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Department of Examinations - North Central Province



තෙවන වාර පරීක්ෂණය

Third Term Test

2025

රසායන විද්‍යාව I
Chemistry I

02

E

I

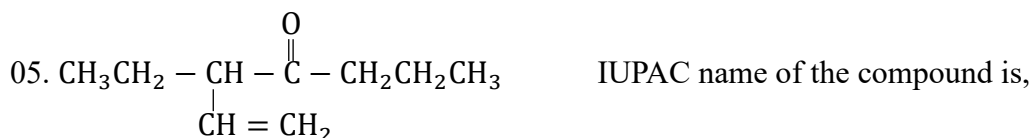
පැය තුනයි
Three Hours

Instructions

- A periodic table is provided.
- Answer all questions.
- Calculators are not allowed.
- Write your examination number in the designated place on the answer sheet.
- Read the other instructions on the back of the answer sheet carefully.
- For each question from 1 to 50, select the correct or most suitable answer from the options (1), (2), (3), (4) and (5) and mark it with a cross (x) as per the instructions on the back of the answer sheet.

Universal Gas Constant , $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$ Planck's constant $h = 6.626 \times 10^{-34} \text{ Js}$
 Avogadro Constant , $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$ Speed of light $c = 3 \times 10^8 \text{ ms}^{-1}$

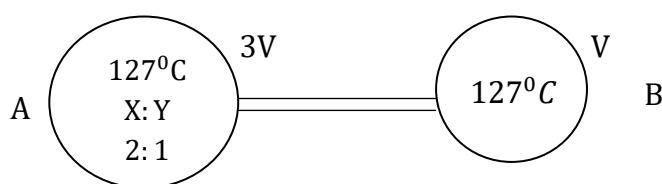
01. For a Cr($z = 24$) atom, the number of electrons with quantum numbers $n = 3$, $l = 1$ and $ml = +1$ respectively are,
 (1) 8, 12, 5 (2) 13, 12, 5 (3) 8, 5, 12 (4) 12, 12, 5 (5) 12, 5, 2
02. An element A forms the T-shaped ion AF_3^- . A is a non-transition element. The group to which A belongs is,
 (1) 14 (2) 15 (3) 17 (4) 16 (5) 18
03. 10 cm^3 of pure $\text{C}_2\text{H}_5\text{OH}$ is diluted with water to a total volume of 100 cm^3 . 20.00 cm^3 of this solution is titrated with $0.5 \text{ mol dm}^{-3} \text{ KMnO}_4$ solution. What is the burette reading?
 (Density of $\text{C}_2\text{H}_5\text{OH}$ (l) is 0.8 g cm^{-3})
 (1) 27 cm^3 (2) 52 cm^3 (3) 17 cm^3 (4) 56 cm^3 (5) 28 cm^3
04. The following first-order reaction occurs in a rigid container at a constant temperature.
 $2\text{X}_{(\text{g})} \rightarrow 2\text{Y}_{(\text{g})} + \text{Z}_{(\text{g})}$
 When only X is present, the pressure is P_1 . If the half-life is 12 seconds, what is the time taken for the pressure in the container to be $\frac{23P_1}{16}$?
 (1) 18 (2) 12 (3) 36 (4) 24 (5) 06



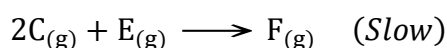
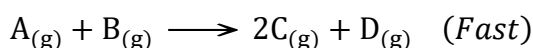
- (1) propyl 2-ethyl-2-butenolate (2) propyl-3-ethyl-3-butenolate
(3) propyl 2-ethyl-3-butenolate (4) 2-ethylpropyl-2-propenoate
(5) propyl-2-ethyl-2-oxopentenoate

06. Initially, when the tap is closed, bulb A contains ideal gases X and Y in a 2:1 mole ratio at a pressure of P. Bulb B is empty. The tap is then opened and the system is allowed to reach equilibrium. The tap is closed again and bulb A is cooled to 27 °C. After that, gas Y is introduced into bulb A at a constant temperature until the pressure in bulb A is P. What is the new mole fraction of Y in bulb A?

- (1) $\frac{4}{7}$ (2) $\frac{5}{8}$ (3) $\frac{3}{8}$ (4) $\frac{1}{2}$ (5) $\frac{3}{4}$



07. A certain reaction proceeds according to the mechanism below.

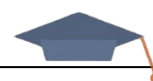


At a constant temperature, gases are introduced into a rigid container and the above reactions are allowed to proceed. The pressure of the system was studied as a function of time. The most correct statement is,

- (1) The pressure decreases and becomes constant.
(2) The pressure increases and then decreases.
(3) The pressure increases and then decreases and becomes constant.
(4) The pressure decreases and then increases.
(5) The pressure increases and becomes constant.

08. The shapes of the species XeOF_3^- , XeOF_4 , BrF_5 , SF_4 & ICl_2^- are respectively,

	XeOF_3^-	XeOF_4	BrF_5	SF_4	ICl_2^-
(1)	Tetrahedral	Trigonal bipyramidal	T-shaped	Tetrahedral	Angular
(2)	Square planar	Angular	Pyramidal	See-saw	Linear
(3)	Square planar	Square pyramidal	Square pyramidal	See-saw	Linear
(4)	Square pyramidal	Square planar	Square pyramidal	See-saw	Linear
(5)	Square planar	Square pyramidal	Trigonal bipyramidal	See-saw	Linear



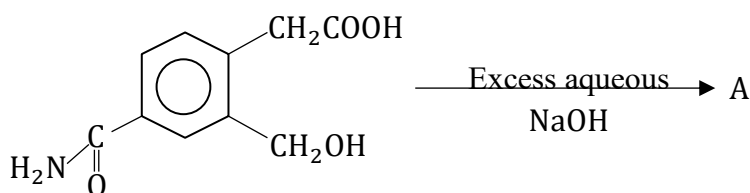
09. At 298 K, the standard enthalpy values for the formation of $\text{H}_2\text{O}(\text{l})$, $\text{CO}_2(\text{g})$, and $\text{C}_6\text{H}_5\text{OH}(\text{l})$ are -286 kJ mol^{-1} , -393 kJ mol^{-1} , and -162 kJ mol^{-1} respectively. What is the standard enthalpy of combustion for $\text{C}_6\text{H}_5\text{OH}(\text{l})$?

- (1) $-1125 \text{ kJ mol}^{-1}$ (2) $-3054 \text{ kJ mol}^{-1}$ (3) $-2375 \text{ kJ mol}^{-1}$
 (4) -179 kJ mol^{-1} (5) $-1025 \text{ kJ mol}^{-1}$

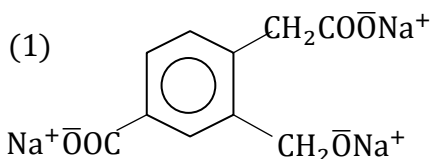
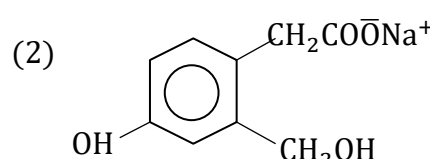
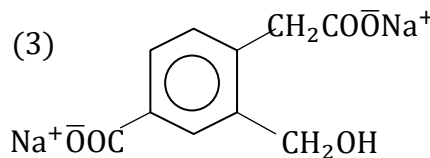
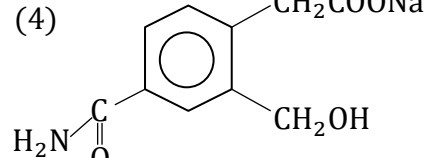
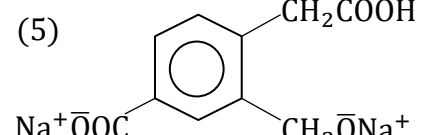
10. Select the true statement from the followings.

