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UNIVERSITI SAINS MALAYSIA

Final Examination  
Academic Session 2008/2009

April 2009

**JK 316 – 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. You may answer **either** in Bahasa Malaysia or in English.

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.

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

*Jawab **LIMA** soalan. Anda dibenarkan menjawab soalan **sama ada** dalam Bahasa Malaysia atau Bahasa Inggeris.*

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

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

...2/-

1. (a) What is meant by the dispersion colloid?  
By providing examples, explain methods how to prepare the dispersion colloid.

*Apakah yang dimaksudkan dengan koloid penyebaran?  
Terangkan dengan memberikan contoh dan cara-cara bagi menyediakan sistem koloid penyebaran ini.*

[10 marks]

- (b) Explain the factors which determine the nature of a colloidal system. Explain the advantage of the light scattering method for understanding the nature of the colloids. List the two theories related to the light scattering theory and also types of colloid investigated.

*Terangkan faktor-faktor yang menentukan tabii suatu sistem koloid. Terangkan kelebihan kaedah penyerakan cahaya untuk memahami ciri-ciri koloid. Senaraikan dua teori yang berkaitan dengan teori penyerakan cahaya serta jenis koloid yang dikaji.*

[10 marks]

2. (a) Explain four specific experimental tests to characterize whether a process is a physical or chemical adsorption.

*Terangkan empat ujian eksperimen khas untuk mencirikan sesuatu proses penjerapan itu sebagai penjerapan fizik atau penjerapan kimia.*

[10 marks]

- (b) Sketch the five adsorption isotherms in the BET (Brunauer, Emmett and Teller) classification. Explain each of the isotherms with an example.

*Lakarkan lima jenis isoterma penjerapan mengikut pengelasan BET (Brunauer, Emmett dan Teller). Terangkan pengertian setiap jenis isoterma ini dan berikan satu contoh bagi setiap isoterma tersebut.*

[10 marks]

3. (a) Define the following terms :

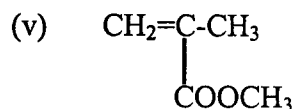
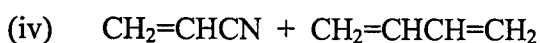
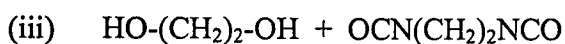
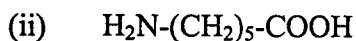
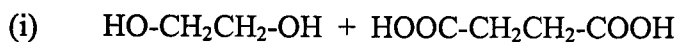
- (i) copolymer
- (ii) steady state condition
- (iii) thermoplastic
- (iv) monomer
- (v) glass transition temperature,  $T_g$

*Takrifkan sebutan-sebutan berikut :*

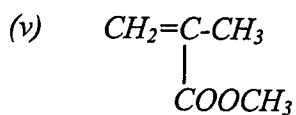
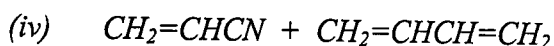
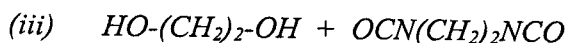
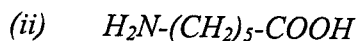
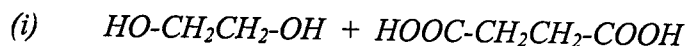
- (i) *kopolimer*
- (ii) *kondisi keadaan mantap*
- (iii) *termoplastik*
- (iv) *monomer*
- (v) *suhu peralihan kaca,  $T_g$*

[5 marks]

(b) Draw the structure of the repeating units of the polymers prepared from the following reactions. Include byproduct if applicable.



(b) Lukiskan struktur unit berulang polimer yang disediakan daripada tindak balas berikut. Sertakan hasil sampingan yang mana berkenaan.



[5 marks]

(c) Sketch a typical plot of stress-strain curve of **rigid, plastic** and **elastomeric** deformation. What are the factors that influence the mechanical properties of a polymer?

*Lakarkan suatu plot lazim keluk tegasan-terikan daripada canggaan tegar, plastik dan elastomerik. Apakah faktor-faktor yang mempengaruhi sifat-sifat mekanik suatu polimer.*

[5 marks]

(d) The following data shows the molecular weight distribution of a new polymer.

Number of molecules	Mass of each molecule
5	10,000
3	31,000
2	60,000

Calculate the number average molecular weight,  $\bar{M}_n$ , the weight average molecular weight,  $\bar{M}_w$  and the polydispersity index of this polymer.

Data berikut menunjukkan taburan berat molekul suatu polimer baru:

<i>Bilangan molekul</i>	<i>Jisim setiap molekul</i>
5	10,000
3	31,000
2	60,000

Hitunglah purata-bilangan berat molekul,  $\bar{M}_n$ , purata-berat berat molekul,  $\bar{M}_w$  dan indeks poliserakan polimer ini.

[5 marks]

4. (a) Give the types of surfactant. One of the function of a surfactant is as a detergent. Discuss how the detergent works during process of dirt removal from cloth.

*Berikan jenis-jenis bahan aktif permukaan. Salah satu fungsi bahan aktif permukaan ialah sebagai detergen. Bincangkan bagaimanakah ia bertindak dalam proses penyingkiran kotoran daripada pakaian.*

[10 marks]

- (b) Palmitic acid,  $\text{CH}_3(\text{CH}_2)_{14}\text{COOH}$ , has been dispersed  $400 \text{ cm}^2$  on the surface of water. Assume that the cross-sectional area of the acid molecule to be  $19.2 \text{ \AA}^2$  and the density of the initial acid is  $0.82 \text{ g cm}^{-3}$ . Calculate the amount of acid that dispersed on the surface of water.

