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UNIVERSITI SAINS MALAYSIA

Final Examination  
Academic Session 2007/2008

April 2008

**JIK 218 – SYSTEMATIC CHEMISTRY AND NUCLEUS CHEMISTRY**  
**[KIMIA BERSISTEM DAN KIMIA NUKLEUS]**

Duration : 3 hours  
[Masa : 3 jam]

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Please ensure that this examination paper contains NINE printed pages before you begin the examination.

Answer **FIVE** questions. You may answer **either** in Bahasa Malaysia or in English.

All answers must be written in the answer booklet provided.

Each questions is worth 20 marks and the marks for each sub question is given at the end of that question.

*Sila pastikan bahawa kertas peperiksaan ini mengandungi SEMBILAN muka surat yang bercetak sebelum anda memulakan peperiksaan ini.*

*Jawab **LIMA** soalan. Anda dibenarkan menjawab soalan **sama ada** dalam Bahasa Malaysia atau Bahasa Inggeris.*

*Setiap jawapan mesti dijawab di dalam buku jawapan yang disediakan.*

*Setiap soalan bernilai 20 markah dan markah subsoalan diperlihatkan di penghujung subsoalan itu.*

1. (a) Account for each of the following observations :
- (i) The first ionization energy of K is lower than that of Li.
  - (ii) The trend of the first ionization energy decreases on going from N to O.
  - (iii) Size of ions increase as one proceeds down a group in the periodic table.
  - (iv) The electron affinity of Li is a negative value, whereas the electron affinity of Be is a positive value.

*Jelaskan setiap pemerhatian berikut :*

- (i) *Tenaga pengionan pertama K lebih rendah dari Li.*
- (ii) *Tren tenaga pengionan pertama semakin kurang dari N ke O.*
- (iii) *Saiz ion bertambah apabila menuruni sesuatu kumpulan dalam jadual berkala.*
- (iv) *Cita elektron Li bernilai negatif, manakala cita elektron Be bernilai positif.*

(12 marks)

- (b) Predict whether each of the following oxides is acidic, basic, amphoteric, or neutral :
- (i)  $\text{NO}_2$
  - (ii)  $\text{CO}_2$
  - (iii)  $\text{BaO}$
  - (iv)  $\text{Al}_2\text{O}_3$

Write chemical equations to show the acid-base and amphoteric characters of the oxide to support your prediction.

*Ramalkan sama ada setiap oksida berikut berasid, berbes, amfoterik atau neutral :*

- (i)  $\text{NO}_2$
- (ii)  $\text{CO}_2$
- (iii)  $\text{BaO}$
- (iv)  $\text{Al}_2\text{O}_3$

*Tuliskan persamaan kimia yang menunjukkan sifat asid-bes dan amfoterik oksida tersebut untuk menyokong ramalan anda.*

(8 marks)

2. (a) How does the structure of graphite account for
- its use as a lubricant,
  - its use as electrodes, and
  - the fact that diamond is the more stable allotrope at very high pressure?

*Bagaimanakah struktur grafit menjelaskan*

- kegunaannya sebagai pelincir,*
- kegunaannya sebagai elektrod, dan*
- fakta yang menyatakan intan adalah alotrop lebih stabil pada tekanan yang tinggi?*

(4 marks)

- (b) Predict the shape of the following molecules or ions :

- ClCN
- $[\text{PbCl}_6]^{2-}$
- $[\text{SiH}_3]^-$
- $[\text{SnCl}_5]^-$ .

*Ramalkan rupabentuk molekul atau ion berikut :*

- ClCN*
- $[\text{PbCl}_6]^{2-}$*
- $[\text{SiH}_3]^-$*
- $[\text{SnCl}_5]^-$ .*

(8 marks)

- (c) Explain the following observations :

- $\text{HNO}_3$  is a stronger oxidizing agent than  $\text{H}_3\text{PO}_4$ .
- Silicon can form an ion with six fluorine atoms,  $\text{SiF}_6^{2-}$ , whereas carbon is able to bond to a maximum of four,  $\text{CF}_4$ .
- $\text{AsH}_3$  is a stronger reducing agent than  $\text{NH}_3$ .
- Xenon forms stable compounds with fluorine, whereas argon does not.