- (1) All hydrogen carbonates of group 1 metals are stable in the solid state.
 (2) All group 1 metals form superoxides with excess oxygen.
 (3) The nitrates of all group 1 metals release oxygen gas upon decomposition.
 (4) Ba salts give a red color in the flame test.
 (5) The carbonates of all group 1 metals are thermally stable.

11.

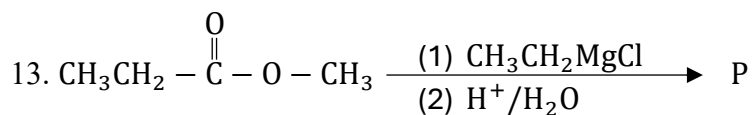


The product A in the above reaction is,

- (1)  (2) 
- (3)  (4) 
- (5) 

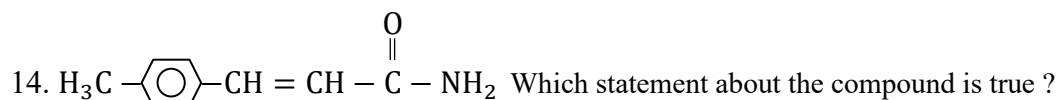
12. The order of increasing electronegativity of the S atom in the species SO_2 , SO_3 , H_2S & H_2SO_4 is,

- (1) $\text{H}_2\text{S} < \text{H}_2\text{SO}_4 < \text{SO}_2 < \text{SO}_3$ (2) $\text{H}_2\text{S} < \text{SO}_2 < \text{SO}_3 < \text{H}_2\text{SO}_4$
 (3) $\text{SO}_2 < \text{SO}_3 < \text{H}_2\text{S} < \text{H}_2\text{SO}_4$ (4) $\text{SO}_2 < \text{H}_2\text{S} < \text{SO}_3 < \text{H}_2\text{SO}_4$
 (5) $\text{H}_2\text{SO}_4 < \text{H}_2\text{S} < \text{SO}_2 < \text{SO}_3$



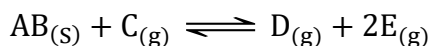
Which statement about product P is true?

- (1) It shows optical isomerism.
- (2) It decolorizes acidified KMnO_4 solution.
- (3) It gives immediate turbidity with anhydrous ZnCl_2 / conc. HCl .
- (4) It gives an orange colour with Brady's reagent.
- (5) It is oxidized to a ketone with PCC



- (1) It gives an orange-yellow precipitate with 2,4-DNP.
- (2) It gives a primary amine with NaBH_4 .
- (3) It gives a silver mirror with Tollen's reagent.
- (4) When heated with aqueous NaOH , it releases ammonia.
- (5) It releases CO_2 with Na_2CO_3 .

15. The following reaction reaches equilibrium at 927°C .



When 0.225 mol of $\text{C}_{(\text{g})}$ reacts with $\text{AB}_{(\text{s})}$ in a closed container of volume 2 dm^3 at 927°C , the equilibrium partial pressure of E is $7.5 \times 10^5 \text{ Pa}$. What is the value of K_C for the above reaction? (in mol m^{-3})

- (1) 5651 (2) 1.50 (3) 18.75 (4) 4254 (5) 750

16. When A and B are mixed, an ideal solution is formed. The vapour pressures of pure A and B at 298 K are $4 \times 10^4 \text{ Pa}$ and $1.2 \times 10^4 \text{ Pa}$ respectively. At 298 K, the mole fraction of A in the vapor phase in equilibrium with this solution is 0.4. What is the total pressure of the system?

- (1) $3.67 \times 10^4 \text{ Pa}$ (2) $2.5 \times 10^4 \text{ Pa}$ (3) $1.67 \times 10^4 \text{ Pa}$
 (4) $6.45 \times 10^4 \text{ Pa}$ (5) $1.67 \times 10^5 \text{ Pa}$

17. What is the pH at the equivalence point when a $1 \times 10^{-3} \text{ mol dm}^{-3}$ CH_3COOH acid solution is titrated with a $1 \times 10^{-3} \text{ mol dm}^{-3}$ NaOH solution?

($K_a(\text{CH}_3\text{COOH}) = 1.8 \times 10^{-5} \text{ mol dm}^{-3}$)

- (1) 7.7 (2) 9.8 (3) 11.4 (4) 6.3 (5) 4.8



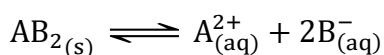
18. A substance A is present in an aqueous solution of volume $2V$. A portion of CCl_4 solution, which is immiscible with water, with volume V is used to extract A in three times. The distribution coefficient of A between CCl_4 and water is 3. If the initial number of moles of A in the aqueous phase is 'a', what is the number of moles of A remaining in the aqueous phase after the third extraction?

- (1) $\frac{a}{512}$ (2) $\frac{8a}{25}$ (3) $\frac{8a}{125}$ (4) $\frac{a}{81}$ (5) $\frac{8a}{27}$

19. 25.00 cm^3 of a mixture containing Fe^{2+} and Fe^{3+} ions was reacted with a KMnO_4 solution. 25.00 cm^3 of KMnO_4 was consumed for the reaction to be complete. Then, Zn powder was added to the same solution and heated. After the reaction was complete, the excess Zn was removed. The same solution was titrated again with the same KMnO_4 solution, and the burette reading was 40.00 cm^3 . What is the mole ratio of $\text{Fe}^{2+} : \text{Fe}^{3+}$ in the initial 25.00 cm^3 solution?

- (1) 5:8 (2) 4:5 (3) 5:3 (4) 3:5 (5) 8:6

20. A sparingly soluble salt $\text{AB}_2(\text{s})$ shows the following equilibrium at 25°C .



The solubility product of the salt $\text{AB}_2(\text{s})$ is $1.08 \times 10^{-7} \text{ mol}^3 \text{ dm}^{-9}$. The concentration of B^- in the solution in mol dm^{-3} is,

- (1) 10.8×10^{-13} (2) 3×10^{-4} (3) 3×10^{-5}
(4) 6×10^{-3} (5) $(108)^{\frac{1}{3}} \times 10^{-3}$

21. Compounds A and B are enantiomers of each other. Which of the following can be the molecular formula for compounds A and B?

