නව නිර්දේශය/ புதிய பாடத்திட்டம்/New Syllabus

NEW

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය (ආදර්ශ), 2021
கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை (மாதிரி), 2021
General Certificate of Education (Adv. Level) Examination (Model), 2021

රසායන විද්‍යාව I
இரசாயனவியல் I
Chemistry I

02 E I

පැය දෙකයි
இரண்டு மணித்தியாலம்
Two Hours

Instructions:

- *Periodic Table is provided.*
- *This paper consists of* **10** *pages.*
- *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.***

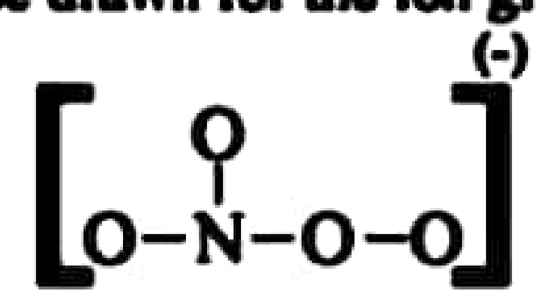
Universal gas constant $R = 8.314\ J\ K^{-1}\ mol^{-1}$ Planck's constant $h = 6.626 \times 10^{-34}\ J\ s$
Avogadro constant $N_A = 6.022 \times 10^{23}\ mol^{-1}$ Velocity of light $c = 3 \times 10^{8}\ m\ s^{-1}$

1. Who is the scientist who discovered the α, β and γ rays emitted by radioactive elements?
   (1) Henri Becquerel
   (2) J.J. Thompson
   (3) Albert Einstein
   (4) Ernest Rutherford
   (5) Eugen Goldstein

2. The quantum number group that cannot exist in nature is,
   (1) $1, 0, 0, -{}^1/_2$
   (2) $3, 2, -2, +{}^1/_2$
   (3) $2, 1, 0, +{}^1/_2$
   (4) $3, 2, +3, -{}^1/_2$
   (5) $2, 0, 0, -{}^1/_2$

3. In which of the following pairs is the electron geometry around the central atom is not the same?
   (1) OF_2 / H_2Se
   (2) SO_4^{2-} / NH_3
   (3) CO_2 / NO_2^+
   (4) ICl_3 / PCl_3
   (5) XeF_2 / $XeOF_2$

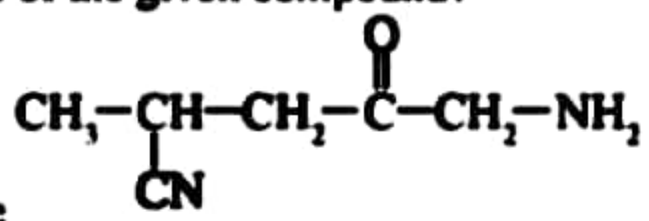
4. How many resonance structures can be drawn for the ion given below?



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

[See page two]

5. What is the correct IUPAC name of the given compound?

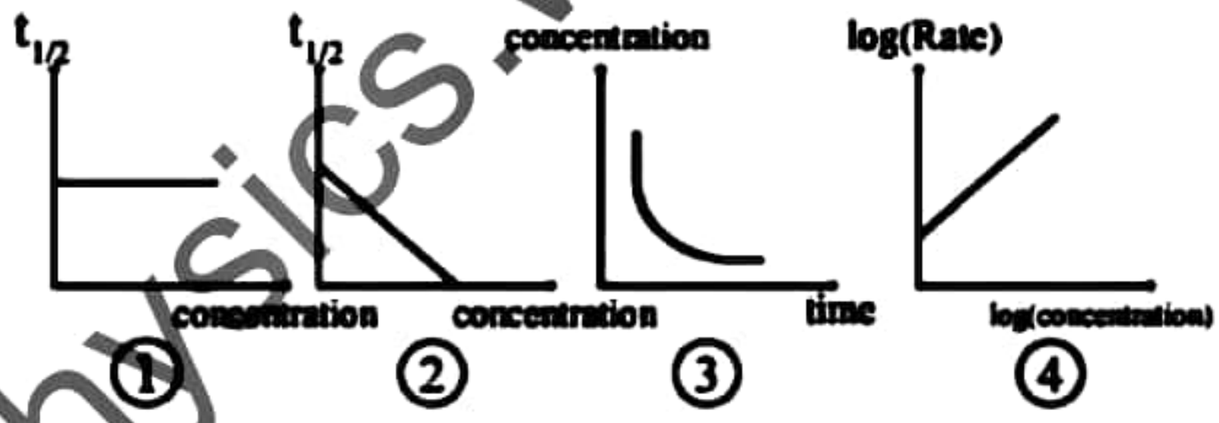


(1) 4-cyano-1-aminopent-2-one
(2) 5-amino-2-methyl-4-oxopentanenitrile
(3) 1-amino-4-cyanopent-2-one
(4) 5-amino-2-cyanopent-4-one
(5) 2-methyl-5-amino-4-oxopentanenitrile

6. The wavelength of the yellow light emitted by Na vapour is 589nm. What is the amount of energy given by one mole of photons, and how many photons would be required to give an energy of 2.2352 × 10^6 kJ?
(1) 2.032 × 10^5 kJ mol^{-1}, 1.099 × 10^7 mol
(2) 203.2 kJ mol^{-1}, 6.618 × 10^{30} mol
(3) 203.2 kJ mol^{-1}, 1.1 × 10^4 mol
(4) 5.09 kJ mol^{-1}, 6.618 × 10^7 mol
(5) 203.2 kJ mol^{-1}, 11 × 10^7 mol

7. Which response out of the following is true regarding a first order reaction?

(1) 3 only
(2) 2 and 3 only
(3) 1 and 3 only
(4) 1, 3 and 4 only
(5) 1 and 4 only



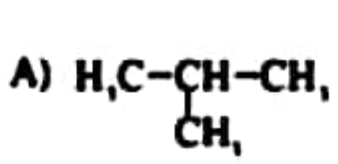
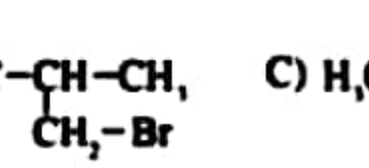
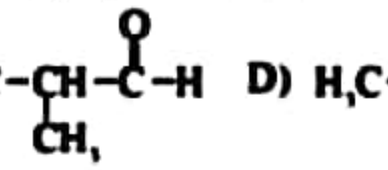
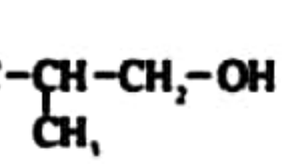
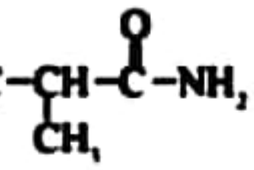
8. Which of the following is not a method that can be used to produce 2 mol of N_2?
(Cu - 63.5 g mol^{-1}, Cr - 52 g mol^{-1}, molar volume of gas at standard temperature / pressure - 22.4 dm^3 mol^{-1})
(1) Reacting 89.6 dm^3 of gaseous NH_3 with 134.4 dm^3 of gaseous Cl_2.
(2) Combustion of 4 mol of NH_3 in air.
(3) Oxidation of NH_3 in the presence of 381 g of red hot Cu.
(4) Mixing and heating 1 dm^3 each of 2.0 mol dm^{-3} NH_4Cl and $NaNO_2$.
(5) Thermal decomposition of 504 g of solid $(NH_4)_2Cr_2O_7$.

9. The total number of isomers that can be drawn for C_4H_8 is,
(1) 2 (2) 4 (3) 5 (4) 6 (5) 7

10. 10 g of the compound X is dissolved in 100 cm^3 of water and 100 cm^3 of ether is used to extract it. What is the percentage of X remaining in the water layer after two equal, consecutive extractions? (K_D between ether and water = 18)
(1) 2% (2) 3% (3) 1% (4) 10% (5) 12%

[See page three]

11. What is the ascending order of water solubility of the following compounds?

A)  B)  C)  D)  E) 

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

12. The correct answer when the compounds NaBr, KCl, NaI and KBr are arranged in increasing order of ionic nature is,
(1) NaI < KBr < NaBr < KCl
(2) NaI < NaBr < KBr < KCl
(3) NaI < NaBr < KCl < KBr
(4) KCl < KBr < NaBr < NaI
(5) KCl < NaBr < KBr < NaI

13. The correct ascending order of these enthalpy changes is,

$K_{(s)} + {}^{1}/_{2}\, Cl_{2(g)} \xrightarrow{\Delta H_1} KCl_{(s)}$ $\qquad$ $K^+_{(g)} + Cl_{(g)} \xrightarrow{\Delta H_2} KCl_{(s)}$

$K_{(g)} + Cl_{(g)} \xrightarrow{\Delta H_3} KCl_{(s)}$ $\qquad$ $K^+_{(g)} + Cl^-_{(g)} \xrightarrow{\Delta H_4} KCl_{(s)}$

(1) $\Delta H_1 < \Delta H_4 < \Delta H_3 < \Delta H_2$
(2) $\Delta H_1 < \Delta H_3 < \Delta H_4 < \Delta H_2$
(3) $\Delta H_1 < \Delta H_3 < \Delta H_2 < \Delta H_4$
(4) $\Delta H_2 < \Delta H_3 < \Delta H_4 < \Delta H_1$
(5) $\Delta H_4 < \Delta H_2 < \Delta H_3 < \Delta H_1$

14. When an aqueous, colourless salt A and aqueous, coloured salt B were mixed, a yellow-coloured solution was obtained. When excess NH_4Cl was added to B and heated, a bluish green solid was obtained. When the solid was separated and excess A was added to it, the solid dissolved, forming a bluish green precipitate. Name A and B.
(1) NaOH, $Ni(OH)_2$
(2) NaCl, K_2CrO_4
(3) K_2CrO_7, NH_4OH
(4) NH_4OH, $K_2Cr_2O_7$
(5) NH_4Cl, $Cu(NO_3)_2$

15. At a certain T temperature, N_2O_4 dissociates as follows.

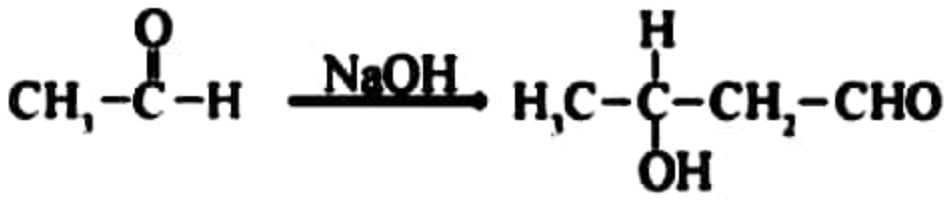
$$N_2O_{4\,(g)} \rightleftharpoons 2NO_{2\,(g)}$$

If the equilibrium constant is K_P, total pressure of the system at equilibrium is P and the degree of dissociation of N_2O_4 is α, which of the following is the correct expression regarding α?

(1) $\frac{K_p}{2P + K_p}$ (2) $\sqrt{\frac{K_p}{2P + K_p}}$ (3) $\sqrt{\frac{K_p}{4P + K_p}}$ (4) $\sqrt{\frac{K_p}{P + K_p}}$ (5) $\frac{K_p}{(2P + K_p)^2}$

[See page four]

16. Consider the following reaction.



The correct statement is,

(1) All Aldehydes, ketones and alcohols undergo aldol condensation as shown above.
(2) α carbon is the carbonyl carbon, while α hydrogen is the hydrogen bound to the adjacent carbon of the carbonyl carbon.
(3) This α hydrogen is comparatively more acidic than hydrogen in alkenes.
(4) This condensation reaction can be applied to all aldehydes.
(5) The product of the above aldol condensation reaction is highly stable, and its dehydration is quite difficult.

17. The pH value of the human blood is 7.4. In order to maintain this pH value, 10 cm^3 of 2 mol dm^{-3} H_2CO_3 and V cm^3 of 5 mol dm^{-3} $NaHCO_3$ is needed. In H_2CO_3, if $K_{a1} = 4.4 \times 10^{-7}$ mol dm^{-3} and $K_{a2} = 4.69 \times 10^{-12}$ mol dm^{-3}, What is the value of V.

(1) 3.62 cm^3
(2) 40 cm^3
(3) 44.2 cm^3
(4) 38.4 cm^3
(5) 43.4 cm^3

18. P, Q and R are three consecutive elements of the same period, within the first 20 elements. Their third ionization energy varies as Q < P < R .The oxide derived from the highest oxidation state of R is acidic. The correct statement regarding P, Q and R,

(1) P and Q are elements of the p block while R is an element of the s block.
(2) R has the highest electronegativity after F in the periodic table.
(3) The electron gain energy of Q has a high (+) value.
(4) The electron affinity of Q is a (+) value.
(5) The oxide formed by the highest oxidation state of P is a liquid.

19. The following equilibrium is formed when 2 mol of gas A is added to a 1 dm^3 vessel.

$$A_{(g)} \rightleftharpoons B_{(g)} + C_{(g)}$$

If K_c = 1 mol dm^{-3}, what is the concentration of B?

(1) 2.5 mol dm^{-3}
(2) 0.5 mol dm^{-3}
(3) 2 mol dm^{-3}
(4) 1 mol dm^{-3}
(5) 0.25 mol dm^{-3}

20. Select the incorrect statement regarding the reactions of $LiAlH_4$ and $NaBH_4$ with organic compounds.

(1) Here, nucleophilic addition reactions occur.
(2) H^- attacks the organic compound.
(3) $LiAlH_4$ and $NaBH_4$ cannot be used in the presence of water or methanol.
(4) Reaction of one ester molecule with $LiAlH_4$ and water yields 2 alcohol molecules.
(5) $NaBH_4$ does not react with carboxylic acids or its derivatives.

[See page five]

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21. Which of the following is correct regarding a system at dynamic equilibrium in a constant volume vessel?

$$Q_{(g)} + 2P_{(g)} \rightleftharpoons 2R_{(g)} \qquad \Delta H<0$$

(1) The rate of the forward reaction decreases when the temperature is increased.
(2) If a part of P is removed, the rate of the forward reaction is increased.
(3) The equilibrium point does not change when an inert gas is added at constant temperature.
(4) The equilibrium constant changes when an equal amount of moles of Q and R are added, at constant temperature.
(5) When R is added to the system, the concentration of Q reduces.

22. The IUPAC name of $[Ni(NH_3)_6]\ [CoCl_4]$
(1) Hexaaminenickel(II) tetrachloridocobaltate(II)
(2) Hexamminenickel(II) ion tetracholoridocobaltate(II) ion
(3) Hexaamminenickel(II) tetrachloridocobalt(II)
(4) hexaamminenickel(II) tetrachloridocobaltate(II)
(5) hexaamminenickel(II) chloridocobaltate(III)

23. A glass bulb of volume 150 cm^3 is connected to another glass bulb of volume 300 cm^3, by a tube with a tap of negligible volume. The whole system is at 112 °C initially. In the system with the tap open, Xe and F are present in the ratio of 3 : 1. When the tap is closed and the smaller bulb is submerged in water at 497 °C, the percentage of change of pressure in the smaller bulb in relation to the initial pressure is. (only at temperatures above 400 °C , the reaction $Xe_{(g)} + F_{2(g)} \rightarrow XeF_{2(s)}$ occurs.)
(1) 33.33%
(2) 50%
(3) 66.66%
(4) 100%
(5) 0%

24. The chemical oxygen demand (COD) of a water sample needs to be determined. 25 cm^3 of 0.1 mol dm^{-3} acidic $K_2Cr_2O_7$ is added to 25 cm^3 of the sample. 20 cm^3 of a 0.15 mol dm^{-3} Fe^{2+} solution is needed to react with the remaining $Cr_2O_7^{2-}$. Calculate the chemical oxygen demand (COD) of the water sample in mg dm^{-3}
(1) 3.84 mg dm^{-3}
(2) 3840 mg dm^{-3}
(3) 96 mg dm^{-3}
(4) 120 mg dm^{-3}
(5) 1920 mg dm^{-3}

25. Correct statement,
(a) A catalyst reduces the activation energy of a reaction.
(b) The order of a reaction can be changed by a catalyst.
(c) When a reaction occurs, the reactant concentration and reaction constant gradually reduces.
(d) When a catalyst is added to a system at equilibrium, the equilibrium point does not change.

(1) a , d
(2) d only.
(3) b , d
(4) a , b , d
(5) a , c

[See page six]

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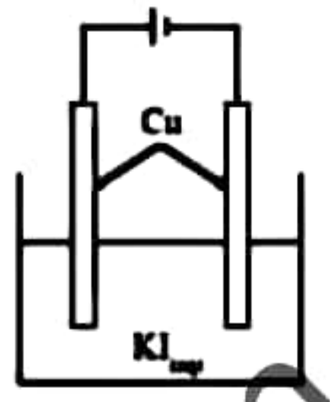
26. An aqueous KI solution is electrolyzed, using Cu electrodes as depicted below. The correct statement is,



(1) $Cu(OH)_2$ is formed at the cathode initially.
(2) KOH is not formed near the cathode.
(3) A blue colour precipitate may form near the anode.
(4) O_2 is liberated at the anode initially.
(5) There is no chance of a white precipitate forming at the anode.

27. The lowest temperature that the reaction $\frac{1}{2}A_2B_{(s)} \longrightarrow A_{(s)} + \frac{1}{2}B_{(g)}$ can occur in is,

($\Delta H = 190.6\ kJ\ mol^{-1}$, $\Delta S = 400\ J\ mol^{-1}\ K^{-1}$)

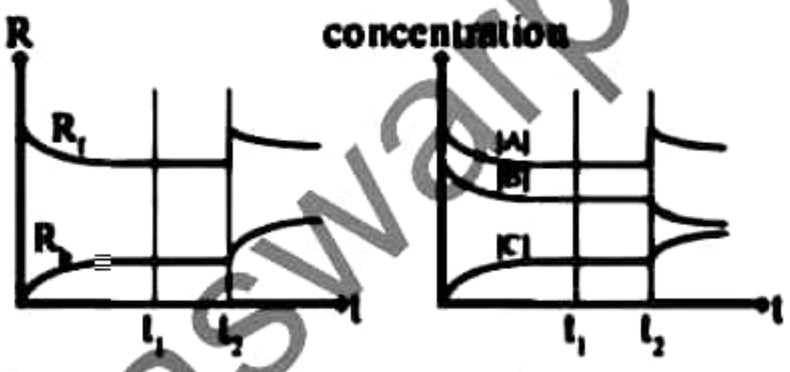
(1) 476.5 °C
(2) 47.65 °C
(3) 203.5 °C
(4) 20.35 °C
(5) 4765 °C

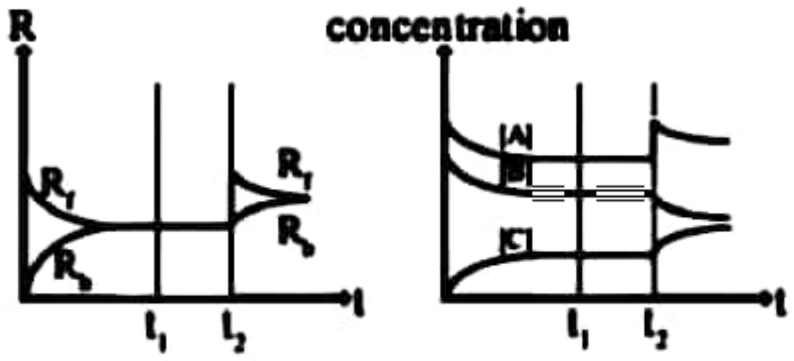
28. The reaction rate for a certain concentration of the reactants of the single step reaction $2A + B \longrightarrow 3C$ is 8×10^{-3} mol dm^{-3} s^{-1}. What is the rate of reaction when the concentrations of the reactants are doubled? (mol dm^{-3} s^{-1})

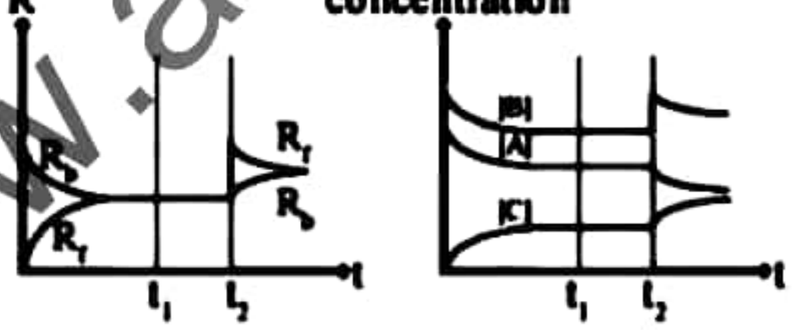
(1) 16×10^{-3}
(2) 6.4×10^{-3}
(3) 1.6×10^{-3}
(4) 64×10^{-2}
(5) 4×10^{-3}

29. $3A_{(g)} + 2B_{(g)} \rightleftharpoons C_{(g)}$ $\Delta H<0$

The above reaction is initiated with a higher number of moles of A than B, and after reaching a dynamic equilibrium, a certain amount of A is added to that system. Select the correct graph depicting the variation of concentrations of A, B and C and the variation of reaction rate, until the system reaches a dynamic equilibrium again.

