

Department of Examinations – Sri Lanka

G.C.E. (A/L) Examination – 2025

02 – Chemistry

Marking Scheme

This has been prepared for the use of marking examiners. Some changes would be made according to the views presented at the Chief Examiners' meeting.

Amendments to be included

ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව

Department of Examinations – Sri Lanka
අ.පො.ස.(උ.පෙළ)විභාගය/G.C.E. (A/L) - 2025

විෂය අංකය
Subject No

02

විෂය
Subject

Chemistry

ලකුණු දීමේ පටිපාටිය/ Marking Scheme
I පත්‍රය/ Paper I

ප්‍රශ්න අංකය வினா இல.	පිළිතුරු අංකය விடை இல.	ප්‍රශ්න අංකය வினா இல.	පිළිතුරු අංකය விடை இல.	ප්‍රශ්න අංකය வினா இல.	පිළිතුරු අංකය விடை இல.	ප්‍රශ්න අංකය வினா இல.	පිළිතුරු අංකය விடை இல.	ප්‍රශ්න අංකය வினா இல.	පිළිතුරු අංකය விடை இல.
01.	2	11.	5	21.	4	31.	4	41.	3
02.	4	12.	5	22.	1	32.	2	42.	1
03.	1	13.	4	23.	3	33.	5	43.	4
04.	1	14.	5	24.	5	34.	1	44.	1
05.	2	15.	4	25.	5	35.	2	45.	4
06.	3	16.	1	26.	5	36.	5	46.	3
07.	5	17.	3	27.	2	37.	5	47.	2
08.	2	18.	4	28.	3	38.	All	48.	1
09.	5	19.	4	29.	2	39.	1	49.	3
10.	5	20.	4	30.	2	40.	3	50.	3

විශේෂ උපදෙස්/Special Instructions:

එක් පිළිතුරකට ලකුණු 01 බැගින්/ 01 Mark for each question
මුළු ලකුණු/Total Marks 01 × 50 = 50

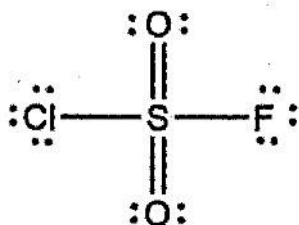
PART A — STRUCTURED ESSAY*Answer all four questions on this paper itself. (Each question carries 100 marks.)*

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

- | | |
|---|-----------------------|
| (i) The pairing of electrons in a particular subshell does not take place until all the orbitals of the subshell are singly occupied by electrons with parallel spins. | true
..... |
| (ii) The atomic orbitals identified by quantum numbers n and l , (I) $n=4, l=1$ (II) $n=4, l=0$ (III) $n=3, l=2$ can be placed in order of increasing energy as (III) < (II) < (I). | false
..... |
| (iii) The electron pair geometry of the SOF_4 molecule is square pyramidal. | false
..... |
| (iv) The second ionization energy of Li is less than that of Be. | false
..... |
| (v) The electron gain energy of fluorine is a negative value. | true
..... |
| (vi) Among the atoms Be, C, Si and S, the atomic radii increase in the order $\text{C} < \text{Be} < \text{S} < \text{Si}$. | false
..... |
| (vii) The boiling point of CH_3NH_2 is higher than that of CH_3F . | true
..... |
| (viii) The ionic radii of Al^{3+} , O^{2-} , F^- and S^{2-} decrease in the order $\text{S}^{2-} > \text{F}^- > \text{O}^{2-} > \text{Al}^{3+}$. | false
..... |

(04 marks X 8 = 32 marks)**1(a): 32 marks**

(b) (i) Draw the **most acceptable** Lewis dot-dash structure for the molecule ClSO_2F .

**(06 marks)**

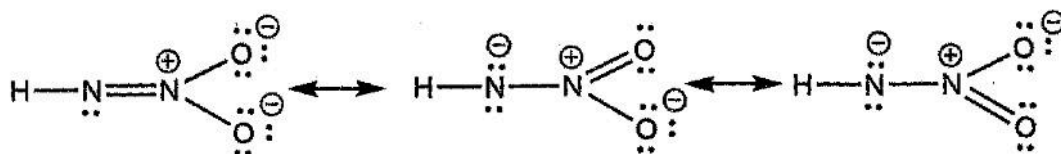
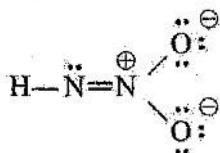
(ii) Give the oxidation state of S in the structure drawn in (i) above.