- (1) $\text{C}_3\text{H}_8\text{O}$ (2) $\text{C}_3\text{H}_6\text{O}_2$ (3) C_7H_{16} (4) C_5H_{10} (5) $\text{C}_3\text{H}_6\text{O}$

22. A compound A gives a white precipitate when treated with $\text{NH}_3/\text{AgNO}_3$. When compound A is treated with $\text{H}_2/\text{Pd}/\text{BaSO}_4/\text{quinoline}$, & the product is treated with dilute H_2SO_4 and heated to give B. When B reacts with acidic KMnO_4 , C is formed. C reacts with Brady's reagent but does not react with Tollen's reagent. The product formed when dilute NaOH is added to product C is,

- (1) $\text{CH}_3\text{CH}_2\overset{\text{OH}}{\underset{|}{\text{CH}}} - \text{CH}_2\text{CH}_2\text{CHO}$ (2) $\text{CH}_3\text{CH}_2 - \overset{\text{OH}}{\underset{\text{CH}_3}{\text{C}}} - \text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$
(3) $\text{CH}_3\text{CH}_2\overset{\text{OH}}{\underset{|}{\text{CH}}} - \text{CH}_2\text{CH}_2 - \overset{\text{OH}}{\underset{|}{\text{CH}}}\text{CH}_3$ (4) $\text{CH}_3 - \overset{\text{OH}}{\underset{\text{CH}_3}{\text{C}}} - \text{CH}_2 - \overset{\text{O}}{\underset{||}{\text{C}}} - \text{CH}_3$
(5) $\text{CH}_3 - \overset{\text{OH}}{\underset{\text{H}}{\text{C}}} - \text{CH}_2 - \text{CH}_2\text{COOH}_3$

23. At 25°C, V_1 cm³ of a mol dm⁻³ B(aq), a weak monoacidic basic solution, is taken into a beaker and V_2 cm³ ($V_2 < V_1$) of a b mol dm⁻³ ($b < a$) HCl solution is added. The pH of the final mixture is, (Dissociation constant of water at 25°C is K_w . Dissociation constant of base B is K_b)

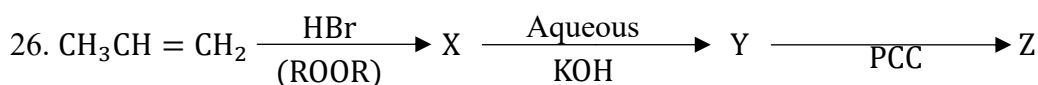
- (1) pK_w (2) $pK_w - \lg \frac{V_2 b - V_1 a}{(V_1 - V_2)}$ (3) $pK_w - pK_b + \lg \frac{aV_1 - bV_2}{bV_2}$
 (4) $pK_w + \lg \frac{bV_2}{(aV_1 - bV_2)}$ (5) $-pK_w + \lg \frac{bV_2}{(aV_1 - bV_2)} - pK_w$

24. The de Broglie wavelength of a particle with a mass of 0.06 mg moving at a speed of 10 ms⁻¹ is,

- (1) 2.1×10^{31} m (2) 1.1×10^{-27} m (3) 1.1×10^{-33} m
 (4) 3.2×10^{-28} m (5) 2.1×10^{-28} m

25. Which of the following answers is true regarding the complexes formed by d-block cations?

	$[\text{CuCl}_4]^{2-}$	$[\text{CoCl}_4]^{2-}$	$[\text{Co}(\text{NH}_3)_6]^{2+}$	$[\text{Ni}(\text{NH}_3)_6]^{2+}$
(1)	Blue	Yellow	Yellow-Brown	Blue
(2)	Yellow	Blue	Blue	Green
(3)	Blue	Pink	Yellow-Brown	Green
(4)	Yellow	Blue	Yellow-Brown	Blue
(5)	Yellow	Blue	Yellow-Brown	Green



In the above reaction sequence, the compound Z is,

- (1) $\text{CH}_3 - \overset{\text{O}}{\underset{\text{||}}{\text{C}}} - \text{CH}_3$ (2) $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$ (3) $\text{CH}_3\underset{\text{OH}}{\text{CH}}\text{CH}_3$
 (4) $\text{CH}_3\text{CH}_2 - \overset{\text{O}}{\underset{\text{||}}{\text{C}}} - \text{H}$ (5) $\text{CH}_3\text{CH}_2\text{COOH}$

27. Select the false statement regarding s- and p-block elements.

- (1) When the residue from the combustion of Li metal in air is hydrolyzed, NH_3 is released.
 (2) NH_3 gas reacts with excess Cl_2 to form NCl_3 and HCl .
 (3) The hydrolysis reaction of Cl_2 gas is a disproportionation reaction.
 (4) When SO_2 gas is passed into an acidic KMnO_4 solution, turbidity is formed.
 (5) H_2S acts as an oxidizing agent in its reaction with Na metal.

28. A current of 6 A was passed through an aqueous CuSO_4 solution for 10 minutes. The mass of Cu metal deposited at the cathode is,

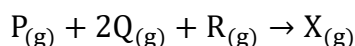
- (IF = 96500 Cmol⁻¹, Cu = 63.5)
 (1) 1.8g (2) 1.5g (3) 1.2g (4) 2.4g (5) 3.2g



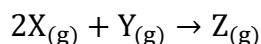
29. When solvents A and B are mixed, an ideal solution is formed. The saturated vapor pressures of solvents A and B are 2×10^4 Pa and 4×10^4 Pa respectively. The mole fraction of A in the vapor phase of a solution where A and B are mixed in a 1:3 mole ratio is ,

- (1) $\frac{1}{8}$ (2) $\frac{1}{6}$ (3) $\frac{1}{7}$ (4) $\frac{1}{5}$ (5) $\frac{6}{7}$

30. In a 1 dm³ container, 2 mol of P(g), 1 mol of Q(g) and 1 mol of R(g) are introduced and allowed to react as follows:



Then, excess Y is added to the reaction mixture to form Z.



At the end of the reaction, the concentration of Z in the system is, (in mol dm⁻³)

- (1) 0.01 (2) 0.35 (3) 0.05 (4) 0.25 (5) 0.40

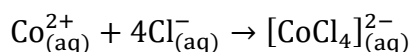
- For each of the questions 31 to 40 , one or more responses out of four responses (a) , (b) , (c) & (d) given is/are correct. Instructions are given below.

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

31. Which of the following statements about the depletion of the ozone layer are false?

- (a) HFCs react with ozone and destroy the O₃ layer.
 (b) F free radicals react with ozone and deplete the ozone.
 (c) HCFCs contribute to the depletion of the ozone layer
 (d) Cl free radicals react with O₃ to form OCl free radicals.

32. When the following equilibrium system is cooled, its color changes from pink to blue.



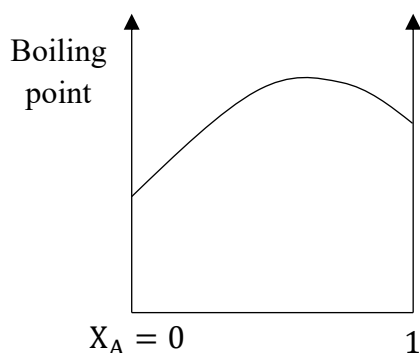
Pink

Blue

Which of the following statements about cooling the above system are true?

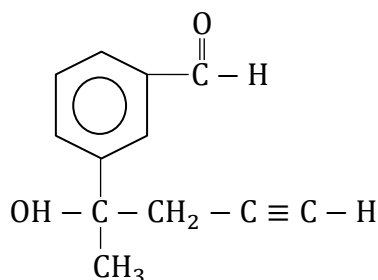
- (a) The value of K_c decreases.
 (b) The initial value of Q_c is greater than the value of K_c.
 (c) The forward reaction is exothermic.
 (d) The value of K_c increases

33. The graph shows the vapor pressure-composition curve at T(K) for an binary system of liquids A and B. Which statement about this system is true?



