UNIVERSITI SAINS MALAYSIA

Peperiksaan Kursus Semasa Cuti Panjang
Sidang Akademik 2007/2008

June 2008

KFT 131 – Physical Chemistry I
[Kimia Fizik I]

Duration: 3 hours
[Masa : 3 jam]

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

Instructions:

Answer **FIVE** (5) questions. Part A is **COMPULSORY**. Answer any **TWO** (2) questions from Part B. All questions carry the same marks.

Answer to each question on a new page.

You may answer either in Bahasa Malaysia or in English.

If a candidate answers more than five questions, only the answers to the first five questions in the answer sheet will be graded.

Appendix: Fundamental constants in physical chemistry

...2/-

SECTION A

Answer ALL questions.

1. (a) Consider n moles of an ideal gas:

(i) Show that at constant volume, $dP = (nR/V)dT + (RT/V)dn$.

(ii) Write the differential change in volume, dV under isothermal condition.

(iii) Show that dV is an exact differential.

(12 marks)

(b) Calculate the final volume of 1.0 mole ideal gas initially at 0 °C and 1 bar that undergoes reversible isothermal expansion involving q = 1000 J. Given R = 0.08314 L bar K^{-1} mol^{-1}.

(8 marks)

2. (a) Derive the rate law for the following mechanism of reaction:

$$A \underset{k_2}{\overset{k_1}{\rightleftharpoons}} B \qquad B + C \xrightarrow{k_3} D$$

where the concentration of B is small compared to that of A, C and D using the steady-state approximation.

(6 marks)

(b) Thermal dissociation of SO_2Cl_2 gas to SO_2 and Cl_2 is a first order reaction. For 0.10 mol of SO_2Cl_2 in a 1-L container at 327 °C, measurement of pressure at several time intervals yields the following data:

Time/hr	0.0	1.0	2.0	4.0	8.0	16.0
Pressure/atm	4.91	5.58	6.32	7.31	8.54	9.50

Plot a suitable graph to determine

(i) the rate constant of dissociation at 320 °C,

(ii) the half-life of the reaction.

What is the pressure of the system after 20 minutes?

(14 marks)

3. (a) Sketch a graph of P vs $\overline{V}$ for CO_2, showing the isotherms at its critical temperature, T_c (31.04 °C), at 20 °C and 50 °C. Label the critical point with an asterisk (*), the two-phase region, the liquid phase and the supercritical fluid phase. Write a mathematical equation that best represents the curve at T_c.

(8 marks)

(b) The viscosity of gases is represented approximately by the following expression:

$$\eta = \frac{1}{2}\lambda \rho \langle c \rangle$$

Show that η can also be written as

$$\eta = \left(\frac{kT}{\pi m}\right)^{1/2} \frac{m}{\pi d^2}$$

where ρ is the gas density and all other symbols have the usual meaning.

(3 marks)

(c) Draw the diagram of a Knudsen cell and label accordingly.

A Knudsen cell has a circular hole of diameter 2.80 mm. A solid sample with a molar mass of 260 g mol^{-1}, was placed in the cell and heated to 400 K. The vapour that is given off by the solid exerts a small pressure of 0.835 Pa.

Calculate:

(i) The flux of vapour molecules that escape through the hole.

(ii) The rate of effusion of the vapour.

(iii) The loss in mass of the solid in a period of 2.00 hours.

(9 marks)

SECTION B

Answer any TWO (2) questions.

4. A 30-L container containing 2 mols of oxygen at 25 °C expands to 150 L. Calculate w, $\triangle U$ and $\triangle H$ for each of the following processes:

(i) Isothermal and reversible.

(ii) Adiabatic and reversible.

(iii) Irreversible.

Assume the gas is ideal.

Given $\gamma = 1.399$ and $R = 8.314$ J mol^{-1} K^{-1}.

(20 marks)

5. (a) The van der Waals equation may be transformed into the ideal gas equation under certain conditions. State the conditions and show how the transformation can be done mathematically.

