අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2026
கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2026
General Certificate of Education (Adv. Level) Examination, 2026

රසායන විද්‍යාව I
இரசாயனவியல் I
Chemistry I

02 E I

පැය දෙකයි
இரண்டு மணித்தியாலம்
Two hours

Instructions:

- *This paper consists of* **09** *pages.*
- *Periodic Table printed on page* **10** *can be detached if necessary.*
- *Answer* ***all*** *the questions.*
- ***Use of calculators is not allowed.***
- *Write your* ***Index Number*** *in the space provided in the answer sheet.*
- *Follow the instructions given on the back of the answer sheet carefully.*
- *In each of the questions* **1** *to* **50**, *pick one of the alternatives from* (1), (2), (3), (4), (5) *which is* ***correct*** *or* ***most appropriate*** *and* ***mark your response on the answer sheet with a cross*** (×) ***in accordance with the instructions given on the back of the answer sheet.***

Universal gas constant $R = 8.314\ \text{J K}^{-1}\ \text{mol}^{-1}$ Planck's constant $h = 6.626 \times 10^{-34}\ \text{J s}$
Avogadro constant $N_A = 6.022 \times 10^{23}\ \text{mol}^{-1}$ Velocity of light $c = 3 \times 10^{8}\ \text{m s}^{-1}$

1. The lines in the Balmer series of the hydrogen emission spectrum result from transitions of electrons denoted by the energy levels, (n = principal quantum number)

(1) $n > 1$ to $n = 1$ (2) $n = 2$ to $n > 2$ (3) $n > 3$ to $n = 3$
(4) $n > 2$ to $n = 2$ (5) $n < 2$ to $n = 2$

2. The outermost p electrons of a nitrogen atom in ground state can be denoted by the quantum numbers $n = 2$ and $l = 1$. According to Hund's rule the m_l and m_s quantum numbers of two of these electrons can be

	electron 1		**electron 2**
(1)	$m_l = +1$, $m_s = +\frac{1}{2}$	and	$m_l = +1$, $m_s = +\frac{1}{2}$
(2)	$m_l = +1$, $m_s = +\frac{1}{2}$	and	$m_l = -1$, $m_s = -\frac{1}{2}$
(3)	$m_l = 0$, $m_s = +\frac{1}{2}$	and	$m_l = +1$, $m_s = +\frac{1}{2}$
(4)	$m_l = 0$, $m_s = +\frac{1}{2}$	and	$m_l = -1$, $m_s = -\frac{1}{2}$
(5)	$m_l = +1$, $m_s = -\frac{1}{2}$	and	$m_l = 0$, $m_s = +\frac{1}{2}$

3. Consider the species Cl^-, Ar and K^+. Which statement is true regarding these species?

(1) They have the same atomic/ionic mass.
(2) They have the same atomic/ionic radius.
(3) They have the same atomic number.
(4) The effective nuclear charge felt by an outermost electron of each species is the same.
(5) They have the same number of p electrons.

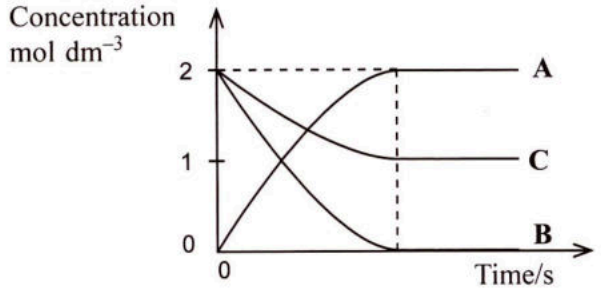
4. Which of the following statements is **false** with regard to Xe and its compounds?

(1) Xe has the highest boiling point among the elements He to Xe in group 18 of the Periodic Table.
(2) Xe has the highest first ionization energy among the group 18 elements of the Periodic Table.
(3) The oxidation numbers of Xe in XeF_4 and XeF_6 are +4 and +6 respectively.
(4) XeF_2 shows a trigonal bipyramidal electron pair geometry.
(5) The atomic radius of Xe is the highest among the first five elements of group 18 of the Periodic Table.

[*See page two*

5. The curves **A**, **B** and **C** given in the diagram show the variations in the concentrations of species that exist in a closed system when the following gas phase reaction takes place.

$$O_2(g) + 2H_2(g) \longrightarrow 2H_2O(g)$$



The correct representation of the species $O_2(g)$, $H_2(g)$ and $H_2O(g)$ respectively, is

(1) **A, B, C** (2) **B, A, C** (3) **B, C, A** (4) **C, A, B** (5) **C, B, A**

6. Which of the following statements is correct about sodium and potassium?

(1) When burnt in air, both sodium and potassium form their peroxides as the main product.
(2) The reaction of both sodium and potassium with water is exothermic.
(3) Both sodium and potassium react with $H_2(g)$ and form their hydroxides.
(4) Potassium does not react with gaseous N_2 whereas sodium forms its nitride by reacting with N_2.
(5) The reaction of both sodium and potassium with dilute mineral acids is endothermic.

7. Consider the following compounds from **A** to **E**.

CH_3CH_2CHO	$CH_3CH_2CH_2CHO$	$CH_3CH_2CH_2OH$	$CH_3CH_2CH_2CH_2OH$	$CH_3\underset{\displaystyle OH}{\underset{\vert}{C}}HCH_2CH_3$
A	**B**	**C**	**D**	**E**

The compound that has the lowest water solubility is

(1) **A** (2) **B** (3) **C** (4) **D** (5) **E**

8. Which of the following is **incorrect**?

(1) When a small amount of 0.10 mol dm^{-3} HCl(aq) is added to a given volume of a mixture of $NH_3(aq)/NH_4Cl(aq)$, the pH of the system drops approximately from 9 to 1.

(2) Dropwise addition of 0.10 mol dm^{-3} NaOH(aq) to a given volume of $H_2O(l)$ results in the rapid increase of pH of the system from approximately 7 to 12.

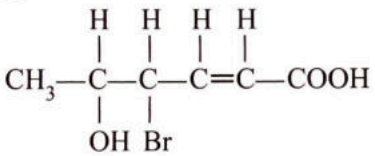
(3) When a small amount of 0.10 mol dm^{-3} NaOH(aq) is added to a given volume of a mixture of $CH_3COOH(aq)/CH_3COONa(aq)$, the change in pH is insignificant.

(4) When a small amount of 0.10 mol dm^{-3} NaOH(aq) is added to a given volume of a mixture of $CH_3COOH(aq)/CH_3COONa(aq)$ the reaction,
$OH^-(aq) + CH_3COOH(aq) \longrightarrow CH_3COO^-(aq) + H_2O(l)$ occurs.

(5) Dropwise addition of 0.10 mol dm^{-3} HCl(aq) to a given volume of 0.10 mol dm^{-3} $NH_3(aq)$ solution results in the change of pH from approximately 11 to 2.

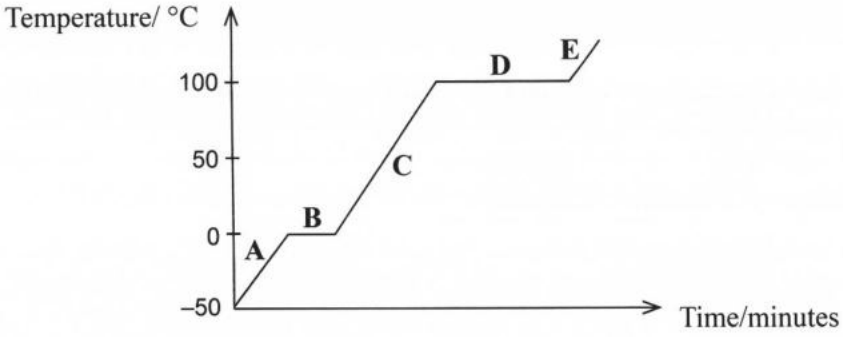
9. What is the IUPAC name of the given compound?

(1) 5-hydroxy-4-bromohex-2-enoic acid
(2) 4-bromo-5-hydroxyhex-4-enoic acid
(3) 4-bromo-5-hydroxyhex-2-enoic acid
(4) 3-bromo-2-hydroxyhex-4-enoic acid
(5) 5-hydroxy-4-bromohex-4-enoic acid



[*See page three*

10. The diagram below shows the temperature variation of a sample of a given mass of water starting from the solid state, upon heating under constant pressure of 1 atm in a closed container.



Which of the following gives the correct representation of the phases or phase equilibria of water present in the regions marked as **A**, **B**, **C**, **D** and **E**? Assume that no mass loss occurred during the process.

