UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2016/2017 Academic Session

June 2017

EKC 108 – Physical and Analytical Chemistry
[Kimia Fizik dan Kimia Analisis]

Duration : 3 hours
[Masa : 3 jam]

Please ensure that this examination paper contains SEVEN printed pages and ONE printed page of Appendix before you begin the examination.

[Sila pastikan bahawa kertas peperiksaan ini mengandungi TUJUH muka surat yang bercetak dan SATU muka surat Lampiran sebelum anda memulakan peperiksaan ini.]

Instruction: Answer **ALL** (4) questions.

*[**Arahan:** Jawab **SEMUA** (4) soalan.]*

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

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

…2/-

Answer ALL questions.

1. [a] Explain the way a double beam spectrophotometer works with the aid of a block diagram.

[7 marks]

[b] Why is a calibration curve likely to be linear over a wider range of concentrations at the wavelength of maximum absorption compared to a wavelength on a shoulder of the absorption curve?

[3 marks]

[c] A mixture of analytes *(A)* and *(B)* and standards of 1.0×10^{-4} M *(A)* and 1.0×10^{-4} M *(B)* gave the following results :

Wavelength (nm)	Absorbances		
	(A) Standard	*(B)* Standard	Mixture *(A)* and *(B)*
266	0.042	0.410	0.766
288	0.082	0.283	0.571
320	0.168	0.158	0.422
350	0.125	0.318	0.672
360	0.056	0.181	0.366

Determine the molar concentration of each analyte in the mixture by using the technique of least square method.

[15 marks]

2. [a] Define the following :-

[i] Elution

[1 mark]

[ii] Mobile phase

[1 mark]

[iii] Stationary phase

[1 mark]

[iv] Distribution factor

[1 mark]

[v] Retention factor

[1 mark]

[b] Describe the characteristics of both High Performance Liquid Chromatography *(HPLC)* and Gas Chromatography *(GC)* along with the advantages of each method.

[6 marks]

[c] Explain the difference in separation process between adsorption chromatography and partition chromatography.

[4 marks]

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Jawab <u>SEMUA</u> soalan.

1. [a] *Terangkan kaedah kerja spektrofotometer alur duaan dengan bantuan gambarajah blok.*

[7 markah]

[b] *Kenapakah lengkung tentukuran boleh dijangka sebagai lelurus merentasi julat kepekatan yang lebih besar ketika jarak gelombang penyerapan maksimum berbanding jarak gelombang pada bentuk bahu lengkungan penyerapan?*

[3 markah]

[c] *Suatu campuran analit* (A) *dan* (B) *dan analit piawai* 1.0×10^{-4} *M* (A) *dan* 1.0×10^{-4} *M* (B) *memberikan keputusan yang berikut :*

Jarak Gelombang (nm)	*Keserapan*		
	Piawai (A)	*Piawai* (B)	*Campuran* (A) *dan* (B)
266	0.042	0.410	0.766
288	0.082	0.283	0.571
320	0.168	0.158	0.422
350	0.125	0.318	0.672
360	0.056	0.181	0.366

Tentukan kepekatan molar bagi setiap analit di dalam campuran tersebut menggunakan teknik kaedah kuasa dua terkecil.

[15 markah]

2. [a] *Definisikan yang berikut :-*

[i] Elutan

[1 markah]

[ii] Fasa bergerak

[1 markah]

[iii] Fasa pegun

[1 markah]

[iv] Faktor taburan

[1 markah]

[v] Faktor penahanan

[1 markah]

[b] *Terangkan ciri-ciri Kromatografi Cecair Berprestasi Tinggi* (HPLC) *dan Kromatografi Gas* (GC) *beserta kelebihan bagi kedua-dua kaedah ini.*

[6 markah]

[c] *Terangkan perbezaan bagi proses pemisahan antara kromatografi jerapan dan kromatografi petakan.*

[4 markah]

…4/-

[d] A mixture of hexane and ethyl benzene was separated using gas chromatography. The following results were obtained.

Compound	**t_r min**	**t_w min**
Solvent	1.62	0.29
Hexane	6.80	0.79
Ethyl benzene	19.02	1.70

Using the values from the table above:

[i] Calculate the resolution between hexane and ethyl benzene.

[2 marks]

[ii] Calculate the retention factors for hexane and ethyl benzene.

[2 marks]

[iii] Calculate the selectivity factor for hexane and ethyl benzene.

[2 marks]

[iv] List four properties of a liquid stationary phase that is suitable for gas chromatography.

[4 marks]

3. A gas is compressed inside a piston at 303 K and 800 bars from an atmospheric condition (1 bar, 303 K). Given van der Waals equation :

$$\left(P + \frac{a}{V_m^{\,2}}\right)\left(V_m - b\right) = RT$$

where, a = 0.2476 L^2.bar.mol^{-2} , b = 0.02661 L^2.bar.mol^{-2}, N_A = 6.022×10^{23} mol^{-1}
M = 38.0 g.mol^{-1}, R = 0.083145 L.bar.mol^{-1}.K^{-1} = 8.314 J.mol^{-1}.K^{-1}

Calculate,

[a] Compressibility factor based on the volume obtained from van der Waals equation.