- (a) The boiling point of liquid A is higher than liquid B.
- (b) The vapor pressure of pure liquid A is higher than liquid B.
- (c) The mixture of A and B shows a positive deviation from Raoult's law.
- (d) No enthalpy change occurs when they are mixed.

34. Which statement(s) is/are true about the compound:



- (a) It decolorizes acidified KMnO_4 solution.
 - (b) It gives a white precipitate with ammoniacal CuCl .
 - (c) When reacts with LiAlH_4 and acidic hydrolysis a carboxylic acid is yield.
 - (d) It gives a silver mirror with Tollen's reagent.
35. A chemical cell consisting of standard $\text{Pt}_{(s)}/\text{Cl}_{2(g)}/\text{Cl}^{-}_{(g)}$ and $\text{Ag}_{(s)}/\text{AgCl}_{(s)}/\text{Cl}^{-}_{(aq)}$ electrode is given below.

$$E^{\circ}_{\text{cell}} = 1.14\text{V} \quad E^{\circ}(\text{Cl}_2/\text{Cl}) = 1.36\text{V}$$

When the cell operates, which of the following happens?

- (a) Reduction occurs near the Cl_2 electrode.
- (b) When the cell operates, the mass of the Ag/AgCl electrode increases.
- (c) When the Cl^{-} ion concentration of the cell is increased, the electromotive force of the cell increases.
- (d) The standard electrode potential of the Ag/AgCl electrode is 2.50 V.



36. Which of the following statements about industrial productions are true?

- (a) In the industrial production of NH_3 , K_2O and Al_2O_3 are used as catalysts.
- (b) Plant oil is mixed with methanol and heated with NaOH to produce bio-diesel.
- (c) In the chlorination for TiO_2 production, Cl_2 is passed over a mixture of TiO_2 and coke.
- (d) In the vulcanization of rubber, 7-9% of S by mass of the rubber is used and heated.

37. Which statement about 3d elements is false?

- (a) Cations formed by the elements Fe, Cu, and Zn form stable complexes with excess NH_4OH .
- (b) Co^{2+} ions form a pink complex with excess HCl .
- (c) Ni^{2+} ions form a blue complex with excess $\text{NH}_3(\text{aq})$.
- (d) Fe^{2+} ions give a dark blue precipitate with $\text{K}_3(\text{Fe}(\text{CN})_6)$

38. Which of the following statements about reaction kinetics are true?

- (a) The graph of rate vs concentration for a second-order reaction is a relationship of the form $y = mx$.
- (b) The concentration of a reactant in a zero-order reaction decreases linearly with time.
- (c) A reaction with a rate constant (K) of $3 \times 10^{-4} \text{s}^{-1}$ is a first-order reaction.
- (d) The reaction rate of a zero-order reaction depends on the reactant concentration.

39. When pure, miscible solvents A and B were mixed, a volume contraction occurred in the resulting solution. Which statement about this solution is true?

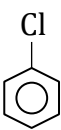
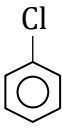
- (a) Raoult's law can be applied to the solution.
- (b) The boiling point of the mixture is higher compared to their pure state.
- (c) The reaction that occurs when the solutions are mixed is exothermic.
- (d) The vapor pressure of the solution changes linearly with the mole fraction of each liquids

40. Which statement about the extraction of essential oils is correct?

- (a) The most common method used for extracting essential oils is steam distillation.
- (b) The main oil component in citrus oil is eugenol.
- (c) The amount of product obtained from the pressing method used in essential oil extraction is very high.
- (d) Essential oils are insoluble in water.

- In question no. 41 – 50 , two statements are given in respect of each question . From the table given below , select the response out of responses (1) , (2) , (3) , (4) & (5)

Response	First statement	Second Statement
1	True	True , & correctly explain the first statement
2	True	True , but does not explain the first statement correctly
3	True	False
4	False	True
5	False	True

	First statement	Second Statement
41.	In the Solvay process for producing Na_2CO_3 , the final byproduct is CaCl_2 .	Na_2CO_3 is used in the paper industry to mix with wood pulp.
42.	The reaction of sulfur with NaOH solution is a disproportionation reaction	The reaction of sulfur with NaOH forms Na_2S , Na_2SO_4 & H_2O
43.	The basicity of aniline is lower than that of NH_3	The lone pair of electrons on the nitrogen in aniline is delocalized within the aromatic ring by conjugation.
44.	Ingestion of excess mercury (Hg) can cause Minamata disease.	Monochloroamine is a byproduct of water disinfection
45.	 The reaction between & $\text{NaOH}_{(\text{aq})}$ is a nucleophilic substitution reaction	 The reaction between & NaOH produces phenols.
46.	The half-life of a first-order reaction is 20 minutes, and the value of its rate constant is $3.5 \times 10^{-2} \text{ min}^{-1}$.	The half-life of a first-order reaction is independent of concentration
47.	When a CuSO_4 solution is electrolyzed using inert electrodes, O_2 is released near the anode.	In a lead accumulator, the positive terminal is PbO_2 and the negative terminal is Pb
48.	Methyl orange indicator can be used for the titration between $0.1 \text{ mol dm}^{-3} \text{ CH}_3\text{COOH}$ solution and $0.1 \text{ mol dm}^{-3} \text{ NaOH}$ solution	The solution obtained from the hydrolysis of CH_3COO^- ions is basic.
49.	When SCl_2 is hydrolyzed, the solution becomes turbid	SCl_2 readily hydrolyzes to give the $\text{S}_2\text{O}_3^{2-}$ ion.
50.	In the reaction between acidic KMnO_4 and $\text{C}_2\text{O}_4^{2-}$ ions, the mole ratio between MnO_4^- : $\text{C}_2\text{O}_4^{2-}$ is 2:5.	In this reaction, KMnO_4 is a self-indicator.



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Department of Educations - North Central Province



තෙවන වාර පරීක්ෂණය

Third Term Test

2025

රසායන විද්‍යාව II
Chemistry II

02

E

II

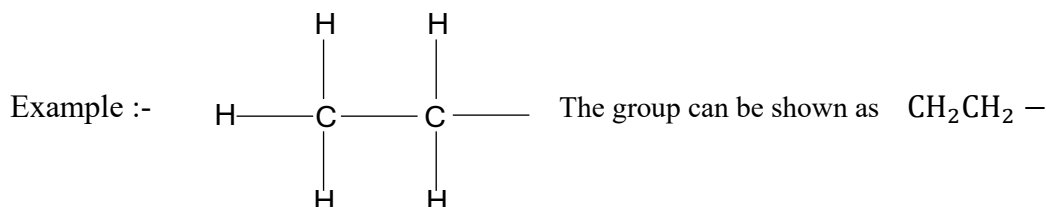
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Three Hours

- Additional Reading Time - 10 minutes

- * A periodic table is provided.
- * Calculators are 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, alkyl groups can be represented in a condensed form.

Index No.

.....

**PART A - Structured Essay**

- Answer all questions on this paper itself.
- You should write your answers in the spaces provided for each question. Note that this space is sufficient for writing the answers and long answers are not expected.

PART B & PART C - Essay

- Answer four questions, selecting two questions from each part. Use the papers provided for this.
- After the allotted time for the entire paper is over, staple the answers for Part A, B, and C as one answer sheet, with Part A first, and hand it over to the invigilator.
- You are permitted to take only Part B and C of the question paper outside the examination hall.
-

Only for the use of examiners.

