INDEX NO: ……....

UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2008/09

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.

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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. An organic compound contains carbon, hydrogen and sulfur. A sample of this compound with a mass of 1.045 g was burned in oxygen to give gaseous CO_2, H_2O and SO_2. These gases were bubbled through 500.0 mL of an acidified 0.0200 M $KMnO_4$ solution (large excess) which caused the SO_2 to be oxidized to SO_4^{2-} and the MnO_4^- was reduced to Mn^{2+}. The resulting solution was labeled as **A**. Next, a 50.0 mL of 0.0300 M $SnCl_2$ was added to a 50.0 mL solution of **A**. There was enough $SnCl_2$ to reduce all the MnO_4^- to Mn^{2+}. The excess Sn^{2+} that remained after the reaction was titrated with 0.0100 M $KMnO_4$ which required 27.28 mL for complete reaction.

   (i) Write all the chemical reactions that take place in the solution phase in the above analysis.
   (ii) Calculate the percentage of sulfur in the original sample of the organic compound.

   (20 marks)

2. (a) The synthetic isotope technetium-99 , which decays by beta emission, is the most widely used isotope in nuclear medicine. The following data were collected on a sample of ^{99}Tc at 300 K.

Time (h)	Disintegration per minute
0.0	180
2.5	130
5.0	104
7.5	77
10.0	59
12.5	46
17.5	24

Using a graph, determine

(i) the rate constant for the decay,

(ii) the half life of the ^{99}Tc.

(iii) If 5.00 mg of a ^{99}Tc containing drug was injected into an animal which weighs 125 kg, what percentage of the ^{99}Tc compound is still present after 3 days?

(iv) If the experimental data were collected at 450 K, by how much will the rate constant change?

(12 marks)

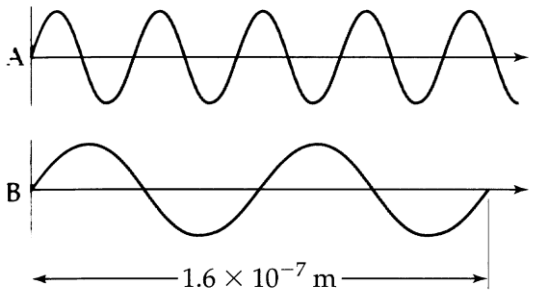
(b) A copper bar with mass of 12.340 g was dipped into 255 mL solution of 0.125 M $AgNO_3$ solution.

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

(ii) If all the silver that forms adhere to the copper bar, what will be the mass of the copper bar after the reaction?

(8 marks)

3. (a) Two electromagnetic waves are shown below:



(i) What is the wavelength and frequency of A?

(ii) What is the wavelength and frequency of B?

(iii) The C ≡ O has an average bond enthalpy of 1072 kJ mol^{-1}. Will the electromagnetic radiation B have enough energy to break this bond?

(6 marks)

(b) The table below shows the variation of atomic radii of Group 3 and 4 elements:

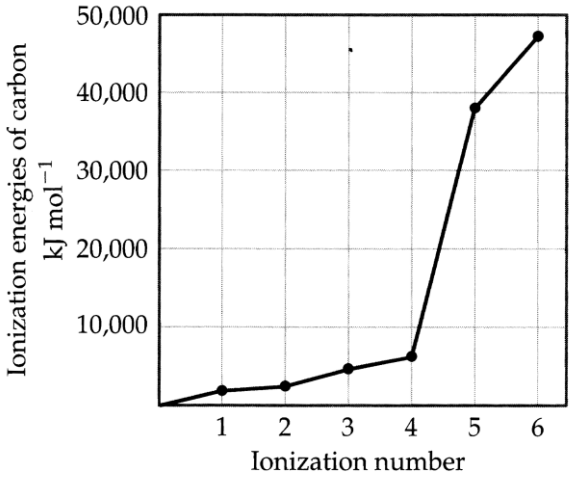
Atomic Radii (Å)			
Sc	1.44	Ti	1.36
Y	1.62	Zr	1.48
La	1.69	Hf	1.50

(i) What do you observe between the two groups?