(1)


(2)


(3)


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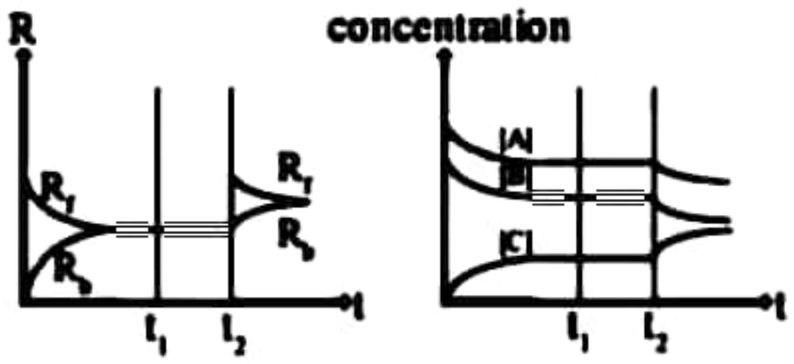

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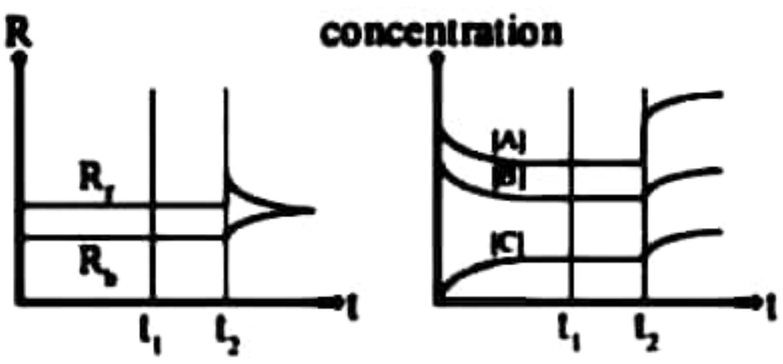
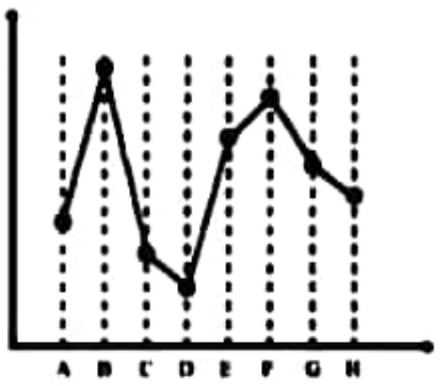


[See page seven]

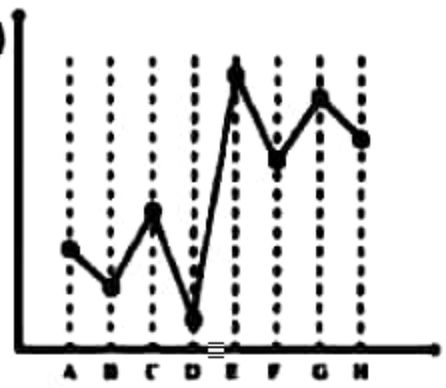
30. Select the graph depicting the correct variation of relative basicity of the following compounds.

(A) H_2O (B) CH_3CH_2MgBr (C) CH_3OH
(D) CH_3COOH (E) $CH_3CH_2CH_2NH_2$ (F) $CH_3NHCH_2CH_3$
(G) CH_3-NH_2 (H) NH_3

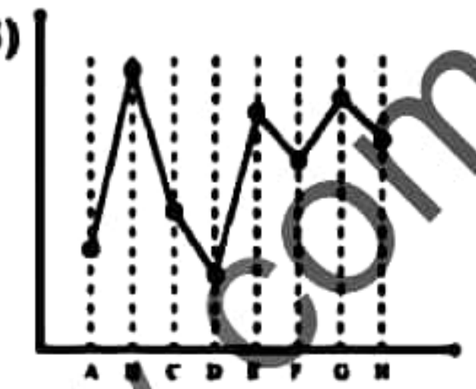
(1)



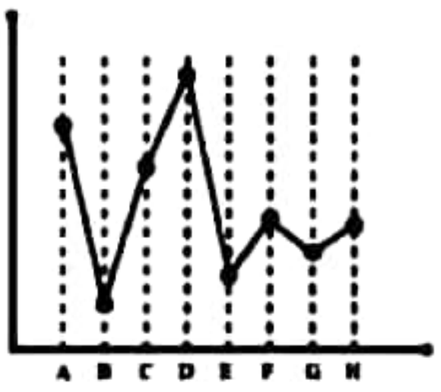
(2)



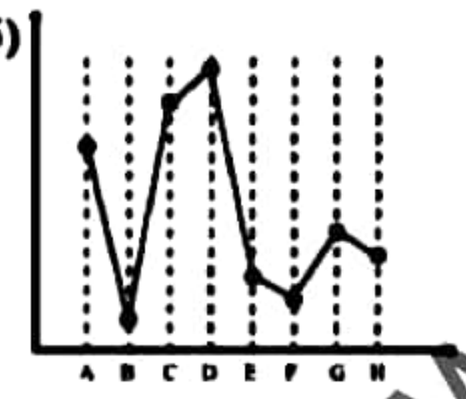
(3)



(4)



(5)



- 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. Correct statement regarding 3d block elements and ions formed by them.

(a) The colours of MnO_4^- and CrO_4^{2-} are resulted due to transfer of electrons between orbitals.
(b) All 3d elements show +2 oxidation state.
(c) 3d elements are sometimes used as sources of radiation.
(d) Due to the presence of half-filled or empty d orbitals that can give or receive electrons, most transition metals show catalytic properties.

[See page eight]

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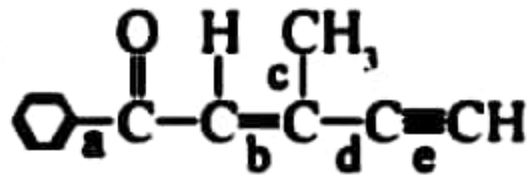
32. True statement regarding 

(a) All carbon atoms are on the same plane.
(b) The C-C bond length increases as e < d < b < a < c.
(c) The C-C bond length increases as e < d < a < b < c.
(d) There are three C atoms with sp^2 hybridization.

33. True statement regarding the equilibrium constant (K)
(a) The value of K remains constant in any condition.
(b) Under standard conditions, K is a quantity with no dimensions.
(c) The K of a reaction that can be presented as an addition of two reactions, can be obtained by the product of the K of the two reactions.
(d) When all the coefficients of a balanced chemical equation of an equilibrium is multiplied by n, the new K value is K^n.

34. True statement/s regarding the process of formation of an ester using an alcohol and a carboxylic acid in the presence of a catalyst.
(a) A nucleophilic addition occurs in the first step of the process.
(b) A tetrahedral intermediate compound is formed.
(c) The C-OH bond undergoes homolysis.
(d) Here, first a nucleophilic addition occurs and then a nucleophilic substitution occurs.

35. MX is a water insoluble ionic compound. HX is a weak acid. Correct statement/s out of the following is/are,
(a) MX dissolves well in strong acids.
(b) In the addition of $HNO_{3(aq)}$ to a saturated solution of MX, the H^+ concentration may reduce sometimes.
(c) If M^+ solution is added to an aqueous solution of HX, the pH of the solution is increased.
(d) When HX is added to a saturated solution of MX, MX is always precipitated.

36. Select the correct statement/s regarding bio diesel out of the following.
(a) The 100% renewable or non- renewable nature of the bio diesel produced is determined by the method by which the raw material ethanol is obtained.
(b) It is essential for free fatty acids to be present in plant oils for the transesterification to occur properly.
(c) Both homogenous and heterogenous catalysts can be used in this process, and the mixture must be stirred well in the steps where the catalysts are added.
(d) Glycerol is the major by-product of bio diesel production.

37. The incorrect statement/s regarding the chemistry of Al is/are,
(a) In Friedel-Craft alkylation and acylation , Al in $AlCl_3$ acts as a Lewis acid.
(b) The hydroxide of Al is white and gelatinous.
(c) The hydroxide of Al dissolves in conc. ammonia and gives a clear colourless solution.
(d) $AlCl_3$ dimerizes in aqueous medium to complete its octet.

[See page nine]

38. The correct statement/s regarding calomel electrodes is/are.
    (a) An oxidation occurs here.
    (b) Hg liquid is deposited at the bottom.
    (c) The Pt wire is used to establish an electrical connection with the external circuit.
    (d) The KCl solution used for electrical conduction should be saturated.

39. Incorrect statement/s regarding gas molecules is/are.
    (a) Repulsion forces between gas molecules become stronger in high pressures.
    (b) The compressibility factor of real gases is less than 1 in high pressures.
    (c) The diffusion rate of gas molecules increase with the increase in molar mass.
    (d) Ideal gas collisions are always perfectly elastic.

40. The correct statement/s regarding polymers is/are.
    (a) There are polymers for which a definite repeating unit cannot be presented.
    (b) The transparency of plastics with crystalline areas is comparatively high.
    (c) The number of ester bonds formed in condensation polymers like polyester can be calculated, if the volume of water released can be measured accurately.
    (d) Phenol formaldehyde is a thermoplastic polymer.

- In question Nos. 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.	Although phenolphthalein can be used as an indicator for a titration of HCl and NaOH in 0.1 mol dm^{-3} concentrations, only bromothymol blue is suitable for concentrations of 0.001 mol dm^{-3}.	As the pH values of strong acids reduce by 1 when diluted by ten times, the range of rapid pH change at the end point reduces.
42.	The solubility of $PbCl_{2(s)}$ in conc. HCl is lower than that in water.	The solubility of a certain salt in a solution is reduced by the presence of a common ion.
43.	HFC is a gas that does not produce any ill effects globally.	The GWP value of HCF gas is very high.
44.	The most stable Lewis structure of carbon monoxide is $C^{(-)} \equiv O^{(+)}$.	As there is a (+) charge on the more electronegative O, it is unstable. Therefore, it does not exist in nature.
45.	$CH_3COO^{(-)}$ is more basic than the ion $CH_3O^{(-)}$.	$CH_3COO^{(-)}$ ion stabilizes through resonance.

[See page ten]

46.	In peroxide medium, addition of HBr to propene occurs against the Markovnikov's rule.	That reaction occurring in the presence of H_2O_2 occurs through a free radical mechanism.
47.	Hardness of water is its capacity to precipitate soap.	The total concentrations of monovalent and multivalent metal cations affect the hardness of water.
48.	The inclination shown by and to be attacked by an electrophile is the same.	Both $-CH_3$ and -OH activate the benzene ring.
49.	The intermediate compound of a multistep reaction can never be observed.	An intermediate is a compound formed in one step, and spent in the next.
50.	The major causative agent of the Minamata disease is the heavy metal Cd.	Since there is no definite defination for heavy metals, various definitions are given in different instances.

•••

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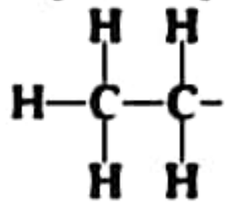
අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය (ආදර්ශ), 2021
கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை (மாதிரி), 2021
General Certificate of Education (Adv. Level) Examination (Model), 2021

රසායන විද්‍යාව II இரசாயனவியல் II Chemistry II	02 E II

පැය තුනයි மூன்று மணித்தியாலம் Three Hours	අමතර කියවීම් කාලය மேலதிக வாசிப்பு நேரம் Additional Reading Time	-	මිනිත්තු 10 යි 10 நிமிடங்கள் 10 minutes

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

- *A periodic Table is provided on page 17.*
- *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 02 - 09)

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

PART B and PART C - Essay (pages 09 - 14)

- *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.*

Index No. : .....

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) State whether the following statements are true or false.

(i) The ionic radius of the following cations varies as $K^+ > Ca^{2+} > Ga^{3+}$ (.....)

(ii) The Van der waals radius is one half the distance between two equivalent bonded atoms in their most stable arrangement. (.....)

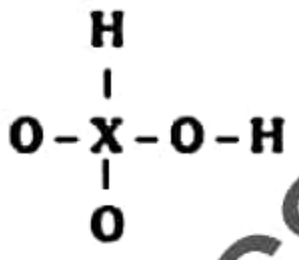
(iii) The energy for a gaseous atom to obtain an electron always becomes more positive when moving down a group. (.....)

(iv) Inter-molecular hydrogen bonds can be seen in Para-Nitrophenol. (.....)

(v) The energy difference between the line with the highest frequency in Balmer series and the line with longest wavelength in Lyman series, gives the energy of the line with the highest energy in the Paschen series. (.....)

(02 Marks)

(b) The skeleton used to construct the Lewis structure of the anion $H_2XO_4^-$ is given below. X is an element belonging to the P block.



(i) If the arrangement with minimum charges on the atoms is stable, draw the most acceptable Lewis Structure for this ion.

(ii) To what group of the periodic table can the element X belong to? .....

(iii) If X belongs to the 3rd period what element could X be? .....

(iv) Draw two other resonance structures for above ion.

[see page three]

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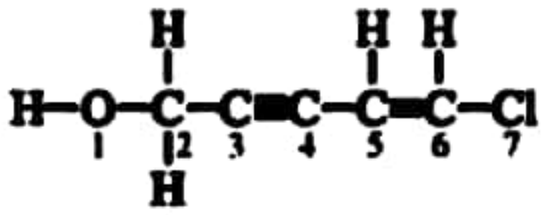
Do not write in this column.

(v) Based on the Lewis structure given below, state the following regarding the O and C atoms given in the table below.

I. VSEPR pairs around the atom
II. Electron pair geometry around the atom
III. Shape around the atom
IV. Hybridization of the atom



	O_1	C_2	C_3	C_5
VSEPR pairs around the atom				
Electron pair geometry around the atom				
Shape around the atom				
Hybridization of the atom				

(vi) Identify the atomic orbitals involved in the formation of the following π bonds in the Lewis structure given in part (v) above.

I. $C_3 - C_4$ C_3 ..... C_4 .....
II. $C_5 - C_6$ C_5 ..... C_6 .....

(vii) Identify the atomic/hybrid orbitals involved in the formation of the following σ bonds in the Lewis structure given in part (V) above.

I. $H - O_1$ H ..... O_1 .....
II. $O_1 - C_2$ O_1 ..... C_2 .....
III. $C_2 - C_3$ C_2 ..... C_3 .....
IV. $C_3 - C_4$ C_3 ..... C_4 .....
V. $C_6 - Cl_7$ C_6 ..... Cl_7 .....

(viii) What is the approximate value of the bond angle around atom C_5 in the Lewis structure given in part (v) above?

.....

(05 Marks)

[see page four]

Do not write in this column.

(c) (i) The dipole moment of LiH is 1.964×10^{-29} Cm. If the bond length of LiH is 1.596×10^{-10} m, Find percentage ionic character of LiH.
(Charge of an electron = 1.602×10^{-19} C)

(ii) Arrange the following in the **increasing** order of the property indicated in parentheses.

I. Na, K, Mg, Mn (metallic bond strength)

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

II. NH_2OH, NO, NO_2^-, NO_3^- (N-O bond length)

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

III. F, O, N, Ne (Second ionization energy)

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

IV. $NaNO_3$, KNO_3, $Mg(NO_3)_2$, NH_4NO_3 (Decomposition Temperature)

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

(03 Marks)

100

2.(a) X, Y and Z are 3 consecutive elements with atomic numbers less than 20. One of them exists as a gas at room temperature. Out of their oxides with the highest oxidation numbers, the oxides of Y and Z react with water giving strong acids while the oxide of the X gives a weak acid.

(i) Identify X,Y and Z.

X: ..... Y: ..... Z: .....

(ii) Write down the reactions of their oxides with the highest oxidation number with water.

.....

.....

.....

(iii) Write the reaction of Z_2 with cold diluted $NaOH_{(aq)}$.

.....

(iv) Which of the products in part (iii) above show bleaching properties?

.....

[see page five]

Do not write in this column.

(v) Show how the product behaves as a bleaching agent by means of chemical reactions.

.....

.....

(vi) Give reactions to show how Y behaves in each of the following cases.

I. Oxidizing agent : .....

II. Reducing agent : .....

(vii) Give the balanced chemical equation for the reaction of Z with water.

.....

(viii) Draw a rough diagram to show the variation of the boiling points of the hydrides in the group to which Z belongs.

(06 Marks)

(b) X and Y are two water soluble salts. The following tests are carried out to identify X and Y.

Test	Observation
(1) Added dilute HCl to X.	A gas (P) with a pungent smell was evolved and a yellow turbidity was obtained
(2) X and Y were mixed together.	Precipitate A and Solution B were obtained.
(3) Only when A was heated	A black precipitate (D) and a colourless gas (Q) was obtained. (Q is a strong acid)
(4) Solution B is heated is the presence of Al in a basic medium.	A gas R with a pungent smell, which turns red litmus blue was released.
(5) Added dilute H_2SO_4 to B.	No observation was noted.
(6) X is subjected to the flame test	Shows a yellowish colour.

(i) Identify X and Y.

X: ..... Y: .....

(ii) Identify precipitate A and D and gases P, Q and R.

A: ..... P: ..... R: .....

D: ..... Q: .....

(iii) Write the reactions taking place in (3) and (4) above.

.....

.....

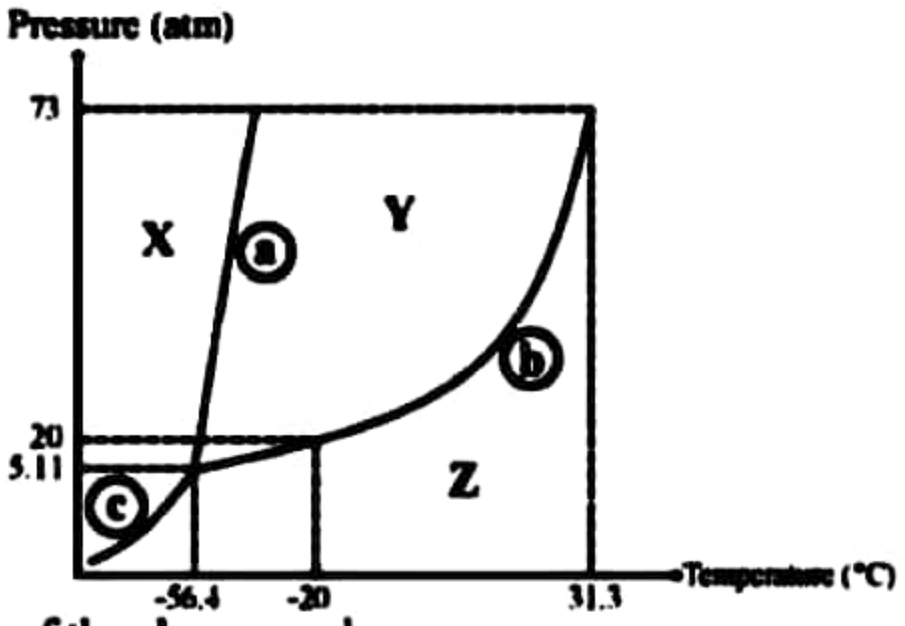
(04 Marks)

100

[see page six]

Do not write in this column.

3.



(i) Identify curves a, b and c of the above graph.

a: .....

b: .....

c: .....

(ii) Identity phases X, Y and Z.

X: .....

Y: .....

Z: .....

(iii) Define the critical pressure of a gas, and state the corresponding value for CO_2.

.....

.....

(iv) "Liquid CO_2 can be obtained by maintaining temperatures below 0°C under standard pressure" Explain whether this statement is true or false by referring to the above graph.

.....

.....

.....

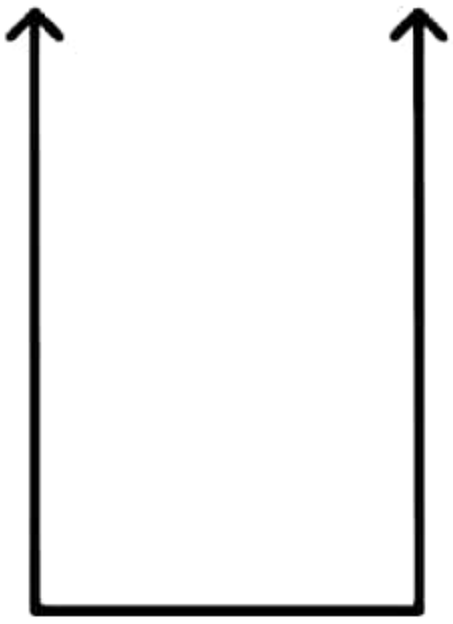
.....

(v) $AB_{2(l)}$ is a non-polar liquid. Draw the temperature - composition diagram of an ideal solution of $AB_{2(l)}$ and $CO_{2(l)}$ placed in a closed container, under a pressure of 20 atm. The melting point of $AB_{2(l)}$ at 20 atm is -5°C

[see page seven]

Do not write in this column.

(vi) Draw the vapour pressure - composition diagram for $CO_{2(l)}$ and $AB_{2(l)}$ at -20°C. Consider the vapour pressure of AB_2 at -20°C to be 16 atm.



(vii) Find P_{CO_2} of a solution, placed in a closed container, where the molar ratio of CO_2 and AB_2 in the liquid phase is 2 : 3, and mark this value on the graph drawn in part (vi) above.

.....

.....

.....

.....

(viii) Find the composition of the solution at the point where curves of P_{CO_2} and P_{AB_2} intersect in the graph drawn in (vi) above.

.....

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.....

(10 Marks)

160

[see page eight]

Do not write in this column.

4.(a) A, B, C, D and E are organic compounds with the same molecular formula C_5H_8O. All five react with Tollen's reagent to give a silver mirror. Only A and B do not show geometric isomerism, but A exhibits optical isomerism. When HBr is added to B in a polar medium and is then treated with Hg/Zn and conc. HCl, F is obtained. F exhibits optical isomerism. When C and E are reacted with Br_2/CCl_4 and the products thus obtained are reacted with alcoholic KOH, G and H, which are positional isomers of each other, are obtained. H underwent self-condensation in diluted NaOH.

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

A B C

D E F

G H

(ii) Draw the structures of the product obtained when A is reacted with Para methyl aniline.

(iii) Name A according to IUPAC Nomenclature.

.....

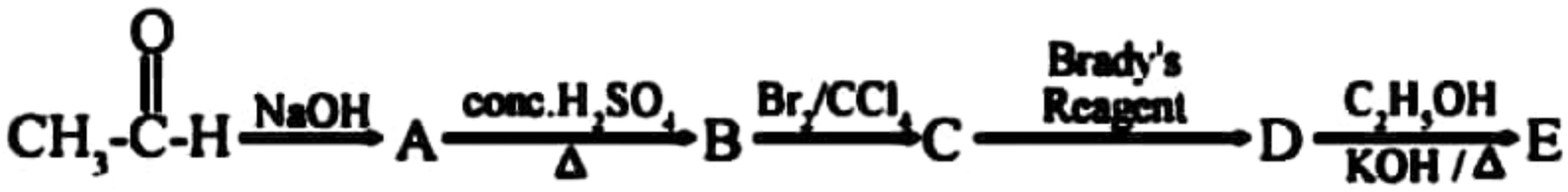
(iv) Draw the isomers of A.