	A	**B**	**C**	**D**	**E**
(1)	$H_2O(l)$	$H_2O(s)$	$H_2O(s) \rightleftharpoons H_2O(l)$	$H_2O(g)$	$H_2O(l) \rightleftharpoons H_2O(g)$
(2)	$H_2O(s) \rightleftharpoons H_2O(l)$	$H_2O(s)$	$H_2O(s) \rightleftharpoons H_2O(l)$	$H_2O(g)$	$H_2O(l) \rightleftharpoons H_2O(g)$
(3)	$H_2O(s)$	$H_2O(s) \rightleftharpoons H_2O(l)$	$H_2O(g)$	$H_2O(l) \rightleftharpoons H_2O(g)$	$H_2O(g)$
(4)	$H_2O(l)$	$H_2O(s) \rightleftharpoons H_2O(l)$	$H_2O(s)$	$H_2O(l) \rightleftharpoons H_2O(g)$	$H_2O(g)$
(5)	$H_2O(s)$	$H_2O(s) \rightleftharpoons H_2O(l)$	$H_2O(l)$	$H_2O(l) \rightleftharpoons H_2O(g)$	$H_2O(g)$

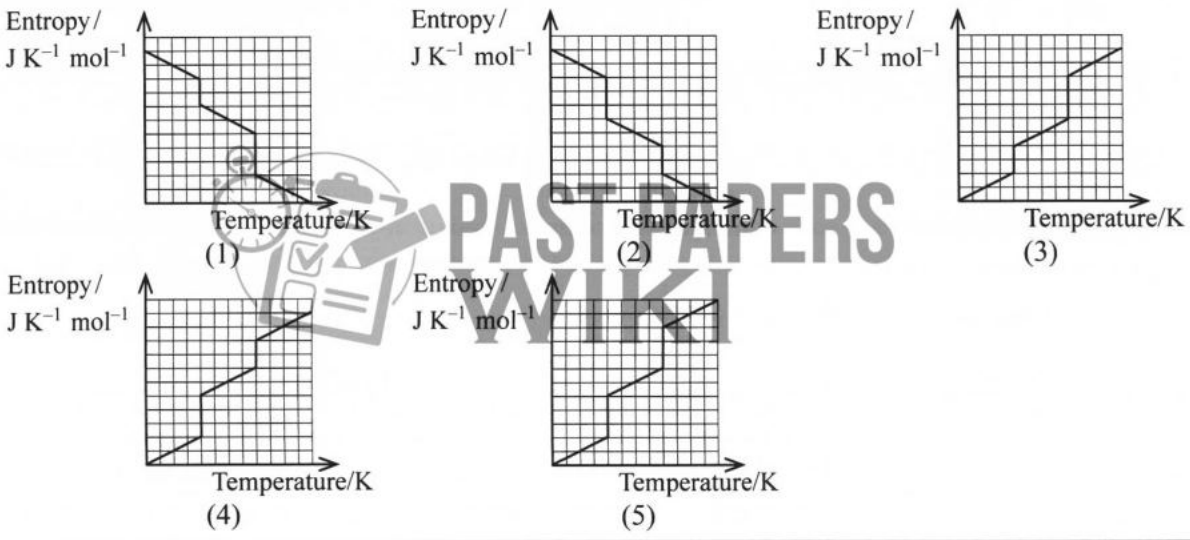
11. To prepare 250.00 cm^3 of 0.005 mol dm^{-3} aqueous solution of Fe^{2+} ions, a student uses a compound with the formula $Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$ found in a bottle in the laboratory. The label on the bottle indicates that the purity of the compound is 80%. The mass of the compound required to prepare the solution is, (H = 1, N = 14, O = 16, S = 32, Fe = 56)

(1) 6.125 g (2) 1.96 g (3) 0.6125 g (4) 0.490 g (5) 0.392 g

12. Which of the following statements is **false** regarding oxoanions of chlorine?

(1) The Lewis dot-dash structures of ClO_2^-, ClO_3^- and ClO_4^- contain one, two and three oxygen-chlorine double bonds respectively.
(2) The oxidation numbers of chlorine in ClO_2^-, ClO_3^- and ClO_4^- are +3, +5 and +7 respectively.
(3) ClO_2^- has an angular shape.
(4) The structure of ClO^- contains an O—Cl double bond.
(5) The electron pair geometry around Cl in ClO_3^- is tetrahedral.

13. Which of the following graphs represents the variation of entropy of a substance when it changes its state as solid ⟶ liquid ⟶ gas upon heating?



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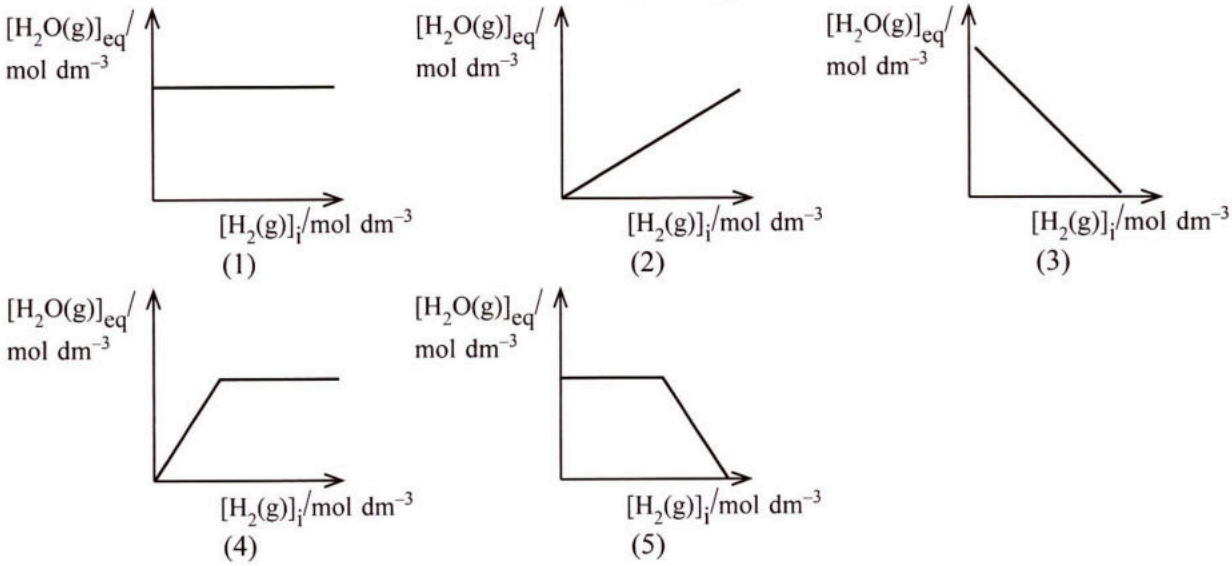
14. Consider the following equilibrium which exists in a closed-rigid container at a given temperature. M is a metal.

$$MO(s) + H_2(g) \rightleftharpoons M(s) + H_2O(g)$$

A series of experiments were carried out with different initial concentrations of $H_2(g)$ keeping MO(s) in excess. Which of the following graphs represents the variation of equilibrium concentration of $H_2O(g)$ with the initial concentration of $H_2(g)$?

initial concentration of $H_2(g)$ $= [H_2(g)]_i$

equilibrium concentration of $H_2O(g)$ $= [H_2O(g)]_{eq}$



15. Consider the reaction scheme given below.

$$CH_3-\underset{\displaystyle CH_3}{\overset{\displaystyle CH_3}{\underset{|}{\overset{|}{C}}}}=CH_2 \xrightarrow{\text{cold conc. } H_2SO_4} \mathbf{X} \xrightarrow[\Delta]{H^+/H_2O} \mathbf{Y}$$

In the reaction scheme given above, the structures of **X** and **Y** are respectively,

(1) $CH_3-\underset{\displaystyle CH_3}{\overset{\displaystyle SO_2OH}{\underset{|}{\overset{|}{C}}}}-CH_3$ and $CH_3-\underset{\displaystyle OH}{\overset{\displaystyle CH_3}{\underset{|}{\overset{|}{C}}}}-CH_3$

(2) $CH_3-\underset{\displaystyle CH_3}{\overset{\displaystyle H}{\underset{|}{\overset{|}{C}}}}-SO_2OH$ and $CH_3-\underset{\displaystyle CH_3}{\overset{\displaystyle H}{\underset{|}{\overset{|}{C}}}}-CH_2OH$

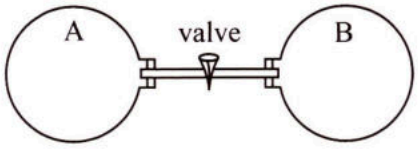
(3) $CH_3-\overset{\displaystyle H}{\underset{\displaystyle H}{\overset{\displaystyle CH_3}{\underset{|}{\overset{|}{C}}}}}-\overset{\displaystyle H}{\underset{\displaystyle H}{\underset{|}{\overset{|}{C}}}}-OSO_2OH$ and $CH_3-\underset{\displaystyle H}{\overset{\displaystyle CH_3}{\underset{|}{\overset{|}{C}}}}-CH_2OH$

(4) $CH_3-\underset{\displaystyle CH_3}{\overset{\displaystyle CH_3}{\underset{|}{\overset{|}{C}}}}-OSO_2OH$ and $CH_3-\underset{\displaystyle OH}{\overset{\displaystyle CH_3}{\underset{|}{\overset{|}{C}}}}-CH_3$

(5) $CH_3-\overset{\displaystyle H}{\underset{\displaystyle H}{\overset{\displaystyle CH_3}{\underset{|}{\overset{|}{C}}}}}-\overset{\displaystyle H}{\underset{\displaystyle H}{\underset{|}{\overset{|}{C}}}}-SO_2OH$ and $CH_3-\underset{\displaystyle H}{\overset{\displaystyle CH_3}{\underset{|}{\overset{|}{C}}}}-CH_2OH$

16. Two rigid containers A and B are connected through a valve as shown below. Initially, container A is filled with an ideal gas while container B is empty. Predict how the entropy and Gibbs free energy of the system change when the valve is opened. (Consider that the temperature does **not** change)

	Entropy	**Gibbs free energy**
(1)	increase	increase
(2)	decrease	decrease
(3)	increase	decrease
(4)	increase	unchanged
(5)	decrease	unchanged



[See page five

17. The elementary reaction $2X(g) + Y(g) \longrightarrow Z(g)$ takes place in a closed container at a given temperature. By what factor would the rate of the reaction increase if the initial concentration of X(g) is doubled and that of Y(g) is tripled?

