G.C.E. (A/L) Examination - 2021 (2022)

02 - Chemistry

	Distribution (of Marks	ar
Paper I :	1 X 50	= 50	Silve
Paper II :		ions	
Part A	: 100 X 4	= 400	
Part B	: 150 X 2	= 300	
Part C	150 X 2	= 300	
Total		= 1000	
Paper II -	Final Marks	= 100	
,e?~			

Common Techniques of Marking Answer Scripts.

It is compulsory to adhere to the following standard method in marking answer scripts and entering marks into the mark sheets.

- 1. Use a red color ball point pen for marking. (Only Chief/Additional Chief Examiner may use a mauve color pen.)
- 2. Note down Examiner's Code Number and initials on the front page of each answer script.
- 3. Write off any numerals written wrong with a clear single line and authenticate the alterations with Examiner's initials.
- 4. Write down marks of each subsection in a A and write the final marks of each question as a rational number in a with the question number. Use the column assigned for Examiners to write down marks.



MCQ answer scripts: (Template)

- 1. Marking templets for G.C.E.(A/L) and GIT examination will be provided by the Department of Examinations itself. Marking examiners bear the responsibility of using correctly prepared and certified templates.
- 2. Then, check the answer scripts carefully. If there are more than one or no answers Marked to a certain question write off the options with a line. Sometimes candidates may have erased an option marked previously and selected another option. In such occasions, if the erasure is not clear write off those options too.
- 3. Place the template on the answer script correctly. Mark the right answers with a 'V' and the wrong answers with a 'X' against the options column. Write down the number of correct answers inside the cage given under each column. Then, add those numbers and write the number of correct answers in the relevant cage.

structured essay type and assay type answer scripts:

- 1. Cross off any pages left blank by candidates. Underline wrong or unsuitable answers. Show areas where marks can be offered with check marks.
- 2. Use the right margin of the overland paper to write down the marks.
- 3. Write down the marks given for each question against the question number in the relevant cage on the front page in two digits. Selection of questions should be in accordance with the instructions given in the question paper. Mark all answers and transfer the marks to the front page, and write off answers with lower marks if extra questions have been answered against instructions.
- 4. Add the total carefully and write in the relevant cage on the front page. Turn pages of answer script and add all the marks given for all answers again. Check whether that total tallies with the total marks written on the front page.

Preparation of Mark Sheets.

Except for the subjects with a single question paper, final marks of two papers will not be calculated within the evaluation board this time. Therefore, add separate mark sheets for each of the question paper. Write paper 01 marks in the paper 01 column of the mark sheet and write them in words too. Write paper II Marks in the paper II Column and wright the relevant details.

விது @ கிடுகர் அடுதே/முழுப் பதிப்புரிமையுடையது/All Rights Reserved]

ශී ලංකා වහාග දෙපාර්තමේන්තුව இலங்கை suji கைத் திணைக்களம் Sei Lunka D Department of Examinations, Sri Lanka අධායන පොදු සහතික පතු (උසස් පෙළ) විභාගය, 2021(2022) கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2021(2022) General Certificate of Education (Adv. Level) Examination, 2021(2022) පැය දෙකයි රසායන විදහාව இரண்டு மணித்தியாலம் இரசாயனவியல் I Two hours I Chemistry 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. Select the correct statement with regard to particles associated with cathode rays observed in a cathode ray tube. (1) The particles are uncharged. (2) They travel from anode to cathode along straight lines. (3) Their charge to mass ratio $\frac{e}{m}$ depends on the nature of gas and pressure inside the cathode ray tube. (4) Their direction of travel is affected by magnetic and electric fields. (5) They are not capable of ionizing the gas inside the cathode ray tube. 2. Which of the following statements is incorrect with regard to an energy level of an atom with principal quantum number (n), n = 3? (1) There are 3 sub shells associated with it. (2) There are 9 orbitals. (3) There can be a maximum of 18 electrons. (4) There can be a maximum of 10 electrons with angular momentum (azimuthal) quantum number (1), l = 2. (5) There can be a maximum of 8 electrons with magnetic quantum number (m_i) , $m_i = 0$. 3. The decreasing order of the first ionization energy of the atoms H, He, Li, Be, B and Na is, (1) He > H > B > Be > Li > Na (2) He > Η Be > B Li > > > (3) He > Be > H > Li > В > Na (4) H > He > B > Be > Li > Na(5) H > He > Be > B > Na > Li4. The shapes of IF_4^+ , IF_4^- and IF_5 are respectively, (1) see-saw, square planar and square pyramidal. (2) square planar, see-saw and square pyramidal. (3) tetrahedral, see-saw and trigonal bipyramidal. (4) see-saw, tetrahedral and square pyramidal. (5) tetrahedral, square planar and trigonal bipyramidal.

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

$$\begin{array}{c} & \text{OH} \quad \text{CH}_2 \\ | \quad \parallel \\ \text{H}_2\text{N}-\text{CH}_2-\text{CH}_2-\text{CH}-\text{C}-\text{CH}_2-\text{CH} \end{array}$$

- (1) 1-amino-4-ethylpent-4-en-3-ol
- (2) 5-amino-2-ethylpent-1-en-3-ol
- (3) 2-ethyl-3-hydroxypent-1-en-5-amine
- (4) 4-ethyl-3-hydroxypent-4-en-1-amine
- (5) 5-amino-2-ethyl-3-hydroxypent-1-ene
- 6. Which of the following statements is correct with regard to boiling points?
 - (1) N₂ has a higher boiling point than NO.
 - (2) PH₃ has a higher boiling point than NH₃.
 - (3) Xe has a higher boiling point than Kr.
 - (4) CH₂CH₂OH has a higher boiling point than CH₂CH₂OH.
 - (5) CH_3CHCH_3 has a higher boiling point than $CH_3CH_2CH_2CH_3$.
 - CH,
- 7. $M(OH)_2$ is a sparingly water soluble solid. The concentration of $M^{2+}(aq)$ in a saturated aqueous solution of $M(OH)_2$ at pH = 8.0 and at a given temperature is 1.0×10^{-6} mol dm⁻³. The pH of a saturated aqueous solution of $M(OH)_2$ having $M^{2+}(aq)$ concentration of 1.0×10^{-4} mol dm⁻³ at this temperature is,
 - (1) 4.0 (2) 5.0 (3) 6.0 (4) 7.0 (5) 8.0

8. Select the correct statement.

- (1) The electron pair geometry and shape of SF_5^* are different from each other.
- (2) The increasing order of radii of atoms/ions F^- , Mg^{2+} , Al, Cl^- and K is $F^- < Mg^{2+} < Cl^- < Al < K$.
- (3) The number of resonance structures that can be drawn for nitric acid (HNO₃) is four.
- (4) CO_3^{2-} has the longest C-O bond among the molecules/ions CO, CO_3 , CO_3^{2-} and CH_3OH .
- (5) Among the molecules CH_4 , $COCl_2$ and HCN, the electronegativity of the carbon atom increases in the order $CH_4 < COCl_2 < HCN$.
- **9.** A and **B** are two organic compounds containing C, H and O. When A and B were separately treated with Br₂/H₂O, only A gave a white precipitate. The product formed when **B** was heated with concentrated H₂SO₄ decolourised Br₂/H₂O. The organic compounds A and B are respectively,

CH ₃ OH
CH ₃ CH ₂ OH
CH ₃ CHCH ₂ OH
C ₆ H ₅ OH
СН ₃ СНСН ₂ ОН СН ₃

- 10. The elementary reaction $A(g) \rightarrow B(g) + C(g)$ occurs in a closed rigid container at constant temperature. The initial pressure of the container when only A(g) is present was measured to be $2P_0$. The pressure of the container after two half lives of A(g) would be,
 - (1) $\frac{P_0}{2}$ (2) $\frac{P_0}{4}$ (3) $\frac{3P_0}{4}$ (4) $\frac{3P_0}{2}$ (5) $\frac{7P_0}{2}$

11. A suitable method to prepare
$$NO_2$$
 is,

B

(1)

$$I'' O''_{2}$$
 $I'' O''_{2}$
 $I''' O''_{2}$
 $I''' O''_{2}$
 $I''' O''_{2}$
 $I'''' O''_{2}$
 I''

NO

- 12. Which expression gives the correct volume (cm³) of 70.0% $\left(\frac{w}{w}\%\right)$ concentrated HNO₃ acid with density 1.42 g cm⁻³ required to prepare 300 cm³ of a 0.150 mol dm⁻³ solution of HNO₃? (Relative atomic mass: H = 1, N = 14, O = 16)
 - (1) $\frac{100}{1.42} \times \frac{70.0}{63} \times \frac{0.150}{1000} \times 300$ (2) $\frac{100}{1.42} \times \frac{63}{70.0} \times \frac{0.150}{1000} \times 300$ (3) $\frac{1.42}{100} \times \frac{63}{70.0} \times \frac{1000}{0.150} \times 300$ (4) $\frac{100}{1.42} \times \frac{63}{70.0} \times \frac{1000}{0.150} \times \frac{1}{300}$ (5) $\frac{1.42}{100} \times \frac{70.0}{63} \times \frac{0.150}{1000} \times 300$
- 13. The elementary reaction, $A(aq) + H_3O^+(aq) \rightarrow B^+(aq)$ occurs in an aqueous solution at constant temperature. Which of the following graphs correctly represents the relationship between Log(Initial rate) vs pH at a constant concentration of A(aq)?