(5 marks)

(b) Hydrogen and nitrogen are two real gases with the following critical parameters:

	P_c/bar	$\overline{V}_c$ / L mol^{-1}	T_c /K
H_2	13.0	0.0650	33.2
N_2	46.0	0.0895	190.6

(i) Calculate the van der Waals constants, *a* and *b* of H_2.

(ii) Calculate the reduced pressure of N_2 at 150 K and a molar volume of 1.30 L mol^{-1}.

(iii) Suppose H_2 is at 139 K and 2.0 bar pressure while N_2 is at 800 K and 10.0 bar pressure. Are they in a corresponding state? Explain your answer.

(iv) Is it possible to obtain liquid H_2 and N_2 by compressing the gases isothermally at -173 °C using a pressure of 1 MPa? Explain.

(15 marks)

6. (a) A 2.0-L flask contains 0.14 mol of gas X (M_r = 71.0, d = 1.09 nm) and 0.06 mol of gas Y (M_r = 160.0, d = 1.65 nm) at 27 °C.
Calculate:
(i) Total kinetic energy of X.
(ii) Partial pressures of X and Y.
(iii) Molecular (or number) density of X and Y.
(iv) Mean free path of Y.
(v) Mean relative speed, $\langle v_{12} \rangle$ of the gases.
(vi) Collision frequency when one moving molecule of X hits all molecules of Y which are stationary.

(13 marks)

(b) (i) Write down an expression that relates the diffusion coefficient, D of a gas to its mean speed. Based on this expression, state and explain two parameters that affect the value of D.
(ii) Find the relative rate of diffusion for two gases, A and B with the following properties:
$M_A = 4M_B$; $d_A = 2.5d_B$; $T_A = T_B$; $P_A = 0.8P_B$.

(7 marks)

7. (a) Methane may be produced from coal in a process represented by the following steps, where coal is approximated by graphite:

$$2C(s) + 2H_2O(g) = 2CO(g) + 2H_2(g)$$
$$CO(g) + H_2O(g) = CO_2(g) + H_2(g)$$
$$CO(g) + 3H_2(g) = CH_4(g) + H_2O(g)$$

The sum of the reactions is

$$2C(s) + 2H_2O(g) = CH_4(g) + CO_2(g)$$

Calculate $\triangle_r H°$ at 500 K for each of these reactions and the sum of the reactions. State and explain from the standpoint of heat balance whether it is better to carry out the overall reactions in three separate reactors or in a single reactor.

(10 marks)

(b) Calculate the standard enthalpy of formation of methane at 1000 K from the value at 298 K using the $H° - H°_{298}$ data in Table 1. The equation for the reaction is

$$C(\text{graphite}) + 2H_2(g) \rightleftharpoons CH_4(g)$$

(10 marks)

...6/-

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	$F=N_A e$	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	$L Torr\ K^{-1}\ mol^{-1}$
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	1.60218×10^{-19} J 96.485 kJ mol^{-1}	2.303 RT/F = 0.0591 V at 25 °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	$1\ V = 1\ J\ C^{-1}$ $= 1\ kg\ m^2\ s^{-3}\ A^{-1}$