(4.5 Marks)

[see page nine]

Do not write in this column.

(b) (i) Draw the structures to fill the spaces in the reaction scheme given below.



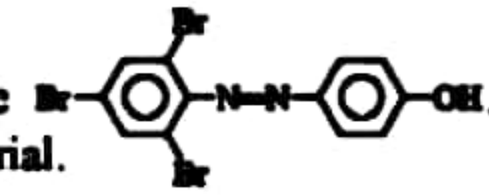
A

B

C

D

E

(ii) Show how you would synthesize  , in not more than 5 steps, using aniline as the only organic material.

(iii) Write the mechanism for the substitution of water to CH_3COCl.

(5.5 Marks) 100

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NEW

Pre Medicine Association, Colombo District 2020

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය (ආදර්ශ), 2021
கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை (மாதிரி), 2021
General Certificate of Education (Adv. Level) Examination (Model), 2021

රසායන විද්‍යාව II
இரசாயனவியல் II
Chemistry II

02 E II

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

PART B – ESSAY

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

5. (a) The compound 'N' present in a certain type of flower is used for the production of various medicinal products. Since the chemical qualities of 'N' are destroyed at temperatures exceeding 40°C, Steam distillation and other methods employing heat cannot be used for its extraction. Hence scientists conducted experiments to extract 'N' using CO_2 liquified under pressure. For this, floral parts of the above flower type are taken, ground and mixed with water to prepare an aqueous solution of 'N'. Then 100cm^3 of this solution is mixed with 100cm^3 of liquified CO_2, stirred and kept aside for a while. It was observed that the water and $CO_{2(l)}$ were separated into phases. Here, they found out that 75% of the compound 'N' travelled from solution to the liquefied $CO_{2(l)}$. Finally, when the $CO_{2(l)}$ phase was separated and the exerted pressure was removed, in order to expel the CO_2 gas, 1.5g of pure 'N' was left.

(Consider the molar mass of 'N' to be $64\ \text{g mol}^{-1}$ and that the whole experiment was conducted at 25 °C).

(i) State two conditions under which the distribution coefficient can be applied.

(ii) Calculate the concentration of 'N' in the initial aqueous solution.

(iii) Calculate K_D of 'N' between CO_2 and water.

(iv) If the above process is repeated twice for a 50cm^3 'N' solution, having half the concentration as that of the above aqueous solution, using 25cm^3 of CO_2 for each procedure, calculate the number of moles of 'N' remaining in the solution.

(b) (i) I. Define the standard lattice dissociation enthalpy of NaCl.

II. Some standard enthalpy changes are given below. Write down balanced chemical equations for each instance.

• Standard enthalpy of sublimation of $Na_{(s)}$	$+ 107\ \text{kJ mol}^{-1}$
• Standard first ionizing enthalpy of $Na_{(g)}$	$+ 496\ \text{kJ mol}^{-1}$
• Standard enthalpy of atomization of $Cl_{2(g)}$	$+ 244\ \text{kJ mol}^{-1}$
• Standard 1st electron gain enthalpy of $Cl_{(g)}$	$- 349\ \text{kJ mol}^{-1}$
• Standard enthalpy of formation of $NaCl_{(s)}$	$- 411\ \text{kJ mol}^{-1}$
• Standard enthalpy of hydration of $Na^{+}_{(g)}$	$- 405\ \text{kJ mol}^{-1}$
• Standard enthalpy of hydration of $Cl^{-}_{(g)}$	$- 364\ \text{kJ mol}^{-1}$

[see page eleven]

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(ii) Calculate the lattice dissociation enthalpy of $NaCl_{(s)}$ using a Born - Haber cycle.

(iii) Out of $NaCl_{(s)}$ and $MgCl_{2(s)}$, which has the higher lattice dissociation enthalpy? Give reasons.

(iv) Using the above data calculate the standard enthalpy of dissolution of $NaCl_{(s)}$.

(v) I. Consider the reaction, $C_{(s)}+O_{2(g)} \rightarrow CO_{2(g)}$

If its enthalpy change (ΔH) = - 393.5 kJ mol^{-1} and its Gibbs free energy (ΔG) = - 394.4 kJ mol^{-1}, calculate its entropy change in J mol^{-1} K^{-1} at 25 °C.

II. Although the reaction should take place spontaneously according to part (vi), this doesn't practically happen. State possible reasons for this.

6. (a) Explain why solubility product is not applicable to water soluble ionic compounds.

(b) A certain mass of $Ca(OH)_2$ is mixed separately with two 100cm^3 portions of distilled water at 25 °C and 50 °C. 25 cm^3 portions from each solution are titrated separately with 2.75×10^{-2} mol dm^{-3} HCl using phenolphthalein as the indicator. The readings obtained are as follow.

For the 25 °C solution - 10 cm^3
For the 50 °C solution - 6.54 cm^3

(i) Find the OH^- concentration of the solutions, in each case.

(ii) What are the values obtained for K_{sp} of $Ca(OH)_2$ at 25 °C and 50 °C?

(iii) What unique change does the K_{sp} of $Ca(OH)_2$ show upon increase of temperature in comparison to most other ionic compounds?

(iv) What can be the reason for the change mention in part (iii) above?

(c) (i) RH is a weakly acidic organic compound. Consider an aqueous 0.1 mol dm^{-3} RH solution. If its pOH is 7.7 and the K_w of water is 2×10^{-14} mol^2 dm^{-6} at 35 °C, find K_a of RH at that temperature.

(ii) When a solution of AgCl is added drop-wise to a 0.144 mol dm^{-3} 250 cm^3 RH solution, 5 drops of AgCl were required to just get a precipitate of AgR at the bottom. Find the concentration of the added AgCl solution.
(The K_{sp} of AgR at 35 °C is 2.4×10^{-12} mol^2 dm^{-6} while the volume of a water droplet is approximately 0.05 ml.)

(iii) 450 cm^3 of a 0.0001 mol dm^{-3} HCl solution is added to 50 cm^3 of the initial solution in part (ii). Find the concentration of H^+ ions in the new solution.

(iv) Find the new concentration of R^- ions in that solution.

(v) Find the mass of $AgNO_3$ required to just begin precipitation of AgR in the new solution.
(Ag-108)

7. (a) (i) Draw and label a silver-silver chloride electrode. Write the reaction that takes place in it.

(ii) I. Write down the cell notation for a cell made by joining a standard chlorine electrode and a standard Calomel electrode.

II. Find the e.m.f. of above cell.
$E^\circ_{(Cl_{2(g)}|Cl^-_{(aq)})} = +1.36$ V and $E^\circ_{(Hg_{(l)}|Hg_2Cl_{2(aq)})} = +0.27$ V

[see page twelve]

(iii) I. Write down the Faraday's laws on electrolysis.

II. Write down three differences between an electrolytic cell and an electrochemical cell.

(iv) A dilute solution of $CuSO_4$ is electrolyzed using inert electrodes..

I. Write down the anode reaction, cathode reaction and overall cell reaction in the above electrolysis.

II. Calculate the volumes of gas released near the anode and cathode, when a 2A current is continuously sent through the above solution for 5 hours. (The molar volume of a gas at 0 °C and 1 atm is 24.4 dm^3)

(b) Four Coordination compounds made by the hydration of $CoCl_2$, $CoBr_2$ and CoI_2 are contained in solutions A, B, C and D. These compounds have octahedral geometry. While their respective halide ions can be present as ligands in the complex, the rest of the ligands in the complex are water molecules. The compounds can be analyzed using the procedures given below.

(Cl-35.5, Ag-108, Br-80, I-127, Co - 59)

Analysis of A

Excess $AgNO_{3(aq)}$ was added to 20 cm^3 of a 0.5 mol dm^{-3} solution of A. A white precipitate was obtained. The dry mass of the precipitate was 1.435 g. The precipitate dissolved when concentrated NH_3 was added.

Analysis of B

Excess $AgNO_{3(aq)}$ was added to 20 cm^3 of a 0.5 mol dm^{-3} solution of B. A yellow precipitate was obtained. The dry mass of the precipitate was 4.7 g. The precipitate did not dissolve even when concentrated NH_3 was added.

Analysis of C

Excess $AgNO_{3(aq)}$ was added to 20 cm^3 of a 0.5 mol dm^{-3} solution of C. A light yellow precipitate was obtained. The dry mass of the precipitate was 1.88 g. While the precipitate did not dissolve in diluted NH_3, it dissolved when concentrated NH_3 was added.

Analysis of D

Excess $AgNO_{3(aq)}$ was added to 10 cm^3 of a 0.5 mol dm^{-3} solution of D. A white precipitate was obtained. The dry mass of the precipitate was 1.435 g. The precipitate dissolved in both diluted and concentrated NH_3.

(i) Write down the electron configuration and oxidation number shown by Co in A, B, C and D.

(ii) Deduce the structures of the coordination complexes in the solutions A, B, C and D.

(iii) Name them according to IUPAC nomenclature.

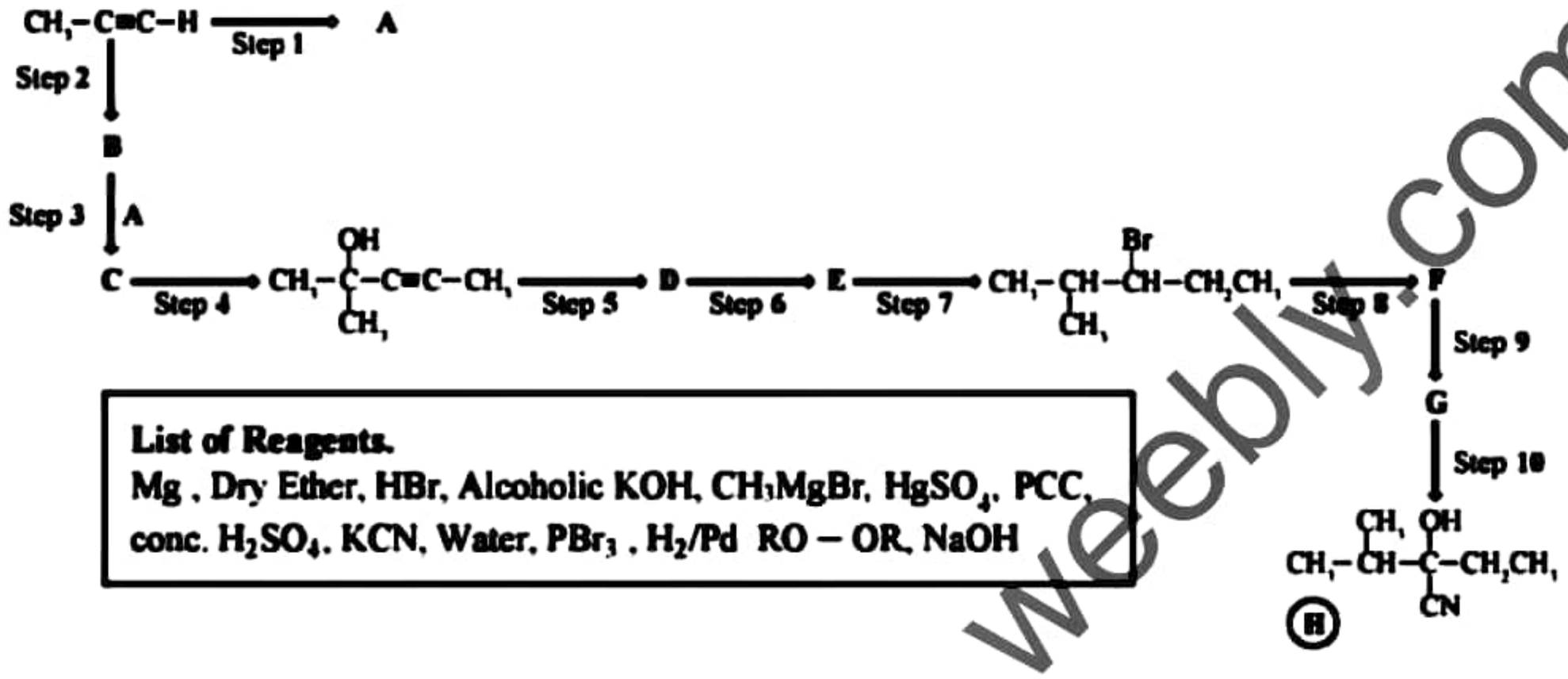
(iv) Draw the structure of A.

[see page thirteen]

PART C – ESSAY

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

8. (a) The following reaction scheme is used to synthesize compound (H) beginning with $CH_3 - C \equiv CH$. Draw the structures A, B, C, D, E, F and G which are required to complete the reaction scheme. Name the reactants used from step 1 - 10, using only the chemicals given in the list.



List of Reagents.
Mg , Dry Ether, HBr, Alcoholic KOH, CH_3MgBr, $HgSO_4$, PCC, conc. H_2SO_4, KCN, Water, PBr_3 , H_2/Pd RO – OR, NaOH

(b) (i) Compare the acidities of phenol and carboxylic acid.

(ii) Show how you would carry out the following conversion in less than 10 Steps, using ⬡ as the only external organic material.

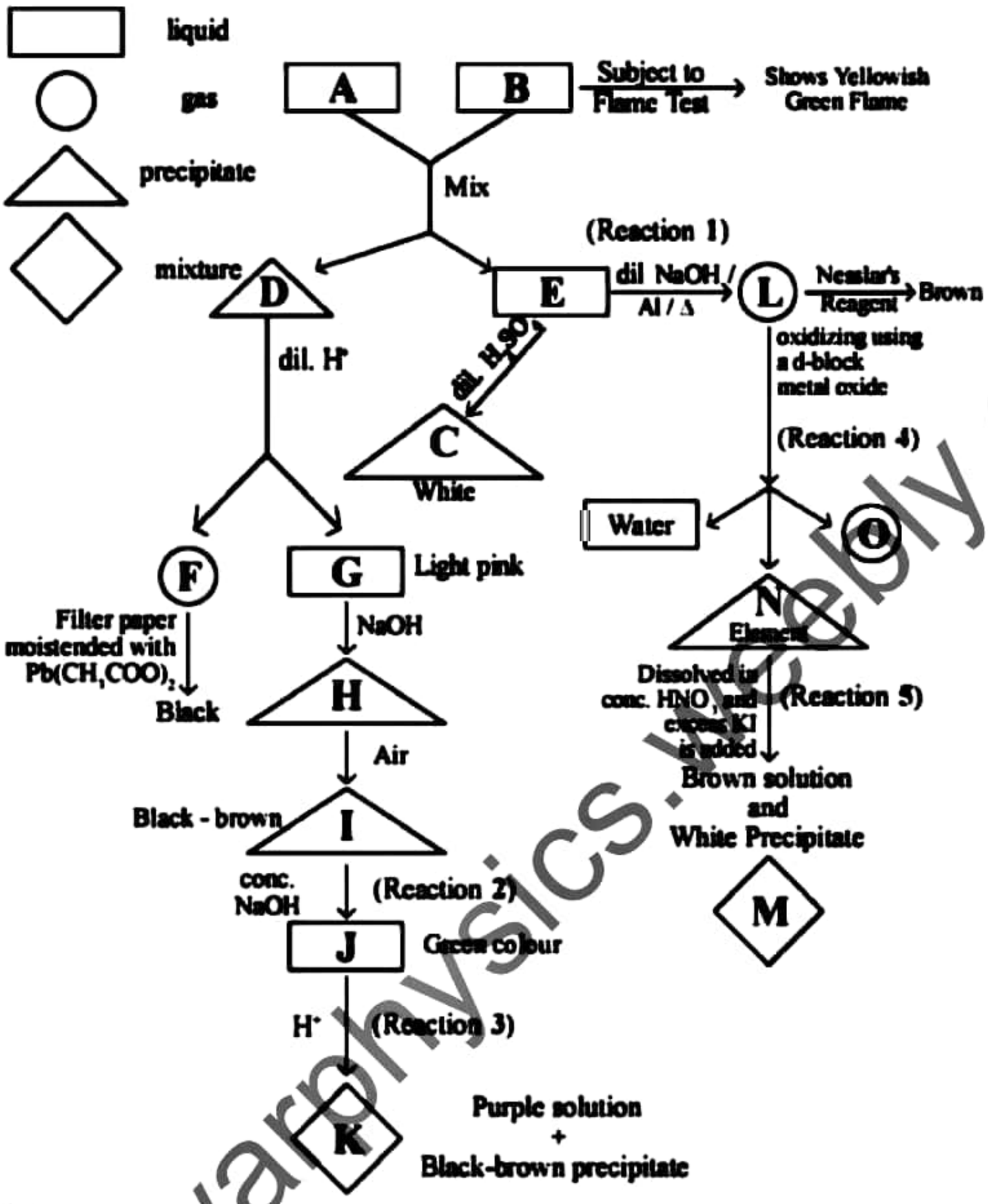
(c) $CH_3 - CH = CH - CH_3$ + cool concentrated H_2SO_4 → Y

(i) Draw the structure of Y.

(ii) Write down the mechanism for the above reaction.

[see page fourteen]

9.(a)



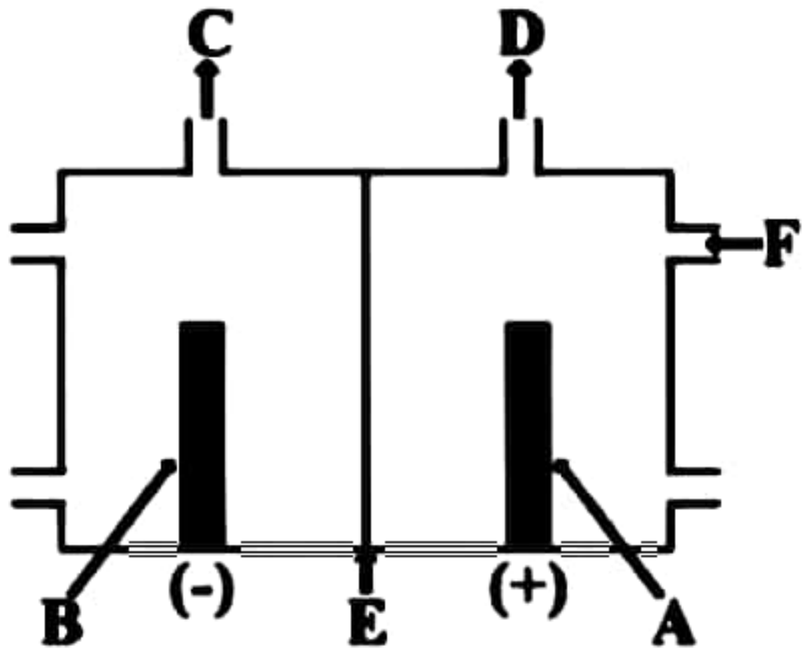
(i) Identify compounds A to O.
(ii) Write down reactions 1 to 5.

(b) An aqueous solution contains $CuSO_4$, $NiSO_4$ and $Fe_2(SO_4)_3$. When excess $BaCl_2$ was added to 100 cm^3 of the initial solution, the mass of the precipitate (X) obtained was 9.32 g. When the filtrate was separated and KI was added, the mass of the precipitate thus obtained (Y) was 1.905 g. When the gas (Z) released during the addition of KI was titrated with a 1 mol dm^3 $Na_2S_2O_3$ Solution, the end point was 20 cm^3.
(Fe – 56, Cu – 63.5, Ni – 58.6, Ba – 137, S – 32, I – 127)

(i) Identify X, Y and Z.
(ii) Write the reaction(s) taking place upon the addition of KI.
(iii) Calculate the concentrations of Ni^{2+}, Fe^{2+}, Cu^{2+}, SO_4^{2-} in the mixture .
(iv) What is the indicator used for the above titration with $Na_2S_2O_3$.

[see page fifteen]

10. (a) The following question is based on the production of Caustic Soda using the membrane cell method and its uses.



(i) Name the electrodes A and B and the metals commonly used to make them.

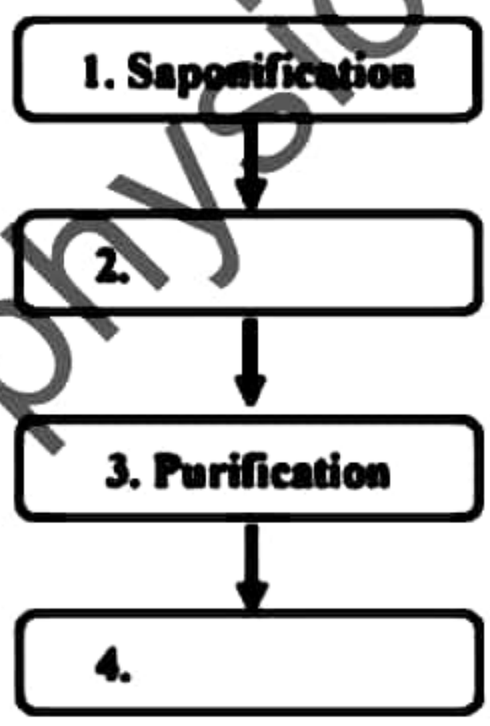
(ii) Write the reactions taking place at A and B and the gases released from C and D, when the cell operates.

(iii) Name E. What is the importance of E in the activity of cell?

(iv) Name the raw materials added into the cell through F and name three ionic impurities removed during their purification.

(v) State the two other methods used to produce NaOH in addition to the membrane cell method.

(vi) One of the principal uses of NaOH is the production of soap.



I. Name steps 2 and 4.

II. Briefly explain the process that takes place in Step 4.

III. TFM is an important parameter in determining quality of soap. What is meant by the TFM value?

[see page sixteen]

(b) The wreckage caused by the 'Xpress Pearl' ship in mid-2021 can be considered to have some of the most adverse effects on Sri Lanka's bio diversity in recent times.