(ii) Give an explanation for your observation above.

(4 Marks)

(c) The graph below shows the ionization energy of carbon.



(i) Write the chemical equations representing each ionization step shown in the graph.

(ii) Explain why the 5^{th} ionization energy is very high compared to the 4^{th}.

(5 marks)

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

(5 marks)

4. (a) Name the types of crystals and describe briefly the nature of their lattice sites.

(4 marks)

(b) The heat of formation of $CaCl_2$ and $CaBr_2$ are 795 and 683 kJ mol^{-1} respectively. Draw and label a Born-Haber cycle for the formation of $CaCl_2(s)$ from the respective elements at the standard states. Calculate the lattice energy of $CaCl_2(s)$ and $CaBr_2(s)$. Comment briefly on the relative stability and ease of formation of $CaCl_2(s)$ and $CaBr_2(s)$ based on these lattice energies. [Relevant energy data is given in Table 1]

(10 marks)

Table 1

Calcium	
Ionization Energy: 1st	1146 kJ mol^{-1}
2nd	590 kJ mol^{-1}
3rd	4912 kJ mol^{-1}
Heat of Sublimation	192 kJ mol^{-1}
Chlorine	
Electron Affinity	350 kJ mol^{-1}
Bond Energy	242 kJ mol^{-1}
Heat of Vaporization	10 kJ mol^{-1}
Bromine	
Electron Affinity	331 kJ mol^{-1}
Bond Energy	192 kJ mol^{-1}
Heat of Vaporization	31 kJ mol^{-1}

(c) Describe the following in terms of the bonding theory:

(i) electron domain

(ii) orbital hybridization

(iii) anti-bonding orbital

(6 marks)

5. (a) Explain how Valence Shell Electron Pair Repulsion (VSEPR) and Valence Bond (VB) bonding theories accommodate the five basic geometrical shapes of molecules.

(9 marks)

(b) State the observed and the basic geometrical shapes for the following molecules and ion; H_2S, CCl_3Br, $AsCl_3$ and $[PF_4]^-$.

(4 marks)

(c) Construct and label the molecular orbital energy diagram and calculate the net bond order of the following diatomic molecules/species; HF, B_2^- and O_2^+. Comment on their existence and stability.

(7 marks)

Terjemahan

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

Bahagian ini mengandungin LIMA soalan.

Jawab sebarang TIGA soalan
Hanya TIGA jawapan yang pertama akan diperiksa. Data Pemalar Fizikal disertakan dalam Lampiran.
Jawab tiap-tiap soalan pada muka surat yang baru.

1. Suatu sebatian organik mengandungi karbon, hidrogen dan sulfur. Satu sampel sebatian ini seberat 1.045 g telah dibakar di dalam oksigen untuk menghasilkan gas CO_2, H_2O dan SO_2. Gas-gas ini dialirkan ke dalam 500.0 mL larutan 0.0200 M $KMnO_4$ berasid (berlebihan) yang mengakibatkan gas SO_2 dioksidakan kepada SO_4^{2-} dan MnO_4^- telah diturunkan kepada Mn^{2+}. Larutan yang terhasil dilabel sebagai **A**. Selanjutnya, 50.0 mL 0.0300 M $SnCl_2$ telah ditambah ke dalam 50.0 mL larutan **A**. Terdapat cukup $SnCl_2$ untuk menurunkan semua MnO_4^- kepada Mn^{2+}. Berlebihan ion Sn^{2+} yang tinggal selepas tindak balas telah dititratkan dengan 0.0100 M $KMnO_4$ yang memerlukan 27.28 mL untuk tindak balas lengkap.

   (i) Tulis semua persamaan tindak balas yang berlaku di dalam fasa cecair di dalam analisis ini.
   (ii) Kira peratus sulfur di dalam sampel organik asal.

   (20 markah)

2. (a) Isotop sintesis teknetium-99, yang menyusut melalui pemancaran beta, merupakan isotop yang paling luas diguna sebagai rawatan nuklear. Data berikut telah diperoleh untuk satu sampel ^{99}Tc pada 300 K.