Jelaskan pemerhatian berikut :

- (i)  $HNO_3$  adalah agen pengoksidaan yang lebih kuat daripada  $H_3PO_4$ .
- (ii) Silikon boleh membentuk suatu ion dengan enam atom fluorin,  $SiF_6^{2-}$ , manakala karbon hanya mampu membentuk ikatan maksima empat,  $CF_4$ .
- (iii)  $AsH_3$  ialah agen penurunan yang lebih kuat daripada  $NH_3$ .
- (iv) Xenon membentuk sebatian yang stabil dengan fluorin, manakala argon tidak.

(8 marks)

3. (a) Write a balance equation for the preparation of  $H_2$  using

- (i) magnesium and an acid
- (ii) carbon and steam
- (iii) methane and steam.

Tulis persamaan berimbang untuk penyediaan  $H_2$  menggunakan

- (i) magnesium dan suatu asid
- (ii) karbon dan stim
- (iii) metana dan stim.

(6 marks)

(b) Account for each of the following observations :

- (i) The  $[TeF_5]^-$  ion is square pyramidal.
- (ii) Phosphorus forms a pentachloride, but nitrogen does not.
- (iii)  $H_3PO_2$  is a monoprotic acid.
- (iv) White phosphorus is extremely reactive.

Jelaskan setiap pemerhatian berikut :

- (i) Ion  $[TeF_5]^-$  ialah piramid persegi.
- (ii) Fosforus membentuk pentaklorida, tetapi nitrogen tidak.
- (iii)  $H_3PO_2$  ialah asid monoprotik.
- (iv) Fosforus putih tersangat reaktif.

(8 marks)

- (c) Suggest why the H—X—H bond angles in NH<sub>3</sub>, PH<sub>3</sub>, AsH<sub>3</sub>, and SbH<sub>3</sub> decrease from 107° for NH<sub>3</sub> to 93° for PH<sub>3</sub>, 92° for AsH<sub>3</sub>, and 91° for SbH<sub>3</sub>.

*Cadangkan kenapa sudut ikatan H—X—H di dalam NH<sub>3</sub>, PH<sub>3</sub>, AsH<sub>3</sub>, and SbH<sub>3</sub> berkurang daripada 107° untuk NH<sub>3</sub> kepada 93° untuk PH<sub>3</sub>, 92° untuk AsH<sub>3</sub>, dan 91° untuk SbH<sub>3</sub>.*

(6 marks)

4. (a) Write balanced nuclear equations for the following processes :

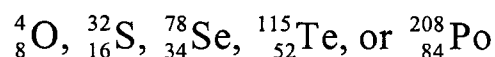
- (i) bismuth-214 undergoes beta decay
- (ii) gold-195 undergoes electron capture
- (iii) potassium-38 undergoes positron emission
- (iv) plutonium-242 emits alpha radiation
- (v) gold-201 decays to a mercury isotope.

*Tuliskan persamaan berimbang untuk proses-proses berikut :*

- (i) *bismut-214 mengalami pereputan beta*
- (ii) *aurum-195 mengalami proses penangkapan elektron*
- (iii) *kalium-38 mengalami proses pemancaran positron*
- (iv) *plutonium-242 memancar radiasi alfa*
- (v) *aurum-201 mereput kepada isotop merkuri.*

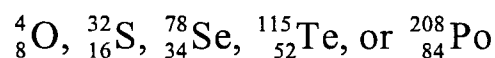
(6 marks)

- (b) Which of the following nuclides of group 16 elements would you expect to be radioactive?



Justify your choices.

*Yang manakah antara nuklid kumpulan 16 yang berikut yang anda jangka beradioaktif?*



*Berikan alasan kepada jawapan anda.*

(6 marks)

- (c) How much energy must be supplied to break a single sodium-23 nucleus into separated protons and neutrons if the nucleus has a mass of 22.983733 amu? How much energy is required per mole of this nucleus?

*Berapa banyak tenaga yang perlu dibekalkan untuk memisahkan satu nukleus natrium-23 kepada proton dan neutron jika jisim nukleus ialah 22.983733 amu? Berapakah tenaga yang diperlukan per mol nukleus tersebut?*

(8 marks)

5. (a) (i) List three industrial uses of O<sub>2</sub> and two industrial uses of O<sub>3</sub>.  
 (ii) Draw the Lewis structure of ozone. Explain why the O—O bond (1.28 Å) is longer in ozone than in O<sub>2</sub> (1.21 Å).

