

AL/2023(2024)/02/E-II(A)

සියලු ම හිමිකම් ඇවිරිණි / முழுப் பதிப்புரிமையுடையது / All Rights Reserved

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 Department of Examinations, Sri Lanka Department of Examinations, Sri Lanka Department of Examinations, Sri Lanka Department of Examinations, Sri Lanka Department of Examinations, Sri Lanka
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අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2023(2024)
 கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2023(2024)
 General Certificate of Education (Adv. Level) Examination, 2023(2024)

රසායන විද්‍යාව II
 இரசாயனவியல் II
 Chemistry II

02 E II

උත්තර පත්‍ර චර්යානිර්දේශ
 மூலக்கடமைகள்

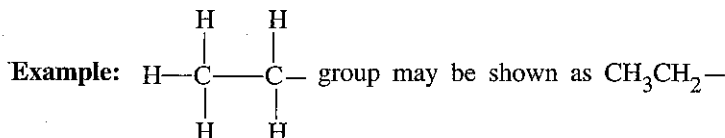
පැය තුනයි
 மூன்று மணித்தியாலம்
 Three hours

අමතර කියවීම් කාලය - මිනිත්තු 10 යි
 மேலதிக வாசிப்பு நேரம் - 10 நிமிடங்கள்
 Additional Reading Time - 10 minutes

Use **additional reading time** to go through the question paper, select the questions and decide on the questions that you give priority in answering.

Index No. :

- * A Periodic Table is provided on page 16.
- * Use of calculators is not allowed.
- * Universal gas constant, $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$
- * Avogadro constant, $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$
- * In answering this paper, you may represent alkyl groups in a condensed manner.



□ PART A — Structured Essay (pages 02 - 08)

- * Answer **all** the questions on the question paper itself.
- * Write your answer in the space provided for each question. Please note that the space provided is sufficient for the answer and that extensive answers are not expected.

□ PART B and PART C — Essay (pages 09 - 15)

- * Answer **four** questions selecting **two** questions from each part. Use the papers supplied for this purpose.
- * At the end of the time allotted for this paper, tie the answers to the three Parts A, B and C together so that Part A is on top and hand them over to the Supervisor.
- * You are permitted to remove **only** Parts B and C of the question paper from the Examination Hall.

For Examiner's Use Only

Part	Question No.	Marks
A	1	
	2	
	3	
	4	
B	5	
	6	
	7	
C	8	
	9	
	10	
Total		

Total

In Numbers	
In Letters	

Code Numbers

Marking Examiner 1	
Marking Examiner 2	
Checked by :	
Supervised by :	

PART A — STRUCTURED ESSAY

Answer all four questions on this paper itself. (Each question carries 100 marks.)

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1. (a) Write the answers to the questions given below on the dotted lines.

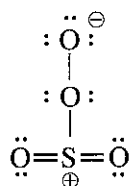
(i) Of the following sets of quantum numbers I, II and III, which one is **not** acceptable in describing an atomic orbital?(I) $n=2$ $l=1$ $m_l=-1$ (II) $n=3$ $l=1$ $m_l=+2$ (III) $n=4$ $l=3$ $m_l=-3$ (ii) Of the three ions Na^+ , K^+ and Ca^{2+} , which one has the **largest** ionic radius?(iii) Of the three cations Li^+ , Na^+ and Mg^{2+} , which one has the **least** polarizing power?(iv) Of the three elements Li, Be and B, which one has the **lowest** second ionization energy?(v) Of the three elements Li, C and Na, which one has the **most** negative value for electron gain energy?(vi) Of the three compounds CH_3OH , $\text{CH}_3\text{CH}_2\text{OH}$ and $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$, which one has the **strongest** intermolecular forces?

(24 marks)

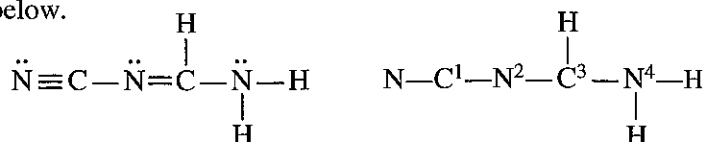
(b) (i) Draw the **most** acceptable Lewis dot-dash structure for the molecule FBrO_3 .

(ii) Give (I) the shape around the central atom and (II) the oxidation number of the central atom of the structure drawn in (i) above.

(I) (shape) (II) (oxidation number)

(iii) The compound SO_4 can be prepared by the reaction of SO_3 and O_3 . An acceptable (stable) Lewis dot-dash structure for the molecule SO_4 is given below. Draw **three** more Lewis dot-dash structures (resonance structures) for this molecule and indicate their stabilities relative to the structure given by writing **stable** or **less stable** or **unstable** under these structures.