Masa (h)	Penyusutan se minit
0.0	180
2.5	130
5.0	104
7.5	77
10.0	59
12.5	46
17.5	24

Dengan menggunakan graf tentukan

(iv) Pemalar kadar bagi penyusutan ini,

(v) masa setengah-hayat bagi ^{99}Tc.

(vi) Jika 5.00 mg satu sebatian yang mengandungi ^{99}Tc disuntik ke dalam satu binatang 125 kg, berapa peratus sebatian ^{99}Tc tersebut yang akan tinggal di dalam badan binatang tersebut selepas 3 hari?

(iv) Jika data di atas diperoleh pada suhu 450 K, berapa banyak pemalar kadar akan berubah?

(12 markah)

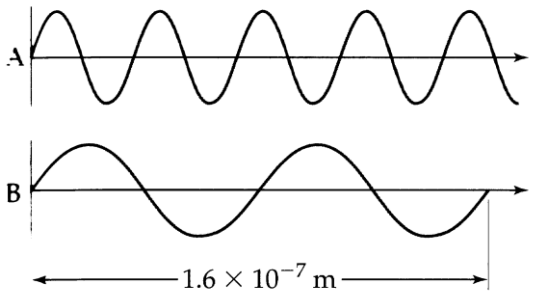
(b) Sebatang kuprum berjisim 12.340 g telah direndam ke dalam 255 mL larutan $AgNO_3$ berkepekatan 0.125 M.

(i) Berapakah jisim kuprum yang tinggal tidak bertindak balas selepas tindak balas selesai?

(ii) Jika semua argentum yang terhasil itu terlekat kepada batang kuprum, berapakah jisim batang kuprum tersebut selepas tindak balas selesai?

(8 markah)

3. (a) Dua gelombang elektromagnet ditunjuk di bawah.



(iv) Apakah jarak gelombang dan frekuensi bagi sinaran A?

(v) Apakah jarak gelombang dan frekuensi bagi sinaran B?

(vi) Ikatan C ≡ O mempunyai tenaga entalpi purata 1072 kJ mol^{-1}.

(vii) Adakah sinaran B mempunyai tenaga yang cukup untuk memecahkan ikatan ini?

(6 markah)

(c) Jadual di bawah menunjukkan perubahan jejari atom di dalam Kumpulan 3 dan 4:

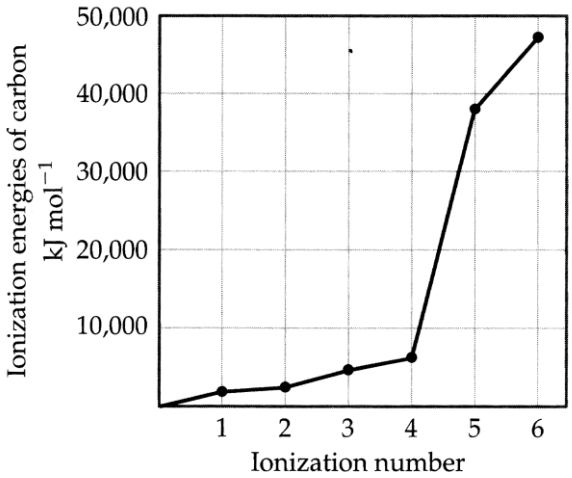
Jejari atom (Å)			
Sc	1.44	Ti	1.36
Y	1.62	Zr	1.48
La	1.69	Hf	1.50

(iii) Apakah yang boleh diperhatikan di antara dua kumpulan di atas?

(iv) Berikan penjelasan bagi pemerhatian di atas.

(4 markah)

(c) Graf di bawah menunjukkan tenaga pengionan karbon.



(i) Tulis semua persamaan kimia yang mewakili setiap langkah pengionan yang ditunjuk di dalam graf.

(ii) Terangkan mengapa tenaga pengionan ke 5 lebih tinggi daripada tenaga pengionan yang ke 4.