$+6$ or $+VI$

(02 marks)

Award marks for (ii) only if the Lewis structure in (i) is correct.

- (iii) A stable Lewis dot-dash structure for the HN_2O_2^- ion is given below. Draw two more Lewis dot-dash structures (resonance structures) for this ion. Indicate the stability of each of the structures drawn by you, relative to the structure given, by writing **stable**, **unstable** or **less stable** under the structure.



(less stable)

(less stable)

(02 marks structure) + (01 mark stability)

(06 marks)

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



		N ¹	N ²	N ³	N ⁴
I	The number of VSEPR pairs around the atom	3	2	3	4
II	electron pair geometry around the atom	trigonal planar	linear	trigonal planar	tetrahedral
III	Shape around the atom	angular/ V / bent	linear	angular/ V / bent	angular/ V / bent
IV	Hybridization of the atom	sp^2	sp	sp^2	sp^3

(01 mark × 16 = 16 marks)

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

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

I.	$N^1 - F$	$N^1 \dots \dots \dots sp^2$	$F \dots \dots \dots 2p \text{ or } sp^3$
II.	$N^1 - N^2$	$N^1 \dots \dots \dots sp^2$	$N^2 \dots \dots \dots sp$
III.	$N^2 - N^3$	$N^2 \dots \dots \dots sp$	$N^3 \dots \dots \dots sp^2$
IV.	$N^3 - N^4$	$N^3 \dots \dots \dots sp^2$	$N^4 \dots \dots \dots sp^3$
V.	$N^4 - H$	$N^4 \dots \dots \dots sp^3$	$H \dots \dots \dots 1s$

(01 mark $\times$ 10 = 10 marks)

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

I.	$N^1 - N^2$	$N^1 \dots \dots \dots 2p$	$N^2 \dots \dots \dots 2p$
II.	$N^2 - N^3$	$N^2 \dots \dots \dots 2p$	$N^3 \dots \dots \dots 2p$

(01 mark $\times$ 4 = 04 marks)

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

$N^1 \dots (118^\circ \pm 1)$	$N^2 \dots (180^\circ \pm 1)$	$N^3 \dots (118^\circ \pm 2)$	$N^4 \dots (104^\circ \pm 1)$
-------------------------------	-------------------------------	-------------------------------	-------------------------------

(01 mark $\times$ 4 = 04 marks)

(viii) Arrange N^1 , N^2 , N^3 and N^4 atoms in increasing order of their electronegativities.

$N^4 < N^3 < N^1 < N^2$

(04 marks)

1(b): 52 marks

(c) (i) Given below are the six successive ionization energies, $IE_1 - IE_6$ (in kJ/mol) of an element in the third period, starting from the first ionization energy (IE_1).

IE_1	IE_2	IE_3	IE_4	IE_5	IE_6
1012	1903	2910	4956	6248	22230

Identify the element and write its electron configuration.

- I. element : P / Phosphorous (02 marks)
- II. electron configuration : $1s^2 2s^2 2p^6 3s^2 3p^3$ (02 marks)

- (ii) A molecule of formula AX_5 has five A—X σ bonds. Here A and X represent symbols of elements and A is the central atom.

Complete the table below by naming the possible molecular shape and giving an example (molecular formula required) for each of the shapes.

	molecular shape	example
I. If AX_5 is polar	square pyramidal	$BrCl_5$ / BrF_5 / ClF_5 / IF_5 / ICl_5
II. If AX_5 is nonpolar	trigonal bipyramidal	PCl_5 / PF_5

IBVs cannot
any one.

(mark independently)
(03 marks $\times$ 4 = 12 marks)

1(c): 16 marks

2. (a) (i) A is a water soluble white coloured compound. It is composed of three elements in the ratio 4:2:3 (in the increasing order of atomic mass). The atomic number of each element is less than 20. Two of these elements belong to the p -block of the Periodic Table. On heating A, a colourless, non-toxic, neutral, tri-atomic gas with a linear structure is evolved as one of the products. A is used as a fertilizer.

