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# UNIVERSITI SAINS MALAYSIA

First Semester Examination  
Academic Session of 2007/2008

October/November 2007

## **EBS 336 – Analytical Chemistry** **[Kimia Analitis]**

Duration: 3 hours  
[Masa: 3 jam]

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Please ensure that this paper consists of TWENTY printed pages and ONE page APPENDIX before you proceed with the examination.

*[Sila pastikan bahawa kertas peperiksaan ini mengandungi DUA PULUH muka surat yang bercetak dan SATU muka surat LAMPIRAN sebelum anda memulakan peperiksaan.]*

This paper contains SEVEN questions.

*[Kertas soalan ini mengandungi TUJUH soalan.]*

**Instruction:** Answer **FIVE** (5) questions. If a candidate answers more than five questions, only the first five questions answered will be examined and awarded marks.

**Arahan:** Jawab **LIMA** (5) soalan. Jika calon menjawab lebih daripada lima soalan hanya lima soalan pertama mengikut susunan dalam skrip jawapan akan diberi markah.]

Answers to any question must start on a new page.

*[Mulakan jawapan anda untuk setiap soalan pada muka surat yang baru.]*

You may answer a question either in Bahasa Malaysia or in English.

*[Anda dibenarkan menjawab soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.]*

1. [a] Distinguish between:
- (i) Confidence limit, confidence interval and confidence level.
  - (ii) A technique, a method, a procedure and a protocol.
  - (iii) A complexing agent and a chelating agent.
  - (iv) A primary standard and a secondary standard.

*Bezakan di antara:*

- (i) *Had keyakinan, selang keyakinan dan paras keyakinan.*
- (ii) *Satu teknik, satu kaedah, satu tatacara dan satu protokol.*
- (iii) *Satu agen pengkompleks dan satu agen pengkelet.*
- (iv) *Satu zat piawai primer dan satu zat piawai sekunder.*

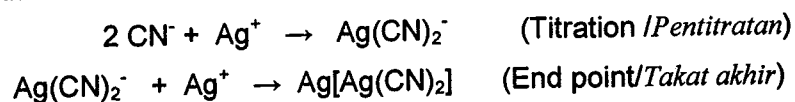
(30 marks/markah)

- [b] In the Liebig titration of cyanide ion, a soluble complex is formed; and at the equivalence point, solid silver cyanide is formed, signaling the end point.

*Dalam pentitratan Liebig ion sianida, satu kompleks yang terlarutkan terbentuk dan pada takat ekuivalen, pepejal argentum sianida terbentuk, menandakan takat akhir.*

**Reaction Equation:**

***Persamaan Tindakbalas:***



A 0.4723 g sample of KCN was titrated with 0.1025 M AgNO<sub>3</sub>, requiring 34.95 mL. What is the percent purity of the KCN?

Given: At. wt. K = 39.10; C = 12; N = 14, Ag = 107.87 g/mol

*Pentitratan satu sampel KCN dengan berat 0.4723 g memerlukan sebanyak 34.95 mL 0.1025 M AgNO<sub>3</sub>. Apakah peratus keceriaan KCN ini?*

*Diberikan: JAR bagi K = 39.10; C = 12; N = 14, Ag = 107.87 g/mol*

(30 marks/markah)

- [c] A solution of KMnO<sub>4</sub> was prepared by dissolving 4.68 g KMnO<sub>4</sub> in distilled water and diluting to 500 mL in a volumetric flask. What is the volume in millimeter of the KMnO<sub>4</sub> solution that will react with iron in 0.500g of an ore containing 35.6% Fe<sub>2</sub>O<sub>3</sub>?

