INDEX NO:- ----------

UNIVERSITI SAINS MALAYSIA

First Semester Examination
2011/2012 Academic Session

January 2012

KFT 131 – Physical Chemistry I
[Kimia Fizik I]

Duration : 3 hours
[Masa : 3 jam]

Please check that this examination paper consists of NINETEEN 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** (3) questions. Answer 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

Answer any **THREE** (3) questions.
Only the first **Three** (3) questions answered in the answer book will be marked.

1. (a) Hexane gas has a molar volume of 0.39 L mol^{-1} at 660 K. For hexane, T_c = 507.7 K and P_c = 30.3 bar.

(i) What is the pressure in bar for hexane according to the van der Waals equation?

(ii) What is the percentage deviation from the ideal gas behavior?

(Given: $P_c = \frac{a}{27b^2}$; $V_{m,c} = 3b$ and $T_c = \frac{8a}{27Rb}$)

(10 marks)

(b) A gas obeys the equation of state $(P + \frac{a}{V_m^2})V_m = RT$, where constant a = 12.4 bar L^2. What is the value of the compressibility factor, Z, for one mole of gas in a 6.34 L container at 250 ^oC? Is this gas behaving ideally at this temperature? Explain.

(10 marks)

2. (a) Derive the integrated rate law and half-life for n^{th}-order reaction:

$$A \rightarrow \text{products}$$

where n = 0 , 2 and 3.

(9 marks)

(b) The decomposition of N_2O_5 at 300 ^oC is described by the equation

$$2N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$$

and yields these data:

Time / min	0	5	8	12	16
$[N_2O_5]$ / M	0.2	0.008	0.00553	0.0035	0.0029

Determine the order and the rate constant for this reaction.

(11 marks)

3. (a) What is activation energy? Sketch a graph to illustrate how a catalyst can decrease the activation energy and foster a chemical reaction.

(6 marks)

(b) Chlorine dioxide, ClO_2 is a strong oxidizing agent and will decompose at high temperature. Given that the rate constant for the decomposition of ClO_2 is 1.70×10^{-2} dm^3 mol^{-1} s^{-1} at 24 °C and 2.01×10^{-2} dm^3 mol^{-1} s^{-1} at 37 °C.

(i) Using the Arrhenius equation, determine the Arrhenius parameter, **A** of the reaction.

(ii) What is the activation energy of the decomposition reaction if the reaction rate is found to be doubled when the temperature is raised from 24 to 49 °C ?

(14 marks)

4. (a) A movable piston having a mass of 8.00 kg and a cross-sectional area of 5.00 cm^2 traps 0.200 moles of an ideal gas in a vertical cylinder. If the piston slides without friction in the cylinder, how much work is done on the gas when its temperature is increased from 20 to 300 °C?

(3 marks)

(b) A sample of ice weighing 16.84 g is heated from -47.3 to 140 °C at a constant pressure of 1.0 atm. Given that the molar heat capacities, C_p for solid, liquid and gaseous water are 37.5 J K^{-1} mol^{-1}, 75.3 J K^{-1} mol^{-1} and 36.4 J K^{-1} mol^{-1}, respectively. The enthalpies of fusion and vaporization are 6.01 kJ mol^{-1} and 40.7 kJ mol^{-1}, respectively. Calculate q, w, ΔU and ΔH for this process.

(11 marks)

(c) Given that

$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$ $\quad \Delta H° = -571.6$ kJ mol^{-1}

$C_3H_4(g) + 4O_2(g) \rightarrow 3CO_2(g) + 2H_2O(g)$ $\quad \Delta H° = -1937$ kJ mol^{-1}

$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$ $\quad \Delta H° = -2220$ kJ mol^{-1}

Determine the heat of the reaction $\Delta H°$, for $C_3H_4(g) + 2H_2(g) \rightarrow C_3H_8(g)$

(6 marks)

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

General data and fundamental constants

Quantity	Symbol	Value	Power of ten	Units
Speed of light	c	2.99792458	10^{8}	m s^{-1}
Elementary charge	e	1.602176	10^{-19}	C
Faraday constant	$F=N_Ae$	9.64853	10^{4}	C mol^{-1}
Boltzmann constant	k	1.38065	10^{-23}	J K^{-1}
Gas constant	$R=N_Ak$	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	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		Useful relation	Unit relations	
1 eV	1.60218 x 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 x 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		

TERJEMAHAN

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** (3) 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

Jawab **TIGA** (3) soalan.
Hanya **TIGA** (3) jawapan yang pertama akan diperiksa.