(i) To assess the extent of the damage due to this incident, researchers obtain and analyze water samples. What are the units used to measure the following three water quality parameters?
I. Turbidity
II. Conductivity
III. Hardness

(ii) There were great quantities of chemical substances onboard the 'Xpress Pearl' ship when it caught on fire. Some of them leaked into the ocean and the others were combusted and mixed with atmospheric air. Further, large amounts of plastic washed ashore on the western coast. Give one additive added to maintain each of the properties of plastic given below.
I. To provide vivid colours
II. To make plastic less rigid
III. Used as fillers in plastic

(iii) There is a possibility of occurrence of acid rain due to the mixing of chemicals into air by the burning of the above ship. Elucidate this statement providing examples where necessary.

(c) Consider the following polymers.
Polyethylene (PE), Nylon 6,6, Polyvinyl Chloride (PVC), Polystyrene (PS), Polyethylene Terypthalate (PET)

(i) According to the reaction taking place during production, polymers can be classified into two classes. Name them and classify the above polymers into these two classes.
(ii) According to the method of production there are two Main types of Polyethylene (PE). What are they?
(iii) Polymers can also be classified as thermoplastic and thermosetting polymers, based on their response to heat. Give an example each for a thermoplastic and a thermosetting polymer.
(iv) Bakelite is a polymer used in several industrial fields due to its electrical insulating properties. What are the two main compounds used in the production of this polymer?

•••

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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

නව නිර්දේශය/ புதிய பாடத்திட்டம்/New Syllabus

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය (ආදර්ශ), 2021
கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை (மாதிரி), 2021
General Certificate of Education (Adv. Level) Examination (Model), 2021

රසායන විද්‍යාව I இரசாயனம் I Chemistry I	02 E I	පැය දෙකයි இரண்டு மணித்தியாலம் Two Hours

ලකුණු පත්‍රය
Marking Scheme

Question Number	Answer	Question Number	Answer	Question Number	Answer	Question Number	Answer	Question Number	Answer
1	4	11	1	21	3	31	3	41	3
2	4	12	2	22	4	32	1	42	4
3	4	13	2	23	5	33	3	43	4
4	2	14	4	24	2	34	1	44	3
5	2	15	3	25	3	35	1	45	4
6	3	16	3	26	3	36	5	46	2
7	5	17	3	27	3	37	3	47	3
8	3	18	4	28	2	38	5	48	4
9	2	19	4	29	2	39	2	49	4
10	3	20	3	30	1	40	5	50	4

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නව නිර්දේශය/ புதிய பாடத்திட்டம்/New Syllabus

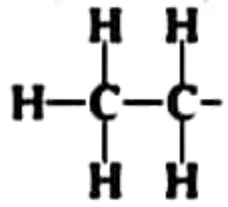
අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය (ආදර්ශ), 2021
கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை (மாதிரி), 2021
General Certificate of Education (Adv. Level) Examination (Model), 2021

රසායන විද්‍යාව II இரசாயனவியல் II Chemistry II	02 E II	පිළිතුරු පත්‍රය Marking Scheme

පැය තුනයි மூன்று மணித்தியாலம் Three Hours	අමතර කියවීම් කාලය - මිනිත්තු 10 යි மேலதிக வாசிப்பு நேரம் - 10 நிமிடங்கள் Additional Reading Time - 10 minutes

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

- *A periodic Table is provided on page 17.*
- ***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 02 - 09)

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

PART B and PART C - Essay (pages 09 - 14)

- *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.*

Index No. : .....

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]

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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) State whether the following statements are true or false.

(i) The ionic radius of the following cations varies as $K^+ > Ca^{2+} > Ga^{3+}$ (...True...)

(ii) The Van der waals radius is one half the distance between two equivalent bonded atoms in their most stable arrangement. (...False...)

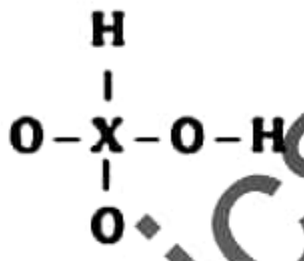
(iii) The energy for a gaseous atom to obtain an electron always becomes more positive when moving down a group. (...False...)

(iv) Inter-molecular hydrogen bonds can be seen in Para-Nitrophenol. (...False...)

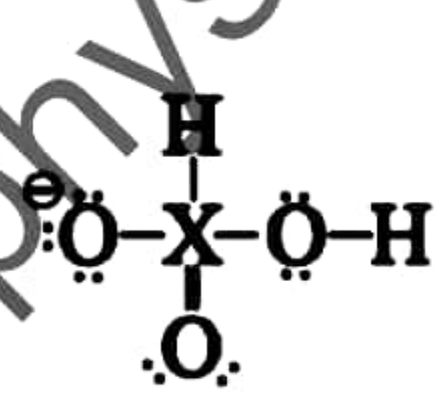
(v) The energy difference between the line with the highest frequency in Balmer series and the line with longest wavelength in Lyman series, gives the energy of the line with the highest energy in the Paschen series. (...False...)

(04 × 5 = 20) **1.(a) : 20 Marks**

(b) The skeleton used to construct the Lewis structure of the anion $H_2XO_5^-$ is given below. X is an element belonging to the P block



(i) If the arrangement with minimum charges on the atoms is stable, draw the most acceptable Lewis Structure for this ion.

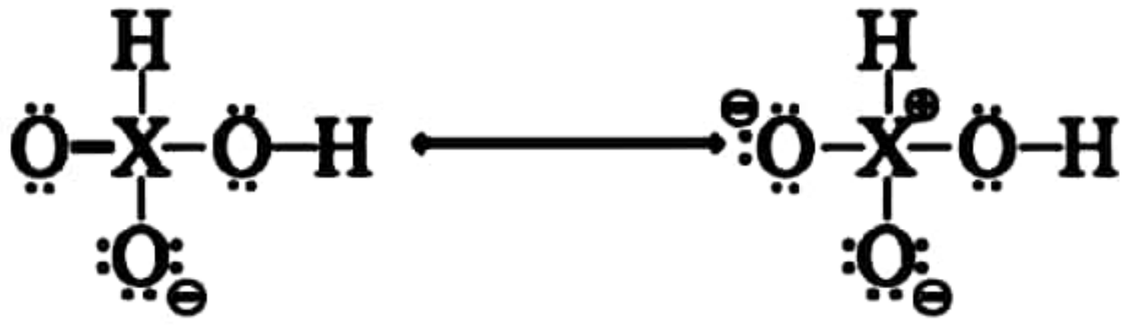


(06)

(ii) To what group of the periodic table can the element X belong to? ...15... (02)

(iii) If X belongs to the 3rd period what element could X be? ...P... (02)

(iv) Draw two other resonance structures for above ion.



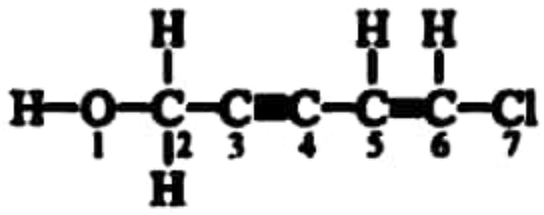
(04 × 2 = 08)

[see page three]

Do not write in this column.

(v) Based on the Lewis structure given below, state the following regarding the O and C atoms given in the table below.

I. VSEPR pairs around the atom
II. Electron pair geometry around the atom
III. Shape around the atom
IV. Hybridization of the atom



	O_1	C_2	C_3	C_5
VSEPR pairs around the atom	4	4	2	3
Electron pair geometry around the atom	Tetrahedral	Tetrahedral	Linear	Trigonal planar
Shape around the atom	Tetrahedral	Tetrahedral	Linear	Trigonal Planar
Hybridization of the atom	sp^3	sp^3	sp	sp^2

(01 × 16 = 16)

(vi) Identify the atomic orbitals involved in the formation of the following π bonds in the Lewis structure given in part (v) above.

I. $C_3 - C_4$ C_3 ..2p atomic orbital.. C_4 ..2p atomic orbital..
II. $C_5 - C_6$ C_5 ..2p atomic orbital.. C_6 ..2p atomic orbital..

(01 × 4 = 04)

(vii) Identify the atomic/hybrid orbitals involved in the formation of the following σ bonds in the Lewis structure given in part (V) above.

I. $H - O_1$ H ..1s atomic orbital.. O_1 ..sp^3 hybridized orbital..
II. $O_1 - C_2$ O_1 ..sp^3 hybridized orbital.. C_2 ..sp^3 hybridized orbital..
III. $C_2 - C_3$ C_2 ..sp^3 hybridized orbital.. C_3 ..sp hybridized orbital..
IV. $C_3 - C_4$ C_3 ..sp hybridized orbital.. C_4 ..sp hybridized orbital..
V. $C_6 - Cl_7$ C_6 ..sp^2 hybridized orbital.. Cl_7 ..sp^3 hybridized orbital/ 3p atomic orbital..

(01 × 10 = 10)

(viii) What is the approximate value of the bond angle around atom C_5 in the Lewis structure given in part (v) above?

Award marks for any value between 118° - 122° (02)

1.(b) : 50 Marks

[see page four]

Do not write in this column.

(c) (i) The dipole moment of LiH is 1.964×10^{-29} Cm. If the bond length of LiH is 1.596×10^{-10} m, Find percentage ionic character of LiH.
(Charge of an electron = 1.602×10^{-19} C)

If LiH is completely ionic
its magnitude dipole moment (μ) = Charge of a Pole (δ) × bond length (m) (02)
$= 1.602 \times 10^{-19}\ C \times 1.596 \times 10^{-10}\ m$

Percentage of ionic character of LiH = $\frac{1.964 \times 10^{-29}\ Cm}{1.602 \times 10^{-19}\ C \times 1.596 \times 10^{-10}\ m} \times 100\ \%$ (1+1) + (1+1) + (1+1)

$= 76.80\% - 76.82\%$ (02)

(ii) Arrange the following in the increasing order of the property indicated in parentheses.

I. Na, K, Mg, Mn (metallic bond strength)
K < Na < Mg < Mn

II. NH_2OH, NO, NO_2^-, NO_3^- (N-O bond length)
NO < NO_2^- < NO_3^- < NH_2OH

III. F, O, N, Ne (Second ionization energy)
N < F < O < Ne

IV. $NaNO_3$, KNO_3, $Mg(NO_3)_2$, NH_4NO_3 (Decomposition Temperature)
NH_4NO_3 < $Mg(NO_3)_2$ < $NaNO_3$ < KNO_3

(05 × 4 = 20) **1.(b) : 30 Marks**

100/100

2.(a) X, Y and Z are 3 consecutive elements with atomic numbers less than 20. One of them exists as a gas at room temperature. Out of their oxides with the highest oxidation numbers, the oxides of Y and Z react with water giving strong acids while the oxide of the X gives a weak acid.

(i) Identify X,Y and Z.
X: P Y: S Z: Cl
(05 × 3 = 15)

(ii) Write down the reactions of their oxides with the highest oxidation number with water.
$P_2O_5 + 3H_2O \rightarrow 2H_3PO_4$ or $P_4O_{10} + 6H_2O \rightarrow 4H_3PO_4$
$SO_3 + H_2O \rightarrow H_2SO_4$ (04 × 3 = 12)
$Cl_2O_7 + H_2O \rightarrow 2HClO_4$

(iii) Write the reaction of Z_2 with cold diluted $NaOH_{(aq)}$.
$Cl_2 + 2NaOH \rightarrow NaOCl + NaCl + H_2O$ (04)

(iv) Which of the products in part (iii) above show bleaching properties?
NaOCl (03)

[see page five]

Do not write in this column.

(v) Show how the product behaves as a bleaching agent by means of chemical reactions.

$2NaOCl + \text{Coloured Flower} \rightarrow 2NaCl + O_2 + \text{Colourless Flower}$ (04)

NaOCl oxidizes the colored flower and makes it colorless. (02)

(vi) Give reactions to show how Y behaves in each of the following cases.

I. Oxidizing agent : $S + 2Na \rightarrow Na_2S$

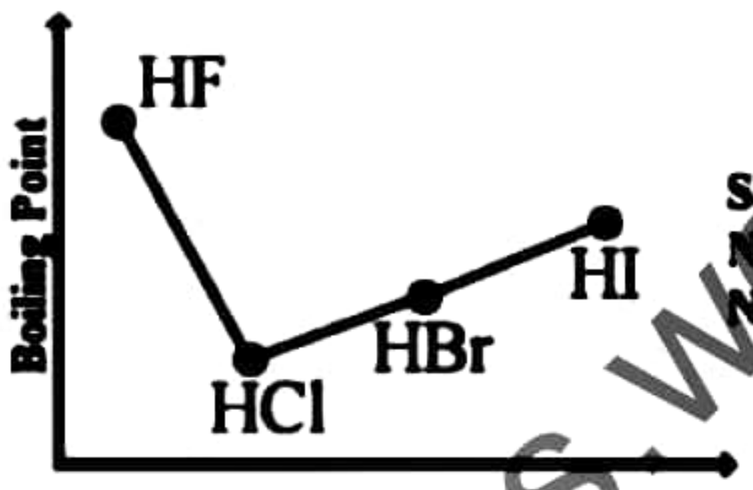
II. Reducing agent : $S + 6HNO_3 \rightarrow H_2SO_4 + 6NO_2 + 2H_2O$

(04 × 2 = 08)

(vii) Give the balanced chemical equation for the reaction of Z with water.

$Cl_2 + H_2O \rightarrow HCl + HOCl$ (04)

(viii) Draw a rough diagram to show the variation of the boiling points of the hydrides in the group to which Z belongs.



Shape - (04)
Naming the axis - (02)
Naming the compounds- (02)

2.(a) : 60 Marks

(b) X and Y are two water soluble salts. The following tests are carried out to identify X and Y.

Test	Observation
(1) Added dilute HCl to X.	A gas (P) with a pungent smell was evolved and a yellow turbidity was obtained
(2) X and Y were mixed together.	Precipitate A and Solution B were obtained.
(3) Only when A was heated	A black precipitate (D) and a colourless gas (Q) was obtained. (Q is a strong acid)
(4) Solution B is heated is the presence of Al in a basic medium.	A gas R with a pungent smell, which turns red litmus blue was released.
(5) Added dilute H_2SO_4 to B.	No observation was noted.
(6) X is subjected to the flame test	Shows a yellowish colour.

(i) Identify X and Y.

X: $Na_2S_2O_3$ Y: $Pb(NO_3)_2$

(05 × 2 = 10)

(ii) Identify precipitate A and D and gases P, Q and R.

A: PbS_2O_3 P: SO_2 R: NH_3

D: PbS Q: SO_3

(04 × 5 = 20)

(iii) Write the reactions taking place in (3) and (4) above.

(3) $PbS_2O_3 \rightarrow PbS + SO_3$

(5) $2H_2O + 3NaNO_3 + 8Al + 5NaOH \rightarrow 8NaAlO_2 + 3NH_3$ (05 × 2 = 10)

2.(b) : 40 Marks

100/100

[see page six]

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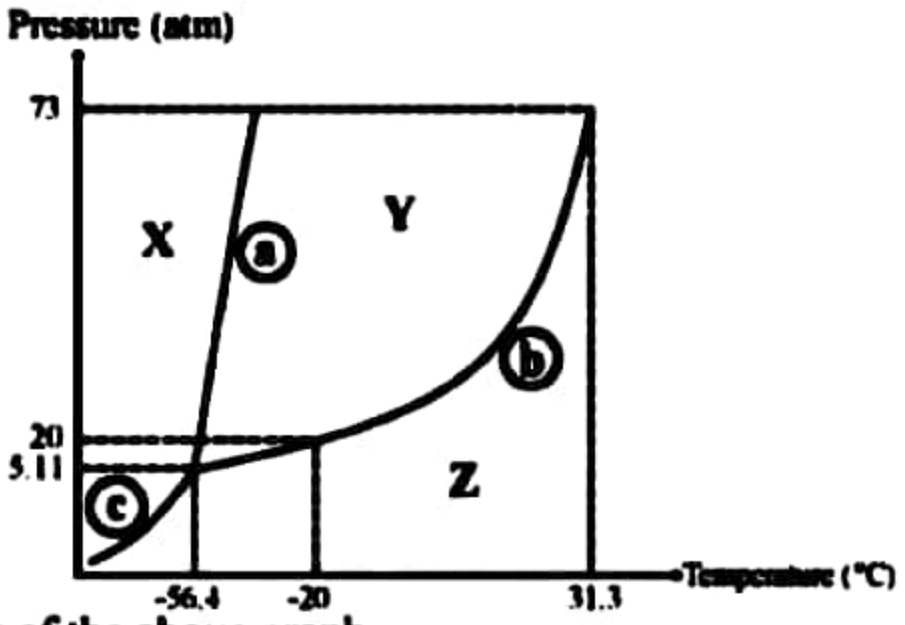
3.



(i) Identify curves a, b and c of the above graph.

a: Curve of variation of melting point of CO_2 against its pressure

b: Curve of variation of boiling point of CO_2 against its pressure

c: Curve of variation of sublimation point of CO_2 against its pressure. (02 × 3 = 06)

(ii) Identity phases X, Y and Z.

X: Solid Phase

Y: Liquid Phase

Z: Vapour/Gas Phase (02 × 3 = 06)

(iii) Define the critical pressure of a gas, and state the corresponding value for CO_2.

The minimum pressure that is required to liquidize a particular vapour / gas at the critical temperature is Critical Pressure. (02)

73 atm (02)

(iv) "Liquid CO_2 can be obtained by maintaining temperatures below 0°C under standard pressure"

Explain whether this statement is true or false by referring to the above graph.

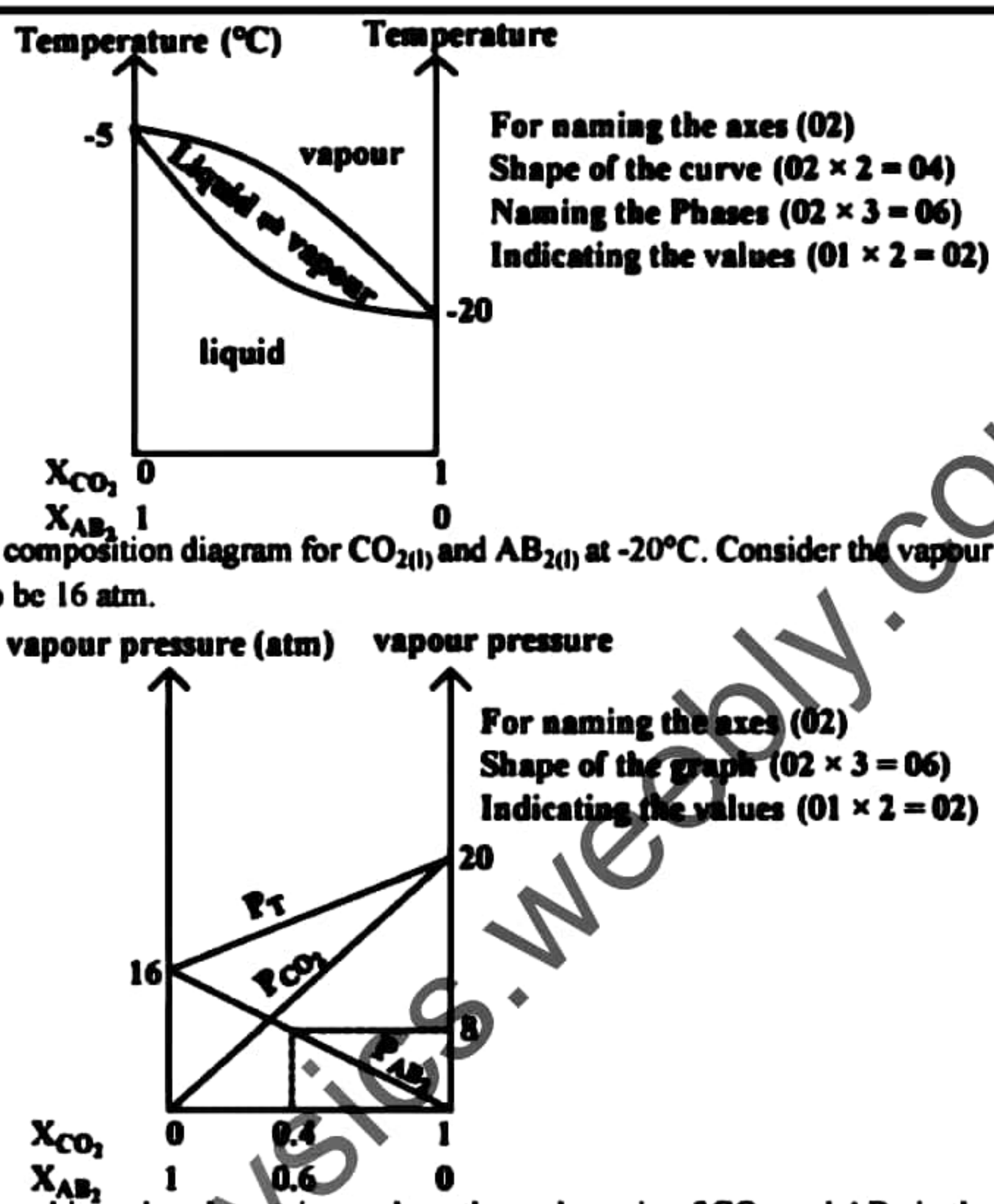
Standard Pressure is 1 atm. The Triple point of CO_2 is at a very higher temperature than the standard temperature taking values such as 5.11 atm. Therefore, when the temperature of CO_2 is reduced at 1 atm, it directly moves from gas phase to the solid phase. Therefore at 1 atm, a Liquid Phase of CO_2 cannot be obtained at any temperature.

or

The Curve of Variation of Boiling point of CO_2 against its pressure is not present at 1 atm. At 1 atm, only the curve of variation of the sublimation point against pressure can be observed. Therefore at 1 atm, a Liquid Phase of CO_2 cannot be obtained at any temperature. (05)

(v) $AB_{2(l)}$ is a non-polar liquid. Draw the temperature - composition diagram of an ideal solution of $AB_{2(l)}$ and $CO_{2(l)}$ placed in a closed container, under a pressure of 20 atm. The melting point of $AB_{2(l)}$ at 20 atm is -5°C.

[see page seven]



For naming the axes (02)
Shape of the curve (02 × 2 = 04)
Naming the Phases (02 × 3 = 06)
Indicating the values (01 × 2 = 02)

Do not write in this column.