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

Total Marks	
In Figures	
In Word	

Examiner 1	
Examiner 2	
Checked by	
Supervised by	



PART A - STRUCTURED ESSAY

Answer all four questions on this paper itself.

(a) State whether the following statements are true or false on the dotted lines. Reasons are not required.

(i) The de Broglie wavelength of an F_2 molecule traveling at the same velocity is greater than the de Broglie wavelength of a Cl_2 molecule.

(ii) The hybridization of the C atom in the most stable Lewis structure of the OCN^- ion is sp.

(iii) Among the three compounds CO , H_2CO , $COCl_2$, the most electronegative carbon atom is in H_2CO

(iv) The three C-O bonds in the HCO_3^- ion are equal in length.

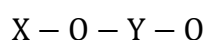
(v) There are 5 electrons with a magnetic quantum number $m_l = +1$ in a Cr atom.

(vi) The boiling point of 2-methylbutane is higher than that of 2,2-dimethylpropane.

(vii) Among the three elements B, C, N, carbon has the lowest second ionization energy.

(viii) Among the three oxides N_2O_5 , P_4O_6 , Bi_2O_3 , Bi_2O_3 shows the most basic nature.

(b) The skeleton for the molecule XO_3Y is given below. Both elements X and Y are from the second period. X shows the highest electronegativity. Y exists in the gaseous state and does not show allotropy. (O is Oxygen)



(i) Identify X and Y.

. X Y

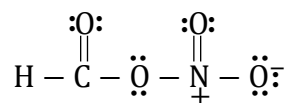
(ii) Draw the most acceptable Lewis structure for the molecule

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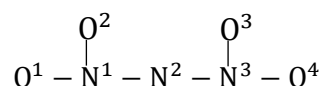
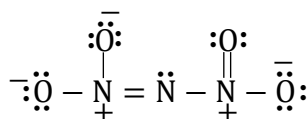
(iii) State the oxidation number and hybridization of the O and Y atoms in the structure drawn in (ii) above.

	1O	Y
Oxidation number		
Hybridization		

- (iv) The most stable Lewis structure for the molecule HCOONOO is given below. Draw 3 more resonance structures for this molecule and state their stabilities below the structures



- (v) Based on the Lewis dot-dash structure and its labeled skeleton below, complete the given table.



	N ¹	N ²	N ³
Number of VSEPR pairs around the atom			
Electron pair geometry around the atom			
Shape around the atom			
Hybridization of the atom			

1. Based on the Lewis structure in (v) above, identify the atomic/hybrid orbitals involved in the formation of sigma (σ) bonds between the following pairs of atoms.

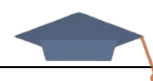
- | | | |
|------------------------------------|----------------------|----------------------|
| 2. N ¹ – O ¹ | N ¹ | O ¹ |
| 3. N ¹ – N ² | N ¹ | N ² |
| 4. N ² – N ³ | N ² | N ³ |
| 5. N ³ – O ³ | N ³ | O ³ |
| 6. N ³ – O ⁴ | N ³ | O ⁴ |

- (vi) Identify the atomic orbitals involved in the formation of pi (π) bonds between the following pairs of atoms.

- | | | |
|------------------------------------|----------------------|----------------------|
| 1. N ¹ – N ² | N ¹ | N ² |
| 2. N ³ – O ³ | N ³ | O ³ |

- (vii) Arrange the atoms O¹, N¹, N², in order of increasing electronegativity

.....



(c) Arrange the following in increasing order of the property given in parenthesis .

(1) Si, C , Na, Mg, Ar (Second ionization energy)

.....

(2) LiF, NaCl, KF, NaBr, KI (Lattice energy)

.....

(3) NO_2^- , NO_4^{3-} , NO_2F , NO_2^+ (Electronegativity Of N)

.....

02. (a)(i) A is a white ionic compound. It consists of three elements in the ratio 1:2:3. (not in order) CO_2 is used to produce A industrially. A is added to soaps and detergents to enhance the cleaning action.

Identify A.

(ii) Compound B contains 3 different types of atoms. When compound B is thermally decomposed, N_2 is released. When a dilute acid is added to the anion in compound B, a brown gas is released.

Identify B.....

(iii) C is a water-soluble compound consisting of three elements in a 1:1:1 ratio, containing a metal from the third period. When a solution of C is heated with compound B, a gas with a pungent odor is released.

Identify C.

(iv) Name the industrial process for the production of compound A.

.....

(v) Write a balanced chemical equation for the reaction that occurs when compound B is heated with a solution of compound C.

.....
.....

(vi) Write a balanced chemical equation for the reaction that occurs when Al metal is added to the solution formed in (v) and heated with an aqueous solution of C.

.....
.....

- (b) The aqueous solutions NH_4OH , $\text{Al}_2(\text{SO}_4)_3$, AgNO_3 , $\text{Na}_2\text{S}_2\text{O}_3$, $\text{Pb}(\text{CH}_3\text{COO})_2$, BaCl_2 are labeled as P, Q, R, X, Y, Z. (not in order) The following observations were obtained by mixing two solutions at a time to identify them.

<u>Mixed Solutions</u>	<u>Observations</u>
(i) P + Q	A white precipitate that turns black when heated.
(ii) X + Y	A white gelatinous precipitate
(iii) X + R	A colourless solution
(iv) P + Z	A white precipitate that turns black over time.
(v) Z + R	A white precipitate that is soluble in X.
(vi) Q + R	A white precipitate that is soluble in hot water.

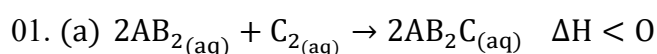
1) Identify P, Q, R, X, Y, Z

P X
 Q Y
 R Z

2) Write a balanced chemical equation for the formation of the precipitate in each of the reactions

(i) to (vi). Use the symbol $\downarrow$ to represent a precipitate. .

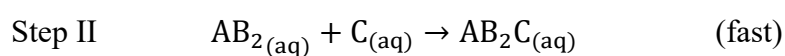
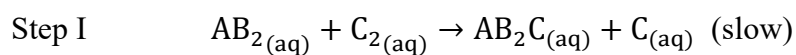
(i)
 (ii)
 (iii).....
 (iv).....
 (v)
 (vi).....



- (i) When the concentrations of $\text{AB}_2(\text{aq})$ and $\text{C}_2(\text{aq})$ were $2 \times 10^{-5} \text{ mol dm}^{-3}$ and 2 mol dm^{-3} , respectively, the reaction rate was $1 \times 10^{-3} \text{ mol dm}^{-3}\text{s}^{-1}$. After some time, when the concentration of $\text{AB}_2(\text{aq})$ was $1 \times 10^{-5} \text{ mol dm}^{-3}$, the reaction rate was $5 \times 10^{-4} \text{ mol dm}^{-3}\text{s}^{-1}$. Calculate the order with respect to AB_2 .



(ii) The mechanism for the above reaction consists of the following 2 elementary reactions.



Find the order with respect to $C_{2(aq)}$ from the reaction mechanism.