(1) 5 (2) 6 (3) 12 (4) 18 (5) 24

18. Consider the following reactions.

$4NH_3(g) + 5O_2(g) \longrightarrow 4NO(g) + 6H_2O(l)$: $\Delta G^\circ_{rxn} = -1010$ kJ mol^{-1}

$2NO_2(g) \longrightarrow 2NO(g) + O_2(g)$: $\Delta G^\circ_{rxn} = 70$ kJ mol^{-1}

$4NO_2(g) + O_2(g) + 2H_2O(l) \longrightarrow 4HNO_3(aq)$: $\Delta G^\circ_{rxn} = -170$ kJ mol^{-1}

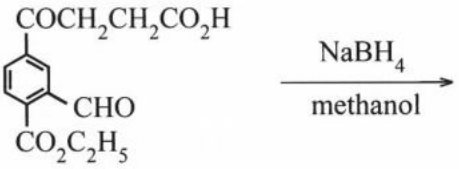
ΔG° of the reaction, $4NH_3(g) + 8O_2(g) \longrightarrow 4HNO_3(aq) + 4H_2O(l)$ in kJ mol^{-1} is

(1) −1320 (2) −1250 (3) −1100 (4) −1040 (5) 1100

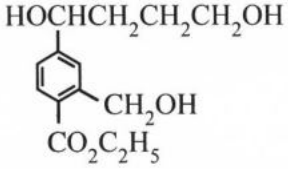
19. Upon the addition of excess dil. HCl which of the solid compounds given below gives a clear solution and evolves a gas which turns a filter paper soaked with acidified $K_2Cr_2O_7$ green?

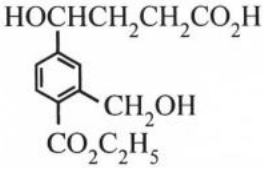
(1) $ZnBr_2$ (2) Ag_2CO_3 (3) $Na_2S_2O_3$ (4) $SrSO_3$ (5) $Cr(OH)_3$

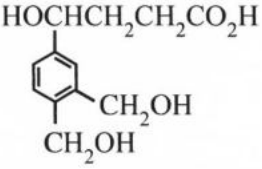
20. Consider the following reaction.

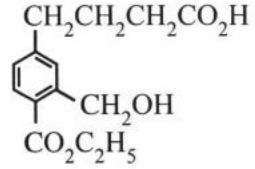


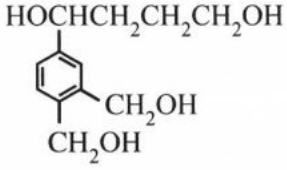
The product formed is,

(1) 

(2) 

(3) 

(4) 

(5) 

21. Consider the reaction, $\frac{1}{2}A_2(g) + \frac{1}{2}B_2(g) \longrightarrow AB(g)$.

The ratio of the values of enthalpy of bond dissociation of $A_2(g)$, $B_2(g)$ and AB(g) is 2 : 1 : 2. The enthalpy change for this reaction is −100 kJ mol^{-1}. Bond dissociation enthalpy value of $A_2(g)$ in kJ mol^{-1} is,

(1) 100 (2) 300 (3) 350 (4) 400 (5) 450

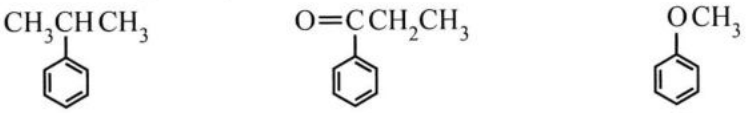
22. An electrochemical cell was constructed using Pt(s) | Fe^{2+}(aq), Fe^{3+}(aq) and Pt(s) | Mn^{2+}(aq), H^+(aq), MnO_4^-(aq) half cells at 25 °C. Which of the following is correct about this cell at 25 °C?

$E^\circ_{Fe^{3+}(aq)/Fe^{2+}(aq)} = +0.77$ V, $E^\circ_{MnO_4^-(aq)/Mn^{2+}(aq)} = +1.51$ V

	Anode	Cathode	Cell notation	e.m.f./V
(1)	Fe^{3+}(aq) | Fe^{2+}(aq)	MnO_4^-(aq) | Mn^{2+}(aq)	Pt(s) | Fe^{2+}(aq), Fe^{3+}(aq) || MnO_4^-(aq), H^+(aq), Mn^{2+}(aq) | Pt(s)	−0.74
(2)	Fe^{3+}(aq) | Fe^{2+}(aq)	MnO_4^-(aq) | Mn^{2+}(aq)	Pt(s) | Fe^{2+}(aq), Fe^{3+}(aq) || MnO_4^-(aq), H^+(aq), Mn^{2+}(aq) | Pt(s)	+0.74
(3)	MnO_4^-(aq) | Mn^{2+}(aq)	Fe^{3+}(aq) | Fe^{2+}(aq)	Pt(s) | Fe^{2+}(aq), Fe^{3+}(aq) || MnO_4^-(aq), H^+(aq), Mn^{2+}(aq) | Pt(s)	+0.74
(4)	Fe^{3+}(aq) | Fe^{2+}(aq)	MnO_4^-(aq) | Mn^{2+}(aq)	Pt(s) | Mn^{2+}(aq), H^+(aq), MnO_4^-(aq) || Fe^{3+}(aq), Fe^{2+}(aq) | Pt(s)	+0.74
(5)	Fe^{3+}(aq) | Fe^{2+}(aq)	MnO_4^-(aq) | Mn^{2+}(aq)	Pt(s) | Mn^{2+}(aq), H^+(aq), MnO_4^-(aq) || Fe^{3+}(aq), Fe^{2+}(aq) | Pt(s)	−0.74

[*See page six*

23. Consider the following compounds.



A **B** **C**

The increasing order of ease of the Friedel-Crafts acylation of these compounds is

(1) **A** < **B** < **C** (2) **A** < **C** < **B** (3) **B** < **A** < **C** (4) **B** < **C** < **A** (5) **C** < **B** < **A**

24. The steps in the mechanism of a reaction in the presence of a catalyst are shown below.

Step I : $Ag^{+}(aq) + Ce^{4+}(aq) \longrightarrow Ag^{2+}(aq) + Ce^{3+}(aq)$

Step II : $Tl^{+}(aq) + Ag^{2+}(aq) \longrightarrow Tl^{2+}(aq) + Ag^{+}(aq)$

Step III : $Tl^{2+}(aq) + Ce^{4+}(aq) \longrightarrow Tl^{3+}(aq) + Ce^{3+}(aq)$

Which of the following correctly identifies the overall reaction, the catalyst and the intermediate/ intermediates?

	overall reaction	**catalyst**	**intermediate/intermediates**
(1)	$2Ce^{4+}(aq) + Tl^{+}(aq) \longrightarrow 2Ce^{3+}(aq) + Tl^{3+}(aq)$	$Ag^{+}(aq)$	$Ag^{2+}(aq)$, $Tl^{2+}(aq)$
(2)	$2Ce^{4+}(aq) + Tl^{+}(aq) \longrightarrow 2Ce^{3+}(aq) + Tl^{3+}(aq)$	$Tl^{2+}(aq)$	$Ag^{2+}(aq)$
(3)	$Ce^{4+}(aq) + Tl^{+}(aq) \longrightarrow Tl^{2+}(aq) + Ce^{3+}(aq)$	$Ag^{+}(aq)$	$Ag^{2+}(aq)$
(4)	$Ce^{4+}(aq) + Tl^{+}(aq) \longrightarrow Tl^{2+}(aq) + Ce^{3+}(aq)$	$Ag^{2+}(aq)$	$Ag^{+}(aq)$
(5)	$Ce^{4+}(aq) + Tl^{2+}(aq) \longrightarrow Tl^{3+}(aq) + Ce^{3+}(aq)$	$Ag^{+}(aq)$	$Ag^{2+}(aq)$, $Tl^{+}(aq)$

25. Which of the following statements is **incorrect**?

(1) When an inert gas is added to a gaseous equilibrium system in a closed-rigid container at a given temperature, total pressure of the system increases while the equilibrium constant remains unchanged.

(2) When an inert gas is added to a gaseous equilibrium system in a closed-flexible container at a given temperature keeping the total pressure constant, the equilibrium constant remains unchanged.