Identify A NH_4NO_3 or ammonium nitrate

- (ii) B is also a water soluble white coloured compound. It is composed of the same three elements as A. These elements are in the ratio 4:2:2 (in the increasing order of atomic mass). On heating B, a colourless, odourless, homo diatomic gas having a high bond dissociation energy is evolved. This gas is obtained industrially by fractional distillation of liquified air.

Identify B NH_4NO_2 or ammonium nitrite.

- (iii) C is a white coloured ionic compound. It is composed of four elements in the ratio 8:2:4:1 (in the increasing order of atomic mass). The atomic number of each element is less than 20. Three of these elements are found in both A and B. On heating C, a colourless basic gas X having a strong smell, and a strong acid are formed. On addition of $BaCl_2(aq)$ to an aqueous solution of C, a white precipitate that is insoluble in dil. HCl is obtained.

Identify C $(NH_4)_2SO_4$ or

- (iv) D is a white coloured ionic compound. It is composed of four elements in the ratio 8:1:2:3 (in the increasing order of atomic mass). Three of these elements are found in all three compounds A, B and C. Of the products formed on heating D, gas X and another gas that turns lime water milky are obtained as two of the products.

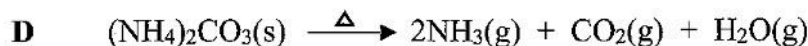
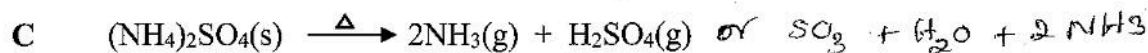
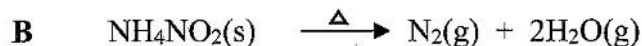
Identify D $(NH_4)_2CO_3$ or

- (v) E is a strong acid. It is composed of the same elements as A and B. They are in the ratio 3:1:1 (not in the increasing order of atomic mass). E is a strong oxidizing agent. E is manufactured using X.

Identify E HNO_3 or nitric acid.

2(a): $08 \times 5 = 40$ marks

- (b) Give balanced chemical equations for the reactions that take place on heating A, B, C and D identified in (a) above.



[Physical states are not required. Δ is not required.]

2(b): $08 \times 4 = 32$ marks

- (c) (i) Identify X based on the information given in part (a) above.

X = NH_3 (04)

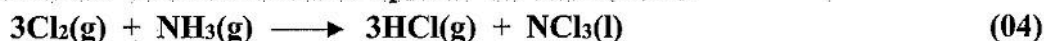
- (ii) Name the process by which E, identified in part (a)(v) above, is manufactured using X.

Ostwald Process (04)

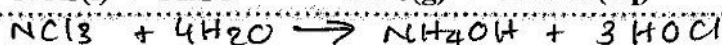
- (iii) State the other raw material/s used in the above process.

O_2 (Air) + H_2O or O_2 (Air) and H_2O . (02 + 02) (04)

- (iv) I. On reacting X with excess $\text{Cl}_2(\text{g})$ a compound Y is formed as one of the products. Write the balanced chemical equation for this reaction.



- II. When Y reacts with water, a compound that can be used to disinfect water is formed. Write the balanced chemical equation for the reaction of Y with water.



- (v) Give one chemical test to identify X, along with its observation.

Test : X is reacted with conc. HCl without conc. just (02) marks.

Observation : white fumes are formed (04 + 04)

or

Test : X is bubbled through Nessler's reagent / or using a filter paper soaked with Nessler.

Observation : brown precipitate/ colouration

* No marks for Litmus.

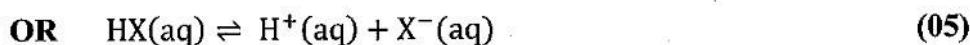
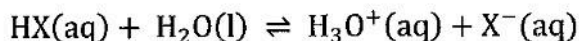
2(c) 28 marks

NOTE: PHYSICAL STATES ARE NECESSARY

The symbol of equilibrium $\rightleftharpoons$ also needed for all the reactions

3. (a) HX(aq) is a weak acid with $pK_a = 4$ at 25°C .