(iv) Complete the given table based on the Lewis dot-dash structure and its labelled skeleton given below.



		C ¹	N ²	C ³	N ⁴
I.	the number of VSEPR pairs around the atom				
II.	electron pair geometry around the atom				
III.	shape around the atom				
IV.	hybridization of the atom				

[see page three]

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- Parts (v) to (viii) are based on the Lewis dot-dash structure given in part (iv) above. Labelling of atoms is as in part (iv).

(v) Identify the atomic/hybrid orbitals involved in the formation of σ bonds between the two atoms given below.

- | | | | |
|------|-----------|-------------|-------------|
| I. | $N-C^1$ | N | C^1 |
| II. | C^1-N^2 | C^1 | N^2 |
| III. | N^2-C^3 | N^2 | C^3 |
| IV. | C^3-N^4 | C^3 | N^4 |
| V. | N^4-H | N^4 | H |
| VI. | C^3-H | C^3 | H |

(vi) Identify the orbitals involved in the formation of π bonds between the two atoms given below.

- | | | | |
|-----|-----------|-------------|-------------|
| I. | $N-C^1$ | N | C^1 |
| | | N | C^1 |
| II. | N^2-C^3 | N^2 | C^3 |

(vii) State the approximate bond angles around the C^1 , N^2 , C^3 and N^4 atoms.

C^1 , N^2 , C^3 , N^4

(viii) Arrange the atoms C^1 , N^2 , C^3 and N^4 in the **increasing** order of electronegativity.

..... < < < (56 marks)

(c) State whether the following statements are **true** or **false**. Give reasons for your choice.

(i) An acceptable Lewis dot-dash structure **cannot** be drawn for the OF_4 molecule.

(ii) The **increasing** order of electronegativity of nitrogen in NO_2^+ , NBr_3 , NO_2Cl and HNO_2 is $NBr_3 < NO_2Cl < HNO_2 < NO_2^+$.

(20 marks)

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2. (a) **A** is a *s*-block element in the Periodic Table. Its atomic number is less than 20. When **A** is heated with nitrogen and oxygen separately, two stable compounds **B** and **C** are formed respectively. **B** reacts with water to give the basic compound **D**, and a colourless gas **E** with a pungent odour that turns red litmus blue. Reaction of **A** with water at room temperature also gives **D**, and liberates a colourless, odourless, homonuclear diatomic gas **F**. **A** reacts with dil. H_2SO_4 and gives salt **G** and gas **F**. Compound **H** is formed on reaction of **D** with CO_2 . **H** decomposes on heating to give compound **C** and CO_2 .

(i) Identify species **A** to **H**. (Give chemical formulae.)

A	E
B	F
C	G
D	H

(ii) Write balanced chemical equations for the following reactions.

I. A with water	
II. A with dil. H_2SO_4	
III. B with water	
IV. Decomposition of H	

(iii) Write the colour of the flame given by salts of **A** in the flame test.

..... (65 marks)

(b) Write the chemical formulae of **P**, **Q**, **R** and **S**.

- (i) **P** is a colourless solution. When CO_2 is bubbled through **P**, the solution turns milky. When excess CO_2 is bubbled through the milky solution, a clear colourless solution is obtained. **P** gives an orange-red flame when subjected to the flame test. Identify **P**.

P

- (ii) The metal **M** belongs to the third row of the Periodic Table. **M** reacts with dilute aqueous strong acids and bases. When **M** reacts with a certain dilute aqueous strong acid, it gives the salt **Q** as one of the products. When aqueous BaCl_2 is added to this solution, a white precipitate is formed. The precipitate is insoluble in dilute acids. Identify **Q**.

Q

- (iii) **R** is an ionic compound. When **R** is reacted with dil HCl , a colourless, odourless, linear triatomic gas is evolved as one of the products. **R** gives a yellow colour flame when subjected to the flame test. The metal ion in **R** is found in borax. Identify **R**.

R

- (iv) **S** is an ionic compound. When **S** is heated, a red-brown gas is evolved. The metal in **S** burns with a bright light in air. The metal reacts slowly with hot water, to give a basic compound and $\text{H}_2(\text{g})$. The metal ion contributes to hardness of water. Identify **S**.

S

- (v) Give balanced chemical equations for the following reactions. Indicate precipitates with the symbol $\downarrow$.

I. **P** with **Q**

II. **P** with **R**

III. **R** with **S**

(35 marks)

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3. (a) (i) A closed non-rigid container contains n moles of an ideal gas at a given temperature (T) and pressure (P). Write the relationship between the number of moles of the gas and volume V .