(5 markah)

(d) Terangkan mengapa afiniti elektron bagi bromin bernilai negatif tetapi bagi Kr ia adalah positif.

(5 markah)

4. (a) Namakan jenis-jenis kristal dan terangkan secara ringkas keadaan tapak kekisinya.

(4 markah)

(b) Haba pembentukan bagi $CaCl_2$ and $CaBr_2$ masing-masing adalah 795 dan 683 kJ mol^{-1}. Lukis dan label satu kitaran Born-Haber bagi pembentukan $CaCl_2(p)$ daripada masing-masing unsur pada keadaan piawai. Kira tenaga kekisi bagi $CaCl_2(p)$ dan $CaBr_2(p)$. Berdasarkan kepada tenaga kekisinya, berikan komen ringkas mengenai kestabilan relatif dan mudah bentuk bagi $CaCl_2(p)$ dan $CaBr_2(p)$. [Data tenaga bersabit seperti dalam Jadual 1]

(10 markah)

Jadual 1

Kalsium	
Tenaga Pengionan: 1st	1146 kJ mol^{-1}
2nd	590 kJ mol^{-1}
3rd	4912 kJ mol^{-1}
Haba Pemejalwapan	192 kJ mol^{-1}
Klorin	
Afiniti Elektron	350 kJ mol^{-1}
Tenaga Ikatan	242 kJ mol^{-1}
Haba Pengwapan	10 kJ mol^{-1}
Bromin	
Afiniti Elektron	331 kJ mol^{-1}
Tenaga Ikatan	192 kJ mol^{-1}
Haba Pengwapan	31 kJ mol^{-1}

(c) Terangkan yang berikut dari segi teori ikatan:

(i) domain electron

(ii) penghibridan orbital

(iii) orbital anti-ikatan

(6 markah)

5. (a) Huraikan bagaimana teori ikatan Penolakan Pasangan Elektron Petala Valens dan teori Ikatan Valens menerangkan lima geometri asas molekul.

(9 markah)

(b) Nyatakan bentuk-bentuk sebenar dan geometri asas bagi molekul dan ion berikut; H_2S, CCl_3Br, $AsCl_3$ dan $[PF_4]^-$.

(4 markah)

(c) Bina dan label rajah tenaga orbital molekul dan kira tertib ikatan bagi molekul diatom/spesies berikut; HF, B_2^- and O_2^+**.** Bincangkan mengenai kewujudan dan kestabilannya.

(7 markah)

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APPENDIX:

Table of relative atomic mass and physical constants

Symbol	Name	Atomic Wt		Symbol	Name	Atomic Wt
Ac	Actinium	[227]		**Mo**	Molybdenum	95.94(2)
Al	Aluminium	26.981538(2)		**Nd**	Neodymium	144.24(3)
Am	Americium	[243]		**Ne**	Neon	20.1797(6)
Sb	Antimony	121.760(1)		**Np**	Neptunium	[237]
Ar	Argon	39.948(1)		**Ni**	Nickel	58.6934(2)
As	Arsenic	74.92160(2)		**Nb**	Niobium	92.90638(2)
At	Astatine	[210]		**N**	Nitrogen	14.0067(2)
Ba	Barium	137.327(7)		**No**	Nobelium	[259]
Bk	Berkelium	[247]		**Os**	Osmium	190.23(3)
Be	Beryllium	9.012182(3)		**O**	Oxygen	15.9994(3)
Bi	Bismuth	208.98038(2)		**Pd**	Palladium	106.42(1)
Bh	Bohrium	[264]		**P**	Phosphorus	30.973761(2)
B	Boron	10.811(7)		**Pt**	Platinum	195.078(2)
Br	Bromine	79.904(1)		**Pu**	Plutonium	[244]
Cd	Cadmium	112.411(8)		**Po**	Polonium	[209]
Cs	Caesium	132.90545(2)		**K**	Potassium	39.0983(1)
Ca	Calcium	40.078(4)		**Pr**	Praseodymium	140.90765(2)
Cf	Californium	[251]		**Pm**	Promethium	[145]
C	Carbon	12.0107(8)		**Pa**	Protactinium	231.03588(2)
Ce	Cerium	140.116(1)		**Ra**	Radium	[226]
Cl	Chlorine	35.453(2)		**Rn**	Radon	[222]
Cr	Chromium	51.9961(6)		**Re**	Rhenium	186.207(1)
Co	Cobalt	58.933200(9)		**Rh**	Rhodium	102.90550(2)
Cu	Copper	63.546(3)		**Rb**	Rubidium	85.4678(3)
Cm	Curium	[247]		**Ru**	Ruthenium	101.07(2)
Db	Dubnium	[262]		**Rf**	Rutherfordium	[261]
Dy	Dysprosium	162.500(1)		**Sm**	Samarium	150.36(3)
Es	Einsteinium	[252]		**Sc**	Scandium	44.955910(8)
Er	Erbium	167.259(3)		**Sg**	Seaborgium	[266]
Eu	Europium	151.964(1)		**Se**	Selenium	78.96(3)
Fm	Fermium	[257]		**Si**	Silicon	28.0855(3)
F	Fluorine	18.9984032(5)		**Ag**	Silver	107.8682(2)
Fr	Francium	[223]		**Na**	Sodium	22.989770(2)
Gd	Gadolinium	157.25(3)		**Sr**	Strontium	87.62(1)
Ga	Gallium	69.723(1)		**S**	Sulfur	32.065(5)
Ge	Germanium	72.64(1)		**Ta**	Tantalum	180.9479(1)
Au	Gold	196.96655(2)		**Tc**	Technetium	[98]
Hf	Hafnium	178.49(2)		**Te**	Tellurium	127.60(3)
Hs	Hassium	[277]		**Tb**	Terbium	158.92534(2)
He	Helium	4.002602(2)		**Tl**	Thallium	204.3833(2)
Ho	Holmium	164.93032(2)		**Th**	Thorium	232.0381(1)
H	Hydrogen	1.00794(7)		**Tm**	Thulium	168.93421(2)
In	Indium	114.818(3)		**Sn**	Tin	118.710(7)

I	Iodine	126.90447(3)		**Ti**	Titanium	47.867(1)
Ir	Iridium	192.217(3)		**W**	Tungsten	183.84(1)
Fe	Iron	55.845(2)		**Uub**	Ununbium	[285]
Kr	Krypton	83.798(2)		**Uuh**	Ununhexium	
La	Lanthanum	138.9055(2)		**Uun**	Ununnilium	[281]
Lr	Lawrencium	[262]		**Uuo**	Ununoctium	
Pb	Lead	207.2(1)		**Uuq**	Ununquadium	[289]
Li	Lithium	[6.941(2)]		**Uuu**	Unununium	[272]
Lu	Lutetium	174.967(1)		**U**	Uranium	238.02891(3)
Mg	Magnesium	24.3050(6)		**V**	Vanadium	50.9415(1)
Mn	Manganese	54.938049(9)		**Xe**	Xenon	131.293(6)
Mt	Meitnerium	[268]		**Yb**	Ytterbium	173.04(3)
Md	Mendelevium	[258]		**Y**	Yttrium	88.90585(2)
Hg	Mercury	200.59(2)		**Zn**	Zinc	65.409(4)
				Zr	Zirconium	91.224(2)

Physical constants:

1 amu = 1.6606×10^{-24} g N_A = 6.022×10^{23} particles mol^{-1} R = 0.08206 L atm mol^{-1} K^{-1} = 1.987 cal mol^{-1} K^{-1} = 8.3145 J mol^{-1} K^{-1} = 8.3145 kPa dm^3 mol^{-1} K^{-1} h = 6.6262×10^{-34} J s. = 6.6262×10^{-27} erg s. c = 2.9979×10^{8} m s^{-1}. e = 1.60219×10^{-19} coulomb	1 electron volt = 1.6022×10^{-19} J = 96.485 kJ mol^{-1}. π = 3.1416 R_H = 1.0968×10^{5} cm^{-1} (Rydberg constant)