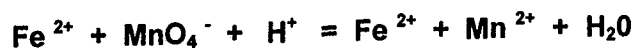
Given: At. wt. K = 39.10; Mn = 54.9; O = 16, Fe = 56 g/mol

*Satu larutan KMnO<sub>4</sub> telah disediakan dengan melarutkan sebanyak 4.68 g KMnO<sub>4</sub> dalam air suling dan mencairkannya kepada 500 mL dalam kelalang volumetrik. Apakah isipadu larutan KMnO<sub>4</sub> dalam millimeter yang akan bertindakbalas dengan ferum dalam 0.500g bijih yang mengandungi 35.6% Fe<sub>2</sub>O<sub>3</sub>?*

*Diberikan: JAR bagi K = 39.10; Mn = 54.9; O = 16, Fe = 56 g/mol*

**Reaction Equation:**

**Persamaan tindakbalas:**



Write the balance reaction for this equation.

*Tuliskan tindakbalas seimbang bagi persamaan ini.*

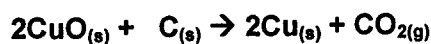
(40 marks/markah)

2. [a] Coke is an impure form of carbon that is often used in the industrial production of metals from their oxides. If a sample of coke is 95% carbon by mass, determine the mass of coke needed to react completely with 1.0 ton of copper (II) oxide.

*Kok adalah bentuk karbon yang tak tulen yang biasa digunakan dalam industri penghasilan logam dari oksidanya. Jika satu sampel kok mengandung karbon dengan jisim 95%, tentukan jisim kok yang diperlukan untuk bertindakbalas sepenuhnya dengan 1.0 tan kuprum (II) oksida.*

**Reaction Equation:**

***Persamaan Tindakbalas:***



Given: At wt. Cu = 64 g/mol; O = 16g/mol; C = 14 g/mol

Diberikan: JAR bagi Cu = 64 g/mol; O = 16g/mol; C = 14 g/mol

(20 marks/markah)

[b] Replicate water samples are analyzed for water hardness with the following results: 102.2, 102.8, 103.1 and 102.3 ppm  $\text{CaCO}_3$ .

Calculate the:

- (i) standard deviation
- (ii) relative standard deviation
- (iii) standard deviation of the mean
- (iv) relative standard deviation of the mean

*Replikat sampel air telah dianalisiskan untuk keliatan air.*

*Keputusan keliatan air adalah seperti berikut: 102.2, 102.8, 103.1 dan 102.3 ppm  $\text{CaCO}_3$ .*

*Kirakan:*

- (i) *sisihan piawai*
- (ii) *sisihan piawai relatif*
- (iii) *sisihan piawai bagi purata*
- (iv) *sisihan piawai relatif bagi purata*

(30 marks/markah)

- [c] A calibration curve for the colorimetric determination of arsenic in a polluted river water is prepared by reacting 0.5, 1.0, 2.0, 5.0, 10.0 and 15.0 mL of arsenic solution (10  $\mu\text{g/mL}$ ) in a concentrated nitric acid followed by the process of evaporation and baking the residue in an oven at 130° C for 45 minutes. The residue is then dissolved in a mixture of ammonium molybdate-hydrazine sulphate solution and heating to boil for 15 minutes before cooling and transferring the solution into a 50 mL volumetric flask and finally diluting to volume with ammonium molybdate-hydrazine sulphate solution and reducing the heteropoly arsenomolybdic acid complex to produce the characteristic blue reduced complex. The measured absorbance  $A$  of the reduced arseno molybdic acid solution at 845 nm is plotted against the concentration of arsenic solution. From the data in Table 2.1, determine the linear least-squares line and calculate the arsenic concentration in the polluted river water. Use a graph paper to accurately draw the straight lines.

**Table 2.1: Absorption signal for As**

As (ppm)	A (Abs)
0.10	0.052
0.20	0.104
0.40	0.179
1.00	0.454
2.00	0.889
Polluted river water	0.54

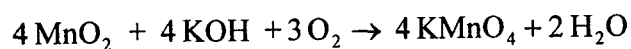
Satu keluk kalibrasi bagi penentuan kalorimetrik arsenik dalam sungai yang tercemar disediakan dengan mencampurkan sebanyak 0.5, 1.0, 2.0, 5.0, 10.0 dan 15.0 mL larutan arsenik ( $10 \mu\text{g/mL}$ ) dalam satu asid nitrik pekat diikuti dengan proses penyejatan dan membakar sisa pepejal tersebut dalam oven pada  $130^\circ \text{C}$  selama 45 minit. Sisa pepejal ini kemudian dilarutkan dalam satu campuran larutan ammonium molybdate-hydrazin sulfat dan memanaskannya hingga dididih selama 15 minit sebelum disejukkan dan dipindahkan ke dalam kelalang volumetrik 50 mL dan akhir sekali mencairkannya ke isipadu dengan larutan ammonium molybdate-hydrazin sulfat dan menurunkan kompleks asid heteropoly arsenomolybdik untuk menghasilkan warna biru ciri kompleks terturun. Absorban  $A$  yang diukur bagi larutan asid arseno molybdik yang terturun pada  $845 \text{ nm}$  diplotkan melawan kepekatan larutan arsenik. Dari data dalam Jadual 2.1 berikutnya, tentukan garis lurus "linear least-squares" dan kirakan kepekatan arsenik dalam air sungai tercemar ini. Gunakan kertas graf untuk melukis dengan tepat garis lurus tersebut.

**Jadual 2.1: Signal penyerapan bagi As**

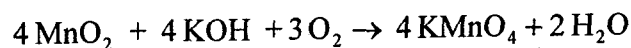
<i>As (ppm)</i>	<i>A (Abs)</i>
0.10	0.052
0.20	0.104
0.40	0.179
1.00	0.454
2.00	0.889
<i>Air sungai tercemar</i>	0.54

(50 marks/markah)

3. [a] Manganese dioxide, potassium hydroxide and oxygen react in the following fashion:



*Manganese dioksida, kalium hidroksida dan oksigen bertindakbalas mengikut persamaan tindakbalas berikut:*



A mixture of 272.9 g of  $\text{MnO}_2$ , 26.6 L of 0.250 M KOH, and 41.92 g of  $\text{O}_2$  is allowed to react as shown in the equation above. After the reaction is completed, 234.6 g of  $\text{KMnO}_4$  is separated from the reaction mixture. What is the per cent yield of this reaction?

Given: At wt K = 39.0, O = 16; H = 1.0 and Mn = 54.9 g/mol

*Satu campuran sebanyak 272.9 g of  $\text{MnO}_2$ , 26.6 L 0.250 M KOH dan 41.92 g  $\text{O}_2$  dibiarkan bertindakbalas mengikut persamaan yang ditunjukkan di atas. Selepas tindakbalas lengkap, sebanyak 234.6 g  $\text{KMnO}_4$  dipisahkan dari campuran tindakbalas. Apakah peratus hasil bagi tindakbalas ini?*

*Diberikan: JAR bagi K = 39.10; O = 16; H = 1.0 dan Mn = 54.9 g/mol*

(25 marks/markah)

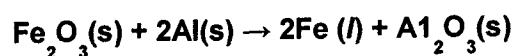


- [b] Over the years, the thermite reaction has been used for welding rail road rails, in incendiary bombs, and to ignite solid fuel rocket motors.

*Selama beberapa tahun, tindak balas thermit telah digunakan dalam kimpalan rel keretapi dan digunakan dalam pencucuhan bahan api pepejal bagi motor roket.*

**Reaction Equation:**

*Persamaan Tindakbalas:*



- (i) What mass of iron (III) oxide must be used to produce 15.0 g iron?

*Apakah jisim Fe (III) oksida yang mesti digunakan untuk menghasilkan sebanyak 15.0 g Fe?*

(10 marks/markah)

- (ii) If you started with 10.0 g of Al and the amount of iron (III) oxide calculated in part (i), how much aluminum metal is left over?

*Jika anda memulakan dengan 10.0 g of Al dan amaun Fe (III) oksida seperti yang dikirakan dalam (i), berapakah kuantiti logam aluminium yang masih tinggal?*

(20 marks/markah)

- [c] (i) Distinguish between iodimetry and iodometry.  
Briefly state the ways in which the end points of redox titrations may be detected visually.

*Bezakan di antara iodimetri and iodometri.*

*Nyatakan dengan ringkas kaedah-kaedah di mana pengesanan visual takat akhir bagi pentitratan redoks dibuat.*

(15 marks/markah)

- (ii) The sulfur content of a steel sample is determined by converting it to  $H_2S$  gas, absorbing the  $H_2S$  in 10.0 mL of 0.005 M  $I_2$  and then back-titrating the excess  $I_2$  with 0.002 M  $NaS_2O_3$ .  
If 2.6 mL  $NaS_2O_3$  is required for the titration, how many milligrams of sulfur are contained in the sample?  
Given: At wt. S = 32.06, H = 1.0 and O = 16 g/mol

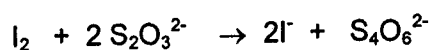
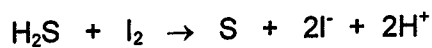
*Kandungan sulfur dalam satu sampel keluli telah ditentukan dengan menukarkan sulfur itu ke dalam bentuk gas  $H_2S$ . Penyerapan gas  $H_2S$  itu dibuat dengan menggunakan 10.0 mL larutan 0.005 M  $I_2$  dan kemudiannya melakukan pentitratan balik  $I_2$  yang berlebihan dengan larutan 0.002 M  $NaS_2O_3$ .*

*Jika 2.6 mL isipadu  $NaS_2O_3$  diperlukan untuk pentitratan, berapakah milligram sulfur yang terkandung dalam sampel?*

*Diberikan: JAR S = 32.06, H = 1.0, O = 16 g/mol*

**Reaction Equation:**

**Persamaan Tindakbalas:**



(30 marks/markah)

4. [a] (i) Lead on leaves by the road side was measured spectrophotometrically by reaction with dithiazone. The standard deviation for a triplicate analysis was 2.3 ppm. What is the 90% confidence limit?

*Please refer to the Table 1A in the Appendix.*

*Plumbum pada daun di pinggir jalan diukur secara spektrometri oleh tindakbalas dengan dithiazon. Jika sisihan piawai bagi analisis replikat adalah 2.3 ppm, apakah bacaan plumbum pada had keyakinan 90%?*

*Sila rujuk Jadual 1A dalam Lampiran.*

(20 marks/markah)

- (ii) Calculate the percentage of copper by mass in a sample of rock containing 0.50 % by mass of chalcopyrite, assuming this is the only source of copper in the rock.

Given: At. wt.: Cu = 63.55; Fe = 55.85 and S = 32.07

*Kirakan peratus jisim kuprum dalam satu sampel batuan yang mengandungi 0.50 % jisim kalkopirit, dengan menganggap ia adalah satu-satunya sumber kuprum dalam batuan.*

*Diberikan: JAR: Cu = 63.55; Fe = 55.85 dan S = 32.07 g/mol*

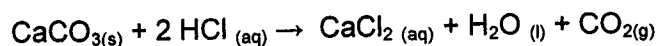
(15 marks/markah)

- [b] A chemical reaction familiar to geologists is that used to identify limestone. The reaction of hydrochloric acid with limestone, which is largely calcium carbonate, is seen through an effervescence - a bubbling due to the liberation of gaseous carbon dioxide as shown in the equation below.

*Satu tindakbalas kimia yang selalu digunakan oleh seorang geologi adalah dalam mengenalpasti suatu batu kapur. Tindakbalas asid hidroklorik dengan batu kapur, yang mana ia adalah keseluruhannya kalsium karbonat dapat dilihat melalui satu effervescence akibat pembebasan buih gas karbon dioksida seperti yang ditunjukkan dalam persamaan tindakbalas berikut.*

**Reaction Equation:**

***Persamaan Tindakbalas:***

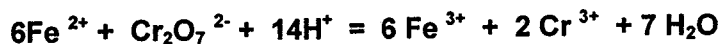


How many grams of  $\text{CaCO}_{3(s)}$  are consumed in a reaction with 225 mL of 3.25 M HCl?

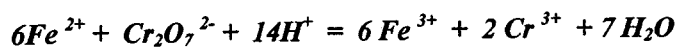
*Berapakah gram  $\text{CaCO}_{3(s)}$  yang digunakan dalam tindakbalas dengan 225 mL 3.25 M HCl ?*

(25marks/markah)

[c]  $\text{Fe}^{2+}$  and  $\text{Cr}_2\text{O}_7^{2-}$  react according to the reaction below:



*$\text{Fe}^{2+}$  dan  $\text{Cr}_2\text{O}_7^{2-}$  bertindakbalas seperti berikut:*



The equilibrium constant for the reaction is  $1.00 \times 10^{57}$ . Calculate the equilibrium concentration for Fe and Cr species if 10.0 mL solution of 0.02 M  $\text{K}_2\text{Cr}_2\text{O}_7$  in 1.14 M HCl reacts with 10.0 mL solution of 0.12 M  $\text{FeSO}_4$  in 1.14 M HCl.

*Pemalar keseimbangan bagi tindakbalas tersebut adalah  $1.00 \times 10^{57}$ . Kirakan kepekatan keseimbangan bagi spesi ferum dan kromium jika 10.0 mL larutan 0.02 M  $\text{K}_2\text{Cr}_2\text{O}_7$  dalam 1.14 M HCl bertindakbalas dengan 10.0 mL larutan 0.12 M  $\text{FeSO}_4$  dalam 1.14 M HCl.*

(40 marks/markah)

5. [a] (i) What pH is required to just precipitate iron (III) hydroxide from a 0.10 M  $\text{FeCl}_3$  solution?  
Given:  $K_{sp} [\text{Fe}(\text{OH})_3] = 4.0 \times 10^{-38}$

*Apakah pH yang diperlukan untuk memendakkan iron (III) hidroksida dari larutan 0.10 M  $\text{FeCl}_3$ ?*

*Diberikan:  $K_{sp} [\text{Fe}(\text{OH})_3] = 4.0 \times 10^{-38}$*

**Reaction Equation:**

*Persamaan Tindakbalas:*



(15 markah/marks)

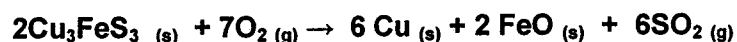
- (ii) Calculate the pH at 30 mL of titrant in the titration of 50.0 mL of 0.10 M NaOH with 0.20 M HCl.

*Kirakan pH pada penambahan 30 mL titran dalam pentitratan 50.0 mL 0.10 M NaOH dengan 0.20 M HCl.*

(15 markah/marks)

[b] Bornite ( $\text{Cu}_3\text{FeS}_3$ ) is a copper ore used in the production of copper.

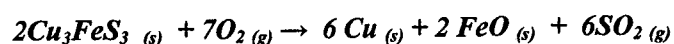
When heated, the following reaction occurs:



If 2.50 metric tons of bornite is reacted with excess oxygen and the process has an 86.3% yield of copper, how much copper is produced?

*Bornit ( $\text{Cu}_3\text{FeS}_3$ ) adalah satu bijih kuprum yang digunakan dalam penghasilan kuprum.*

*Apabila dipanaskan, tindakbalas berikut berlaku:*



*Jika 2.50 metrik ton bornit bertindakbalas dengan oksigen berlebihan dan proses hanya memberikan peratus hasil sebanyak 86.3% kuprum, berapa banyakkah kuprum yang dihasilkan?*

(30 marks/markah)

- [c] (i) The label of a stock bottle of aqueous ammonia indicates that the solution is 28.0%  $\text{NH}_3$  by mass and has a density of 0.898 g/mL. Calculate the molarity of the solution.

*Label pada botol stok akuas ammonia menunjukkan larutan tersebut mengandungi jisim peratus ammonia sebanyak 28.0% dan ketumpatan 0.898 g/mL. Kirakan kemolaran larutan tersebut.*

(20 marks/markah)

- (ii) A concentrated solution of perchloric,  $\text{HClO}_4$  is 11.7 M and has a density of 1.67 g/mL. What is the mass percent perchloric acid in this solution?

*Kemolaran satu larutan pekat perchlorik,  $\text{HClO}_4$  adalah 11.7 M dengan ketumpatan 1.67 g/mL. Apakah peratus jisim asid perklorik dalam larutan?*

(20 marks/markah)



6. [a] Draw a schematic diagram of the basic instrumental parts of an atomic absorption spectrometer. Describe briefly the technique of a flame atomic absorption spectroscopy (FAAS) and state the functions of all of its component involve in its operation. Why is a sharp line source desirable for an atomic absorption spectroscopy?

*Lukiskan gambarajah skema menunjukkan bahagian asas peralatan spektrometer penyerapan atom. Huraikan secara ringkas teknik spektroskopi penyerapan atom nyalaan (FAAS) dan nyatakan fungsi setiap komponen yang terlibat dalam operasinya. Mengapa satu sumber garis yang jelas dikehendaki bagi spektroskopi penyerapan atom?*

(40 marks/markah)

- [b] Deviations from linearity usually occur in atomic absorption spectrometry as the concentration of metallic analytes increases. Briefly explain any **three** factors or classes of interferences that may affect the ability of the instrument to read the signal?

*Sisihan dari garisan lurus biasanya berlaku dalam spektrometri penyerapan atom apabila kepekatan analit logam bertambah. Terangkan secara ringkas **tiga** faktor atau kelas gangguan yang mungkin mempengaruhi keupayaan alatan untuk membaca signal.*

(30 marks/markah)

- [c] Briefly describe Electromagnetic radiation.  
How does matter absorb radiation? Why do we "see" objects as colored?

*Terangkan secara ringkas sinaran elektromagnet.*

*Bagaimanakah jirim menyerap sinaran? Mengapakah suatu objek itu kita nampak sebagai berwarna?*

(30 marks/markah)

... 18/-

7. [a] Calcium in a sample solution is determined by atomic absorption spectrophotometry. A stock solution of calcium is prepared by dissolving 1.834 g  $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$  in water and diluting to 1 L. This is diluted to 1:10. Working solutions are prepared by diluting the second solution respectively, 1:20, 1:10 and 1:5. The sample is diluted 1:25. strontium chloride is added to all solutions before dilutions, sufficient to give 1% (wt/vol) to avoid phosphate interference. A blank is prepared, to give 1%  $\text{SrCl}_2$ . Absorbance signals on the strip chart recorder, when the solutions are aspirated into an air-acetylene flame, are as shown in Table 7.1.

**Table 7.1: Absorbance signal for Ca**

Measurements	Absorbance signal
<b>Standard solution:</b>	
S <sub>1</sub>	10.6
S <sub>2</sub>	20.1
S <sub>3</sub>	38.5
<b>Sample solution</b>	29.6
<b>Blank solution</b>	1.5

From the plot of net signal against concentration of standards, what is the concentration of calcium in the sample in parts per million?

Given: At. wt Ca = 40.08, Cl = 35.5, H = 1.0 and O = 16.0 g/mol

Kalsium dalam satu larutan sampel ditentukan oleh penyerapan atom. Satu larutan stok kalsium disediakan dengan melarutkan 1.834 g  $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$  dalam air dan mencairkan ke 1 L. Ini kemudiannya dicairkan kepada 1:10. Larutan piawai disediakan dengan mencairkan larutan kedua mengikut nisbah 1:20, 1:10 and 1:5 masing-masing. Sampel dicairkan kepada nisbah 1:25. Strontium klorida ditambahkan kepada semua larutan sebelum pencairan, cukup untuk memberikan 1% (wt/vol) untuk mengelakkan gangguan fosfat. Satu blank disediakan, untuk memberikan 1%  $\text{SrCl}_2$ . Signal penyerapan yang direkodkan apabila larutan diaspirasikan ke dalam nyalaan udara-asetilena ditunjukkan dalam **Jadual 7.1**.

**Jadual 7.1: Signal penyerapan bagi Ca**

<b>Pengukuran</b>	<b>Signal Penyerapan</b>
<b>Larutan Piawai :</b>	
$S_1$	10.6
$S_2$	20.1
$S_3$	38.5
<b>Larutan Sampel</b>	29.6
<b>Larutan Blank</b>	1.5

Dari plot signal net melawan kepekatan larutan piawai, apakah kepekatan kalsium dalam sampel dalam bahagian per juta?

Diberikan: JAR bagi Ca = 40.08, Cl = 35.5, H = 1.0 and O = 16.0 g/mol

(50 marks/markah)

- [b] Write the complete form of Beer-Lambert equations and define percent transmittance, absorptivity and molar absorptivity.

*Tuliskan bentuk-bentuk persamaan Beer-Lambert yang lengkap dan takrifkan peratus transmittan, absorptiviti dan molar absorptiviti.*

(20 marks/markah)

- [c] (i) A compound of formula weight 280 absorbed 65.0% of the radiation at a certain wavelength in a 2-cm cell at a concentration of 15.0  $\mu\text{g/mL}$ . Calculate its molar absorptivity at this wavelength.

*Satu sebatian dengan berat formula 280 menyerap 65.0% dari sinaran pada satu jarak gelombang dalam satu sel 2-cm pada kepekatan 15.0  $\mu\text{g/mL}$ . Kirakan absorptiviti molarnya pada jarak gelombang tersebut.*

(15 marks/markah)

- (ii) A solution containing 1.00 mg ion (as the thiocyanate complex) in 100 mL was observed to transmit 70.0 % of the incident light compared to an appropriate blank. What is the absorbance of the solution at this wavelength?

*Satu larutan yang mengandungi 1.00 mg ion (sebagai kompleks tiosianat) dalam 100 mL diperhatikan memberikan peratus transmittan sebanyak 70.0 % dari sinaran yang masuk berbanding kepada blank. Apakah penyerapan larutan pada jarak gelombang ini?*

(15 marks/markah)

**APPENDIX**  
**LAMPIRAN**

**Table 1A / Jadual 1A**  
Values of t for  $\nu$  Degrees of Freedom for Various Confidence Levels  
*Nilai-nilai t bagi darjah kebebasan  $\nu$  pada pelbagai paras keyakinan*

$\nu$	Confidence Level			
	90%	95%	99%	99.5%
1	6.314	12.706	63.657	127.32
2	2.920	4.303	9.925	14.089
3	2.353	3.182	5.841	7.453
4	2.132	2.776	4.604	5.598
5	2.015	2.571	4.032	4.773
6	1.943	2.447	3.707	4.317
7	1.895	2.365	3.500	4.029
8	1.860	2.306	3.355	3.832
9	1.833	2.262	3.250	3.690
10	1.812	2.228	3.169	3.581
15	1.753	2.131	2.947	3.252
20	1.725	2.086	2.845	3.153
25	1.708	2.060	2.787	3.078
$\infty$	1.645	1.960	2.576	2.807

<sup>a</sup> $\nu = N - 1 =$  degrees of freedom.

**Table 1A / Jadual 1A**  
Values of F at the 95% Confidence Level  
*Nilai-nilai F pada paras keyakinan 95%*

	$\nu_1 = 2$	3	4	5	6	7	8	9	10	15	20	30
$\nu_2 = 2$	19.0	19.2	19.2	19.3	19.3	19.4	19.4	19.4	19.4	19.4	19.4	19.5
3	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.70	8.66	8.62
4	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.86	5.80	5.75
5	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.62	4.56	4.50
6	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	3.94	3.87	3.81
7	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.51	3.44	3.38
8	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.22	3.15	3.08
9	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.01	2.94	2.86
10	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.85	2.77	2.70
15	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.40	2.33	2.25
20	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.20	2.12	2.04
30	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16	2.01	1.93	1.84