(3) When the pressure of the equilibrium system $2HgO(s) \rightleftharpoons 2Hg(l) + O_2(g)$ in a closed-rigid container at a given temperature is increased, the equilibrium point shifts to the right side.

(4) To increase the yield of $SO_3(g)$ in the equilibrium system $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ at a constant temperature in a closed-flexible container the volume of the container should be decreased by applying an external pressure.

(5) When the pressure of the equilibrium system $C(s) + 2H_2(g) \rightleftharpoons CH_4(g)$ in a closed-rigid container at constant temperature is increased, rate of the forward reaction increases.

26. The solubility of $Mg(OH)_2(s)$ in water at 25 °C and 100 °C are 1.0×10^{-4} mol dm^{-3} and 4.0×10^{-3} mol dm^{-3}, respectively. How do the concentration of $OH^{-}(aq)$ and the pH value of a $Mg(OH)_2$ solution at 100 °C differ from those of a solution at 25 °C?

At 25 °C, $K_w = 1.0 \times 10^{-14}$ mol^2 dm^{-6} and at 100 °C $K_w = 5.5 \times 10^{-14}$ mol^2 dm^{-6}.

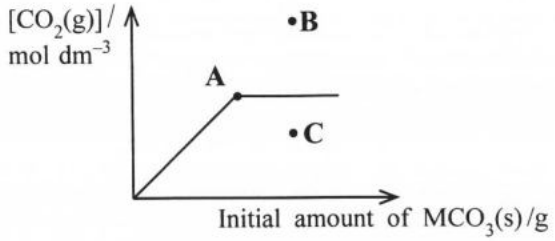
	[$OH^{-}(aq)$]	**pH**
(1)	higher	no change
(2)	higher	higher
(3)	no change	higher
(4)	lower	lower
(5)	higher	lower

27. How many isomeric compounds exist with the molecular formula C_8H_8O, which have a benzene ring in its structure and gives a coloured precipitate with 2,4-dinitrophenylhydrazine (2,4-DNP)?

(1) 2 (2) 3 (3) 4 (4) 5 (5) 6

[*See page seven*

28. The given graph was obtained from several experiments carried out for the dissociation of the metal carbonate $MCO_3(s)$ to $MO(s)$ and $CO_2(g)$ at a particular temperature in a closed-rigid container. The concentrations of $CO_2(g)$ were measured on changing the initial amount of $MCO_3(s)$.



Which of the following statements is **incorrect** about this system? K is the equilibrium constant and Q is the reaction quotient.

(1) The equilibrium, $MCO_3(s) \rightleftharpoons MO(s) + CO_2(g)$ is established only after the point **A**.
(2) At the point **B**, $Q > K$.
(3) At the point **C**, $Q < K$.
(4) Beyond the point **A**, pressure of the system does not change.
(5) At both points **B** and **C**, $Q = K$.

29. The reaction of metallic sodium with water is an irreversible reaction. 1.80 g of pure water was cautiously added to 460 g of metallic Na. Maximum amount of H_2 gas produced, in moles, is, (H = 1, O = 16 and Na = 23)

(1) 20 (2) 10 (3) 0.20 (4) 0.10 (5) 0.05

30. When dilute HCl is added to a solid sample of a mixture containing $CaCO_3$ and $ZnCO_3$ in a 1:1 mass ratio, a clear solution was obtained. The $Ca^{2+} : Zn^{2+}$ mole ratio in the final solution is approximately,
(C = 12, O = 16, Ca = 40 and Zn = 65)

(1) 1 : 1 (2) 5 : 4 (3) 4 : 5 (4) 2 : 1 (5) 1 : 2

- For each of the questions **31** to **40**, one or more responses out of the four responses (*a*), (*b*), (*c*) and (*d*) given is/are correct. Select the correct response/responses. In accordance with the instructions given on your answer sheet, mark

(1) if only (*a*) and (*b*) are correct.
(2) if only (*b*) and (*c*) are correct.
(3) if only (*c*) and (*d*) are correct.
(4) if only (*d*) and (*a*) are correct.
(5) if **any other** number or combination of responses is correct.

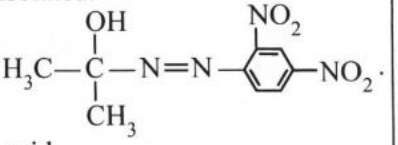
Summary of above Instructions

(1)	(2)	(3)	(4)	(5)
Only (*a*) and (*b*) are correct	Only (*b*) and (*c*) are correct	Only (*c*) and (*d*) are correct	Only (*d*) and (*a*) are correct	**Any other** number or combination of responses is correct

31. Which of the following statements is/are correct regarding the standard hydrogen electrode?

(*a*) $E°$ value of the electrode is considered as 0.00 V.
(*b*) The half-reaction is irreversible.
(*c*) The half-reaction is always spontaneous.
(*d*) It can act as the anode or cathode depending on the electrochemical cell under consideration.

32. Which of the following statements is/are correct regarding the reaction of acetone with 2,4-dinitrophenylhydrazine (2,4-DNP)?

(*a*) It is a two-step reaction where the second step is a dehydration reaction.
(*b*) The product formed in the first step of this reaction can be isolated.
(*c*) The structure of the coloured product formed in this reaction is  .
(*d*) This reaction can be used to distinguish acetone from acetic acid.

[*See page eight*

33. Soap is a sodium or potassium salt of fatty acids. Identify the correct statement/statements regarding hard water and soap.

(*a*) The cleaning efficiency of soap is higher in hard water than in pure water.
(*b*) Precipitates formed by reacting polyvalent cations with soap are more dense than water.
(*c*) A precipitate is formed by the attraction of anions of fatty acids to a polyvalent cation.
(*d*) Some of the polyvalent cations in hard water are Ca^{2+}, Mg^{2+} and Fe^{2+}.

34. Which of the following statements is/are true with regard to the chemistry of nitrogen?

(*a*) Nitrogen is slightly soluble in water under atmospheric pressure while the solubility of nitrogen in water increases with pressure.
(*b*) Nitrogen shows oxidation numbers from –3 to +5 in compounds.
(*c*) Nitrogen has several allotropes.
(*d*) Atmospheric nitrogen is converted to NH_3 during lightning.

35. Consider the following half reactions at 25 °C.

$Ag^+(aq) + e \longrightarrow Ag(s)$: $E° = +0.80$ V
$Cu^{2+}(aq) + 2e \longrightarrow Cu(s)$: $E° = +0.34$ V
$Zn^{2+}(aq) + 2e \longrightarrow Zn(s)$: $E° = -0.76$ V

Which of the following statements is/are correct?

(*a*) When a rod of Zn(s) metal is placed in a $CuSO_4(aq)$ solution, Cu(s) metal is deposited on the Zn(s) rod.
(*b*) Among the electrochemical cells that could be assembled from the half-cells represented by the above, $Zn(s) \mid Zn^{2+}(aq) \parallel Ag^+(aq) \mid Ag(s)$ has the highest e.m.f. value.
(*c*) When a rod of Ag(s) metal is placed in a $CuSO_4(aq)$ solution, Cu(s) metal is deposited on the Ag(s) rod.
(*d*) $H_2(g)$ is not liberated when Cu(s) is added to a solution of 0.50 mol dm^{-3} $H_2SO_4(aq)$ acid.

36. Which of the following compounds will **not** form a Grignard reagent as the final product, when it is reacted with Mg in dry ether?

(*a*) $CH_3\overset{\overset{O}{\|}}{C}CH_2CH_2Br$
(*b*) $CH_3\overset{\overset{NH_2}{|}}{C}HCH_2CH_2Cl$
(*c*) $CH_3C{\equiv}C{-}H$
(*d*) $BrCH_2CH{=}CH_2$

37. Dichlorodifluoromethane (R-12) is used as a refrigerant in household refrigerators. Identify the correct statement/statements.

(*a*) The volatile compound R-12 once released has a high potential to reach the stratosphere.
(*b*) While R-12 is stable in the troposphere, it decomposes to form chlorine radicals, in the stratosphere.
(*c*) R-12 is a greenhouse gas that contributes to global warming.
(*d*) R-12 depletes the ozone formed from photochemical smog.

38. At a given temperature, a rigid-closed container having a volume of 1.0 dm^3 filled with a real gas has a lower pressure than the pressure calculated for the equal amount of an ideal gas. Which of the following statements **does not/do not** give valid reasons for the observed non-ideal behaviour?

(*a*) The volume of the real gas molecules cannot be neglected when compared to the volume of the container.
(*b*) Velocities of the real gas molecules are lower than that of an ideal gas.
(*c*) Because the molecules of the real gas are attracted to each other, they do not exert a force on the container walls which is equal to that exerted by an ideal gas.
(*d*) The molecules of the real gas are attracted towards the walls of the container.

39. Which of the following industrial processes utilize/utilizes the counter current principle?

(*a*) The production of NaOH by the membrane cell method
(*b*) The extraction of Fe by a blast furnace
(*c*) The production of H_2SO_4 by the contact process
(*d*) The production of NH_3 by the Haber-Bosch process

[*See page nine*

40. Which of the following statements is/are true with regard to oxoacids of sulfur?

(*a*) Concentrated sulfuric acid can act as a dehydrating agent.

