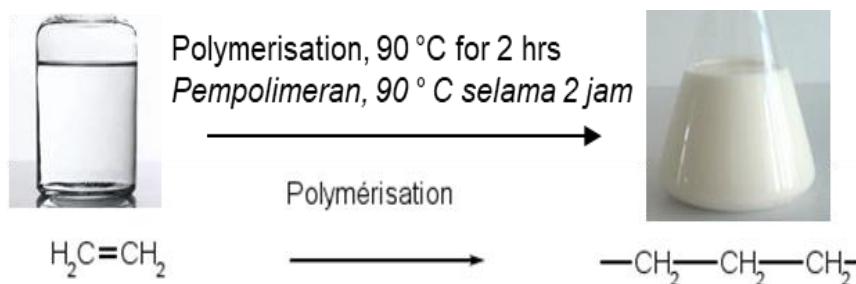


Figure 2: Polymerization process for polymer X

Rajah 2: Proses pempolimeran polimer X

- (a). Describe the reaction scheme for the synthesis of polymer X in Figure 2 through addition polymerization. State the mechanism of the reaction.

Huraikan skema tindak balas untuk sintesis polimer X dalam Rajah 2 melalui pempolimeran penambahan. Nyatakan mekanisme tindak balas.

(8 marks/markah)

- (b). Describe the parameters to obtain high monomer conversion of polymer X.

Huraikan parameter-parameter untuk mendapatkan pertukaran monomer tinggi bagi polimer X.

(6 marks/markah)

- (c). Discuss the effect of monomer replacement, $\text{H}_2\text{C}=\text{CH}_2$ with $\text{H}_2\text{C}=\text{CHCN}$ in the backbone chain on the thermal property of the final polymer X? Verify the suggestion.

Bincangkan kesan penggantian monomer, $\text{CH}_2=\text{CH}_2$ dengan $\text{CH}_2=\text{CHCN}$ di rantaian tulang belakang ke atas sifat terma polimer X? Sahkan cadangan tersebut.

(6 marks/markah)

- (3). (a). In general, there are TWO (2) types of polymerization reactions. Compare the two types of polymerization reactions. Discuss the different types of polymerizations with examples by comparing each mechanism.

Secara amnya, terdapat DUA (2) jenis tindak balas pempolimeran. Bandingkan dua jenis tindak balas pempolimeran. Bincangkan jenis pempolimeran dengan contoh dengan membandingkan setiap mekanisme.

(6 marks/markah)

- (b). Derive an expression the rate of radical polymerization is proportional to the monomer concentration and square root of initiator concentration

Terbitkan persamaan yang menunjukkan kadar pempolimeran radikal adalah berkadar terus dengan kepekatan monomer dan punca kuasa dua dengan kepekatan pemula.

(4 marks/markah)

- (c). Many factors can affect the reaction rate of polymerization such as residence time, temperature, and volume. Explain these factors.

Pelbagai faktor boleh mempengaruhi kadar tindak balas pempolimeran seperti masa residen, suhu, dan isipadu. Jelaskan faktor-faktor ini?

(6 marks/markah)

- (d). Explain how to determine the rate of reaction?

Jelaskan bagaimana untuk menentukan kadar tindak balas?

(4 marks/markah)

PART B / BAHAGIAN B

- (4). (a). Explain the batch and continuous processes. Describe the answer by comparing the processes and list down the advantages and disadvantages of each process.

Terangkan proses berperingkat dan berterusan. Jelaskan jawapan anda dengan membezakan proses-proses tersebut dan senaraikan kebaikan dan keburukan bagi setiap proses.

(8 marks/markah)

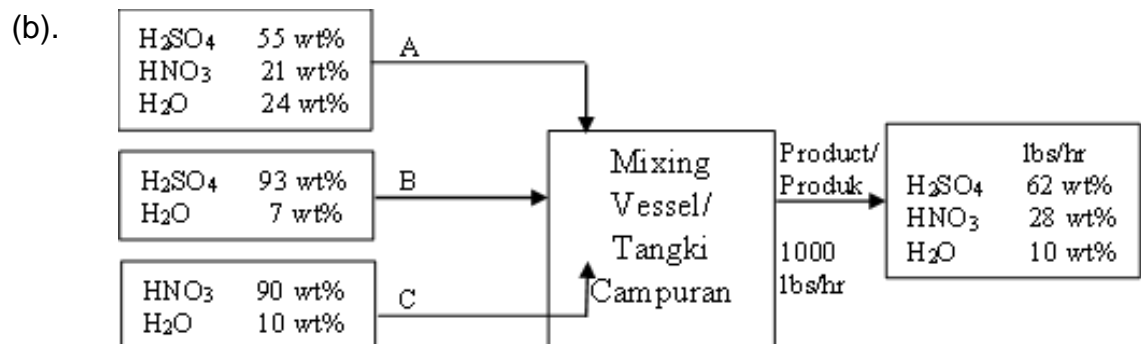


Figure 3: Block Flow Diagram of Produk X

Rajah 3: Aliran blok diagram bagi produk X

Monomer A contains 55% H₂SO₄, 21% of HNO₃, and 24% H₂O in weight percent. To achieve a higher yield of conversion, the addition of (1) concentrated acid containing 93% H₂SO₄ and (2) 7% H₂O as well as concentrated nitric acid containing 90% HNO₃ and 10% H₂O are needed to form a product with the composition of 62% H₂SO₄, 28% HNO₃ and 10% H₂O. If 1000 kg/h of the product stream is desired, calculate the flow rates of streams A, B and C.

Monomer A mengandungi 55% H_2SO_4 , 21% HNO_3 , dan 24% H_2O dalam peratusan peratusan berat. Untuk mencapai penukaran hasil yang lebih tinggi, penambahan (1) asid pekat yang mengandungi 93% H_2SO_4 dan 7% H_2O dan (2) asid pekat asid nitrik yang mengandungi 90% HNO_3 dan 10% H_2O diperlukan untuk menghasilkan produk yang mengandungi 62% H_2SO_4 , 28% HNO_3 dan 10% H_2O . Jika 1000 kg/h produk diperlukan, kira kadar aliran bagi aliran A, B dan C.

(12 marks/markah)

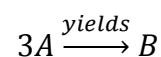
- (5). (a). Write the mole balance equation in terms of conversion for a Continuous Stirred Tank Reactor (CSTR).

Tuliskan persamaan keseimbangan mol dari segi pertukaran bagi Reaktor Tangki Teraduk Berterusan (CSTR).

(4 marks/markah)

- (b). The elementary liquid phase reaction is carried out isothermally in a Continuous Stirred Tank Reactor (CSTR) by following the reaction order below.

Reaksi asas fasa cecair dijalankan secara adiabatik di dalam Reaktor Tangki Teraduk Berterusan (CSTR) menggunakan susunan tindakbalas seperti di bawah.



Write the mole balance equation for the reaction for CSTR.

Tuliskan persamaan keseimbangan mol bagi reaktor CSTR.

(6 marks/markah)

- (c). Using the same condition in (b), liquid A enters at a volumetric flow rate of $35 \text{ dm}^3/\text{s}$ and at a concentration of $0.4 \text{ mol}/\text{dm}^3$. Calculate the volume of Continuous Stirred Tank Reactor (CSTR) to achieve 95% conversion when k is $10 \text{ dm}^3/(\text{mol}\cdot\text{s})$?

Dengan menggunakan kondisi yang sama seperti (b), cecair A disuap ketika kadar aliran isipadu pada $35 \text{ dm}^3/\text{s}$ dan pada kepekatan $0.4 \text{ mol}/\text{dm}^3$. Kira isipadu bagi Reaktor Tangki Teraduk Berterusan (CSTR) untuk mencapai 95% penukaran apabila k ialah $10 \text{ dm}^3/(\text{mol}\cdot\text{s})$?

(10 marks/markah)

PART C / BAHAGIAN C

- (6). Table 1 shows the rate constants for kinetics of free radical addition polymerization of polymer. It shows the values of the following rate constants, K_i , K_p , and K_t , respectively. The concentration of propagation, $[M]$ is $10^{-3} \text{ mol dm}^{-3}$ and concentration of termination, $[M_0]$ is $10^{-3} \text{ mol dm}^{-3}$.

Jadual 1 menunjukkan pemalar kadar bagi kinetik pemolimeran penambahan radikal bebas bagi polimer. Ia menunjukkan nilai pemalar kadar berikut, masing-masing K_i , K_p , dan K_t . Kepekatan percambahan, $[M]$ ialah $10^{-3} \text{ mol dm}^{-3}$ dan kepekatan penamatan $[M_0]$ is $10^{-3} \text{ mol dm}^{-3}$.

Table 1: Rate constants

Jadual 1: Nilai pemalar kadar

The rate constant <i>Pemalar kadar</i>	Values (s^{-1}) <i>Nilai (s^{-1})</i>
K_i	$1 \times 10^{-3} \text{ s}^{-1}$
K_p	$2 \times 10^{-3} \text{ s}^{-1}$
K_t	$4 \times 10^{-3} \text{ s}^{-1}$

Note: $[M]$ = concentration of propagation, $[M_0]$ = concentration of termination, K_i = rate constant of initiation, K_p = rate constant of propagation, K_t = rate constant of termination

- (a). Draw and describe the formation of free radical, including the rate constant of reaction mechanism?

Lukiskan dan huraikan pembentukan radikal bebas, termasuk pemalar kadar mekanisme tindak balas?

(8 marks/markah)

- (b). Define the kinetic chain length?

Takrifkan panjang rantai kinetik?

(2 marks/markah)

- (c). Calculate the kinetic chain length using the values in Table 1

Kira panjang rantai kinetik dengan menggunakan nilai dalam Jadual 1.

(4 marks/markah)

- (d). Discuss the importance of the kinetic chain length on polymer properties.

Bincangkan kepentingan panjang rantai kinetik pada sifat polimer.

(6 marks/markah)

- (7). Table 2 shows the following molecular weight distribution of a polymer respectively.

Jadual 2 berikut menunjukkan taburan berat molekul bagi suatu polimer.

Table 2: Molecular weight distribution of polymer

Jadual 2: Taburan berat molekul polimer

Number of chains <i>Bilangan rantai</i>	Molecular weight (kg / mol) <i>Berat molekul (kg / mol)</i>
20	10
25	15
20	20
5	50

- (a). Determine the M_w , M_n and polydispersity index of the polymer (PDI)

Tentukan M_w , M_n dan polimer indeks polidispersi di (PDI)

(6 marks/markah)

(b). Discuss the parameters below that could modify the end polymers properties during the radical polymerization process:

- (i). Monomer concentration
- (ii). Initiator concentration

Bincangkan parameter di bawah yang boleh mengubah suai sifat polimer akhir semasa proses pempolimeran radikal:

- (i). *Kepekatan monomer*
- (ii). *Kepekatan pemula*

(6 marks/markah)

(c). Describe a procedure to measure the molecular weight of polymer using the Mark-Houwink equation as shown below:

Huraikan satu prosedur untuk mengukur berat molekul polimer menggunakan persamaan Mark-Houwink seperti ditunjukkan di bawah : $[\eta] = KM^a$

(8 marks/markah)

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