UNIVERSITI SAINS MALAYSIA

First Semester Examination
2010/2011 Academic Session

November 2010

KFT 131 – Physical Chemistry I
[Kimia Fizik I]

Duration : 3 hours
[Masa : 3 jam]

Please check that this examination paper consists of TWENTY TWO 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.

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

1. (a) An equation of state of a gas is given by :
$(P + a/TV_m^2)(V_m - b) = RT$

Given that the parameters '*a*' = $27R^2T_c^3/64P_c$, '*b*' = $RT_c/8P_c$ and $R=8P_cV_{m,c}/3T_c$, write an expression for the pressure of the gas in the reduced form.

(6 marks)

(b) Gas C having a molar mass of 16 g mol^{-1} has a mass of 1 kg at – 43 ^oC and 68 bar. The gas occupies a volume of 12.3 L. Explain whether it is easier or more difficult to compress this gas than if it behaves ideally.

(4 marks)

(c) Gas A at 27 ^oC has a molar mass of 30 g mol^{-1}. The mean free path and the collision diameter of the gas is 1.00 x 10^{-5} cm and 3.16 x 10^{-8} cm, respectively. Calculate:

(i) The pressure of the gas in Pascal.
(ii) The flux of the gas if the concentration gradient is 1.00 x 10^{-7} mol cm^{-4}.
(iii) What would happen to the flux of the gas if the pressure is increased? Explain.

(10 marks)

2. (a) At 518 ºC, the rate of decomposition of a sample of gaseous acetaldehyde, initially at a pressure of 363 Torr, was 1.07 Torr s^{-1}, when 5.0 % had reacted and 0.76 Torr s^{-1} when 20.0 % had reacted. Determine the order of the reaction.

(8 marks)

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

$$NH_4CNO \rightarrow NH_2CONH_2$$

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

Initially 22.9 g of ammonium cyanate was dissolved in enough water to prepare 1.00 L of solution. Determine

(i) the order of the reaction,
(ii) the rate constant, and
(iii) the mass of ammonium cyanate left after 300 min.

(12 marks)

3. (a) The half-life for the first-order radioactive decay of ^{14}C is 5730 years that emitted β rays with an energy of 0.16 MeV. An archaeological sample contained wood that had only 72 % of the ^{14}C found in living trees. What is its age?

(5 marks)

(b) The energy of activation for a reaction at 25 ºC is 50 kJ mol^{-1}. Upon addition of a catalyst, the reaction rate increased by a factor of 10^6. What is the energy of activation after the addition of the catalyst?

(5 marks)

(c) A 1.00 mol sample of monatomic ideal gas, for which $C_{v,m}$ = 3/2 R, initially at P_1 = 1.00 atm and T_1 = 300 K, is heated reversibly to 400 K at constant volume. Calculate

(i) the final pressure,
(ii) the change in internal energy, ΔU,
(iii) heat, q, and
(iv) work, w.

(10 marks)

4. (a) Given the reactions below:

(1) $H_2(g) + Cl_2(g) \longrightarrow 2HCl(g)$ $\Delta_r H^\theta = -184.62 \text{ kJ mol}^{-1}$

(2) $2H_2(g) + O_2(g) \longrightarrow 2H_2O(g)$ $\Delta_r H^\theta = -483.64 \text{ kJ mol}^{-1}$

(3) $4HCl(g) + O_2(g) \longrightarrow 2Cl_2(g) + 2H_2O(g)$

Determine at 298 K,

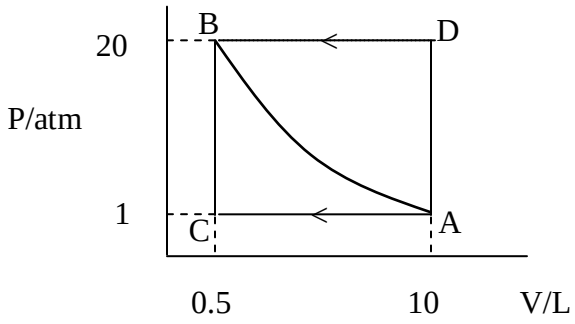
i. The standard reaction enthalpy changes, $\Delta_r H^\theta$ and the standard internal energy changes, $\Delta_r U^\theta$ for reaction (3), and

ii. $\Delta_r H^\theta$ for both HCl(g) and $H_2O(g)$

Assume all gases are ideal.

(10 marks)

(b) With reference to the following figure and assuming ideal gas behaviour,



Calculate:

(i) the amount of gas (in moles) in this system,
(ii) the work done on the gas along the paths ACB and ADB , and
(iii) the work done on the gas along the isotherm AB.

(10 marks)

APPENDIX **UNIVERSITI SAINS MALAYSIA**
School of Chemical Sciences

General data and fundamental constants

Quantity	Symbol	Value	Units
Speed of light	c	2.99792458×10^{8}	$m\ s^{-1}$
Elementary charge	e	1.602176×10^{-19}	C
Faraday constant	$F=N_A e$	9.64853×10^{4}	$C\ mol^{-1}$
Boltzmann constant	k	1.38065×10^{-23}	$J\ K^{-1}$
Gas constant	$R=N_A k$	8.31447	$J\ K^{-1}\ mol^{-1}$
		8.31447×10^{-2}	$L\ bar\ K^{-1}\ mol^{-1}$
		8.20574×10^{-2}	$L\ atm\ K^{-1}\ mol^{-1}$
		6.23637×10^{1}	$LTorr\ K^{-1}\ mol^{-1}$
Planck constant	h	6.62608×10^{-34}	J s
	$\hbar = h/2\pi$	1.05457×10^{-34}	J s
Avogadro constant	N_A	6.02214×10^{23}	mol^{-1}
Standard acceleration of free fall	g	9.80665	$m\ s^{-2}$

Conversion factors

1 eV	1.60218×10^{-19} J 96.485 kJ mol^{-1}	2.303 RT/F = 0.0591 V at 25 ^{o}C	Energy	1 J = 1 kg m^2 s^{-2} = 1 A V s
	8065.5 cm^{-1}		Force	1 N = 1 kg m s^{-2}
1 cal 1 atm	4.184 J 101.325 kPa 760 Torr		Pressure	1 Pa = 1 N m^{-2} = 1 kg m^{-1} s^{-2} = 1 J m^{-3}
1 cm^{-1}	1.9864×10^{-23} J		Charge	1 C = 1 A s
1 Å 1 L atm	10^{-10} m 101.325 J		Potential difference	1 V = 1 J C^{-1} = 1 kg m^2 s^{-3} A^{-1}
1 Poise			Viscosity	1 P = 0.1 kg m^{-1} s^{-1}

Atomic Weights

Al	26.98	C	12.01	Fe	55.85	P	30.97
Sb	121.76	Cs	132.92	Kr	83.80	K	39.098
Ar	39.95	Cl	35.45	Pb	207.2	Ag	107.87
As	74.92	Cr	51.996	Li	6.941	Na	22.99
Ba	137.33	Co	58.93	Mg	24.31	S	32.066
Be	9.012	Cu	63.55	Mn	54.94	Sn	118.71
Bi	208.98	F	18.998	Hg	200.59	W	183.84
B	10.81	Au	196.97	Ne	20.18	Xe	131.29
Br	79.90	He	4.002	Ni	58.69	Zn	65.39
Cd	112.41	H	1.008	N	14.01		
Ca	40.078	I	126.90	O	15.999		

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BAHAGIAN B

Bahagian ini mengandungi EMPAT soalan.
Jawab sebarang TIGA soalan.

1. (a) Persamaan keadaan bagi suatu gas diberi oleh :
$(P + a/TV_m^2)(V_m - b) = RT$

Jika parameter '*a*' = $27R^2T_c^3/64P_c$, '*b*' = $RT_c/8P_c$ dn $R=8P_cV_{m,c}/3T_c$, tulis suatu ungkapan bagi tekanan gas tersebut dalam bentuk terturun.

(6 markah)

(b) Gas C yang mempunyai jisim molar 16 g mol^{-1} mempunyai jisim 1 kg pada – 43 ^oC dan 68 bar. Gas tersebut menempati bekas 12.3 L. Terangkan sama ada gas tersebut lebih mudah atau lebih sukar dimampatkan berbanding jika gas tersebut bersifat unggul.