(vi) Draw the vapour pressure - composition diagram for $CO_{2(l)}$ and $AB_{2(l)}$ at -20°C. Consider the vapour pressure of AB_2 at -20°C to be 16 atm.

For naming the axes (02)
Shape of the graph (02 × 3 = 06)
Indicating the values (01 × 2 = 02)

(vii) Find P_{CO_2} of a solution, placed in a closed container, where the molar ratio of CO_2 and AB_2 in the liquid phase is 2 : 3, and mark this value on the graph drawn in part (vi) above.

Raoul's Law $P_{CO_2} = X_{CO_2} \times P^{\circ}_{CO_2}$ (05)

$= 0.4 \times 20$ atm (4) + (4+1)

$= 8$ atm (4+1)

Marking on the graph (02)

(viii) Find the composition of the solution at the point where curves of P_{CO_2} and P_{AB_2} intersect in the graph drawn in (vi) above.

At the point where the 2 curves meet. $P_{CO_2} = P_{AB_2}$ (05)

$P_{CO_2} = X_{CO_2} \times P^{\circ}_{CO_2}$ $P_{AB_2} = X_{AB_2} \times P^{\circ}_{AB_2}$

$X_{CO_2} \times P^{\circ}_{CO_2} = X_{AB_2} \times P^{\circ}_{AB_2}$ (05)

$X_{CO_2} \times 20$ atm $= (1-X_{CO_2}) \times 16$ atm (4) + (4+1) + (4) + (4+1)

$X_{CO_2} \times 20 = 16$ atm $- X_{CO_2} \times 16$ $X_{CO_2} = {}^{16}/_{36}$

$X_{CO_2} = 0.44$ (04)

$1-X_{CO_2} = X_{AB_2}$

$X_{AB_2} = 0.55$ (04)

3. : 100 Marks

100/100

[see page eight]

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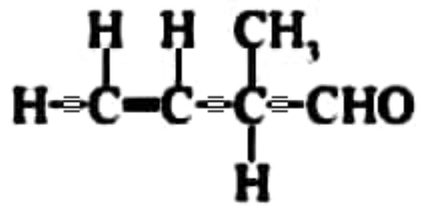
Do not write in this column.

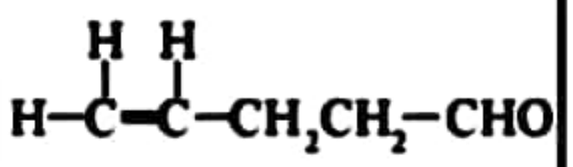
4.(a) A, B, C, D and E are organic compounds with the same molecular formula C_5H_8O. All five react with Tollen's reagent to give a silver mirror. Only A and B do not show geometric isomerism, but A exhibits optical isomerism. When HBr is added to B in a polar medium and is then treated with Hg/Zn and conc. HCl, F is obtained. F exhibits optical isomerism. When C and E are reacted with Br_2/CCl_4 and the products thus obtained are reacted with alcoholic KOH, G and H, which are positional isomers of each other, are obtained. H underwent self-condensation in diluted NaOH.

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

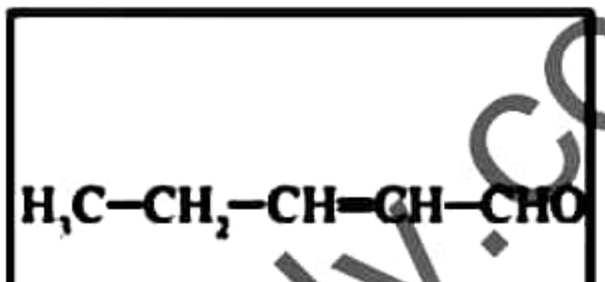
A



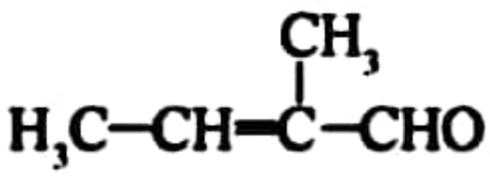
B



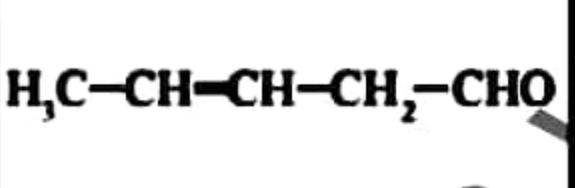
C



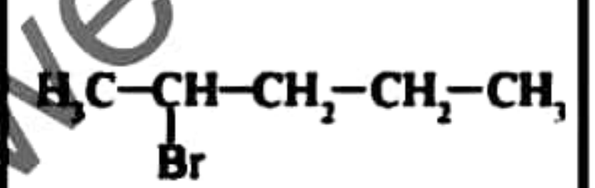
D



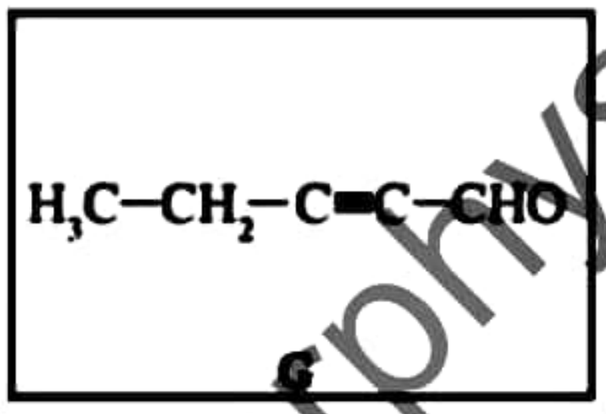
E



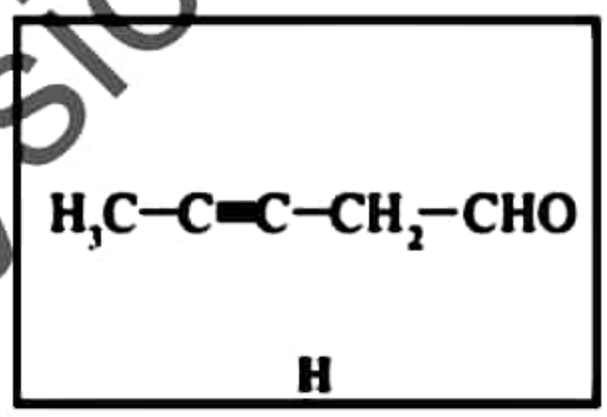
F



G

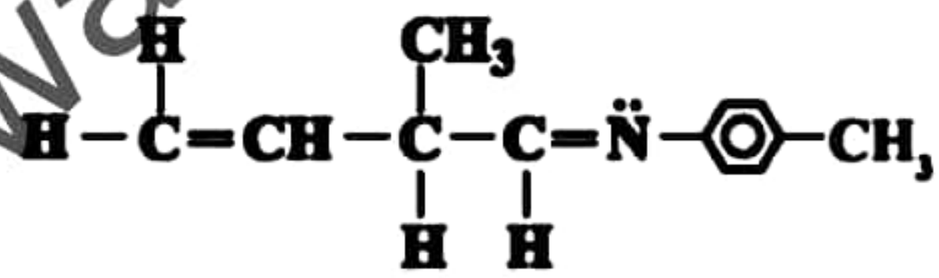


H



(04 × 8 = 32)

(ii) Draw the structures of the product obtained when A is reacted with Para methyl aniline.

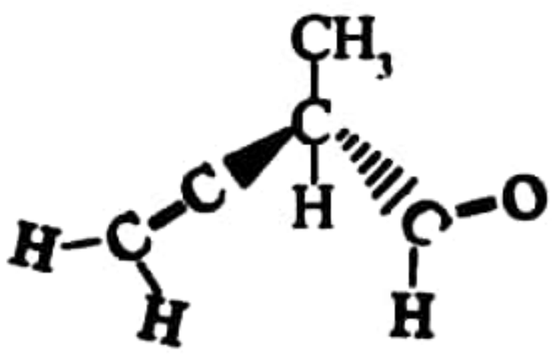


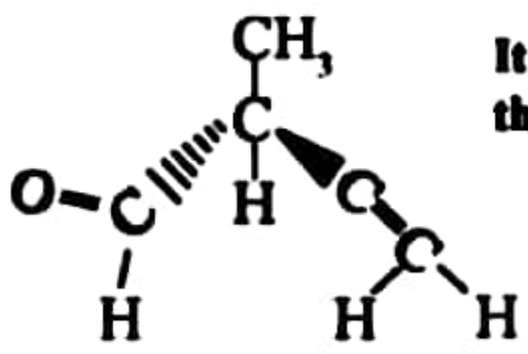
(04)

(iii) Name A according to IUPAC Nomenclature.

2-methylbut-3-enal or 2-methyl-3-butenal (03)

(iv) Draw the isomers of A.





It is not essential to inidcate the 3D nature.

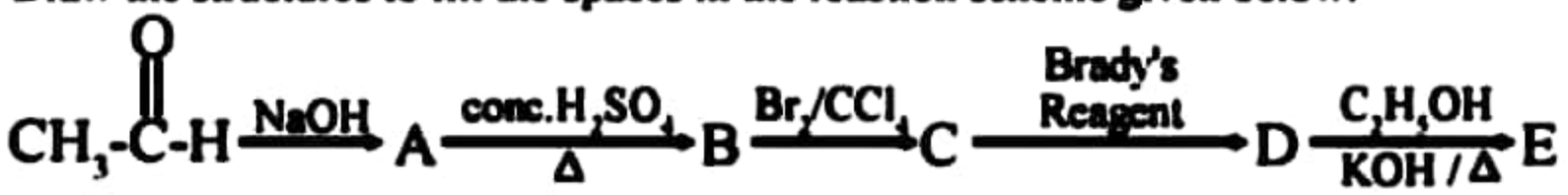
(03 × 2 = 06)

4.(a) : 45 Marks

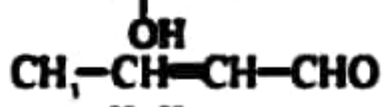
[see page nine]

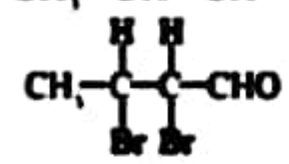
Do not write in this column.

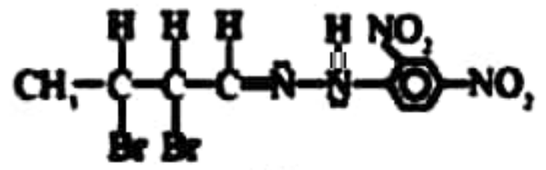
(b) (i) Draw the structures to fill the spaces in the reaction scheme given below.

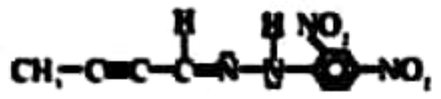


A 

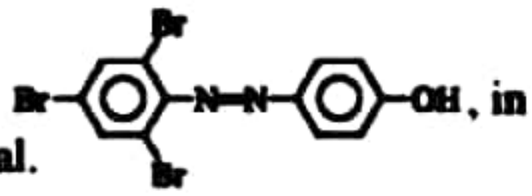
B 

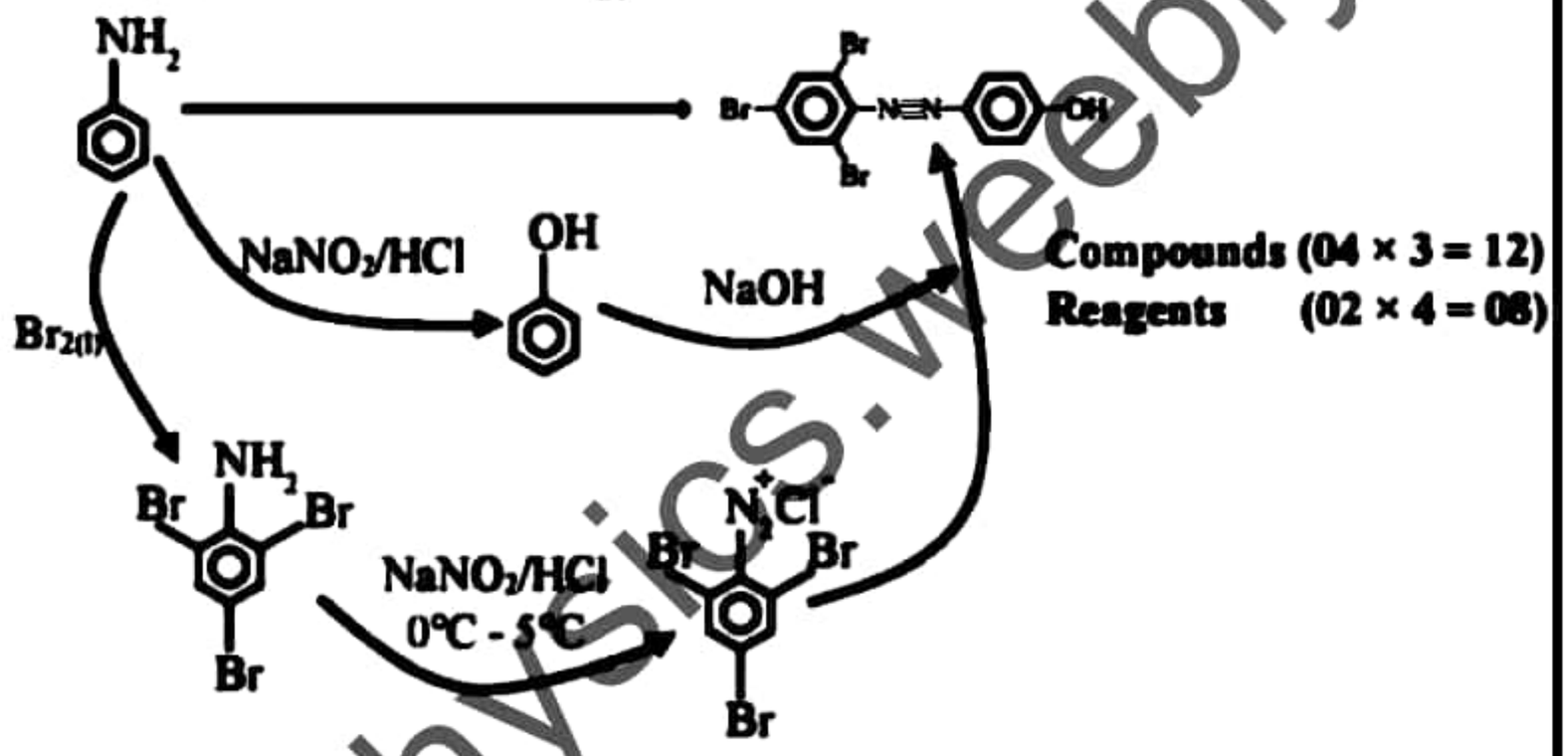
C 

D 

E 

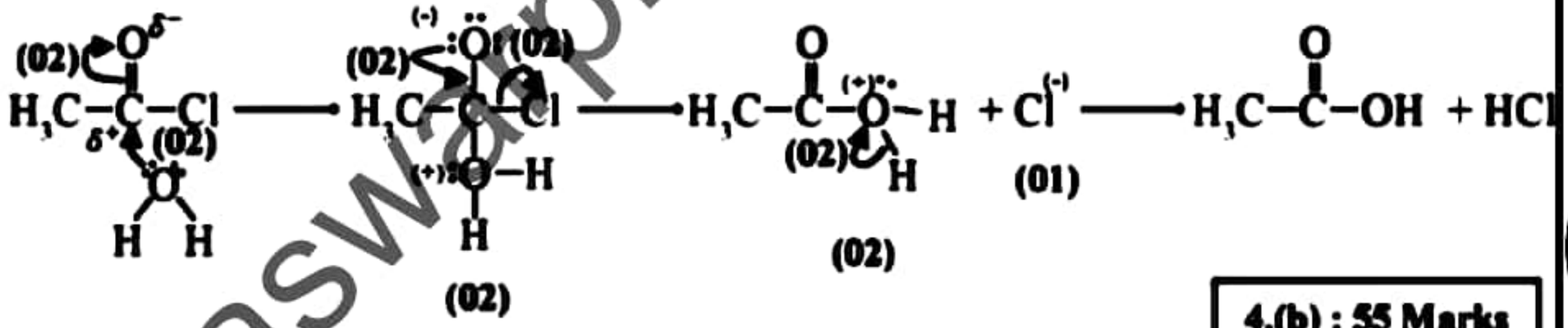
(04 × 5 = 20)

(ii) Show how you would synthesize  , in not more than 5 steps, using aniline as the only organic material.



Compounds (04 × 3 = 12)
Reagents (02 × 4 = 08)

(iii) Write the mechanism for the substitution of water to CH_3COCl.



100/100

4.(b) : 55 Marks

•••

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නව නිර්දේශය/ புதிய பாடத்திட்டம்/New Syllabus

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය (ආදර්ශ), 2021
கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை (மாதிரி), 2021
General Certificate of Education (Adv. Level) Examination (Model), 2021

රසායන විද්‍යාව II இரசாயனவியல் II Chemistry II	**සලකුණු පත්‍රය** **Marking Scheme**	**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) The compound 'N' present in a certain type of flower is used for the production of various medicinal products. Since the chemical qualities of 'N' are destroyed at temperatures exceeding 40°C, Steam distillation and other methods employing heat cannot be used for its extraction. Hence scientists conducted experiments to extract 'N' using CO_2 liquified under pressure. For this, floral parts of the above flower type are taken, ground and mixed with water to prepare an aqueous solution of 'N'. Then $100cm^3$ of this solution is mixed with $100cm^3$ of liquified CO_2, stirred and kept aside for a while. It was observed that the water and $CO_{2(l)}$ were separated into phases. Here, they found out that 75% of the compound 'N' travelled from solution to the liquefied $CO_{2(l)}$. Finally, when the $CO_{2(l)}$ phase was separated and the exerted pressure was removed, in order to expel the CO_2 gas, 1.5g of pure 'N' was left .

(Consider the molar mass of 'N' to be $64\ g\ mol^{-1}$ and that the whole experiment was conducted at 25 °C).

(i) State two conditions under which the distribution coefficient can be applied.

- The temperature of both phases should be constant
- The two solutions should be immiscible
- The solute should be in the same molecular form in both the solvents. (02)

(ii) Calculate the concentration of 'N' in the initial aqueous solution.

$$\text{Mass of 'N' in initial mixture} = \frac{1.5\ g}{75} \times 100 \qquad (01)$$

$$= 2\ g$$

$$N_{(aq)}\ mol = \frac{2\ g}{64\ g\ mol^{-1}} \qquad (1+1)$$

[see page eleven]

$$= 0.03125 \text{ mol}$$

$$\text{Initial } [N_{(aq)}] = \frac{0.03125 \text{ mol}}{100 \times 10^{-3} \text{ dm}^3} \quad (4+1)$$

$$= 0.3125 \text{ mol dm}^{-3} \quad (4+1)$$

(iii) Calculate K_D of 'N' between CO_2 and water.

$$N_{(aq)} \rightleftharpoons N_{(CO_2)} \quad (02)$$

Initial	**2 g**	**-**
React	**- 1.5 g**	**+ 1.5 g**
Final	**0.5 g**	**1.5 g**

$$K_D = \frac{[N_{(CO_2)}]}{[N_{(aq)}]} \quad (03)$$

$$= \frac{\left(\frac{1.5 \text{ g} / 64 \text{ g mol}^{-1}}{100 \times 10^{-3} \text{ dm}^3}\right)}{\left(\frac{0.5 \text{ g} / 64 \text{ g mol}^{-1}}{100 \times 10^{-3} \text{ dm}^3}\right)} \quad (4+1)$$

$$= \frac{1.5}{0.5}$$

$$K_D = 3 \quad (04)$$

(iv) If the above process is repeated twice for a 50cm^3 'N' solution, having half the concentration as that of the above aqueous solution, using 25cm^3 of CO_2 for each procedure, calculate the number of moles of 'N' remaining in the solution.

$$\text{'N' concentration in the new solution} = \frac{0.3125 \text{ mol dm}^{-3}}{2}$$

$$= 0.15625 \text{ mol dm}^{-3}$$

$$\text{Therefore no. of moles os 'N'} = 0.15625 \text{ mol dm}^{-3} \times 50 \times 10^{-3} \text{ dm}^3 \quad (4+1)$$

$$= 7.8125 \times 10^{-3} \text{ mol}$$

1st Instance,

$N_{(aq)}$	$\rightleftharpoons$	$N_{(CO_2)}$
7.8125×10^{-3} mol – x		+x mol

[see page twelve]

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$$K_D = 3 = \left(\frac{x \text{ mol} / 25 \text{ cm}^3}{(7.8125 \times 10^{-3} - x) \text{ dm}^3 / 50 \text{ cm}^3}\right) \quad (4+1)$$

$$2x = 3 \times 7.8125 \times 10^{-3} - 3x$$

$$x = \frac{3 \times 7.8125 \times 10^{-3}}{5} \text{ mol} \quad (02)$$

2nd Instance,

$$N_{(aq)} \rightleftharpoons N_{(CO_2)}$$

$$7.8125 \times 10^{-3} \text{ mol} - x - y \quad +y \text{ mol}$$

Substitute x

$$7.8125 \times 10^{-3} - x - y = 7.8125 \times 10^{-3} - \left(\frac{3 \times 7.8125 \times 10^{-3}}{5}\right) - y$$

$$= \left(\frac{2 \times 7.8125 \times 10^{-3}}{5}\right) - y \text{ mol}$$

$$K_D = 3 = \left(\frac{y \text{ mol} / 25 \text{ cm}^3}{(\frac{2}{5} \times 7.8125 \times 10^{-3} - y) \text{ dm}^3 / 50 \text{ cm}^3}\right) \quad (4+1)$$

$$2y = 3\left(\frac{2}{5} \times 7.8125 \times 10^{-3}\right) - 3y$$

$$y = \frac{3\left(\frac{2}{5} \times 7.8125 \times 10^{-3}\right)}{5} \text{ mol} \quad (02)$$

'N' mol left $= (7.8125 \times 10^{-3} - x) - y$ mol

$= \left(7.8125 \times 10^{-3} \times \frac{2}{5}\right) - y$ mol

$= \left(7.8125 \times 10^{-3} \times \frac{2}{5}\right) - \frac{3}{5}\left(\frac{2}{5} \times 7.8125 \times 10^{-3}\right)$ mol

$= 7.8125 \times 10^{-3} \times \frac{2}{5}\left(1 - \frac{3}{5}\right)$ mol

$= 7.8125 \times 10^{-3} \times \frac{2}{5} \times \frac{2}{5}$ mol

$= 1.25 \times 10^{-3}$ mol (or 1.2×10^{-3} mol or 1.3×10^{-3} mol) (4+1)

5.(a) : 53 Marks

[see page thirteen]

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(b) (i) I. Define the standard lattice dissociation enthalpy of NaCl.