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		

...7/-

Tables of Physical Chemical Data

Table 1

T/K	$\overline{C}_P^\circ$ / J K^{-1} mol^{-1}	$\overline{S}^\circ$ / J K^{-1} mol^{-1}	$\overline{H}_T^\circ - \overline{H}_{298}^\circ$ / kJ mol^{-1}	$\Delta_f H^\circ$ / kJ mol^{-1}	$\Delta_f G^\circ$ / kJ mol^{-1}
500	14.623	11.662	2.365	0.000	0.000
1000	21.610	24.457	11.795	0.000	0.000
2000	24.094	40.771	35.525	0.000	0.000
3000	26.611	51.253	61.427	0.000	0.000
		C(g)			
0	0.000	0.000	−6.536	711.185	711.185
298	20.838	158.100	0.000	716.670	671.244
500	20.804	168.863	4.202	718.507	639.906
1000	20.791	183.278	14.600	719.475	560.654
2000	20.952	197.713	35.433	716.577	402.694
3000	21.621	206.322	56.689	711.932	246.723
		CH_4(g)			
0	0.000	0.000	−10.024	−66.911	−66.911
298	35.639	186.251	0.000	−74.873	−50.768
500	46.342	207.014	8.200	−80.802	−32.741
1000	71.795	247.549	38.179	−89.849	19.492
2000	94.399	305.853	123.592	−92.709	130.802
3000	101.389	345.690	222.076	−91.705	242.332
		CO(g)			
0	0.000	0.000	−8.671	−113.805	−113.805
298	29.142	197.653	0.000	−110.527	−137.163
500	29.794	212.831	5.931	−110.003	−155.414
1000	33.183	234.538	21.690	−111.983	−200.275
2000	36.250	258.714	56.744	−118.896	−286.034
3000	37.217	273.605	93.504	−127.457	−367.816
		CO_2(g)			
0	0.000	0.000	−9.364	−393.151	−393.151
298	37.129	213.795	0.000	−393.522	−394.389
500	44.627	234.901	8.305	−393.666	−394.939
1000	54.308	269.299	33.397	−394.623	−395.886
2000	60.350	309.293	91.439	−396.784	−396.333
3000	62.229	334.169	152.852	−400.111	−395.461
		C_2H_4(g)			
0	0.000	0.000	−10.518	60.986	60.986
298	43.886	219.330	0.000	52.467	68.421
500	63.477	246.215	10.668	46.641	80.933
1000	93.899	300.408	50.665	38.183	119.122
		C_2H_6(g)			
298	52.63	229.60	0.00	−84.68	−32.86
500	78.07	262.91	13.22	−93.89	4.96
1000	122.72	332.28	64.56	−105.77	109.55
		C_4H_{10}(g, *n*-butane)			
298	97.45	310.23	0.00	−126.15	−17.02
500	147.86	372.90	24.94	−140.21	61.10
1000	226.86	502.86	120.96	−155.85	270.31

(*continued*)

...8/-

Table 1 *(continued)*.

T/K	$\overline{C}^\circ_p$ / J K^{-1} mol^{-1}	$\overline{S}^\circ$ / J K^{-1} mol^{-1}	$\overline{H}^\circ_T - \overline{H}^\circ_{298}$ / kJ mol^{-1}	$\Delta_f H^\circ$ / kJ mol^{-1}	$\Delta_f G^\circ$ / kJ mol^{-1}
		$C_6H_6(g)$			
298	81.67	269.31	0.00	82.93	129.73
500	137.24	325.42	22.43	73.39	164.29
1000	209.87	446.71	112.01	62.01	260.76
		$CH_3OH(g)$			
298	43.89	239.81	0.00	−201.17	−162.46
500	59.50	266.13	10.42	−207.94	−134.27
1000	89.45	317.59	48.41	−217.28	−56.16
		Cl(g)			
0	0.000	0.000	−6.272	119.621	119.621
298	21.838	165.189	0.000	121.302	105.306
500	22.744	176.752	4.522	122.272	94.203
1000	22.233	192.430	15.815	124.334	65.288
2000	21.341	207.505	37.512	127.058	5.081
3000	21.063	216.096	58.690	128.649	−56.297
		HCl(g)			
0	0.000	0.000	−8.640	−92.127	−92.127
298	29.136	186.901	0.000	−92.312	−95.300
500	29.304	201.989	5.892	−92.913	−97.166
1000	31.628	222.903	21.046	−94.388	−100.799
2000	35.600	246.246	54.953	−95.590	−106.631
3000	37.243	261.033	91.478	−96.547	−111.968
		$Cl_2(g)$			
0	0.000	0.000	−9.180	0.000	0.000
298	33.949	223.079	0.000	0.000	0.000
500	36.064	241.228	7.104	0.000	0.000
1000	37.438	266.764	25.565	0.000	0.000
2000	38.428	293.033	63.512	0.000	0.000
3000	40.075	308.894	102.686	0.000	0.000
		H(g			
0	0.000	0.000	6.197	216.035	216.035
298	20.786	114.716	0.000	217.999	203.278
500	20.786	125.463	4.196	219.254	192.957
1000	20.786	139.871	14.589	222.248	165.485
2000	20.786	154.278	35.375	226.898	106.760
3000	20.786	162.706	56.161	229.790	46.007
		$H^+(g)$			
0	0.000	0.000	−6.197	1528.085	
298	20.786	108.946	0.000	1536.246	1516.990
500	20.786	119.693	4.196	1541.697	1502.422
1000	20.786	134.101	14.589	1555.084	1457.958
2000	20.786	148.509	35.375	1580.520	1350.840
3000	20.786	156.937	56.161	1604.198	1230.818

