
UNIVERSITI SAINS MALAYSIA

Second Semester Examination
Academic Session 2008/2009

April/May 2009

KFT 131 – Physical Chemistry I
[Kimia Fizik I]

Duration : 3 hours
[Masa : 3 jam]

Please check that this examination paper consists of **TWENTY SIX** printed pages before you begin the examination.

Instructions:-

PART A (40 marks), comprising 25 multiple-choice questions (MCQ), **has to be answered within 1 hour of the examination on the OMR forms provided. The completed OMR forms will be collected 1 hour after the commencement of the examination.**

PART B (60 marks), consists of essay-type questions. Answer any **THREE** questions only, beginning the answer to each question on a new page.

You may answer either in Bahasa Malaysia or in English.

Ensure that your OMR form is complete [with your index number, course code, answers to the questions] Use only a 2B pencil on your OMR form.

Submit the answer scripts and question paper to the invigilator before you leave the examination hall at the end of the examination.

Appendix: Fundamental constants in physical chemistry

PART B**This section has FOUR questions.****Answer any THREE questions.**

1. (a) For a van der Waals gas, the compressibility factor is given by

$$Z = \frac{1}{(1-b/V_m)} - \frac{a}{RTV_m}$$

- (i) Using the above equation, show that for a given gas, the initial slope of Z versus P graph is:

$$\lim_{P \rightarrow 0} \left(\frac{\partial Z}{\partial P} \right)_T = \frac{1}{RT} \left(b - \frac{a}{RT} \right)$$

$$\left[\text{Given : Expansion for } \frac{1}{(1-b/V_m)} \text{ is } \frac{1}{(1-x)} = 1+x+x^2+x^3\dots \text{ for } |x| < 1 \right]$$

- (ii) Calculate the initial slopes for NH₃ and H₂ at 700 K, then sketch their Z versus P curves on the same graph. Determine which intermolecular forces are dominant in each case.

$$\begin{aligned} \text{[Given: NH}_3\text{ : } a = 4.225 \text{ dm}^6 \text{ bar mol}^{-2} \text{ and } b = 0.0371 \text{ dm}^3 \text{ mol}^{-1}. \\ \text{H}_2 \text{ : } a = 0.2452 \text{ dm}^6 \text{ bar mol}^{-2} \text{ and } b = 0.0265 \text{ dm}^3 \text{ mol}^{-1}] \end{aligned}$$

(10 marks)

- (b) An equal number of moles of H₂ and Cl₂ are mixed and held at 298 K and a total pressure of 1 bar. Calculate the frequencies of collisions between H₂ and Cl₂, ($z_b(c)$ and $z_c(b)$). Then determine the mean free path for H₂ in the mixture.

$$\text{[Given: } d(\text{H}_2) = 0.272 \text{ nm ; } d(\text{Cl}_2) = 0.544 \text{ nm}]$$

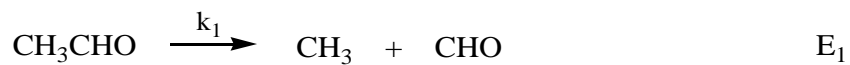
(7 marks)

- (c) Prove that the viscosity of a gas is independent of pressure but is proportional to $M^{1/2}$. Give an equation that relates diffusion coefficient with viscosity.

(3 marks)

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2. The following mechanism is proposed for the decomposition of acetaldehyde, CH_3CHO .



(The CHO reacts to form minor amounts of various species).

- (a) Identify the initiation, propagation, and termination steps. (3 marks)

- (b) Write the overall reaction, neglecting minor products formed in initiation and termination steps. (2 marks)

- (c) Show that the rate of formation of methane, CH_4 , is

$$r = k[\text{CH}_3\text{CHO}]^{3/2}$$

where k is a constant.

(10 marks)

- (d) Calculate the activation energy for the overall reaction. (5 marks)

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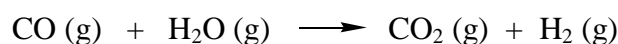
3. (a) The following rate constants, k , were obtained for the thermal decomposition of malonic acid at various temperatures:

$T / ^\circ\text{C}$	153.6	143.5	136.4	133.6	125.9
$k \times 10^3 / \text{s}^{-1}$	1.083	0.410	0.208	0.160	0.0763

Determine the energy of activation, E_a , and the pre-exponential factor, A , for this reaction.

(10 marks)

- (b) Determine ΔH and ΔU for the following reaction at 500 K:



Given the following data:

Substance	$C_p / \text{J mol}^{-1} \text{K}^{-1}$	$\Delta_f H_{298} / \text{kJ mol}^{-1}$
CO	29.12	-110.5
H ₂ O	33.58	-241.8
CO ₂	37.11	-393.5
H ₂	29.89	0.0

(10 marks)

4. The van der Waals equation of state for gases is

$$\left(P + \frac{an^2}{V^2} \right) (V - nb) = nRT$$

where a and b are the van der Waals constants. One mole of N_2 gas obeying the van der Waals equation expands isothermally from 0.400 to 0.800 L at 300 K. Calculate q , ΔU , w and ΔH in kJ for the process.

Given:
$$\left(\frac{\partial U}{\partial V} \right)_T = T \left(\frac{\partial P}{\partial T} \right)_V - P$$

$$a = 1.35 \times 10^6 \text{ cm}^6 \text{ atm mol}^{-2}; \quad b = 38.6 \text{ cm}^3 \text{ mol}^{-1}$$

(20 marks)

TERJEMAHAN

Arahan:

BAHAGIAN A (40 markah, mengandungi 25 soalan objektif (MCQ), **perlu dijawab dalam masa 1 jam pertama di dalam borang jawapan OMR yang disediakan. Borang OMR akan dikutip 1 jam selepas peperiksaan bermula.**

BAHAGIAN B (60 markah), mengandungi soalan bertulis. Jawab **TIGA** soalan sahaja. Jawab setiap soalan di muka surat yang baru.