(4 markah)

(c) Gas A pada 27 ^oC mempunyai jisim molar 30 g mol^{-1}. Laluan bebas min dan garis pusat pelanggaran bagi gas tersebut adalah masing-masing 1.00 x 10^{-5} cm dan 3.16 x 10^{-8} cm.
Hitung :

(i) Tekanan gas tersebut.
(ii) Kadar pembauran gas jika ketumpatan kepekatan adalah 1.00 x 10^{-7} mol cm^{-4}.
(iii) Apakah yang akan berlaku kepada kadar pembauran jika tekanan ditingkatkan? Terangkan.

(10 markah)

2. (a) Pada 518 ºC, kadar penguraian suatu sampel asetaldehid bergas pada tekanan awal 363 Torr, adalah 1.07 Torr s^{-1} apabila 5.0 % telah bertindak balas dan 0.76 Torr s^{-1} apabila 20.0 % telah bertindak balas. Tentukan tertib tindak balas.

(8 markah)

(b) Data dibawah berlaku terhadap pembentukan urea daripada ammonium sianat,

$NH_4CNO \rightarrow NH_2CONH_2$

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

Pada awalnya 22.9 g of ammonium sianat dilarutkan ke dalam air yang secukupnya untuk menyediakan 1.00 L larutan. Tentukan

(i) tertib tindak balas,
(ii) pemalar kadar, dan
(iii) jisim ammonium sianat yang tinggal selepas 300 min.

(12 markah)

3. (a) Setengah hayat bagi tertib pertama susutan radioaktif ^{14}C adalah 5730 tahun yang memancar sinar β dengan tenaga 0.16 MeV. Suatu sampel arkeologi mengandungi kayu yang hanya mengandungi 72 % ^{14}C ditemui di dalam pokok hidup. Berapakah umurnya?

(5 markah)

(b) Tenaga pengaktifan bagi suatu tindak balas pada 25 ºC adalah 50 kJ mol^{-1}. Dengan penambahan suatu mangkin, kadar tindak balas meningkat dengan faktor 10^6. Apakah tenaga pengaktifan selepas penambahan mangkin?

(5 markah)

(b) Suatu sampel 1.00 mol gas unggul monatom, dengan $C_{v,m}$ = 3/2 R, mulanya pada tekanan P_1 = 1.00 atm dan T_1 = 300 K, dipanaskan secara berbalik kepada 400 K pada isipadu tetap. Kiralah

(i) tekanan akhir,
(ii) perubahan tenaga dalam, ΔU,
(iii) haba, q, dan
(iv) kerja, w.

(10 markah)

4. (a) Diberikan tindak balas berikut:

(1) $H_2(g) + Cl_2(g) \longrightarrow 2HCl(g)$ $\Delta_r H^\theta = -184.62 \text{ kJ mol}^{-1}$

(2) $2H_2(g) + O_2(g) \longrightarrow 2H_2O(g)$ $\Delta_r H^\theta = -483.64 \text{ kJ mol}^{-1}$

(3) $4HCl(g) + O_2(g) \longrightarrow 2Cl_2(g) + 2H_2O(g)$

Tentukan pada 298 K,

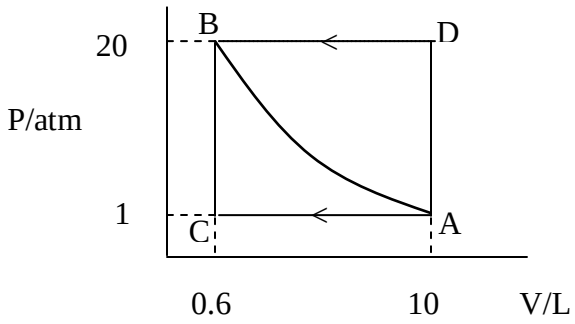
(i) perubahan entalpi tindak balas piawai, $\Delta_r H^\theta$ dan perubahan tenaga dalam piawai, $\Delta_r U^\theta$ bagi tindak balas (3), dan

(ii) $\Delta_r H^\theta$ bagi kedua-dua HCl(g) dan $H_2O(g)$.

Anggapkan semua gas adalah unggul.

(10 markah)

(b) Dengan merujuk kepada rajah berikut dan menganggap gas berkelakuan unggul,



Kiralah:

(i) jumlah gas (dalam mol) didalam system ini,
(ii) kerja yang dilakukan terhadap gas sepanjang laluan ACB dan ADB, dan
(iii) kerja dilakukan terhadap gas sepanjang isoterm AB.

(10 markah)

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