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UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2010/2011

KTT 111 – Inorganic Chemistry I
[Kimia Takorganik I]

Duration : 3 hours
[Masa : 3 jam]

Please check that this examination paper consists of THIRTY THREE pages of printed material before you begin the examination.

Instructions:

Section A: (40 marks) comprising 40 multiple-choice questions (MCQ), has to be answered within the first hour of the examination on the OMR answer sheet provided. The completed OMR answer sheet will be collected 1 hour after the commencement of the examination.

Section B: (60 marks) consists of essay-type questions. Answer any **THREE** (3) questions. If a candidate answer more than three question only the first three questions in the answer sheet will be graded.

Answers each question on a new page.

You may answer the questions either in Bahasa Malaysia or in English.

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

Appendix: Table of relative atomic mass and physical constants.

SECTION B (60 marks) **[TIME: 2 HOURS]**

This section contains FIVE questions.

Answer any THREE questions.
Only the first THREE questions answered in the answer book will be marked. Supporting data constants needed for the questions are included on the last page.
You must start each question on a new page.

1. (a) Police officers confiscate a packet of white powder that they believe to be heroin. A 38.70 mg of the powder was used for combustion analysis. This sample gave 97.46 mg of CO_2 and 20.81 mg of H_2O on complete combustion. A second sample was analyzed for its nitrogen content, and was found to contain 3.8 % of N.

   i. What is the empirical formula of heroin?

   ii. If the molecular mass of heroin was 368 g mol^{-1}, determine the molecular formula of heroin.

   iii. Name one modern method that could have been used to determine the molecular mass of heroin.

   (9 marks)

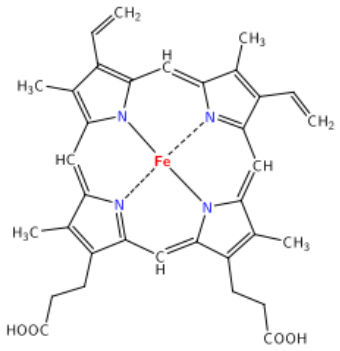
   (b) A copper bar with mass of 12.340 g was dipped into 255 mL solution of 0.125 M $AgNO_3$ solution.

   i. What will be the mass of the unreacted copper that remains after the reaction is complete?

   ii. If all the silver that forms adheres to the copper bar, what will be the mass of the copper bar after the reaction?

   (8 marks)

(c) In most humans, the hemoglobin molecule is an assembly of four globular protein subunits. Each subunit is composed of a protein chain tightly associated with a non-protein heme group. There is one atom of iron in each molecule of the heme group. The mass percentage of iron in a heme molecule is 9.07 %. Calculate the molar mass of the heme unit.



Heme group of a globular subunit of hemoglobin

(3 marks)

2. (a) The ionization energy of lithium atoms in the gas phase is about half as large as the ionization energy of beryllium atoms in the gas phase. In contrast, the ionization energy of Li^+ is about four times larger than the ionization energy of Be^+. Explain the difference between the atoms and the ions.

(5 marks)

(b) The human eye can detect as little as 2.35×10^{-18} J of green light with a wavelength of 510 nm. Calculate the minimum number of photons of green light that can be detected by the human eye.

(4 marks)

(c) Explain why the electron affinity of Br is a negative value while it is positive for Kr.

(4 marks)

(d) Bohr gave the formula for the radius of the electron's orbit as

$$r_n = \frac{n^2 h^2 \varepsilon_0}{\pi m_e e^2}$$

where m_e is the electron mass, e is the charge, and ε_0 is a constant related to charge attraction in a vacuum. Given that $m_e = 9.109 \times 10^{-31}$ kg, $e = 1.602 \times 10^{-19}$ C, and $\varepsilon_0 = 8.854 \times 10^{-12}$ C^2 $J^{-1}m^{-1}$, calculate the following:

i. The radius of the 1st orbit for H atom.

ii. The energy difference between the 10th and the 1st orbit in the H atom.
Given that $E_n = -\frac{A}{n^2}$ J, where $A = 2.18 \times 10^{-18}$ J.

(7 marks)

3. (a) Technitium-99m is a metastable nuclide used in numerous cancer diagnostic and treatment programs. It is prepared just before use because it decays rapidly through γ emission:

$$^{99m}Tc \rightarrow {}^{99}Tc + \gamma$$

The decay data for Tc-99m was obtained as follows:

Time (h)	γ (photons s^{-1})
0	5000
4	3150
8	2000
12	1250
16	788
20	495

Using the above data in an appropriate manner, determine

i. the half-life of ^{99m}Tc and

ii. the percentage of the isotope that is lost if it takes 2.5 h to prepare and administer the dose.