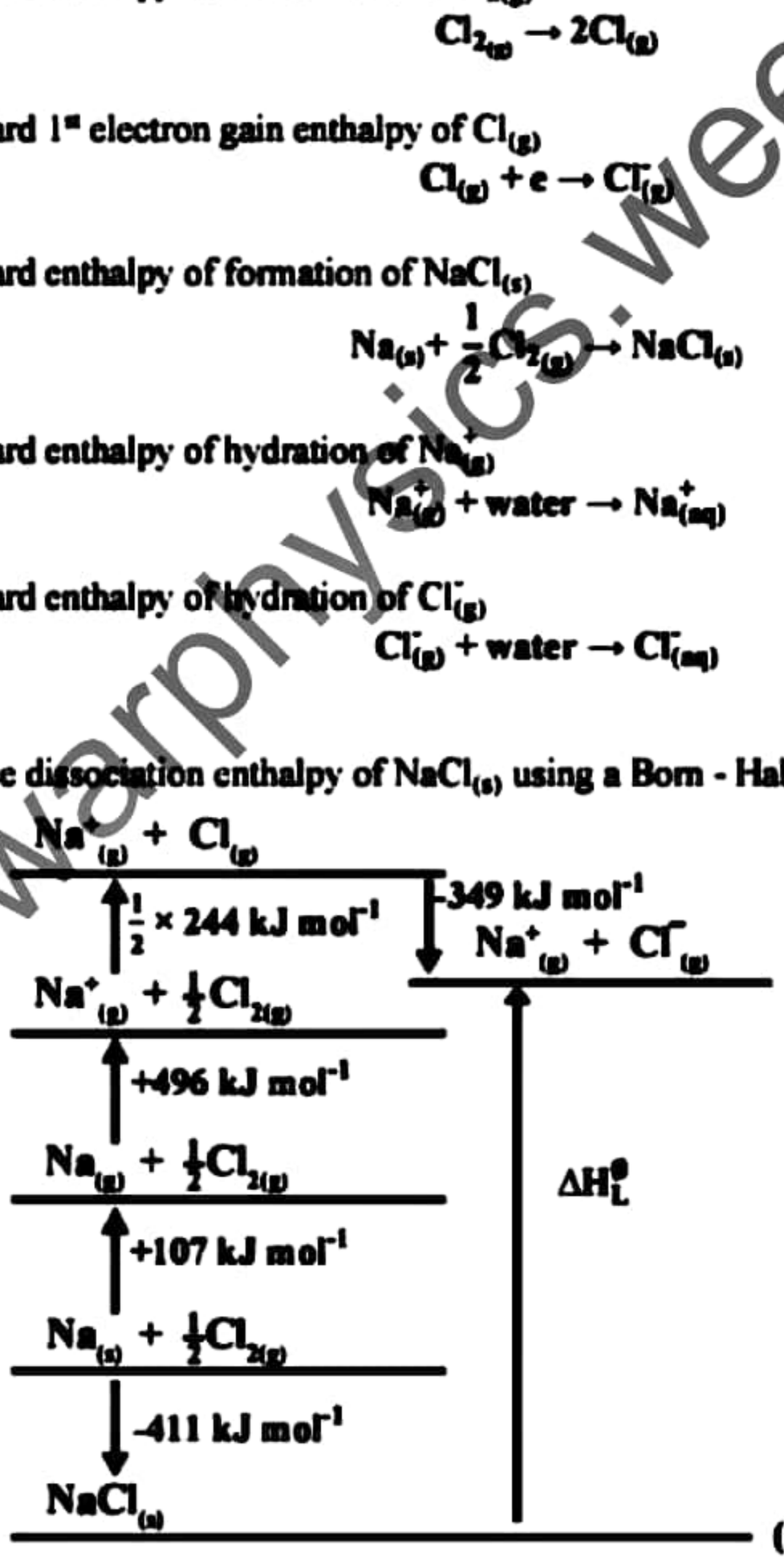
It is the enthalpy change when one mole of solid NaCl at the standard state is converted to gaseous $Na^+_{(g)}$ and $Cl^-_{(g)}$ ions at the standard state. **(05)**

II. Some standard enthalpy changes are given below. Write down balanced chemical equations for each instance.

- Standard enthalpy of sublimation of $Na_{(s)}$ + 107 kJ mol^{-1}
  $Na_{(s)} \rightarrow Na_{(g)}$
- Standard first ionizing enthalpy of $Na_{(g)}$ + 496 kJ mol^{-1}
  $Na_{(g)} \rightarrow Na^+_{(g)} + e$
- Standard enthalpy of atomization of $Cl_{2(g)}$ + 244 kJ mol^{-1}
  $Cl_{2(g)} \rightarrow 2Cl_{(g)}$
- Standard 1st electron gain enthalpy of $Cl_{(g)}$ − 349 kJ mol^{-1}
  $Cl_{(g)} + e \rightarrow Cl^-_{(g)}$
- Standard enthalpy of formation of $NaCl_{(s)}$ − 411 kJ mol^{-1}
  $Na_{(s)} + \frac{1}{2}Cl_{2(g)} \rightarrow NaCl_{(s)}$
- Standard enthalpy of hydration of $Na^+_{(g)}$ − 405 kJ mol^{-1}
  $Na^+_{(g)} + water \rightarrow Na^+_{(aq)}$
- Standard enthalpy of hydration of $Cl^-_{(g)}$ − 364 kJ mol^{-1}
  $Cl^-_{(g)} + water \rightarrow Cl^-_{(aq)}$

(04×7=28)

(iii) Calculate the lattice dissociation enthalpy of $NaCl_{(s)}$ using a Born - Haber cycle.



(02+02+02+02+02+02=12)

[see page fourteen]

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According to Hess' law, (02)

$$+107\ kJ\ mol^{-1} + 496\ kJ\ mol^{-1} + \left(\frac{1}{2} \times 244\ kJ\ mol^{-1}\right) + (-349\ kJ\ mol^{-1}) = -411\ kJ\ mol^{-1} + \Delta H_L^{\theta}$$

(4+1)

$$\Delta H_L^{\theta} = 725\ kJ\ mol^{-1} - 349\ kJ\ mol^{-1} + 411\ kJ\ mol^{-1}$$

$$= +787\ kJ\ mol^{-1}$$ (4+1)

(iv) Out of $NaCl_{(s)}$ and $MgCl_{2(s)}$, which has the higher lattice dissociation enthalpy? Give reasons.

According to the Lattice Dissociation Enthalpy values,

$$MgCl_{2(s)} > NaCl_{(s)}$$

In NaCl and $MgCl_2$, the cations different, while anions are the same.

Considering cations radius,

$$Na^+ > Mg^{2+}$$

Considering Cations charge,

$$Mg^{2+} > Na^+$$

According to the Coulombs Law,

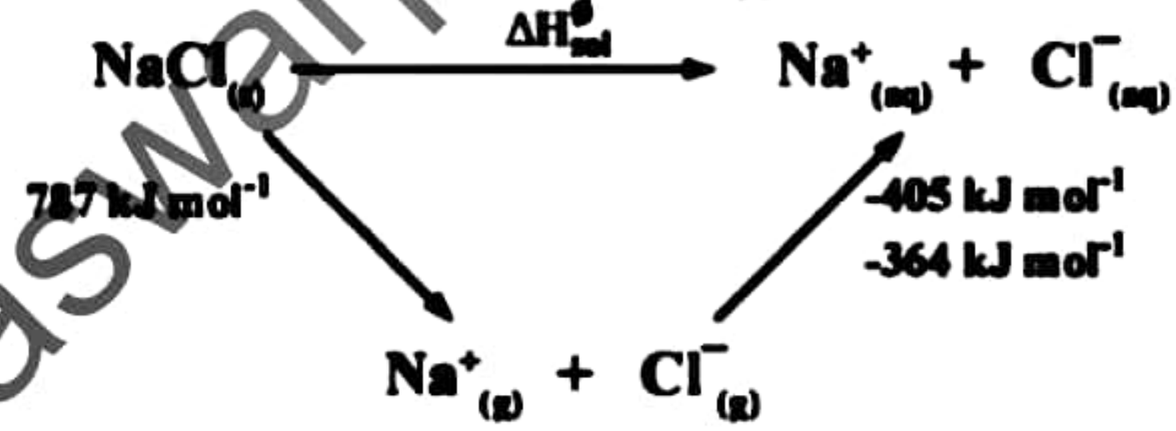
when the charge increases and radius decreases, lattice energy increases.

Lattice Dissociation enthalpy,

$$MgCl_{2(s)} > NaCl_{(s)}$$

Award Marks for any right explanation. (07)

(v) Using the above data calculate the standard enthalpy of dissolution of $NaCl_{(s)}$.



(02+02+02=06)

According to Hess' law,

$$\Delta H_{sol}^{\theta} = 787\ kJ\ mol^{-1} - 405\ kJ\ mol^{-1} - 364\ kJ\ mol^{-1}$$ (4+1)

$$\Delta H_{sol}^{\theta} = 18\ kJ\ mol^{-1}$$ (4+1)

[see page fifteen]

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(v) I. Consider the reaction, $C_{(s)}+O_{2(g)} \rightarrow CO_{2(g)}$

If its enthalpy change (ΔH) = - 393.5 kJ mol^{-1} and its Gibbs free energy (ΔG) = - 394.4 kJ mol^{-1}, calculate its entropy change in J mol^{-1} K^{-1} at 25 °C.

$\Delta G = \Delta H - T.\Delta S$ (03)

$-394.4 \text{ kJ mol}^{-1} = -393.5 \text{ kJ mol}^{-1} - 298K.\Delta S$ (4+1)

$298K \times \Delta S = (394.4 \ominus 393.5) \text{ kJ mol}^{-1}$

$$\Delta S = \frac{0.9 \text{ kJ mol}^{-1}}{298K}$$

$\Delta S = 3.02 \text{ J mol}^{-1} \text{ K}^{-1}$ (or 3 J mol^{-1} K^{-1}) (4+1)

II. Although the reaction should take place spontaneously according to part (vi), this doesn't practically happen. State possible reasons for this.

Since the activation energy of the reaction takes a large value. (04)

5.(b) : 97 Marks

6. (a) Explain why solubility product is not applicable to water soluble ionic compounds.

In a saturated Solution of the water-soluble ionic compound, there is a high concentration of ions. Therefore, interactions take place between ions. Then ions cannot behave independently. Therefore, the Solubility Product will not be valid for this instance. (05)

6.(a) : 05 Marks

(b) A certain mass of $Ca(OH)_2$ is mixed separately with two 100cm^3 portions of distilled water at 25 °C and 50 °C. 25 cm^3 portions from each solution are titrated separately with 2.75×10^{-2} mol dm^{-3} HCl using phenolphthalein as the indicator. The readings obtained are as follow.

For the 25 °C solution - 10 cm^3

For the 50 °C solution - 6.54 cm^3

(i) Find the OH^- concentration of the solutions, in each case.

$$Ca(OH)_{2(aq)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + 2H_2O_{(l)}$$

or

$$OH^-_{(aq)} + H^+_{(aq)} \rightarrow H_2O_{(l)}$$ (02)

In a 25 °C Solution,

$$[OH^-_{(aq)}] = \frac{2.75 \times 10^{-2} \times 10 \times 10^{-3} \text{ mol}}{25 \times 10^{-3} \text{ dm}^3}$$ (4+1)

$= 1.1 \times 10^{-2} \text{ mol dm}^{-3}$ (2+1)

[see page sixteen]

In a 50 °C Solution,

$$[OH^-_{(aq)}] = \frac{2.75 \times 10^{-2} \times 6.54 \times 10^{-3} \text{ mol}}{25 \times 10^{-3} \text{ dm}^3} \quad (4+1)$$

$$= 0.72 \times 10^{-2} \text{ mol dm}^{-3} \quad (2+1)$$

(ii) What are the values obtained for K_{sp} of $Ca(OH)_2$ at 25 °C and 50 °C?

$$Ca(OH)_{2(s)} \rightleftharpoons Ca^{2+}_{(aq)} + 2OH^-_{(aq)} \quad (02)$$

$$+x \qquad +2x$$

$$K_{sp} = [Ca^{2+}_{(aq)}] [OH^-_{(aq)}]^2 \quad (03)$$

$$= 4x^3 \quad (01)$$

In a 25 °C Solution,

$$K_{sp} = 4 \times \left(\frac{1.1 \times 10^{-2} \text{ mol dm}^{-3}}{2} \right)^3 \quad (4+1)$$

$$= 6.655 \times 10^{-7} \text{ mol}^3 \text{ dm}^{-9} \text{ (or } 6.6 \times 10^{-7} \text{ mol}^3 \text{ dm}^{-9}\text{)}$$

$$\text{(or } 6.7 \times 10^{-7} \text{ mol}^3 \text{ dm}^{-9}\text{)} \quad (3+1)$$

In a 50 °C Solution,

$$K_{sp} = 4 \times \left(\frac{0.72 \times 10^{-2} \text{ mol dm}^{-3}}{2} \right)^3 \quad (4+1)$$

$$= 1.866 \times 10^{-7} \text{ mol}^3 \text{ dm}^{-9} \text{ (or } 1.8 \times 10^{-7} \text{ mol}^3 \text{ dm}^{-9}\text{)}$$

$$\text{(or } 1.9 \times 10^{-7} \text{ mol}^3 \text{ dm}^{-9}\text{)} \quad (3+1)$$

(iii) What unique change does the K_{sp} of $Ca(OH)_2$ show upon increase of temperature in comparison to most other ionic compounds?

The K_{sp} of most ionic compounds increase with temperature.

But the K_{sp} of $Ca(OH)_2$ reduces. (04)

(iv) What can be the reason for the change mention in part (iii) above?

The dissolution of most ionic compounds in water is endothermic. Hence according to Le Chatlier's Principle, its solubility should increase at higher temperatures. But the dissolving of in $Ca(OH)_2$ exothermic. Therefore, when the temperature is increased its solubility is decreased. (06)

6.(b) : 52 Marks

(c) (i) RH is a weakly acidic organic compound. Consider an aqueous 0.1 mol dm^{-3} RH solution. If its pOH is 7.7 and the K_w of water is 2×10^{-14} mol^2 dm^{-6} at 35 °C, find K_a of RH at that temperature.

At 25°C $K_w = 2 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6}$

[see page seventeen]

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$pK_w = 13.7$ (01)

pOH value of solution $= 7.7$

$pH + pOH = pK_w$ (02)

$\therefore pH = 6$

$[H^+_{(aq)}] = 1 \times 10^{-6}$ mol dm^{-3}

$RH_{(aq)} + H_2O_{(l)} \rightleftharpoons R^-_{(aq)} + H_3O^+_{(aq)}$ (02)

(mol dm^{-3}) 0.1 - x x 1×10^{-6}

$x = 1 \times 10^{-6}$ mol dm^{-3}

$K_a = \frac{[R^-_{(aq)}]\,[H_3O^+_{(aq)}]}{[RH_{(aq)}]}$ (03)

$= \frac{(1 \times 10^{-6}\ \text{mol dm}^{-3})^2}{0.1\ \text{mol dm}^{-3}}$ (4+1)

$= 1 \times 10^{-11}$ mol dm^{-3} (4+1)

(ii) When a solution of AgCl is added drop-wise to a 0.144 mol dm^{-3} 250 cm^3 RH solution, 5 drops of AgCl were required to just get a precipitate of AgR at the bottom. Find the concentration of the added AgCl solution.

(The K_{sp} of AgR at 35 °C is 2.4×10^{-12} mol^2 dm^{-6} while the volume of a water droplet is approximately 0.05 ml.)

$RH_{(aq)} + H_2O_{(l)} \rightleftharpoons R^-_{(aq)} + H_3O^+_{(aq)}$

Equilibrium (mol dm^{-3}) 0.144 - a a a

Since RH is a weak acid, a is very small (01)

$\therefore 0.144 - a \approx 0.144$

$K_a = \frac{[R^-_{(aq)}]\,[H_3O^+_{(aq)}]}{[RH_{(aq)}]}$

$1 \times 10^{-11}\ \text{mol dm}^{-3} = \frac{a^2}{0.144\ \text{mol dm}^{-3}}$ (4+1)

$a = [R^-_{(aq)}] = 12 \times 10^{-7}$ mol dm^{-3}

$AgR_{(s)} \rightleftharpoons Ag^+_{(aq)} + R^-_{(aq)}$ (02)

$K_{sp} = [Ag^+_{(aq)}]\,[R^-_{(aq)}]$ (03)

When it just begins to precipitate, the product of the ion concentration is equal to K_{sp} then,

$2.4 \times 10^{-12}\ \text{mol}^2\ \text{dm}^{-6} = [Ag^+_{(aq)}] \times 12 \times 10^{-7}\ \text{mol dm}^{-3}$ (4+1)

$[Ag^+_{(aq)}] = 0.2 \times 10^{-5}$ mol dm^{-3}

New volume after addition of AgCl,

$250\ \text{cm}^3 + (5 \times 0.05\ \text{cm}^3) = 250.25\ \text{cm}^3$

$\approx 250\ \text{cm}^3$ (01)

[see page eighteen]

Hence no. of moles of Ag^+ AgCl added,

$= 0.2 \times 10^{-5}$ mol $dm^{-3} \times 250 \times 10^{-3}$ dm^3 (4+1)

$= 50 \times 10^{-8}$ mol

$$\text{AgCl concentration} = \frac{50 \times 10^{-8} \text{ mol}}{5 \times 0.05 \times 10^{-3} \text{ dm}^3} \quad (4+1)$$

$= 2 \times 10^{-3}$ mol dm^{-3} (1+1)

(iii) 450 cm^3 of a 0.0001 mol dm^{-3} HCl solution is added to 50 cm^3 of the initial solution in part (ii). Find the concentration of H^+ ions in the new solution.

Added H^+ mol $= 0.0001$ mol $dm^{-3} \times 450 \times 10^{-3}$ dm^3 (4+1)

$= 0.45 \times 10^{-4}$ mol

Since K_a of RH is a very small value (1×10^{-11} mol dm^{-3}) the number of moles of H^+ added to the solution by RH is very small. Hence H^+ mol in new solution ≈ Added H^+ mol (01)

Hence,

$$[H^+_{(aq)}] = \frac{0.45 \times 10^{-4} \text{ mol}}{500 \times 10^{-3} \text{ dm}^3} \quad (4+1)$$

$= 0.9 \times 10^{-4}$ mol dm^{-3} (4+1)

(iv) Find the new concentration of R^- ions in that solution.

$$RH_{(aq)} + H_2O_{(l)} \rightleftharpoons R^-_{(aq)} + H_3O^+_{(aq)}$$

$\frac{0.144 \times 50}{500}$ y 0.9×10^{-4}

$$K_a = \frac{[R^-_{(aq)}][H_3O^+_{(aq)}]}{[RH_{(aq)}]}$$

1×10^{-11} mol $dm^{-3} = \frac{y \times 0.9 \times 10^{-4}}{0.0144}$ (4+1)

$y = 0.016 \times 10^{-7}$ mol dm^{-3}

$[R^-_{(aq)}] = 1.6 \times 10^{-9}$ mol dm^{-3} (4+1)

(v) Find the mass of $AgNO_3$ required to just begin precipitation of AgR in the new solution. (Ag=108)

$$AgR_{(s)} \rightleftharpoons Ag^+_{(aq)} + R^-_{(aq)}$$

$K_{sp} = [Ag^+_{(aq)}][R^-_{(aq)}]$

2.4×10^{-12} mol^2 $dm^{-6} = [Ag^+_{(aq)}] \times 1.6 \times 10^{-9}$ mol dm^{-3} (4+1)

$[Ag^+_{(aq)}] = 1.5 \times 10^{-3}$ mol dm^{-3}

Ag^+ mol to be added $= 1.5 \times 10^{-3}$ mol $dm^{-3} \times 500 \times 10^{-3}$ dm^3 (4+1)

$= 0.75 \times 10^{-3}$ mol

[see page nineteen]

$AgNO_3$ mol to be added $= 0.75\times 10^{-3}$ mol

Mass of $AgNO_3$ $= 0.75\times 10^{-3}$ mol $\times$ 170 g mol^{-1} (4+1)

$= 0.1275$ g

$= 127.5$ mg (or 127.0 mg or 128.0 mg) (4+1)

6.(c) : 93 Marks

7. (a) (i) Draw and label a silver-silver chloride electrode. Write the reaction that takes place in it.