[8 marks]

[b] The number of gas molecules per mol.

[5 marks]

[c] Density difference after the gas is compressed.

[4 marks]

[d] Work and entropy change (in J.mol^{-1}) assuming ideal gas behavior when the gas is expanded to the atmospheric condition.

[8 marks]

[d] Suatu campuran heksana dan etil benzena dipisahkan dengan menggunakan kromatografi gas. Keputusan berikut telah diperolehi.

Komponen	***t_r min***	***t_w min***
Pelarut	1.62	0.29
Heksana	6.80	0.79
Etil benzena	19.02	1.70

Menggunakan nilai data daripada jadual di atas :

[i] Kirakan resolusi antara heksana dan etil benzena.

[2 markah]

[ii] Kirakan faktor penahanan bagi heksana dan etil benzena.

[2 markah]

[iii] Kirakan faktor pemilihan bagi heksana dan etil benzena.

[2 markah]

[iv] Nyatakan empat sifat bagi fasa pegun cecair yang sesuai untuk kromatografi gas.

[4 markah]

3. Suatu gas dipadatkan di dalam omboh pada 303 K dan 800 bar daripada keadaan atmosfera (1 bar, 303 K). Diberikan persamaan van der Waals :

$$\left(P + \frac{a}{V_m^{\,2}}\right)(V_m - b) = RT$$

Di mana, a = $0.2476\ L^2.bar.mol^{-2}$, b = $0.02661\ L^2.bar.mol^{-2}$, $N_A = 6.022\times10^{23}\ mol^{-1}$ M = $38.0\ g.mol^{-1}$, R = $0.083145\ L.bar.mol^{-1}.K^{-1} = 8.314\ J.mol^{-1}.K^{-1}$

Kirakan,

[a] Faktor kemampatan berdasarkan isipadu yang diperolehi daripada persamaan van der Waals.

[8 markah]

[b] Bilangan molekul gas per mol.

[5 markah]

[c] Perbezaan ketumpatan selepas gas dimampat.

[4 markah]

[d] Kerja dan perubahan entropi (dalam $J.mol^{-1}$) andainya gas berkelakuan unggul apabila gas mengembang kepada keadaan atmosfera.

[8 markah]

4. Given liquid-vapor equilibrium data for benzene-toluene solution at 200 K as follows :

Pressure, bar	**1.24**	**1.51**	**1.68**	**2.22**	**2.70**	**2.85**	**2.90**
Liquid benzene	0.000	0.136	0.262	0.587	0.850	0.927	1.000
Vapor benzene	0.000	0.200	0.363	0.711	0.912	0.961	1.000

W_{benzene} = 15.0 g, M_{benzene} = 78 g.mol^{-1},
W_{toluene} = 10.0 g, M_{toluene} = 92 g.mol^{-1},

$$\Delta_{mix}G = RT \sum_{t} n_t \ln x_t$$

[a] Assuming the mixed solution behaves ideally, calculate $\Delta_{mix}G$, $\Delta_{mix}V$, $\Delta_{mix}H$ and $\Delta_{mix}S$.

[10 marks]

[b] Which solution shows less tendency to escape to the vapor phase at 1.68 bars?

[10 marks]

[c] Calculate $\Delta_{mix}G$ and $\Delta_{mix}S$ for the mixed solution using the activity coefficient calculated in part [b].

[5 marks]

4. *Diberikan data keseimbangan cecair-wap bagi cecair benzena-tulena pada 200 K seperti berikut :*

Tekanan, bar	**1.24**	**1.51**	**1.68**	**2.22**	**2.70**	**2.85**	**2.90**
Cecair benzena	0.000	0.136	0.262	0.587	0.850	0.927	1.000
Wap benzena	0.000	0.200	0.363	0.711	0.912	0.961	1.000

W_{benzena} = 15.0 g, M_{benzena} = 78 g.mol^{-1},
W_{tolena} = 10.0 g, M_{tolena} = 92 g.mol^{-1},

$$\Delta_{campuran}G = RT \sum_t n_t \ln x_t$$

[a] *Andainya larutan campuran berkelakuan unggul, kirakan* $\Delta_{campuran}G$, $\Delta_{campuran}V$, $\Delta_{campuran}H$ *dan* $\Delta_{campuran}S$

[10 markah]

[b] *Larutan manakah menunjukkan kecondongan ke arah fasa wap pada 1.68 bar?*

[10 markah]

[c] *Kirakan* $\Delta_{campuran}G$ *dan* $\Delta_{campuran}S$ *bagi larutan campuran menggunakan pekali aktiviti yang diperolehi di bahagian [b].*

[5 markah]

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Appendix

slope of regression line

$$m = \frac{\Sigma(x_i - \bar{x})(y_i - \bar{y})}{\Sigma(x_i - \bar{x})^2}$$

$$b = \bar{y} - m\bar{x}$$

Easier Form of Least Squares Equations

$$m = \frac{\Sigma x_i y_i - [(\Sigma x_i \Sigma y_i)/n]}{\Sigma x_i^2 - [(\Sigma x_i)^2/n]}$$

- n is the number of data points