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UNIVERSITI SAINS MALAYSIA

Second 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.

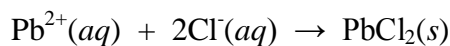
Appendix: Table of relative atomic mass and physical constants.

SECTION B (60 marks)**[TIME: 2 HOURS]****This section contains FIVE questions.****Answer any THREE questions.**

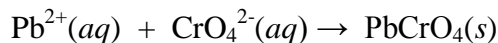
Only the first THREE questions answered in the answer book will be marked. Supporting data constants needed for the questions are included on the last page.

You must start each question on a new page.

1. (a) Lead may have been the first metal ever recovered from its ore by humans. Its cation, Pb^{2+} , forms a precipitate with Cl^- according to the equation



When PbCl_2 is dissolved in hot water, its presence can be confirmed by its reaction with CrO_4^{2-} , with which it forms a yellow precipitate:

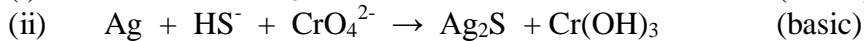
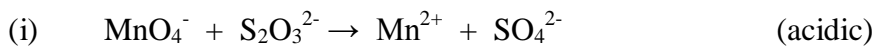


The precipitate is used as a rust inhibitor and in pigments.

- (i) What type of reaction does each of the above equations represents?
- (ii) If 100 mL of a Pb^{2+} solution produces 1.65 g of lead chromate, what was the concentration of the lead solution?
- (iii) What volume of potassium chromate solution containing 0.503 g of solute per 250.0 mL is needed for this reaction?
- (iv) If all the PbCrO_4 originated from PbCl_2 , what volume of a 1.463 M NaCl solution was needed for the initial reaction?

(12 marks)

- (b) Balance each of the following reaction under the condition indicated:

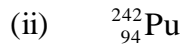


(8 marks)

2. (a) Vanadium has been found to be a key component in a biological catalyst that reduces nitrogen to ammonia.
- What is the valence electron configuration of vanadium?
 - What are the quantum numbers for each of the valence electrons?
 - How many unpaired electrons does vanadium have?
- (6 marks)
- (b) The compound Fe_2O_3 was called lodestone in ancient times, because it responded to Earth's magnetic field and can be used to construct a primitive compass. Today Fe_2O_3 is commonly called magnetite, because it contains both Fe^{2+} and Fe^{3+} , and the unpaired electrons on these ions align to form tiny magnets.
- How many unpaired electrons does each ion have?
 - Would you expect to observe magnetic behavior in compounds containing Zn^{2+} ? Why or why not?
 - Would you expect Fe or Zn to have the lower third ionization energy? Why?
- (6 marks)
- (c) Arsenic is capable of forming two different cations. What charges would you expect on these cations? Why?
- (3 marks)
- (d) (i) In a hydrogen atom, the $1s$ subshell is at an energy of $-1.31 \times 10^3 \text{ kJ mol}^{-1}$, whereas in a helium atom it is at $-2.37 \times 10^3 \text{ kJ mol}^{-1}$. Explain why the level is not the same in the two cases.
- (ii) For hydrogen-like atoms, Bohr's equation can be written as
- $$E_n = -B \frac{Z^2}{n^2}, \text{ where } B \text{ is a constant and } Z \text{ is the nuclear charge.}$$
- Calculate the energy (in kJ mol^{-1}) of the $1s$ subshell for He^+ using this equation, and explain why the value you get is not the same as that given for helium. [$B = 2.18 \times 10^{-18} \text{ J}$]
- (5 marks)

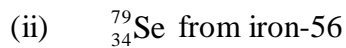
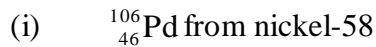
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3. (a) Predict (with explanation) the kind of nuclear change each unstable nuclide undergoes when it decays:



(6 marks)

- (b) At the end of a star's life cycle, it can collapse, resulting in a supernova explosion that leads to the formation of heavy elements by multiple neutron-capture events. Write reactions for the formation of the following nuclides during such an event.



(6 marks)

- (c) Bombarding ${}^{249}\text{Cf}$ with ${}^{12}\text{C}$ produced a transuranium element with a mass of 257 amu, plus several neutral subatomic particles. Identify the element, and write a nuclear reaction for this transmutation.

(4 marks)

- (d) Would you expect non-ionizing or ionizing radiation to be more effective at treating cancer? Why?