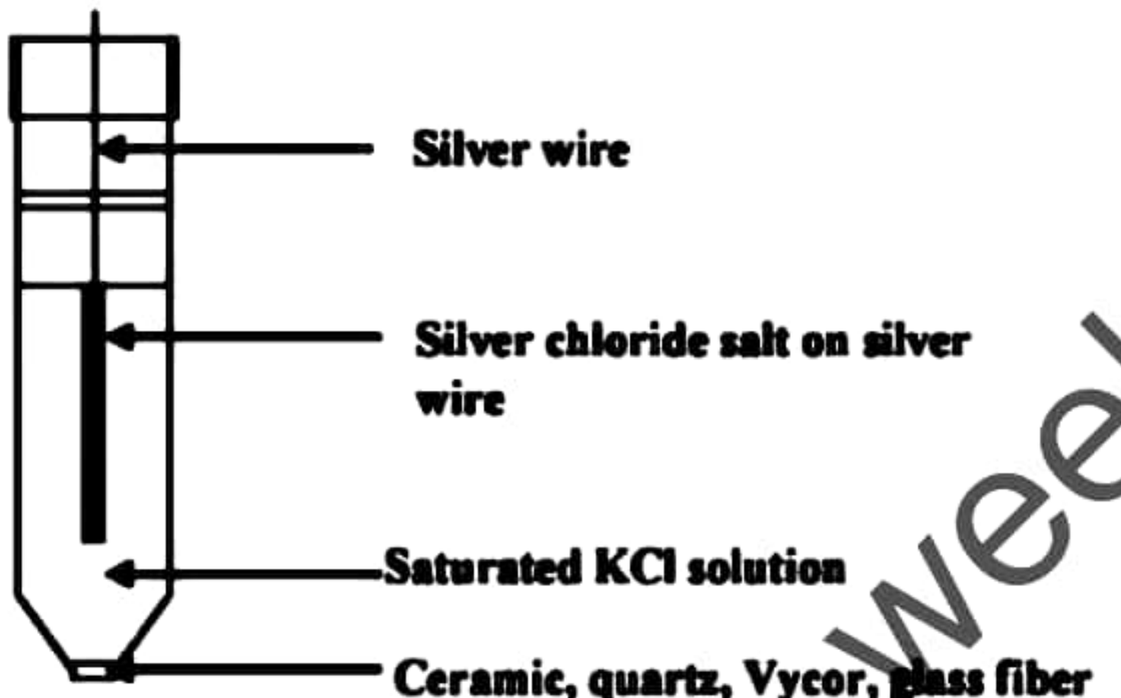

Diagram (05)
Compounds (02×4=08)

$$AgCl_{(s)} + e \rightarrow Ag_{(s)} + Cl^-_{(aq)} \quad (06)$$

I. Write down the cell notation for a cell made by joining a standard chlorine electrode and a standard Calomel electrode.

$$Pt_{(s)} \mid Hg_{(l)} \mid HgCl_{2(s)} \mid Cl^-_{(aq,\ 1\ mol\ dm^{-3})} \mid Cl_{2(g,\ 1\ atm)} \mid Pt_{(s)} \quad (06)$$

II. Find the e.m.f. of above cell.

$E^\bullet_{(Cl_2(g)|Cl^-_{(aq)})} = +1.36$ V and $E^\bullet_{(Hg_{(l)}|Hg_2Cl_{2(aq)})} = +0.27$ V

$E^\bullet_{cell} = E^\bullet_{cathode} - E^\bullet_{anode}$

$= (1.36 - 0.27)$ V (4+1)

$= 1.09$ V (1+1)

(iii) I. Write down the Faraday's laws on electrolysis.

First Law: The amount of chemical reaction which occurs at any electrode during electrolysis by a current is proportional to the quantity of electricity passed through the electrolyte (solution or melt).

Second Law: The amounts of different substances liberated by the same quantity of electricity passing through the electrolytic solution are proportional to their chemical equivalent weights (Atomic Mass of Metal / Number of electrons required to reduce the cation).

(03×2= 06)

[see page twenty]

II. Write down three differences between an electrolytic cell and an electrochemical cell.

Electro chemical cell	Electrolytic cell
Cell reaction is spontaneous.	Cell reaction is not spontaneous.
Anode is negatively charged or Cathode is positively charged.	Cathode is negatively charged or Anode is positively charged.
Electricity is generated.	Electricity should be supplied from an external source.

(04×3= 12)

(iv) A dilute solution of $CuSO_4$ is electrolyzed using inert electrodes.

I. Write down the anode reaction, cathode reaction and overall cell reaction in the above electrolysis.

Anode - $2H_2O_{(l)} \rightarrow O_{2(g)} + 4H^+_{(aq)} + 4e$ (06)

Cathode - $2e + Cu^{2+}_{(aq)} \rightarrow Cu_{(s)}$ (06)

Overall - $2H_2O_{(l)} + 2Cu^{2+}_{(aq)} \rightarrow 2Cu_{(s)} + O_{2(g)} + 4H^+_{(aq)}$ (02)

II. Calculate the volumes of gas released near the anode and cathode, when a 2A current is continuously sent through the above solution for 5 hours. (The molar volume of a gas at 0 °C and 1 atm is 24.4 dm^3)

$Q = It$

$= 2A \times 5 \times 60 \times 60\ s$ (4+1)

$= 36000\ C$

No. of moles e^- exchange $= \frac{36000\ C}{96485\ C\ mol^{-1}}$ (4+1)

$= 0.373$ mol (or 0.37 mol)

O_2 moles generated $= 0.373 \times \frac{1}{4}$ mol (4+1)

$= 0.093$ mol (or 0.09 mol)

$Vol_{O_2} = 0.093\ mol \times 24.4\ dm^3\ mol^{-1}$ (4+1)

$= 2.2692\ dm^3$ (or 2.2 dm^3 or 2.3 dm^3) (1+1)

or

$= 2.2692 \times 10^{-3}\ m^3$ (or $2.2 \times 10^{-3}\ m^3$ or $2.3 \times 10^{-3}\ m^3$)

7.(a) : 86 Marks

[see page twenty one]

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(b) Four Coordination compounds made by the hydration of $CoCl_2$, $CoBr_2$ and CoI_2 are contained in solutions A, B, C and D. These compounds have octahedral geometry. While their respective halide ions can be present as ligands in the complex, the rest of the ligands in the complex are water molecules. The compounds can be analyzed using the procedures given below.

(Cl-35.5, Ag-108, Br-80, I-127, Co - 59)

Analysis of A

Excess $AgNO_{3(aq)}$ was added to 20 cm^3 of a 0.5 mol dm^{-3} solution of A. A white precipitate was obtained. The dry mass of the precipitate was 1.435 g. The precipitate dissolved when concentrated NH_3 was added.

Analysis of B

Excess $AgNO_{3(aq)}$ was added to 20 cm^3 of a 0.5 mol dm^{-3} solution of B. A yellow precipitate was obtained. The dry mass of the precipitate was 4.7 g. The precipitate did not dissolve even when concentrated NH_3 was added.

Analysis of C

Excess $AgNO_{3(aq)}$ was added to 20 cm^3 of a 0.5 mol dm^{-3} solution of C. A light yellow precipitate was obtained. The dry mass of the precipitate was 1.88 g. While the precipitate did not dissolve in diluted NH_3, it dissolved when concentrated NH_3 was added.

Analysis of D

Excess $AgNO_{3(aq)}$ was added to 10 cm^3 of a 0.5 mol dm^{-3} solution of D. A white precipitate was obtained. The dry mass of the precipitate was 1.435 g. The precipitate dissolved in both diluted and concentrated NH_3.

(i) Write down the electron configuration and oxidation number shown by Co in A, B, C and D.

Oxidation no. - +2 **(03)**

Electronic Configuration - $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^7$ **(03)**

(ii) Deduce the structures of the coordination complexes in the solutions A, B, C and D.

A

AgCl moles precipitated $= \frac{1.435\ g}{143.5\ g\ mol^{-1}}$ **(02)**

$= 0.01$ mol

No. of A in the solution $= 0.5\ mol\ dm^{-3} \times 20 \times 10^{-3}\ dm^3$ **(02)**

$= 0.01$ mol

$A : Cl^- = 1 : 1$

Therefore,

$A = [Co(Cl)(H_2O)_5]Cl$ or $[Co(Cl)(OH_2)_5]Cl$ **(06)**

[see page twenty two]

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B

$$\text{AgI moles precipitated} = \frac{4.7\ \text{g}}{235\ \text{g mol}^{-1}} \quad (02)$$

$$= 0.02\ \text{mol}$$

$$\text{No. of B in the solution} = 0.5\ \text{mol dm}^{-3} \times 20 \times 10^{-3}\ \text{dm}^3 \quad (02)$$

$$= 0.01\ \text{mol}$$

$$B : I^- = 1 : 2$$

Therefore,

$$B = [Co(H_2O)_6]I_2 \text{ or } [Co(OH_2)_6]I_2 \quad (06)$$

C

$$\text{AgBr moles precipitated} = \frac{1.88\ \text{g}}{188\ \text{g mol}^{-1}} \quad (02)$$

$$= 0.01\ \text{mol}$$

$$\text{No. of C in the solution} = 0.5\ \text{mol dm}^{-3} \times 20 \times 10^{-3}\ \text{dm}^3 \quad (02)$$

$$= 0.01\ \text{mol}$$

$$C : Br^- = 1 : 1$$

Therefore,

$$C = [Co(Br)(H_2O)_5]Br \text{ or } [Co(Br)(OH_2)_5]Br \quad (06)$$

D

$$\text{AgCl moles precipitated} = \frac{1.435\ \text{g}}{143.5\ \text{g mol}^{-1}} \quad (02)$$

$$= 0.01\ \text{mol}$$

$$\text{No. of D in the solution} = 0.5\ \text{mol dm}^{-3} \times 10 \times 10^{-3}\ \text{dm}^3 \quad (02)$$

$$= 0.005\ \text{mol}$$

$$D : Cl^- = 1 : 2$$

Therefore,

$$D = [Co(H_2O)_6]Cl_2 \text{ or } [Co(OH_2)_6]Cl_2 \quad (06)$$

(iii) Name them according to IUPAC nomenclature.

A - pentaaquachloridocobalt(II) chloride

B – hexaaquacobalt(II) iodide

C – pentaaquabromidocobalt(II) bromide

D – hexaaquacobalt(II) chloride

(03×4= 12)

[see page twenty three]

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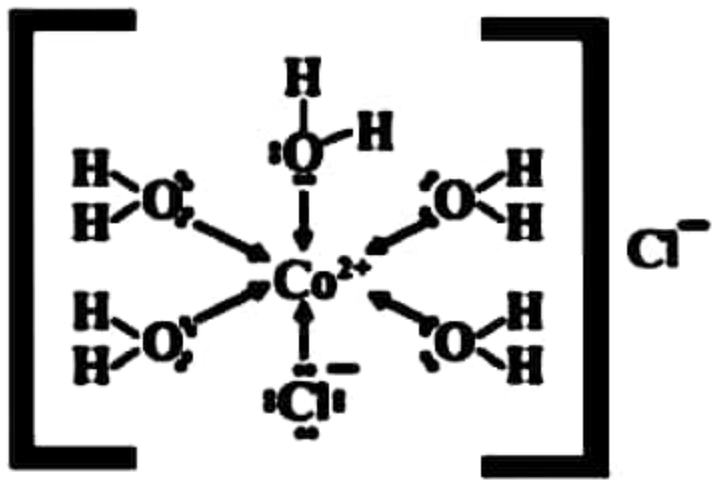
(iv) Draw the structure of A.



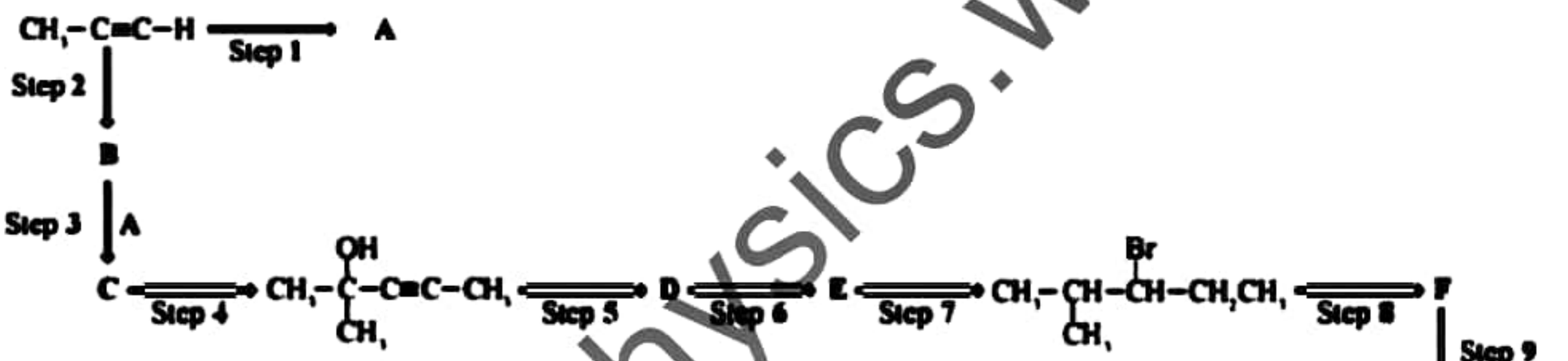
(06)

7.(b) : 64 Marks

PART C – ESSAY

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

8. (a) The following reaction scheme is used to synthesize compound (H) beginning with $CH_3 - C \equiv CH$. Draw the structures A, B, C, D, E, F and G which are required to complete the reaction scheme. Name the reactants used from step 1 - 10, using only the chemicals given in the list.



List of Reagents.
Mg , Dry Ether, HBr, Alcoholic KOH, CH_3MgBr, $HgSO_4$, PCC, conc. H_2SO_4, KCN, Water, PBr_3 , H_2/Pd RO – OR, NaOH

A - $CH_3-C(=O)-CH_3$

B - $CH_3-C\equiv C^{-}\,{}^{+}MgBr$

C - $CH_3-C(OMgBr)(CH_3)-C\equiv C-CH_3$

D - $CH_3-C(OH)(CH_3)-CH_2-CH_2CH_3$

E - $CH_3-C(CH_3)=CH-CH_2CH_3$

F - $CH_3-CH(OH)-CHCH_2CH_3$ (CH_3)

G – $CH_3-CH(CH_3)-C(=O)-CH_2CH_3$

(04×7=28)

[see page twenty four]

1 - $HgSO_4$, conc. H_2SO_4, water

2 - CH_3MgBr

3 - $CH_3-\overset{O}{\overset{\|}{C}}-CH_3$

4 - H_2O, conc. H_2SO_4

5 - H_2 / Pd

6 - conc. H_2SO_4 and heat

7 - HBr, RO – OR

8 - NaOH

9 - P.C.C.

10 - KCN, conc. H_2SO_4, water (04×10=40)

8.(a) : 68 Marks

(b) (i) Compare the acidities of phenol and carboxylic acid.

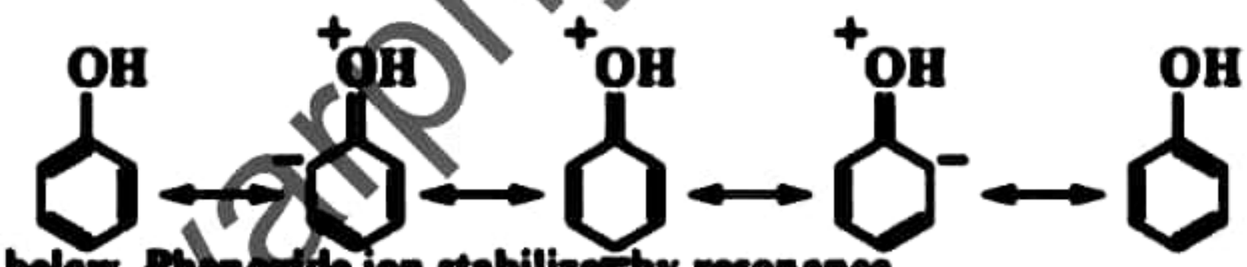
Phenol dissociate as follows in aqueous solutions.

$$C_6H_5OH + H_2O \rightleftharpoons C_6H_5O^- + H_3O^+ \quad (1) \qquad (02)$$

Carboxylic acids dissociate as follows in aqueous solutions.

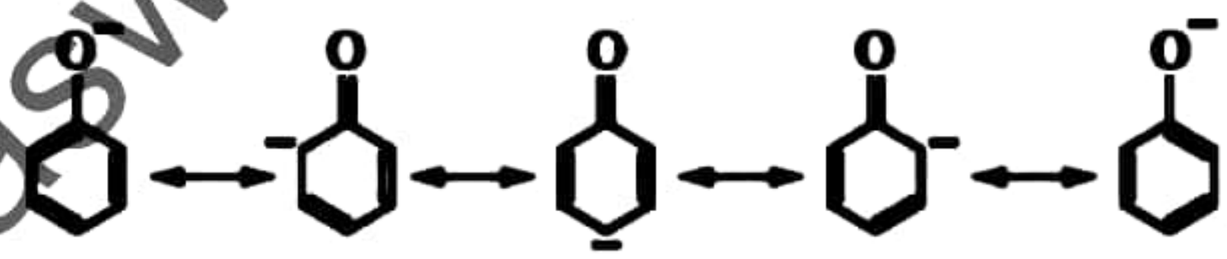
$$R-\overset{O}{\overset{\|}{C}}-O-H + H_2O \rightleftharpoons R-\overset{O}{\overset{\|}{C}}-O^- + H_3O^+ \quad (2) \qquad (02)$$

As shown below, Phenol stabilises by the resonance.



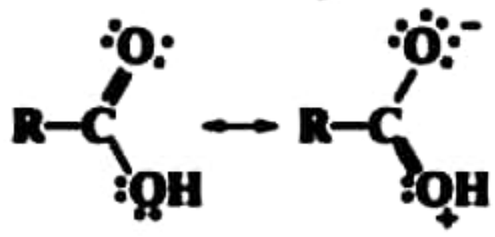
(02)

As shown below, Phenoxide ion stabilizes by resonance.



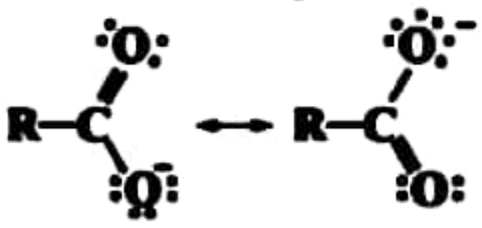
(02)

As shown below, Carboxylic acids stabilizes by resonance.



(02)

As shown below, Carboxylate ion stabilizes by resonance.



(02)

[see page twenty five]

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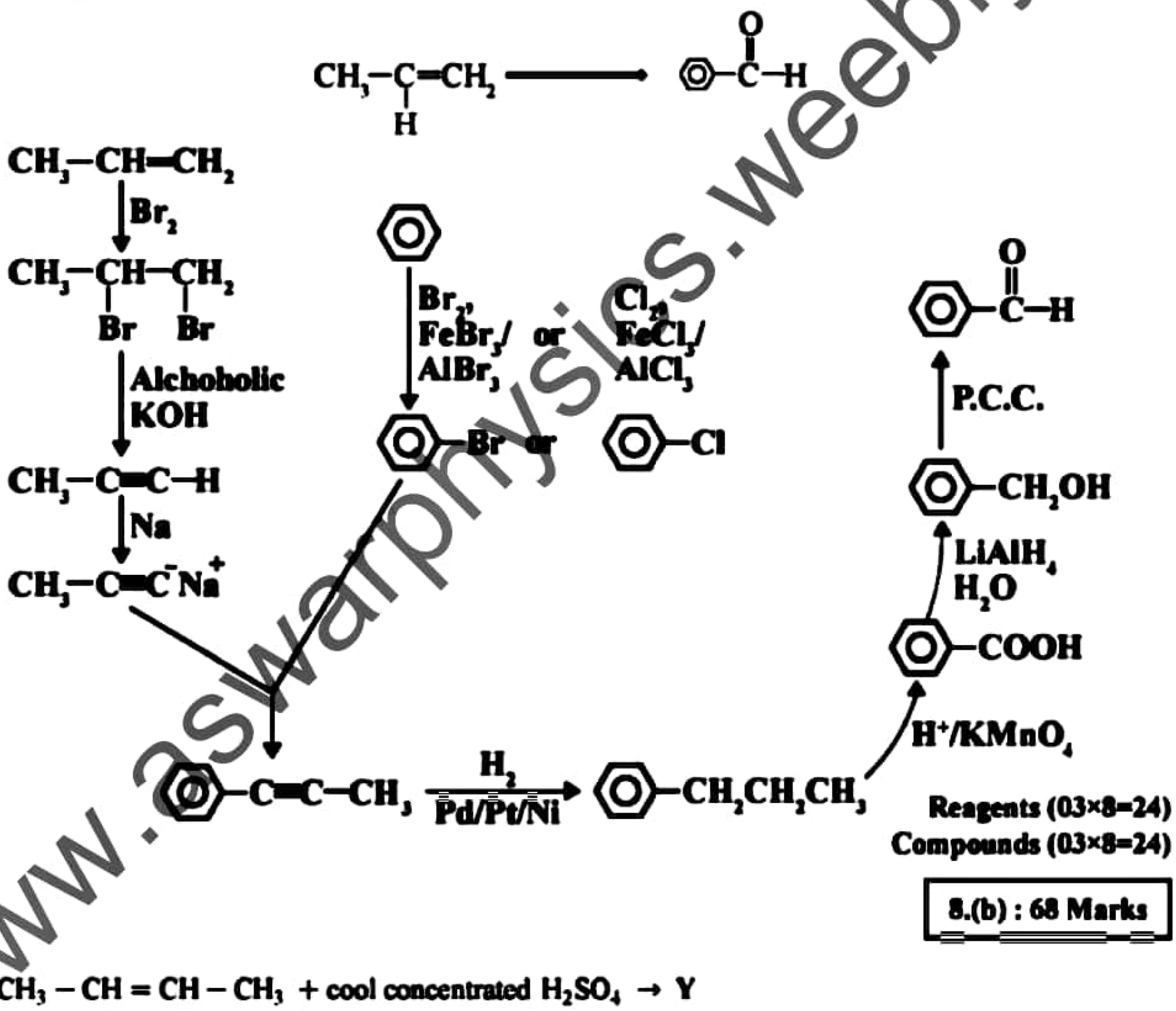
In the Phenoxide ion, the negative charge is displaced on Oxygen and Carbon atoms. But the Carboxylate ion stabilizes by the displacement of its negative charge between 2 equal electronegative oxygen atoms. (02)

The relative stability of phenoxide over phenol is higher than the relative stability of the carboxylate ion over carboxylic acid. (02)

The equilibrium constant of reaction 2 is shifted more towards the products than in reaction 1. (02)

Therefore, Carboxylic acid is more acidic than phenol. (02)

(ii) Show how you would carry out the following conversion in less than 10 Steps, using ⬡ as the only external organic material.