(iii) Assuming the slow step is endothermic, draw the energy profile diagram for the reaction in (a)(I). Show the positions of the reactants and products. Label the enthalpy change (ΔH), the activation energy of the forward reaction of the first step (E_{a1}), and the activation energy of the reverse reaction of the second step (E_{a2})

(b) Since the volumes of solvents A, B, C and D are 50.00cm³, the total volume of the mixtures obtained when mixed is as follows . ($P_A^0 > P_B^0$), $P_A^0 > P_C^0$, $P_A^0 > P_D^0$)

Solution A – B 100.00cm³ P_A^0 = Saturated vapour pressure of A

Solution A – C 100.05cm³ P_B^0 = Saturated vapour pressure of B

Solution A – D 99.90cm³ P_C^0 = Saturated vapour pressure of C

P_D^0 = Saturated vapour pressure of D

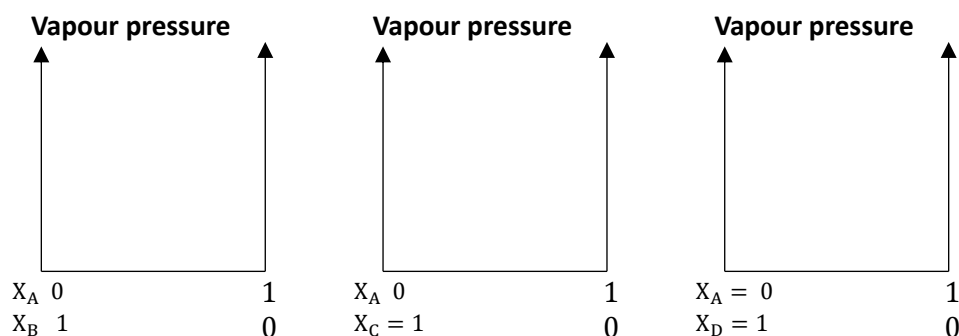
A mixture containing 0.1mol of solvent A and 0.2mol of solvent B exhibits a total pressure of 2.5×10^5 Pa at a certain temperature. When another 0.1mol of A was added to this same mixture, the total pressure was 3×10^5 Pa.

(i) Which mixture behaves according to Raoult's law?

.....

(ii) Calculate the saturated vapor pressures of A and B in the above solution.

(iii) Sketch the graphs considering the above solution mixtures



04. (a) A, B, C and D are four isomers of a monosubstituted aromatic compound with the molecular formula $C_9H_{12}O$. Only A and B are optical active. Compound C reacts very rapidly with anhydrous $ZnCl_2$ /concentrated HCl . When A, B, D were heated with concentrated H_2SO_4 E, F and G were formed respectively. Only E shows diastereomerism. Compounds A, B, D when reacted with PCC compounds H, I and J are formed respectively. Compound H does not give a silver mirror with Tollens reagent, while I and J give a silver mirror.

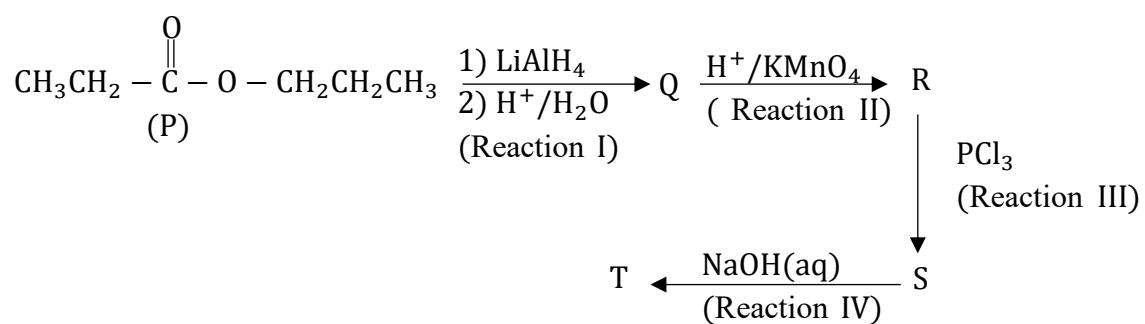
(i) Draw the structure of A, B, C, D, E, F, G, H, I, & J in the boxes given below.



<i>A</i>	<i>B</i>	<i>C</i>
<i>D</i>	<i>E</i>	<i>F</i>
<i>G</i>	<i>H</i>	<i>I</i>
<i>J</i>		

(ii) Draw the structure of the product obtained when compound J reacts with 2,4-DNP

(b) Consider the following sequence of reactions.



(i) Draw the structures of Q, R, S & T in the boxes given below

Q

R

S

T

(ii) Write the mechanism for the reaction (IV)

.....

.....

.....

.....

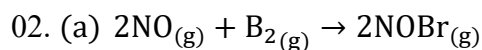
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PART B – ESSAY



- Answer two questions only .

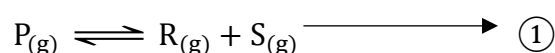


	25°C $\Delta H_f^{\circ} / \text{kJ mol}^{-1}$	25°C $S^{\circ} / \text{J K}^{-1} \text{mol}^{-1}$
$\text{NO}_{(g)}$	+90	210
$\text{Br}_{2(g)}$	+31	245
$\text{NOBr}_{(g)}$	+80	275

- Calculate the standard enthalpy change of the reaction using the data given above
- Calculate the standard entropy change of the reaction
- By that predict the spontaneity of the reaction

(b) 3mol of gas P and 2mol of gas Q in a 5dm^3 vessel which has a variable volume at 300 K

- Calculate the pressure in the vessel at 300K
- At the above pressure, when the temperature of the system is increased to 400K, only gas P reaches the following equilibrium.



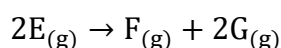
At equilibrium, the total number of moles in the system is 6mol.

- Calculate the new volume of the container.
- Calculate the percentage dissociation of $\text{P}_{(g)}$.

(iii) Calculate K_p for the equilibrium (I) at 400K.

(iv) Hence, calculate K_c for the equilibrium (I) at 400K.

(c) Compound E thermally decomposes in an aqueous solution into F and G as follows.



The data obtained from studying the kinetics of the above reaction are shown below. The initial rates for two solutions of E at a given temperature are shown below.

Concentration (mol dm^{-3})	Initial Rate ($\text{mol dm}^{-3}\text{s}^{-1}$)
0.01	1.2×10^{-5}
0.02	2.4×10^{-5}

- Using the above data, calculate the order of the reaction with respect to E.
- Calculate the rate constant (k).
- Calculate the half-life of the reaction.

06. (a) 25.00 cm³ of a 0.10mol dm⁻³ aqueous solution of a weak monoacidic base B was taken into a titration flask and titrated with a 0.10mol dm⁻³ HCl solution.

$$K_W = 1 \times 10^{-14} \text{mol}^2 \text{dm}^{-6}, \quad K_b(B) = 1 \times 10^{-5} \text{mol dm}^{-3}$$

- (i) Calculate the pH of the solution in the titration flask before starting the titration.
- (ii) Calculate the pH of the solution in the titration flask when 10cm³ of the HCl acid is added.
- (iii) Calculate the pH of the solution in the titration flask at the equivalence point.
- (iv) Find the pH of the solution in the titration flask when 10.00cm³ of HCl acid is added beyond the equivalence point.

