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UNIVERSITI SAINS MALAYSIA

Peperiksaan Kursus Semasa Cuti Panjang
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.

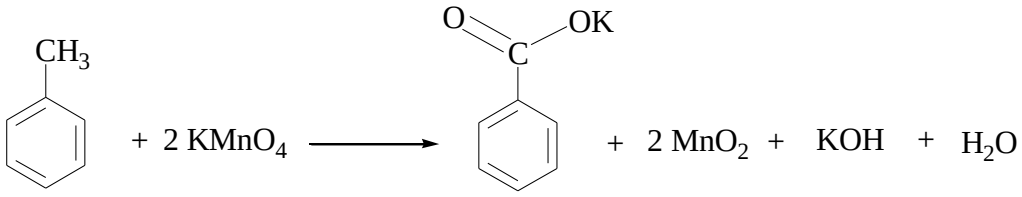
Appendix: Table of relative atomic mass and physical constants.

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) Potassium benzoate ($KC_7H_5O_2$) can be synthesized from the reaction of toluene (C_7H_8) with potassium permanganate as follows:



If the yield of the product, potassium benzoate cannot exceed 71 %, calculate the minimum mass of toluene that will be required in order to obtain 11.5 g of potassium benzoate from the above reaction.

(5 marks)

(b) Barium sulfate, $BaSO_4$ was prepared from the following reaction:

$$Ba(NO_3)_2\ (aq) + Na_2SO_4\ (aq) \rightarrow BaSO_4\ (s) + 2\ NaNO_3\ (aq)$$

An experiment to prepare $BaSO_4$ was carried out with 82.0 g of $Ba(NO_3)_2$ and excess Na_2SO_4. After the reaction went to completion, the $BaSO_4(s)$ obtained was filtered, washed and dried at 110 ^oC. The mass of $BaSO_4$ obtained was found to be 65.27 g. Calculate the percentage yield and the theoretical yield of the reaction.

(6 marks)

(c) A solution of hydrogen peroxide (H_2O_2) is commonly used as an antiseptic. A sample of such a solution weighing 1.000 g was acidified with H_2SO_4 and titrated with 0.02000 M $KMnO_4$ solution. The unbalanced ionic equation for the reaction is

$$H_2O_2 + MnO_4^- \rightarrow O_2 + Mn^{2+}$$

The titration required 17.60 mL $KMnO_4$ solution.

(i) How many grams of H_2O_2 reacted in the titration?

(ii) What is the percentage by mass of the H_2O_2 in the original antiseptic solution?

(9 marks)

2. (a) In one atom of iron, how many electrons have

(i) $l = 0$

(ii) $m_l = 1$

(4 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) Explain why oxygen is paramagnetic while neon is diamagnetic.

(4 marks)

(d) 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)

(e) State the Rydberg equation. Calculate the wavelength of light emitted when an electron drops from the tenth excited state to the fourth Bohr orbit in a hydrogen atom. (Rydberg constant = 109678 cm^{-1}).

(4 marks)

3. (a) Generate a table containing the values for n, l, m_l and m_s for all the electrons with the principal quantum number n = 4. From your table, state the number of electrons that has s = -½.

(8 marks)

(b) How many unpaired electrons are there in the ground state of

(i) phosphorous and

(ii) vanadium.

(4 marks)

(c) When the bond between two chlorine atoms forms to yield Cl_2 molecules, 328 kJ mol^{-1} of energy is released. What is the wavelength (in nanometer) of the light required to break the bond in the chlorine molecule?

(8 marks)

4. (a) The Valence Shell Electron Pair Repulsion (VSEPR) and the Valence Bond (VB) theories are two bonding theories that best describe the shape of molecules.

(i) State or describe the principle of these theories.

(ii) By using urea, $(H_2N)_2C=O$, as example, show how the above theories explain the shape of urea molecule.

(14 marks)

(b) Define or differentiate TWO of the followings. Give specific example of each.

(i) Coordinate covalent and covalent bonds.

(ii) Lone pair electrons and electron domains.

(iii) Bonding and anti-bonding molecular orbitals.

(6 marks)

5. (a) With the aid of suitable drawings, show that a face centred cube (fcc) structure is actually a cubic close packed (ccp) arrangement. Give two examples of metal that adopts fcc/ccp structure.

(10 marks)

(b) By using the Molecular Orbital (MO) approach for each of the following ions, B_2^- and N_2^+, evaluate or calculate,

(i) the number of bonds,

(ii) the number of unpaired electrons and

(iii) the bond order.

(10 marks)

TERJEMAHAN

Arahan:

Bahagian A: (40 markah) mengandungi 40 soalan berbentuk objektif (MCQ), perlu dijawab dalam masa 1 jam pertama di dalam borang jawapan OMR yang disediakan. Borang OMR akan dikutip satu jam selepas peperiksaan bermula.

Bahagian B: (60 markah) mengandungi soalan bertulis. Jawab **TIGA** (3) soalan. Jika calon menjawab lebih daripada tiga soalan, hanya tiga soalan pertama mengikut susunan dalam skrip jawapan akan diberi markah.

Jawab setiap soalan pada muka surat yang baru.

Anda dibenarkan menjawab soalan ini sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.

Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah digunapakai.

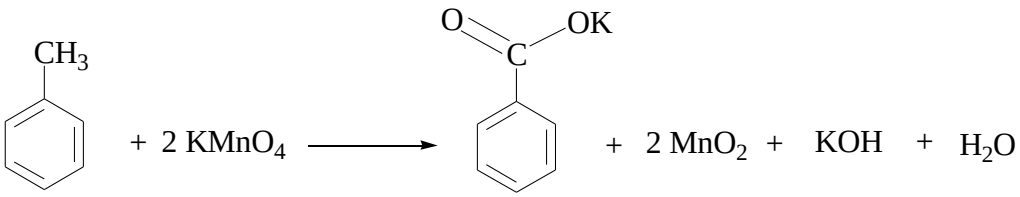
Appendix: Jadual jisim atom relatif dan data pemalar fizikal.

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) Garam kalium benzoat ($KC_7H_5O_2$) boleh disintesiskan melalui tindak balas toluena (C_7H_8) dengan kalium permanganat seperti di dalam persamaan berikut:



Jika hasil kalium benzoat tidak boleh melebihi 71 %, kira jisim minimum toluena yang diperlukan untuk mencapai peratus ini serta menghasilkan 11.5 g kalium benzoat.

(5 markah)

(b) Barium sulfat, $BaSO_4$ telah disediakan melalui tindak balas berikut:

$$Ba(NO_3)_2\ (ak) + Na_2SO_4\ (ak) \rightarrow BaSO_4\ (p) + 2\ NaNO_3\ (ak)$$

Satu eksperimen untuk menyediakan $BaSO_4$ telah dilakukan dengan 82.0 g $Ba(NO_3)_2$ dan berlebihan Na_2SO_4. Setelah tindak balas selesai, hasil $BaSO_4$ (p) telah diperolehi dengan menuras melalui kertas turas. Setelah dikeringkan pada suhu 110 ^oC, 65.27 g $BaSO_4$ telah diperolehi. Kira peratus hasil dan hasil teoretis bagi tindak balas yang telah dilakukan.

(6 markah)

(d) Larutan hidrogen peroksida (H_2O_2) biasa digunakan sebagai antiseptik. Satu sampel larutan ini seberat 1.000 g telah diasidkan dengan H_2SO_4 dan dititratkan dengan 0.02000 M larutan $KMnO_4$. Rangka persamaan ionik bagi tindak balas adalah seperti di bawah:

$$H_2O_2 + MnO_4^- \rightarrow O_2 + Mn^{2+}$$

Pentitratan telah memerlukan 17.60 M larutan $KMnO_4$.

(i) Berapakah jisim H_2O_2 telah bertindak balas di dalam pentitratan di atas?

(ii) Berapakah peratus H_2O_2 mengikut jisim, di dalam larutan antiseptik asal?

(9 markah)

2. (a) Di dalam satu atom ferum, berapa elektron yang mempunyai

(j) $l = 0$

(ii) $m_l = 1$

(4 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) Terangkan mengapa atom oksigen bersifat paramagnetik sedangkan atom neon pula bersifat diamagnetik.

(4 markah)

(d) 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)

(e) Berikan persamaan Rydberg. Kiralah jarak gelombang spektrum garis hidrogen bila satu elektron jatuh dari keadaan teruja yang kesepuluh ke orbit keempat Bohr. (Pemalar Rydberg ialah 109678 cm^{-1}).

(4 markah)

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3. (a) Terbitkan satu jadual yang mengandungi nilai n, *l*, m_l dan m_s bagi semua elektron dengan nombor kuantum n = 4. Dari jadual yang anda telah terbitkan, nyatakan bilangan elektron yang mempunyai s = -½.

(8 markah)

(b) Berapakah bilangan elektron tak berpasangan pada keadaan asas bagi

(i) fosforus dan

(ii) vanadium.

(4 markah)

(c) Apabila ikatan di antara atom klorin terbentuk untuk menghasilkan molekul Cl_2, 328 kJ mol^{-1} tenaga dibebaskan. Berapakah jarak gelombang (dalam nanometer) bagi cahaya yang diperlukan untuk memecahkan ikatan kimia pada satu molekul klorin?

(8 markah)

4. (a) Teori Penolakan Pasangan Elektron Petala Valens (VSEPR) dan teori Ikatan Valens (VB) adalah dua teori yang terbaik bagi menerangkan bentuk molekul.

(i) Nyatakan atau terangkan prinsip teori tersebut.

(ii) Dengan menggunakan urea, $(H_2N)_2C=O$, sebagai contoh, tunjukkan bagaimana kedua-dua teori di atas menjelaskan bentuk molekul urea.

(12 markah)

(b) Takrifkan atau bezakan DUA daripada yang berikut. Beri contoh khusus setiapnya.

(i) Ikatan kovalen dan kovalen koordinat.

(ii) Pasangan elektron tersendiri dan domain elektron.

(iii) Orbital molekul pengikatan dan anti-pengikatan.

(8 markah)

5. (a) Dengan berbantukan lakaran yang sesuai, tunjukkan bahawa kiub berpusat muka (fcc) adalah sebenarnya suatu susunan kuib padat rapat (ccp). Berikan dua contoh logam yang berstruktur fcc/ccp.

(10 markah)

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(b) Dengan menggunakan pendekatan Orbital Molekul (MO) bagi setiap ion berikut, B_2^- dan N_2^+, cari atau kira,

(i) bilangan ikatan,

(ii) bilangan elektron tak berpasangan dan

(iii) tertib ikatan.

(10 markah)

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APPENDIX:

Table of relative atomic mass and physical constants

	Symbol	Name	Atomic Wt			Symbol	Name	Atomic Wt
89	**Ac**	Actinium	[227]		42	**Mo**	Molybdenum	95.94(2)
13	**Al**	Aluminium	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**	Caesium	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)

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)