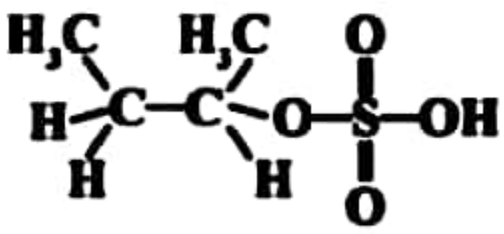


Reagents (03×8=24)
Compounds (03×8=24)

8.(b) : 68 Marks

(c) (i) $CH_3 - CH = CH - CH_3$ + cool concentrated $H_2SO_4 \rightarrow Y$

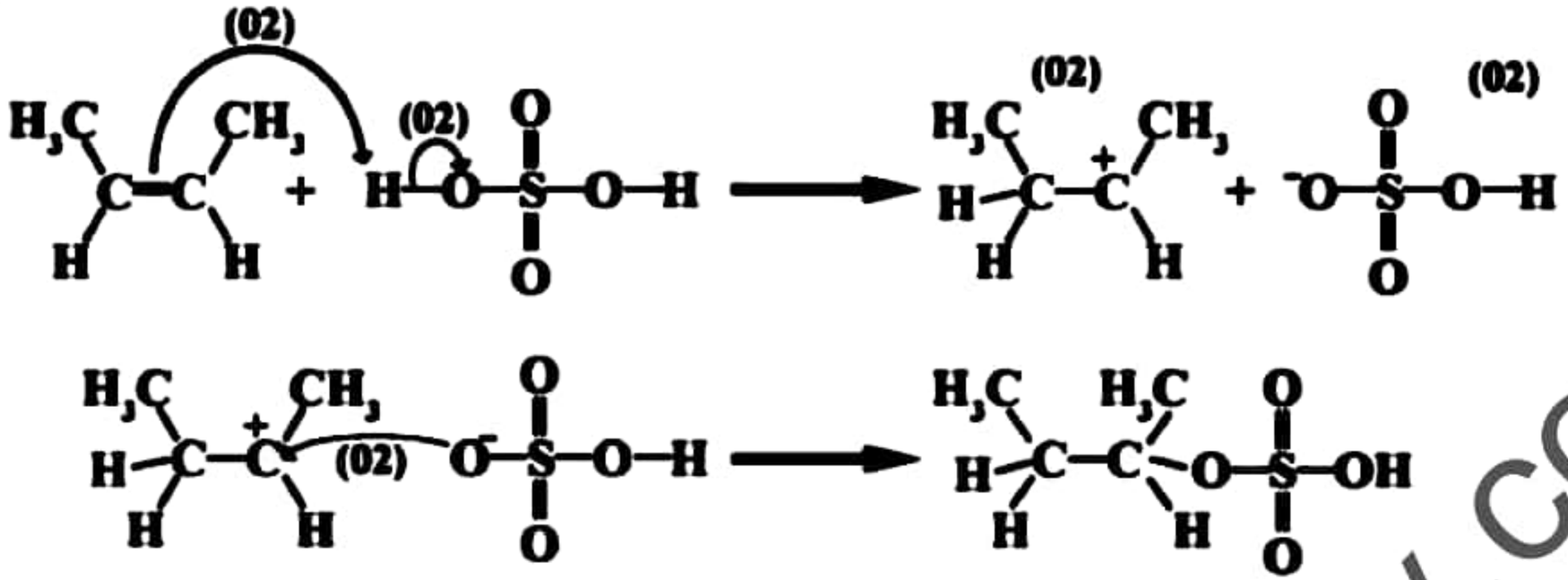
(i) Draw the structure of Y.



(04)

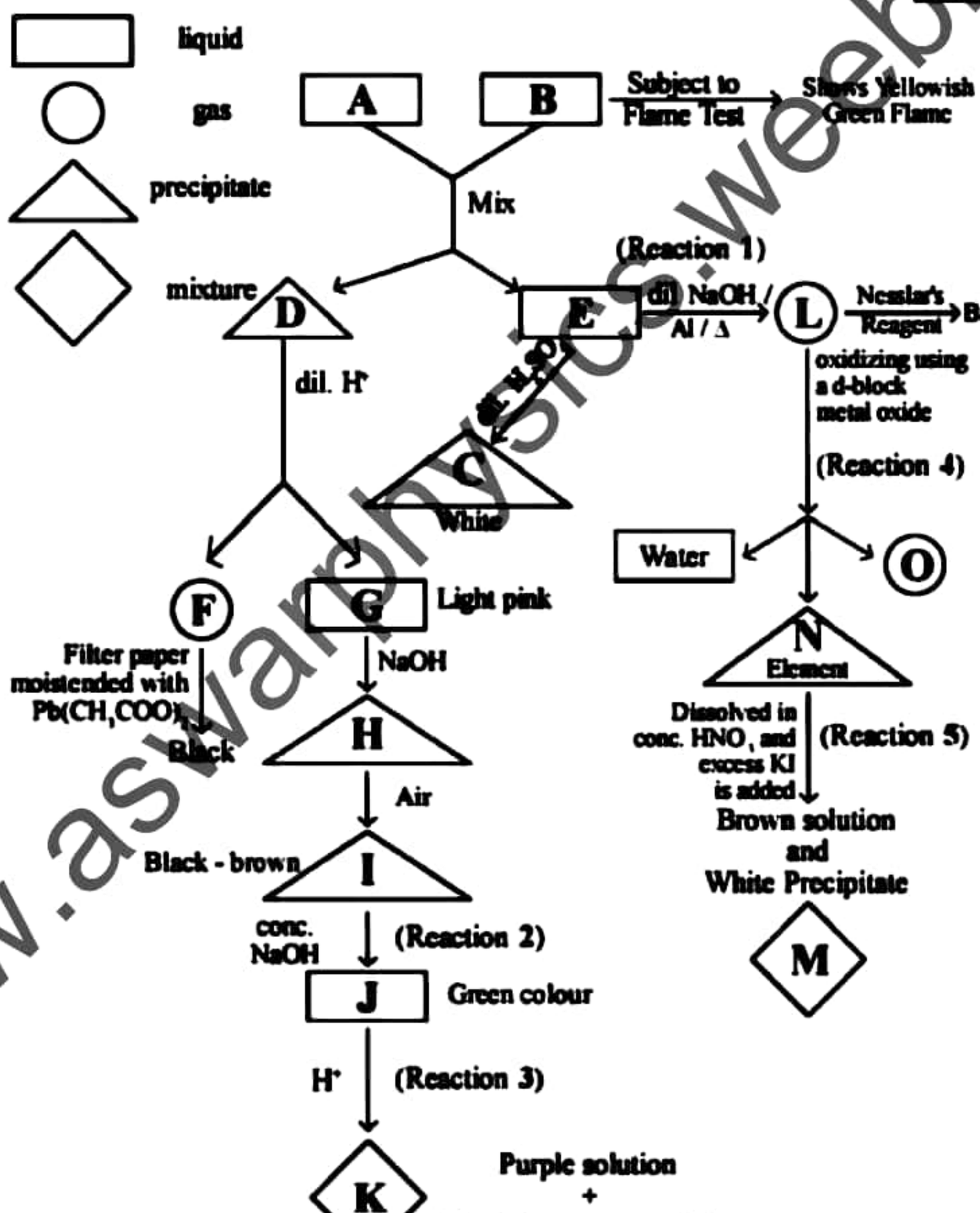
[see page twenty six]

(ii) Write down the mechanism for the above reaction.



8.(c) : 14 Marks

9.(a)



[see page twenty seven]

(i) Identify compounds A to O.

A - $Mn(NO_3)_2$
B - BaS
C - $BaSO_4$
D - MnS
E - $Ba(NO_3)_2$
F - H_2S
G - Mn^{2+}
H - $Mn(OH)_2$
I - MnO_2
J - Na_2MnO_4 / MnO_4^{2-}
K - $MnO_4^- + MnO_2$
L - NH_3
M - CuI / Cu_2I_2
N - Cu
O - N_2

((04×16=64))

(ii) Write down reactions 1 to 5.

1. $4H_2O + 16Al + 3Ba(NO_3)_2 + 10NaOH \rightarrow 3Ba(AlO_2)_2 + 6NH_3 + 10NaAlO_2$
2. $O_2 + 2MnO_2 + 4NaOH \rightarrow 2Na_2MnO_4 + 2H_2O$
3. $4H^+ + 3MnO_4^{2-} \rightarrow 2MnO_4^- + MnO_2 + 2H_2O$

   or

   $4H^+ + 3Na_2MnO_4 \rightarrow 2NaMnO_4 + MnO_2 + 2H_2O + 4Na^+$
4. $2NH_3 + 3CuO \rightarrow N_2 + 3H_2O + 3Cu$
5. $Cu + 4HNO_3 \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$

   $2Cu^{2+} + 4I^- \rightarrow 2CuI + I_2$

   $2Cu + 4I^- \rightarrow Cu_2I_2 + I_2$

   $I_2 + I^- \rightleftharpoons I_3^-$

(Award marks for any 3 reactions of above.)
(03×7=21)

9.(a) : 85 Marks

(b) An aqueous solution contains $CuSO_4$, $NiSO_4$ and $Fe_2(SO_4)_3$. When excess $BaCl_2$ was added to 100 cm^3 of the initial solution, the mass of the precipitate (X) obtained was 9.32 g. When the filtrate was separated and KI was added, the mass of the precipitate thus obtained (Y) was 1.905 g. When the gas (Z) released during the addition of KI was titrated with a 1 mol dm^3 $Na_2S_2O_3$ Solution, the end point was 20 cm^3.
(Fe – 56, Cu – 63.5, Ni – 58.6, Ba – 137, S – 32, I – 127)

(i) Identify X,Y and Z.

X – $BaSO_4$
Y – CuI / Cu_2I_2
Z – I_2

(04×3=12)

(ii) Write the reaction(s) taking place upon the addition of KI.

$4I^- + 2Cu^{2+} \rightarrow 2CuI + I_2$

or

$4KI + 2CuSO_4 \rightarrow 2CuI + 2K_2SO_4 + I_2$

[see page twenty eight]

$$2Fe^{3+} + 2I^- \rightarrow I_2 + 2Fe^{2+}$$

or

$$Fe_2(SO_4)_3 + 2KI \rightarrow I_2 + 2FeSO_4 + K_2SO_4 \qquad (04\times2=08)$$

(iii) Calculate the concentrations of Ni^{2+}, Fe^{2+}, Cu^{2+}, SO_4^{2-} in the mixture.

$$4I^- + 2Cu^{2+} \rightarrow 2CuI + I_2$$

$$\text{Moles of CuI precipitated} = \frac{1.905\ g}{190.5\ g\ mol^{-1}} \qquad (02)$$

$$= 0.01\ mol$$

$$\text{Moles of } Cu^{2+} \text{ in the initial solution} = 0.01\ mol \times \frac{1}{1}$$

$$[Cu^{2+}] = \frac{0.01\ mol}{100 \times 10^{-3}\ dm^3} \qquad (02)$$

$$= 0.1\ mol\ dm^{-3} \qquad (3+1)$$

$$\text{Moles of } I_2 \text{ released due to } Cu^{2+} = 0.01\ mol \times \frac{1}{2}$$

$$= 0.005\ mol$$

$$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$$

or

$$I_2 + 2Na_2S_2O_3 \rightarrow 2NaI + Na_2S_4O_6 \qquad (03)$$

$$\text{Total no. of } Na_2S_2O_3 \text{ used} = 1\ mol\ dm^{-3} \times 20 \times 10^{-3}\ dm^3$$

$$\text{No. of } I_2 \text{ mol released} = 1\ mol\ dm^{-3} \times 20 \times 10^{-3}\ dm^3 \times \frac{1}{2} \qquad (02)$$

$$= 0.01\ mol$$

$$\text{Moles of } I_2 \text{ released} = \text{Moles of } I_2 \text{ released due to } Cu^{2+} + \text{Moles of } I_2 \text{ released due to } Fe^{3+}$$

$$0.01\ mol = 0.005\ mol + \text{Moles of } I_2 \text{ released due to } Fe^{3+}$$

$$\text{Moles of } I_2 \text{ released due to } Fe^{3+} = 0.005\ mol \qquad (02)$$

$$2Fe^{3+} + 2I^- \rightarrow I_2 + 2Fe^{2+}$$

$$\text{Total number of moles of } Fe^{3+} \text{ in the initial solution} = 0.005\ mol \times \frac{2}{1}$$

$$[Fe^{3+}] = \frac{0.01\ mol}{100 \times 10^{-3}\ dm^3} \qquad (02)$$

$$= 0.1\ mol\ dm^{-3} \qquad (3+1)$$

$$BaCl_2 + SO_4^{2-} \rightarrow BaSO_4 + 2Cl^- \qquad (03)$$

$$\text{No. of mol of } BaSO_4 \text{ Precipitated} = \frac{9.32\ g}{233\ g\ mol^{-1}} \qquad (02)$$

[see page twenty nine]

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$= 0.04 \text{ mol}$

$$[SO_4^{2-}] = \frac{0.04 \text{ mol}}{100 \times 10^{-3} \text{ dm}^3} \quad (02)$$

$= 0.4 \text{ mol dm}^{-3}$ (3+1)

Total moles of SO_4^{2-} in the solution = SO_4^{2-} from $NiSO_4$ + SO_4^{2-} from $Fe_2(SO_4)_3$ + SO_4^{2-} from $CuSO_4$

$0.04 \text{ mol} = SO_4^{2-}$ from $NiSO_4$ $+ 0.01 \text{ mol} \times \frac{3}{2} + 0.01 \text{ mol}$

mol

SO_4^{2-} from $NiSO_4$ mol $= 0.04 \text{ mol} - \left(0.01 \text{ mol} \times \frac{3}{2} + 0.01 \text{ mol}\right)$ (02)

SO_4^{2-} from $NiSO_4$ mol $= 0.015$ mol

$$[Ni^{2+}] = \frac{0.015 \text{ mol}}{100 \times 10^{-3} \text{ dm}^3} \quad (02)$$

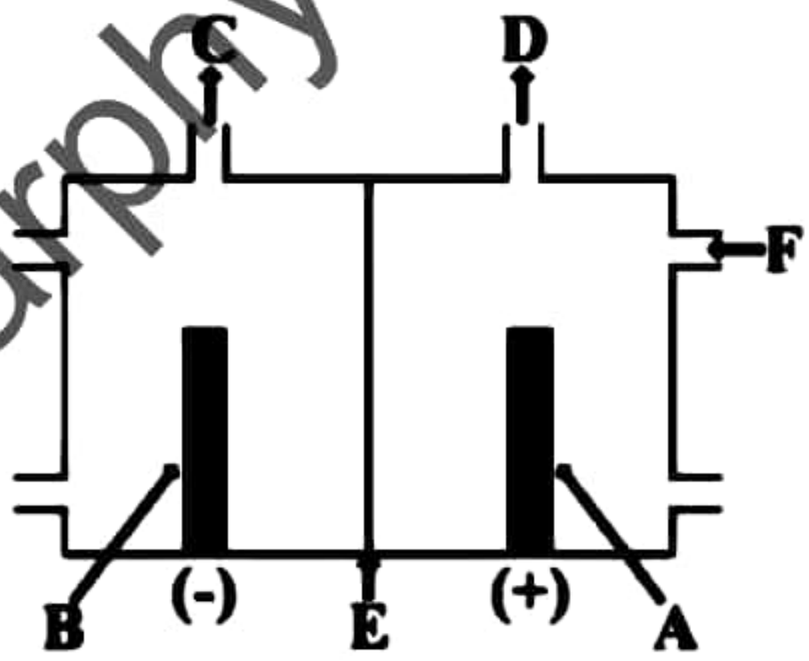
$= 0.15 \text{ mol dm}^{-3}$ (3+1)

(iv) What is the indicator used for the above titration with $Na_2S_2O_3$.

Starch (05)

9.(b) : 65 Marks

10. (a) The following question is based on the production of Caustic Soda using the membrane cell method and its uses.



(i) Name the electrodes A and B and the metals commonly used to make them.

A – anode, Titanium / Ti

B – cathode, Nickel / Ni (03×4=12)

[see page thirty]

(ii) Write the reactions taking place at A and B and the gases released from C and D, when the cell operates.

A – $2Cl^-_{(aq)} \rightarrow Cl_{2(g)} + 2e$

B – $H_2O_{(l)} + 2e \rightarrow 2OH^-_{(aq)} + H_{2(g)}$ (04×2=08)

C – Hydrogen / H_2

D – Chlorine / Cl_2 (04×2=08)

(iii) Name E. What is the importance of E in the activity of cell?

Selective membrane (03)

It prevents movement of OH^- ions produced at the cathode into the anode. (03)

(iv) Name the raw materials added into the cell through F and name three ionic impurities removed during their purification.

Concentrated Salt Solution / Concentrated NaCl Solution / Brine Solution (03)

Mg^{2+} ions

Ca^{2+} ions

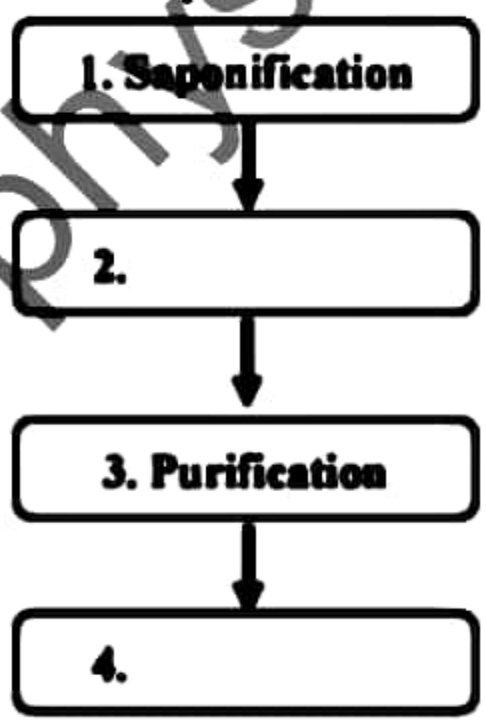
SO_4^{2-} ions (02×3=06)

(v) State the two other methods used to produce NaOH in addition to the membrane cell method.

Diaphragm Cell method

Mercury cell method (04×2=08)

(vi) One of the principal uses of NaOH is the production of soap.



I. Name steps 2 and 4.

2 – Removal of Glycerin.

4 – Finishing. (04×2=08)

[see page thirty one]

II. Briefly explain the process that takes place in Step 4.
To reduce the water content in soap to 12% ($^{w}/_{w}$),
Soap is heated to about 120 °C. (02)
Sprayed into a low-pressure zone in the form of small droplets. (02)
As heat is absorbed for the vaporization of water, the temperature of the droplets decreases.
While water vapour is removed, (02)
soap settles down in the low-pressure vessels. (02)
Dry soap is then separated.
Dry Soap are decorated by adding and mixing Fillers, Colours and Flavours as necessary. (02)

III. TFM is an important parameter in determining quality of soap. What is meant by the TFM value?
Percentage of Fatty Matter in a cake of soap (03)

10.(a) : 72 Marks

(b) The wreckage caused by the 'Xpress Pearl' ship in mid-2021 can be considered most adverse effects on Sri Lanka's bio diversity in recent times.

(i) To assess the extent of the damage due to this incident, researchers obtain and analyze water samples. What are the units used to measure the following three water quality parameters?

I. Turbidity
Nephlometric turbidity unit / NTU

II. Conductivity
$\mu S\ cm^{-1}$

III. Hardness
$mg\ L^{-1}$

(02×3=06)

(ii) There were great quantities of chemical substances onboard the 'Xpress Pearl' ship when it caught on fire. Some of them leaked into the ocean and the others were combusted and mixed with atmospheric air. Further, large amounts of plastic washed ashore on the western coast. Give one additive added to maintain each of the properties of plastic given below.

I. To provide vivid colours
$PbCrO_4$ / Pb_3O_4 / $PbCO_3$

II. To make plastic less rigid
phthalates / dimethyl phthalate / di (2-ethyl hexyl) phthalate / dioctyl phthalate

III. Used as fillers in plastic
pyrene / benzopyrene

(04×3=12)

[see page thirty two]

(iii) There is a possibility of occurrence of acid rain due to the mixing of chemicals into air by the burning of the above ship. Elucidate this statement providing examples where necessary.
Due to leakage of great amount of acidic gases from the ship, they accumulate within the atmosphere and later precipitate in the form of rain. **(02)**

$4NO_2 + 2H_2O + O_2 \rightarrow 4HNO_3$
$2SO_2 + O_2 \rightarrow 2SO_3$
$SO_3 + H_2O \rightarrow H_2SO_4$
$2SO_2 + 2H_2O + O_2 \rightarrow 2H_2SO_4$

Equations (04×4=16)

10.(b) : 36 Marks

(c) Consider the following polymers.
Polyethylene (PE), Nylon 6,6, Polyvinyl Chloride (PVC), Polystyrene (PS), Polyethylene Terypthalate (PET)

(i) According to the reaction taking place during production, polymers can be classified into two classes. Name them and classify the above polymers into these two classes.
Addition polymers
Condensation polymers **(04×2=08)**

Addition polymers - polyethylene (PE), Polyvinyl chloride (PVC) , polystyrene (PS)
Condensation polymers - Nylon 6,6 **polyethylene terephthalate (PET)** **(02×5=10)**

(ii) According to the method of production there are two Main types of Polyethylene (PE). What are they?
High Density polyethylene (HDPE)
Low Density polyethylene (LDPE) **(04×2=08)**

(iii) Polymers can also be classified as thermoplastic and thermosetting polymers, based on their response to heat. Give an example each for a thermoplastic and a thermosetting polymer.
Thermoplastics - polyethylene (PE), Polyvinyl chloride (PVC) , polystyrene (PS)
Thermoset - Bakelite (phenol-formaldehyde) **(04×2=08)**

(iv) Bakelite is a polymer used in several industrial fields due to its electrical insulating properties. What are the two main compounds used in the production of this polymer?
phenol
formaldehyde **(04×2=08)**

10.(c) : 42 Marks

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