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UNIVERSITI SAINS MALAYSIA

First Semester Examination  
Academic Session 2008/2009

November 2008

**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 EIGHT** 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

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**PART B**

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

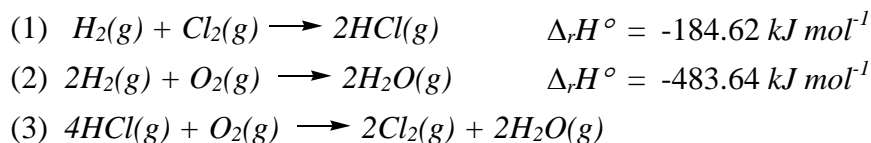
1. (a) (i) By direct differentiation of  $H = U + PV$ , obtain a relation between  $(\partial H/\partial U)_p$  and  $(\partial U/\partial V)_p$
- (ii) Confirm that  $(\partial H/\partial U)_p = 1 + P(\partial V/\partial U)_p$  by expressing  $(\partial H/\partial U)_p$  as the ratio of two derivatives (with respect to volume) and using the definition of enthalpy.

(8 marks)

- (b) Given the reactions (1) and (2) below, determine

- (i)  $\Delta_r H^\circ$  and  $\Delta_r U^\circ$  for reaction (3), and
- (ii)  $\Delta_f H^\circ$  for both HCl(g) and H<sub>2</sub>O(g),

all at 298 K.



(6 marks)

- (c) Decomposition of a solid yellow complex, NH<sub>3</sub>SO<sub>2</sub>, to ammonia and sulfur dioxide gases at 298 K involves the heat of reaction,  $\Delta_r H^\circ = +40 \text{ kJ mol}^{-1}$ . Calculate

- (i)  $\Delta_f H^\circ$  for the complex, and
- (ii)  $\Delta_r U^\circ$  for the reaction.

Values of the relevant constants are provided in Table C.2.

(6 marks)

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2. (a) (i) Derive the relation  $C_v = -(\partial U/\partial V)_T(\partial V/\partial T)_U$  from the expression for the total differential of  $U(T, V)$ .
- (ii) Starting from the expression for the total differential of  $H(T, P)$ , express  $C_p$  in terms of  $(\partial P/\partial T)_H$ ,  $(\partial H/\partial T)_p$ , and  $(\partial H/\partial P)_T$ .

(8 marks)

- (b) The constant-pressure heat capacity of a sample of perfect gas was found to vary with temperature according to the expression  $C_p / (JK^{-1}) = 20.17 + 0.3665T / (K)$ . Calculate  $q$ ,  $w$ ,  $\Delta U$ , and  $\Delta H$  when the temperature is raised from 25 °C to 200 °C

- (i) at constant pressure, and
- (ii) at constant volume.

(12 marks)

3. (a) Consider the following mechanism for renaturation of a double helix from its strand A and B:

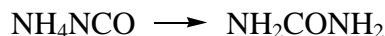


- (ii) Derive the rate equation for the formation of the double helix. State your assumption(s).
- (ii) Express the rate constant of the renaturation reaction in terms of the rate constants of the individual steps.

(8 marks)

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- (b) The data below apply to the formation of urea from ammonium cyanate,



Initially 22.9 g of ammonium cyanate was dissolved in enough water to prepare 1.0 liter of solution. Determine the order of the reaction, the rate constant, and the mass of ammonium cyanate left after 300 min.

t / min	0	20.0	50.0	65.0	150
Mass (urea) / g	0	7.0	12.1	13.8	17.7

Relative atomic weights of relevant atoms are provided in Appendix.

(12 marks)

4. (a) A sample consisting of 2.0 mol of perfect gas atoms, initially at  $P_1=1.00$  atm and  $T_1=300$  K, is heated reversibly to 400 K at constant volume. Calculate the final pressure,  $\Delta U$ ,  $q$ , and  $w$ . Given for the above gas is  $C_{V,m} = \frac{3}{2}R$ .

(10 marks)

- (b) A sample of 4.0 mol  $\text{O}_2$  is originally confined in 2 liter at 270 K and then undergoes adiabatic expansion against a constant pressure of 600 Torr until the volume has increased by a factor of 3.0. Calculate  $q$ ,  $w$ ,  $\Delta T$ ,  $\Delta U$ , and  $\Delta H$ .

(10 marks)

**BAHAGIAN B**

**Bahagian ini mengandungi EMPAT soalan.**

**Jawab sebarang TIGA soalan.**

1. (a) (i) Secara pembezaan langsung ke atas  $H = U + PV$ , terbitkan suatu persamaan yang menghubungkan antara  $(\partial H/\partial U)_p$  dan  $(\partial U/\partial V)_p$ .