14. An excess amount of A(g) and a small amount of B(g) are introduced into an evacuated rigid container. Then, the following elementary reactions take place at a constant temperature.

$$A(g) + B(g) \rightarrow C(g)$$
 fast

$$A(g) + C(g) \rightarrow 3D(g)$$
 slow

Which of the following statements is correct regarding the variation of pressure of the system with time?

- (1) Pressure remains unchanged.
- (2) Pressure increases and then becomes constant.
- (3) Pressure decreases and then becomes constant.
- (4) Pressure decreases and returns to the initial value again.
- (5) Pressure increases initially, then decreases and returns to the initial value again.
- 15. The solute A present in volume V of an aqueous solution is extracted twice using 2V volume portions of a water immiscible organic solvent. The partition coefficient of A between the organic solvent and water, $\frac{[A]_{(org)}}{[A]_{(aq)}} = 4.0$. The initial amount of A in the aqueous phase is a (mol). The amount (mol) of A remaining in the aqueous phase after the second extraction is, (1) $\frac{a}{2}$ (2) $\frac{a}{9}$ (3) $\frac{a}{18}$ (4) $\frac{a}{25}$ (5) $\frac{a}{81}$

16. Compound A reacts with NaNO,/dilute HCl to give B. When B is treated with acidified aqueous $K_2Cr_2O_2$, the solution turns green. When treated with Fehling's reagent A did not give a brick red precipitate. Compound A could be,



- 17. MCl₂ is a solid which is sparingly soluble in water ($K_{sp} = 1.0 \times 10^{-8} \text{ mol}^3 \text{ dm}^{-9}$). Which of the following is correct regarding a saturated aqueous solution of MCl₂?
 - (1) Evaporation of water from the solution increases M2+ and chloride ion concentrations of the solution.
 - (2) Chloride ion concentration of the solution can be increased by adding NaCl(s).
 - (3) The solution cannot be acidified by adding HCl.
 - (4) Chloride ion concentration of the solution cannot be increased above 1.0×10^{-4} mol dm⁻³.
 - (5) Chloride ion concentration of the solution can be lowered by adding distilled water and maintaining the saturated condition.
- 18. When a mass of 0.0119 g of KBr is dissolved in 500.0 cm³ of distilled water, the K⁺ composition of the solution in mol dm-3 and ppm (mg kg-1) are respectively,

(Relative atomic mass: K = 39, Br = 80; density of solution = 1.00 kg dm⁻³)

- (1) 1.0×10^{-4} and 3.9 (2) 1.0×10^{-4} and 7.8
- (3) 2.0×10^{-4} and 1.3 (4) 2.0×10^{-4} and 3.9
- (5) 2.0×10^{-4} and 7.8

19. The correct reaction relevant to the standard enthalpy of hydration of the sodium ion is,

- (1) $Na^+(g) + OH^-(aq) \longrightarrow NaOH(s)$
- (2) NaCl(g) + H₂O(l) \longrightarrow Na⁺(aq) + OH⁻(aq) + HCl(aq)
- (3) $\operatorname{Na}^{+}(g) + \operatorname{H}_{2}O(l) \longrightarrow \operatorname{Na}^{+}(aq)$ (4) $\operatorname{Na}^{+}(g) + \operatorname{H}_{2}O(l) \longrightarrow \operatorname{Na}^{+}(aq) + \operatorname{OH}^{-}(aq) + \operatorname{H}^{+}(aq)$
- (5) $\operatorname{Na}^+(g) + \operatorname{Cl}^-(g) + \operatorname{H}_2O(l) \longrightarrow \operatorname{Na}^+(aq) + \operatorname{Cl}^-(aq)$
- 20. Which of the following is not a step in the chlorination of methane?
 - (1) $Cl_2 \xrightarrow{hv} 2Cl^{\bullet}$
 - (2) $CH_4 + CI \longrightarrow CH_3 + HCI$
 - (3) $^{\circ}CH_3 + Cl_2 \longrightarrow CH_3CI + Cl^{\circ}$
 - (4) $CH_3Cl + Cl^{\bullet} \longrightarrow {}^{\bullet}CH_2Cl + HCl$
 - (5) $^{\circ}CH_2Cl + HCl \longrightarrow CH_2Cl_2 + H^{\circ}$
- 21. Which of the following statements regarding the critical temperature of a real gas is correct? (1) It is the temperature at which the intermolecular forces can be neglected.
 - (2) It is the temperature corresponding to the lowest pressure at which the gas can be liquified.
 - (3) It is the temperature at which the gas is in equilibrium with its solid.
 - (4) It is the highest temperature at which the gas phase and the liquid phase are in equilibrium.
 - (5) It is the temperature given by the van der Waals equation at any pressure.

- 22. In an experiment, Mg metal was made to react with excess N₂ gas and the product obtained was reacted with H₂O. The volume of the gas evolved at standard temperature (273 K) and pressure (1.0 atm) was 672 cm³. The mass of Mg used in the experiment is, (Assume that 1.0 mol of gas occupies a volume of 22.4 dm³ at 273 K and 1.0 atm. Relative atomic mass: Mg = 24) (2) 0.48 g (3) 0.72 g (4) 1.08 g (5) 1.50 g (1) 0.24 g
- 23. The mean square speed of H₂ at absolute temperature T is equal to the mean square speed of N₂ at absolute temperature T'. Which of the following equations gives the correct relationship between T'and T'? (Relative atomic mass: H = 1, N = 14)
 - (2) T = 14T' (3) $T = \frac{T'}{4}$ (4) T = 7T' (5) $T = \frac{T'}{14}$ (1) T = T'
- 24. A buffer solution at constant temperature contains a monobasic weak acid ($K_a = 1.00 \times 10^{-5} \text{ mol dm}^{-3}$) and its sodium salt. The concentrations of the weak acid and the sodium salt in the solution are 0.10 mol dm⁻³ each. The volume of 1.00 mol dm⁻³ weak acid that should be added to change the pH of 10.00 cm³ of this solution by one unit, and the pH value of the solution after the addition of the weak acid are respectively,
 - (2) 9.00 cm^3 , 6.0(5) 11.00 cm^3 , 4.0 (3) 10.00 cm^3 , 4.0(1) 9.00 cm^3 , 4.0(4) 10.00 cm^3 , 5.0
- 25. A gaseous discharge/production that contributes to all three environmental issues, namely, global warming, acid rain and photochemical smog is,
 - (1) exhaust gas released from fossil fuel burning vehicles.
 - (2) exhaust gas released from coal power plants.
 - (3) gases released during repair of air conditioners and refrigerators.
 - (4) gases produced from the improper discharge of municipal solid waste.
 - (5) exhaust gas released from biofuel burning vehicles.
- 26. Which of the following statements is incorrect with regard to element Lithium (Li) and its compounds?
 - (1) Among the Group I elements from Li Cs, lithium has the most negative value for electron gain energy.
 - (2) Lithium forms two products when heated in air.
 - (3) Considering the gases evolved, upon heating LiNO₃(s) produces two gases whereas Li₂CO₂(s) gives only one gas.
 - (4) Among Group I elements, lithium has the weakest metallic bonding.
 - (5) Lithium gives a red coloured flame in the flame test.
- 27. The number of moles of KMnO₄ that are required to react completely with one mole of Fe(NO₂)₂ in acidic medium is,

(Note: Neglect the loss of NO_2^- due to acidic conditions.)

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

- 28. Which of the following statements is correct regarding water and aqueous solutions at a given temperature?
 - (1) The solubility of a polar gas in water is lower than the solubility of a non polar gas in water.
 - (2) Any gas undergoes ionization in an aqueous solution.
 - (3) The solubility of a gas in water is proportional to its pressure.
 - (4) Boiling point of water decreases with increasing pressure.
 - (5) The temperature of the triple point of water increases with increasing pressure,

- 29. Select the correct statement with regard to chromium (Cr) and its compounds.
 - (1) When an aqueous solution of K₂CrO₄ is treated with dilute H₂SO₄, a colour change is not observed.
 - (2) The electronegativity of Cr is greater than that of Co.
 - (3) An aqueous solution of $Cr(H_2O)_6^{2+}$ when treated with excess NaOH, followed by the addition of H₂O₂ gives a yellow coloured solution.
 - (4) Cr₂O₂ shows basic properties.
 - (5) When H₂S gas is passed into an acidic solution of K₂Cr₂O₇, a clear green coloured solution is observed.
- 30. Which of the following statements is incorrect regarding carboxylic acids?
 - (1) The product formed by the reaction of a carboxylic acid with LiAlH₄ gives an alcohol upon hydrolysis.
 - (2) Carbon dioxide is liberated when carboxylic acids are reacted with aqueous NaOH.
 - (3) Carboxylic acids react with PCl₅ to give acid chlorides.
 - (4) Methane is liberated when carboxylic acids are reacted with CH3MgBr.
 - (5) Carboxylic acids are formed when aldehydes are treated with H+/K, Cr, O,
 - 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 give(s) 3-bromo-3-methylhexane as the major product when reacted with HBr?
 - (a) $CH_{3}CH_{5}CH_{5}C = CHCH_{3}$

CH,

CH,

- (c) $CH_{CH} = CHCHCH_{3}CH_{3}$
- 32. Which of the following statements is/are correct regarding products related to plant sources? (a) Essential oils contain complex mixtures of volatile constituents of plants.
 - (b) Biodiesel is produced from volatile plant oils.
 - (c) Methanol is not used in the production of biodiesel.
 - (d) Ethanol produced by fermentation of plant materials is regarded as a renewable energy source.
- 33. On which of the following factor/factors does the electrode potential of the electrode M²⁺(aq)/M(s) depend?
 - (a) Surface area of M(s)
- (b) Concentration of $M^{2+}(aq)$

CH₃

CH,CH,

(b) $CH_2CH_2CH_2CHCH = CH_2$

(d) $CH_2CH_2CH_2C = CH_2$

(c) Temperature

(d) Volume of $M^{2+}(aq)$ solution

34. Which of the following give(s) CO₂ when treated with aqueous Na₂CO₃?



- 35. Which of the following statements is/are always correct regarding an aqueous solution of a weak electrolyte?
 - (a) When conducting an electric current, the fraction of the current carried by the anion is greater than the fraction of the current carried by the cation.
 - (b) The conductivity of the anion is greater than the conductivity of the cation.
 - (c) Only a small percentage of molecules of the weak electrolyte is dissociated into ions.
 - (d) The fraction of molecules of the weak electrolyte dissociated increases with dilution.
- **36.** Which of the following statements is/are correct regarding the relationship between global environmental issues and volatile halogenated hydrocarbons?
 - (a) CFC, HCFC and HFC all three contribute to global warming.
 - (b) CFC contributes to ozone layer depletion by producing chlorine radicals in the troposphere.
 - (c) HFC contributes to ozone layer depletion by producing chlorine radicals in the stratosphere.
 - (d) Both CFC and HCFC contribute to ozone layer depletion by producing chlorine radicals in the stratosphere.
- 37. Which of the following statements is/are correct with regard to the two allotropes of carbon, namely, graphite and diamond?
 - (a) Carbon atoms in diamond are tetrahedrally surrounded by four other carbon atoms to give a three-dimensional lattice.
 - (b) Because graphite is composed of two-dimensional layers held together by weak van der Waals forces (secondary interactions), it acts as a good lubricant.
 - (c) Diamond is a good conductor of heat and electricity.
 - (d) Graphite has a considerably higher melting point than diamond.
- 38. Which of the following statements is/are correct regarding gases?
 - (a) Molecules move at different speeds in a sample of a real gas whereas all the molecules move at the same speed in a sample of an ideal gas.
 - (b) Ideal gases can be liquified at extremely high pressures.
 - (c) The Maxwell-Boltzmann speed distribution curve of an ideal gas is symmetric about the maximum point.
 - (d) The compressibility factor of a real gas depends on pressure.

39.



> Temperature

Which of the following statements is/are correct regarding the phase diagram of a pure substance given above?

- (a) The number of molecules in a unit volume is always higher in the gas phase than in the liquid phase.
- (b) The liquid phase and the gas phase never co-exist at the same temperature.
- (c) The solid phase and the gas phase never co-exist at the same pressure.
- (d) When the system is at the triple point, the rate at which the gas is converted to the liquid is equal to the rate at which the liquid is converted to the gas.

- 40. Which of the following statements is/are correct regarding the given industrial processes?
 - (a) Sea water can be used directly as a raw material in the extraction of Mg by the Dow process.
 - (b) In the production of NaOH, the use of membrane cells is more environmentally friendly than the use of mercury cells.
 - (c) The efficiency of the Solvay process used to produce Na_2CO_3 can be increased by cooling the ammonification tower.
 - (d) Rh metal is used as a catalyst in the production of H_2SO_4 by the contact process.
- 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.	When an acidic solution of MnO_4^- is treated with H_2O_2 , it turns colourless with the evolution of O_2 , whereas, an acidic solution of Fe ²⁺ on treatment with H_2O_2 turns yellow-brown.	H ₂ O ₂ can act as an oxidizing agent as well as a reducing agent in acidic medium.
42.	Energy of a gas in a closed rigid container with thermally insulated walls remains constant,	Both energy and matter of an isolated system do not exchange with the surroundings.
43.	Cl ₂ gas undergoes disproportionation on reaction with water giving HOCl(aq) and HCl(aq).	HOCl has the highest oxidizing ability among the oxoacids of chlorine.
44.	When a catalyst is added, the position of equilibrium of a reversible reaction changes.	A catalyst always increases the rate of the forward reaction more than the rate of the reverse reaction.
45.	$RC \equiv CMgBr$ can be prepared by the reaction between $RC \equiv CH$ and methylmagnesium bromide.	The alkyl group of a Grignard reagent can react as a base.
46.	Reaction of HCN with any aldehyde gives a product containing a chiral carbon atom.	A carbon atom joined to four different groups is called a chiral carbon atom.
47.	The main by-product in the production of Na_2CO_3 by the Solvay process is $CaCl_2$.	CaO is used to regenerate NH_3 in the Solvay process.
48.	Benzenediazonium chloride reacts with phenol in the presence of aqueous NaOH to give the following compound.	Diazonium ions can react as electrophiles.
49.	When strong acids are titrated with aqueous ammonia, a neutral solution is not obtained at the equivalence point.	NH_4^+ reacts with water forming H_3O^+ .
50.	Atomic oxygen is an essential factor for the formation of ozone in the atmosphere.	Atomic oxygen in the atmosphere is produced only by decomposition of molecular oxygen.
	N1	

ශී ලංකා විභාග දෙපාර්තමේන්තුව

Department of Examinations - Sri Lanka

අ.පො.ස.(උ.පෙළ)විභාගය/G.C.E. (A/L)- 2021 (2022)

ຍ ຄ	මයය අං ubject No	කය)	02	වි Su	ෂයය Ibject	Cl	nemistr	y]	20
			ලකු	ණු දීමේ	පටිපාටිය I පතුය/	5/Marki Paper I	ing Sche	me	~?	501
	පුශ්න අංකය Questio n No.	පිළිතුරු අංකය Answe r No.								
	01.	4	11.	3	21.	4	31.	4	41.	1
	02.	5	12.	2	22.	4	32.	4	42.	1
	03.	2	13.	5	23.	5	33.	2	43.	2
	04.	1	14.	4	24.		34.	3	44.	5
	05.	2	15.	5	25.	1	35.	5	45.	1
	06.	3	16.	2	26.	4	36.	4	46.	4
	07.	4	17.	2	27.		37.	1	47.	
	08.	5	18.	5	28.	3	38.	5	48.	1
C	09.	3	19.	3	29.	<u>3 or 4</u>	39.	5	49.	1
	10.	5	20.	5	30.	2	40.	2	50.	3

ට්විශේෂ උපදෙස්/Special Instructions:

චක් පිළිතුරකට ලකුණු 01 බැගින්/ 01 Mark for each question මුළු ලකුණු/Total Marks 01 \times 50 = 50



(ii) Give the oxidation states of the two chlorine atoms in the structure drawn in (i) above. The chlorine atoms are labelled as follows.

$$Cl^{1} - O - Cl^{2} - O$$
 $Cl^{1} + I (+1)$, $Cl^{2} + VII (+7)$

0

Η

(01 + 01)

(iii) The most stable Lewis dot-dash structure for the ion $N_2O_2^{2-}$ is shown below. Draw two additional Lewis dot-dash structures (resonance structures) for this ion.

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

	\ddot{F} \ddot{F} $=$ \ddot{N} $=$ \dot{C} $=$ \ddot{N} $=$ \ddot{O} $:$	$F-N^1-C^2-C$	³ —N ⁴ —O		
		N ¹	C ²	C ³	N ⁴
I	VSEPR pairs around the atom	3	3	2	2
II	electron pair geometry around the atom	trigonal planar	trigonal planar	linear	linear
III	shape around the atom	angular/V	trigonal planar	linear	linear
ĪV	hybridization of the atom	sp ²	sp ²	sp	sp

(01 mark x 16 = 16 marks)

	v) fucin	ify the atom	nic/hybric	l orbitals invol	lved in the f	formation	of σ bo	nds between the t	WO
	atom	s given belo	w.	an ²			2n or	on ³	
	Ι.	N ¹ —F	$N^1 \cdots$	sp-		F	2p 0i	sp	
	П.	$N^{1}-C^{2}$	N ¹	sp-		C ²	sp-		
	III.	C ² —H	C ²	sp²		н	1s		
	IV.	$C^{2}-C^{3}$	C^{2}	sp ²		C ³	sp		
	V.	$C^{3}-N^{4}$	C ³	sp		N ⁴	sp		S 1
	VI.	N4-0	N ⁴	sp		0	2p or	sp ³	X
(v	i) Ident	ify the atom	nic orbita	ls involved in	the formati	on of π b	(01 onds be	mark $x 12 = 12$ tween the two ato	mark
(,	giver	i below.	ne orona	0n	the formati	on or re c	On On		
	Ι.	$N^{1}-C^{2}$	N ¹			C ²	2p		
	II.	$C^3 - N^4$	C ³	2р		N ⁴	2р		
			C ³	2р		N ⁴	2p		
6.0	() Stata	the energy	mata hai	d angles area	nd ML C2	3 and M4	(0)	1 mark x 6 = 06	mark
(V1	1) State	the approxi	$18^{\circ} + 1^{\circ}$	$\sim (120^{\circ})$	$(10 N^{2}, C^{2}, C^{2})$	(180°	+ 1)	$(180^{\circ} + 1)$	
		N ¹		C ²	,' C°		· (01	mark x 4 = 04	mark
	I.	To which	region o	f the electron	nagnetic spe	ectrum do	these	photons belong?	
	I. II. E (I T =	To which Visibl Calculate t Velocity of inergy of a p inergy of a r $N_A = Avogacherefore, Er6.63 × 10-3.4$	region o le regio he energe light ohoton (E mole of p dro const nergy of $\frac{4}{(J s) \times 3}$	f the electron n y of a mole $c = 3.00 \times 10^{6}$ $c = 3.00 \times 10^{6}$ c = h = h hotons $= h c$ a mole of phot 3.00×10^{8} (m 69^{6}	of these pl $m s^{-1}$ P $\frac{C}{\lambda}$ $\times N_A$ $\frac{S^{-1}}{\lambda} \times 6.022$ 5×10^{-9} (m)	ectrum de notons in Planck co ×10 ²³ (me	kJ mol' nstant	photons belong? (02) $^{-1}$. $h = 6.63 \times 10^{-34}$ J (01) (01) (03+01)	ſs
	I. II. E (I T =	To which Visibl Visibl Calculate t Velocity of inergy of a p inergy of a r N _A = Avogac herefore, Er 6.63×10^{-34} = 172	region o le regio he energ light photon (E mole of p dro const hergy of $\frac{4}{(J s) \times \frac{1}{2}}$	f the electron n y of a mole $c = 3.00 \times 10^{5}$ $c = 3.00 \times 10^{5}$ c = h hotons $= h \frac{c}{c}$ $a mole of phot 3.00 \times 10^{8} (m s)695$	of these pl $m s^{-1}$ P $\frac{1}{\lambda}$ $\times N_A$ $\frac{1}{\lambda}$ $\frac{1}{\lambda} \times 6.022$ 5×10^{-9} (m)	ectrum de notons in Planck co	kJ mol ¹ nstant	photons belong? (02) $^{-1}$. $h = 6.63 \times 10^{-34}$ J (01) (01) (03+01) (02)	Г s
	I. II. E (I T =	To which Visibl Calculate t Velocity of inergy of a p inergy of a r $N_A = Avogacherefore, Er6.63 × 10-3= 172lote: Marksh = 6$	region o le regio he energio he energio light photon (E mole of p dro const hergy of $\frac{4}{(J s) \times 3}$ kJ mol ⁻¹ can be a 5.626 × 1	f the electron n y of a mole $c = 3.00 \times 10^{4}$ $c = 3.00 \times 10^{4}$ c = h hotons = h <u>c</u> a mole of phot 3.00 × 10 ⁸ (m 698 warded for con 0 ⁻³⁴ (J s) is acc	of these pl of these pl $m s^{-1}$ P $\frac{C}{\lambda}$ × NA $\frac{s^{-1} \times 6.022}{5 \times 10^{-9}}$ (m) mbining step cepted.	ectrum de notons in Planck co ×10 ²³ (me os.	kJ mol nstant	photons belong? (02) $^{-1}$. $h = 6.63 \times 10^{-34}$ J (01) (01) (03+01) (02)	Г s
G	I. II. E (I T = N i) A mo elem Nam	To which a Visible Visible Visible Calculate the Velocity of a present of the second	region o le regio he energy light photon (E mole of p dro const nergy of $\frac{4}{(J s) \times \frac{1}{3}}$ kJ mol ⁻¹ can be a 5.626 × 1 ormula A is the cer ular shap	f the electron n y of a mole $c = 3.00 \times 10^{3}$ $c = 3.00 \times 10^{3}$ c = h hotons = h c a mole of phot 3.00×10^{8} (m 0^{-34} (J s) is acc X_{3} has three a hotal atom. e(s) possible f	of these pl $m s^{-1}$ P $\frac{1}{2}$ λ \times NA $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ λ \times NA $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$	ectrum de hotons in Planck co ×10 ²³ (me os. ls. Here, 4 and II gi	b these kJ mol nstant ol ⁻¹) A and X ven belo	photons belong? (02) $^{-1}$. $h = 6.63 \times 10^{-34}$ J (01) (01) (03+01) (02) represent symbols ow.	s of
	I. II. E (I T = (I) A mo elem Nam I.	To which Visibl Calculate t Velocity of inergy of a p inergy of a r $N_A = Avogacherefore, Er6.63 × 10-3= 172lote: Marksh = 6olecule of foents and A ie the molecu-$	region o le regio he energio light bhoton (E mole of p dro const hergy of $\frac{1}{4}$ (J s) × $\frac{1}{2}$ kJ mol ⁻¹ can be a 5.626 × 1 brmula A is the cer ular shap polar	f the electron n y of a mole $c = 3.00 \times 10^{4}$ $c = 3.00 \times 10^{4}$ c = h hotons = h <u>c</u> a mole of phot 3.00 × 10 ⁸ (m 698 warded for con 0 ⁻³⁴ (J s) is acc X ₃ has three hotons = h c = 10^{10}	of these pl $m s^{-1}$ P $r c_{\lambda}$ $\times N_{A}$ r cons $s^{-1} \times 6.022$ 5×10^{-9} (m) mbining step cepted. A-X σ bond for AX ₃ in I trigor	ectrum de notons in Planck con ×10 ²³ (me os. ls. Here, 4 and II gi nal pyram	b these kJ molinstant (<u>bl-1)</u> A and X ven belonidal	photons belong? (02) (02) (01) (01) (03+01) (02) represent symbols ow. (02 + 02	s of
G	I. II. E (I T = (I T = (I) A ma elem Nam I. II.	To which Visibl Calculate t Velocity of inergy of a p inergy of a r $N_A = Avogacherefore, Er6.63 × 10^{-34}= 172lote: Marksh = 6blecule of foents and A ie the molecu-if AX3 isif AX3 is$	region o le regio he energio light photon (E mole of p dro const hergy of $\frac{4}{(J s) \times 3}$ kJ mol ⁻¹ can be a 5.626 × 1 ormula A is the cer ular shap polar non-pola	f the electron n by of a mole $c = 3.00 \times 10^{3}$ $c = 3.00 \times 10^{3}$ c = h hotons = h <u>c</u> a mole of phot 3.00 × 10 ⁸ (m 698 warded for con 0 ⁻³⁴ (J s) is acc X ₃ has three trial atom. e(s) possible f T shape, ar trigonal pla	of these pl of these pl $m s^{-1}$ P $\frac{C}{\lambda}$ $\times N_A$ $\frac{C}{2}$ $\frac{1}{\lambda} \times 6.022$ 5×10^{-9} (m) mbining step cepted. A-X σ bond for AX ₃ in I trigor anar	ectrum de notons in Planck co ×10 ²³ (me os. ls. Here, 4 and II gi nal pyram	b these kJ molinstant (<u>bl-1</u>) A and X ven belo hidal	photons belong? (02) (02) (01) (01) (03+01) (02) represent symbols ow. (02 + 02 (02)	s of
G	I. II. E (I T = N i) A mo elem Nam I. II. III.	To which X Visibl Calculate t Velocity of inergy of a p inergy of a p	region o le regio he energ light boton (E mole of p dro const hergy of $\frac{4}{(J s) \times 3}$ kJ mol ⁻¹ can be a 5.626 × 1 ormula A is the cer ular shap polar non-pola example olecular	f the electron n y of a mole $c = 3.00 \times 10^{3}$ $c = 3.00 \times 10^{3}$ c = h hotons = h c a mole of phot 3.00×10^{8} (m 69^{3} warded for con 0^{-34} (J s) is acc X ₃ has three A a trigonal plate each, for the formulae are	of these pl $m s^{-1}$ P $\frac{n}{2}$ $\lambda = NA$ $\frac{n}{2}$ $\lambda = NA$ $\frac{n}{2}$ $\frac{n}{2}$ $\lambda = NA$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$ $\frac{n}{2}$	ectrum de hotons in Planck co ×10 ²³ (me os. ls. Here, 4 and II gi hal pyram ted by ye	b these kJ molinstant ol-1) A and X ven belo hidal	photons belong? (02) $^{-1}$. $h = 6.63 \times 10^{-34}$ J (01) (01) (03+01) (02) represent symbols ow. (02 + 02 (02) and II above.	s of

	solution. Write the chemical formula of C. KIO ₃ (10)	2(c): 10 marks
	(c) C is an oxidizing agent. It is composed of three elements in the ratio 1:1:3. O elements of C is A. The other two elements belong to the <i>p</i> -block of the Period One of these two elements is also present in B . The salt formed between Ag anion of one of these elements is vellow in colour, and insoluble in concentrated.	ne of the dic Table.
	anion. K ₂ S ₂ O ₃	2(b): 25 marks
	(v) Write the chemical formula for the compound which has A as the cation and	B as the
	Note: Test must be correct to award marks for observation.	
	Any one of the above. Test (02), Observation (03)	
	3. Add AgNO ₃ White precipitate which turns black on standing / heating	
	2. Add Pb(OAc) ₂ White precipitate which turns black on heating	
	1. Add dil. H ₂ SO ₄ Colourless gas with a pungent smell and colloidal sulfur precipitate (or milky solution)	
	Test Observation (s) is/are also requ	nred.)
	(iv) Give a chemical test to identify B (Note: Observation(a) island all	
	(iii) Give the oxidation state of the central atom of R $+\Lambda$	(05)
		(05)
	(ii) Draw the Lewis dot-dash structure of B . S.	
	(i) Write the chemical formula, including the charge, of B . $S_2O_3^{2-}$	(05)
	with a pungent smell is evolved as one of the products.	a colouriess gas
	atomic number of each element is less than 20. The electronegativity of X electronegativity of Y. When X reacts with hot concentrated sulfuria said	is less than the
	X and Y are <i>p</i> -block elements that belong to the same group in the Per	riodic Table. The
	(b) B is an anion containing only the two elements \mathbf{V} and \mathbf{V} in the artic 2.2	2(a): 35 marks
	(vii) Give the chemical formula of the compound of A in SylviteKCI Note: (vi) Award marks for reasoning only if 'lower' is written	(05)
	Therefore, attraction of outer electron to nucleus decreases.	(01) (01)
	(or Z_{eff}) for the outer most / last electron is negligible.	(01)
	Lower When going down the group, change in effective nuclear charge	(02)
	(VI) is the first ionization energy of A higher or lower than that of the ele- group and the period above it in the Periodic Table? Briefly explain	ment in the same
	$K + O_2 \longrightarrow KO_2$	(05)
	(v) Write the balanced chemical equation for the reaction of A with	
	(iv) What is the colour given by A in the flame test? Lilac (violet) (05)
	(iii) Name the gas evolved in the reaction of A with water Hvdrogen o	r H ₂ (05)
	(ii) Write the complete electronic configuration of Λ 1s ² 2s ² 2p ⁶ 3s ² 3p ⁶ 4	s ¹ (05)
	(i) Write the chemical symbol of A K	(05)
	excess $O_2(g)$ to give the superoxide. The naturally occurring ore Sylvite con of A	tains a compound
	(a) A is a s-block element. It has an atomic number less than 20. It reacts with with ignition to give a strongly basic solution with the evolution of a g	water vigorously
2.	The questions $[(a)-(d)]$ given below relate to elements/species designated as	A, B, C and D.

(i) When C(aq) is mixed with an excess of D(aq) in acidic medium, a reddish-brown solution results. I. Identify \mathbf{D} . $\mathbf{D} = \mathbf{KI}$ (05) II. Write the balanced ionic equation for the reaction that takes place. $IO_3^- + 5I^- + 6H^+ \longrightarrow 3I_2 + 3H_2O$ (10)(ii) On addition of an excess of a solution containing **B**, to the reddish-brown solution obtained in (i) above, the reddish-brown solution becomes colourless. Write the balanced ionic equation for the reaction that takes place. $I_2 + 2S_2O_3^{2-} \longrightarrow S_4O_6^{2-} + 2I^{-}$ (05) ar a chair a tha chair ann an an an an ann an 🔶 ann an a (iii) The concentration of a solution containing **B** can be determined by volumetric analysis utilizing the reactions in (i) and (ii) above. State an indicator which can be used and give the expected colour change at the end point. Indicator – starch (05) Indicator Colour change - blue / dark blue/ blue-violet to colourless (05) 2(d): 30 marks phase diagram (at a pressure of 1.0×10^5 Pa) for a system containing X and Y is given below. Temperature °C 130 Parts (i) to (v) are based on the given phase Q or vapour (02) 120 diagram. 110 (i) Indicate the following regions on the phase 100 diagram by writing the letters P, Q, R. R or vapour + liquid (02) 90 P - region where only the liquid phase is 80 present 70 Q – region where only the vapour phase 60 is present P or liquid (02) 50 R – region where the liquid phase and the vapour phase are in equilibrium 100% 50% 0% (ii) Give the boiling points of pure X and pure Y. Composition (X, mol%) $X = 60 \ ^{0}C$ Y= 120 °C (02+01)x2(iii) What is the temperature at which a liquid mixture of X and Y containing 40 mol% of X begins to boil?

(iv) What is the lowest temperature at which a mixture of X and Y containing 60 mol% of X is completely converted to vapour?

02 - Chemistry (Marking Scheme) | G.C.E. (A/L) Examination 2021 (2022) | Amendments to be included.

(02+01)

Confidential

3. (a) X and Y are two volatile liquids that form an ideal solution. The temperature-composition

(d) **D** is a compound composed of two elements. Both these elements are also present in **C**.

100 °C

(02+01)

(v) Calculate the saturated vapour pressure of X at the temperature of 100 °C.

$$P_X^g = P_X^0 x_X^l \tag{03}$$
$$P_X^g = P^{\text{total}} x_X^g \tag{03}$$

Therefore,
$$P_X^0 = \frac{P^{total} x_X^g}{x_X^l}$$
 (03)

$$P_X^0 = \frac{1 \times 10^5 \, Pa \times 60}{15} \tag{05+01}$$

$$P_X^0 = 4.0 \times 10^5 \, Pa \tag{04+01}$$

(vi) In a separate experiment, a mixture containing X and Y was allowed to reach equilibrium in a **closed rigid** container at temperature T. It was then found that the liquid phase in equilibrium with the vapour phase contained 0.10 mol of X and 0.10 mol of Y. Saturated vapour pressures of X and Y at this temperature are 4.0×10^5 Pa and 2.0×10^5 Pa, respectively. Using Raoult law, calculate the partial pressures of X and Y.

$P_X = \frac{0.1 mol \times 4.0 \times 10^5 Pa}{0.1 mol + 0.1 mol}$	(02+01)
$P_X = 2.0 \times 10^5 Pa$	(02+01)
$P_Y = \frac{0.1 \ mol \times 2.0 \times 10^5 \ Pa}{0.1 \ mol + 0.1 \ mol}$	(02+01)
$P_X = 1.0 \times 10^5 Pa$	(02+01)
	3(a): 50 marks

- (b) The concentration of an aqueous solution of acetic acid (solution Z) was determined by titrating with an aqueous solution of NaOH. A volume of 12.50 cm³ of solution Z required 25.00 cm³ of NaOH solution of concentration 0.050 mol dm⁻³ to reach the end point.
 - (i) Calculate the concentration of acetic acid in solution Z.

$$[CH_3COOH(aq)] = \frac{25.00 \text{ cm}^3 \times 0.05 \text{ mol } dm^{-3}}{12.50 \text{ cm}^3}$$
(02+01)
= 0.10 mol dm^{-3} (02+01)

(ii) Calculate the pH value of solution Z. Acid dissociation constant of acetic acid (K_a) at the temperature at which the experiment was carried out is 1.80×10^{-5} mol dm⁻³.

$$CH_3COOH(aq) \rightleftharpoons CH_3COO^-(aq) + H^+(aq)$$

Or

$$CH_3COOH(aq) + H_2O(l) \rightleftharpoons CH_3COO^-(aq) + H_3O^+(aq)$$

Initial concentration of acetic acid = C

Fraction dissociated = α (or amount dissociated = x)

[Physical states are required for K_a]

$$X_a = \frac{[H^+(aq)][CH_3COO^-(aq)]}{[CH_3COOH(aq)]} \text{ or } K_a = \frac{[H_3O^+(aq)][CH_3COO^-(aq)]}{[CH_3COOH(aq)]}$$
(02)

$$K_a = \frac{C \alpha C \alpha}{C(1-\alpha)}$$
 or $K_a = \frac{x^2}{C-x}$ (02)

[if the equation, $K_a = \frac{C\alpha C\alpha}{C(1-\alpha)}$ or $K_a = \frac{x^2}{C-x}$ is not written but the calculation is done correctly, award 02 marks for the calculation]

Since
$$\alpha <<1$$
 or $x << c$ (02)

(02)

Ľ

pH calculation

0

(Do not deduct marks if physical states are not given)

$$[H^{+}(aq)] = \sqrt{K_{a}C}$$

$$[H^{+}(aq)] = \sqrt{1.80 \times 10^{-5} \, mol \, dm^{-3}} \qquad (02)$$

$$[H^{+}(aq)] = 0.00134 \, mol \, dm^{-3} \qquad (02)$$

$$pH = -\log\left[\frac{H_{3}O^{+}(aq)}{1.0 \, mol \, dm^{-3}}\right] \text{ or } pH = -\log\left[\frac{H^{+}(aq)}{1.0 \, mol \, dm^{-3}}\right] \qquad (02)$$

$$pH = 2.87 \qquad (02)$$

Alternate answer for pH_calculation	S
(Do not deduct marks if physical states are not $g - \log[H^+(aq)] = 1/2(-\log(K_ac))$	iven) (02)
$pH = 1/2(-\log(1.8 \times 10^{-5} \times 0.1))$	(04)
<i>pH</i> = 2.87	(02)

(iii) To another portion (100.00 cm^3) of solution Z, 0.200 g of pure solid NaOH was added and dissolved. Calculate the pH value of this solution assuming that the volume and the temperature of the solution remain unchanged. [Relative atomic mass: Na = 23, O = 16, H = 1]

Amount of CH_3COOH in 100.00 cm³ of solution = 1.0 x 10^{-2} mol(Amount of NaOH added = 0.005 mol(Amount of CH_3COOH left in the medium (after reacting with NaOH) = 5.00 x 10^{-3} m	(02) (02) nol (02)
Therefore, in solution, (Do not deduct marks if physical states are not given) $[CH_3COOH(aq)] = 0.05 \text{ mol dm}^{-3}$	(02)
[CH ₃ COONa(aq)] = 0.05 mol dm ⁻³ ((02)
pH calculation (Do not deduct marks if physical states are not given)	
$[H^+(aq)] = \frac{K_a [CH_3 COOH(aq)]}{[CH_3 COO^-(aq)]} $	(02)
$[H^+(aq)] = \frac{1.80 \times 10^5 \mod dm^{-3} \times 0.050 \mod dm^{-3}}{0.050 \mod dm^{-3}} $	(02)
$[H^+(aq)] = 1.80 \times 10^{-5} mol dm^{-3}$	

Alternate answer for pH calculation		
$pH = pK_a + \log[\frac{[CH_3COO^-(aq)]}{[CH_3COOH(aq)]}]$	(02)	
$pH = -\log(1.8 \times 10^{-5}) + \log[\frac{[0.05]}{[0.05]}]$	(02)	
pH = 4.74	(02)	dr'

(iv) Does the solution described in (iii) above behave as a buffer solution? Explain your answer.

The solution in (iii) above behaves as a buffer solution. (02) The solution contains a weak acid and the sodium salt of its conjugate base (02+02)

(v) In a separate experiment, 0.800 g of pure solid NaOH was dissolved in a 100.00 cm³ volume of solution Z. Does this solution behave as a buffer solution? Explain your answer using a suitable calculation. Assume that the volume and temperature of the solution remain unchanged.

The amount of CH₃COOH in 100.00 cm³ = 0.01 mol

The amount of NaOH added = 0.02 mol	(02) (02) (02)
Solution does not behave as a buffer solution	(02)
131	3(b): 50 marks
Ŏ	
C I	
21	
~ ex	

4. (a) A, B and C are structural isomers having the molecular formula C₅H₁₁Br. Of these three isomers, only B exhibits optical isomerism. A and C are positional isomers of each other. When A, B and C were reacted separately with aqueous NaOH, compounds D, E and F having the molecular formula C₅H₁₂O were formed respectively. D, E and F were treated separately with PCC. F did not react with PCC. D and E reacted with PCC and gave G and H respectively. Both compounds G and H gave coloured precipitates with 2,4-dinitrophenylhydrazine (2,4-DNP) and silver mirrors with ammonical AgNO₃.

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





(c) Give the mechanism and the structure of the product formed for the reaction between $CH_3CH = CHCH_3$ and Br_2/CCl_4 .



(b) Draw the structures of the products I, J, K and L of the following reactions, in the given boxes.

Answer two questions only. (Each question carries 150 marks.)	
5. (a) (i) A gas mixture containing CH_4 , C_2H_6 and excess O_2 was introduced into rigid container. The volume of the container was 8.314×10^{-3} m ³ . The pres at 400 K was 4.80×10^6 Pa. Calculate the total number of moles of ga	an evacuated closed ssure of the contained uses in the contained
Assume that an the gases behave ideally and that there is no reaction at	(05)
$4.8 \times 10^6 Pa 8.314 \times 10^{-3} m^3$	(05)
At 400K, $n_1 = \frac{10010 \text{M} \text{M} \text{M}}{8.314 J \text{mol}^{-1} K^{-1} 400 K}$	(04+01)
$n_1 = 12.0 \ mol$	(04+01)
(ii) All the hydrocarbons in the container were completely combusted by increas of the container to 800 K. The pressure of the container after the combustion was 1.00×10^7 Pa. Calculate the total number of moles of gases in the contain Assume that H ₂ O is present as a gas under these conditions.	asing the temperature on reactions at 800 k ner after combustion
At 800K. $n_2 = \frac{1.0 \times 10^7 Pa 8.314 \times 10^{-3} m^3}{10^7 m^3}$	(04+01)
$8.314 J mol^{-1}K^{-1} 800K$	(04+01)
n1 – 12.5 mot	(04:01)
 (iii) Write balanced chemical equations (giving physical states, at 800 K) reactions of the gases given below. I. CH₄(g) II. C₂H₄(g) 	for the combustion
$CH_4(g) + 2 O_2(g) \rightarrow CO_2(g) + 2 H_2O(g)$	(05)
$2 C_2 H_6 (g) + 7 O_2(g) \rightarrow 4 CO_2(g) + 6 H_2 O(g)$	(05)
 (iv) Only one of the two hydrocarbons above contributes to the change in th of gases before and after combustion. Calculate the number of moles of this hydrocarbon initially introduced 	e number of moles into the container.
Hydrocarbon that contributes to the change of the number of m	oles before and
after the combustion is C_2H_6	(05)
No. of moles increased after combustion = 0.5 mol	
The amount of C_2H_6 introduced initially = 0.5 mol x 2 = 1.0 m	iol (04+01)
 (v) The container was then cooled to 300 K and the water was removed. of the container was 2.10 × 10⁶ Pa. Calculate the following. Amount (moles) of gases after removing water, 	Then the pressure
$n_{1} = \frac{2.1 \times 10^{6} Pa 8.314 \times 10^{-3} m^{3}}{10^{-3} m^{3}}$	(0/1+01)
$8.314 J mol^{-1}K^{-1} 300K$	
$n_3 = 7.0 mol$	(04+01)
I. Total number of moles of H ₂ O produced	
The amount of water formed = $(12.7 - 7.0)$ mol = 5.5 mol	(04+01)
II. Number of moles of H_2O produced from the combustion of C_2H_6	
The amount of water dependent of from the compustion of $C_{2}H_{2} = \frac{6.0 \text{ mol}^{2}}{10000000000000000000000000000000000$	×3.0 mol
	mol

III. Number of moles of H_2O produced from the combustion of CH_4 The amount of water generated from the combustion of $CH_4 = (5.5 - 3)$ = 2.5 mole	3.0)mol l (04+01)
IV. Number of moles of O2 introduced initially into the container	
The amount of O ₂ introduced initially = $12.0 \text{ mol} - (1.0 \text{ mol} + \text{amount} + 12.0 \text{ mol} - (1.0 + 2.5/2) \text{ mol} = 12.0 \text{ mol} - (1.0 + 2.5/2) \text{ mol} = 9.75 \text{ mol}$	of CH₄ introduced) (04+01)
	5(a) : 75 marks
Alternate answer for (iv) and (v)	
(iv) Hydrocarbon that contributes to the change of the number of moles before and af	ter the combustion
is C ₂ H ₆ .	(05)
Let the number of moles of the species as follows	. ,
Initially,	
$CH_4 = n_1 C_2H_6 = n_2$ and $O_2 = 2n_1 + 7/2n_2 + n_{excess}$	
After combustion,	
$CO_2 = n_1 + 2n_2$, $H_2O=2n_1+3n_2$ and $O_2 = 2n_1 + 7/2n_2 + n_{excess}$	
Before combustion the number of moles in the container => 12.0 mol = $n_1 + n_2 + 2n_1$	+ 7/2n ₂ +n _{excess} (1)
After combustion the number of moles in the container => $12.5 \text{ mol} = n_1 + 2n_2 + 2n_1$	+ 3n ₂ + n _{excess} (2)
(2)-(1) => $0.5 = 1/2n_2$ Amount of C ₂ H ₆ introduced = $n_2 = 1.0$ mol	(04+01)
(v) The total amount of water formed = $2n_1 + 3n_2$	
Amount (moles) of gases after removing water,	
$n_1 + 2n_2 + n_{excess} = \frac{2.1 \times 10^6 Pa 8.314 \times 10^{-3} m^3}{8.314 J mol^{-1} K^{-1} 300 K}$	(04+01)
$n_1 + 2n_2 + n_{excess} = 7.0 \ mol$	(04+01)
Therefore, from part (iv) equation (2),	
n ₁ = ½(12.5- (n ₁ + 2n ₂ +3n ₂ + n _{excess})) = ½(12.5-10.0)mol = 1.25 mol	
(I) The total amount of water formed = $2n_1 + 3n_2 = (2x1.25+3x1.0)$ mol = 5.5 mol	(04+01)
(II) The amount of water formed from C_2H_6 combustion = $3n_2 = 3.0$ mol	(04+01)
(III) The amount of water formed from CH_4 combustion = $2n_1 = 2.5$ mol	(04+01)
(IV) The amount of O ₂ introduced initially = $(12.0 - (1.25 + 1.0))$ mol = 9.75 mol	(04+01)

(b) (i) Using a **thermochemical cycle** and the data given, calculate the standard enthalpy change for the reaction given below.

$4 \operatorname{CH}_4(g) + \operatorname{O}_2(g)$	$\rightarrow 2 C_2 H_6(g) + 2 H_2 C_2$	D(g)
	$\left(\Delta H_{f}^{\mathrm{o}}\right)(\mathrm{kJ\ mol^{-1}})$	S° (J mol ⁻¹ K ⁻¹)
$CH_4(g)$	-74.8	186.3
$C_2H_6(g)$	-84.7	229.6
$CO_2(g)$	-393.5	213.7
$H_2O(g)$	-214.8	188.8
C(s), graphite	0.0	5.7
O ₂ (g)	0.0	205.1
$H_2(g)$	0.0	130.7



For the thermochemical cycle:

For the correct species, correct stoichiometry and correct physical state

 $\Delta H_{2}^{0} = \Delta H_{1}^{0} - \Delta H_{3}^{0}$ Or $\Delta H_{2}^{0} = \sum \Delta H^{0}(products) - \sum \Delta H^{0}(reactants)$ (02 marks x 7 = 14)
(03)
(03)

(02)

(06)

(06)

 $\Delta H_2^0 = [-84.7x2 - 214.8x2 - (-74.8x4)] \text{ kJ mol}^{-1}$

(06)

= -299.8 kJ mol⁻¹

(03+01)