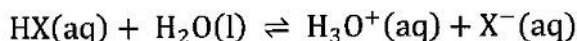
(i) Write the equation for the ionization of HX(aq) in an aqueous solution.



(ii) Write the expression for the equilibrium constant of (i) above.

$$K_a = \frac{[\text{H}_3\text{O}^+(\text{aq})][\text{X}^-(\text{aq})]}{[\text{HX(aq)}]} \quad \text{OR} \quad K_a = \frac{[\text{H}^+(\text{aq})][\text{X}^-(\text{aq})]}{[\text{HX(aq)}]} \quad (05)$$

(iii) Calculate the pH of a 0.01 mol dm^{-3} solution of HX(aq) at a temperature of 25°C .



Initial con.	0.01	0	0	mol dm^{-3}
Change con.	-x	x	x	mol dm^{-3}
Equi. con.	$0.01 - x$	x	x	mol dm^{-3}

(02+01)

$$K_a = 1.0 \times 10^{-4} = \frac{x \cdot x}{0.01 - x} \approx \frac{x^2}{0.01} \quad (02+02+02)$$

$$x^2 = 1.0 \times 10^{-6}$$

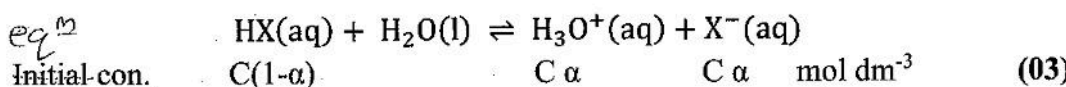
$$x = [\text{H}_3\text{O}^+(\text{aq})] = 1.0 \times 10^{-3} \text{ mol dm}^{-3} \quad (02+01)^*$$

$$\text{pH} = -\log [\text{H}_3\text{O}^+(\text{aq})] = 3 \quad (05)^*$$

* The above steps can be combined.

Alternate answer:

$$K_a = \text{antilog} [-pK_a] = \text{antilog } -4 \\ = 1 \times 10^{-4} \text{ mol dm}^{-3} \quad (02)$$



$$\text{Initial con.} \quad C(1-\alpha) \quad C\alpha \quad C\alpha \quad \text{mol dm}^{-3} \quad (03)$$

$$[\text{H}_{(\text{aq})}^+]^2 = K_a \times [\text{HX}_{\text{aq}}] \quad [\text{H}_{(\text{aq})}^+] = \sqrt{K_a \times [\text{HX}_{\text{aq}}]} \quad (02)$$

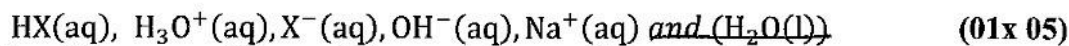
$$[\text{H}_{(\text{aq})}^+] = \sqrt{1 \times 10^{-4} \times 0.01} \quad (02)$$

$$[\text{H}_{(\text{aq})}^+] = 1 \times 10^{-3} \text{ mol dm}^{-3} \quad (02+01)$$

$$\text{pH} = -\log [\text{H}_3\text{O}^+(\text{aq})] = -\log 1 \times 10^{-3} = 3 \quad (05)$$

- (iv) A volume of 10.00 cm^3 of 0.02 mol dm^{-3} NaOH(aq) solution was added to 25.00 cm^3 of 0.01 mol dm^{-3} HX(aq) solution at a temperature of 25°C .