*Asid palmitik,  $\text{CH}_3(\text{CH}_2)_{14}\text{COOH}$  telah diserakkan diatas permukaan air seluas  $400 \text{ cm}^2$ . Andaikan luas keratan rentas molekul asid ini diketahui sebesar  $19.2 \text{ \AA}^2$  dan ketumpatan asid awal adalah  $0.82 \text{ g cm}^{-3}$ . Hitunglah jumlah asid yang terserak diatas permukaan air tersebut.*

[10 marks]

5. (a) (i) Sketch the BET-Langmuir model. List the assumptions used by Brunauer Emmett and Teller (BET) in deriving the BET equation to determine the monolayer capacity,  $V_m$ .
- (ii) Discuss how the value of  $c$  in the BET equation determines the shape of the isotherm and the surface area of an adsorbent.
- (i) *Lakarkan model BET-Langmuir. Senaraikan andaian-andaian yang digunakan oleh Brunauer, Emmett dan Teller (BET) dalam menerbitkan persamaannya yang digunakan di dalam penentuan muatan ekalapisan,  $V_m$ .*
- (ii) *Bincangkan bagaimanakah nilai  $c$  didalam persamaan BET menentukan bentuk isoterma dan luas permukaan suatu zat penyerap.*

[12 marks]

- (b) The adsorption of nitrogen gas on a porous alumina gel at 77 K produced an isotherm of Type IV based on the BET classification. Assuming the pore to be cylindrical and obtained to be  $9.86 \times 10^{-8}$  cm in diameter, calculate the relative pressure when capillary condensation occurs at that pore size.

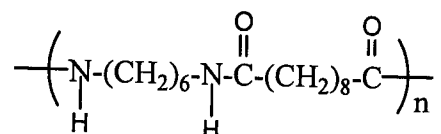
Given : Surface tension,  $\gamma$ , for  $N_2$  at 77 K =  $8.85 \text{ dyne cm}^{-1}$ , liquid density of liquid  $N_2$  at 77 K =  $0.808 \text{ g cm}^{-3}$ .

*Penjerapan gas nitrogen ke atas gel alumina berliang pada 77 K menghasilkan isoterma Jenis IV berdasarkan pengelasan BET. Anggapkan liang berbentuk silinder dan berukuran diameter  $9.86 \times 10^{-8}$  cm. Hitunglah tekanan relatif pada jejari liang tersebut apabila terjadinya kondensasi rerambut.*

*Diberi : Tegangan permukaan,  $\gamma$ , bagi  $N_2$  pada 77 K =  $8.85 \text{ dyne cm}^{-1}$ , ketumpatan cecair  $N_2$  pada 77 K =  $0.808 \text{ g cm}^{-3}$ .*

(8 marks)

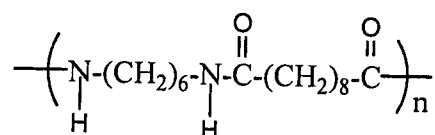
6. (a) Nylon is commonly made by step-growth polymerisation. The structure of nylon 6,10 is given below :-



- (i) Draw the chemical group that defines this polymer as nylon.
- (ii) Draw the structure of the two chemicals (monomers) that were used to make nylon 6,10.
- (iii) Explain why this is a condensation polymerisation and what molecule condenses (byproduct) ?
- (iv) When equal molar amounts of these two monomers are used, determine the fractional conversion of the polymerisation,  $p$ , if  $M_n$  equal to 35,400.

(Given: Relative atomic mass : C = 12.0, H = 1.0, O = 16.0, N = 14.0)

*Nilon umumnya disediakan melalui pempolimeran langkah-pertumbuhan. Struktur nilon 6,10 diberikan dibawah :-*



- (i) *Lukiskan kumpulan kimia yang mentakrifkan polimer ini sebagai nilon.*
- (ii) *Lukiskan struktur dua bahan kimia (monomer) yang digunakan untuk menghasilkan nilon 6,10.*
- (iii) *Terangkan mengapa ini adalah pempolimeran kondensasi dan apakah molekul yang terkondensasi (hasil sampingan)?*
- (iv) *Apabila jumlah molar yang sama bagi kedua monomer digunakan, tentukan pecahan penukaran pempolimeran,  $p$ , jika  $M_n$  sama dengan 35,400.*

*(Diberi: Jisim atom relatif : C = 12.0, H = 1.0, O = 16.0, N = 14.0)*

[10 marks]

- (b) For the free radical polymerisation of vinyl polymers, the following expressions can be obtained :

$$R_i = 2k_d f [I], R_p = k_p [M][M\bullet], R_t = 2k_t [M\bullet]^2.$$

- (i) State the meaning of the terms,  $f$  and  $[M\bullet]$ .  
(ii) Use the kinetic expressions to show how changing monomer concentration  $[M]$  and initiator concentration  $[I]$  affects the overall rate of polymerisation under conditions of steady state.

*Bagi pempolimeran radikal bebas polimer vinil, ungkapan berikut dapat diperolehi :*

$$R_i = 2k_d f [I], R_p = k_p [M][M\bullet], R_t = 2k_t [M\bullet]^2.$$

- (i) *Nyatakan maksud sebutan-sebutan,  $f$  dan  $[M\bullet]$ .*  
(ii) *Gunakan ungkapan kinetik untuk menunjukkan bagaimana menukarkan kepekatan monomer,  $[M]$  dan pemula,  $[I]$  mempengaruhi keseluruhan kadar pempolimeran pada kondisi keadaan mantap.*

[10 marks]