(ii) Buktikan bahawa  $(\partial H/\partial U)_p = 1 + P(\partial V/\partial U)_p$  dengan mengungkapkan  $(\partial H/\partial U)_p$  sebagai nisbah dua derivatif (terhadap isipadu) dan menggunakan takrifan entalpi.

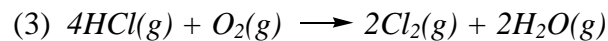
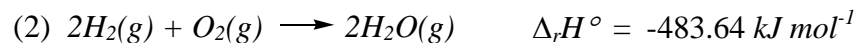
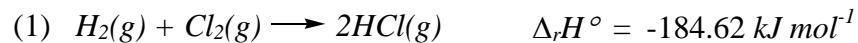
(8 markah)

(b) Diberikan tindakbalas (1) dan (2) seperti dibawah, tentukan

(i)  $\Delta_r H^\circ$  dan  $\Delta_r U^\circ$  bagi tindakbalas (3), dan

(ii)  $\Delta_f H^\circ$  bagi kedua-duanya HCl(g) dan H<sub>2</sub>O(g),

kesemuanya pada 298 K.



(6 markah)

(c) Tindakbalas penguraian suatu kompleks kuning pepejal, NH<sub>3</sub>SO<sub>2</sub>, kepada gas ammonia dan sulfur dioksida pada 298 K melibatkan haba tindakbalas,  $\Delta_r H^\circ = +40 \text{ kJ mol}^{-1}$ . Kiralah

(i)  $\Delta_f H^\circ$  bagi sebatian kompleks tersebut, dan

(ii)  $\Delta_r U^\circ$  bagi tindakbalas penguraian.

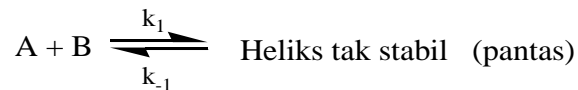
Nilai pemalar-pemalar yang berkenaan terdapat pada Jadual C.2.

(6 markah)

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2. (a) (i) Terbitkan hubungan  $C_v = -(\partial U/\partial V)_T(\partial V/\partial T)_U$  daripada ungkapan pembeza total bagi  $U(T, V)$ .
- (ii) Bermula daripada ungkapan pembeza total bagi  $H(T, P)$ , ungkapkan  $C_p$  dalam sebutan  $(\partial P/\partial T)_H$ ,  $(\partial H/\partial T)_p$ , dan  $(\partial H/\partial P)_T$ .
- (8 markah)
- (b) Muatan haba tekanan tetap bagi suatu sampel gas unggul didapati berubah dengan suhu menurut hubungan  $C_p / (JK^{-1}) = 20.17 + 0.3665T / (K)$ . Kiralah  $q$ ,  $w$ ,  $\Delta U$ , dan  $\Delta H$  apabila suhu dinaikkan daripada 25 °C kepada 200 °C
- (iii) pada tekanan tetap, dan
- (ii) pada isipadu tetap.
- (12 markah)

3. (a) Timbangkan mekanisme tindakbalas bagi pembentukan semula suatu pasangan heliks daripada utas A dan B:



- (iv) Terbitkan persamaan kadar bagi pembentukan heliks berpasangan. Nyatakan andaian anda.
- (ii) Ungkapkan pemalar kadar bagi tindakbalas pembentukan semula dalam sebutan pemalar-pemalar langkah-langkah individu.

(8 markah)

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- (b) Data dibawah diperolehi daripada tindakbalas pembentukan urea daripada ammonia sianat,



Pada mulanya 22.9 g ammonia sianat telah dilarutkan dalam kuantiti air yang mencukupi untuk menyediakan 1 liter larutan . Tentukan tertib tindbalas ini, pemalar kadar, dan jisim baki ammonia sianat pada 300 minit.

t / min	0	20.0	50.0	65.0	150
jisim(urea) / g	0	7.0	12.1	13.8	17.7

Berat atom relatif disediakan dalam Appendix.

(12 markah)

4. (a) Suatu sampel terdiri daripada 2.0 mol atom gas unggul yang berada pada  $P_1=1.00$  atm dan  $T_1=300$  K dipanaskan secara berbalik ke 400 K pada isipadu tetap. Kiralah tekanan akhir,  $\Delta U$ ,  $q$ , dan  $w$ . Diberikan bagi gas di atas  $C_{V,m} = \frac{3}{2}R$ .

(10 markah)

- (b) Suatu sample 4.0 mol  $\text{O}_2$  yang terkandung dalam bekas berisipadu 2 liter pada awalnya kini menjalani pengembangan adiabatik pada tekanan tetap 600 Torr sehingga isipadu meningkatkan sebanyak 3.0 kali ganda. Kiralah  $q$ ,  $w$ ,  $\Delta T$ ,  $\Delta U$ , dan  $\Delta H$ .

(10 markah)