I. Write the chemical species present in the solution obtained.



II. What is this type of solution commonly known as?

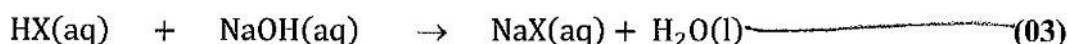
Buffer solution (03)

III. Write the expression for the calculation of pH of this solution.

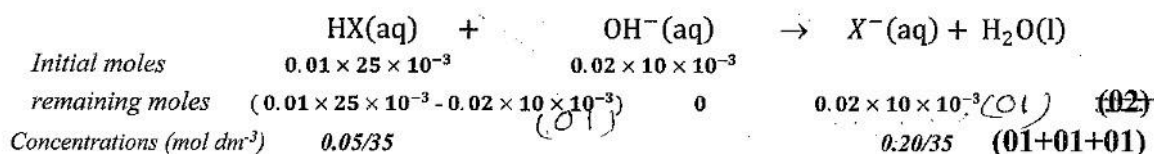
$$\text{pH} = \text{pK}_a + \log \left(\frac{[\text{X}^-(\text{aq})]}{[\text{HX(aq)}]} \right) \quad \text{or} \quad \text{pH} = \text{pK}_a + \log \frac{[\text{NaX(aq)}]}{[\text{HX(aq)}]} \quad (05) \quad \left\{ \begin{array}{l} \text{[Salt]} \\ \text{[Acid]} \end{array} \right.$$

IV. Calculate the pH of this solution. (log values for 1–10 are given below.)

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



Or



Substituting in $\text{pH} = \text{pK}_a + \log \left(\frac{[\text{X}^-(\text{aq})]}{[\text{HX(aq)}]} \right)$

$\text{pH} = 4 + \log \left(\frac{0.20/35}{0.05/35} \right) = 4 + \log(4) = 4 + 0.6 = 4.6$ (03+02)

Marks can be awarded with the use of K_a expression

- V. Calculate the volume of 0.02 mol dm^{-3} NaOH(aq) solution required to be mixed with 100.00 cm^3 of 0.01 mol dm^{-3} HX(aq) to obtain a solution of pH 4.00.

Volume of 0.02 mol dm^{-3} NaOH needed : $V \text{ cm}^3$

$\text{pH} = 4$ gives $4 = 4 + \log \left(\frac{[\text{X}^-(\text{aq})]}{[\text{HX(aq)}]} \right)$

$\log \left(\frac{[\text{X}^-(\text{aq})]}{[\text{HX(aq)}]} \right) = 0$; $\frac{[\text{X}^-(\text{aq})]}{[\text{HX(aq)}]} = 1$; $[\text{X}^-(\text{aq})] = [\text{HX(aq)}]$ (04)

$[\text{HX(aq)}] = \frac{(0.01 \times 100 \times 10^{-3} - 0.02 \times V \times 10^{-3})}{(100 + V) \times 10^{-3}} \text{ mol dm}^{-3}$ (02+01)

$$[X^-(aq)] = \frac{(0.02 \times V \times 10^{-3})}{(100 + V) \times 10^{-3}} \text{ mol dm}^{-3} \quad (02+01)$$

$$\frac{(0.01 \times 100 \times 10^{-3} - 0.02 \times V \times 10^{-3})}{(100 + V) \times 10^{-3}} = \frac{(0.02 \times V \times 10^{-3})}{(100 + V) \times 10^{-3}} \quad (02)$$

$$(0.01 \times 100 \times 10^{-3} - 0.02 \times V \times 10^{-3}) = 0.02 \times V \times 10^{-3}$$

$$(1.0 - 0.02V) = 0.02V$$

$$V = 25 \text{ cm}^3$$

(04+01)

Alternative Answer:

$$\text{pH} = 4 = \text{pK}_a \quad (05)$$

This is as same as the half equivalence point (03)

Concentration of NaOH is twice the concentration of HX (03)

Volume of HX at the equivalence point is half the volume of NaOH. (03)

Therefore the volume of ~~NaOH~~ ^{NaOH} at the half equivalence point is

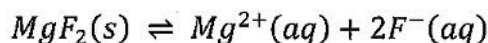
$$\frac{1}{4} \text{ volume of } \text{NaOH} = 25 \text{ cm}^3 \quad (03)$$

3(a) 70 marks

- (b) At 25 °C, $\text{MgF}_2(\text{s})$ is sparingly soluble in water ($K_{\text{sp}} = 6.4 \times 10^{-9} \text{ mol}^3 \text{ dm}^{-9}$). Calculate the maximum mass of $\text{MgF}_2(\text{s})$ that is completely soluble in 500.00 cm^3 of 0.20 mol dm^{-3} NaF(aq) solution. Assume that there is no change in volume of the solution upon the addition of $\text{MgF}_2(\text{s})$. (F = 19, Mg = 24)



$$K_{\text{sp}} = [\text{Mg}^{2+}(\text{aq})][\text{F}^-(\text{aq})]^2 \quad (04)$$