(continued)

Table 1 (*continued*)

T/K	$\overline{C}_p^\circ$ / J K^{-1} mol^{-1}	$\overline{S}^\circ$ / J K^{-1} mol^{-1}	$\overline{H}_T^\circ - \overline{H}_{298}^\circ$ / kJ mol^{-1}	$\Delta_f H^\circ$ / kJ mol^{-1}	$\Delta_f G^\circ$ / kJ mol^{-1}
			$H^-(g)$		
0	0.000	0.000	−6.197	143.266	
298	20.786	108.960	0.000	139.032	132.282
500	20.786	119.707	4.196	136.091	128.535
1000	20.786	134.114	14.589	128.692	123.819
2000	20.786	148.522	32.375	112.557	125.012
3000	20.786	156.950	56.161	94.662	135.055
			HI(g)		
0	0.000	0.000	−8.656	28.535	28.535
298	29.156	206.589	0.000	26.359	1.560
500	29.736	221.760	5.928	−5.622	−10.088
1000	33.135	243.404	21.641	−6.754	−14.006
2000	36.623	267.680	56.863	−7.589	−21.009
3000	37.918	282.805	94.210	−10.489	−27.114
			$H_2(g)$		
0	0.000	0.000	−8.467	0.000	0.000
298	28.836	130.680	0.000	0.000	0.000
500	29.260	145.737	5.883	0.000	0.000
1000	30.205	166.216	20.680	0.000	0.000
2000	34.280	188.418	52.951	0.000	0.000
3000	37.087	202.891	88.740	0.000	0.000
			$H_2O(g)$		
0	0.000	0.000	−9.904	−238.921	−238.921
298	33.590	188.834	0.000	−241.826	−228.582
500	35.226	206.534	6.925	−243.826	−219.051
1000	41.268	232.738	26.000	−247.857	−192.590
2000	51.180	264.769	72.790	−251.575	−135.528
3000	55.748	286.504	126.549	−253.024	−77.163
			I(g)		
0	0.000	0.000	−6.197	107.164	107.164
298	20.786	180.786	0.000	106.762	70.174
500	20.786	191.533	4.196	75.990	50.203
1000	20.795	205.942	14.589	76.937	24.039
2000	21.308	220.461	35.566	77.992	−29.410
3000	22.191	229.274	57.332	77.406	−82.995
			$I_2(g)$		
0	0.000	0.000	−10.116	65.504	65.504
298	36.887	260.685	0.000	62.421	19.325
500	37.464	279.920	7.515	0.000	0.000
1000	38.081	306.087	26.407	0.000	0.000
2000	42.748	332.521	66.250	0.000	0.000
3000	44.897	351.615	110.955	0.000	0.000

(*continued*)

...10/-

Table 1 (*continued*)