1. (a) Gas heksana mempunyai isipadu molar sebesar 0.39 L mol^{-1} pada 660 K. Bagi heksana, T_c = 507.7 K and P_c = 30.3 bar.

(i) Apakah tekanan bagi heksana dalam unit bar mengikut persamaan van der Waals?

(ii) Apakah peratus penyimpangan daripada kelakuan gas unggul?

(Diberikan : $P_c = \frac{a}{27b^2}$; $V_{m,c} = 3b$ dan $T_c = \frac{8a}{27Rb}$)

(10 markah)

(b) Satu gas mematuhi persamaan keadaan $(P + \frac{a}{V_m^2})V_m = RT$, dengan pemalar a = 12.4 bar L^2. Apakah nilai faktor ketermampatan, Z, bagi satu mol gas dalam satu bekas berisipadu 6.34 L pada 250 ^oC? Adakah gas tersebut berkelakuan unggul pada suhu ini? Terangkan.

(10 markah)

2. (a) Terbitkan hukum kadar kamiran dan separuh hayat bagi tindak balas tertib-n:

$$A \rightarrow \text{Hasil}$$

di mana n = 0, 2 dan 3.

(9 markah)

(b) Penguraian N_2O_5 pada 300 ^oC dijelaskan dengan persamaan

$$2N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$$

dan menghasilkan data-data berikut:

Masa / min	0	5	8	12	16
$[N_2O_5]$ / M	0.2	0.008	0.00553	0.0035	0.0029

Tentukan tertib dan pemalar kadar bagi tindak balas ini.

(11 markah)

3. (a) Apa itu tenaga pengaktifan? Lakarkan graf bagi menggambarkan bagaimana mangkin boleh mengurangkan tenaga pengaktifan dan mencepatkan tindak balas kimia.

(6 markah)

(b) Klorin dioksida, ClO_2 ialah agen pengoksidaan yang kuat dan akan terurai pada suhu yang tinggi. Diberikan bahawa pemalar kadar bagi penguraian ClO_2 1.70×10^{-2} $dm^3\ mol^{-1}\ s^{-1}$ pada 24 °C dan 2.01×10^{-2} $dm^3\ mol^{-1}\ s^{-1}$ pada 37 °C.

(i) Dengan menggunakan persamaan Arrhenius, tentukan parameter Arrhenius, **A** bagi tindak balas ini.

(ii) Berapakah tenaga pengaktifan bagi tindak balas penguraian jika kadar tindak balas didapati dua kali lebih cepat apabila suhu dinaikkan dari 24 kepada 49 °C?

(14 markah)

4. (a) Omboh alih yang mempunyai jisim 8.00 kg dan luas keratan rentas 5.00 cm^2 memerangkap 0.200 mol gas unggul di dalam sebuah silinder tegak. Jika omboh bergerak tanpa geseran di dalam silinder, berapa banyak kerja dilakukan ke atas gas apabila suhunya meningkat dari 20 hingga 300 °C?

(3 markah)

(b) Satu sampel ais seberat 16.84 g dipanaskan dari -47.3 kepada 140 °C pada tekanan malar 1.0 atm. Diberikan bahawa muatan haba tentu, C_p bagi pepejal, cecair dan wap air masing-masing adalah 37.5 J K^{-1} mol^{-1}, 75.3 J K^{-1} mol^{-1} dan 36.4 J K^{-1} mol^{-1}. Entalpi pelakuran dan entalpi pengewapan masing-masing adalah 6.01 kJ mol^{-1} dan 40.7 kJ mol^{-1}. Kirakan q, w, ΔU dan ΔH bagi proses ini.

(11 markah)

(c) Diberikan

$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$ $\quad \Delta H° = -571.6$ kJ mol^{-1}

$C_3H_4(g) + 4O_2(g) \rightarrow 3CO_2(g) + 2H_2O\ (g)$ $\quad \Delta H° = -1937$ kJ mol^{-1}

$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$ $\quad \Delta H° = -2220$ kJ mol^{-1}

Tentukan haba bagi tindak balas $\Delta H°$; $C_3H_4(g) + 2H_2(g) \rightarrow C_3H_8(g)$

(6 markah)

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