First we need to calculate the solubility of $\text{MgF}_2(\text{s})$ in the NaF(aq) and take that as sInitial concentration 0 0 0.20 mol dm^{-3}

Concentration change 0 s 2s

Equilibrium concentration s s (2s + 0.20) mol dm^{-3} (04+01)

$$K_{\text{sp}} = 6.4 \times 10^{-9} = s(0.20 + 2s)^2 \approx s(0.20)^2 \quad (02)$$

$$s = 1.6 \times 10^{-7} \text{ mol dm}^{-3} \quad (04+01)$$

Number of moles of $\text{MgF}_2(\text{s})$ that can be dissolved in 500 cm^3 of NaF is

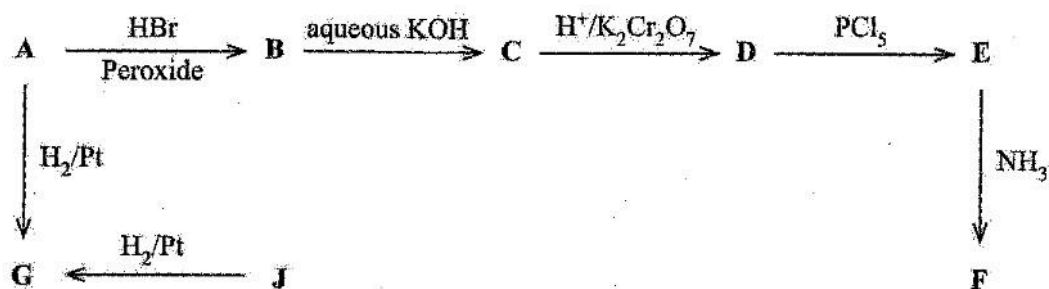
$$1.6 \times 10^{-7} \times 0.5 = 8.0 \times 10^{-8} \text{ mol} \quad (04+01)$$

$$\text{Mass of } \text{MgF}_2(\text{s}) = 8.0 \times 10^{-8} \times 62 = 4.96 \times 10^{-6} \text{ g} \quad (04+01)$$

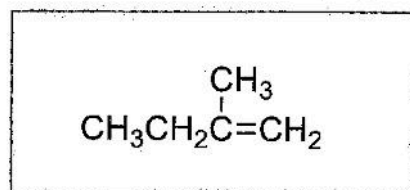
3(b) 30 marks

4. (a) Consider the reaction scheme given below, in which,

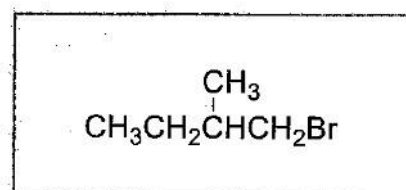
- A is a hydrocarbon having the molecular formula C_5H_{10} .
- D has the molecular formula $C_5H_{10}O_2$. It exhibits optical isomerism. When D is reacted with aqueous Na_2CO_3 , CO_2 is liberated.
- J has the molecular formula C_5H_8 . J gives a precipitate with ammonical $AgNO_3$.



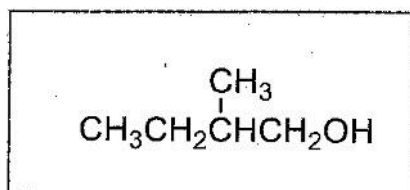
(i) Draw the structures of A, B, C, D, E, F, G and J in the relevant boxes.