T/K	$\overline{C}_p^\circ$ / J K^{-1} mol^{-1}	$\overline{S}^\circ$ / J K^{-1} mol^{-1}	$\overline{H}_T^\circ - \overline{H}_{298}^\circ$ / kJ mol^{-1}	$\Delta_f H^\circ$ / kJ mol^{-1}	$\Delta_f G^\circ$ / kJ mol^{-1}
			N(g)		
0	0.000	0.000	−6.197	470.820	470.820
298	20.786	153.300	0.000	472.683	455.540
500	20.786	164.047	4.196	473.923	443.584
1000	20.786	178.454	14.589	476.540	412.171
2000	20.790	192.863	35.375	479.990	346.339
3000	20.963	201.311	56.218	482.543	278.946
			NO(g)		
0	0.000	0.000	−9.192	89.775	89.775
298	29.845	210.758	0.000	90.291	86.606
500	30.486	226.263	6.059	90.352	84.079
1000	33.987	248.536	22.229	90.437	77.775
2000	36.647	273.128	57.859	90.494	65.060
3000	37.466	288.165	94.973	89.899	52.439
			NO_2(g)		
0	0.000	0.000	−10.186	35.927	35.927
298	36.974	240.034	0.000	33.095	51.258
500	43.206	260.638	8.099	32.154	63.867
1000	52.166	293.889	32.344	32.005	95.779
2000	56.441	331.788	87.259	33.111	159.106
3000	57.394	354.889	144.267	32.992	222.058
			N_2(g)		
0	0.000	0.000	−8.670	0.000	0.000
298	29.124	191.609	0.000	0.000	0.000
500	29.580	206.739	5.911	0.000	0.000
1000	32.697	228.170	21.463	0.000	0.000
2000	35.971	252.074	56.137	0.000	0.000
3000	37.030	266.891	92.715	0.000	0.000
			N_2O_4(g)		
0	0.000	0.000	−16.398	18.718	18.718
298	77.256	304.376	0.000	9.079	97.787
500	97.204	349.446	17.769	8.769	158.109
1000	119.208	425.106	72.978	15.189	305.410
2000	129.030	511.743	198.518	33.110	588.764
3000	131.200	564.555	328.840	49.178	862.983
			NH_3(g)		
0	0.000	0.000	−10.045	−38.907	−38.907
298	35.652	192.774	0.000	−45.898	−16.367
500	42.048	212.659	7.819	−49.857	4.800
1000	56.491	246.486	32.637	−55.013	61.910
2000	72.833	291.525	98.561	−54.833	179.447
3000	78.902	322.409	174.933	−50.433	295.689

...11/-

Table 1 (*continued*)

T/K	$\overline{C}^{\circ}_{P}$ / J K^{-1} mol^{-1}	$\overline{S}^{\circ}$ / J K^{-1} mol^{-1}	$\overline{H}^{\circ}_{T} - \overline{H}^{\circ}_{298}$ / kJ mol^{-1}	$\Delta_f H^{\circ}$ / kJ mol^{-1}	$\Delta_f G^{\circ}$ / kJ mol^{-1}
			O(g)		
0	0.000	0.000	−6.725	246.790	246.790
298	21.911	161.058	0.000	249.173	231.736
500	21.257	172.197	4.343	250.474	219.549
1000	20.915	186.790	14.860	252.682	187.681
2000	20.826	201.247	35.713	255.299	121.552
3000	20.937	209.704	56.574	256.741	54.327
			O^-(g)		
0	0.000	0.000	−6.571	105.814	105.814
298	21.692	157.790	0.000	101.846	91.638
500	21.184	168.860	4.318	98.926	85.532
1000	20.899	183.426	14.817	90.723	75.219
2000	20.816	197.878	35.661	72.545	66.619
3000	20.800	206.314	56.467	53.146	67.810
			O_2(g)		
0	0.000	0.000	−8.683	0.000	0.000
298	29.376	205.147	0.000	0.000	0.000
500	31.091	220.693	6.084	0.000	0.000
1000	34.870	243.578	22.703	0.000	0.000
2000	37.741	268.748	59.175	0.000	0.000
3000	39.884	284.466	98.013	0.000	0.000
			e^-(g)		
0	0.000	0.000	−6.197	0.000	0.000
298	20.786	20.979	0.000	0.000	0.000
500	20.786	31.725	4.196	0.000	0.000
1000	20.786	46.133	14.584	0.000	0.000
2000	20.786	60.541	35.375	0.000	0.000
3000	20.786	68.969	56.161	0.000	0.000

...12/-

TERJEMAHAN

Arahan:

Jawab **LIMA** (5) soalan. Bahagian A **WAJIB** dijawab. Pilih sebarang **DUA** (2) soalan sahaja bagi Bahagian B. Semua soalan membawa jumlah markah yang sama.

Jawab setiap soalan pada muka surat yang baru.

