

නව නිර්දේශය / புதிய பாடத்திட்டம் / New Syllabus

NEW

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2019 අගෝස්තු
கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2019 ஓகஸ்ட்
General Certificate of Education (Adv. Level) Examination, August 2019

16.08.2019 / 0830 - 1030

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 09 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 (x) in accordance with the instructions given on the back of the answer sheet.

$$\text{Universal gas constant } R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$$

$$\text{Avogadro constant } N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$$

$$\text{Planck's constant } h = 6.626 \times 10^{-34} \text{ Js}$$

$$\text{Velocity of light } c = 3 \times 10^8 \text{ m s}^{-1}$$

1. Consider the following statements, I and II.

I. The energy absorbed or released by atoms is quantized.

II. Small particles under appropriate conditions show wave properties.

The two scientists who proposed the theories as given by statements I and II respectively are,

- (1) Louis de Broglie and Albert Einstein
- (2) Max Planck and Louis de Broglie
- (3) Max Planck and Ernest Rutherford
- (4) Niels Bohr and Louis de Broglie
- (5) Louis de Broglie and Max Planck

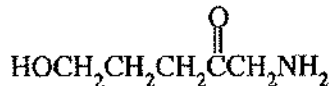
2. The maximum number of **electron pairs** of an atom that are associated with principal quantum number $n = 3$ is,

- (1) 3
- (2) 4
- (3) 5
- (4) 8
- (5) 9

3. The number of stable resonance structures that can be drawn for the oxalate ion $\left[\text{C}_2\text{O}_4^{2-} / (\text{O}_2\text{C}-\text{CO}_2)^{2-} \right]$ is,

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

4. What is the IUPAC name of the following compound?



- (1) 5-hydroxy-2-oxo-1-pentanamine
- (2) 1-amino-5-hydroxy-2-oxopentane
- (3) 1-amino-5-hydroxy-2-pentanone
- (4) 5-hydroxy-1-amino-2-pentanone
- (5) 5-amino-4-oxo-1-pentanol

5. Identify the pair of elements which has the **largest** difference in electronegativities.

- (1) B and Al
- (2) Be and Al
- (3) B and Si
- (4) B and C
- (5) Al and C

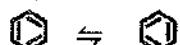
6. The electron pair geometry and shape around the two nitrogen atoms (labelled as N^1 and N^2) in the H_2NNO

molecule (skeleton: $H-\overset{H}{\underset{|}{N^1}}-N^2-O$) respectively are,

N^1		N^2	
(1) tetrahedral	pyramidal	trigonal planar	angular
(2) pyramidal	trigonal planar	trigonal planar	angular
(3) trigonal planar	pyramidal	trigonal planar	trigonal planar
(4) tetrahedral	pyramidal	angular	trigonal planar
(5) tetrahedral	angular	trigonal planar	trigonal planar

7. Which of the following statements is **incorrect** regarding benzene?

(1) The resonance hybrid of benzene is depicted as follows:



- (2) All six carbon atoms of benzene are sp^2 hybridized.
 (3) The bond lengths between any two carbon atoms of benzene have the same value.
 (4) All the C—C—C and the C—C—H bond angles of benzene have the same value.
 (5) All the hydrogen atoms of benzene lie in the same plane.
8. $TiCl_4(g)$ reacts with liquid magnesium metal ($Mg(l)$) to give $Ti(s)$ metal and $MgCl_2(l)$ at high temperature. When 0.95 kg of $TiCl_4(g)$ is made to react with 97.2 g of $Mg(l)$, the reactant that is completely consumed (this is commonly referred to as limiting reactant) and the amount of $Ti(s)$ metal formed respectively are, (Molar mass: $TiCl_4 = 190 \text{ g mol}^{-1}$; $Mg = 24.3 \text{ g mol}^{-1}$; $Ti = 48 \text{ g mol}^{-1}$)
- (1) $TiCl_4$ and 96 g
 (2) Mg and 96 g
 (3) Mg and 48 g
 (4) $TiCl_4$ and 192 g
 (5) Mg and 192 g
9. The ideal gas equation can be expressed in the form, $P = \rho \frac{RT}{M}$ where ρ is the density of the gas, M is the molar mass (g mol^{-1}) of the gas, P is the pressure (Pa) and T is the temperature (K). If the units of R are $\text{J mol}^{-1} \text{K}^{-1}$, units of ρ in this equation should be,
- (1) kg m^{-3}
 (2) g m^{-3}
 (3) g cm^{-3}
 (4) g dm^{-3}
 (5) kg cm^{-3}
10. The **decreasing** order of conductivity of the following aqueous solutions including H_2O is, 0.01 M KCl, 0.1 M KCl, 0.1 M HAC; (HAC = acetic acid; $M = \text{mol dm}^{-3}$)
- (1) $H_2O > 0.1 \text{ M HAC} > 0.1 \text{ M KCl} > 0.01 \text{ M KCl}$
 (2) $0.01 \text{ M KCl} > 0.1 \text{ M HAC} > 0.1 \text{ M KCl} > H_2O$
 (3) $0.01 \text{ M KCl} > 0.1 \text{ M KCl} > 0.1 \text{ M HAC} > H_2O$
 (4) $0.1 \text{ M KCl} > 0.01 \text{ M KCl} > 0.1 \text{ M HAC} > H_2O$
 (5) $0.1 \text{ M HAC} > H_2O > 0.01 \text{ M KCl} > 0.1 \text{ M KCl}$

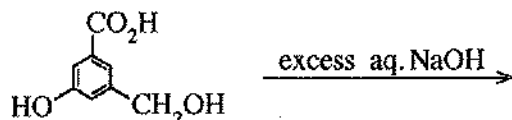
11. The correct answer when the chemical species SO_2 , SO_3 , SO_3^{2-} , SO_4^{2-} and SO_2^{2-} and SO_2 are arranged in the **increasing** order of the electronegativity of sulphur (S) atom is,

- (1) $SO_2 < SO_3^{2-} < SO_2 < SO_3 < SO_4^{2-}$
 (2) $SO_3 < SO_4^{2-} < SO_2 < SO_3^{2-} < SO_2$
 (3) $SO_3^{2-} < SO_4^{2-} < SO_2 < SO_3 < SO_2$
 (4) $SO_2 < SO_3^{2-} < SO_4^{2-} < SO_2 < SO_3$
 (5) $SO_2 < SO_4^{2-} < SO_3^{2-} < SO_2 < SO_3$

12. Which of the following answers gives the maximum hydroxide concentration that can exist in a $1.775 \text{ mol dm}^{-3}$ aqueous solution of MgCl_2 at 25°C ? At this temperature, solubility product of $\text{Mg}(\text{OH})_2$ is $7.1 \times 10^{-12} \text{ mol}^3 \text{ dm}^{-9}$.

- (1) $4.0 \times 10^{-6} \text{ mol dm}^{-3}$ (2) $2.0 \times 10^{-6} \text{ mol dm}^{-3}$ (3) $1.775 \times 10^{-12} \text{ mol dm}^{-3}$
 (4) $\sqrt{7.1} \times 10^{-6} \text{ mol dm}^{-3}$ (5) $1.0 \times 10^{-6} \text{ mol dm}^{-3}$

13. What is the major product of the following reaction?



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

14. Identify the correct statement from the following.

- (1) The bond angle of NF_3 is larger than the bond angle of NH_3 .
 (2) Elements in group 17 (or 7A) exhibit oxidation states from -1 to $+7$.
 (3) Monoclinic sulphur is the most stable allotrope of sulphur at room temperature.
 (4) The density of graphite is higher than the density of diamond.
 (5) Aluminium chloride satisfies the octet rule in the gaseous state.

15. The standard electromotive force of the electrochemical cell $\text{Mn(s)}|\text{Mn}^{2+}(\text{aq})||\text{Br}^-(\text{aq})|\text{Br}_2(\text{g})|\text{Pt(s)}$ is 2.27 V . The standard reduction potential of $\text{Br}_2(\text{g})|\text{Br}^-(\text{aq})$ is 1.09 V . The standard reduction potential of $\text{Mn}^{2+}(\text{aq})|\text{Mn(s)}$ is,

- (1) -3.36 V (2) -1.18 V (3) 0.59 V (4) 1.18 V (5) 3.36 V

16. The enthalpy change of vaporization and the entropy change of vaporization of a liquid are, $45.00 \text{ kJ mol}^{-1}$ and $90.0 \text{ J K}^{-1} \text{ mol}^{-1}$ respectively. The boiling point of the liquid is,

- (1) 45.0°C (2) 62.7°C (3) 100.0°C (4) 135.0°C (5) 227.0°C

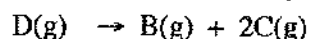
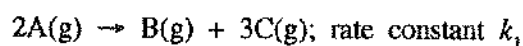
17. What is the **incorrect** statement about $\text{C}_6\text{H}_5\text{N}^+\equiv\text{NCl}^-$?

- (1) $\text{C}_6\text{H}_5\text{N}^+\equiv\text{NCl}^-$ can be obtained by reacting aniline with HNO_2 (NaNO_2/HCl) at $0 - 5^\circ\text{C}$.
 (2) $\text{C}_6\text{H}_5\text{N}^+\equiv\text{NCl}^-$ reacts with KI to give iodobenzene.
 (3) The $\text{C}_6\text{H}_5\text{N}^+\equiv\text{N}$ ion can act as an electrophile.
 (4) When an aqueous solution of $\text{C}_6\text{H}_5\text{N}^+\equiv\text{NCl}^-$ is heated, it decomposes to give benzene.
 (5) $\text{C}_6\text{H}_5\text{N}^+\equiv\text{NCl}^-$ reacts with phenols in a basic medium to give coloured compounds.

18. $\text{H}_2\text{S}(\text{g})$ reacts with $\text{O}_2(\text{g})$ to give only water vapour ($\text{H}_2\text{O}(\text{g})$) and $\text{SO}_2(\text{g})$, as products. When 4 dm^3 of $\text{H}_2\text{S}(\text{g})$ reacts with 10 dm^3 of $\text{O}_2(\text{g})$ at a constant pressure and 250°C , the final volume of the mixture is,

- (1) 6 dm^3 (2) 8 dm^3 (3) 10 dm^3 (4) 12 dm^3 (5) 14 dm^3

19. A mixture of A(g) and D(g) was introduced in to a rigid evacuated container at the temperature T . At this temperature, both A(g) and D(g) decompose according to the elementary reactions given below.



The initial pressure of the container P , changed to $2.7P$ after the complete decomposition of both reactants. The initial rate of decomposition of A(g) at this temperature is, (R is the universal gas constant)

- (1) $1.7k_1\left(\frac{P}{RT}\right)$ (2) $2.7k_1\left(\frac{P}{RT}\right)$ (3) $0.09k_1\left(\frac{P}{RT}\right)^2$
 (4) $2.89k_1\left(\frac{P}{RT}\right)^2$ (5) $7.29k_1\left(\frac{P}{RT}\right)^2$

20. An organic compound (X) decolourizes bromine water (Br_2/H_2O). X does not give a precipitate with ammoniacal CuCl. When X is treated with an acidic $K_2Cr_2O_7$ solution, a green coloured solution is obtained. X could be:

- (1) $\begin{array}{c} OH \\ | \\ CH_3CHCH_2C\equiv C-H \end{array}$ (2) $\begin{array}{c} OH \\ | \\ CH_3CCH_2C\equiv C-CH_3 \\ | \\ CH_3 \end{array}$ (3) $\begin{array}{c} OH \\ | \\ CH_3CHCH_2CH=CHCH_3 \end{array}$
 (4) $\begin{array}{c} CH_3 \\ | \\ HOCH_2CHC\equiv C-H \end{array}$ (5) $\begin{array}{c} OH \\ | \\ CH_3CHCH_2CH_2CH_2CH_3 \end{array}$

21. A buffer solution of pH 5.0 was prepared by mixing equal volumes of a 0.10 mol dm^{-3} monobasic weak acid solution and a 0.10 mol dm^{-3} solution of the sodium salt of this acid. The pH of the resultant solution, when 20.00 cm^3 of this buffer solution was mixed with 90.00 cm^3 of 0.10 mol dm^{-3} weak acid solution, is,

- (1) 3.0 (2) 4.0 (3) 4.5 (4) 5.5 (5) 6.0

22. Consider the following three aqueous solutions.

P - a weak acid,

Q - an equimolar mixture of the weak acid and its sodium salt,

R - titration mixture at the equivalence point of the titration of the weak acid and a strong base

When each solution is diluted by the same amount at constant temperature, the pH of P, Q and R respectively, will

- (1) decrease, increase, not change. (2) increase, not change, decrease.
 (3) increase, not change, not change. (4) increase, not change, increase.
 (5) increase, increase, increase.

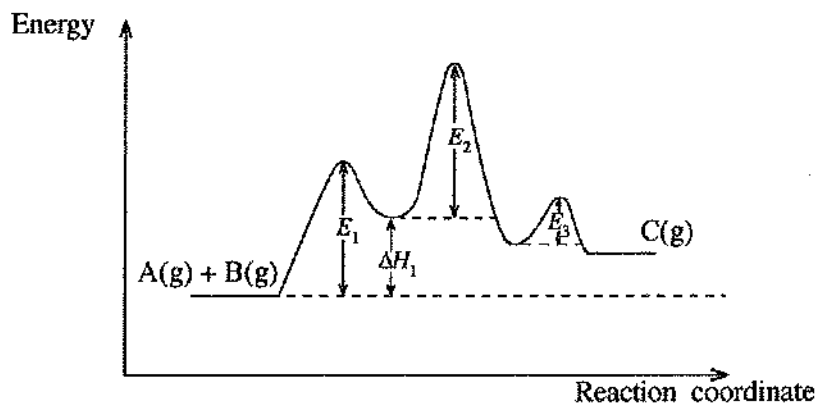
23. The **incorrect** statement with regard to the oxoacids of chlorine HOCl, $HClO_2$, $HClO_3$ and $HClO_4$ is,

- (1) The shapes around chlorine in $HClO_2$, $HClO_3$ and $HClO_4$ respectively are angular, pyramidal and tetrahedral.
 (2) The oxidation states of chlorine in HOCl, $HClO_2$, $HClO_3$ and $HClO_4$ respectively are +1, +3, +5 and +7.
 (3) The acid strength of the oxoacids varies as $HOCl < HClO_2 < HClO_3 < HClO_4$.
 (4) All these oxoacids contain at least one double bond.
 (5) All these oxoacids contain at least one OH group.

24. The density of an aqueous acidic solution at $25^\circ C$ is 1.0 kg dm^{-3} . If the pH of this solution is 1.0, its H^+ concentration in ppm would be,

- (1) 0.1 (2) 1 (3) 100 (4) 1000 (5) 10,000

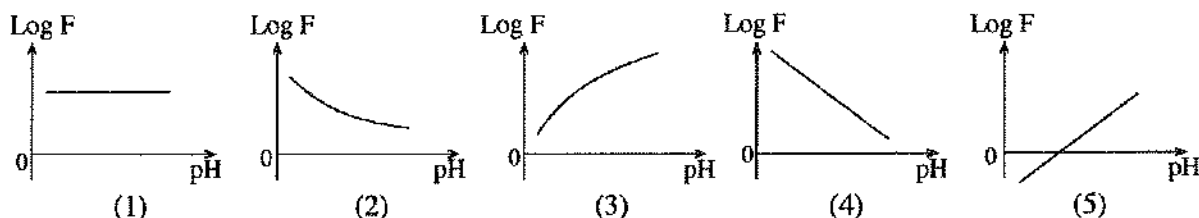
25. A 25.0 g sample of polluted air containing ozone (O_3) is treated with an acidic solution containing excess KI. Ozone is converted to O_2 and H_2O during this reaction. The iodine liberated is titrated with $0.002 \text{ mol dm}^{-3}$ $Na_2S_2O_3$ solution. Volume of $Na_2S_2O_3$ required was 25.0 cm^3 . The mass percent of O_3 in the air sample is, ($O = 16$)
- (1) 4.8×10^{-3} (2) 6.4×10^{-3} (3) 9.6×10^{-3} (4) 1.0×10^{-2} (5) 3.2×10^{-2}
26. Which of the following reaction steps is **not** present in the Born-Haber cycle of $NaCl(s)$ formation?
- (1) $Na^+(aq) + Cl^-(aq) \longrightarrow NaCl(aq)$ (2) $Na(s) \longrightarrow Na(g)$ (3) $Cl_2(g) \longrightarrow 2Cl(g)$
 (4) $Cl(g) + e \longrightarrow Cl^-(g)$ (5) $Na^+(g) + Cl^-(g) \longrightarrow NaCl(s)$
27. Activation energy of the elementary reaction $A(g) + B(g) \longrightarrow C(g)$ is E_a . This reaction is catalysed by the metal M . The energy diagram of the catalysed reaction is given below.



Which of the following is always correct with regard to this reaction?

- (1) $E_a < E_1$ (2) $E_a = E_1 + E_2 + E_3 - \Delta H_1$ (3) $E_a < E_1, E_a < E_2$ and $E_a < E_3$
 (4) $E_a > E_1 + E_2$ (5) $E_a > \Delta H_1 + E_2$
28. For a weak acid, it can be given that $F = \frac{\text{Amount of the acid dissociated}}{\text{Amount of the acid undissociated}}$

Which of the following graphs shows the relationship between $\text{Log } F$ and pH ?



29. Which of the following statements with regard to polymers is correct?
- (1) Nylon is an addition polymer.
 (2) Teflon is a condensation polymer.
 (3) Bakelite is a linear polymer.
 (4) The number of carbon atoms in the repeating unit of natural rubber is 4.
 (5) Small covalent molecules are eliminated when monomers combine to form condensation polymers.
30. Two ideal gases that do not react with each other are separated by a valve and kept in a rigid container. This system is maintained at constant temperature and pressure. Which of the following correctly describes the change in Gibbs energy, enthalpy and entropy of the system respectively when the valve is opened?
- (1) decreased, decreased, decreased (2) decreased, decreased, increased
 (3) decreased, unchanged, increased (4) decreased, increased, increased
 (5) increased, increased, increased

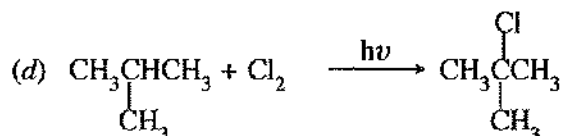
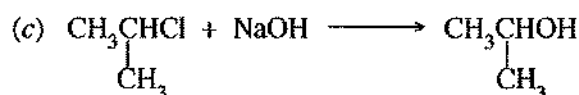
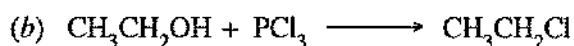
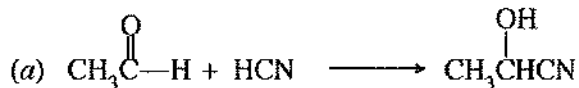
- For each of the questions 31 to 40, one or more responses out of the four responses (a), (b), (c) and (d) given is/are correct. Select the correct response/responses. In accordance with the instructions given on your answer sheet, mark

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

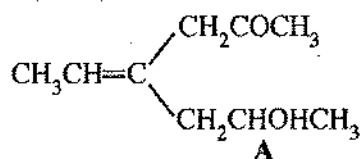
Summary of above Instructions

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

31. Which of the following statement/statements is/are correct with regard to simple covalent molecules containing oxygen and sulphur atoms?
- (a) H_2O shows amphoteric properties.
 - (b) The boiling point of H_2O_2 is higher than the boiling point of H_2O .
 - (c) H_2O_2 can act as an oxidizing agent only in an acidic medium.
 - (d) Both H_2S and SO_2 have the capacity to act only as reducing agents.
32. Which of the following statement/statements is/are correct with regard to hydrocarbons?
- (a) All hydrocarbons give CO_2 and H_2O when completely reacted with excess O_2 .
 - (b) All alkynes react with Grignard reagents to give alkynylmagnesium halides.
 - (c) The boiling point of a branched alkane is higher than the boiling point of an unbranched alkane with the same relative molecular mass.
 - (d) None of the hydrocarbons react with aqueous NaOH .
33. If an endothermic reaction occurs spontaneously at constant temperature and pressure, then,
- (a) enthalpy of the system decreases.
 - (b) entropy of the system increases.
 - (c) enthalpy of the system increases.
 - (d) entropy of the system does not change.
34. Which of the following statement/statements is/are correct regarding the precipitation of metal ions by passing $\text{H}_2\text{S}(\text{g})$ in to their aqueous solutions?
- (a) When the pressure of $\text{H}_2\text{S}(\text{g})$ is decreased, the sulphide ion concentration is increased.
 - (b) When the temperature is increased, the sulphide ion concentration is decreased.
 - (c) Addition of $\text{Na}_2\text{S}(\text{s})$ to the solution, decreases the dissociation of dissolved $\text{H}_2\text{S}(\text{aq})$.
 - (d) Increase in pH of the solution decreases sulphide ion concentration.
35. Which of the following is/are nucleophilic substitution reaction/reactions?