(*b*) The reaction of $SO_2(g)$ with water produces sulfuric acid.

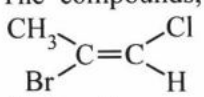
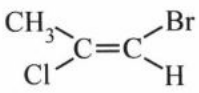
(*c*) Hot concentrated sulfuric acid can react as an oxidizing agent with certain metals and non-metals.

(*d*) Both H_2SO_4 and H_2SO_3 contain two S=O bonds each, in their structures.

- In question numbers **41** to **50**, two statements are given in respect of each question.

From the Table given below, select the response, out of the responses (1), (2), (3), (4) and (5), that **best** fits the two statements and mark appropriately on your answer sheet.

Response	First Statement	Second Statement
(1)	True	True, and correctly explains the first statement
(2)	True	True, but does **not** explain the first statement correctly
(3)	True	False
(4)	False	True
(5)	False	False

	First Statement	Second statement
41.	Benzene reacts with Cl_2 in the presence of $FeCl_3$ and yields  .	Cl_2 reacts with $FeCl_3$ to form the electrophile Cl^+, which reacts with the electron rich benzene ring.
42.	Unlike *s*-block elements, *p*-block elements do **not** give a characteristic colour to the oxidizing flame in the flame test.	The first ionization energies of all *p*-block elements of periods 2 and 3 in the Periodic Table are greater than those of *s*-block elements of the corresponding period.
43.	$H_2O(s) \rightleftharpoons H_2O(l)$ is an endothermic process.	The process of melting of ice is favoured by high temperature and high pressure.
44.	Ozone reduces the mechanical strength of rubber.	Ozone reacts with double bonds present in rubber.
45.	Even though the number of valence shell electron pairs of the central atoms in ICl_2^-, N_3^- and $BeCl_2$ differ from each other, they have the same shape.	In molecules and ions, lone pairs of electrons on the central atom are held as far as possible from each other to reduce repulsing each other.
46.	The entropy change of freezing of liquid water to ice is higher than the entropy change of sublimation of ice.	Solids have less entropy compared to liquids and gases.
47.	At a given temperature, the molar solubility of $Ag_2C_2O_4(s)$ in a $HNO_3(aq)$ solution is higher than its molar solubility in distilled water.	In the presence of a dilute acid, $C_2O_4^{2-}(aq)$ ions are converted to $HC_2O_4^-(aq)$ ions and/or to $H_2C_2O_4(aq)$.
48.	The compounds,  and  are diastereoisomers.	Any two compounds which are **not** mirror images of each other are diastereoisomers.
49.	Polyethylene is categorized as an addition polymer.	The double bonds in ethylene are responsible for its reactions.
50.	Concentrated nitric acid is stored in brown coloured glass bottles in laboratories.	Nitric acid decomposes to nitrogen dioxide in the presence of light.

* * *

The Periodic Table

	1																2
1	**H**																**He**
	3	4											5	6	7	8	9	10
2	**Li**	**Be**											**B**	**C**	**N**	**O**	**F**	**Ne**
	11	12											13	14	15	16	17	18
3	**Na**	**Mg**											**Al**	**Si**	**P**	**S**	**Cl**	**Ar**
	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
4	**K**	**Ca**	**Sc**	**Ti**	**V**	**Cr**	**Mn**	**Fe**	**Co**	**Ni**	**Cu**	**Zn**	**Ga**	**Ge**	**As**	**Se**	**Br**	**Kr**
	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
5	**Rb**	**Sr**	**Y**	**Zr**	**Nb**	**Mo**	**Tc**	**Ru**	**Rh**	**Pd**	**Ag**	**Cd**	**In**	**Sn**	**Sb**	**Te**	**I**	**Xe**
	55	56	**La-**	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
6	**Cs**	**Ba**	**Lu**	**Hf**	**Ta**	**W**	**Re**	**Os**	**Ir**	**Pt**	**Au**	**Hg**	**Tl**	**Pb**	**Bi**	**Po**	**At**	**Rn**
	87	88	**Ac-**	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118
7	**Fr**	**Ra**	**Lr**	**Rf**	**Db**	**Sg**	**Bh**	**Hs**	**Mt**	**Ds**	**Rg**	**Cn**	**Nh**	**Fl**	**Mc**	**Lv**	**Ts**	**Og**

57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
La	**Ce**	**Pr**	**Nd**	**Pm**	**Sm**	**Eu**	**Gd**	**Tb**	**Dy**	**Ho**	**Er**	**Tm**	**Yb**	**Lu**
89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
Ac	**Th**	**Pa**	**U**	**Np**	**Pu**	**Am**	**Cm**	**Bk**	**Cf**	**Es**	**Fm**	**Md**	**No**	**Lr**

AL/2026/02/E-II(A)

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2026
கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2026
General Certificate of Education (Adv. Level) Examination, 2026

රසායන විද්‍යාව II
இரசாயனவியல் II
Chemistry II

02 E II

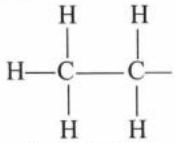
පැය තුනයි
மூன்று மணித்தியாலம்
Three hours

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 you will answer and decide which of them you will prioritise.

Index No. : .....

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

Example:  group may be shown as CH_3CH_2—

❑ PART A — Structured Essay (pages 2 - 8)

- *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 9 - 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 :	

[*see page two*

PART A — STRUCTURED ESSAY

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

Do not write in this column.

1. (*a*) You are provided with the following list of chemical species (elements, ions and compounds). Selecting from the list, write the answers to the questions on the relevant dotted lines.

Li^+, Cs^+, Br^-, I^-, CCl_4, ICl, C, Al, SO_3, SO_2, S

(i) element which as the central atom in a compound, can display *sp*, sp^2, sp^3 hybridizations .....

(ii) ion having the highest polarizability .....

(iii) ion having the highest polarizing power .....

(iv) element which can form electron deficient compounds .....

(v) compound having the strongest London forces .....

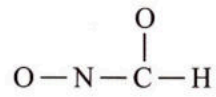
(vi) compound which displays the strongest dipole-dipole interactions .....

(vii) compound displaying bond angles of 120° .....

(viii) element which can form compounds by exceeding 8 valence electrons .....

(32 *marks*)

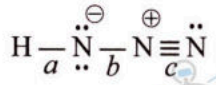
(*b*) (i) Draw the **most** acceptable Lewis dot-dash structure for the molecule $HCNO_2$. Its skeleton is given below.



(ii) Draw **two** Lewis dot-dash structures (resonance structures) for $HCNO_2$, excluding the Lewis structure you have drawn above.

(21 *marks*)

(*c*) (i) In the given HN_3 molecule, identify the bonds (as *a*, *b*, *c*) formed by the overlap of the following atomic/hybrid orbitals. Indicate whether the bond is σ or π type.
Note: *c* is a triple bond.



orbitals	bond	σ or π
$s - sp^3$		
$sp - sp$		
$sp - sp^3$		
$p - p$		

[*see page three*

Do not write in this column.

(ii) Write the number of VSEPR pairs, electron pair geometry, shape and hybridization of the central sulfur atom in each of the following molecules.

molecule	number of VSEPR pairs	electron pair geometry	shape around central atom	hybridization
SF_3N				
Cl_2SO				

(32 *marks*)

(*d*) Arrange the following species in increasing order of the property given in parenthesis.

I. Li_2CO_3 , Na_2CO_3 , $MgCO_3$ (decomposition temperature)

..... < ..... < .....

II. Li , Na , B (atomic radius)

..... < ..... < .....

III. SO_3^{2-} , SO_4^{2-} , SO_3 (electronegativity of S)

..... < ..... < .....

(15 *marks*)

100

2. (*a*) (i) **W** is a *p*-block element in the Periodic Table. Its atomic number is less than 20. It has two allotropes; one of them (**A**) is odourless and the other (**B**), has a pungent smell. In many countries **B** is used to disinfect water.

Identify **W** ..... **A** ..... **B** .....

(ii) **W** and the other elements in the group which **W** belongs to, form simple covalent hydrides. **C** is the hydride formed by **W**. Except for **C**, the other hydrides in the group are poisonous.

I. Identify **C**. .....

II. **C** has remarkably different properties to those of the other hydrides. List **three** such properties (other than being non-poisonous) and give **the reason** for those differences.

properties : (1) .....

(2) .....

(3) .....

reason : .....

III. On going down the group;

- Does the covalent bond angle of these hydrides increase or decrease?

  .....

  Briefly explain your answer.

  .....

- Does the bond length of these hydrides increase or decrease?

  .....

  Briefly explain your answer.

  .....

[*see page four*

Do not write in this column.

(iii) **D** is a compound composed of the same elements as **C** (ratio of elements is different). It is a viscous liquid. It can act as both an oxidizing agent as well as a reducing agent. It also undergoes disproportionation.

I. Identify **D**. .....

II. Write balanced **half reactions** for the following.

- **D** acting as an oxidizing agent

.....

- **D** acting as a reducing agent

.....

III. Write the balanced chemical equation for the disproportionation of **D**.

.....

(54 *marks*)

(*b*) (i) **X** is also a *p*-block element of the Periodic Table with an atomic number less than 20. It also exists as allotropes. One of the allotropes is a thermal and electrical conductor.