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

Jika calon menjawab lebih daripada lima soalan, hanya lima soalan pertama mengikut susunan dalam skrip jawapan akan diberi markah.

Lampiran: Pemalar asas dalam kimia fizik.

BAHAGIAN A

Jawab **SEMUA** soalan.

1. (a) Pertimbangkan *n* mol suatu gas unggul.

(i) Tunjukkan bahawa pada isipadu tetap $dP = (nR/V)dT + (RT/V)dn$

(ii) Tuliskan pembezaan isipadu, dV, pada keadaan isoterma.

(iii) Buktikan bahawa dV adalah pembezaan tepat.

(12 markah)

(b) Kira isipadu akhir bagi 1.0 mol gas unggul pada 0 °C dan 1 bar yang berkembang secara berbalik dan isoterma melibatkan q = 1000 J. Diberikan R = 0.08314 L bar K^{-1} mol^{-1}.

(8 markah)

2. (a) Terbitkan hukum kadar bagi mekanisme tindak balas berikut:

$$A \underset{k_2}{\overset{k_1}{\rightleftharpoons}} B \qquad B + C \xrightarrow{k_3} D$$

yang mana kepekatan B adalah kecil berbanding dengan A, C, dan D secara kaedah anggaran keadaan mantap.

(6 markah)

(b) Penguraian terma gas SO_2Cl_2 kepada SO_2 and Cl_2 adalah suatu tindakbalas tertib pertama. Bagi sejumlah 0.10 mol gas SO_2Cl_2 dalam suatu bekas berisipadu 1-L pada 327 °C, pengukuran tekanan yang dilakukan pada beberapa sela masa telah menghasilkan data berikut:

Masa/j	0.0	1.0	2.0	4.0	8.0	16.0
Tekanan/atm	4.91	5.58	6.32	7.31	8.54	9.50

Plot suatu graf yang sesuai untuk menentukan

(i) pemalar kadar penguraian pada 320 °C,

(ii) masa separuh hayat penguraian.

Apakah tekanan sistem selepas 20 minit?

(14 markah)

3. (a) Lakarkan graf P vs $\overline{V}_c$ bagi CO_2 yang menunjukkan isoterma-isoterma pada suhu gentingnya, T_c (31.04 °C), pada 20 °C dan 50 °C. Labelkan takat genting dengan asterisk (*), kawasan dua-fasa, fasa cecair dan fasa cecair superkritikal. Tuliskan satu persamaan matematik terbaik yang mewakili keluk pada T_c.

(8 markah)

(b) Kelikatan gas diwakili secara anggaran oleh ungkapan berikut:

$$\eta = \frac{1}{2}\lambda \rho \langle c \rangle$$

Tunjukkan bahawa η boleh juga dituliskan sebagai

$$\eta = \left(\frac{kT}{\pi m}\right)^{1/2} \frac{m}{\pi d^2}$$

yang mana ρ ialah ketumpatan gas dan simbol-simbol lain mempunyai makna yang lazim.

(3 markah)

(c) Lukiskan gambarajah suatu sel Knudsen dan labelkan.

Sebuah sel Knudsen mempunyai sebuah liang bulat bergarispusat 2.80 mm. Suatu sampel pepejal dengan jisim molar 260 g mol^{-1} diletakkan ke dalam sel tersebut dan dipanaskan ke suhu 400 K. Wap yang dikeluarkan oleh pepejal itu mengenakan tekanan kecil sejumlah 0.835 Pa.

Hitung:

(i) Fluks molekul wap yang terlepas melalui liang.

(ii) Kadar efusi wap tersebut.

(iii) Kehilangan berat pepejal dalam jangka masa 2.00 jam.

(9 markah)

BAHAGIAN B

Jawab sebarang **DUA** (2) soalan sahaja.

4. Suatu bekas berisipadu 30 L yang mengandungi 2 mol oksigen pada 25 °C telah mengembang menjadi 150 L. Kiralah w, $\triangle U$ dan $\triangle H$ bagi setiap proses berikut.