*(i) Senaraikan tiga kegunaan O<sub>2</sub> dan dua kegunaan O<sub>3</sub> dalam industri.  
 (ii) Lukiskan struktur ozon. Jelaskan kenapa ikatan O—O (1.28 Å) lebih panjang di dalam O<sub>3</sub> daripada di dalam O<sub>2</sub> (1.21 Å).*

(6 marks)

- (b) (i) Write a brief account of the chemistry of the xenon fluorides.

*Tulis nota ringkas tentang kimia xenon fluorida.*

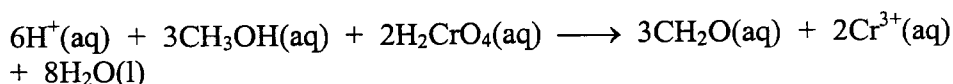
(6 marks)

- (ii) Predict the structures of [XeO<sub>6</sub>]<sup>4-</sup>, XeOF<sub>2</sub>, XeOF<sub>4</sub>, and XeO<sub>2</sub>F<sub>2</sub>.

*Ramalkan struktur [XeO<sub>6</sub>]<sup>4-</sup>, XeOF<sub>2</sub>, XeOF<sub>4</sub> dan XeO<sub>2</sub>F<sub>2</sub>.*

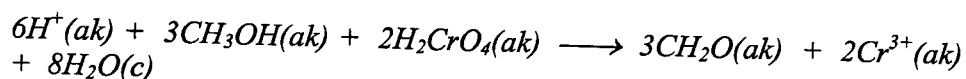
(8 marks)

6. (a) The oxidation of methanol to formaldehyde can be accomplished by reaction with chromic acid :



The reaction can be studied with the stable isotope tracer <sup>18</sup>O and mass spectrometry. When a small amount of CH<sub>3</sub><sup>18</sup>OH is present in the alcohol reactant, H<sub>2</sub>C<sup>18</sup>O forms. When a small amount of H<sub>2</sub>Cr<sup>18</sup>O<sub>4</sub> is present, H<sub>2</sub><sup>18</sup>O forms. Does chromic acid or methanol supply the O atom to the aldehyde? Explain.

*Pengoksidaan metanol kepada formaldehid boleh dilaksanakan melalui tindakbalas dengan asid kromik :*



*Tindakbalas tersebut boleh dikaji dengan penyureh  $^{18}O$  dan spektrometri jisim. Apabila sedikit  $CH_3^{18}OH$  wujud dalam reaktan alkohol,  $H_2C^{18}O$  terbentuk. Apabila sedikit  $H_2Cr^{18}O_4$  wujud,  $H_2^{18}O$  terbentuk. Adakah asid kromik atau metanol yang membekalkan atom O kepada aldehyd? Jelaskan.*

(10 marks)

- (b) A wooden artifact from a Chinese temple has a  $^{14}C$  activity of 24.9 counts per minute as compared with an activity of 32.5 counts per minute for a standard of zero age. From the half-life for  $^{14}C$  decay, 5715 yr, determine the age of the artifact.

*Suatu artifak kayu dari kuil China mempunyai aktiviti 24.9 kiraan per minit berbanding dengan 32.5 kiraan per minit bagi suatu piawai umur zero. Daripada tempoh separuh hayat pereputan  $^{14}C$ , 5715 tahun, tentukan umur artifak tersebut.*

(10 marks)

### FUNDAMENTAL CONSTANTS\*

Atomic mass unit	1 amu = $1.66053873 \times 10^{-24}$ g
	1 g = $6.02214199 \times 10^{23}$ amu
Avogadro's number	$N$ = $6.02214199 \times 10^{23}$ / mol
Boltzmann's constant	$k$ = $1.3806503 \times 10^{-23}$ J/K
Electron charge	$e$ = $1.602176462 \times 10^{-19}$ C
Faraday's constant	$F$ = $9.64853415 \times 10^4$ C/mol
Gas constant	$R$ = 0.082058205 L-atm/ mol-K
Mass of electron	$m_e$ = $5.485799 \times 10^{-4}$ amu = $9.10938188 \times 10^{-28}$ g
Mass of neutron	$m_n$ = 1.0086649 amu = $1.67492716 \times 10^{-24}$ g
Mass of proton	$m_p$ = 1.0072765 amu = $1.67262158 \times 10^{-24}$ g
Pi	$\pi$ = 3.1415927
Planck's constant	$h$ = $6.62606876 \times 10^{-34}$ J-s
Speed of light	$c$ = $2.99792458 \times 10^8$ m/s