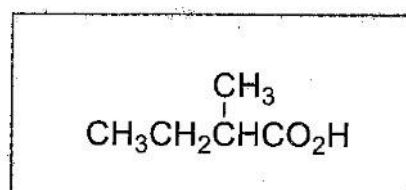
A



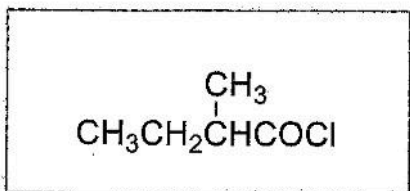
B



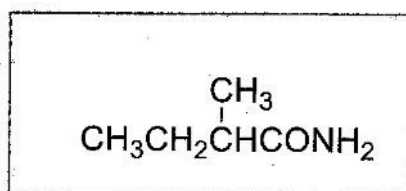
C



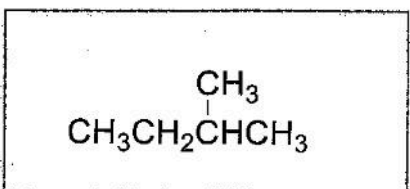
D



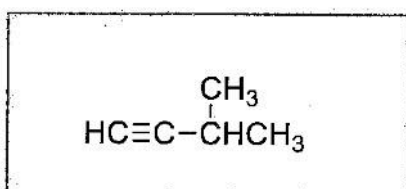
E



F



G

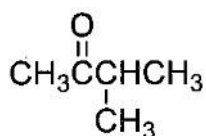


J

06 × 8 = 48 Marks

- When **J** is reacted with $\text{HgSO}_4/\text{dil. H}_2\text{SO}_4$, **K** is formed. **K** can be converted to **G** in one (01) step.

- (ii) Draw the structure of **K** and give the reagent/s that can be used to convert **K** to **G** in the relevant boxes.



Zn(Hg)/Conc. HCl

Reagent/s

when 'J' is wrong K also wrong.

do not mark independently.

06 × 2 = 12 Marks

4(a) 60 Marks

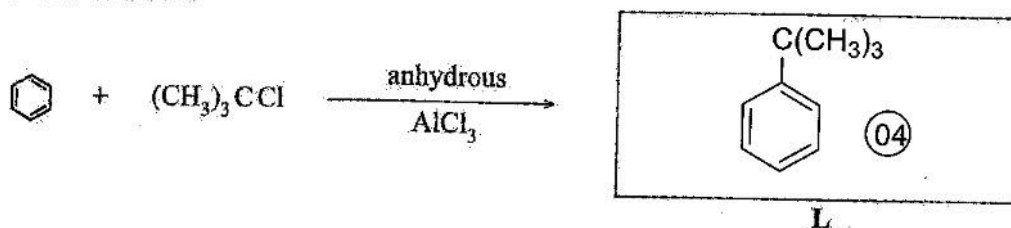
- (b) For the reactions given below, write the type of reaction [nucleophilic addition (A_N), electrophilic addition (A_E), nucleophilic substitution (S_N), electrophilic substitution (S_E), elimination (E)] and the major product in the relevant cages in the table.

Reaction	Reaction type	Major product
(i) $\text{CH}_3\text{CH}=\text{C}(\text{CH}_3)_2 \xrightarrow{\text{Br}_2}$	A_E	$\text{CH}_3\text{CH}(\text{Br})\text{C}(\text{Br})(\text{CH}_3)_2$
(ii) $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_2\text{CH}_3 \xrightarrow[\text{heat}]{\text{anhydrous Al}_2\text{O}_3}$	E	$\text{CH}_3\text{CH}=\text{CHCH}_2\text{CH}_3$
(iii) $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH} \xrightarrow{\text{HBr}}$	S_N	$\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$

