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UNIVERSITI SAINS MALAYSIA

First Semester Examination  
2009/2010 Academic Session

November 2009

**KFT 131 – Physical Chemistry I**  
***[Kimia Fizik I]***

Duration : 3 hours  
*[Masa : 3 jam]*

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

**Instructions:**

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

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

**Appendix:** Fundamental constants in physical chemistry.

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**PART B**

**This section has FOUR questions.**

**Answer any THREE questions.**

1. (a) Normal air contains 78 % N<sub>2</sub>, 20.9 % O<sub>2</sub>, 0.03 % CO<sub>2</sub> and 1.07 % H<sub>2</sub> by weight. Determine the molar volume, molar mass and density (g cm<sup>-3</sup>) of dry air at STP. Repeat the calculations for air saturated with water vapour at 25 °C and 1 atm. Assume ideal behaviour.

(Vapour pressure of H<sub>2</sub>O at 25 °C = 23.756 mm Hg)

(10 marks)

- (b) The compressibility factor, Z, for a real gas is a measure of the deviation from the ideal gas behaviour. Use the following data to plot Z against P for O<sub>2</sub> at 0 °C.

P/atm	1	100	200	400	600	800	1000
V <sub>m</sub> /L mol <sup>-1</sup>	22.4138	0.2077	0.1024	0.0589	0.0474	0.0421	0.0389

Give three important comments on the shape of the plot.

(10 marks)

2. (a) The rate of formation of C in the reaction



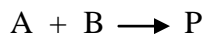
is 1.0 mol dm<sup>-3</sup> s<sup>-1</sup>. State the reaction rate, the rates of formation or consumption of A, B and D.

(6 marks)

- (b) At 400 K, the rate of decomposition of a gaseous compound initially at a pressure of 12.6 kPa, was 9.71 Pa s<sup>-1</sup> when 10 % had reacted and 7.67 Pa s<sup>-1</sup> when 20 % had reacted. Determine the order of the reaction.

(6 marks)

- (c) A second-order reaction of the type



was carried out in a solution that was initially  $0.050 \text{ mol dm}^{-3}$  in A and  $0.080 \text{ mol dm}^{-3}$  in B. After 1.0 h the concentration of A had fallen to  $0.020 \text{ mol dm}^{-3}$ . Calculate the rate constant of the reaction.

(8 marks)

3. (a) A sample consisting of 1.00 mol of monoatomic perfect gas, for which  $C_{V,m} = 3/2R$ , initially at pressure 1.0 atm and temperature 300 K is heated reversibly to 400 K at constant volume. Calculate the

- (i) internal energy change,  $\Delta U$ ,
- (ii) heat,  $q$ , and
- (iii) work,  $w$ .

(8 marks)

- (b) Consider a system consisting of 2.0 mol  $\text{CO}_2$  (assumed to be a perfect gas) at  $25^\circ\text{C}$  confined to a cylinder of cross-section  $10 \text{ cm}^2$  at 10 atm. The gas is allowed to expand adiabatically and irreversibly against a constant pressure of 1.0 atm. Calculate the following when the piston has moved 20 cm:

- (i) Work,  $w$
- (ii) Heat,  $q$
- (iii) Internal energy change,  $\Delta U$
- (iv) Entalphy change,  $\Delta H$
- (v) Temperature change,  $\Delta T$

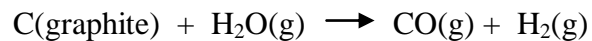
(Given:  $1 \text{ atm} = 1.01 \times 10^5 \text{ Pa}$ ;  $C_{p,m} = 37.11 \text{ J K}^{-1} \text{ mol}^{-1}$ )

(12 marks)

4. (a) The rate constant for the decomposition of a certain substance is  $2.80 \times 10^{-3} \text{ L mol}^{-1} \text{ s}^{-1}$  at  $30^\circ\text{C}$  and  $1.38 \times 10^{-2} \text{ L mol}^{-1} \text{ s}^{-1}$  at  $50^\circ\text{C}$ . Evaluate the Arrhenius parameters of the reaction.