I. Identify **X**. .....

II. Name **three** allotropes of **X**.

.....

(ii) **E** is a compound of **X** and **W**, in the ratio 1:1. It is an odourless, poisonous gas.

Identify **E**. .....

(iii) **F** is a compound of **X** and **W**, in the ratio 1:2. It contributes to global warming. Its solid form is used as a freezing agent in the food industry.

I. Identify **F**. .....

II. What is the common name used for the solid form of **F**? .....

(24 *marks*)

(*c*) **M** is a *s*-block element in the Periodic Table. Its first three successive ionization energies in kJ mol^{-1} are respectively; 589, 1145 and 4912. **M** reacts readily with cold water to give compound **G** and a gas. The cation of **M** is a major contributor to hardness of water.

(i) Identify **M** and **G**.

M ..... **G** .....

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

I. The initial reaction of **G** with **F** .....

II. The reaction of **G** with excess **F**.....

(14 *marks*)

(*d*) **J** is a common oxoacid of **X**. It can be prepared by dissolving **F** in **C** under pressure.

(i) Write the chemical formula of **J**. .....

(ii) Draw the structure of **J** showing all the bonds.

J

(08 *marks*)

100

[*see page five*

Do not write in this column.

3. HA(aq) is a weak acid with $K_a = 4.0 \times 10^{-4}$ mol dm^{-3} at 25 °C. In an experiment, 20.00 cm^3 of 0.25 mol dm^{-3} HA(aq) solution was titrated with 0.10 mol dm^{-3} KOH(aq) solution at 25 °C.

(i) Calculate the initial pH value of the HA(aq) solution at 25 °C. (log values for 1–10 are given below.)

number	1	2	3	4	5	6	7	8	9	10
log value	0.00	0.30	0.48	0.60	0.70	0.78	0.85	0.90	0.95	1.00

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(ii) Calculate the volume of KOH(aq) solution needed to reach the equivalence point.

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(iii) State whether the mixture at the equivalence point is acidic, basic or neutral.

.....

Justify your answer using an appropriate calculation.

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[see page six

Do not write in this column.

(iv) It was found that the pH value of the mixture after the addition of 80.00 cm^3 of KOH(aq) was between 12 and 13. Explain this observation with an appropriate calculation.

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(v) Calculate the pH value of the mixture at the half-equivalence point.

.....

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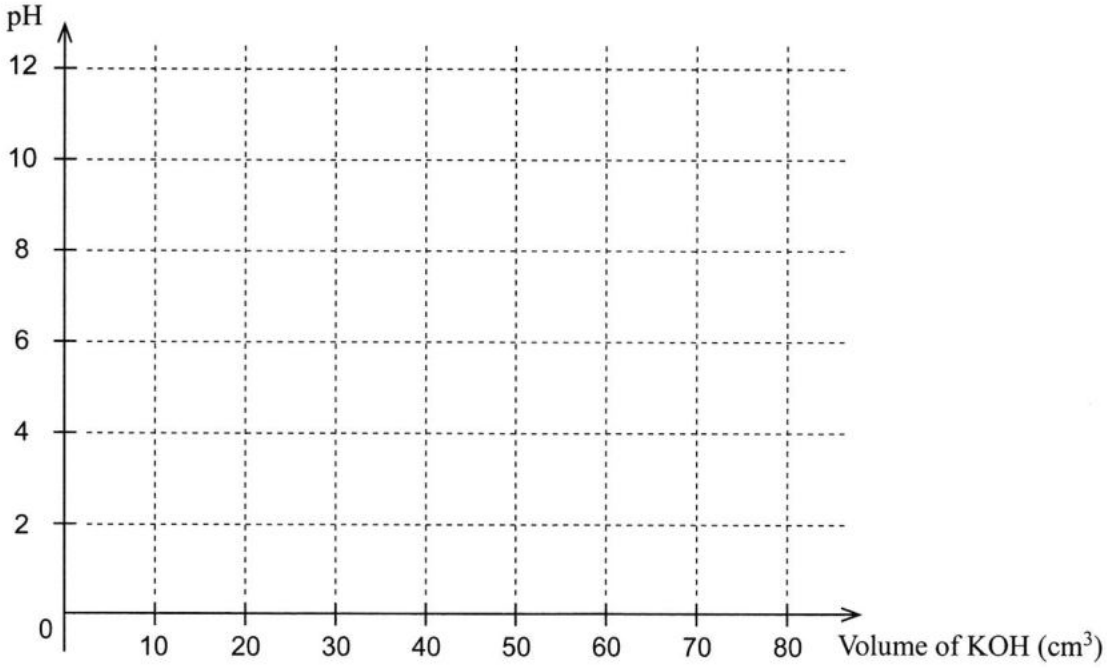
(vi) Sketch the titration curve below for this titration. Mark the points of pH values and corresponding volumes of KOH(aq) obtained in (i) – (v) above on the titration curve.



(vii) Explain why the pH of the solution is acidic in the range of 10 – 40 cm^3 volume of KOH added, and basic after the equivalence point.

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.....

[see page seven

Do not write in this column.

(viii) pK_a values of acid-base indicators of methyl red and bromothymol blue are 5.1 and 7.1, respectively. Identify, giving reasons which indicator is the most suitable to observe a sharp end point of the above titration.

.....

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.....

.....

(100 *marks*)

100

4. (*a*) The compound **A** having five (05) carbon atoms contains only C, H, and Cl. Its relative molecular mass is 137. When **A** reacts with aqueous NaOH, compound **B** having a relative molecular mass of 100 is formed. (C = 12, H = 1, O = 16, Cl = 35.5)

(i) Write the molecular formula of **A**. .....

(ii) Write the molecular formula of **B**. .....

When **A** is hydrogenated with H_2/Pd in the presence of $BaSO_4$/quinoline, compound **C** having a relative molecular mass of 139 is formed. Both compounds **A** and **B** exhibit optical isomerism. **A** and **B** do not give precipitates with ammoniacal $AgNO_3$. When **B** is oxidised with pyridinium chlorochromate, compound **D** ($C_5H_4O_2$) is formed. When treated with aqueous NaOH, **D** undergoes a self condensation reaction. Compound **B** is converted to **E** (C_5H_7OCl) when treated with conc. HCl and $ZnCl_2$.

(iii) Draw the structures of **A**, **B**, **C**, **D** and **E** in the relevant boxes.

A

B

C

D

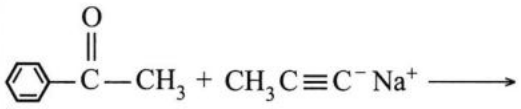
E

(55 *marks*)

[*see page eight*

Do not write in this column.

(*b*) For the reactions given below, write the type of reaction [Nucleophilic addition (A_N), Nucleophilic substitution (S_N), Electrophilic addition (A_E), Electrophilic substitution (S_E), Elimination (E), acid-base (AB)] and draw the structure of the major product in the relevant box in the table.

	Reaction	Type of reaction	Major product
(i)	$CH_3CH_2C{\equiv}C{-}H$ + HBr (excess) $\longrightarrow$		
(ii)	$CH_3CH_2MgBr + H_2O \longrightarrow$		
(iii)	$CH_3{-}\underset{\displaystyle CH_3}{\underset{\vert}{CH}}{-}Br$ + alcoholic KOH $\longrightarrow$		
(iv)	 + $CH_3C{\equiv}C^-Na^+ \longrightarrow$		

(24 *marks*)

(*c*) (i) Draw the structure of the major product **F** of the following reaction in the given box.

$$CH_3CH_2CH{=}CHCH_2CH_3 \xrightarrow{Br_2}$$

F

(ii) Write the mechanism of the reaction stated above.

(21 *marks*)

100

* *

[*see page nine*

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கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2026
General Certificate of Education (Adv. Level) Examination, 2026

රසායන විද්‍යාව II
இரசாயனவியல் II
Chemistry II

02 E II

* Universal gas constant $R = 8.314$ J K^{-1} mol^{-1}
* Avogadro constant $N_A = 6.022 \times 10^{23}$ mol^{-1}

PART B — ESSAY

Answer ***two*** *questions only.* (*Each question carries* **150** ***marks.***)

5. (*a*) Consider the reaction shown below at 300 K and 1 atm.

$$Fe_2O_3(s) + 3CO(g) \rightleftharpoons 2Fe(s) + 3CO_2(g)$$

The following thermodynamic data at 300 K and 1 atm are given.

	CO(g)	CO_2(g)	Fe(s)	Fe_2O_3(s)
ΔH_f°/ kJ mol^{-1}	–111	–394	0	–824
S°/ J K^{-1} mol^{-1}	197	213	27	87

(i) Calculate the ΔH°_{rxn} of the reaction at 300 K.

(ii) Calculate the ΔS°_{rxn} of the reaction at 300 K.

(iii) Show that the reaction is "Theoretically possible at any temperature". State the assumption you made.

(iv) Write the expression for the equilibrium constant, K_P of the reaction at 300 K.

(v) Derive the expression for the equilibrium constant, K_C of the reaction, in terms of K_P at 300 K.

