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UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2011/2012

January 2012

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]**

Answer any **THREE** (3) questions.

1. (a) When fish decay, one of the many chemical compounds formed is cadaverine which has a strong odor of decaying fish. Cadaverine consists of carbon, hydrogen and nitrogen only. When a sample of 0.03560 g of cadaverine is burned completely in excess oxygen it produces 0.07665 g of CO_2 and 0.04392 g H_2O. Mass spectrometry indicates that cadaverine has a molar mass of 102.2 g mol^{-1}.

(i) What is the empirical formula of cadaverine?

(ii) What is its molecular formula?

(6 marks)

(b) A copper bar with a mass of 12.3 g was dipped into V mL of T mol L^{-1} $AgNO_3$ solution. If the relative atomic mass of Cu and Ag are represented by W_{Cu} and W_{Ag},

(i) derive an expression in terms of V, T and W_{Cu} for 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, derive an expression for the mass of the copper bar after the reaction.

(12 marks)

(c) Three students were asked to prepare nickel sulphate by the reaction of a nickel compound with a sulphate compound in water and then evaporate off the water. The three students chose the following pairs of reactants:

Student 1	$Ni(OH)_2$ and H_2SO_4
Student 2	$Ni(NO_3)_2$ and Na_2SO_4
Student 3	$NiCO_3$ and H_2SO_4

From your experience, state which of the student(s) will be successful and why.

(2 marks)

2. (a) X-rays have been routinely used to project images of human body. Recently a more superior technique called magnetic resonance imaging (MRI) has been developed which uses proton spin to image the human tissue in spectacular detail. In MRI, the spinning hydrogen nuclei in an organic material are irradiated with photons that contain enough energy to flip the proton to the opposite orientation.

(i) If 33.121 kJ mol^{-1} of energy is required to flip a proton, what is the resonance frequency required to produce an MRI spectrum?

(ii) Suggest why this frequency of electromagnetic radiation would be preferred over X-rays.

(5 marks)

(b) The energy levels of a particle trapped in a one-dimensional harmonic well is given by,

$$E_n = (n + ½)\hbar\omega$$

Where $\hbar = h/2\pi$.

(i) Calculate the value of ω, given that light of frequency $\upsilon = 10^4$ Hz is required to excite the particle from n = 0 level to n = 1. Give the correct unit of ω.

(ii) Comparing the energy equation above with the energy equation derived by Bohr for the hydrogen atom, state one main difference between them.

(7 marks)

(c) Use the Rydberg equation to calculate the wavelength in nanometers of the spectral line of hydrogen for which $n_2 = 6$ and $n_1 = 3$. Would you be able to see the light corresponding to this spectral line?

(3 marks)

(d) The ionization energy of H is 13.6 eV. With only this information and without referring to any of the given physical constants, calculate the difference in energy between n = 1 and n = 5 levels in the hydrogen atom.

(5 marks)

3. (a) An unidentified corpse was discovered on 21 April at 7:00 AM. The pathologist discovered that there were 1.24×10^{37} atoms of $^{32}_{15}P$ remaining in the victim's bones and placed the time of death sometime on 15 March. The half life of $^{32}_{15}P$ is 14.28 days. How many atoms of $^{32}_{15}P$ were present in the bones at the time of death?

(5 marks)

(b) ^{214}Bi decays to isotope **A** by alpha emission. **A** then decays to **B** by beta emission, which decays to **C** by another beta emission. Element **C** decays to **D** by still another beta emission, and **D** decays to **E** by alpha emission. Identify all the elements and isotopes from **A** to **E** by their proper symbols and write the nuclear transformation that result in their production.

(10 marks)

(c) A small amount of the radioactive $^{24}NaBr$ was dissolved in hot concentrated solution of sodium bromide containing the non-radioactive isotope sodium – 23. The solution is cooled, and sodium bromide precipitates out. Explain using basic chemical principles and appropriate chemical equations, whether the sodium bromide precipitate will be radioactive.

(5 marks)

4. (a) Draw the Lewis structure for PCl_3, PCl_5 and $OPCl_3$.

(3 marks)

(b) Explain the concept of electron domains in the Valance Shell Electron Pair Repulsion (VSEPR) theory. Using the VSEPR theory, describe the shape of PCl_3, PCl_5 and $OPCl_3$.

(9 marks)

(c) Among the chlorides in (a) above, which is/are capable of forming addition compound(s)? Explain your answer and give appropriate example.

(8 marks)

5. (a) The molecular orbital (M.O.) arrangement in ascending energy for CO is

$\sigma 1s$, $\sigma^* 1s$, $\sigma 2s$, $\sigma^* 2s$, $\{\pi 2p_y, \pi 2p_z\}$, $\sigma 2p_x$, $\{\pi^* 2p_y, \pi^* 2p_z\}$, $\sigma^* 2p_x$

(i) Draw a filled M.O. energy diagram for CO molecule.

(ii) Based on the M. O. theory, calculate the bond order of each member of the following isoelectronic pairs: CO and N_2, CO^- and NO, and CO^+ and BeO^-. Compare the bonding in each pair.

(8 marks)

(b) If M is a Group 2 element, draw a labelled Born Haber cycle for the formation of MBr_2 from their respective elements in standard state. Explain the trend in the lattice energy down the Group for MBr_2 series in term of the followings:

(i) Ionization energy.

(ii) Heat of atomization.

(iii) Electron affinity.

(12 marks)

<u>Bahagian B</u> (60 markah) **[MASA: 2 JAM]**

Jawab **TIGA** (3) soalan.

1. (a) Apabila ikan reput, salah satu daripada bahan kimia yang dibentuk ialah kadaverina yang mempunyai bau yang kuat. Kadaverina mengandungi karbon, hidrogen dan nitrogen sahaja. Apabila sampel 0.03560 g kadaverina dibakar sepenuhnya dalam oksigen berlebihan ia menghasilkan 0.07665 g CO_2 dan H_2O 0.04392 g. Spektrometri jisim menunjukkan bahawa kadaverina mempunyai jisim molar 102.2 g mol^{-1}.

(i) Apakah formula empirik kadaverina?

(ii) Apakah formula molekul kadaverina?

(6 markah)

(b) Sebatang kuprum dengan jisim 12.3 g telah dicelup ke dalam V mL larutan T mol L^{-1} $AgNO_3$. Jika jisim atom relatif Cu dan Ag diwakili oleh W_{Cu} dan W_{Ag},

(i) terbitkan satu ungkapan bagi baki jisim kuprum dalam sebutan V, T dan W_{Cu} setelah tindak balas selesai.

(ii) Jika semua argentum yang membentuk itu berpegang teguh kepada batang kuprum, terbitkan ungkapan bagi jisim bar kuprum selepas tindakbalas.

(12 markah)

(c) Tiga pelajar telah diminta untuk menyediakan sebatian nikel sulfat oleh tindak balas sebatian nikel dengan sebatian sulfat dalam air dan kemudian meruapkan semua air. Ketiga-tiga pelajar memilih pasangan bahan tindak balas berikut:

Pelajar 1	$Ni(OH)_2$ dan H_2SO_4
Pelajar 2	$Ni(NO_3)_2$ dan Na_2SO_4
Pelajar 3	$NiCO_3$ dan H_2SO_4

Dari pengalaman anda, pelajar yang mana akan berjaya dan mengapa.

(2 markah)

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2. (a) Sinar-X telah digunakan secara rutin untuk menggambarkan imej tubuh manusia. Baru-baru ini satu teknik yang lebih unggul yang dikenali sebagai pengimejan resonans magnetik (MRI) telah dibangunkan yang menggunakan putaran proton untuk mengimejkan tisu manusia secara terperinci yang menakjubkan. Di dalam kaedah MRI, nukei hidrogen yang sedang berputar di dalam bahan organik dipancarkan dengan radiasi foton yang mengandungi tenaga yang cukup untuk memesongkan orientasi putaran proton.

(i) Jika 33.121 kJ mol^{-1} tenaga diperlukan untuk memesongkan putaran proton, apakah frekuensi resonans yang diperlukan untuk menghasilkan spektrum MRI?

(ii) Cadangkan mengapa sinar elektromagnet MRI ini akan lebih digemari berbanding sinar-X.

(5 markah)

(b) Tahap tenaga zarah yang terperangkap di dalam telaga harmonik datu dimensi yang diberikan oleh,

$$E_n = (n + ½)\hbar\omega$$

Di mana $\hbar = h/2\pi$.

(i) Kira nilai ω, jika diberikan frekuensi sinaran $\upsilon = 10^4$ Hz, diperlukan untuk merangsang jasad dari aras n = 0 kepada n = 1. Berikan unit yang betul bagi ω.

(ii) Dengan membandingkan persamaan tenaga di atas dengan persamaan tenaga yang diperoleh oleh Bohr bagi atom hidrogen, berikan satu perbezaan utama di antara kedua persamaan itu.

(7 markah)

(c) Gunakan persamaan Rydberg untuk mengira panjang gelombang dalam nanometer, bagi garis spektrum hidrogen yang akan dihasilkan apabila elektron jatuh dari $n_2 = 6$ dan $n_1 = 3$. Adakah anda dapat melihat cahaya yang sama dengan garis spektrum ini?

(3 marks)

(d) Tenaga pengionan H adalah 13.6 eV. Dengan hanya maklumat ini dan tanpa merujuk kepada mana-mana pemalar fizikal yang diberikan, kira perbezaan tenaga antara aras orbit n = 1 dan n = 5 dalam atom hidrogen.

(5 markah)

3. (a) Satu mayat yang tidak dikenali telah ditemui pada 21 April waktu 07:00 pagi. Pakar patalogi mendapati bahawa terdapat 1.24×10^{37} atom $^{32}_{15}P$ yang tinggal dalam tulang mangsa dan meletakkan masa kematian pada persekitaran 15 Mac. Setengah hayat $^{32}_{15}P$ ialah 14.28 hari. Berapakah bilangan atom $^{32}_{15}P$ yang hadir dalam tulang pada masa kematian?

(5 markah)

(b) ^{214}Bi mereput kepada isotop **A** melalui pemancaran alfa. **A** kemudian menyusut kepada **B** melalui pemancaran beta, yang kemudian mereput kepada **C** melalui pemancaran beta juga. Unsur **C** mereput kepada **D** melalui pemancaran beta lagi. Kemudian **D** mereput kepada **E** melalui pemancaran alfa. Kenalpasti semua unsur dan isotop dari **A** ke **E** dengan simbol kimia yang betul dan tulis semua transformasi nuklear yang menghasilkan unsur-unsur tersebut.

(10 markah)

(c) Sejumlah kecil sebatian radioaktif $^{24}NaBr$ telah dilarutkan dalam larutan pekat natrium bromida yang panas yang hanya mengandungi natrium-23 yang tidak radioaktif. Larutan itu disejukkan dan natrium bromida keluar sebagai mendakan. Terangakan dengan menggunakan prinsip asas kimia serta persamaan tindak balas yang sesuai, adakah mendakan natrium bromida yang dihasilkan itu radioaktif.

(5 markah)

4. (a) Lukis struktur Lewis bagi PCl_3, PCl_5 dan $OPCl_3$.

(3 markah)

(b) Terangkan konsep domain elektron dalam teori Penolakan Pasangan Elektron Petala Valens (VSEPR). Dengan mengunakan teori VSEPR, jelaskan bentuk PCl_3, PCl_5 dan $OPCl_3$.

(9 markah)

(c) Antara klorida pada (a) di atas, yang manakah berupaya membentuk sebatian tambah? Huraikan jawapan anda dan berikan contoh bersesuaian.

(8 markah)

5. (a) Susunan orbital molekul dalam tenaga menaik bagi molekul CO adalah
$\sigma 1s$, $\sigma^* 1s$, $\sigma 2s$, $\sigma^* 2s$, $\{\pi 2p_y, \pi 2p_z\}$, $\sigma 2p_x$, $\{\pi^* 2p_y, \pi^* 2p_z\}$, $\sigma^* 2p_x$

(i) Lukis rajah orbital molekul terisi bagi molekul CO.

(ii) Berdasarkan teori Orbital Molekul, kira tertib ikatan setiap ahli pasangan isoelektron berikut: CO dan N_2, CO^- dan NO, and CO^+ dan BeO^-. Bandingkan ikatan dalam setiap pasangan.

(8 markah)

(b) Jika M ialah unsur Kumpulan 2, lukis kitaran Born Haber berlabel bagi pembentukan MBr_2 dari unsur masing-masing pada keadaan piawai.Terangkan tren tenaga kekisi bagi siri MBr_2 menurun Kumpulan dari segi berikut:

(i) Tenaga pengionan.

(ii) Haba pengatoman.

(iii) Afiniti elektron.

(12 markah)

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APPENDIX:

Table of relative atomic mass and physical constants

Atomic No.	Symbol	Name	Atomic Wt		Atomic No.	Symbol	Name	Atomic Wt
89	**Ac**	Actinium	[227]		42	**Mo**	Molybdenum	95.94(2)
13	**Al**	Aluminum	26.981538(2)		60	**Nd**	Neodymium	144.24(3)
95	**Am**	Americium	[243]		10	**Ne**	Neon	20.1797(6)
51	**Sb**	Antimony	121.760(1)		93	**Np**	Neptunium	[237]
18	**Ar**	Argon	39.948(1)		28	**Ni**	Nickel	58.6934(2)
33	**As**	Arsenic	74.92160(2)		41	**Nb**	Niobium	92.90638(2)
85	**At**	Astatine	[210]		7	**N**	Nitrogen	14.0067(2)
56	**Ba**	Barium	137.327(7)		102	**No**	Nobelium	[259]
97	**Bk**	Berkelium	[247]		76	**Os**	Osmium	190.23(3)
4	**Be**	Beryllium	9.012182(3)		8	**O**	Oxygen	15.9994(3)
83	**Bi**	Bismuth	208.98038(2)		46	**Pd**	Palladium	106.42(1)
107	**Bh**	Bohrium	[264]		15	**P**	Phosphorus	30.973761(2)
5	**B**	Boron	10.811(7)		78	**Pt**	Platinum	195.078(2)
35	**Br**	Bromine	79.904(1)		94	**Pu**	Plutonium	[244]
48	**Cd**	Cadmium	112.411(8)		84	**Po**	Polonium	[209]
55	**Cs**	Cesium	132.90545(2)		19	**K**	Potassium	39.0983(1)
20	**Ca**	Calcium	40.078(4)		59	**Pr**	Praseodymium	140.90765(2)
98	**Cf**	Californium	[251]		61	**Pm**	Promethium	[145]
6	**C**	Carbon	12.0107(8)		91	**Pa**	Protactinium	231.03588(2)
58	**Ce**	Cerium	140.116(1)		88	**Ra**	Radium	[226]
17	**Cl**	Chlorine	35.453(2)		86	**Rn**	Radon	[222]
24	**Cr**	Chromium	51.9961(6)		75	**Re**	Rhenium	186.207(1)
27	**Co**	Cobalt	58.933200(9)		45	**Rh**	Rhodium	102.90550(2)
29	**Cu**	Copper	63.546(3)		37	**Rb**	Rubidium	85.4678(3)
96	**Cm**	Curium	[247]		44	**Ru**	Ruthenium	101.07(2)
105	**Db**	Dubnium	[262]		104	**Rf**	Rutherfordium	[261]
66	**Dy**	Dysprosium	162.500(1)		62	**Sm**	Samarium	150.36(3)
99	**Es**	Einsteinium	[252]		21	**Sc**	Scandium	44.955910(8)
68	**Er**	Erbium	167.259(3)		106	**Sg**	Seaborgium	[266]
63	**Eu**	Europium	151.964(1)		34	**Se**	Selenium	78.96(3)
100	**Fm**	Fermium	[257]		14	**Si**	Silicon	28.0855(3)
9	**F**	Fluorine	18.9984032(5)		47	**Ag**	Silver	107.8682(2)
87	**Fr**	Francium	[223]		11	**Na**	Sodium	22.989770(2)
64	**Gd**	Gadolinium	157.25(3)		38	**Sr**	Strontium	87.62(1)
31	**Ga**	Gallium	69.723(1)		16	**S**	Sulfur	32.065(5)
32	**Ge**	Germanium	72.64(1)		73	**Ta**	Tantalum	180.9479(1)
79	**Au**	Gold	196.96655(2)		43	**Tc**	Technetium	[98]
72	**Hf**	Hafnium	178.49(2)		52	**Te**	Tellurium	127.60(3)
108	**Hs**	Hassium	[277]		65	**Tb**	Terbium	158.92534(2)
2	**He**	Helium	4.002602(2)		81	**Tl**	Thallium	204.3833(2)
67	**Ho**	Holmium	164.93032(2)		90	**Th**	Thorium	232.0381(1)
1	**H**	Hydrogen	1.00794(7)		69	**Tm**	Thulium	168.93421(2)
49	**In**	Indium	114.818(3)		50	**Sn**	Tin	118.710(7)
53	**I**	Iodine	126.90447(3)		22	**Ti**	Titanium	47.867(1)
77	**Ir**	Iridium	192.217(3)		74	**W**	Tungsten	183.84(1)
26	**Fe**	Iron	55.845(2)		112	**Uub**	Ununbium	[285]
36	**Kr**	Krypton	83.798(2)		116	**Uuh**	Ununhexium	
57	**La**	Lanthanum	138.9055(2)		119	**Uun**	Ununnilium	[281]
103	**Lr**	Lawrencium	[262]		118	**Uuo**	Ununoctium	
82	**Pb**	Lead	207.2(1)		114	**Uuq**	Ununquadium	[289]
3	**Li**	Lithium	[6.941(2)]		111	**Uuu**	Unununium	[272]
71	**Lu**	Lutetium	174.967(1)		92	**U**	Uranium	238.02891(3)
12	**Mg**	Magnesium	24.3050(6)		23	**V**	Vanadium	50.9415(1)
25	**Mn**	Manganese	54.938049(9)		54	**Xe**	Xenon	131.293(6)
109	**Mt**	Meitnerium	[268]		70	**Yb**	Ytterbium	173.04(3)
101	**Md**	Mendelevium	[258]		39	**Y**	Yttrium	88.90585(2)
80	**Hg**	Mercury	200.59(2)		30	**Zn**	Zinc	65.409(4)
					40	**Zr**	Zirconium	91.224(2)

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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)