(8 marks)

- (b) Calculate  $\Delta H$  and  $\Delta U$  at 298 K and  $\Delta H$  at 378 K for the reaction



Assume all heat capacities to be constant over the temperature range involved.

Given:

$$\Delta_f H: \text{C}(\text{graphite}) = 0 \text{ kJ mol}^{-1}, \text{H}_2\text{O}(\text{g}) = -241.82 \text{ kJ mol}^{-1}, \\ \text{CO}(\text{g}) = -110.53 \text{ kJ mol}^{-1} \text{ and } \text{H}_2(\text{g}) = 0 \text{ kJ mol}^{-1}.$$

$$C_{p,m}: \text{C}(\text{graphite}) = 8.53 \text{ J K}^{-1} \text{ mol}^{-1}, \text{H}_2\text{O}(\text{g}) = 33.58 \text{ J K}^{-1} \text{ mol}^{-1}, \\ \text{CO}(\text{g}) = 29.14 \text{ J K}^{-1} \text{ mol}^{-1} \text{ and } \text{H}_2(\text{g}) = 28.83 \text{ J K}^{-1} \text{ mol}^{-1}.$$

All values are at 298 K.

(12 marks)

## TERJEMAHAN

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### Arahan:

**BAHAGIAN A** (40 markah) mengandungi 25 soalan berbentuk objektif (MCQ), **perlu dijawab dalam masa satu jam pertama di dalam borang jawapan OMR yang**

**disediakan. Borang OMR akan dikutip satu jam selepas peperiksaan bermula.**

**BAHAGIAN B** (60 markah) mengandungi soalan bertulis. Jawab **TIGA** soalan sahaja. Jawab tiap-tiap 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.

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

## **BAHAGIAN B**

**Bahagian ini mengandungi EMPAT soalan.**

**Jawab sebarang TIGA soalan.**

1. (a) Udara biasa mengandungi 78 % N<sub>2</sub>, 20.9 % O<sub>2</sub>, 0.03 % CO<sub>2</sub> dan 1.07 % H<sub>2</sub> mengikut berat. Tentukan isipadu molar, jisim molar dan ketumpatan (g cm<sup>-3</sup>) bagi udara kering pada STP. Ulangi pengiraan bagi udara yang tepu dengan wap air pada 25 °C dan 1 atm. Anggapkan gas berkelakuan unggul.

(Tekanan wap bagi H<sub>2</sub>O pada 25 °C = 23.756 mm Hg)

(10 markah)

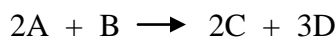
- (c) Faktor ketertampatan, Z, bagi suatu gas sejati adalah ukuran penyimpangan daripada kelakuan gas unggul. Gunakan data berikut untuk melakarkan plot Z lawan P bagi O<sub>2</sub> pada 0 °C.

P/atm	1	100	200	400	600	800	1000
V <sub>m</sub> /L mol <sup>-1</sup>	22.4138	0.2077	0.1024	0.0589	0.0474	0.0421	0.0389

Berikan tiga komen penting mengenai rupa bentuk plot tersebut.

(10 markah)

2. (a) Kadar pembentukan C di dalam tindak balas



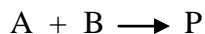
ialah 1.0 mol dm<sup>-3</sup> s<sup>-1</sup>. Tentukan kadar tindak balas, kadar pembentukan atau kadar penggunaan A, B and D.

(6 markah)

- (b) Pada 400 K, kadar penguraian sebatian bergas mulanya pada suatu tekanan 12.6 kPa adalah 9.71 Pa s<sup>-1</sup> apabila 10 % telah bertindakbalas dan 7.67 Pa s<sup>-1</sup> apabila 20 % telah bertindakbalas. Tentukan tertib tindak balas.