(4 marks)

4. (a) Metals are made up of positive ions held together by sea of electrons. These ions are packed in one of the following arrangements;

(i) cubic close-packed (ccp) or face-centred cubic (fcc)

(ii) hexagonal close-packed (hcp)

(iii) body-centered cubic (bcc)

Draw the above packing arrangements and state the nearest neighbor of the ion. For the close-packed arrangements, show by way of sketch, how these ions are arranged to give the respective packing.

(12 marks)

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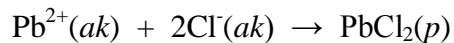
- (b) Define or differentiate the followings;
- (i) polar and non-polar covalent bonds
 - (ii) electronegativity and formal charge
 - (iii) bonding and anti-bonding molecular orbitals
 - (iv) symmetric and asymmetric molecules
- (8 marks)
5. (a) Draw an energy diagram that constitutes the electronic configuration, atomic orbitals and molecular orbitals for carbon monoxide (CO) and nitric oxide (NO). Describe the bond order of the isoelectronic species, CO^+ and NO^{2+} .
- (10 marks)
- (b) COCl_2 molecule adopts a planar triangular shape. However, its bond angles, $\text{O-C-Cl} \neq \text{Cl-C-Cl} \neq 120^\circ$. Draw the Lewis structure of COCl_2 and use the VB theory to explain the observation.
- (5 marks)
- (c) Explain the significance of electron domain in the VSEPR theory?
- (5 marks)

BAHAGIAN B (60 markah)**[MASA: 2 JAM]****Bahagian ini mengandungi LIMA soalan.****Jawab sebarang TIGA soalan**

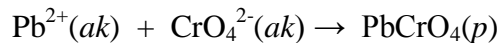
Hanya TIGA jawapan yang pertama akan diperiksa. Data pemalar fizikal disertakan dalam Lampiran.

Jawab setiap soalan pada muka surat yang baru.

1. (a) Plumbum mungkin merupakan logam pertama dipencilkan daripada bijihnya oleh manusia. Kationnya, Pb^{2+} , membentuk mendakan dengan Cl^- mengikut persamaan



Apabila PbCl_2 dilarutkan dalam air panas, kehadirannya boleh ditetapkan melalui tindakbalasnya dengan CrO_4^{2-} , yang akan membentuk mendakan kuning:

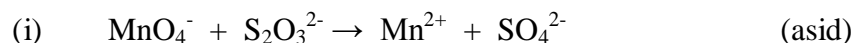


Mendakan ini digunakan sebagai penghambat karat dan di dalam pewarna.

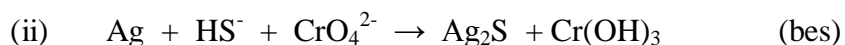
- (i) Apakah jenis tindak balas yang diwakili oleh kedua-dua persamaan di atas?
- (ii) Jika 100 mL larutan Pb^{2+} menghasilkan 1.65 g plumbum kromat, apakah kepekatan larutan plumbum?
- (iii) Apakah isipadu larutan kalium kromat yang mengandungi 0.503 g bahan larut dalam 250.0 mL diperlukan bagi tindak balas ini?
- (iv) Jika semua PbCrO_4 datang daripada PbCl_2 , apakah isipadu larutan NaCl berkepekatan 1.463 M yang diperlukan bagi tindak balas pertama?

(12 markah)

- (b) Imbangkan persamaan tindak balas berikut dalam keadaan yang diberikan:



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(8 markah)

2. (a) Vanadium merupakan komponen penting di dalam satu mangkin biologi yang menurunkan nitrogen kepada ammonia.

(i) Apakah konfigurasi elektron bagi elektron valens vanadium?

(ii) Apakah nombor-nombor kuantum bagi setiap elektron valensnya?

(iii) Berapakah bilangan elektron valens vanadium?

(6 markah)

(b) Sebatian Fe_2O_3 dikenali sebagai *lodestone* pada masa silam kerana ia bertindak dengan medan magnet Bumi. Ia boleh digunakan untuk membina kompas ringkas. Pada hari ini Fe_2O_3 biasanya dipanggil *magnetite* oleh kerana ia mengandungi Fe^{2+} dan Fe^{3+} . Elektron tidak berpasangan di dalam ion-ion ini akan menyelaraskan diri untuk membentuk magnet kecil.