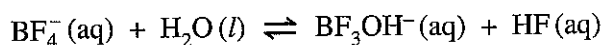
- (ii) A closed non-rigid container of volume 150 cm^3 , contains 3.75 g of $\text{O}_2(\text{g})$ at a given temperature and pressure. If another 1.25 g of $\text{O}_2(\text{g})$ is introduced into this container at the same temperature and pressure, what will be the new volume of the container? ($\text{O} = 16$)

- (iii) At constant temperature and pressure, show that the molar mass (M) of an ideal gas is directly proportional to its density (d).

(40 marks)

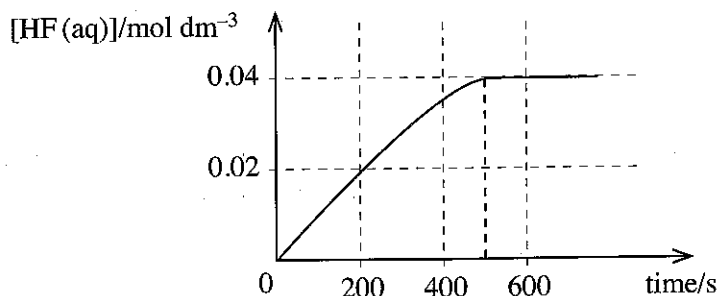
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(b) Consider the reversible reaction given below.



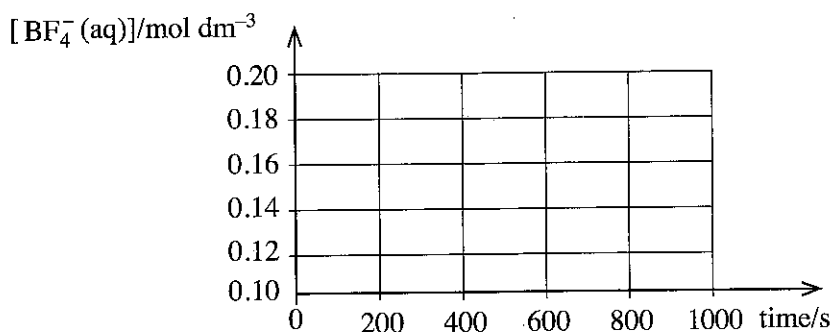
(Note: Neglect the ionization of HF.)

In an experiment carried out to study the kinetics of the above reaction, 0.20 mol dm^{-3} $\text{BF}_4^-(\text{aq})$ was used and the concentration of the product $\text{HF}(\text{aq})$ was measured with time, at a constant temperature. The results obtained are shown in the graph below.



Concentration of $\text{HF}(\text{aq})$ reached the constant value of 0.04 mol dm^{-3} at the equilibrium. It was found that the forward reaction follows the rate law, $\text{rate} = k_f[\text{BF}_4^-(\text{aq})]$ and the value of k_f is $1.0 \times 10^{-5} \text{ s}^{-1}$.

(i) Draw a graph to show the variation of $[\text{BF}_4^-(\text{aq})]$ with time.



(ii) At this temperature, calculate the rate of the forward reaction after 600 s.

(iii) It was found that the reverse reaction is first order with respect to $[\text{BF}_3\text{OH}^-(\text{aq})]$ and first order with respect to $[\text{HF}(\text{aq})]$. Taking k_r as the rate constant of the reverse reaction, write the rate law of the reverse reaction and calculate the value of k_r at this temperature.

(iv) State whether the initial rate method can be used to find the rate law of the reverse reaction in the above experiment. Give reasons for your answer.

(60 marks)