(6 markah)

- (c) Suatu tindak balas tertib kedua dari jenis



telah dilakukan di dalam suatu larutan yang mulanya mengandungi  $0.050 \text{ mol dm}^{-3}$  A dan  $0.080 \text{ mol dm}^{-3}$  B. Selepas 1.0 jam kepekatan A telah berkurang kepada  $0.020 \text{ mol dm}^{-3}$ . Hitunglah pemalar kadar tindak balas.

(8 markah)

3. (a) Suatu sampel terdiri daripada  $1.00 \text{ mol}$  gas jitu monoatom, yang mana  $C_{V,m} = 3/2R$ , mulanya pada tekanan  $1.0 \text{ atm}$  dan suhu  $300 \text{ K}$  dipanas secara berbalik ke suhu  $400 \text{ K}$  pada isipadu malar. Hitunglah

- (i) perubahan tenaga dalam,  $\Delta U$ ,
- (ii) haba,  $q$ , dan
- (iv) kerja,  $w$ .

(8 markah)

- (b) Pertimbangkan suatu sistem terdiri daripada  $2.0 \text{ mol CO}_2$  (anggapkan sebagai suatu gas jitu) pada  $25^\circ\text{C}$  ditempatkan ke dalam suatu silinder berkeratan rentas  $10 \text{ cm}^2$  pada  $10 \text{ atm}$ . Gas dibiarkan mengembang secara adiabatik dan tak berbalik melawan suatu tekanan malar  $1.0 \text{ atm}$ . Hitunglah bagi perkara berikut apabila umbuh telah digerakkan  $20 \text{ cm}$ :

- (i) Kerja,  $w$
- (ii) Haba,  $q$
- (vi) Perubahan tenaga dalam,  $\Delta U$
- (vii) Perubahan entalpi,  $\Delta H$
- (viii) Perubahan suhu,  $\Delta T$

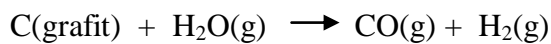
(Diberi:  $1 \text{ atm} = 1.01 \times 10^5 \text{ Pa}$ ;  $C_{p,m} = 37.11 \text{ J K}^{-1} \text{ mol}^{-1}$ )

(12 markah)

4. (a) Pemalar kadar bagi peruraian suatu zat tertentu ialah  $2.80 \times 10^{-3} \text{ L mol}^{-1} \text{ s}^{-1}$  pada  $30^\circ\text{C}$  dan  $1.38 \times 10^{-2} \text{ L mol}^{-1} \text{ s}^{-1}$  pada  $50^\circ\text{C}$ . Taksirkan parameter Arrhenius tindak balas tersebut.

(8 markah)

- (b) Hitunglah  $\Delta H$  dan  $\Delta U$  pada 298 K dan  $\Delta H$  pada 378 K bagi tindak balas



Anggapkan semua muatan haba sebagai malar terhadap julat suhu terlibat.

Diberi:

$$\Delta_f H: \text{C(grafit)} = 0 \text{ kJ mol}^{-1}, \text{H}_2\text{O(g)} = -241.82 \text{ kJ mol}^{-1}, \\ \text{CO(g)} = -110.53 \text{ kJ mol}^{-1} \text{ dan } \text{H}_2\text{(g)} = 0 \text{ kJ mol}^{-1}.$$

$$C_{p,m}: \text{C(grafit)} = 8.53 \text{ J K}^{-1} \text{ mol}^{-1}, \text{H}_2\text{O(g)} = 33.58 \text{ J K}^{-1} \text{ mol}^{-1}, \\ \text{CO(g)} = 29.14 \text{ J K}^{-1} \text{ mol}^{-1} \text{ and } \text{H}_2\text{(g)} = 28.83 \text{ J K}^{-1} \text{ mol}^{-1}.$$

Semua nilai adalah pada 298 K.

(12 markah)