(b) An aqueous solution contains Cl⁻ and I⁻ ions. Their concentrations are 0.05mol dm⁻³ and 0.02mol dm⁻³, respectively. An AgNO₃ solution is gradually added to this solution.

$$K_{SP}(\text{AgCl}) = 1.8 \times 10^{-10} \text{mol}^2 \text{dm}^{-6}, \quad K_{SP}(\text{AgI}) = 8.5 \times 10^{-17} \text{mol}^2 \text{dm}^{-6}$$

- (i) Calculate the Ag⁺ concentration in a saturated aqueous solution of AgCl.
- (ii) When the AgNO₃ solution is gradually added to the mixture, which one precipitates first? Explain with a calculation.
- (iii) Calculate the concentration of the anion of the first precipitated salt when the second cation begins to precipitate.

(c) Water and CCl₄ layers form an immiscible two-phase system. The distribution coefficient, for the solute A between CCl₄ and water at 25°C is 4 at 25°C

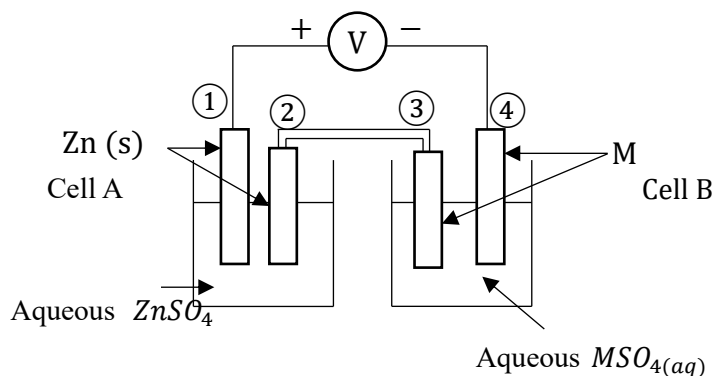
$$K = \frac{[A]_{\text{CCl}_4}}{[A]_{\text{H}_2\text{O}}} = 4$$

0.5mol of A is added to a system containing 100.00cm³ of CCl₄ and 100.00cm³ of water and allowed to reach equilibrium at 25°C.

- (i) Calculate the number of moles of A in 50.00 cm³ of the aqueous layer at equilibrium.
- (ii) Calculate the concentration of A in the CCl₄ layer.



07. (a) The following setup was used to determine the molar mass of a metal M. A constant current was passed for 15 minutes for electrolysis. ($1F = 96500 \text{ C mol}^{-1}$) ($Zn = 65$)

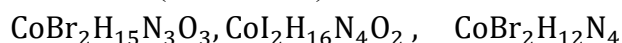


At the end of 15 minutes, a mass of the cathode of cell A is increased by 32.50 mg, and mass of the cathode of cell B is increase by 44.4 mg.

- Identify the anode and cathode of each of the cells A and B using the numbers 1, 2, 3, 4.
- Write the balanced half-reaction that occurs at each electrode of each cell.
- Calculate the constant current used for the electrolysis.
- Calculate the molar mass of metal M.

(b)

- A, B and C are coordination compounds. They have an octahedral geometry. Each compound has two types of ligands coordinated to the ion. The molecular formulas of the compounds are as follows. (not in order)



When the aqueous solutions of above compounds are treated with an $AgNO_3$ solution, the following observations are obtained.

A - A yellow precipitate soluble in concentrated NH_3 .

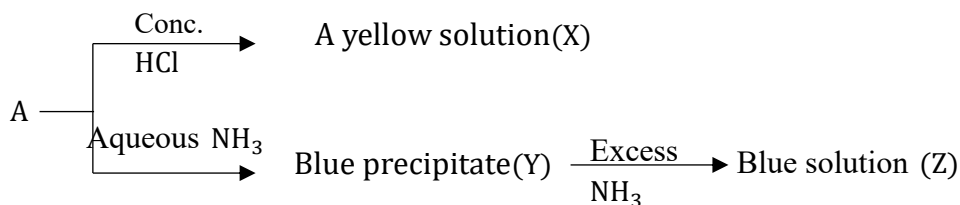
B - No precipitate.

C - A yellow precipitate insoluble in concentrated NH_3 .

(I) Identify compounds A, B and C.

(II) Write the chemical formulas of the precipitates obtained when treated with $AgNO_3(aq)$. State the compound it belongs to.

- The element M forms a complex ion A in an aqueous medium. It has the chemical formula $[M(H_2O)_6]_n^{m+}$. It undergoes the following reactions.
Concentrated HCl

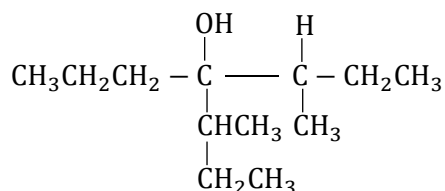


- (I) Identify the metal M and state the oxidation number of M in the complex ion A.
- (II) Write the electronic configuration of M in the complex ion A.
- (III) State the values of n and m.
- (IV) Write the structural formulas of X, Y and Z.
- (V) Write the IUPAC names of the complex ions A, X and Z.

PART C – ESSAY

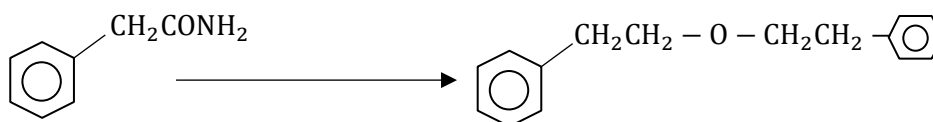
- Answer two questions only

08. (a) Using the only organic compound $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$ as a starting material, synthesize the following compound in no more than 8 steps

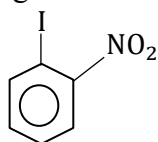


Reagents[®] Conc. H_2SO_4 , dilute H_2SO_4 , Mg, dry ether, LiAlH_4 , PCC, HBr

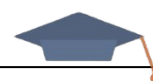
(b) Carried out the following conversion in not more than five steps .



(c) Starting from aniline, synthesize the following compound in no more than 3 steps



(d) Write the mechanism for the reaction between benzene and CH_3Cl in the presence of anhydrous AlCl_3



09. (a) An aqueous solution x contains 5 metal cations and 2 anions.

Tests for Cation

	Test	Observation
1.	Dilute cold HCl solution was added.	P ₁ white precipitate was obtained.
2.	P ₁ was filtered off. H ₂ S was bubbled through the filtrate	P ₂ black precipitate was obtained.
3.	P ₂ was filtered off. The filtrate was boiled until H ₂ S was removed. Concentrated HNO ₃ was added, heated, cooled and then NH ₄ Cl/NH ₄ OH was added.	A brown precipitate was obtained. (P ₃)
4.	P ₃ was removed and H ₂ S gas was bubbled.	A black precipitate was obtained. (P ₄)
5.	To a portion of the aqueous solution x, 8-hydroxy quinoline was added.	A yellow-green precipitate was obtained.
6.	To a portion of the aqueous solution x, NaOH(aq) was added.	A dirty -green precipitate was obtained.