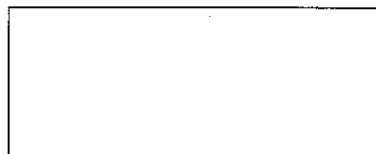
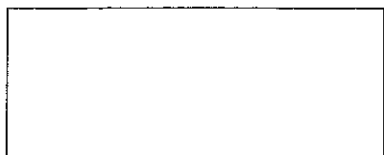
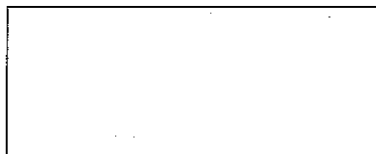
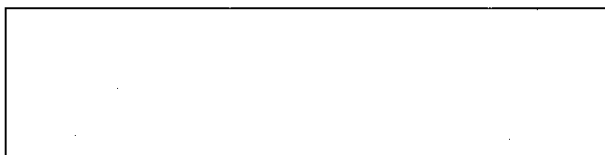
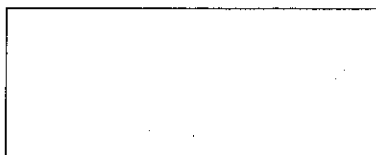
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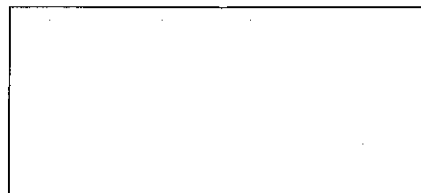
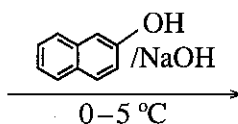
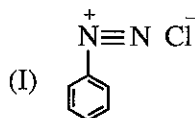
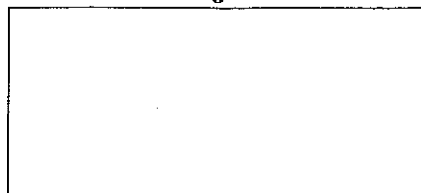
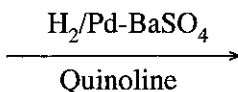
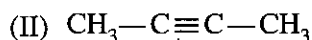
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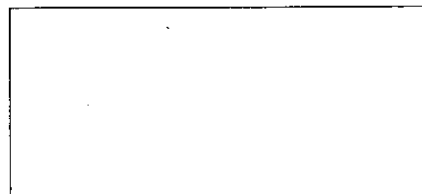
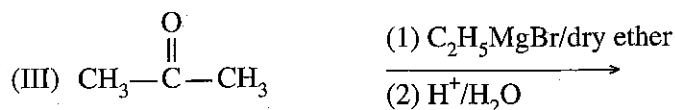
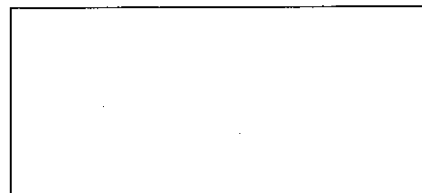
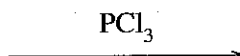
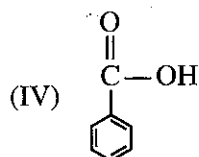
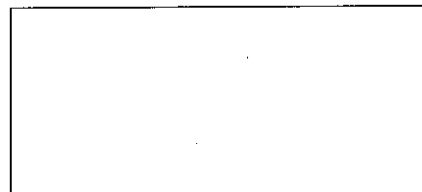
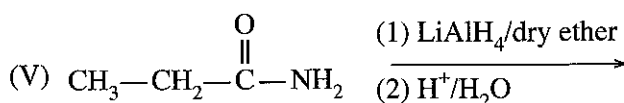
4. (a) A, B and C are structural isomers having the molecular formula $C_5H_{10}O$. None of them show optical isomerism. All three compounds A, B and C give coloured precipitates with 2,4-dinitrophenylhydrazine (2,4-DNP). Of the three compounds A, B and C, only B gives a silver mirror with ammonical $AgNO_3$. When A, B and C are reacted separately with $NaBH_4/CH_3OH$, compounds D, E and F are produced respectively. When D is heated with conc. H_2SO_4 , compounds G and H, which are diastereomers of each other are formed. When E and F are heated separately with conc. H_2SO_4 , compound E gives I while compound F gives all three compounds G, H and I. Compounds G, H and I decolourize Br_2/H_2O .

Draw the structures of A, B, C, D, E, F, G, H and I in the boxes given below.

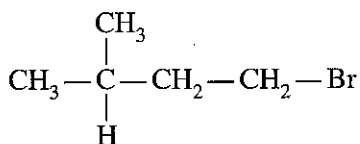
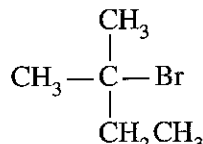
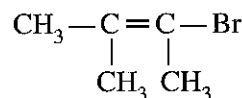
**A****B****C****D****E****F****G and H****I****(54 marks)**

- (b) (i) Draw the structures of the products J, K, L, M and N of the following reactions (I–V) in the given boxes.

**J****K**

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column.**L****M****N****(25 marks)**

(c) Consider the compounds **P**, **Q** and **R** given below.

**P****Q****R**

(i) When compounds **P**, **Q** and **R** are separately treated with aqueous NaOH;

I. Which compound is least likely to undergo a nucleophilic substitution reaction?

.....

II. Which compound is most likely to undergo a nucleophilic substitution reaction which takes place in **one step**?

.....

III. Which compound is most likely to undergo a nucleophilic substitution reaction which takes place in **two steps**?

.....

(12 marks)

(ii) Give the mechanism and the structure of the product formed relevant to the reaction in (c)(i)III above.

(09 marks)

100