(vi) It was found that the K_P value of the reaction is 125 at 300 K, while the value is 27 at 900 K.

I. Calculate the ratios of partial pressures of CO_2(g) and CO(g), $(P_{CO_2(g)} / P_{CO(g)})$ at these two temperatures.

II. Give reasons for the difference in the two values obtained in I above.

(vii) Explain the effect on the equilibrium position when the total pressure of the system is increased at a given temperature.

(viii) The reduction of Fe_2O_3(s) to Fe(s) can be carried out in a blast furnace by using CO(g). The maximum temperature achievable in a blast furnace is 2300 K. Even though Al_2O_3(s) can be reduced to Al(s) in a similar reaction using CO(g), explain by means of a suitable calculation why it is **not** carried out in a blast furnace. Use the data given below for your calculation.

	CO(g)	CO_2(g)	Al(s)	Al_2O_3(s)
ΔH_f°/ kJ mol^{-1}	–111	–394	0	–1676
S°/ J K^{-1} mol^{-1}	197	213	28	51

(120 *marks*)

(*b*) Ag_2CrO_4(s) is a sparingly soluble salt in water with $K_{sp} = 4.0 \times 10^{-12}$ mol^3 dm^{-9} at 25 °C.

(i) Write the equilibrium reaction that exists in a saturated aqueous solution of Ag_2CrO_4(s) at 25 °C.

(ii) Calculate the concentration of Ag^+(aq) in a saturated aqueous solution of Ag_2CrO_4(s) at 25 °C.

[*see page ten*

(iii) When dil. HCl was added dropwise to a saturated Ag_2CrO_4 solution in a beaker, first the reddish-colour of the solution decreased and turned yellow with formation of a precipitate on the bottom of the beaker. When the addition of HCl is further continued, the colour of the solution turned to an intense-orange. Explain these observations using appropriate chemical reactions.

(30 *marks*)

6. (*a*) At a given temperature, the rate law of a first-order reaction A $\longrightarrow$ P can be expressed as $2.303 \log\left(\frac{A_0}{A_t}\right) = kt$, where A_0 is the concentration of A at time, $t = 0$, A_t is the concentration of A at time, $t = t$, and k is the rate constant.

Note: partial pressures can also be used instead of concentrations.

(i) In an experiment carried out for a gas-phase first order reaction, the time required to complete 99% of the reaction was t_1, and that for the 90% completion was t_2. Show that $t_1 = 2t_2$.

(ii) Show that the half-life $\left(t_{1/2}\right)$ of the above reaction is given by the expression $t_{1/2} = \frac{0.693}{k}$. k is the rate constant. ($\log_{10} 2 = 0.301$)

(iii) A first-order gas phase elementary decomposition reaction A(g) $\longrightarrow$ B(g) + C(g) occurs in a closed-rigid container at a given temperature. When pure A(g) was placed initially in the empty container, the pressure of the system was 40 mmHg. The pressure of the system was 76 mmHg, when $t = 300$ s. Calculate the rate constant (k) and half-life $\left(t_{1/2}\right)$ of the reaction at this temperature.

(iv) Calculate the rate of the reaction given in part (iii) above in mmHg s^{-1} when the pressure of the system is 50 mmHg.

(90 *marks*)

(*b*) (i) Explain the following observation.

The boiling point of a liquid mixture prepared by mixing two completely miscible liquids A and B in a specified ratio was greater than the boiling points of each of the two liquids A and B.

(ii) Sketch the diagram for the variation of partial pressures of A and B against composition of liquid mixtures of A and B. Pure liquid B has a higher boiling point than pure liquid A.

(30 *marks*)

(*c*) (i) Define the partition coefficient (K_D) of a substance which distributes in two immiscible liquid phases.

(ii) In an experiment to evaluate the partition coefficient of ammonia between trichloromethane and water, at a given temperature the following procedure was carried out. A given amount of liquid ammonia was added to a given volume of water and then a given volume of trichloromethane was added and shaken vigorously. After reaching the equilibrium, 10.00 cm^3 of aqueous layer required 12.00 cm^3 of 0.25 mol dm^{-3} HCl(aq) for the complete neutralization, while 25.00 cm^3 of trichloromethane layer required 6.00 cm^3 of 0.05 mol dm^{-3} HCl(aq). Calculate K_D of ammonia between trichloromethane and aqueous layers at this temperature.

(30 *marks*)

[*see page eleven*

7. (*a*) Consider the following reduction potentials at 25 °C.

$$E^{\circ}_{H^+(aq)/H_2(g)} = 0.00\ V\ ,\ E^{\circ}_{H_2O(l)/H_2(g)} = -0.83\ V\ ,\ E^{\circ}_{Na^+(aq)/Na(s)} = -2.71\ V$$

$$E^{\circ}_{Cl_2(g)/Cl^-(aq)} = 1.36\ V\ ,\ E^{\circ}_{O_2(g)/H_2O(l)} = 1.23\ V$$

(i) Sketch a labelled diagram of an electrochemical cell that can be used to electrolyse an aqueous NaCl solution using inert electrodes.

(ii) Write **all the possible** half reactions that can take place at the anode and the cathode.

(iii) Giving reasons, identify the half reactions actually occurring at the anode and the cathode.

(iv) If the gas formed at the anode is collected at 1 atm and 25 °C by passing a constant current of 1.2 A for 2 hours through the cell, calculate the volume of the gas. (1 F = 96 500 C mol^{-1})

Note: Assume that the gas does not react with or dissolve in the electrolyte solution.

State any other assumptions made in your calculation. (1 atm = 101 kPa)

(v) Write the half reactions occurring at the anode and the cathode, when molten NaCl(*l*) is used as the electrolyte in the above cell.

(75 *marks*)

(*b*) **X** is a *d*-block element that belongs to the fourth period of the Periodic Table. **X** forms an amphoteric oxide $\mathbf{X_1}$. The most common ion of **X** is $\mathbf{X^{n+}}$. In dilute aqueous solution, $\mathbf{X^{n+}}$ forms the coloured species $\mathbf{X_2}$.

On treatment of the solution containing $\mathbf{X_2}$ separately with:

- aqueous NH_3, the blue-green gelatinous precipitate $\mathbf{X_3}$ is formed.
- excess dil. NaOH, followed by H_2O_2, the yellow species $\mathbf{X_4}$ is formed.

In acidic medium $\mathbf{X_4}$ gives species $\mathbf{X_5}$.

On bubbling $SO_2(g)$ through an acidic solution containing $\mathbf{X_5}$, the ions $\mathbf{X^{n+}}$ and SO_4^{2-} are formed.

(i) Identify **X**, $\mathbf{X^{n+}}$, $\mathbf{X_1}$, $\mathbf{X_2}$, $\mathbf{X_3}$, $\mathbf{X_4}$ and $\mathbf{X_5}$. (Give chemical formulae. Reasons are **not** required.)

(ii) Write balanced ionic equations for I, II and III given below.

I. Formation of $\mathbf{X_4}$ from $\mathbf{X_2}$ on treatment with excess dil. NaOH followed by H_2O_2

II. Formation of $\mathbf{X_5}$ from $\mathbf{X_4}$ in acidic medium

III. Reaction of $\mathbf{X_5}$ with $SO_2(g)$ in acidic medium

(iii) Write the IUPAC name of $\mathbf{X_2}$.

(47 *marks*)

(*c*) **Y** is also a *d*-block element, which belongs to the fourth period in the Periodic Table. **Y** has two common oxidation numbers, **p** and **q**. **q** is greater than **p**. $\mathbf{Y^{p+}}$ forms the dirty-green precipitate $\mathbf{Y_1}$ with dil. NaOH. $\mathbf{Y^{q+}}$ forms a yellow/yellow-brown species $\mathbf{Y_2}$ in aqueous solution. On reaction of $\mathbf{Y^{q+}}$ with NH_4SCN(aq), a red complex $\mathbf{Y_3}$ is formed.

(i) Identify **Y**, $\mathbf{Y_1}$, $\mathbf{Y_2}$ and $\mathbf{Y_3}$. (Give chemical formulae). Write the oxidation numbers **p** and **q**. (Reasons are **not** required.)

(ii) Give the balanced ionic equation for the reaction of $\mathbf{Y^{p+}}$ with an acidic solution of MnO_4^- ions.

(iii) Write the IUPAC name of $\mathbf{Y_2}$.

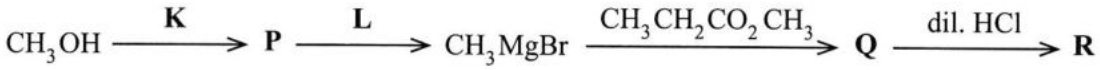
(28 *marks*)

[*see page twelve*

PART C — ESSAY

*Answer **two** questions only. (Each question carries **150 marks.**)*

8. (*a*) Identify the reagents **K** and **L**, and the products **P**, **Q** and **R** of the following reaction scheme.



(30 *marks*)

(*b*) Two products are obtained from the compound $CH_3CH_2CH_2Br$ when it reacts with $CH_3\underset{\displaystyle CH_3}{\overset{|}{C}}HO^-$ ion.

(i) Draw the structures of these **two** products.