Tests for Precipitates

	Test	Observation
1.	P ₂ precipitate was heated	The precipitate gradually dissolved.
2.	P ₂ precipitate was dissolved in dilute HNO ₃ . Excess NH ₄ OH solution was added	A blue solution was obtained. (S ₁)
3.	P ₄ precipitate was dissolved in a small amount of dilute HNO ₃ . Excess concentrated HCl was added	A blue solution was obtained. (S ₂)

Tests for Anions

	Test	Observation
1.	Dilute HCl solution was added.	A colourless gas was released, and the solution became turbid.
2.	The solution was heated with NaOH and Al powder	A gas that fumes with concentrated HCl was released

3.	A $(\text{CH}_3\text{COO})_2\text{Pb}$ solution was added to solution x	A white precipitate was obtained.
----	---	-----------------------------------

- Identify the 5 cations contained in solution x.
- Identify the precipitates P_1 , P_2 , P_3 , P_4 .
- Write the chemical formulas of the solutions S_1 , S_2 .
- Write the IUPAC names of the species S_1 , S_2 .
- Identify the two anions in solution x.

- (b) The following procedure was followed to determine the percentage by mass of Cu, Fe and Sulfur in a soil sample. These elements exist as CuS and FeS .

Procedure

A 1.0g sample of soil was heated with concentrated HNO_3 acid until the sulfide ions were oxidized to sulfate ions and Fe^{2+} ions to Fe^{3+} ions. The resulting solution was filtered, the filtrate was diluted with distilled water to a total volume of 250 cm^3 to prepare solution x.

When 25.00 cm^3 of solution x was acidified with dilute HNO_3 acid & excess amount of BaCl_2 solution was added, the mass of the precipitate obtained was 0.1864 g .

A 25.00 cm^3 of solution x was acidified with dilute H_2SO_4 acid and excess KI solution was added. 20.00 cm^3 of 0.04 mol dm^{-3} $\text{Na}_2\text{S}_2\text{O}_3$ solution was consumed to react with the I_2 released. The mass of the white precipitate deposited at the bottom of the titration flask, at the end of the titration, was 0.0381 g .

- Write the balanced chemical equations for the reactions that occurred in the above procedure.
- Calculate the percentage by mass of copper, iron, and sulfur in the soil sample. ($\text{Cu} = 63.5$, $\text{Fe} = 56$, $\text{S} = 32$, $\text{Ba} = 137$, $\text{I} = 127$)

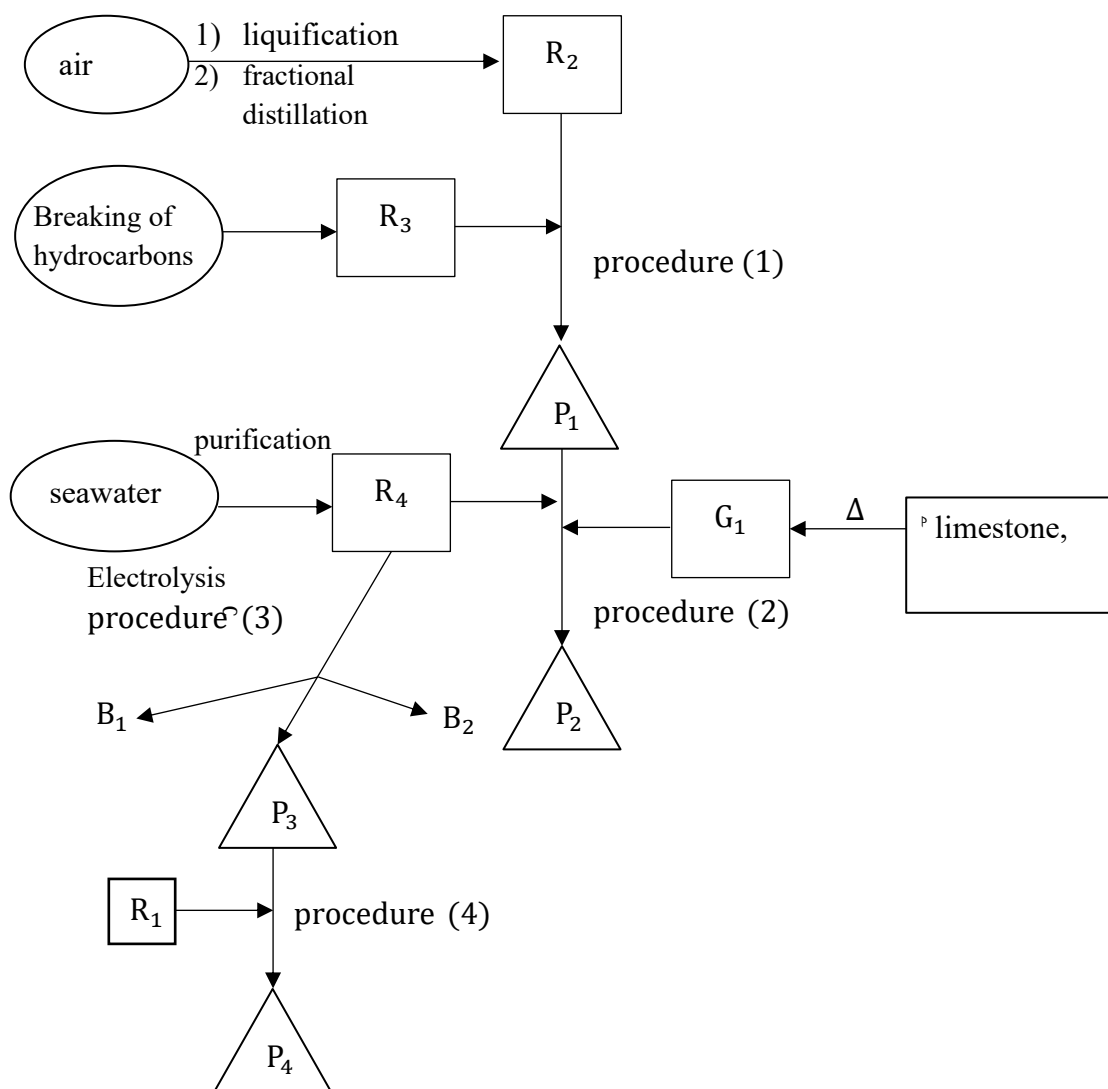
10. (a) The following details were obtained from an experiment to determine the concentration of dissolved oxygen in a water sample.

A reagent bottle was filled completely with the water sample, and a small amount of alkaline KI and MnSO_4 solutions were added immediately. The bottle was sealed well, mixed, and a small amount of concentrated H_2SO_4 was added. After the reaction was complete, 50.00 cm^3 of the solution was taken into a titration flask and titrated with 0.1 mol dm^{-3} $\text{Na}_2\text{S}_2\text{O}_3$ solution, and the burette reading was 30.00 cm^3 .

- Write the balanced ionic equations for all the reactions that occur here.
- Calculate the O_2 concentration in the water sample in mol dm^{-3} and ppm. ($\text{O} = 16$)



- (b) Consider the following flow chart related to several industrial production processes. P_1 , P_2 , P_3 , P_4 are the main products. P_1 is used for fertilizer production. P_4 is used daily to maintain good health. B_1 shows bleaching properties. B_1 and B_2 are by-products. (Flowchart with air, hydrocarbons, seawater, limestone, and various processes and products)



- Identify the starting materials R_1 , R_2 , R_3 , R_4 .
- Identify P_1 , P_2 , P_3 , P_4 .
- State the balanced chemical reaction for process (1) and mention the required conditions.
- State the anode and cathode reactions for process (3) separately.
- Name the 4 main steps in the production of P_4 .
- Write 2 industrial uses of B_2 .
- Write one environmental effect of G_1 .