(12 marks)

(b) $^{237}_{93}Np$ is the parent nuclide of a decay series that starts with α emission, followed by β^- emission, and then two more α emissions. Write balanced nuclear equations for each step.

(4 marks)

(c) A bone sample containing strontium-90 emits 6.93×10^4 β^- particles per month. How long will it take for the emission to decrease to 1.0×10^4 particles per month? ($t_{½}$ for ^{90}Sr = 29 yr). Give your answer to the nearest year.

(4 marks)

4. (a) State the principles of Valence Shell Electron Pair Repulsion (VSEPR) and Valence Bond (VB) theories.

(4 marks)

(b) Using NH_3 and SF_6 as examples, elborate how VSEPR and VB theories explain their moleculars shapes.

(8 marks)

(c) Draw a fully labelled molecular orbital (MO) energy level diagram for HF and BeO molecules.

(6 marks)

(d) Why is the *s* orbital (and the electrons) of F not represented in the MO energy level diagram of HF?

(2 marks)

5. PCl_3 and $AlCl_3$ are chlorides of the main group that have applications in industry. For example, PCl_3 is used as chlorinating agent while $AlCl_3$ is used in Friedel-Craft reaction. In gaseous phase, PCl_3 exists as a monomer whereas $AlCl_3$ exists as a dimer. In the gaseous phase, a mixture of PCl_3 and $AlCl_3$ formed an addition compound (adduct).

(a) Give Lewis formula for PCl_3, $AlCl_3$, dimer of $AlCl_3$ and the adduct. Describe briefly the weakness of Lewis formula in reflecting the true structure of these compounds.

(8 marks)

(b) Explain why in the gaseous phase, PCl_3 exists as a monomer whereas $AlCl_3$ exists as a dimer?

(6 marks)

(c) Write a balanced equation for the formation of dimer of $AlCl_3$ and the adduct between PCl_3 and $AlCl_3$ and compare the bonding between the two.

(6 marks)

BAHAGIAN B (60 markah) **[MASA: 2 JAM]**

Bahagian ini mengandungi LIMA soalan.

Jawab sebarang TIGA soalan
Hanya TIGA jawapan yang pertama akan diperiksa. Data pemalar fizikal disertakan dalam Lampiran.
Jawab setiap soalan pada muka surat yang baru.

1. (a) Pegawai polis telah merampas suatu paket serbuk putih yang dipercayai heroin. 38.70 mg serbuk tersebut telah digunakan untuk analisis pembakaran. Sampel ini telah menghasilkan 97.46 mg CO_2 dan 20.81 mg H_2O setelah pembakaran lengkap. Satu sampel lain telah dianalisis bagi penetuan peratus kandungan nitrogen dan didapati mengandungi 3.8 % N.

   i. Tentukan formula empiris bagi heroin.

   ii. Jika jisim molekul heroin ialah 368 g mol^{-1}, maka tentukan formula molekulnya.

   iii. Namakan suatu alat moden yang mungkin telah diguna untuk menentukan jisim molekul heroin.

   (9 markah)

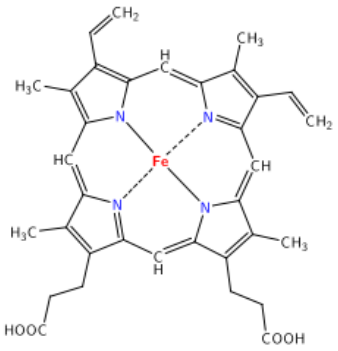
   (b) Sebatang kuprum berjisim 12.340 g telah dimasukkan ke dalam 255 mL larutan 0.125 M $AgNO_3$.

   i. Apakah jisim kuprum yang tertinggal selepas tindak balas selesai?

   ii. Jika semua argentum yang terbentuk terlekat pada batang kuprum tersebut, apakah jisim batang kuprum selepas tindak balas selesai?

   (8 markah)

(c) Di dalam manusia, molekul hemoglobin terdiri dari empat subunit protein globul. Setiap subunit rantai protein diikat kepada kumpulan heme ia itu bahagian bukan protein. Terdapat satu atom ferum di dalam setiap molekul heme. Peratus jisim ferum di dalam molekul heme ialah 9.07 %. Kira jisim molar heme tersebut.



Kumpulan heme daripada subunit globul hemoglobin

(3 markah)

2. (a) Tenaga pengionan atom litium dalam fasa gas adalah hanya setengah tenaga pengionan atom berilium dalam fasa gas. Pada hal tenaga pengionan Li^+ adalah empat kali lebih besar daripada tenaga pengionan Be^+. Terangkan perbezaan di antara atom dan ion kedua unsur tersebut.