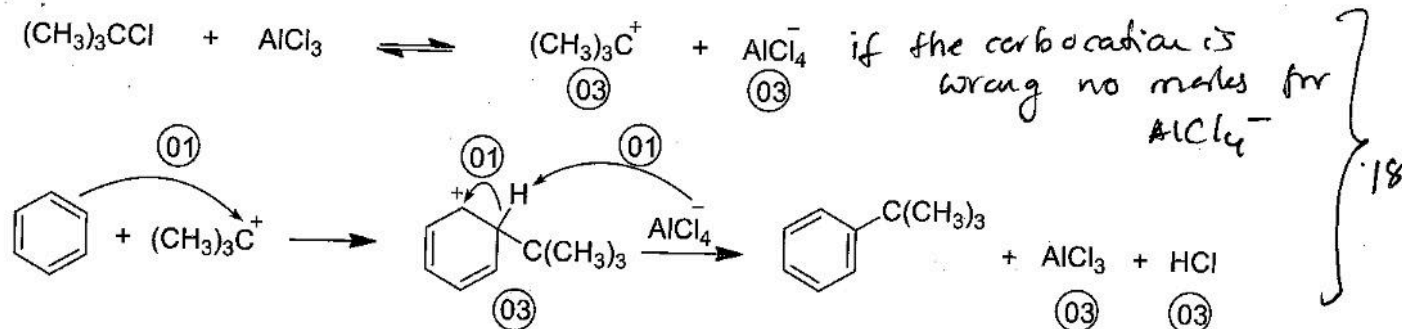
03 × 6 = 18 Marks

4(b) 18 Marks

- (c) Draw the structure of the major product L of the reaction given below. Write the mechanism of this reaction.



mechanism:



4(c) 22 Marks

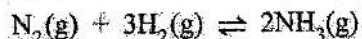
* Only C_2H_5 is accepted. Others should be clearly shown.
(C_3H_7 is not accepted)

PART B — ESSAY

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

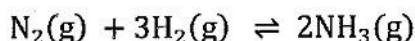
NOTE: PHYSICAL STATES ARE NECESSARY

5. (a) At 450 °C, 1.0 mol of $N_2(g)$ and 2.0 mol of $H_2(g)$ were mixed in a 1.0 dm³ previously evacuated closed-rigid container and allowed to reach the equilibrium given below.



It was found that 1.0 mol of $NH_3(g)$ was present at the equilibrium.

- (i) Calculate the total pressure of the equilibrium system at 450 °C ($RT = 6 \times 10^3 \text{ J mol}^{-1}$ at 450 °C).



Initial con	1.0	2.0	0	mol dm ⁻³	
Changed con	-x	-3x	2x	mol dm ⁻³	
Eqm con.	1-x	2-3x	1.0	mol dm ⁻³	(04+01)

At equilibrium 1.0 mol of $NH_3(g)$ is present

$$\therefore \text{Equilibrium Concentration of } NH_3(g): 2x = 1: x = 0.5 \text{ mol dm}^{-3} \quad (01+01)$$

$$\therefore \text{Eqm mixture con.} \quad 0.5 \quad 0.5 \quad 1.0 \quad \text{mol dm}^{-3} \quad (02+01)$$

Total number of moles in the mixture at equilibrium = 2 mol

(Assuming ideal gas behavior: $PV = nRT$) (03)

$$P = \frac{nRT}{V} = \frac{2 \text{ mol} \times (6 \times 10^3 \text{ J mol}^{-1})}{1.0 \times 10^{-3} \text{ m}^3} = 1.20 \times 10^7 \text{ Pa} \quad (04+01)$$

- (ii) Calculate the partial pressures of $N_2(g)$, $H_2(g)$ and $NH_3(g)$ at 450 °C in the equilibrium system.

$$\text{Using } P_i = X_i P \quad (02)$$

$$P_{N_2(g)} = \frac{0.5}{2} \times 1.20 \times 10^7 \text{ Pa} = 3.0 \times 10^6 \text{ Pa} \quad (03+01)$$

$$P_{H_2(g)} = \frac{0.5}{2} \times 1.20 \times 10^7 \text{ Pa} = 3.0 \times 10^6 \text{ Pa} \quad (03+01)$$

$$P_{NH_3(g)} = \frac{1.0}{2} \times 1.20 \times 10^7 \text{ Pa} = 6.0 \times 10^6 \text{ Pa} \quad (03+01)$$

(OR use $PV = nRT$ for three gases)

- (iii) Calculate the equilibrium constant K_p of the system at 450 °C.

$$K_p = \frac{P_{NH_3(g)}^2}{P_{N_2(g)} P_{H_2(g)}^3} = \frac{(6.0 \times 10^6 \text{ Pa})^2}{(3.0 \times 10^6 \text{ Pa}) (3.0 \times 10^6 \text{ Pa})^3} = 4.40 \times 10^{-13} \text{ Pa}^{-2} \quad (04+01) \quad (05) \quad (03+02+04+01)$$