36. Which of the following statement/statements is/are correct regarding the elevation of carbon dioxide level in the atmosphere?
- It contributes to the increase in acidity of sea water.
 - It reduces the hardness of water bodies.
 - It strongly absorbs UV radiation coming from the sun.
 - It does not contribute to acid rain.
37. Which of the following statement/statements is/are correct with regard to 3d-block elements?
- Zn has the highest first ionization energy among the 3d-block elements.
 - In contrast to the ions of most main group elements (*s* and *p*-block), 3d-block metal ions rarely attain the noble gas configuration.
 - Although the electronegativities of 3d-block elements are higher than the electronegativities of the corresponding *s*-block elements, their atomic radii are smaller than the atomic radii of the corresponding *s*-block elements.
 - The 3d-block elements that form colourless compounds are Ti and Zn.
38. Volatile liquids A and B having saturated vapour pressures P_A° and P_B° ($P_A^\circ \neq P_B^\circ$) form an ideal solution. A mixture of the liquids A and B is in equilibrium with their vapour phase, in a closed container. When the volume of the container is increased and the equilibrium is re-established at the same temperature, which of the following statement/statements is/are correct?
- While some amount of A and B go to the gas phase, the composition of the liquid phase remains unchanged.
 - While some amount of A and B go to the gas phase, the composition of the gas phase remains unchanged.
 - While some amount of A and B go to the gas phase, the composition of the liquid phase changes.
 - While some amount of A and B go to the gas phase, the composition of the gas phase changes.
39. Which of the following statement/statements is/are correct regarding an aqueous solution of a weak acid?
- Conductivity of the solution increases as the concentration of the weak acid decreases.
 - Conductivity of the solution increases as the temperature increases.
 - Conductivity of the solution decreases but the fraction dissociated of the weak acid increases as more water is added to the solution.
 - When NaCl(s) is dissolved in the weak acid solution, conductivity decreases.
40. Which of the following statement/statements regarding compound A is/are correct?



- A exhibits geometric isomerism.
- A does not exhibit optical isomerism.
- The product obtained when A is reacted with pyridinium chlorochromate (PCC) exhibits optical isomerism.
- The product obtained when A is reacted with pyridinium chlorochromate does not exhibit geometric isomerism.

- 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.	Among the halogens, I ₂ is a solid whereas Br ₂ is a liquid.	London forces become stronger with increase in molecular surface area.
42.	At a given pressure, the spontaneity of the reaction between N ₂ and H ₂ to give NH ₃ drops with increasing temperature.	Entropy change of the reaction between N ₂ and H ₂ to give NH ₃ is negative.
43.	Essential oils are generally extracted from plant materials by steam distillation.	Essential oils have a high solubility in water.
44.	A spontaneous reaction always has a negative Gibbs energy change no matter what the conditions are.	Gibbs energy change can be used to predict the direction of a reaction only under constant temperature and constant pressure conditions.
45.	Solubility of 1-butanol in water is less than the solubility of methanol in water.	The solubility of alcohols in water decreases as the size of the non-polar alkyl group increases relative to the polar OH group.
46.	The reaction, $\text{CH}_3-\text{CH}=\text{CH}_2 \xrightarrow{\text{HBr}} \text{CH}_3-\underset{\text{Br}}{\text{CH}}-\text{CH}_3$ is a nucleophilic addition reaction.	A secondary carbocation is formed as a reaction intermediate in the following reaction. $\text{CH}_3-\text{CH}=\text{CH}_2 \xrightarrow{\text{HBr}} \text{CH}_3-\underset{\text{Br}}{\text{CH}}-\text{CH}_3$
47.	Coke is used in several industrial processes.	Coke is only used industrially as a fuel.
48.	The carbonyl carbon atom of a ketone and the other atoms bonded to it lie in the same plane.	The carbonyl carbon atom of a ketone is sp ² hybridized.
49.	Any two ideal gases have the same average kinetic energies at the same temperature.	At a given temperature, the average speed of gas molecules adjust according to their masses.
50.	Although CFC contribute to ozone layer depletion, the contribution from HFC is negligible.	HFC undergoes complete decomposition before reaching the upper atmosphere.

නව කිරීමේ යොදා ගැනීම / புதிய பாடத்திட்டம் / New Syllabus

NEW Department of Examinations, Sri Lanka

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2019 අගෝස්තු
 கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2019 ஆகஸ்ட்
 General Certificate of Education (Adv. Level) Examination, August 2019

රසායන විද්‍යාව II
 இரசாயனவியல் II
 Chemistry II

02 E II

19.08.2019 / 0830 - 1140

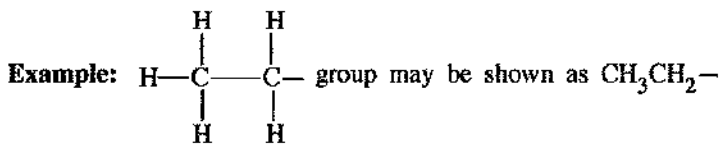
පැය තුනයි
 மூன்று மணித்தியாலம்
 Three hours

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

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

Index No. :

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



□ PART A – Structured Essay (pages 2 - 8)

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

□ PART B and PART C – Essay (pages 9 - 15)

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

For Examiner's Use Only

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

Total	
In Numbers	
In Letters	

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

PART A — STRUCTURED ESSAY

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

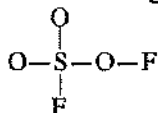
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1. (a) The following questions are related to the elements of the second row in the Periodic Table. Write the **symbol** of the element in the space provided in answering parts (i) to (vi).

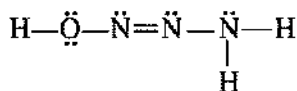
- (i) Identify the element that has the highest electronegativity (disregard the noble gas).
- (ii) Identify the element that has an allotrope which conducts electricity.
- (iii) Identify the element that forms the monoatomic ion largest in size (this should be a stable ion).
- (iv) Identify the element that has **no** *p* electrons but has a stable *s* configuration.
- (v) Identify the element that has the highest first ionization energy.
- (vi) Identify the element that forms mostly electron deficient trigonal planar covalent compounds.

(24 marks)

(b) (i) Draw the **most acceptable** Lewis dot-dash structure for the molecule SO_3F_2 . Its skeleton is given below.



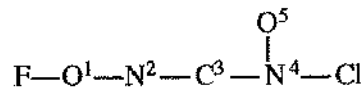
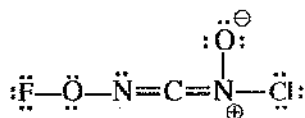
(ii) The most stable Lewis dot-dash structure for the molecule $\text{H}_3\text{N}_3\text{O}$ is shown below. Draw **two** more Lewis dot-dash structures (resonance structures) for this molecule. Write 'unstable' under the more unstable structure drawn by you.



(iii) Based on the Lewis dot-dash structure given below, state the following regarding the C, N and O atoms given in the table.

- I. VSEPR pairs around the atom II. electron pair geometry around the atom
III. shape around the atom IV. hybridization of the atom

The atoms are numbered as follows.



	O ¹	N ²	C ³	N ⁴
I. VSEPR pairs				
II. electron pair geometry				
III. shape				
IV. hybridization				

[see page three]

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(iv) Identify the atomic/hybrid orbitals involved in the formation of the following σ bonds in the Lewis dot-dash structure given in part (iii) above. (Numbering of atoms is as in part (iii).)

- I. F—O¹ F O¹
- II. O¹—N² O¹ N²
- III. N²—C³ N² C³
- IV. C³—N⁴ C³ N⁴
- V. N⁴—O⁵ N⁴ O⁵
- VI. N⁴—Cl N⁴ Cl

(v) Identify the atomic orbitals involved in the formation of the following π bonds in the Lewis dot-dash structure given in part (iii) above. (Numbering of atoms is as in part (iii).)

- I. N²—C³ N² C³
- II. C³—N⁴ C³ N⁴

(vi) I. How are the two double bonds oriented in the Lewis dot-dash structure given in part (iii)?

.....

II. Give an example of a molecule/ion that has a similar orientation of double bonds.

.....

Note: Your example should not contain more than 3 atoms.

The elements in your example should be restricted to the first and second periods of the Periodic Table. (52 marks)

(c) (i) An atomic orbital is described by three quantum numbers n , l and m_l .

Write the appropriate quantum numbers and the name of the atomic orbital in the boxes given below.

	n	l	m_l	atomic orbital
I.	<input type="text"/>	<input type="text"/>	+1	3p
II.	3	2	-2	<input type="text"/>
III.	<input type="text"/>	<input type="text"/>	<input type="text"/>	2s

(ii) Arrange the following in the increasing order of the property indicated in parenthesis. (Reasons are not required.)

I. LiF, LiI, KF (melting point)

..... < <

II. NO₂⁻, NO₄³⁻, NF₅ (stability)

..... < <

III. NOCl, NOCl₃, NO₂F (N—O bond distance)

..... < <

(24 marks)

100

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2.(a) X is an *s*-block element in the Periodic Table. The first, second and third ionization energies of X, in kJ mol^{-1} are 738, 1451 and 7733 respectively. X reacts slowly with hot water, liberating $\text{H}_2(\text{g})$ and forming its hydroxide. The hydroxide is basic. X also liberates $\text{H}_2(\text{g})$ on reaction with dilute acids. X burns in air with a bright white light. The cation of X contributes to hardness of water.

(i) Identify X. X:

(ii) Write the ground state electronic configuration of X.

(iii) Write the chemical formulae of the two compounds formed when X burns in air.

..... and

(iv) Consider the given compounds of the elements in the group in the Periodic Table to which X belongs. In the given boxes, write whether the indicated property increases or decreases down the group.

I. Solubility of sulphates in water

II. Solubility of hydroxides in water

III. Thermal stability of metal carbonates

Give reasons for your answer in III.

.....
.....
.....

(v) Identify the element in the *s*-block of the Periodic Table, which reacts in a similar manner to X with $\text{H}_2(\text{g})$, $\text{O}_2(\text{g})$ and $\text{N}_2(\text{g})$, but does not belong to the same group as X.

.....

(vi) Identify another metal ion that contributes to hardness of water.

.....

(vii) Identify the compound most commonly used to remove hardness of water.

.....

(viii) X is a component of a well-known reagent used in organic chemistry. Give the name of this reagent.

.....

(50 marks)

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- (b) Test tubes labelled A to E contain aqueous solutions of $\text{Na}_2\text{S}_2\text{O}_3$, Na_2CO_3 , KNO_2 , KBr and Na_2S (not in order). The characteristics of the solutions obtained and gases evolved on addition of dil. HCl (warming if required) to each of the test-tubes A to E are given in the table below.

Test-tube	Appearance of solution	Gas
A	colourless	colourless and odourless
B	colourless	reddish-brown with a pungent odour
C	colourless	colourless with a rotten egg odour
D	turbid	colourless with a pungent odour
E	colourless	not evolved

- (i) Identify the solutions in each of the test-tubes A to E.

A : C : E :

B : D :

- (ii) Write balanced chemical equations for the reactions that take place in test-tubes A, B, C and D.

In A :

In B :

In C :

In D :

- (iii) Write a chemical test to identify each of the gases evolved in A, C and D.

Note: Observations are also required.

In A :

.....

In C :

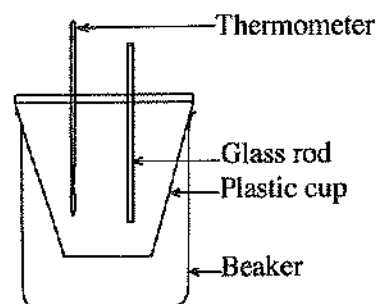
.....

In D :

.....

(50 marks)

3. The set up shown in the figure was used to calculate the heat change associated with the dissolution of $\text{MX}(s)$ in water. 100.00 cm^3 of distilled water was added to the cup. The initial temperature of distilled water was measured to be 25.0°C . Then 0.10 mol of $\text{MX}(s)$ was added to the water and stirred continuously. It was observed that the temperature of the solution decreased gradually. The lowest temperature measured was 17.0°C . The amount of water used was sufficient to completely dissolve $\text{MX}(s)$. Density and specific heat capacity of water are 1.00 g cm^{-3} and $4.20 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1}$ respectively. Assume that the density and the specific heat capacity of water are not changed due to the dissolution of $\text{MX}(s)$.



- (i) Calculate the amount of heat that should be supplied to bring the system (solution) back to 25.0°C .

.....

.....

.....

100

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(ii) Is the dissolution of MX(s) in water an endothermic or exothermic process? Explain your answer.

.....
.....

(iii) Calculate the enthalpy change (in kJ mol⁻¹) associated with reaction



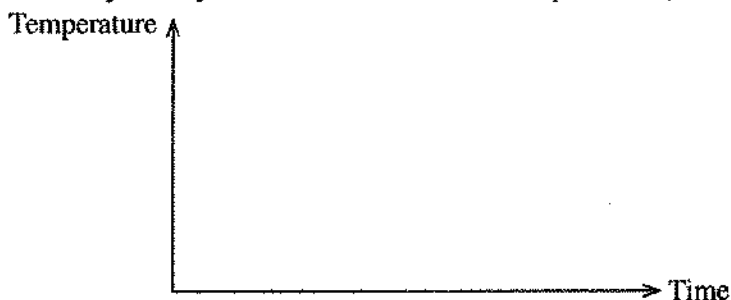
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(iv) If this experiment was conducted using 200.00 cm³ of water, would you expect the temperature change to be larger than the above value? Explain your answer.

.....
.....

(v) Show the variation of temperature of the system (solution) by drawing the temperature – time curve.

Note: Eventually the system reaches the room temperature (25.0 °C).



(vi) In this experiment, explain why a plastic cup is used instead of a metal cup.

.....
.....
.....

(vii) Gibbs energy change (ΔG) for the dissolution of MX(s) in water at the temperature of 25.0 °C and pressure of 1.0 atm was calculated to be -26.0 kJ mol⁻¹. Calculate the entropy change (ΔS) of dissolution of MX(s) in water at 25.0 °C using the enthalpy change calculated above.

.....
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(viii) Would you expect the solubility of MX(s) to increase or decrease with increasing temperature? Give reasons for your answer.

.....
.....
.....

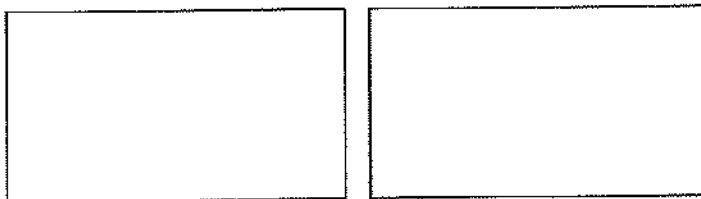
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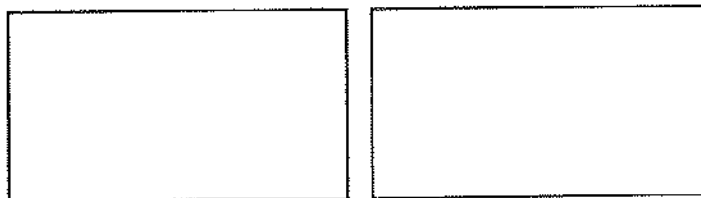
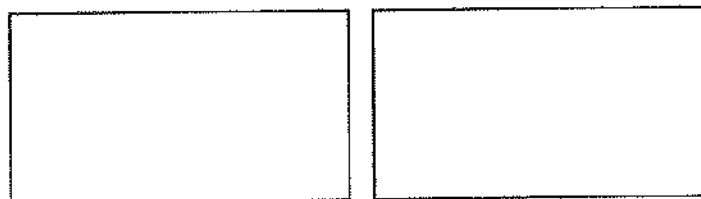
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4. (a) Compounds **A** and **B** both have the same molecular formula $C_5H_{10}O$. Both **A** and **B** give orange/red precipitates with 2,4-dinitrophenylhydrazine. When **A** and **B** are reacted separately with $NaBH_4$ in methanol, compound **A** gives **C** and compound **B** gives **D**. When **C** is heated with Al_2O_3 , two alkenes **E** (C_5H_{10}) and **F** (C_5H_{10}) are formed. When **E** and **F** are reacted separately with conc. H_2SO_4 and the products obtained are hydrolysed, compound **E** gives **G**, while compound **F** gives **H**. **G** gives a turbidity immediately with the Lucas reagent. **H** also gives a turbidity with the Lucas reagent but not immediately.

- (i) Draw the structures of **G** and **H**.

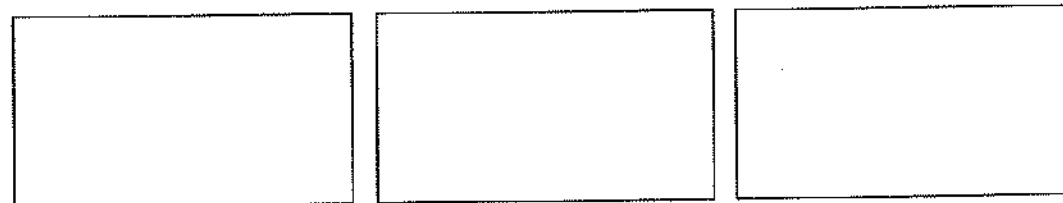
**G****H**

- (ii) Draw the structures of **A**, **C**, **E** and **F**.

**A****C****E****F**

When heated with Al_2O_3 , **D** gives alkene **I** (C_5H_{10}). When **I** is reacted with conc. H_2SO_4 and the product obtained hydrolysed, **G** is obtained.

- (iii) Draw the structures of **B**, **D** and **I**.

**B****D****I**

- (iv) Describe a test/reaction to distinguish between **A** and **B**.

.....

.....

.....

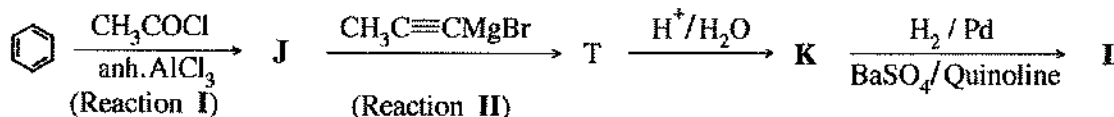
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(50 marks)

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- (b) (i) Give the structures of J, K, L and M in the following reaction sequences.



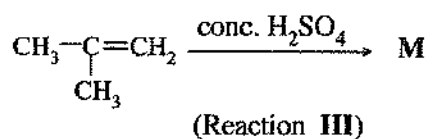
J



K



L



M

- (ii) Selecting from the list given below, write the type of reaction taking place in reactions I, II and III.

Nucleophilic Addition,	Nucleophilic Substitution,
Electrophilic Addition,	Electrophilic Substitution, Elimination

Reaction I:

Reaction II:

Reaction III:


- (iii) Using your knowledge of the mechanism of the reaction between alkenes and HBr, give the mechanism of reaction III.

(50 marks)

100

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සියලු ම හිමිකම් ඇවිරිණි/முழுப் பதிப்புரிமையுடையது/All Rights Reserved


 ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව
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 Sri Lanka Department of Examinations, Sri Lanka Department of Examinations, Sri Lanka Department of Examinations, Sri Lanka Department of Examinations, Sri Lanka Department of Examinations, Sri Lanka

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2019 අගෝස්තු
கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2019 ஓகஸ்ட்
General Certificate of Education (Adv. Level) Examination, August 2019

රසායන විද්‍යාව	II
இரசாயனவியல்	II
Chemistry	II

02	E	II
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* 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) A titration between the mono acidic weak base **B** (0.15 mol dm^{-3}) and HCl (0.10 mol dm^{-3}) was carried out using a suitable indicator as described below.

The HCl solution (25.00 cm^3) was kept in the titration flask and the weak base **B** was added using a burette. The dissociation constant, K_b of the weak base at 25°C is $1.00 \times 10^{-5} \text{ mol dm}^{-3}$. All the experiments were conducted at 25°C .

- Calculate the pH of the acid solution in the titration flask, before the addition of the base, **B**.
- Calculate the pH of the solution in the titration flask, after the addition of 10.00 cm^3 of the solution of **B**. Can the solution in the titration flask act as a buffer solution? Explain your answer.
- Calculate the volume of the weak base solution required to reach the equivalence point.
- Another 10.00 cm^3 volume of the weak base was added to the titration flask after reaching the equivalence point. Calculate the pH of the solution in the titration flask.
- Can the solution obtained in (iv) above act as a buffer solution? Explain your answer.
- Sketch the variation in pH of the mixture in the titration flask with the volume of the weak base solution added (titration curve). Label the axes, indicate pH on the y-axis and the volume of weak base solution added on the x-axis. Mark the equivalence point approximately. [Calculation of pH at equivalence point is not expected.] (75 marks)

(b) The following two experiments were carried out at a constant temperature using the volatile liquids **C** and **D** which form an ideal solution.

Experiment I: The liquids **C** and **D** were introduced in to an evacuated rigid container and allowed to reach equilibrium. When the system was at equilibrium, it was observed that the mole fractions of **C** and **D** in the liquid phase (L_I) were 0.3 and 0.7 respectively. Total pressure in the container was $2.70 \times 10^4 \text{ Pa}$.

Experiment II: This experiment was conducted using different amounts of **C** and **D**. When the equilibrium was established, it was observed that the mole fractions of **C** and **D** in the liquid phase (L_{II}) were 0.6 and 0.4 respectively. Total pressure of the container was $2.40 \times 10^4 \text{ Pa}$.

- Give the relationship between the partial pressure of **C** in the vapour phase (P_C), its saturated vapour pressure (P_C°) and its mole fraction in the liquid phase (X_C) in the form of an equation. This equation states a commonly used law in physical chemistry. Write the name of the law.
- Calculate the saturated vapour pressures of **C** and **D**.
- Calculate the mole fractions of **C** and **D** in the vapour phase (V_I) of experiment I.
- Calculate the mole fractions of **C** and **D** in the vapour phase (V_{II}) of experiment II.
- Show the compositions of liquid and vapour phases (L_I , L_{II} , V_I and V_{II}) and relevant pressures in the above two experiments on a pressure-composition phase diagram drawn at constant temperature. (75 marks)

[see page ten]

6. (a) An organic solvent (org-1) and water(aq) are immiscible and form a biphasic system. Partition coefficient for the distribution of X between org-1 and water at temperature T is, $K_D = \frac{[X]_{\text{org-1}}}{[X]_{\text{aq}}} = 4.0$

An amount of 0.50 mol of X was added to a system containing 100.00 cm³ of org-1 and 100.00 cm³ of water. The system was allowed to reach equilibrium at temperature T.

- Calculate the concentration of X in org-1.
- Calculate the concentration of X in water.

(20 marks)

- (b) The compound Y is soluble only in the aqueous phase. In the aqueous phase, X and Y react to form Z. The presence of Y and Z does not affect the distribution of X between org-1 and water.

A series of biphasic systems containing org-1 and water were prepared. Then different amounts of X were distributed in the biphasic systems and the systems were allowed to reach equilibrium. The initial rate of the reaction between X and Y in the aqueous phase was measured after adding Y into the aqueous phase of these biphasic systems. Results of these experiments conducted at temperature T are given in the table.

Experiment Number	Volume of water (cm ³)	Volume of org-1 (cm ³)	Total amount of X added (mol)	Total amount of Y added (mol)	Initial rate of the reaction (mol dm ⁻³ s ⁻¹)
1	100.00	100.00	0.05	0.02	2.00×10^{-6}
2	100.00	100.00	0.10	0.04	1.60×10^{-5}
3	50.00	50.00	0.25	0.02	4.00×10^{-4}

Orders of the reaction with respect to X and Y are m and n respectively. The rate constant of the reaction at temperature T is k .

- Given that the concentrations of X and Y in the aqueous phase are $[X]_{\text{aq}}$ and $[Y]_{\text{aq}}$ respectively, write the rate expression for the reaction in terms of $[X]_{\text{aq}}$, $[Y]_{\text{aq}}$, m , n and k .
- Calculate the initial concentration of X in the aqueous phase in each experiment.
- Calculate the initial concentration of Y in the aqueous phase in each experiment.
- Calculate the orders m and n of the reaction with respect to X and Y respectively.
- Calculate the rate constant of the reaction.
- An experiment is designed to study the effect of temperature on the reaction rate using the partition coefficient given above.

Is this a suitable experiment to study the effect of temperature on the rate of the reaction? Explain your answer.

(105 marks)

- (c) The organic solvent org-2 and water are also immiscible and form a biphasic system. X (0.20 mol) was added to a system containing 100.00 cm³ of org-2 and 100.00 cm³ of water and allowed to reach equilibrium at the temperature T. Then Y (0.01 mol) was added to the aqueous phase and the initial rate of the reaction was measured. Y does not dissolve in org-2. The initial rate of the reaction between X and Y in the aqueous phase was found to be 6.40×10^{-7} mol dm⁻³ s⁻¹.

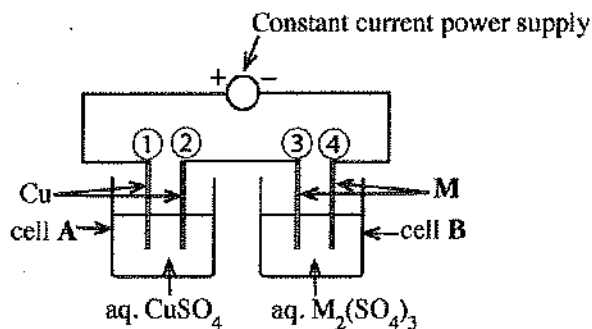
Calculate the partition coefficient $\frac{[X]_{\text{org-2}}}{[X]_{\text{aq}}}$ for the distribution of X between org-2 and water.

$[X]_{\text{org-2}}$ is the concentration of X in the org-2 phase.

(25 marks)

7. (a) The setup shown in the figure was used to find the relative atomic mass of the metal, M .

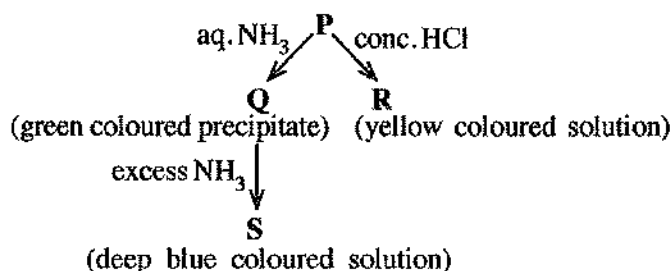
The electrolysis was carried out for 10 minutes using a constant current. The mass of the cathode in cell A was increased by 31.75 mg whereas the mass of the cathode in cell B increased by 147.60 mg during this time period. (Assume that the electrolysis of water does not take place in cells A and B.)



- (i) Identify the anode and cathode in each of the cells A and B (in terms of the numbers ①, ②, ③, and ④).
 - (ii) Write the half reaction taking place at each electrode in each cell.
 - (iii) Calculate the constant current used in electrolysis.
 - (iv) Calculate the relative atomic mass of metal, M .
- (75 marks)
- (b) (i) A, B and C are coordination compounds. They have an octahedral geometry. In each compound, **two types** of ligands are coordinated to the metal ion. The molecular formulae of the compounds are (not in order): $\text{NiCl}_2\text{H}_{12}\text{N}_4$, $\text{NiI}_2\text{H}_{16}\text{N}_4\text{O}_2$ and $\text{NiCl}_2\text{H}_{15}\text{N}_3\text{O}_3$.
- Given below are the observations when aqueous solutions of the compounds are treated with $\text{Pb}(\text{CH}_3\text{COO})_2(\text{aq})$.

Compound	$\text{Pb}(\text{CH}_3\text{COO})_2(\text{aq})$
A	A white precipitate that is soluble in hot water
B	No precipitate
C	A yellow precipitate that is soluble in hot water

- I. Give the structures of A, B and C.
 - II. Write the chemical formulae of the precipitates formed on treatment of the compounds with $\text{Pb}(\text{CH}_3\text{COO})_2(\text{aq})$.
(Note: Indicate compound and reagent)
 - III. State a chemical test, together with the observation, to identify each of the anion/s if present, that is/are not coordinated to the metal ion in the compounds given above.
(Note: The tests given by you should not be a test stated here.)
- (ii) A transition metal M forms a coloured complex ion P in aqueous medium. It has the general formula $[\text{M}(\text{H}_2\text{O})_n]^{m+}$. It undergoes the reactions given below.



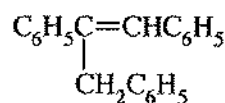
- I. Identify the metal M . Give the oxidation state of M in complex ion P .
- II. Give the electronic configuration of M in the complex ion P .
- III. Give the values of n and m .
- IV. Give the geometry of P .
- V. Give the structures of Q , R and S .
- VI. Give the IUPAC names of the complex ions, P , R and S .

(75 marks)

PART C — ESSAY

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

8. (a) Using $C_6H_5CO_2CH_3$ as the only organic starting material and as reagents only those given in the list, show how you would synthesize the following compound in **not more than seven (7) steps**.

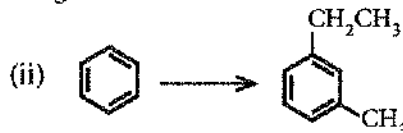
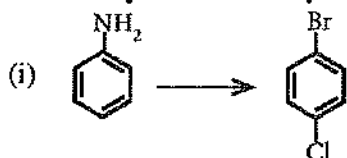


List of reagents

 PCl_3 , Mg/dry ether, H^+/H_2O , $LiAlH_4$, conc. H_2SO_4

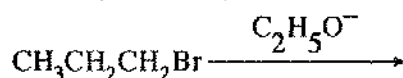
(60 marks)

- (b) Show how you would carry out each of the following conversions in **not more than three (3) steps**.



(60 marks)

- (c) The following reaction gives two products.



- (i) Write the structures of the two products.

- (ii) Write the mechanisms for the formation of these two products.

(30 marks)

9. (a) Solution X contains **four** metal cations. The following tests were carried out to identify these cations.

	Test	Observation
①	Dilute HCl was added to a small portion of X.	No precipitate.
②	H_2S was bubbled through the solution from ① above.	A black precipitate (P_1)
③	P_1 was separated by filtration. The filtrate was boiled to remove the H_2S , cooled, and NH_4Cl/NH_4OH was added.	A green precipitate (P_2)
④	P_2 was separated by filtration and H_2S was bubbled through the filtrate.	A white precipitate (P_3)
⑤	P_3 was separated by filtration. The filtrate was boiled to remove the H_2S , cooled, and $(NH_4)_2CO_3$ was added.	A white precipitate (P_4)

The following tests were carried out on precipitates P_1 , P_2 , P_3 and P_4 .

Precipitate	Test	Observation
P_1	P_1 was dissolved in hot dil. HNO_3 and conc. NH_4OH was added in excess.	A deep blue coloured solution (solution 1)
P_2	* Excess dil. $NaOH$ was added to P_2 followed by H_2O_2 .	A yellow coloured solution (solution 2)
	* Dilute H_2SO_4 was added to solution 2.	An orange coloured solution (solution 3)
P_3	* P_3 was dissolved in dil. HCl and dil. $NaOH$ was added gradually.	A white precipitate (P_5)
	* Addition of dil. $NaOH$ was continued.	P_5 dissolved to give a colourless solution (solution 4)
P_4	P_4 was dissolved in conc. HCl and subjected to the flame test.	A brick-red flame

[see page thirteen]

- (i) Identify the **four** metal cations in solution **X** (Reasons are not required.)
- (ii) Identify the precipitates **P₁**, **P₂**, **P₃**, **P₄** and **P₅** and the chemical species responsible for the colours of **solutions 1, 2, 3** and **4**.

(Note: Write chemical formulae only.)

(75 marks)

- (b) The water sample **Y** contains the anions SO_3^{2-} , SO_4^{2-} and NO_3^- . The following procedures were carried out for the quantitative analysis of the anions present in the water sample.

Procedure 1

To 25.00 cm³ of sample **Y**, an excess of a dilute solution of BaCl_2 was added with stirring. Thereafter, excess dilute HCl was added with stirring to the precipitate formed until there was no further evolution of a gas with pungent odour. The solution was allowed to stand for 10 minutes and filtered. The precipitate was washed with distilled water and dried in an oven at 105 °C until a constant mass was obtained. The mass of the precipitate was 0.174 g. The filtrate obtained was kept for further analysis (see **procedure 3**).

Procedure 2

To 25.00 cm³ of sample **Y**, an excess of dilute H_2SO_4 and acidified 5% KIO_3 solutions were added. The liberated I_2 was immediately titrated with 0.020 mol dm⁻³ $\text{Na}_2\text{S}_2\text{O}_3$ solution using starch as the indicator. The volume of $\text{Na}_2\text{S}_2\text{O}_3$ used was 20.00 cm³. (Assume that in this procedure, SO_3^{2-} ions are oxidized to sulphate ions (SO_4^{2-}) without any loss to the atmosphere.)

Procedure 3

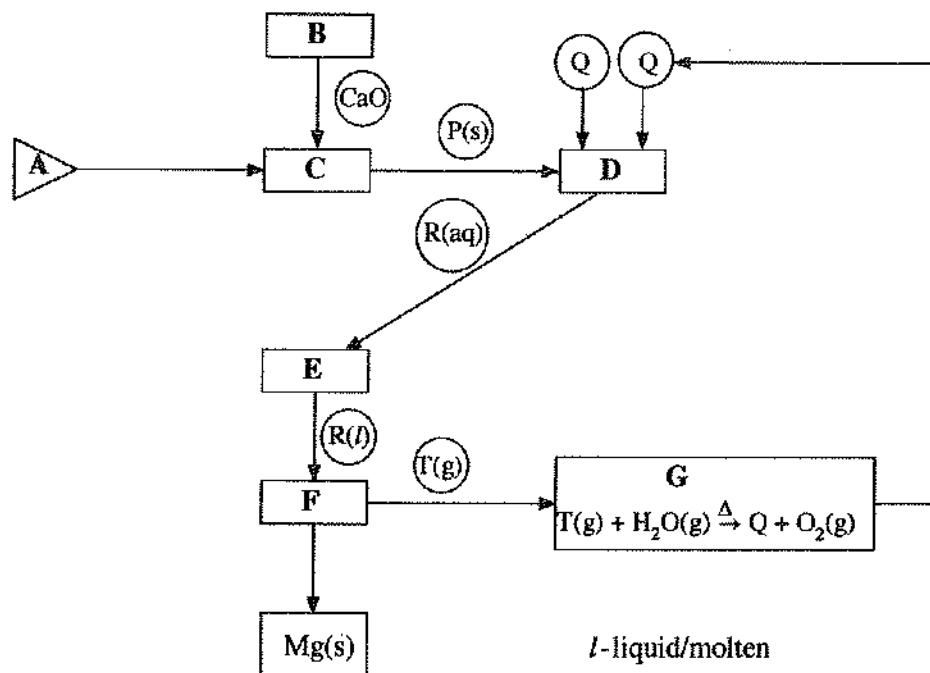
The filtrate from **procedure 1** was neutralized with dilute NaOH and to it excess Al powder and dilute NaOH were added. The solution was heated and the gas evolved was transferred quantitatively to react with a 20.00 cm³ volume of 0.11 mol dm⁻³ HCl solution. Completion of the reaction was tested with litmus. The HCl remaining after reacting with the gas evolved was titrated with 0.10 mol dm⁻³ NaOH solution using methyl orange as the indicator. The volume of NaOH required was 10.00 cm³.

- (i) Write balanced ionic/non-ionic equations for the reactions taking place in **procedures 1, 2** and **3**.
- (ii) Determine the concentrations (mol dm⁻³) of SO_3^{2-} , SO_4^{2-} and NO_3^- in water sample **Y**.
(Ba = 137; S = 32; O = 16)
- (iii) Give colour changes that would be observed in the titrations in **procedures 2** and **3**.

(Note: Assume that other ions that may interfere with the analysis are not present in sample **Y**.)

(75 marks)

10.(a)



The flow chart given above indicates the production of metal magnesium (Mg) using the Dow Process.

Answer the following questions based on the flow chart.

- (i) Identify the starting material A.
- (ii) Identify the processes employed at B, C, D, E, F and G from the list below.
evaporation, dissolution, thermal decomposition, electrolysis, recycling of a reagent, precipitation
- (iii) Identify the chemical compound used in B.
- (iv) Identify the chemical species P, Q, R and T.
- (v) Give balanced chemical equations/half reactions for the processes taking place in B, C, D, and F.
(Note: When writing half reactions, identify the anode and cathode where applicable.)
- (vi) State the importance of the reaction occurring in G. (50 marks)

- (b) (i) Consider the industries given below.

Coal power plants
Refrigeration and air conditioning
Transport
Agriculture
Animal farming

- I. All five industries given above contribute to global warming. Identify the gaseous chemical species associated with each of these industries that contribute to global warming.
 - II. State **three** adverse climate changes that could occur due to global warming.
- (ii) Identify the main industry/industries given in (i) above that contribute to
- I. photochemical smog,
 - II. acid rain,
 - III. eutrophication.

- (iii) Due to the reduction in rainfall in Sri Lanka, inducing artificial rain has been tested near catchment areas of reservoirs that are used for hydro-power generation. In this process, fine particles of hygroscopic salts (NaCl, CaCl₂, NaBr) are sprayed to induce cloud formation by condensation of water vapour.

From the list given below, select the water quality parameters that are directly

I. affected

II. unaffected

due to salts entering water around catchment areas. Give reasons for your choice briefly.

List of water quality parameters:

pH, conductivity, turbidity, dissolved oxygen

(50 marks)

- (c) The following questions are based on biodiesel production.

- (i) State the raw materials used in the manufacture of biodiesel.
- (ii) Name the main chemical compound present in each raw material where applicable.
- (iii) State the name of the chemical compound used as the catalyst in the manufacture of biodiesel in the school laboratory.
- (iv) Give a balanced chemical equation to show the synthesis of biodiesel using the chemical compounds stated in part (ii) above.
- (v) Identify a side reaction that would take place, along with its products, if the catalyst is used in excess.

(50 marks)

* * *

AL/2019/02/E-1(NEW)

සියලු ම හිමිකම් ඇවිරිණි / முழுப் பதிப்புரிமையுடையது / All Rights Reserved

නව නිර්දේශය/புதிய பாடத்திட்டம்/New Syllabus

NEW

ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව
 திணைக்களம் இலங்கைப் பரீட்சைத் திணைக்களம் இலங்கைப் பரීட்சைத் திணைக்களம் இலங்கைப் பரීட்சைத் திணைக்களம் இலங்கைப் பரීட்சைத் திணைக்களம்
 Department of Examinations, Sri Lanka
 இலங்கைப் பரීட்சைத் திணைக்களம் இலங்கைப் பரීட்சைத் திணைக்களம் இலங்கைப் பரීட்சைத் திணைக்களம் இலங்கைப் பரීட்சைத் திணைக்களம் இலங்கைப் பரීட்சைத் திணைக்களம்

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2019 අගෝස්තු
 கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2019 ஓகஸ்த்
 General Certificate of Education (Adv. Level) Examination, August 2019

16.08.2019 / 0830 - 1030

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 09 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 (x) in accordance with the instructions given on the back of the answer sheet.

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

1. Consider the following statements, I and II.
 I. The energy absorbed or released by atoms is quantized.
 II. Small particles under appropriate conditions show wave properties.
 The two scientists who proposed the theories as given by statements I and II respectively are,
 (1) Louis de Broglie and Albert Einstein
 (2) Max Planck and Louis de Broglie
 (3) Max Planck and Ernest Rutherford
 (4) Niels Bohr and Louis de Broglie
 (5) Louis de Broglie and Max Planck
2. The maximum number of **electron pairs** of an atom that are associated with principal quantum number $n = 3$ is,
 (1) 3 (2) 4 (3) 5 (4) 8 (5) 9
3. The number of stable resonance structures that can be drawn for the oxalate ion $[\text{C}_2\text{O}_4^{2-}/(\text{O}_2\text{C}-\text{CO}_2)^{2-}]$ is,
 (1) 2 (2) 3 (3) 4 (4) 5 (5) 6
4. What is the IUPAC name of the following compound?

$$\text{HOCH}_2\text{CH}_2\text{CH}_2\overset{\text{O}}{\parallel}\text{CCH}_2\text{NH}_2$$

 (1) 5-hydroxy-2-oxo-1-pentanamine (2) 1-amino-5-hydroxy-2-oxopentane
 (3) 1-amino-5-hydroxy-2-pentanone (4) 5-hydroxy-1-amino-2-pentanone
 (5) 5-amino-4-oxo-1-pentanol
5. Identify the pair of elements which has the **largest** difference in electronegativities.
 (1) B and Al (2) Be and Al (3) B and Si (4) B and C (5) Al and C

AL/2019/02/E-1(NEW)

- 2 -

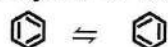
6. The electron pair geometry and shape around the two nitrogen atoms (labelled as N¹ and N²) in the H₂NNO

molecule (skeleton: $\text{H}-\overset{\text{H}}{\underset{|}{\text{N}^1}}-\text{N}^2-\text{O}$) respectively are,

N ¹		N ²	
(1) tetrahedral	pyramidal	trigonal planar	angular
(2) pyramidal	trigonal planar	trigonal planar	angular
(3) trigonal planar	pyramidal	trigonal planar	trigonal planar
(4) tetrahedral	pyramidal	angular	trigonal planar
(5) tetrahedral	angular	trigonal planar	trigonal planar

7. Which of the following statements is **incorrect** regarding benzene?

(1) The resonance hybrid of benzene is depicted as follows:



- (2) All six carbon atoms of benzene are sp² hybridized.
- (3) The bond lengths between any two carbon atoms of benzene have the same value.
- (4) All the C—C—C and the C—C—H bond angles of benzene have the same value.
- (5) All the hydrogen atoms of benzene lie in the same plane.
8. TiCl₄(g) reacts with liquid magnesium metal (Mg(l)) to give Ti(s) metal and MgCl₂(l) at high temperature. When 0.95 kg of TiCl₄(g) is made to react with 97.2 g of Mg(l), the reactant that is completely consumed (this is commonly referred to as limiting reactant) and the amount of Ti(s) metal formed respectively are, (Molar mass: TiCl₄ = 190 g mol⁻¹; Mg = 24.3 g mol⁻¹; Ti = 48 g mol⁻¹)
- (1) TiCl₄ and 96 g (2) Mg and 96 g (3) Mg and 48 g
- (4) TiCl₄ and 192 g (5) Mg and 192 g
9. The ideal gas equation can be expressed in the form, $P = \rho \frac{RT}{M}$ where ρ is the density of the gas, M is the molar mass (g mol⁻¹) of the gas, P is the pressure (Pa) and T is the temperature (K). If the units of R are J mol⁻¹ K⁻¹, units of ρ in this equation should be,
- (1) kg m⁻³ (2) g m⁻³ (3) g cm⁻³
- (4) g dm⁻³ (5) kg cm⁻³
10. The **decreasing** order of conductivity of the following aqueous solutions including H₂O is, 0.01 M KCl, 0.1 M KCl, 0.1 M HAC; (HAC = acetic acid; M = mol dm⁻³)
- (1) H₂O > 0.1 M HAC > 0.1 M KCl > 0.01 M KCl
- (2) 0.01 M KCl > 0.1 M HAC > 0.1 M KCl > H₂O
- (3) 0.01 M KCl > 0.1 M KCl > 0.1 M HAC > H₂O
- (4) 0.1 M KCl > 0.01 M KCl > 0.1 M HAC > H₂O
- (5) 0.1 M HAC > H₂O > 0.01 M KCl > 0.1 M KCl
11. The correct answer when the chemical species SO₂, SO₃, SO₃²⁻, SO₄²⁻ and SCl₂ are arranged in the **increasing** order of the electronegativity of sulphur (S) atom is,
- (1) SCl₂ < SO₃²⁻ < SO₂ < SO₃ < SO₄²⁻
- (2) SO₃ < SO₄²⁻ < SO₂ < SO₃²⁻ < SCl₂
- (3) SO₃²⁻ < SO₄²⁻ < SCl₂ < SO₃ < SO₂
- (4) SCl₂ < SO₃²⁻ < SO₄²⁻ < SO₂ < SO₃
- (5) SCl₂ < SO₄²⁻ < SO₃²⁻ < SO₂ < SO₃

ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව
இலங்கைப் பரீட்சைத் திணைக்களம்

අ.පො.ස. (උ.පෙළ) විභාගය/ க.பொ.த. (உயர் தர)ப் பரீட்சை - 2019

නව නිර්දේශය/ புதிய பாடத்திட்டம்

විෂය අංකය
பாட இலக்கம்

02

විෂය
பாடம்

Chemistry

ලකුණු දීමේ පටිපාටිය/புள்ளி வழங்கும் திட்டம்

I පත්‍රය/பத்திரம் 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 or 4	11.	4	21.	2	31.	1 or 5	41.	1
02.	5	12.	2	22.	2	32.	4	42.	1
03.	3	13.	2	23.	4	33.	2	43.	3
04.	all	14.	2 or 5	24.	3	34.	2	44.	4
05.	5	15.	2	25.	1	35.	2	45.	1
06.	1	16.	5	26.	1	36.	4	46.	4
07.	1	17.	4	27.	5	37.	5	47.	3
08.	2	18.	4	28.	5	38.	3	48.	1
09.	2	19.	3	29.	5	39.	2	49.	1
10.	4	20.	3	30.	3	40.	4	50.	all

☛ විශේෂ උපදෙස්/ விசேட அறிவுறுத்தல் :

එක් පිළිතුරකට/ ஒரு சரியான விடைக்கு 01 ලකුණු බැගින්/புள்ளி வீதம்

මුළු ලකුණු/மொத்தப் புள்ளிகள் 1 × 50 = 50

PART A – STRUCTURED ESSAY

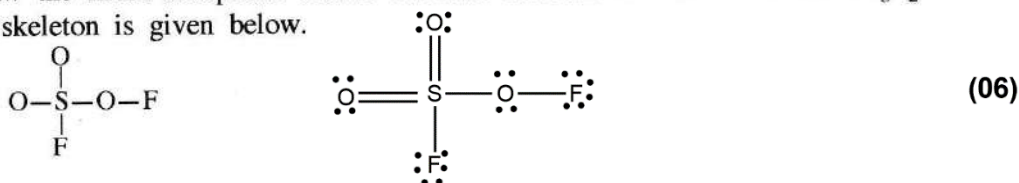
Answer **all four** questions on this paper itself. (Each question carries **100** marks.)

1. (a) The following questions are related to the elements of the second row in the Periodic Table. Write the **symbol** of the element in the space provided in answering parts (i) to (vi).
- (i) Identify the element that has the highest electronegativity (disregard the noble gas). F
.....
- (ii) Identify the element that has an allotrope which conducts electricity. C
.....
- (iii) Identify the element that forms the monoatomic ion largest in size (this should be a stable ion). N
.....
- (iv) Identify the element that has **no** *p* electrons but has a stable *s* configuration. Be
.....
- (v) Identify the element that has the highest first ionization energy. Ne
.....
- (vi) Identify the element that forms mostly electron deficient trigonal planar covalent compounds. B
.....

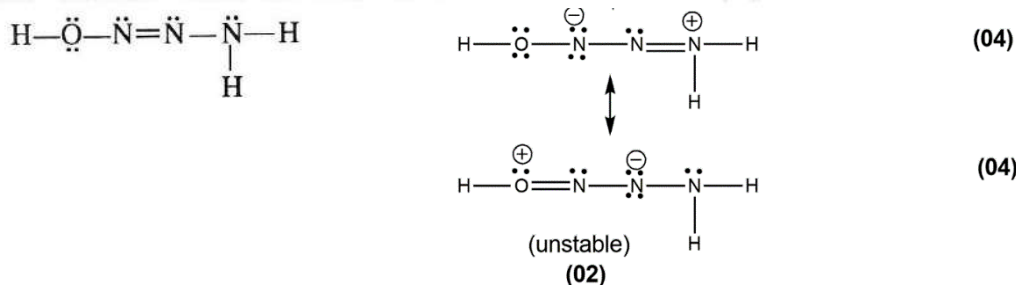
Note: If name is given instead of symbols do not award marks (04 X 6 = 24)

1(a): 24 marks

- (b) (i) Draw the **most** acceptable Lewis dot-dash structure for the molecule SO_3F_2 . Its skeleton is given below.

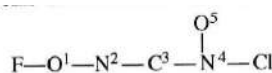
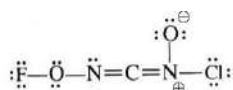


- (ii) The most stable Lewis dot-dash structure for the molecule $\text{H}_3\text{N}_3\text{O}$ is shown below. Draw **two** more Lewis dot-dash structures (resonance structures) for this molecule. Write 'unstable' under the more unstable structure drawn by you.



- (iii) Based on the Lewis dot-dash structure given below, state the following regarding the C, N and O atoms given in the table.

- I. VSEPR pairs around the atom II. electron pair geometry around the atom
III. shape around the atom IV. hybridization of the atom
The atoms are numbered as follows.



		O ¹	N ²	C ³	N ⁴
I	VSEPR pairs	4	3	2	3
II	electron pair geometry	tetrahedral	trigonal planar	linear	trigonal planar
III	shape	angular / V / bent	angular / V / bent	linear	trigonal planar
IV	hybridization	sp^3	sp^2	sp	sp^2

(01 X 16 = 16)

(iv) Identify the atomic/hybrid orbitals involved in the formation of the following σ bonds in the Lewis dot-dash structure given in part (iii) above. (Numbering of atoms is as in part (iii).)

I.	F—O ¹	F	..... $2p$ OR sp^3	O ¹	..... sp^3
II.	O ¹ —N ²	O ¹	..... sp^3	N ²	..... sp^2
III.	N ² —C ³	N ²	..... sp^2	C ³	..... sp
IV.	C ³ —N ⁴	C ³	..... sp	N ⁴	..... sp^2
V.	N ⁴ —O ⁵	N ⁴	..... sp^2	O ⁵	..... $2p$ OR sp^3
VI.	N ⁴ —Cl	N ⁴	..... sp^2	Cl	..... $3p$ OR sp^3 (01 X 12 = 12)

(v) Identify the atomic orbitals involved in the formation of the following π bonds in the Lewis dot-dash structure given in part (iii) above. (Numbering of atoms is as in part (iii).)

I.	N ² —C ³	N ²	..... $2p$	C ³	..... $2p$
II.	C ³ —N ⁴	C ³	..... $2p$	N ⁴	..... $2p$ (01 X 4 = 04)

(vi) I. How are the two double bonds oriented in the Lewis dot-dash structure given in part (iii)?

Double bonds are perpendicular to each other (02)

OR

Sigma bonds linear, π bonds perpendicular (01 + 01)

II. Give an example of a molecule/ion that has a similar orientation of double bonds.

..... CO_2 , NO_2^+ , CN_2^{2-} , N_3^- (02)

Note: Your example should not contain more than 3 atoms.

The elements in your example should be restricted to the first and second periods of the Periodic Table.

1(b): 52 marks

(c) (i) An atomic orbital is described by three quantum numbers n , l and m_l .

Write the appropriate quantum numbers and the name of the atomic orbital in the boxes given below.

	n	l	m_l	atomic orbital	
I.	3	1	+1	3p	
II.	3	2	-2	3d	
III	2	0	0	2s	(01 X 6 = 06)

(ii) Arrange the following in the **increasing** order of the property indicated in parenthesis. (Reasons are **not** required.)

I. LiF, LiI, KF (melting point)

..... LiI < LiF < KF

II. NO_2^- , NO_4^{3-} , NF_5 (stability)

..... NF_5 < NO_4^{3-} < NO_2^-

III. NOCl, $NOCl_3$, NO_2F (N—O bond distance)

..... NOCl < NO_2F < $NOCl_3$

(06 X 3 = 18)

1(c): 24 marks

2.(a) **X** is an *s*-block element in the Periodic Table. The first, second and third ionization energies of **X**, in kJ mol^{-1} are 738, 1451 and 7733 respectively. **X** reacts slowly with hot water, liberating $\text{H}_2(\text{g})$ and forming its hydroxide. The hydroxide is basic. **X** also liberates $\text{H}_2(\text{g})$ on reaction with dilute acids. **X** burns in air with a bright white light. The cation of **X** contributes to hardness of water.

(i) Identify **X**. **X**: Mg OR Magnesium (07)

(ii) Write the ground state electronic configuration of **X**. $1s^2 2s^2 2p^6 3s^2$ (04)

(iii) Write the chemical formulae of the **two** compounds formed when **X** burns in air.
 MgO and Mg_3N_2 (03 + 03)

Note: If X has been identified correctly marks can be awarded for XO and X_3N_2

(iv) Consider the given compounds of the elements in the group in the Periodic Table to which **X** belongs. In the given boxes, write whether the indicated property **increases** or **decreases** down the group.

I. Solubility of sulphates in water Decreases (03)

II. Solubility of hydroxides in water Increases (03)

III. Thermal stability of metal carbonates Increases (03)

Give reasons for your answer in III.

Cation size increases down the group. Charge same. (03)

OR
 Charge density decreases down the group. (03)

Therefore, polarizing power decreases down the group. (02)

Hence, decomposition of the carbonates become difficult on going down the group. (03)

(v) Identify the element in the *s*-block of the Periodic Table, which reacts in a similar manner to **X** with $\text{H}_2(\text{g})$, $\text{O}_2(\text{g})$ and $\text{N}_2(\text{g})$, but does **not** belong to the same group as **X**.

Lithium OR Li (04)

(vi) Identify another **metal ion** that contributes to hardness of water.

Ca^{2+} (No marks for Ca OR Calcium) (04)

(vii) Identify the compound most commonly used to remove hardness of water.

Na_2CO_3 OR Soda Ash (04)

(viii) **X** is a component of a well-known reagent used in organic chemistry. Give the **name** of this reagent.

Grignard reagent (04)

Note: If X is incorrect, do not award marks for (a)(ii) – (iv).

2(a): 50 marks

- (b) Test tubes labelled A to E contain aqueous solutions of $\text{Na}_2\text{S}_2\text{O}_3$, Na_2CO_3 , KNO_2 , KBr and Na_2S (not in order). The characteristics of the solutions obtained and gases evolved on addition of dil. HCl (warming if required) to each of the test-tubes A to E are given in the table below.

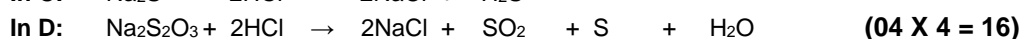
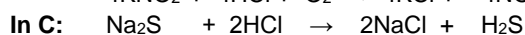
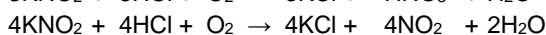
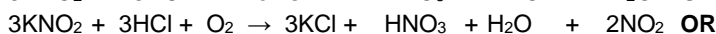
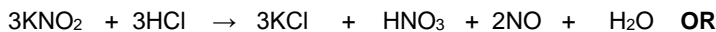
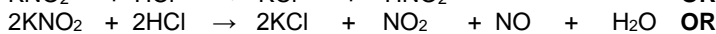
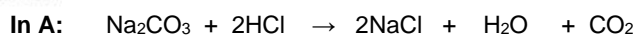
Test-tube	Appearance of solution	Gas
A	colourless	colourless and odourless
B	colourless	reddish-brown with a pungent odour
C	colourless	colourless with a rotten egg odour
D	turbid	colourless with a pungent odour
E	colourless	not evolved

- (i) Identify the solutions in each of the test-tubes A to E.

A : ... Na_2CO_3 C : Na_2S E : KBr

B : ... KNO_2 D : $\text{Na}_2\text{S}_2\text{O}_3$ (04 X 5 = 20)

- (ii) Write balanced chemical equations for the reactions that take place in test-tubes A, B, C and D.



- (iii) Write a chemical test to identify each of the gases evolved in A, C and D.

Note: Observations are also required.

In A: (CO_2) Pass through a solution of $\text{Ca}(\text{OH})_2$. (02)

Solution turns milky. On continued passing, milky solution becomes colourless. (02)

In C: (H_2S) Test with filter paper moistened with lead acetate. (03)

Filter paper turns black. (02)

OR

Test with filter paper moistened with cadmium acetate. (03)

Filter paper turns yellow. (02)

OR

Pass through a solution of acidified KMnO_4 . (03)

(Purple) solution becomes colourless, but solution is not clear (cloudy) (02)

OR

Pass through a solution of acidified $\text{K}_2\text{Cr}_2\text{O}_7$. (03)

(Orange) solution becomes green, but solution is not clear (cloudy) (02)

In D: (SO_2) Pass through a solution of acidified KMnO_4 . (03)

(Purple) solution becomes colourless. (02)

OR

Pass through a solution of acidified $\text{K}_2\text{Cr}_2\text{O}_7$. / Test with filter paper moistened with acidified $\text{K}_2\text{Cr}_2\text{O}_7$ (03)

(Orange) solution becomes green. / Filter paper turns green. (02)

OR

Pass through a solution of $\text{Ca}(\text{OH})_2$. (03)

Solution turns milky. On continued passing, milky solution becomes colourless. (02)

OR

Test with moist coloured flower petals. (03)

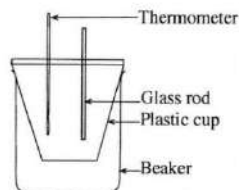
Petals are decolorized /bleached. (02)

Note: Identification in (b)(i) must be correct for award of marks for respective

answers in (b)(ii) & (b)(iii).

2(b): 50 marks

3. The set up shown in the figure was used to calculate the heat change associated with the dissolution of MX(s) in water. 100.00 cm^3 of distilled water was added to the cup. The initial temperature of distilled water was measured to be 25.0°C . Then 0.10 mol of MX(s) was added to the water and stirred continuously. It was observed that the temperature of the solution decreased gradually. The lowest temperature measured was 17.0°C . The amount of water used was sufficient to completely dissolve MX(s). Density and specific heat capacity of water are 1.00 g cm^{-3} and $4.20 \text{ J g}^{-1}\text{C}^{-1}$ respectively. Assume that the density and the specific heat capacity of water are not changed due to the dissolution of MX(s).



- (i) Calculate the amount of heat that should be supplied to bring the system (solution) back to 25.0°C .

$$\begin{aligned} \dots q &= m \cdot s \cdot \Delta T. \text{ (OR } q = m \cdot c \cdot \Delta T) \dots & (5) \\ \dots &= 100.00 \cdot \text{cm}^3 \times 1.0 \text{ g cm}^{-3} \times 4.2 \text{ J } ^\circ\text{C}^{-1} \text{ g}^{-1} \times (25.0 - 17.0) ^\circ\text{C} & (4+1)+(4+1)+(4+1)+(4+1) \\ &= 3360 \text{ J} & (4+1) \end{aligned}$$

(ii) Is the dissolution of MX(s) in water an endothermic or exothermic process? Explain your answer.

Dissolution of MX(s) has absorbed heat (OR temperature of water decreased) (2)
 Process is endothermic (2)

(iii) Calculate the enthalpy change (in kJ mol⁻¹) associated with reaction



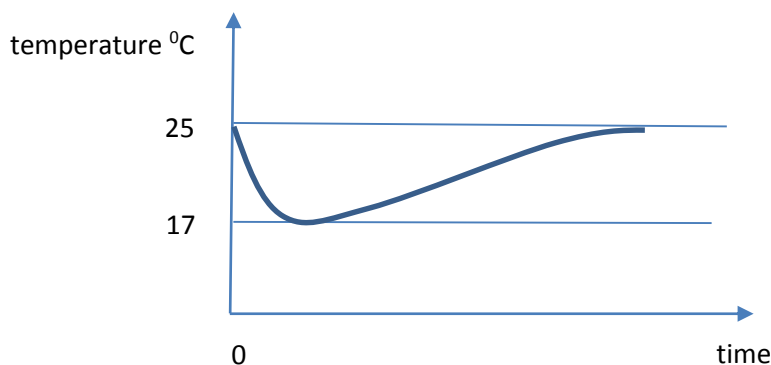
$\Delta H = \frac{3360 \text{ J}}{0.10 \text{ mol}} = 33.6 \text{ kJ mol}^{-1}$ (OR 33600 J mol^{-1}) (4+1)+(4+1)
 (4+1)

(iv) If this experiment was conducted using 200.00 cm³ of water, would you expect the temperature change to be larger than the above value? Explain your answer.

No (OR the temperature change would be smaller) (2)
 Amount of heat (q) is constant, the mass (m) has increased. Therefore, the temperature change (ΔT) would be smaller (OR More water is available to release heat) (2)

(v) Show the variation of temperature of the system (solution) by drawing the temperature – time curve.

Note: Eventually the system reaches the room temperature (25.0 °C).



Curve starts from t=0 (or the time of salt addition is marked) (2)
 Curve starts from 25 °C (2)
 Curve goes down to 17 °C (2)
 Curve has the correct shape (4)

(vi) In this experiment, explain why a plastic cup is used instead of a metal cup.

Metals are good thermal conductors. (OR when the temperature is decreased, metal provides and conducts heat from surroundings) (2)
 Plastics are poor thermal conductors and have low heat capacity (2)

(vii) Gibbs energy change (ΔG) for the dissolution of MX(s) in water at the temperature of 25.0 °C and pressure of 1.0 atm was calculated to be $-26.0 \text{ kJ mol}^{-1}$. Calculate the entropy change (ΔS) of dissolution of MX(s) in water at 25.0 °C using the enthalpy change calculated above.

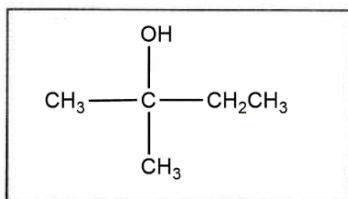
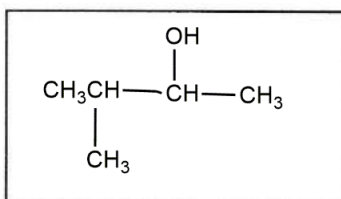
$\Delta G = \Delta H - T \Delta S$ (No marks for $\Delta G^0 = \Delta H^0 - T \Delta S^0$) (5)
 $\Delta S = \frac{\Delta H - \Delta G}{T}$
 $= \frac{33.6 \text{ kJ mol}^{-1} - (-26.0 \text{ kJ mol}^{-1})}{298 \text{ K}}$ (4+1)+(4+1)+(4+1)
 $= 200 \text{ J mol}^{-1} \text{ K}^{-1}$ (4+1)

(viii) Would you expect the solubility of MX(s) to increase or decrease with increasing temperature? Give reasons for your answer.

Solubility of MX(s) in water increases with increasing temperature (4)
 because ΔG becomes more negative. (4)
 (OR because the dissolution of MX(s) is endothermic)

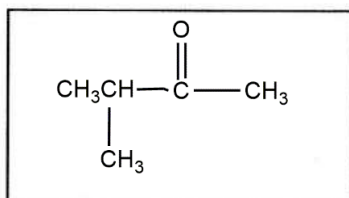
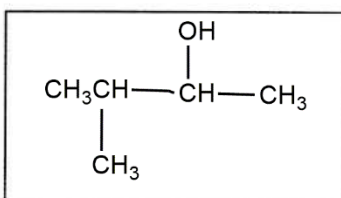
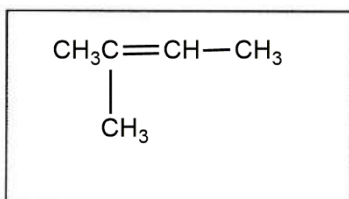
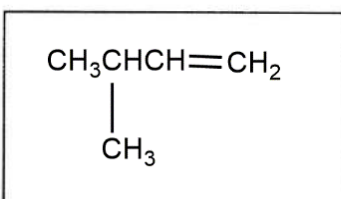
4. (a) Compounds **A** and **B** both have the same molecular formula $C_5H_{10}O$. Both **A** and **B** give orange/red precipitates with 2,4-dinitrophenylhydrazine. When **A** and **B** are reacted separately with $NaBH_4$ in methanol, compound **A** gives **C** and compound **B** gives **D**. When **C** is heated with Al_2O_3 , two alkenes **E** (C_5H_{10}) and **F** (C_5H_{10}) are formed. When **E** and **F** are reacted separately with conc. H_2SO_4 and the products obtained are hydrolysed, compound **E** gives **G**, while compound **F** gives **H**. **G** gives a turbidity immediately with the Lucas reagent. **H** also gives a turbidity with the Lucas reagent but not immediately.

- (i) Draw the structures of **G** and **H**.

**G****H**

(05 x 2 = 10)

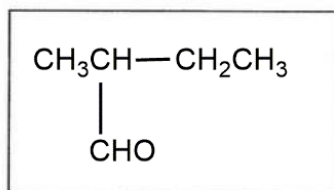
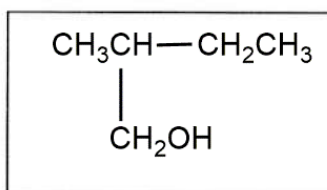
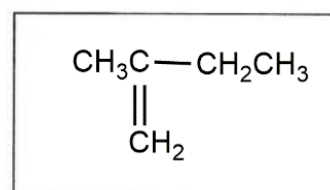
- (ii) Draw the structures of **A**, **C**, **E** and **F**.

**A****C****E****F**

(05 x 4 = 20)

When heated with Al_2O_3 , **D** gives alkene **I** (C_5H_{10}). When **I** is reacted with conc. H_2SO_4 and the product obtained hydrolysed, **G** is obtained.

- (iii) Draw the structures of **B**, **D** and **I**.

**B****D****I**

Note : 1. Mark A-I Independently

2. If the correct structure is given for either **C** or **H**, award full marks for both **C** and **H** (05x2 = 10)

(05 x 3 = 15)

- (iv) Describe a test/reaction to distinguish between **A** and **B**.

B gives

- | | |
|--------------------------|---------------------|
| Tollens reagent | - Silver mirror |
| Fehlings solution | - Red colouration |
| Acidic $K_2Cr_2O_7$ | - Green colouration |
| Dilute $KMnO_4$ solution | - Decolourization |

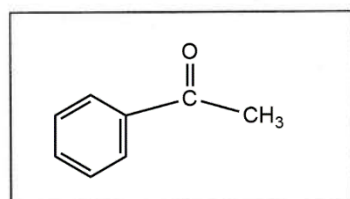
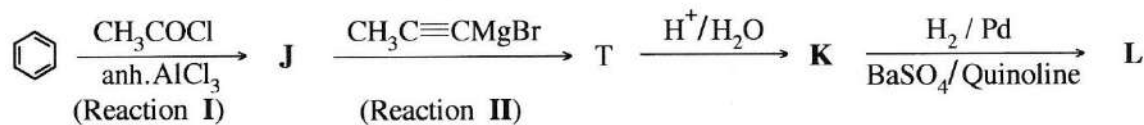
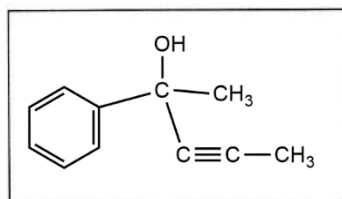
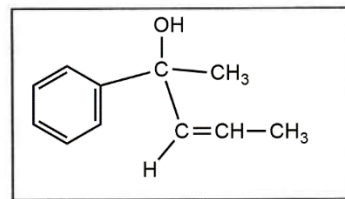
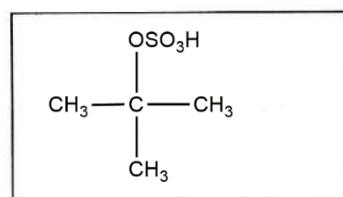
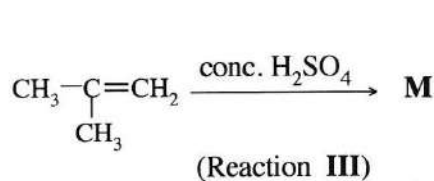
(05)

(Any one)

Note: Marks awarded only if **A** and **B** are correct.

4(a): 50 marks

(b) (i) Give the structures of **J**, **K**, **L** and **M** in the following reaction sequences.

**J****K****L****M****(05 x 4 = 20)**

(ii) Selecting from the list given below, write the type of reaction taking place in reactions **I**, **II** and **III**.

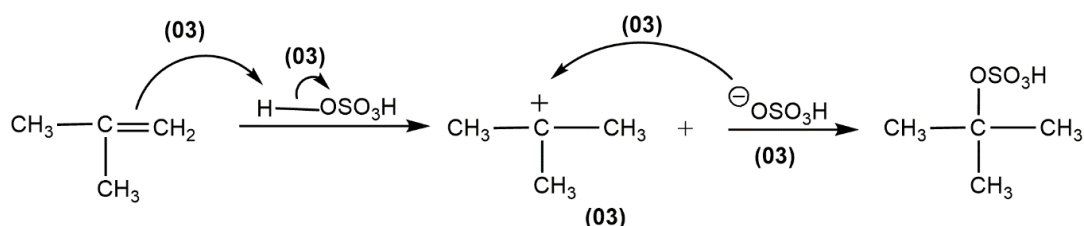
Nucleophilic Addition,	Nucleophilic Substitution,
Electrophilic Addition,	Electrophilic Substitution, Elimination

Reaction I - Electrophilic substitution
 Reaction II - Nucleophilic addition
 Reaction III - Electrophilic addition

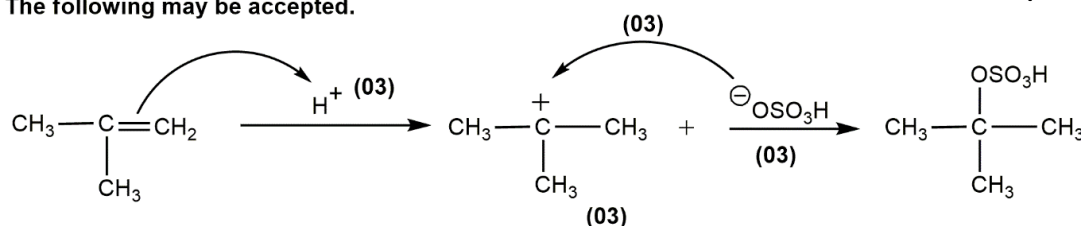
(05 x 3 = 15)

Note : Marks awarded only if each of the reactions I, II and III correct as given in the marking scheme

(iii) Using your knowledge of the mechanism of the reaction between alkenes and HBr, give the mechanism of reaction **III**.

**(15 marks)**

The following may be accepted.

**(12 marks)**
4(b): 50 marks

PART B - ESSAY*Answer two questions only. (Each question carries 150 marks)*

5. (a) A titration between the mono acidic weak base **B** (0.15 mol dm^{-3}) and HCl (0.10 mol dm^{-3}) was carried out using a suitable indicator as described below.

The HCl solution (25.00 cm^3) was kept in the titration flask and the weak base **B** was added using a burette. The dissociation constant, K_b of the weak base at 25°C is $1.00 \times 10^{-5} \text{ mol dm}^{-3}$. All the experiments were conducted at 25°C .

- (i) Calculate the pH of the acid solution in the titration flask, before the addition of the base, **B**.

pH of the HCl solution.

$$\text{pH} = -\log[\text{H}^+] \quad (2)$$

$$= -\log(0.1)$$

$$= 1.0 \quad (2+1)$$

- (ii) Calculate the pH of the solution in the titration flask, after the addition of 10.00 cm^3 of the solution of **B**. Can the solution in the titration flask act as a buffer solution? Explain your answer.

pH after addition of 10.00 cm^3 of B solution.

$$[\text{H}^+] = \frac{0.1 \text{ mol dm}^{-3} \times 25.00 \text{ cm}^3 - 0.15 \text{ mol dm}^{-3} \times 10.00 \text{ cm}^3}{35.00 \text{ cm}^3} \quad (4+1)$$

$$= 0.028 \text{ mol dm}^{-3}$$

$$\text{pH} = 1.5 \text{ (OR } 1.6) \quad (4+1)$$

No **OR** this solution cannot act as a buffer solution. (3)

Only protonated base (conjugate acid) is present (No unreacted or unprotonated base) (3)

Note : If correctly explained using the addition of H^+ and OH^- , award full marks

- (iii) Calculate the volume of the weak base solution required to reach the equivalence point.

Volume of base required to reach equivalence point.

$$V = \frac{0.1 \text{ mol dm}^{-3} \times 25.00 \text{ cm}^3}{0.15 \text{ mol dm}^{-3}} \quad (4+1)$$

$$= 16.66 \text{ cm}^3$$

$$(16.67 \text{ cm}^3 \text{ OR the answer reported to one decimal place is also accepted}) \quad (4+1)$$

- (iv) Another 10.00 cm^3 volume of the weak base was added to the titration flask after reaching the equivalence point. Calculate the pH of the solution in the titration flask.

pH after addition of 10.00 cm^3 of base after reaching the equivalence point.

Weak base dissociates according to,



$$K_b = \frac{[\text{BH}^+(\text{aq})][\text{OH}^-(\text{aq})]}{[\text{B(aq)}]} \quad (4)$$

OR

$$pOH = pK_b + \log \left(\frac{[\text{BH}^+(\text{aq})]}{[\text{B(aq)}]} \right)$$

Note : Physical states are required for the award of marks

Assuming that the amount dissociated is negligible, (2)

$$\text{Concentration of the weak base [B(aq)]} = \frac{0.15 \text{ mol dm}^{-3} \times 10.00 \text{ cm}^3}{(25.00 \text{ cm}^3 + 16.66 \text{ cm}^3 + 10.00 \text{ cm}^3)} \quad (4+1)$$

$$\text{Concentration of the protonated weak base [BH}^+(\text{aq})] = \frac{0.15 \text{ mol dm}^{-3} \times 16.66 \text{ cm}^3}{(25.00 \text{ cm}^3 + 16.66 \text{ cm}^3 + 10.00 \text{ cm}^3)} \quad (4+1)$$

$$pOH = -\log(1 \times 10^{-5}) + \log\left(\frac{0.15 \text{ mol dm}^{-3} \times 16.66 \text{ cm}^3}{0.15 \text{ mol dm}^{-3} \times 10.00 \text{ cm}^3}\right) \quad (4+1)$$

$$pOH = 5.0 + 0.221 = 5.221$$

$$pH = 8.78 \text{ (or 8.7 or 8.9 or 9)} \quad (4+1)$$

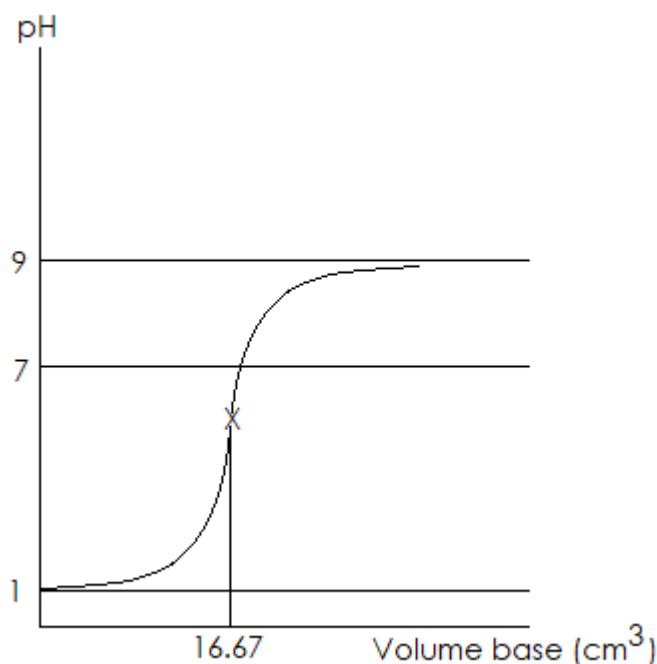
(v) Can the solution obtained in (iv) above act as a buffer solution? Explain your answer.

Yes **OR** it can act as a buffer solution. (3)

The solution in the titration flask contains the protonated base (conjugate acid) and unreacted base. (3)

Note : If correctly explained using the addition of H⁺ and OH⁻, award full marks

(vi) Sketch the variation in pH of the mixture in the titration flask with the volume of the weak base solution added (titration curve). Label the axes, indicate pH on the y-axis and the volume of weak base solution added on the x-axis. Mark the equivalence point approximately. [Calculation of pH at equivalence point is not expected.]



Curve starts at pH=1 and reaches pH=9 and has the correct shape (4)

Equivalence volume marked (2)

Equivalence pH (between pH = 5 and pH=7) marked (2)

Axes are labeled (with units where applicable) (1+1)

5 (a): 75 marks

- (b) The following two experiments were carried out at a constant temperature using the volatile liquids **C** and **D** which form an ideal solution.

Experiment I: The liquids **C** and **D** were introduced in to an evacuated rigid container and allowed to reach equilibrium. When the system was at equilibrium, it was observed that the mole fractions of **C** and **D** in the liquid phase (L_I) were 0.3 and 0.7 respectively. Total pressure in the container was 2.70×10^4 Pa.

Experiment II: This experiment was conducted using different amounts of **C** and **D**. When the equilibrium was established, it was observed that the mole fractions of **C** and **D** in the liquid phase (L_{II}) were 0.6 and 0.4 respectively. Total pressure of the container was 2.40×10^4 Pa.

- (i) Give the relationship between the partial pressure of **C** in the vapour phase (P_C), its saturated vapour pressure (P_C^0) and its mole fraction in the liquid phase (X_C) in the form of an equation. This equation states a commonly used law in physical chemistry. Write the name of the law.

$$P_C = x_C P_C^0 \quad \text{(Award marks only for these symbols)} \quad (5)$$

$$\text{Raoult's law} \quad (4)$$

- (ii) Calculate the saturated vapour pressures of **C** and **D**.

Experiment I

$$2.7 \times 10^4 \text{ Pa} = 0.3 P_C^0 + 0.7 P_D^0 \quad \text{---(1)} \quad (4+1)$$

Experiment II

$$2.4 \times 10^4 \text{ Pa} = 0.6 P_C^0 + 0.4 P_D^0 \quad \text{---(2)} \quad (4+1)$$

$$(1) \times 2 - (2)$$

$$P_D^0 = 3.0 \times 10^4 \text{ Pa} \quad (4+1)$$

$$P_C^0 = (2.4 \times 10^4 \text{ Pa} - 0.4 \times 3.0 \times 10^4 \text{ Pa}) / 0.6 \\ = 2.0 \times 10^4 \text{ Pa} \quad (4+1)$$

- (iii) Calculate the mole fractions of **C** and **D** in the vapour phase (V_I) of experiment I.

Mole fractions in the gas phase (experiment I, V_I)

$$X_{C,I}^g = \frac{0.3 \times 2.0 \times 10^4 \text{ Pa}}{2.7 \times 10^4 \text{ Pa}} \quad (1+1)$$

$$= 0.2 \quad \text{(OR } 0.22 \text{ OR } 2/9) \quad (1+1)$$

$$X_{D,I}^g = 1 - 0.2 \quad (1+1)$$

$$= 0.8 \quad \text{(OR } 0.78 \text{ OR } 7/9) \quad (1+1)$$

- (iv) Calculate the mole fractions of **C** and **D** in the vapour phase (V_{II}) of experiment II.

Mole fractions in the gas phase (experiment II, V_{II})

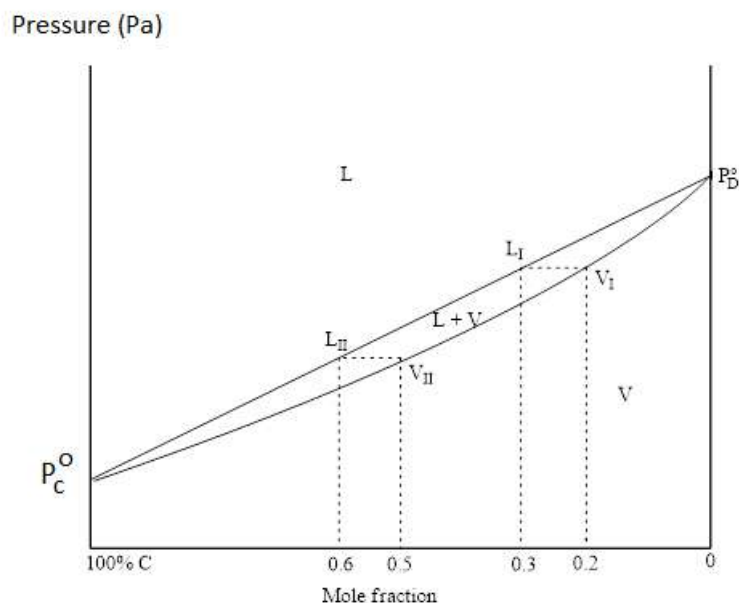
$$X_{C,II}^g = \frac{0.6 \times 2.0 \times 10^4 \text{ Pa}}{2.4 \times 10^4 \text{ Pa}} \quad (1+1)$$

$$= 0.5 \quad (1+1)$$

$$X_{D,II}^g = 1 - 0.5 \quad (1+1)$$

$$= 0.5 \quad (1+1)$$

- (v) Show the compositions of liquid and vapour phases (L_I , L_{II} , V_I and V_{II}) and relevant pressures in the above two experiments on a pressure-composition phase diagram drawn at constant temperature.



L=liquid, V= vapour

Note :Graph could also be drawn by reversing the increasing direction of the mole fraction of C.

Mark accordingly

Axes labeled (with appropriate units where applicable)	(2+2)
P_C^0 and P_D^0 marked	(2+2)
Line & curve (starts and ends at correct pressures)	(2+2)
Phases at equilibrium in each region identified	(2+2+2)
point L_I marked at $X_C = 0.3$	(2)
point L_{II} marked at $X_C = 0.6$	(2)
point V_I marked at $X_C = 0.2$	(2)
point V_{II} marked at $X_C = 0.5$	(2)
points L_I and V_I are at the same level	(2)
points L_{II} and V_{II} are at the same level	(2)

Note : No marks for temperature composition phase diagram

5 (b): 75 marks

6. (a) An organic solvent (org-1) and water(aq) are immiscible and form a biphasic system. Partition coefficient for the distribution of **X** between org-1 and water at temperature T is, $K_D = \frac{[X]_{org-1}}{[X]_{aq}} = 4.0$

An amount of 0.50 mol of **X** was added to a system containing 100.00 cm³ of org-1 and 100.00 cm³ of water. The system was allowed to reach equilibrium at temperature T.

- (i) Calculate the concentration of **X** in org-1.

Calculation of $[X]_{org-1}$

$$K_D = \frac{[X]_{org-1}}{[X]_{aq}} = 4.0$$

V = volume, x = amount (mols) in aqueous phase.

$$K_D = \frac{\frac{0.5 \text{ mol} - x}{V}}{\frac{x}{V}} = 4.0 \quad (\text{No marks for substitution in mols}) \quad (4+1)$$

$$x = 0.1 \text{ mol} \quad (4+1)$$

$$[x]_{org-1} = \frac{0.4 \text{ mol}}{100 \times 10^{-3} \text{ dm}^3} = 4.0 \text{ mol dm}^{-3} \quad (4+1)$$

- (ii) Calculate the concentration of **X** in water.

$$[x]_{aq} = \frac{0.1 \text{ mol}}{100 \times 10^{-3} \text{ dm}^3} = 1.0 \text{ mol dm}^{-3} \quad (4+1)$$

6 (a): 20 marks

- (b) The compound **Y** is soluble only in the aqueous phase. In the aqueous phase, **X** and **Y** react to form **Z**. The presence of **Y** and **Z** does not affect the distribution of **X** between org-1 and water.

A series of biphasic systems containing org-1 and water were prepared. Then different amounts of **X** were distributed in the biphasic systems and the systems were allowed to reach equilibrium. The initial rate of the reaction between **X** and **Y** in the aqueous phase was measured after adding **Y** into the aqueous phase of these biphasic systems. Results of these experiments conducted at temperature T are given in the table.

Experiment Number	Volume of water (cm ³)	Volume of org-1 (cm ³)	Total amount of X added (mol)	Total amount of Y added (mol)	Initial rate of the reaction (mol dm ⁻³ s ⁻¹)
1	100.00	100.00	0.05	0.02	2.00×10^{-6}
2	100.00	100.00	0.10	0.04	1.60×10^{-5}
3	50.00	50.00	0.25	0.02	4.00×10^{-4}

Orders of the reaction with respect to **X** and **Y** are m and n respectively. The rate constant of the reaction at temperature T is k .

- (i) Given that the concentrations of **X** and **Y** in the aqueous phase are $[X]_{aq}$ and $[Y]_{aq}$ respectively, write the rate expression for the reaction in terms of $[X]_{aq}$, $[Y]_{aq}$, m , n and k .

$$\text{Rate} = k [X]_{aq}^m [Y]_{aq}^n \quad \text{OR} \quad \frac{-\Delta[X]_{aq}}{\Delta t} = k [X]_{aq}^m [Y]_{aq}^n \quad \text{OR} \quad \frac{-\Delta[Y]_{aq}}{\Delta t} = k [X]_{aq}^m [Y]_{aq}^n \quad (10)$$

(ii) Calculate the initial concentration of **X** in the aqueous phase in each experiment.

Let x be the amount (moles) of **X** in the aqueous phase and n_x be the total amount (moles) of **X** added.

Equal volumes of org-1 and water are used in all the experiments.

$$[X]_{aq} = \frac{n_x}{5 \times V_{aq}}$$

Experiment	$[X]_{aq}/\text{mol dm}^{-3}$	
1	0.1	(4)
2	0.2	(4)
3	1.0	(4)

(iii) Calculate the initial concentration of **Y** in the aqueous phase in each experiment.

Let n_y be the total amount of **Y** (moles) added.

Y is only soluble in the aqueous phase.

$$[Y]_{aq} = \frac{n_y}{V_{aq}}$$

Experiment	$[Y]_{aq}/\text{mol dm}^{-3}$	
1	0.2	(4)
2	0.4	(4)
3	0.4	(4)

(iv) Calculate the orders m and n of the reaction with respect to **X** and **Y** respectively.

$$2.00 \times 10^{-6} \text{ mol dm}^{-3} \text{ s}^{-1} = k (0.1 \text{ mol dm}^{-3})^m (0.2 \text{ mol dm}^{-3})^n \quad \text{---(1)} \quad (10 + 2)$$

$$1.60 \times 10^{-5} \text{ mol dm}^{-3} \text{ s}^{-1} = k (0.2 \text{ mol dm}^{-3})^m (0.4 \text{ mol dm}^{-3})^n \quad \text{---(2)} \quad (10 + 2)$$

$$4.00 \times 10^{-4} \text{ mol dm}^{-3} \text{ s}^{-1} = k (1.0 \text{ mol dm}^{-3})^m (0.4 \text{ mol dm}^{-3})^n \quad \text{---(3)} \quad (10 + 2)$$

Finding of the order m

From (2)/(3)

$$\frac{1.60 \times 10^{-5} \text{ mol dm}^{-3} \text{ s}^{-1}}{4.00 \times 10^{-4} \text{ mol dm}^{-3} \text{ s}^{-1}} = \frac{k (0.2 \text{ mol dm}^{-3})^m (0.4 \text{ mol dm}^{-3})^n}{k (1.0 \text{ mol dm}^{-3})^m (0.4 \text{ mol dm}^{-3})^n} \quad (5)$$

$$0.04 = (0.2)^m$$

$$0.04 = (0.2)^m$$

$$m = 2 \quad (4+1)$$

Finding of the order n

From (3)/(1)

$$\frac{4.00 \times 10^{-4} \text{ mol dm}^{-3} \text{ s}^{-1}}{2.00 \times 10^{-6} \text{ mol dm}^{-3} \text{ s}^{-1}} = \frac{k (1.0 \text{ mol dm}^{-3})^m (0.4 \text{ mol dm}^{-3})^n}{k (0.1 \text{ mol dm}^{-3})^m (0.2 \text{ mol dm}^{-3})^n} \quad (5)$$

$$200 = 10^2 (2)^n$$

$$200 = 10^2 (2)^n$$

$$n = 1 \quad (4+1)$$

(v) Calculate the rate constant of the reaction.

Rate constant

From (1)

$$k = \frac{2.00 \times 10^{-6} \text{ mol dm}^{-3} \text{ s}^{-1}}{(0.1 \text{ mol dm}^{-3})^2 (0.2 \text{ mol dm}^{-3})^1} \quad (4+1)$$

$$= 1.0 \times 10^{-3} \text{ mol}^{-2} \text{ dm}^6 \text{ s}^{-1} \quad (4+1)$$

(vi) An experiment is designed to study the effect of temperature on the reaction rate using the partition coefficient given above.

Is this a suitable experiment to study the effect of temperature on the rate of the reaction?

Explain your answer.

Not suitable (2)

Partition coefficient depends on temperature. (3)

6 (b): 105 marks

(c) The organic solvent org-2 and water are also immiscible and form a biphasic system. **X** (0.20 mol) was added to a system containing 100.00 cm³ of org-2 and 100.00 cm³ of water and allowed to reach equilibrium at the temperature T. Then **Y** (0.01 mol) was added to the aqueous phase and the initial rate of the reaction was measured. **Y** does not dissolve in org-2. The initial rate of the reaction between **X** and **Y** in the aqueous phase was found to be $6.40 \times 10^{-7} \text{ mol dm}^{-3} \text{ s}^{-1}$.

Calculate the partition coefficient $\frac{[\text{X}]_{\text{org-2}}}{[\text{X}]_{\text{aq}}}$ for the distribution of **X** between org-2 and water.

$[\text{X}]_{\text{org-2}}$ is the concentration of **X** in the org-2 phase.

Reaction takes place in the aqueous medium. Therefore, the rate constant is the same. (5)

$$\text{Rate} = k [\text{X}]_{\text{aq}}^2 [\text{Y}]_{\text{aq}}$$

$$6.40 \times 10^{-7} \text{ mol dm}^{-3} \text{ s}^{-1} = 1.00 \times 10^{-3} \text{ mol}^{-2} \text{ dm}^6 \text{ s}^{-1} [\text{X}]_{\text{aq}}^2 \cdot 0.1 \text{ mol dm}^{-3} \quad (4+1)$$

$$[\text{X}]_{\text{aq}}^2 = 6.4 \times 10^{-3} \text{ mol}^2 \text{ dm}^{-6} = 64 \times 10^{-4} \text{ mol}^2 \text{ dm}^{-6}$$

$$[\text{X}]_{\text{aq}} = 8.0 \times 10^{-2} \text{ mol dm}^{-3} \quad (4+1)$$

$$K_D = \frac{[\text{X}]_{\text{org-2}}}{[\text{X}]_{\text{aq}}} = \frac{\left(\frac{0.2 \text{ mol}}{0.1 \text{ dm}^3} - 0.08 \text{ mol dm}^{-3}\right)}{0.08 \text{ mol dm}^{-3}} \quad (4+1)$$

$$K_D = 24 \quad (4+1)$$

Alternate answer for 6(c)

$$K_D = \frac{\left(\frac{0.2 \text{ mol} - x}{0.1 \text{ dm}^3}\right)}{\left(\frac{x}{0.1 \text{ dm}^3}\right)} \quad (4+1)$$

$$x = \frac{0.2 \text{ mol}}{K_D + 1}$$

$$[X]_{aq} = \frac{\frac{0.2 \text{ mol}}{(K_D + 1)}}{0.1 \text{ dm}^3} = \frac{2}{(K_D + 1)} \text{ mol dm}^{-3} \quad (4+1)$$

$$\text{Rate} = k [X]_{aq}^m [Y]_{aq}^n$$

$$6.4 \times 10^{-7} \text{ mol dm}^{-3} \text{ s}^{-1} = 1 \times 10^{-3} \text{ mol dm}^{-3} \text{ s}^{-1} \left(\frac{2 \text{ mol dm}^{-3}}{(K_D + 1)}\right)^2 (0.1 \text{ mol dm}^{-3}) \quad (4+1)$$

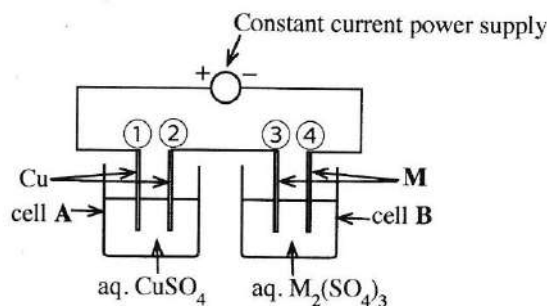
$$64 \times 10^{-4} = \left(\frac{2}{K_D + 1}\right)^2 \quad (4+1)$$

$$K_D = 24 \quad (4+1)$$

6 (c): 25 marks

7. (a) The setup shown in the figure was used to find the relative atomic mass of the metal, **M**.

The electrolysis was carried out for 10 minutes using a constant current. The mass of the cathode in cell **A** was increased by 31.75 mg whereas the mass of the cathode in cell **B** increased by 147.60 mg during this time period. (Assume that the electrolysis of water does not take place in cells **A** and **B**.)



- (i) Identify the anode and cathode in each of the cells **A** and **B** (in terms of the numbers ①, ②, ③, and ④).

Cell A

Anode = 1 (5)

Cathode = 2 (5)

Cell B

Anode = 3 (5)

Cathode = 4 (5)

- (ii) Write the half reaction taking place at each electrode in each cell.

Electrode reactions

Cell A electrode 1 $\text{Cu(s)} \rightarrow \text{Cu}^{2+}(\text{aq}) + 2\text{e}^-$ (6)

Cell A electrode 2 $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu(s)}$ (6)

Cell B electrode 3 $\text{M(s)} \rightarrow \text{M}^{3+}(\text{aq}) + 3\text{e}^-$ (6)

Cell B electrode 4 $\text{M}^{3+}(\text{aq}) + 3\text{e}^- \rightarrow \text{M(s)}$ (6)

Note : physical states must be given

(iii) Calculate the constant current used in electrolysis.

$$\begin{aligned} \text{Amount of Cu(s) dissolved} &= 31.75 \times 10^{-3} \text{ g} \\ \text{Charge required for this} &= \frac{2 \times 96500 \text{ C mol}^{-1} \times 31.75 \times 10^{-3} \text{ g}}{63.5 \text{ g mol}^{-1}} = i \times 10 \times 60 \text{ s} \end{aligned}$$

(1+1)+(1+1)+(1+1)+(1+1)

Correct stoichiometry (5)
The current used in the electrolysis = $i = 0.16 \text{ A}$ (4+1)

Alternative Answer for 7(a) (iii)

$$\begin{aligned} \text{Amount of Cu deposited} &= \frac{31.75 \times 10^{-3} \text{ g}}{63.5 \text{ g mol}^{-1}} \\ &= 0.5 \times 10^{-3} \text{ mol} \\ \text{Amount of charge required} &= 0.5 \times 10^{-3} \times 2 \text{ mol} \quad \text{For using correct stoichiometry} \quad (5) \\ &= 10^{-3} \text{ mol} \\ &= 10^{-3} \text{ mol} \times 96500 \text{ C mol}^{-1} \quad (1+1) \\ &= 96.5 \text{ C} \\ \text{Current} &= \frac{96.5 \text{ C}}{10 \times 60 \text{ s}} \quad (1+1) \\ &= 0.16 \text{ A} \quad (4+1) \end{aligned}$$

(iv) Calculate the relative atomic mass of metal, **M**.

$$\begin{aligned} \text{Increase in mass of the electrode 4 in cell B is due to deposition of M(s)} \\ \text{Increase in mass} &= 147.6 \times 10^{-3} \text{ g} \\ \text{Amount of M deposited} &= 147.6 \times 10^{-3} \text{ g} / W \\ W &= \text{molecular weight of M} \\ \text{Charge needed for this} &= \frac{3 \times 96500 \text{ C mol}^{-1} \times 147.6 \times 10^{-3} \text{ g}}{W} = 0.16 \text{ A} \times 600 \text{ s} \end{aligned}$$

(1+1)+(1+1)+(1+1)

Correct stoichiometry (5)
 $W = 445.1 \text{ g mol}^{-1}$ (1+1)

Alternative Answer (I) for 7(a) (iv)

$$\begin{aligned} \text{The amount of charge flown is equal.} \\ \text{M mol} \times 3 &= \text{Cu mol} \times 2 \\ \frac{147.6 \times 10^{-3} \text{ g} \times 3 \text{ mol}}{W} &= \frac{31.75 \times 10^{-3} \text{ g} \times 2 \text{ mol}}{63.5 \text{ g mol}^{-1}} \quad \text{For using correct stoichiometry} \quad (5) \\ W &= \frac{147.6 \times 3 \times 63.5}{31.75 \times 2} \text{ g mol}^{-1} \\ &= 442.8 \text{ g mol}^{-1} \quad (1+1) \end{aligned}$$

Alternative Answer (II) for 7(a) (iv)

$$\begin{aligned} \text{Amount of M deposited} &= \text{Amount of charge flown} / 3 \\ &= \frac{10^{-3}}{3} \text{ mol} \quad \text{For using correct stoichiometry} \quad (5) \\ \text{Molar mass of M} &= \frac{147.6 \times 10^{-3} \text{ g}}{\frac{10^{-3}}{3} \text{ mol}} \quad (1+1) \\ &= 147.6 \times 3 \text{ g mol}^{-1} \\ &= 442.8 \text{ g mol}^{-1} \quad (1+1) \end{aligned}$$

Note : If symbols (or any other values) are used for the atomic mass of Cu and Faraday constant and the answers are provided with those symbols or using those values, award full marks.

7 (a): 75 marks

- (b) (i) **A**, **B** and **C** are coordination compounds. They have an octahedral geometry. In each compound, **two types** of ligands are coordinated to the metal ion. The molecular formulae of the compounds are (**not** in order): $\text{NiCl}_2\text{H}_{12}\text{N}_4$, $\text{NiI}_2\text{H}_{16}\text{N}_4\text{O}_2$ and $\text{NiCl}_2\text{H}_{15}\text{N}_3\text{O}_3$.
Given below are the observations when aqueous solutions of the compounds are treated with $\text{Pb}(\text{CH}_3\text{COO})_2(\text{aq})$.

Compound	$\text{Pb}(\text{CH}_3\text{COO})_2(\text{aq})$
A	A white precipitate that is soluble in hot water
B	No precipitate
C	A yellow precipitate that is soluble in hot water

I. Give the structures of **A**, **B** and **C**.

- A:** $[\text{Ni}(\text{NH}_3)_3(\text{H}_2\text{O})_3]\text{Cl}_2$ **OR** $[\text{Ni}(\text{H}_2\text{O})_3(\text{NH}_3)_3]\text{Cl}_2$ **(06)**
- B:** $[\text{Ni}(\text{NH}_3)_4\text{Cl}_2]$ **OR** $[\text{NiCl}_2(\text{NH}_3)_4]$ **(06)**
- C:** $[\text{Ni}(\text{NH}_3)_4(\text{H}_2\text{O})_2]\text{I}_2$ **OR** $[\text{Ni}(\text{H}_2\text{O})_2(\text{NH}_3)_4]\text{I}_2$ **(06)**

Note: OH_2 may be used instead of H_2O .

II. Write the chemical formulae of the precipitates formed on treatment of the compounds with $\text{Pb}(\text{CH}_3\text{COO})_2(\text{aq})$.

(**Note:** Indicate compound and reagent)

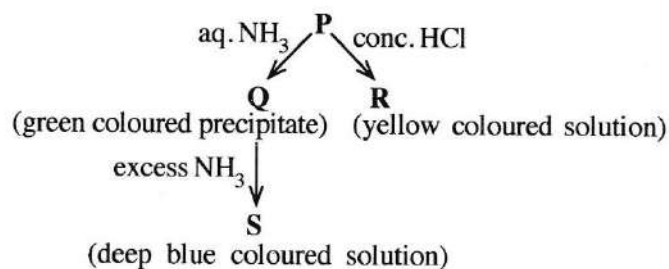
- A** with $\text{Pb}(\text{CH}_3\text{COO})_2$ $\text{PbCl}_2 \downarrow$ **(03)**
- C** with $\text{Pb}(\text{CH}_3\text{COO})_2$ $\text{PbI}_2 \downarrow$ **(03)**

III. State a chemical test, together with the observation, to identify each of the anion/s if present, that is/are not coordinated to the metal ion in the compounds given above.

(**Note:** The tests given by you should not be a test stated here.)

- Cl⁻** Add a solution of AgNO_3 . **(03)**
- A white precipitate is formed. The white precipitate dissolves in dilute NH_4OH . **(03)**
- I⁻** Add a solution of AgNO_3 . **(03)**
- A yellow precipitate is formed. The yellow precipitate does not dissolve in conc. NH_4OH . **(03)**
- OR**
- Add a few drops of CHCl_3 and then a little Cl_2 water. **(03)**
- Shake the tube.
- CHCl_3 layer turns violet. **(03)**

- (ii) A transition metal **M** forms a coloured complex ion **P** in aqueous medium. It has the general formula $[M(H_2O)_n]^{m+}$. It undergoes the reactions given below.



- I. Identify the metal **M**. Give the oxidation state of **M** in complex ion **P**.

Ni, +2 OR Ni²⁺ (06 + 03)

- II. Give the electronic configuration of **M** in the complex ion **P**.

1s²2s²2p⁶3s²3p⁶3d⁸ (03)

- III. Give the values of *n* and *m*.

n = 6 *m* = 2 (03 + 03)

- IV. Give the geometry of **P**.

octahedral (03)

- V. Give the structures of **Q**, **R** and **S**.

Q: Ni(OH)₂ (03)

R: [NiCl₄]²⁻ (03)

S: [Ni(NH₃)₆]²⁺ (03)

- VI. Give the IUPAC names of the complex ions, **P**, **R** and **S**.

P: hexaamminenickel(II) ion (03)

R: tetrachloridonickelate(II) ion (03)

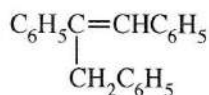
S: hexaamminenickel(II) ion (03)

7(b): 75 marks

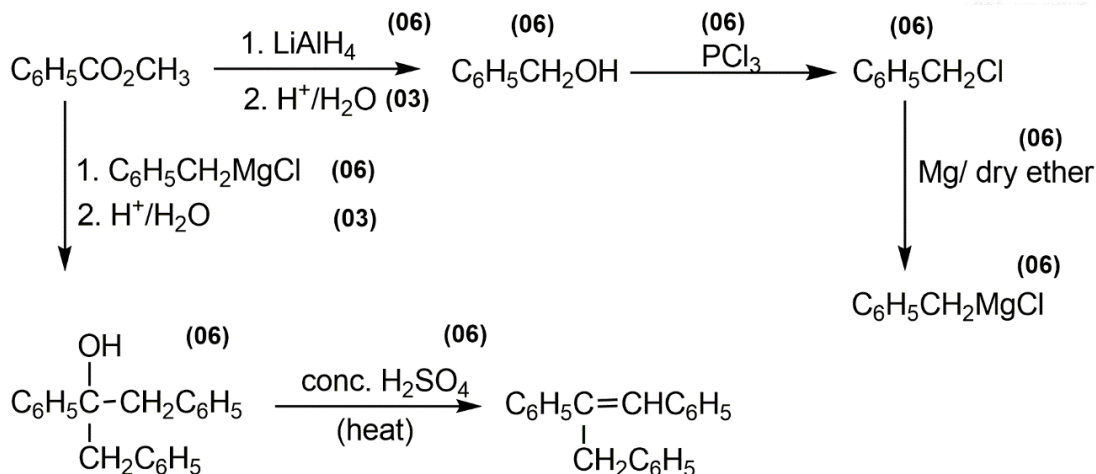
PART C – ESSAY

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

8. (a) Using $C_6H_5CO_2CH_3$ as the only organic starting material and as reagents only those given in the list, show how you would synthesize the following compound in **not more than seven (7) steps**.

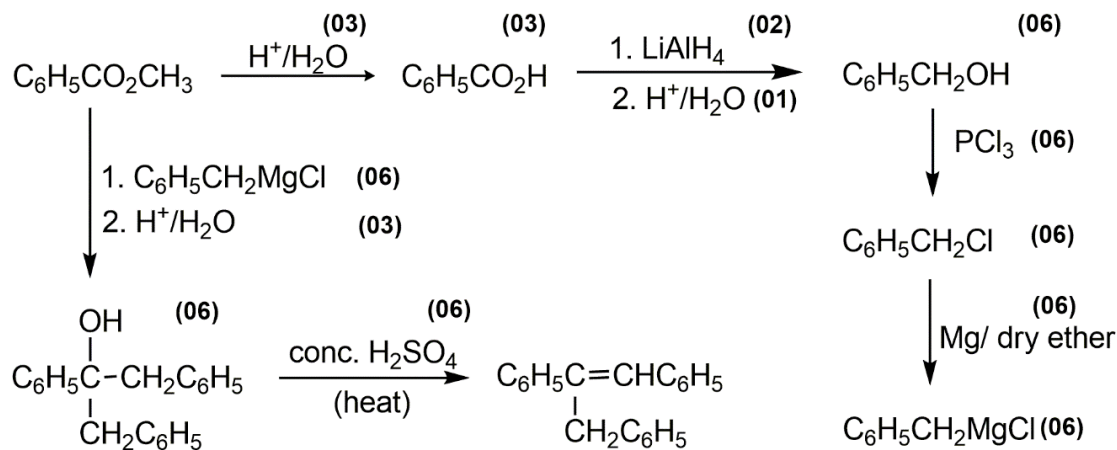


List of reagents

 PCl_3 , Mg/dry ether, H^+/H_2O , $LiAlH_4$, conc. H_2SO_4


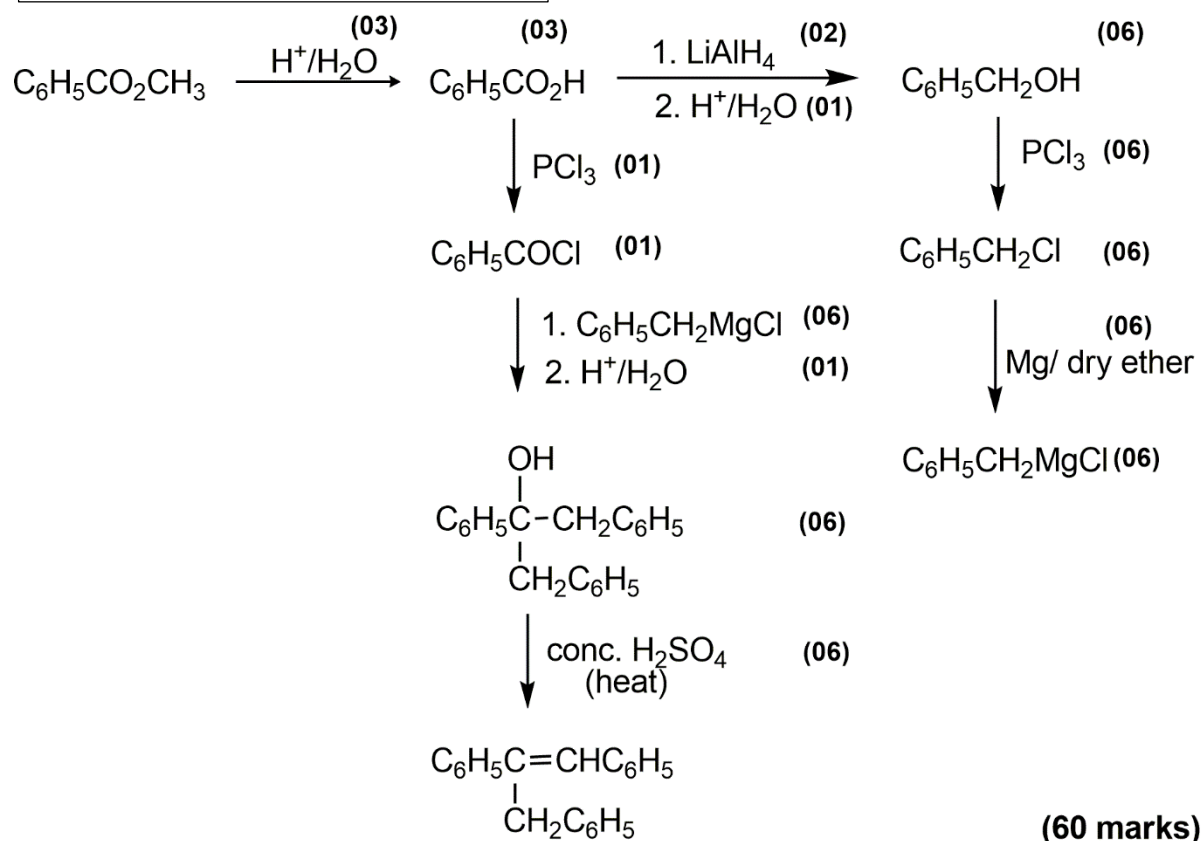
(60 marks)

Alternative Answer (I) for 8(a)



(60 marks)

Alternative Answer (II) for 8(a)

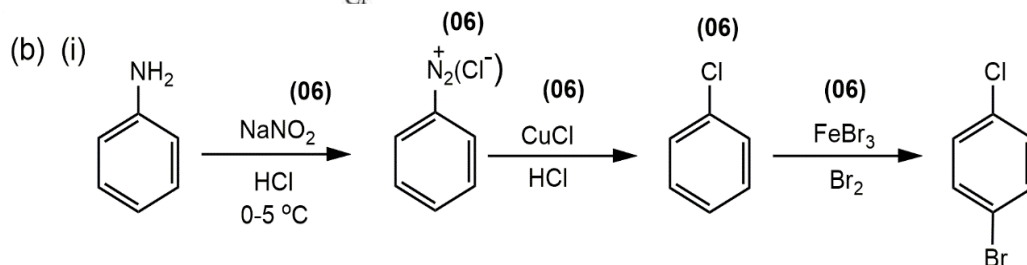
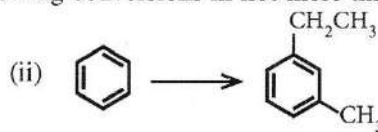
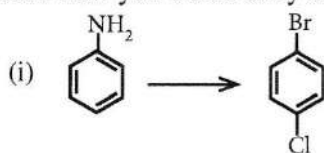


Note : 1. Do not award any marks if there are more than 7 steps.

2. Do not count the hydrolysis steps subsequent to the reaction with Grignard reagent and with LiAlH_4 as separate steps.

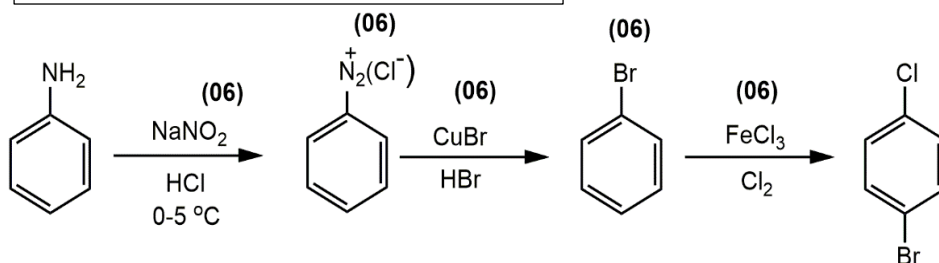
8 (a) : 60 marks

(b) Show how you would carry out each of the following conversions in **not more than three (3) steps**.

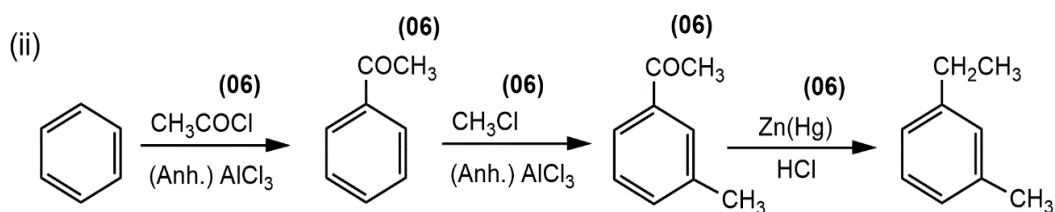


Alternative Answer for 8(b) (i)

(30 marks)

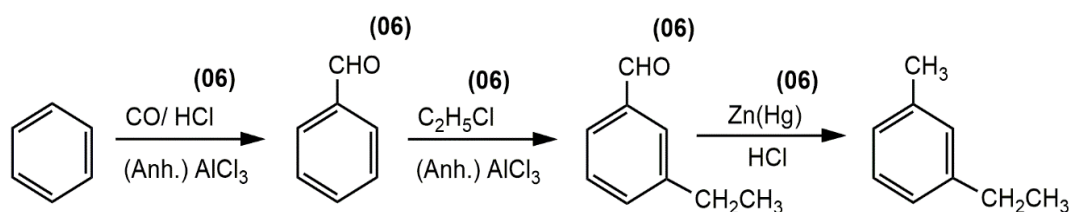


(30 marks)



(30 marks)

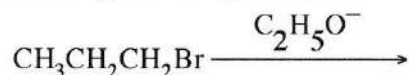
Alternative Answer for 8(b) (ii)



(30 marks)

8 (b) : 60 marks

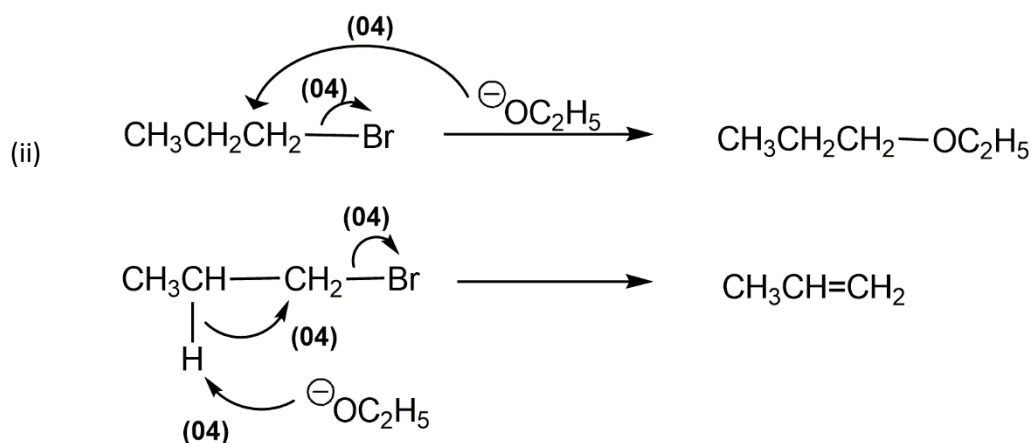
(c) The following reaction gives two products.



(i) Write the structures of the two products.

(ii) Write the mechanisms for the formation of these two products.

(i). Products $\text{CH}_3\text{CH}_2\text{CH}_2\text{-OC}_2\text{H}_5$ $\text{CH}_3\text{CH}=\text{CH}_2$ (05 + 05)



(20 marks)

8 (c) :30 marks

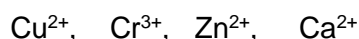
9. (a) Solution X contains **four** metal cations. The following tests were carried out to identify these cations.

	Test	Observation
①	Dilute HCl was added to a small portion of X.	No precipitate.
②	H ₂ S was bubbled through the solution from ① above.	A black precipitate (P ₁)
③	P ₁ was separated by filtration. The filtrate was boiled to remove the H ₂ S, cooled, and NH ₄ Cl/NH ₄ OH was added.	A green precipitate (P ₂)
④	P ₂ was separated by filtration and H ₂ S was bubbled through the filtrate.	A white precipitate (P ₃)
⑤	P ₃ was separated by filtration. The filtrate was boiled to remove the H ₂ S, cooled, and (NH ₄) ₂ CO ₃ was added.	A white precipitate (P ₄)

The following tests were carried out on precipitates P₁, P₂, P₃ and P₄.

Precipitate	Test	Observation
P ₁	P ₁ was dissolved in hot dil. HNO ₃ and conc. NH ₄ OH was added in excess.	A deep blue coloured solution (solution 1)
P ₂	* Excess dil. NaOH was added to P ₂ followed by H ₂ O ₂ . * Dilute H ₂ SO ₄ was added to solution 2.	A yellow coloured solution (solution 2) An orange coloured solution (solution 3)
P ₃	* P ₃ was dissolved in dil. HCl and dil. NaOH was added gradually. * Addition of dil. NaOH was continued.	A white precipitate (P ₅) P ₅ dissolved to give a colourless solution (solution 4)
P ₄	P ₄ was dissolved in conc. HCl and subjected to the flame test.	A brick-red flame

(i) Identify the **four** metal cations in solution **X** (**Reasons are not required.**)



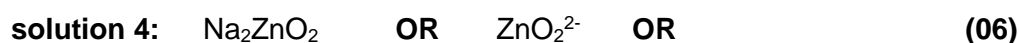
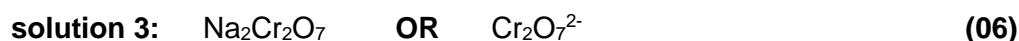
(05 marks x 4 = 20)

(ii) Identify the precipitates **P₁**, **P₂**, **P₃**, **P₄** and **P₅** and the chemical species responsible for the colours of **solutions 1, 2, 3** and **4**.

(Note: Write chemical formulae only.)



(06 marks x 5 = 30)



9(a): 75 marks

(b) The water sample **Y** contains the anions SO₃²⁻, SO₄²⁻ and NO₃⁻. The following procedures were carried out for the quantitative analysis of the anions present in the water sample.

Procedure 1

To 25.00 cm³ of sample **Y**, an excess of a dilute solution of BaCl₂ was added with stirring. Thereafter, excess dilute HCl was added with stirring to the precipitate formed until there was no further evolution of a gas with pungent odour. The solution was allowed to stand for 10 minutes and filtered. The precipitate was washed with distilled water and dried in an oven at 105 °C until a constant mass was obtained. The mass of the precipitate was 0.174 g. The filtrate obtained was kept for further analysis (see procedure 3).

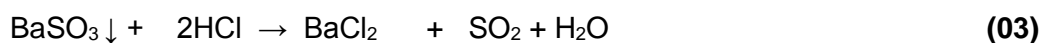
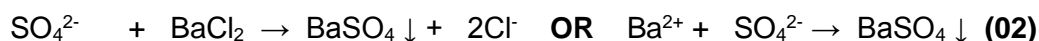
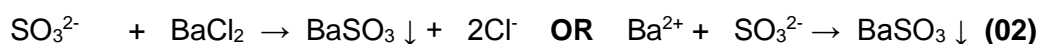
Procedure 2

To 25.00 cm³ of sample **Y**, an excess of dilute H₂SO₄ and acidified 5% KIO₃ solutions were added. The liberated I₂ was immediately titrated with 0.020 mol dm⁻³ Na₂S₂O₃ solution using starch as the indicator. The volume of Na₂S₂O₃ used was 20.00 cm³. (Assume that in this procedure, SO₃²⁻ ions are oxidized to sulphate ions (SO₄²⁻) without any loss to the atmosphere.)

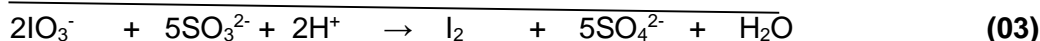
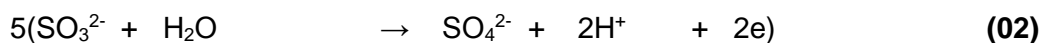
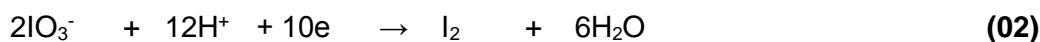
Procedure 3

The filtrate from **procedure 1** was neutralized with dilute NaOH and to it excess Al powder and dilute NaOH were added. The solution was heated and the gas evolved was transferred quantitatively to react with a 20.00 cm³ volume of 0.11 mol dm⁻³ HCl solution. Completion of the reaction was tested with litmus. The HCl remaining after reacting with the gas evolved was titrated with 0.10 mol dm⁻³ NaOH solution using methyl orange as the indicator. The volume of NaOH required was 10.00 cm³.

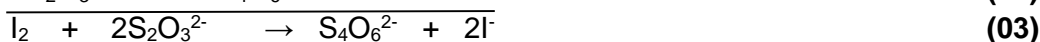
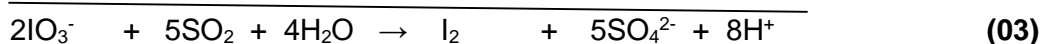
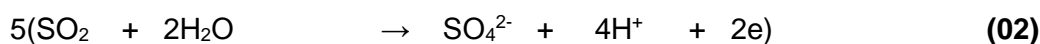
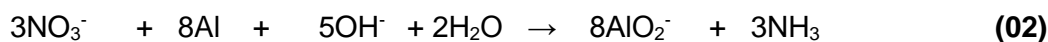
(i) Write balanced ionic/non-ionic equations for the reactions taking place in **procedures 1, 2** and **3**.

Procedure 1

BaSO_4 will remain insoluble

Procedure 2

OR

Procedure 3

- (ii) Determine the concentrations (mol dm^{-3}) of SO_3^{2-} , SO_4^{2-} and NO_3^- in water sample Y.
(Ba = 137; S = 32; O = 16)

Procedure I – Determination of SO_4^{2-}

$$\text{Molar mass of BaSO}_4 = 137 + 32 + 64 = 233 \quad (02)$$

$$\text{Mass of BaSO}_4 \text{ precipitate} = 0.174 \text{ g}$$

$$\text{Therefore, moles of BaSO}_4 = \frac{0.174}{233} \quad (02)$$

$$\text{Therefore, moles of SO}_4^{2-} = \frac{0.174}{233} = 7.47 \times 10^{-4} \quad (02)$$

$$\text{Concentration of SO}_4^{2-} = \frac{7.47 \times 10^{-4}}{25} \times 1000 \quad (02)$$

$$= \mathbf{0.029 (0.03) \text{ mol dm}^{-3}} \quad (03 + 01)$$

Procedure 2 – Determination of SO_3^{2-}

$$\text{Moles of } \text{S}_2\text{O}_3^{2-} = \frac{0.02}{1000} \times 20 \quad (02)$$

$$\text{Therefore, moles of } \text{SO}_3^{2-} = \frac{0.02}{1000} \times 20 \times \frac{5}{2} \quad (02)$$

$$\begin{aligned} \text{Concentration of } \text{SO}_3^{2-} &= \frac{0.02}{1000} \times 20 \times \frac{5}{2} \times \frac{1000}{25} \quad (02) \\ &= \mathbf{0.04 \text{ mol dm}^{-3}} \quad (03 + 01) \end{aligned}$$

Procedure 3 – Determination of NO_3^-

$$\text{Moles of HCl} = \frac{0.11}{1000} \times 20 \quad (02)$$

$$\text{Moles of NaOH} = \frac{0.10}{1000} \times 10 \quad (02)$$

Since NaOH and HCl react in the ratio of 1:1

$$\text{Moles of HCl reacted with } \text{NH}_3 = \frac{0.11}{1000} \times 20 - \frac{0.10}{1000} \times 10 \quad (02)$$

$$= \frac{1}{1000} (2.2 - 1) = \frac{1.2}{1000} \quad (02)$$

$$\text{Therefore, moles of } \text{NH}_3 = \frac{1.2}{1000} \quad (02)$$

$$\text{Therefore, moles of } \text{NO}_3^- = \frac{1.2}{1000} \quad (02)$$

$$\begin{aligned} \text{Concentration of } \text{NO}_3^- &= \frac{1.2}{1000} \times \frac{1000}{25} \quad (02) \\ &= \mathbf{0.048 \text{ mol dm}^{-3}} \quad (03 + 01) \end{aligned}$$

(iii) Give colour changes that would be observed in the titrations in **procedures 2 and 3**.

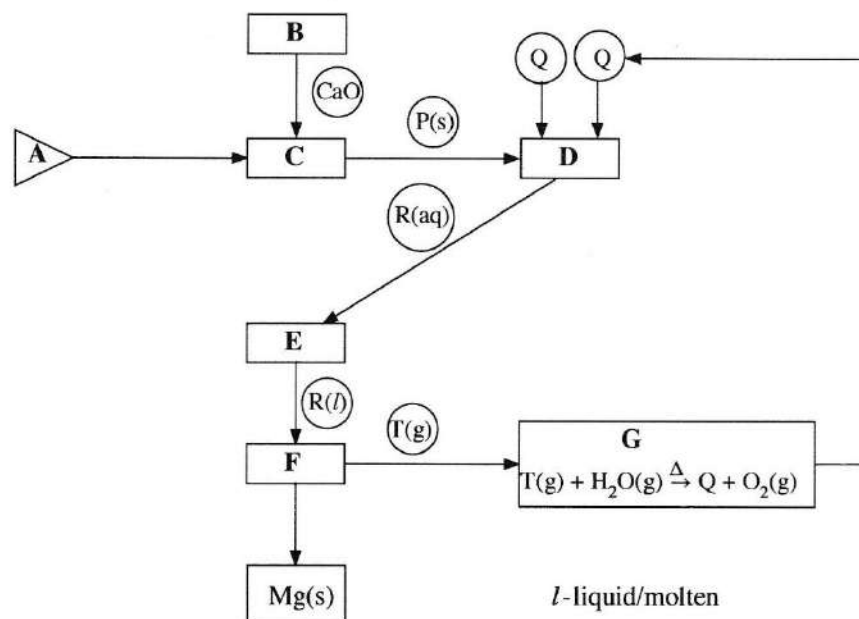
(Note: Assume that other ions that may interfere with the analysis are not present in sample Y.)

Procedure 2: Blue → Colourless (03)

Procedure 3: Red → Yellow (03)

9(b): 75 marks

10. (a)



The flow chart given above indicates the production of metal magnesium (Mg) using the Dow Process.

Answer the following questions based on the flow chart.

(i) Identify the starting material **A**.

Sea water/ Bittern solution

(03)

(ii) Identify the processes employed at **B**, **C**, **D**, **E**, **F** and **G** from the list below.

evaporation, dissolution, thermal decomposition, electrolysis, recycling of a reagent, precipitation

B: thermal decomposition

C: precipitation

D: dissolution

E: evaporation

F: electrolysis

G: recycling of a reagent

(02 x 6 = 12 marks)

(iii) Identify the chemical compound used in **B**.

CaCO_3 OR lime stone

(03)

(iv) Identify the chemical species **P**, **Q**, **R** and **T**.

P: $\text{Mg}(\text{OH})_2$

Q: HCl

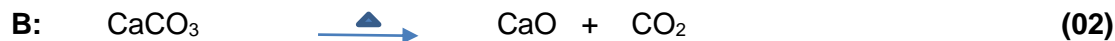
R: MgCl_2

T: Cl_2

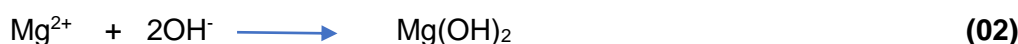
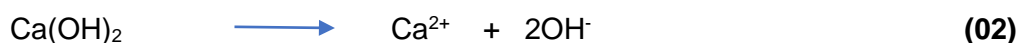
(02 x 4 = 8 marks)

(v) Give balanced chemical equations/half reactions for the processes taking place in **B**, **C**, **D**, and **F**.

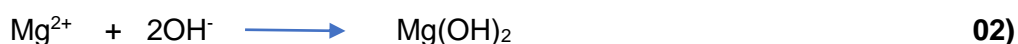
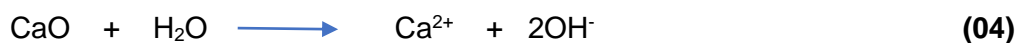
(Note: When writing half reactions, identify the anode and cathode where applicable.)



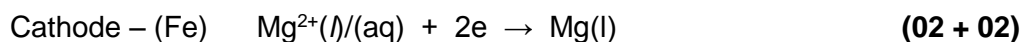
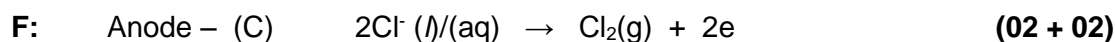
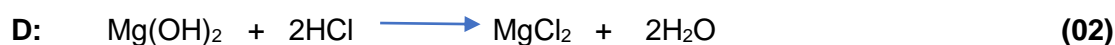
Note : Award marks even if heating is not shown.



OR



OR



Note: Physical states are required for the award of marks for half reactions.

(vi) State the importance of the reaction occurring in **G**.

Here a product is recycled / reproduced. (03)

It is very cost effective. (03)

10(a): 50 marks

(b) (i) Consider the industries given below.

Coal power plants
Refrigeration and air conditioning
Transport
Agriculture
Animal farming

I. All five industries given above contribute to global warming. Identify the gaseous chemical species associated with each of these industries that contribute to global warming.

Coal power plants – CO_2

Refrigeration and air conditioning industry – CFC OR HFC OR HCFC

Transportation – CO_2

Agriculture – N_2O , CH_4

Animal farming – CH_4

(03 x 5 = 15 marks)

II. State **three** adverse climate changes that could occur due to global warming.

- Rise in sea level
- Frequent strong cyclones and tornadoes
- Severe floods in certain areas
- Reduction in rainfall in certain areas (severe droughts) / Desertification
- Sea water infusion to rivers
- Heavy rainfall in certain areas

(Any three)

(03 x 3 = 9 marks)

(ii) Identify the main industry /industries given in (i) above that contribute to

I. photochemical smog,

Transportation

II. acid rain,

Coal power plants and transportation

III. eutrophication.

Agriculture and animal farming

(02 x 5 = 10 marks)

- (iii) Due to the reduction in rainfall in Sri Lanka, inducing artificial rain has been tested near catchment areas of reservoirs that are used for hydro-power generation. In this process, fine particles of hygroscopic salts (NaCl, CaCl₂, NaBr) are sprayed to induce cloud formation by condensation of water vapour.

From the list given below, select the water quality parameters that are directly

I. affected

Conductivity (02)

- Concentration of ions increases. Therefore, conductivity increases. (02)

II. unaffected

due to salts entering water around catchment areas. Give reasons for your choice briefly.

List of water quality parameters:

pH, conductivity, turbidity, dissolved oxygen

pH, turbidity and dissolved oxygen (02 + 02 + 02)

- These salts do not undergo hydrolysis. Therefore, pH is unaffected.
- These salts are very soluble in water. Hence, ions do not contribute to turbidity.
- These salts do not react with O₂.

(02 x 3 = 6 marks)

10(b): 50 marks

- (c) The following questions are based on biodiesel production.

(i) State the raw materials used in the manufacture of biodiesel.

Vegetable oil / plant oil (palm oil etc.) and

CH₃OH / methanol / C₂H₅OH / ethanol/ alcohol/ ROH (05 + 05)

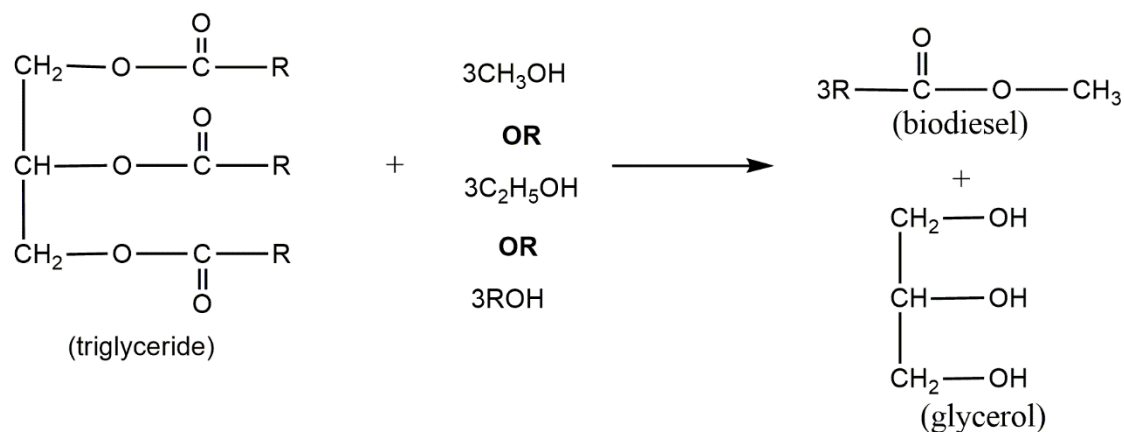
(ii) Name the main chemical compound present in each raw material where applicable.

Vegetable oil – triglycerides (05)

(iii) State the name of the chemical compound used as the catalyst in the manufacture of biodiesel in the school laboratory.

Sodium hydroxide (NaOH) / potassium hydroxide (KOH) (05)

- (iv) Give a balanced chemical equation to show the synthesis of biodiesel using the chemical compounds stated in part (ii) above.



(20)

Note: 1. R could be written as R₁, R₂ and R₃. Equation should be balanced accordingly.

2. For correct balanced equation (20 marks). If equation is not balanced award (04) for each correct reactant and product.

3. C₂H₅OH and ROH may be accepted for this year ONLY.

- (v) Identify a side reaction that would take place, along with its products, if the catalyst is used in excess.

Saponification reaction OR its description (05)

Product – soap (R-COO⁻Na⁺) (05)

10(c): 50 marks