(5 markah)

(b) Mata manusia boleh mengesan cahaya hijau dengan tenaga serendah 2.35 x 10^{-18} J yang mempunyai jarak gelombang 510 nm. Kira bilangan foton cahaya hijau yang minimum yang boleh dikesan oleh mata manusia.

(4 markah)

(c) Terangkan mengapa afiniti elektron Br adalah negatif sedangkan bagi Kr ianya adalah positif.

(4 markah)

(d) Bohr telah memberi formula bagi jejari orbit elektron sebagai

$$r_n = \frac{n^2 h^2 \varepsilon_0}{\pi m_e e^2}$$

dengan m_e ialah jisim elektron, e ialah cas, dan ε_0 ialah satu pemalar berkait dengan penarikan cas dalam vakum. Diberi $m_e = 9.109 \times 10^{-31}$ kg, $e = 1.602 \times 10^{-19}$ C, dan $\varepsilon_0 = 8.854 \times 10^{-12}$ $C^2 J^{-1} m^{-1}$, kiralah:

(i) Jejari pertama atom H.
(ii) Tenaga di antara orbit pertama dan orbit ke sepuluh atom H. Diberi $E_n = -\frac{A}{n^2}$ J, di mana $A = 2.18 \times 10^{-18}$ J.

(7 markah)

3. (a) Teknitium-99m ialah nuklida meta stabil yang digunakan dalam program pengubatan dan diagnostik kanser. Ia hanya disediakan bila perlu oleh kerana ia akan cepat menyusut melalui pemancaran γ:

$$^{99m}Tc \rightarrow {}^{99}Tc + \gamma$$

Data penyusutan Tc-99m telah diperoleh seperti berikut:

Masa (j)	γ (foton s^{-1})
1	5000
5	3150
9	2000
13	1250
17	788
20	495

Dengan menggunakan data di atas dengan cara yang sesuai, tentukan

i. masa setengah hayat ^{99m}Tc dan

ii. peratus isotop yang hilang jika ia mengambil masa 2.5 j untuk menyediakan dan memberikan dos.

(12 markah)

(b) Nuklida $^{237}_{93}Np$ ialah ibu suatu siri penyusutan yang bermula dengan pemancaran α, ini diikuti dengan pemancaran β^-, dan kemudian diikuti dengan dua lagi pemancaran α. Tulis persamaan tindak balas nuklear bagi setiap langkah penyusutan yang berlaku.

(4 markah)

(c) Suatu sampel tulang mengandungi strontium-90 memancarkan 6.93×10^4 zarah β^- setiap bulan. Berapa lama akan diambil supaya pemancaran akan berkurang kepada 1.0×10^4 zarah setiap bulan? ($t_{½}$ bagi ^{90}Sr = 29 tahun). Berikan jawapan ke tahun yang paling hampir.

(4 markah)

4. (a) Nyatakan prinsip teori Penolakan Pasangan Elektron Petala Valens (VSEPR) dan teori Ikatan Valens (VB).

(4 markah)

(b) Dengan menggunakan sebatian NH_3 dan SF_3 sebagai contoh, jelaskan bagaimana teori VSEPR dan teori VB menerangkan struktur sebenar sebatian tersebut.

(8 markah)

(c) Lukis rajah aras tenaga orbital molekul berlabel bagi molekul HF dan BeO.

(6 markah)

(d) Kenapa orbital (dan elektron) *s* atom F tidak terlibat dalam rajah aras tenaga orbital molekul HF?

(2 markah)

5. PCl_3 dan $AlCl_3$ adalah klorida kumpulan utama yang mempunyai penggunaan dalam industri. Contoh: PCl_3 digunakan sebagai agen pengklorinan manakala $AlCl_3$ digunakan dalam tindak balas Friedel-Craft. Dalam fasa gas, PCl_3 wujud sebagai monomer manakala $AlCl_3$ wujud sebagai dimer. Dalam fasa gas, suatu campuran PCl_3 and $AlCl_3$ membentuk sebatian tambah (aduk).

(a) Berikan formula Lewis bagi PCl_3, $AlCl_3$, dimer $AlCl_3$ dan aduk. Jelaskan secara ringkas kelemahan formula Lewis dalam mencerminkan struktur sebenar sebatian tersebut.

(8 markah)

(b) Terangkan mengapa dalam fasa gas, PCl_3 wujud sebagai monomer manakala $AlCl_3$ wujud sebagai dimer?

(6 markah)

(c) Tuliskan persamaan berimbang bagi pembentukan dimer $AlCl_3$ dan aduk diantara PCl_3 dan $AlCl_3$ dan bandingkan pengikatan antara keduanya.

(6 markah)

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