(ii) Write the mechanisms of the reactions giving these **two** products.

(iii) Give reasons as to why **both** these mechanisms take place.

(30 *marks*)

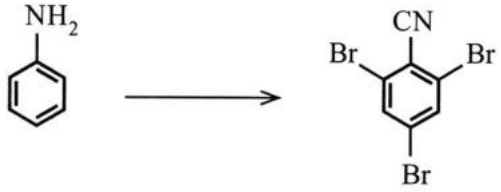
(*c*) (i) Draw the resonance structures of aniline.

(ii) Consider the two compounds aniline and ethylamine. Giving reasons, state which of these two compounds is more basic.

(20 *marks*)

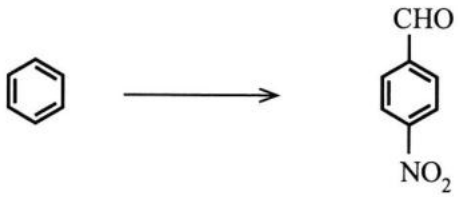
(*d*) Answer the following parts.

(i) Show how you would carry out the following conversion using not more than **three** steps.



(25 *marks*)

(ii) Show how you would carry out the following conversion using not more than **five** steps.



(45 *marks*)

[*see page thirteen*

9. (*a*) **A**, **B**, **C** and **D** are water soluble inorganic compounds. Only two of these compounds contain *d*-block elements. **A** and **B** are white solids, while **C** and **D** are coloured solids. When aqueous solutions of **A** and **B** are mixed together the white precipitate **E** is formed. **E** is insoluble in hot water and in dil. HCl. When **E** is separated by filtration and dil. NaOH is added to the filtrate, the white gelatinous precipitate **F** is formed. **F** dissolves in excess dil. NaOH and gives **G**.

Mixing aqueous solutions of **B** and **C** gives the white precipitate **H**. **H**, is soluble in hot water. **H** is separated by filtration and the filtrate is divided into two portions. On addition of dil. NH_4OH to one portion of the filtrate a light-blue precipitate, **I** is formed. On addition of more dil. NH_4OH to the precipitate **I**, a deep blue solution **J** is formed.

To the other portion of the filtrate, when a saturated solution of **D** is added, followed by the slow addition of conc. H_2SO_4 along the wall of the test tube, a brown ring is formed.

On mixing **B** and **D** the white precipitate **E** is formed.

Identify the compounds **A**, **B**, **C**, **D**, **E**, **F**, **G**, **H**, **I** and **J**. (Give chemical formulae. Explanations are **not** required.)

(75 *marks*)

(*b*) A sample of 5.00 g of white brass [Cu–Zn–Sn alloy] used to make inexpensive jewellery, was dissolved in 10.00 cm^3 of conc. HNO_3 acid and diluted to 1.00 dm^3 in a volumetric flask with water.

The resultant solution **X**, contains Cu^{2+}, Zn^{2+} and Sn^{2+} as the only metal ions.
(Sn = 118.7, Zn = 65.3, Cu = 63.5, O = 16.0, C = 12.0, H = 1.0)

Experiment A

Upon adding dilute NaOH to 50.00 cm^3 of solution **X**, a precipitate is formed. On the addition of excess NaOH, part of the precipitate dissolves, resulting in a precipitate having a mass of 0.0925 g.

Note: Consider that Sn^{2+} reacts with dil. NaOH in a manner similar to that of Zn^{2+}.

Experiment B

To 25.00 cm^3 portion of solution **X**, solid Na_2CO_3 was added to reduce the acidity of the medium. Then excess 5% KI solution was added.

Upon adding I^-, Cu^{2+} reduces to CuI(s), producing I_2. A certain amount of the total I_2 formed is reduced back to I^- by Sn^{2+}, which completely oxidizes to Sn^{4+}. The remaining I_2 was titrated with standard 0.05 mol dm^{-3} $Na_2S_2O_3$ solution using a few drops of starch solution as the indicator. The volume of $Na_2S_2O_3$ consumed was 8.00 cm^3.

Note: Consider that NO_3^- ions do not react under the above conditions.

Experiment C

To a 50.00 cm^3 portion of solution **X**, excess saturated Na_2CO_3 was added resulting in a precipitate having a mass of 0.4380 g.

Note: Saturated Na_2CO_3 will precipitate all metal ions except Li^+, Na^+ and K^+.

(i) Write balanced ionic equations for all the reactions relevant to **experiment A**.

(ii) Calculate the percentage of Cu in the solid white brass sample.

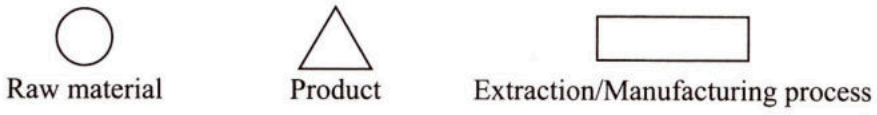
(iii) Write balanced chemical or ionic equations for all the reactions relevant to **experiments B and C**.

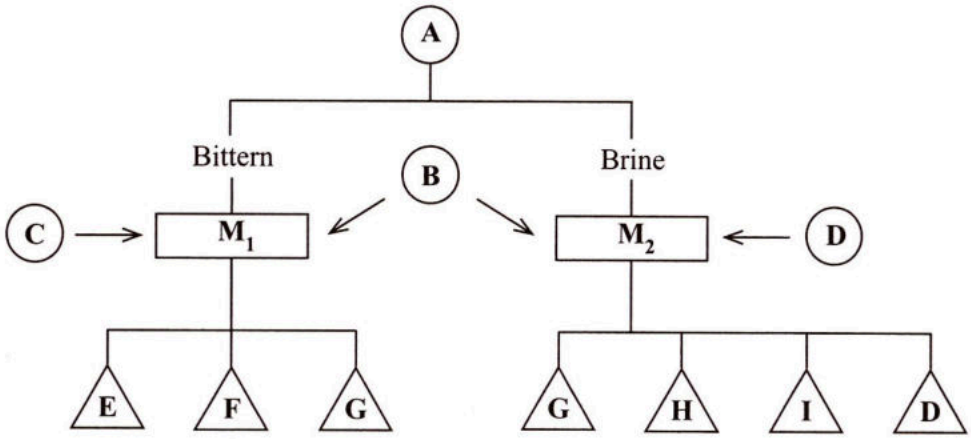
(iv) Calculate the mass ratio between Sn and Zn (Sn/Zn) in the white brass sample.

(75 *marks*)

[*see page fourteen*

10. (*a*) The following flow chart shows the industrial extraction/manufacturing process of an element and a compound. The following symbols are used to represent raw materials, products, and extraction/manufacturing processes.





A and **B** are naturally occurring while **C** and **D** are produced by other industrial processes.

C can be regenerated by reacting **E** with water. **D** is regenerated in $\mathbf{M_2}$. **H** is used to remove hardness of water.

G is a gaseous pollutant, which can be reused in $\mathbf{M_2}$.

(i) Write the raw materials **A**, **B**, **C** and **D**.

(ii) Name the extraction/manufacturing processes $\mathbf{M_1}$ and $\mathbf{M_2}$.

(iii) Write the products **E**, **F**, **G**, **H** and **I**.

(iv) State **two** ways in which the efficiency of the $\mathbf{M_2}$ process can be increased.

(v) State the importance of regenerating **C** and **D**.

(vi) Give **two** uses each for **D** and **E** (other than what is indicated in the flow chart or given in the question).

(60 *marks*)

(*b*) Oxygen is essential for life. Aquatic organisms depend on dissolved oxygen in water. Dissolved oxygen is an important indicator of water quality, commonly measured using the Winkler method. (H = 1, O = 16, S = 32, I = 127)

(i) Explain briefly why, oxygen has a poor solubility in water.

(ii) I. State **two** processes that increase dissolved oxygen in a waterbody.

II. State **three** processes that decrease dissolved oxygen in a waterbody.

(iii) In the Winkler method, determination of dissolved oxygen is done in three steps. First, dissolved oxygen is fixed by oxidizing $Mn(OH)_2$ to MnO_2. Next, excess KI is added in an acidic medium to reduce MnO_2 to Mn^{2+} liberating iodine. Finally, the released iodine is titrated with a standard thiosulfate solution.

I. Write balanced ionic equations to represent the above **three** steps in the Winkler method.

II. If 12.40 cm^3 of 0.015 mol dm^{-3} thiosulfate solution was required for the determination of the amount of dissolved oxygen in a 100.00 cm^3 water sample, calculate the amount of dissolved oxygen in water in mg dm^{-3}.

(50 *marks*)

[*see page fifteen*

(*c*) The questions given below are related to the process of manufacturing coconut toddy from sweet toddy.

(i) Write the main compound produced by the fermentation of sweet toddy.

(ii) Write balanced chemical equations to show the chemical changes that take place in sweet toddy during the formation of the main compound you stated in (i) above.

(iii) Name the method used to separate the main compound given by you in (i) above, from coconut toddy.

(iv) State why the method named in (iii) above is used to separate the main compound.

(40 *marks*)

* * *

[*see page sixteen*

The Periodic Table

1	1 H																2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	La-Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	Ac-Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og

57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr