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UNIVERSITI SAINS MALAYSIA

Final Examination  
2015/2016 Academic Session

May/June 2016

**JIK 420 – Advanced Physical Chemistry**  
*[Kimia Fizik Lanjutan]*

Duration : 3 hours  
[Masa : 3 jam]

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Please ensure that this examination paper contains **EIGHT** printed pages before you begin the examination.

Answer **FIVE** questions. Answer the questions in English. You may also answer the questions in Bahasa Malaysia, but not a mix of both languages.

All answers must be written in the answer booklet provided.

Each question is worth 20 marks and the mark for each sub question is given at the end of that question.

In the event of any discrepancies in the exam questions, the English version shall be used.

*Sila pastikan bahawa kertas peperiksaan ini mengandungi **LAPAN** muka surat yang bercetak sebelum anda memulakan peperiksaan ini.*

*Jawab **LIMA** soalan. Jawab soalan-soalan dalam Bahasa Inggeris. Anda juga dibenarkan menjawab soalan dalam Bahasa Malaysia, tetapi campuran antara kedua-dua bahasa ini tidak dibenarkan.*

*Setiap jawapan mesti dijawab di dalam buku jawapan yang disediakan.*

*Setiap soalan bernilai 20 markah dan markah subsoalan diperlihatkan di penghujung subsoalan itu.*

*Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai.*

1. (a) Write the Bragg's equation. Explain each of the terminologies in the equation with the aid of diagram.

*Tuliskan persamaan Bragg. Huraikan setiap istilah dalam persamaan tersebut dengan bantuan gambar rajah.*

(8 marks/markah)

- (b) Calculate the value of the spacing between the planes,  $d$ , if the source radiation used is,

(i) Cu

(ii) Mo

Assume that the value of integer  $n = 1$  and  $\theta = 45^\circ$ .

*Kira nilai bagi jarak antara dua satah,  $d$ , jika sumber radiasi yang digunakan adalah,*

(i) Cu

(ii) Mo

*Andaikan nilai integer  $n = 1$  dan  $\theta = 45^\circ$ .*

(8 marks/markah)

- (c) In data collection using X-ray diffractometer, the lower the temperature used, the better the quality of the data obtained. Discuss this statement.

*Dalam pengumpulan data menggunakan alat pembelauan sinar-X, semakin rendah suhu yang digunakan, semakin baik kualiti data yang diperolehi. Bincangkan pernyataan ini.*

(4 marks/markah)

2. (a) State two characteristics of single crystals which are suitable for data collection in X-ray diffraction method. Give a reason for each character.

*Nyatakan dua ciri hablur tunggal yang sesuai bagi pengumpulan data dalam kaedah pembelauan sinar-X. Berikan alasan bagi setiap ciri tersebut.*

(4 marks/markah)

- (b) What is the suitable size for single crystals that can be used in data collection? Explain your answer.

*Apakah saiz yang sesuai bagi hablur tunggal yang boleh digunakan dalam pengumpulan data? Terangkan jawapan anda.*

(4 marks/markah)

- (c) State and explain the steps in the collection of X-ray diffraction data using a single crystal X-ray diffractometer.

*Nyatakan dan jelaskan langkah-langkah dalam pengumpulan data pembelauan sinar-X menggunakan alat pembelauan sinar-X hablur tunggal.*

(12 marks/markah)

3. (a) Explain briefly the wave-particle duality.

*Terangkan dengan ringkas mengenai kedua-dua gelombang-zarah.*

(3 marks/markah)

- (b) For the following functions, state, with reason, whether the function can represent wavefunction:

(i)  $f(x) = \tan x$

(ii)  $f(x) = \exp(-kx^2)$ ,  $k$  is a constant

(iii)  $f(x) = \frac{1}{x}$

*Bagi fungsi yang berikut, nyatakan, dengan alasan, sama ada fungsi tersebut boleh mewakili fungsi gelombang:*

(i)  $f(x) = \tan x$

(ii)  $f(x) = \exp(-kx^2)$ ,  $k$  adalah pemalar

(iii)  $f(x) = \frac{1}{x}$

(6 marks/markah)

- (c) In a particular photoelectric effect experiment, when light with a wavelength of 240 nm shines on a metal plate, it was found that the maximum kinetic energy of the photoelectron is 1.40 eV. Find
- (i) the energy of the photons in the beam of light, in units of joule and eV.
  - (ii) the work function of the metal, in unit joule.
  - (iii) the longest wavelength that would cause electrons to be emitted, for this particular metal.

*Dalam suatu eksperimen kesan fotoelektrik, apabila cahaya dengan jarak gelombang 240 nm memancar ke atas sekeping plat logam, didapati bahawa tenaga kinetik maksimum bagi fotoelektron itu ialah 1.40 eV. Cari*

- (i) tenaga foton dalam pancaran cahaya, dalam unit joule dan eV.*
- (ii) fungsi kerja bagi logam, dalam unit joule.*
- (iii) jarak gelombang terpanjang yang akan menyebabkan elektron tersingkir, bagi logam ini.*

(11 marks/markah)

4. (a) Starting from the Schrödinger equation,

$$H\Psi = E\Psi$$

show that, for a particle in a box of length  $a$ , the states of the particle can be written as

$$\psi_n(x) = \sqrt{\frac{2}{a}} \sin\left(\frac{n\pi x}{a}\right)$$

where  $\psi_n(x)$  are the wavefunctions,  $x$  is the distance along the box and  $n$  is the quantum number.

Hint:  $\int \sin^2 bx \, dx = \left[ \frac{x}{2} - \frac{\sin(2bx)}{4b} \right]$

Bermula daripada persamaan Schrödinger,

$$H\Psi = E\Psi$$

tunjukkan bahawa, bagi suatu zarah di dalam kotak yang panjangnya  $a$ , keadaan zarah tersebut boleh dituliskan sebagai

$$\psi_n(x) = \sqrt{\frac{2}{a}} \sin\left(\frac{n\pi x}{a}\right)$$

di mana  $\Psi_n(x)$  adalah fungsi gelombang,  $x$  adalah jarak sepanjang kotak dan  $n$  adalah nombor kuantum.

Panduan:  $\int \sin^2 bx \, dx = \left[ \frac{x}{2} - \frac{\sin(2bx)}{4b} \right]$

(12 marks/markah)

(b) From the result in (a), sketch the following functions as  $x$  varies from 0 to  $a$ :

(i)  $\Psi_2(x)$

(ii)  $|\Psi_2(x)|^2$

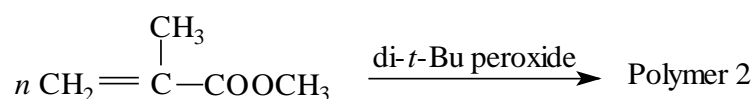
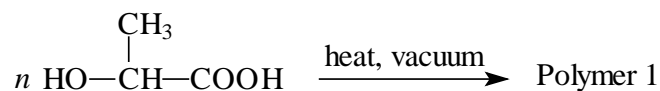
Daripada keputusan dalam (a), lakarkan fungsi berikut apabila  $x$  berubah dari 0 ke  $a$ :

(i)  $\Psi_2(x)$

(ii)  $|\Psi_2(x)|^2$

(8 marks/markah)

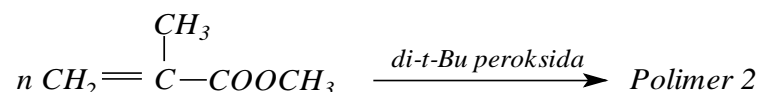
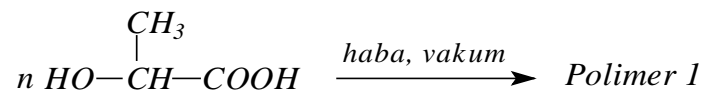
5. (a) Consider the following polymerization reactions:



(i) Draw the structures of Polymer 1 and 2. For each polymer, identify the type of mechanism involved in its polymerization reaction.

- (ii) Draw the structures of the various stereoisomers that are possible for Polymer 2. Which isomer is expected to have the highest degree of crystallinity? Give your reason.

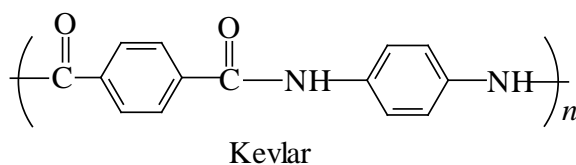
*Pertimbangkan tindak balas pempolimeran berikut:*



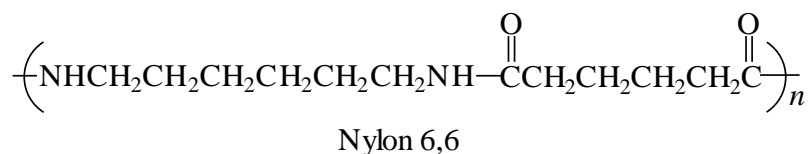
- (i) Lukiskan struktur Polimer 1 dan 2. Bagi setiap polimer, kenalpasti jenis mekanisme yang terlibat dalam tindak balas pempolimerannya.
- (ii) Lukiskan struktur pelbagai stereoisomer yang mungkin wujud bagi Polimer 2. Isomer manakah yang dijangka akan mempunyai darjah kehabluran yang tertinggi? Beri alasan anda.

(10 marks/markah)

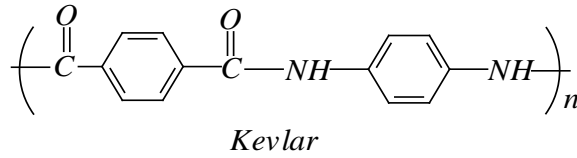
- (b) Kevlar, a polymer used to make bullet-proof jackets and under-sea cables, is one of the strongest polymers ever invented. Explain how Kevlar obtain its super strength.



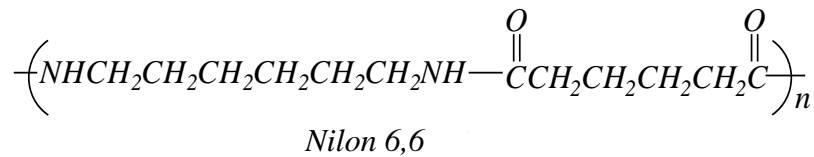
Nylon 6,6 has the same functional groups as Kevlar. If both are compared based on the same length, which one is stronger? Explain.



*Kevlar, polimer yang digunakan untuk membuat jaket kalis-peluru dan kabel bawah laut, merupakan salah satu daripada polimer terkuat yang pernah dicipta. Terangkan bagaimana Kevlar memperoleh kekuatan luar biasanya.*



*Nilon 6,6 mempunyai kumpulan berfungsi yang sama seperti Kevlar. Jika kedua-duanya dibandingkan berdasarkan kepanjangan yang sama, polimer manakah yang lebih kuat? Huraikan.*



(10 marks/markah)

6. (a) Sketch a typical Stress-Strain curve of a semicrystalline polymer. Indicate clearly the plastic and the elastic regions. Label the yield point, the fracture point and the ultimate tensile strength. Define elastic limit.

*Lakarkan keluk Tegasan–Keterikan yang lazim bagi suatu polimer semihablur. Tunjukkan dengan jelas kawasan plastik dan kawasan elastik. Labelkan takat alah, takat pecah dan kekuatan tegangan muktamad. Takrifkan had elastik.*

(8 marks/markah)

- (b) An elastic rope used for bungee jumping is made from polyester with a Young's modulus of 1 GPa. The length of the rope is originally 25 m and the diameter is 6 mm. By how much does the rope stretch when supporting a jumper with a weight of 100 kg?

Given: Acceleration due to gravity,  $g$  is  $9.81 \text{ m s}^{-2}$ .

*Seutas tali elastik yang digunakan untuk terjunan lelabah diperbuat daripada poliester dengan modulus Young 1 GPa. Panjang asal tali itu ialah 25 m dan garis pusatnya ialah 6 mm. Berapa panjangkah tali itu meregang apabila ia menampung seorang penerjun yang beratnya 100 kg?*

*Diberi: Pecutan disebabkan graviti,  $g$  ialah  $9.81 \text{ m s}^{-2}$ .*

(4 marks/markah)

- (c) In an experiment to determine the molecular weight of a polymer sample, four fractions of the sample have been studied. The following results have been obtained:

Sample, $i$	1	2	3	4
Weight fraction	0.3	0.4	0.2	0.1
Molecular mass, $\text{g mol}^{-1}$	$1.2 \times 10^2$	$2.3 \times 10^3$	$5.0 \times 10^4$	$0.50 \times 10^5$

Calculate the number-average molecular weight,  $\overline{M}_n$ , and the weight-average molecular weight,  $\overline{M}_w$ , for this sample. Then determine the number-average degree of polymerization,  $\overline{DP}_n$ , and its polydispersity index. Assume the formula weight of the repeating unit is  $100 \text{ g mol}^{-1}$ .

*Dalam satu eksperimen bagi menentukan berat molekul suatu sampel polimer, empat pecahan sampel itu telah dikaji. Keputusan berikut telah diperolehi:*

<i>Sampel, <math>i</math></i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>
<i>Pecahan berat</i>	<i>0.3</i>	<i>0.4</i>	<i>0.2</i>	<i>0.1</i>
<i>Jisim molekul, <math>\text{g mol}^{-1}</math></i>	<i><math>1.2 \times 10^2</math></i>	<i><math>2.3 \times 10^3</math></i>	<i><math>5.0 \times 10^4</math></i>	<i><math>0.50 \times 10^5</math></i>

*Hitung berat molekul purata-bilangan,  $\overline{M}_n$ , dan berat molekul purata-berat,  $\overline{M}_w$ , bagi sampel ini. Kemudian tentukan darjah pempolimeran purata-bilangan,  $\overline{DP}_n$ , serta indeks polisebarannya. Anggapkan berat formula unit ulangnya adalah  $100 \text{ g mol}^{-1}$ .*

(8 marks/markah)