Anda dibenarkan menjawab soalan ini sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.

Pastikan borang OMR diisi dengan lengkap [nombor angka giliran, kod kursus, jawapan]. Gunakan hanya pensil 2B bagi borang OMR.

Sila serahkan buku jawapan dan kertas soalan ini kepada pengawas sebelum anda keluar dari dewan peperiksaan.

Lampiran: Pemalar asas dalam kimia fizik.

BAHAGIAN B

Bahagian ini mengandungi EMPAT soalan.

Jawab sebarang TIGA soalan.

1. (a) Bagi suatu gas van der Waals, faktor ketertampatannya diberi sebagai:

$$Z = \frac{1}{(1-b/V_m)} - \frac{a}{RTV_m}$$

- (ii) Dengan menggunakan persamaan tersebut, tunjukkan bahawa bagi suatu gas, kecerunan awal bagi graf Z melawan P adalah :

$$\lim_{P \rightarrow 0} \left(\frac{\partial Z}{\partial P} \right)_T = \frac{1}{RT} \left(b - \frac{a}{RT} \right)$$

$$\left[\text{Diberi : Huraian bagi } \frac{1}{(1-b/V_m)} \text{ ialah } \frac{1}{(1-x)} = 1+x+x^2+x^3 \dots \text{ bagi } |x| < 1 \right]$$

- (ii) Hitung kecerunan awal bagi NH_3 dan H_2 pada 700 K, kemudian lakarkan keluk Z melawan P bagi kedua-duanya dalam graf yang sama. Tentukan daya-daya antaramolekul mana yang dominan dalam setiap kes.

[Diberi: NH_3 , $a = 4.225 \text{ dm}^6 \text{ bar mol}^{-2}$ dan $b = 0.0371 \text{ dm}^3 \text{ mol}^{-1}$.
 H_2 , $a = 0.2452 \text{ dm}^6 \text{ bar mol}^{-2}$ dan $b = 0.0265 \text{ dm}^3 \text{ mol}^{-1}$]

(10 markah)

- (b) H_2 dan Cl_2 dengan bilangan mol yang sama telah dicampurkan dan disimpan pada 298 K dengan jumlah tekanan 1 bar. Kirakan frekuensi perlanggaran antara H_2 dan Cl_2 ($z_b(c)$ dan $z_c(b)$). Kemudian tentukan laluan bebas min bagi H_2 dalam campuran tersebut.

[Diberi: $d(\text{H}_2) = 0.272 \text{ nm}$; $d(\text{Cl}_2) = 0.544 \text{ nm}$]

(7 markah)

- (c) Buktikan bahawa kelikatan gas tidak bergantung kepada tekanan tetapi berkadar terus dengan $M^{1/2}$. Berikan satu persamaan yang menghubungkan pekali pembauran dengan kelikatan.

(3 markah)

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2. Mekanisme berikut dicadangkan untuk penguraian asetadehid, CH_3CHO .



(CHO bertindak balas untuk membentuk jumlah kecil bagi beberapa spesies).

- (a) Kenalpastikan langkah pemulaan, perambatan dan pengakhiran bagi mekanisme ini. (3 markah)

- (b) Tuliskan tindak balas keseluruhan dengan mengabaikan hasil kecil yang dibentuk dalam langkah pemulaan dan pengakhiran. (2 markah)

- (c) Tunjukkan bahawa kadar pembentukan metana, CH_4 , ialah

$$r = k[\text{CH}_3\text{CHO}]^{\frac{1}{2}}$$

dengan k ialah satu pemalar.

(10 markah)

- (d) Kiralah tenaga pengaktifan bagi tindak balas keseluruhan. (5 markah)

3. (a) Pemalar kadar, k , yang berikut diperoleh untuk penguraian termal asid malonik pada beberapa suhu.

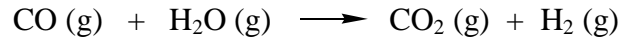
$T / ^\circ\text{C}$	153.6	143.5	136.4	133.6	125.9
$k \times 10^3 / \text{s}^{-1}$	1.083	0.410	0.208	0.160	0.0763

Tentukan tenaga pengaktifan, E_a , dan faktor pra-eksponen, A , untuk tindak balas itu.

(10 markah)

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- (c) Tentukan ΔH dan ΔU bagi tindak balas berikut pada 500 K:



Diberikan data berikut::

Sebatian	$C_p / \text{J mol}^{-1} \text{K}^{-1}$	$\Delta_f H_{298} / \text{kJ mol}^{-1}$
CO	29.12	-110.5
H ₂ O	33.58	-241.8
CO ₂	37.11	-393.5
H ₂	29.89	0.0

(10 markah)

4. Persamaan keadaan van der Waals bagi gas adalah

$$\left(P + \frac{an^2}{V^2} \right) (V - nb) = nRT$$

dengan a dan b adalah pemalar van der Waals. Satu mol gas N₂ yang mematuhi persamaan van der Waals mengembang secara isothermal daripada 0.400 hingga 0.800 L pada 300 K. Kirakan q, ΔU , w dan ΔH dalam unit kJ bagi proses ini.

Diberikan:
$$\left(\frac{\partial U}{\partial V} \right)_T = T \left(\frac{\partial P}{\partial T} \right)_V - P$$

$$a = 1.35 \times 10^6 \text{ cm}^6 \text{ atm mol}^{-2}; \quad b = 38.6 \text{ cm}^3 \text{ mol}^{-1}$$

(20 markah)