(i) Berapakah bilangan elektron tak berpasangan wujud di dalam setiap ion itu?

(ii) Adakah anda akan perhatikan sifat magnet di dalam sebatian yang mengandungi Zn^{2+} ? Mengapa atau mengapa tidak?

(iii) Yang mana satu daripada Fe atau Zn yang mempunyai tenaga pengionan ketiga yang lebih rendah? Mengapa?

(6 markah)

(c) Arsenik boleh membentuk dua jenis kation yang berbeza. Apakah cas di atas setiap kation tersebut? Terangkan.

(3 markah)

(d) (i) Suborbital $1s$ atom hidrogen berada pada tenaga $-1.31 \times 10^3 \text{ kJ mol}^{-1}$, manakala pada atom helium ia mempunyai tenaga $-2.37 \times 10^3 \text{ kJ mol}^{-1}$. Terangkan mengapa aras tenaga kedua-duanya tidak sama.

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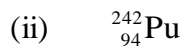
- (ii) Bagi atom bak-hidrogen, persamaan Bohr boleh ditulis sebagai

$$E_n = -B \frac{Z^2}{n^2}, \text{ dengan } B \text{ ialah pemalar dan } Z \text{ ialah cas nukleus.}$$

Kira tenaga (dalam kJ mol^{-1}) suborbital $1s$ bagi He^+ dengan menggunakan persamaan di atas, dan terangkan mengapa nilai yang anda perolehi tidak sama dengan nilai yang diberi untuk helium. [$B = 2.18 \times 10^{-18} \text{ J}$]

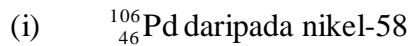
(5 markah)

3. (a) Ramalkan (dengan memberi keterangan) perubahan nuklear setiap nuklida yang tidak stabil ketika ia menyusut:



(6 markah)

- (b) Pada akhir kitaran hidup sebuah bintang, ia akan musnah dan mengakibatkan letupan supernova. Ini boleh mengakibatkan pembentukan unsur-unsur berat melalui peristiwa penangkapan neutron multipel. Tulis tindak balas pembentukan nuklida-nuklida berikut semasa peristiwa seperti itu.



(6 markah)

- (c) Penembakan ${}^{249}\text{Cf}$ dengan ${}^{12}\text{C}$ menghasilkan unsur transurium berjisim 257 amu, bersama beberapa jasad sub-atomik yang neutral. Kenalpastikan unsur tersebut dan tulis persamaan tindak balas bagi transmudasi ini.

(4 markah)

- (d) Adakah anda harapkan radiasi yang tidak mengakibatkan pengionan atau yang mengakibatkan pengionan menjadi lebih efektif untuk merawat kanser? Mengapa?

(4 markah)

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4. (a) Logam terdiri daripada ion-ion positif yang diikat oleh lautan elektron. Ion-ion ini disusun dalam salah-satu susunan berikut;

- (i) kiub padat rapat (ccp) atau kiub berpusat muka (fcc)
- (ii) heksagon padat rapat (hcp)
- (iii) kiub berpusat jasad (bcc)

Lukiskan susunan-susunan di atas dan nyatakan jiran terdekat ionnya. Bagi susunan padat rapat, tunjukkan melalui lakaran, bagaimana ion-ion disusun menghasilkan susunan tersebut.

(12 markah)

(b) Takrifkan atau bezakan yang berikut;

- (i) ikatan kovalen berkutub dan tak berkutub
- (ii) keelektronegatifan dan cas formal
- (iii) orbital molekul ikatan dan anti-ikatan
- (iv) molekul simetrik and asimetrik

(8 markah)

5. (a) Lukiskan rajah tenaga yang merangkumi konfigurasi elektron, orbital-orbital atom dan orbital-orbital molekul bagi karbon monoksida (CO) dan oksida nitrik (NO). Huraikan tertib ikatan bagi spesies isoelektronik, CO^+ dan NO^{2+} .

(10 markah)

(b) Molekul COCl_2 berbentuk sesatah segi tiga. Namun, sudut ikatannya $\text{O}-\text{C}-\text{Cl} \neq \text{Cl}-\text{C}-\text{Cl} \neq 120^\circ$. Lukis struktur Lewis bagi COCl_2 dan gunakan teori VB untuk menerangkan pemerhatian tersebut.

(5 markah)

(c) Terangkan kepentingan domain elektron dalam teori VSEPR?

(5 markah)