   (i) Isotherma dan berbalik

   (ii) Adiabatik dan berbalik

   (iii) Takberbalik

   Anggapkan gas berkelakuan unggul.

   Diberikan $\gamma = 1.399$ dan $R = 8.314\ J\ mol^{-1}\ K^{-1}$.

   (20 markah)

5. (a) Persamaan van der Waals boleh diubah menjadi persamaan gas unggul di bawah keadaan tertentu. Nyatakan keadaan-keadaan itu dan tunjukkan bagaimana pengubahan itu dapat dilakukan secara matematik.

   (5 markah)

   (b) Hidrogen dan nitrogen adalah dua gas sahih dengan parameter genting seperti berikut:

	P_c /bar	$\overline{V}_c$ / L mol-1	T_c /K
H_2	13.0	0.0650	33.2
N_2	46.0	0.0895	190.6

   (i) Hitung pemalar-pemalar van der Waals, a dan b bagi H_2.

   (ii) Hitung tekanan terturun bagi N_2 pada 150 K dan isipadu molar $1.30\ L\ mol^{-1}$.

   (iii) Andaikan H_2 berada pada 139 K dan tekanan 2.0 bar manakala N_2 pada 800 K dan tekanan 10.0 bar. Adakah kedua-duanya berada di dalam keadaan yang sepadan? Terangkan jawapan anda.

(iv) Mungkinkah cecair H_2 dan N_2 dapat diperolehi dengan memampatkan gas-gas tersebut secara isoterma pada -173 °C dengan menggunakan tekanan 1 MPa? Terangkan.

(15 markah)

6. (a) Sebuah kelalang 2.0-L mengandungi 0.14 mol gas X (M_r = 71.0, d = 1.09 nm) dan 0.06 mol gas Y (M_r = 160.0, d = 1.65 nm) pada 27 °C.

Hitung:

(i) Jumlah tenaga kinetik X.

(ii) Tekanan separa X dan Y.

(iii) Ketumpatan molekul (atau bilangan) X dan Y.

(iv) Laluan bebas min bagi Y.

(v) Laju purata relatif, $\langle v_{12} \rangle$ bagi gas-gas tersebut.

(vi) Frekuensi perlanggaran apabila satu molekul X yang bergerak melanggar kesemua molekul Y yang diam.

(13 markah)

(b) (i) Tuliskan satu ungkapan yang menghubungkan pekali pembauran, *D* suatu gas dengan laju puratanya. Berdasarkan ungkapan ini, nyatakan dan jelaskan dua parameter yang mempengaruhi nilai *D*.

(ii) Cari kadar pembauran relatif bagi dua gas, A dan B yang mempunyai sifat-sifat berikut:

$M_A = 4M_B$; $d_A = 2.5d_B$; $T_A = T_B$; $P_A = 0.8P_B$.

(7 markah)

7. (a) Metana boleh dihasilkan daripada arang batu melalui suatu proses yang terdiri daripada langkah-langkah berikut yang mana arang batu dianggarkan sebagai grafit:

$$2C(s) + 2H_2O(g) = 2CO(g) + 2H_2(g)$$
$$CO(g) + H_2O(g) = CO_2(g) + H_2(g)$$
$$CO(g) + 3H_2(g) = CH_4(g) + H_2O(g)$$

Perjumlahan langkah-langkah di atas memberikan:

$$2C(s) + 2H_2O(g) = CH_4(g) + CO_2(g)$$

Kiralah $\triangle_r H°$ pada 500 K bagi setiap langkah tindakbalas dan tindakbalas jumlah. Nyata dan jelaskan dari sudut imbangan haba, sama ada lebih baik menjalankan tindak balas keseluruhan dalam tiga reaktor berasingan ataupun dalam satu reaktor tunggal.

(10 markah)

(b) Kiralah entalpi pembentukan piawai metana pada 1000 K daripada nilai-nilai berkaitan pada 298 K dengan menggunakan data $H° - H°_{298}$ dalam Jadual 1. Persamaan tindakbalasnya ialah

$$C(\text{graphite}) + 2H_2(g) \rightleftharpoons CH_4(g)$$

(10 markah)