$= -2693.4 \text{ kJ mol}^{-1}$	//
$\Delta H_2^0 = \Delta H_1^0 - \Delta H_3^0$	(03)
= (-2993.2-(-2693.4)) kJ mol ⁻¹	()
= -299.8 kJ mol ⁻¹	(03+01)
(ii) Calculate the standard entropy change for the reaction in $(b)(i)$ abo	ve.
(ii) encoune are summare encopy enange for the reaction in (b)(i) abo	
$\Delta S^0 = \sum S^0(nroducts) - \sum S^0(reactants)$	(04)
(02) (02) (02) (02) (01)	
$\Delta S^0 = ((229.6x^2 + 188.8x^2 - (186.2x^4 + 205.1x^1))) \text{ J mol}^{-1} \text{ K}^{-1}$	
= -113.5 J mol ⁻¹ K ⁻¹	(02+01)
(iii) Calculate the standard Gibbs energy change (ΔG°) for the reaction in	(b)(i) above at 500 K.
$\Delta G^{0} = \Delta H^{0} - T \Delta S^{0}$	(04)
= -299.8 kJ mol ⁻¹ – (500 K x (-113.5 x10 ⁻³) kJ mol ⁻¹ K ⁻¹)	(04+01)
= -243.05 kJ mol ⁻¹	(02+01)
Assume that the enthalpy change and entropy change are independed Increasing temperature does not favour the forward reaction	ent of temperature.
(Or increasing temperature makes Gibbs energy change less negative	()
Because the reaction has a negative change in entropy	(03)
Decause the reaction has a negative change in entropy.	(03)
[If the sign of entropy change is incorrect, but prediction agrees with	the sign of the entrop
change award 06 marks)	
	5(b) : 75 marks
 (a) (i) Consider the reversible reaction a A(aq) ⇒ b B(aq) + c C(aq) the medium. Considering that both forward and reverse steps are ele 	at occurs in the aqueou mentary reactions, writ
expressions for the rate of the forward reaction (R_1) and the rate (R_2) . Rate constants for the forward reaction and the reverse respectively.	of the reverse reaction reaction are k_1 and k_2
expressions for the rate of the forward reaction (R_1) and the rate (R_2) . Rate constants for the forward reaction and the reverse respectively. $R_1 = k_1 [A(aq)]^a$	of the reverse reaction reaction are k_1 and k_2 (05+01)
expressions for the rate of the forward reaction (R_1) and the rate (R_2) . Rate constants for the forward reaction and the reverse respectively. $R_1 = k_1 [A(aq)]^a$ $R_2 = k_2 [B(aq)]^b [C(aq)]^c$	of the reverse reaction reaction are k_1 and k_2 (05+01) (05+01)
expressions for the rate of the forward reaction (R_1) and the rate (R_2) . Rate constants for the forward reaction and the reverse respectively. $R_1 = k_1 [A(aq)]^a$ $R_2 = k_2 [B(aq)]^b [C(aq)]^c$ [expression 05 marks, physical states 01 mark]	of the reverse reaction reaction are k_1 and k_2 (05+01) (05+01)
expressions for the rate of the forward reaction (R_1) and the rate (R_2). Rate constants for the forward reaction and the reverse respectively. $R_1 = k_1 [A(aq)]^a$ $R_2 = k_2 [B(aq)]^b [C(aq)]^c$ [expression 05 marks, physical states 01 mark] (ii) Write the relationship between R_1 and R_2 at equilibrium	of the reverse reaction reaction are k_1 and k_2 (05+01) (05+01)
expressions for the rate of the forward reaction (R_1) and the rate (R_2) . Rate constants for the forward reaction and the reverse respectively. $R_1 = k_1 [A(aq)]^a$ $R_2 = k_2 [B(aq)]^b [C(aq)]^c$ [expression 05 marks, physical states 01 mark] (ii) Write the relationship between R_1 and R_2 at equilibrium.	of the reverse reaction reaction are k_1 and k_2 (05+01) (05+01)

(iii) Write down the expression for equilibrium constant $K_{\rm C}$. Also give the relationship between $K_{\rm C}$, k_1 and k_2 .

$$K_{c} = \frac{[B(aq)]^{b}[C(aq)]^{c}}{[A(aq)]^{a}}$$
(05+01)

[expression 05 marks, physical states 01 mark]

$$K_C = \frac{k_1}{k_2}$$

(iv) To study the above equilibrium, three experiments were carried out at a constant temperature. In these experiments, different amounts of A, B and C were mixed, and the system was allowed to reach equilibrium. The following data were obtained at equilibrium.

Experiment	Concentration at equilibrium (mol dm ⁻³)		
Number	[A]	[B]	[C]
1	1.0×10^{-1}	1.0×10^{-2}	1.0×10^{-3}
2	1.0×10^{-2}	1.0×10^{-3}	1.0×10^{-3}
3	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-5}

I. Obtain three relationships by substituting the concentrations of A, B and C given in the table for experiments 1, 2 and 3 in the equilibrium constant expression written in (a)(iii) above.

$$K_{c} = \frac{(1.0 \times 10^{-2})^{b} (1.0 \times 10^{-3})^{c}}{(1.0 \times 10^{-1})^{a}} --(1)$$
(06)

$$K_{c} = \frac{(1.0 \times 10^{-3})^{b} (1.0 \times 10^{-3})^{c}}{(1.0 \times 10^{-2})^{a}} --(2)$$
(06)

$$K_c = \frac{(1.0 \times 10^{-2})^b (1.0 \times 10^{-5})^c}{(1.0 \times 10^{-2})^a} \quad --(3)$$

II. Prove that a = b = 2c using these relationships.

From (1)/(2)=> $1 = \frac{10^b}{10^a}$ (05)

 $10^{a} = 10^{b}$

a=b (05)

From (2)/(3) =>
$$1 = \frac{10^{2c}}{10^{b}}$$
 (05)

 $10^{b} = 10^{2c}$

b = 2c (05)

Therefore, a = b = 2c

(05)





III. Using the smallest integers for the stoichiometric coefficients a, b and c, calculate the value of the equilibrium constant, $K_{\rm C}$ of the above reaction.

Using the smallest set of integers,

a = 2, b=2, c=1

Calculation of Kc

 $K_{\mathcal{C}} = \frac{(1.0 \times 10^{-2} mol \, dm^{-3})^2 (1.0 \times 10^{-3} mol \, dm^{-3})^1}{(1.0 \times 10^{-1} mol \, dm^{-3})^2}$

 $K_C = 1.0 \times 10^{-5} mol \ dm^{-3}$



(b) Consider the reaction, $\mathbf{p} \mathbf{P}(\mathbf{g}) \rightleftharpoons \mathbf{q} \mathbf{Q}(\mathbf{g}) + \mathbf{r} \mathbf{R}(\mathbf{g})$ that takes place in gas phase.

(i) The enthalpy change and activation energy of the forward reaction, $\mathbf{p} \mathbf{P}(\mathbf{g}) \rightarrow \mathbf{q} \mathbf{Q}(\mathbf{g}) + \mathbf{r} \mathbf{R}(\mathbf{g})$ are 50.0 kJ mol⁻¹ and 90.0 kJ mol⁻¹, respectively. Draw the labelled energy diagram (the graph of energy vs reaction coordinate) for this reaction. Show the positions of P, Q and R by marking them on the energy diagram. Also, mark the position of the activated complex as 'activated complex' on it.



(ii) Calculate the activation energy for the reverse reaction.

Activation energy of the reaction = E_a

E _a = (90.0 – 50.0) kJ mol ⁻¹	(05+01)
= 40.0 kJ mol ⁻¹	(04+01]

(iii) Explain the effect of increasing temperature on the equilibrium constant of this reaction.

When the temperature is increased, the equilibrium constant is increased **(05)** because the reaction has a positive change in enthalpy **(05)** When the temperature is increased, the rate constant of the forward reaction is increased more than the rate constant of the reverse reaction. **(05)**

- (iv) Explain the effect of a catalyst
 - I. on the rates of forward and reverse reactions.
 - II. on the equilibrium constant.

(I) Increases the rate of forward reaction (05) and the rate of the reverse reaction (05) by the same factor (extent). (05)

(II) The value of the equilibrium constant is not changed. (05)

Alternate answer

(iv) Addition of a catalyst,

(I) It provides a new pathway for the reaction with higher rate constants for forward and reverse reactions (05). The ratio between the two rate constants does not change (05). Rate constants of the forward and reverse reactions are increased by the same factor (extent). (05)

(II) The value of the equilibrium constant is not changed. (05)

6(b) : 70 marks

7. (a) You are provided with the three metal rods L, M, N and the three solutions L²⁺ (1.0 mol dm⁻³), M²⁺ (1.0 mol dm⁻³), N²⁺ (1.0 mol dm⁻³). When the metal N is dipped in the solution of M²⁺ ions, M²⁺ is reduced to M, whereas when N is dipped in the solution of L²⁺ ions, L²⁺ does not get reduced to L.

(i) Giving reasons arrange the three metals, L, M and N in the increasing order of their reducing ability.

$N(s) + M^{2+}(aq) \rightarrow N^{2+}(aq) + M$ is spontaneous	
Reducing ability N > M or $[E^{0}_{N2+/N} < E^{0}_{M2+/M}]$	(05)
$N(s) + L^{2+}(aq) \rightarrow N^{2+}(aq) + L$ not spontaneous	
Reducing ability of L >N or $[E_{L2+/L}^0 < E_{N2+/N}^0]$	(05)
Increasing order of reducing ability M <n<l< td=""><td>(05)</td></n<l<>	(05)

(Or increasing order of oxidizing ability L<N<M)

(ii) Electromotive forces of the two electrochemical cells prepared using $L^{2+}(aq)/L(s)$ electrode and each of the other two electrodes are +0.30 V and +1.10 V. Using this information and your answer to (i) above, calculate $E_{M^{2+}(aq)/M(s)}^{\circ}$ and $E_{N^{2+}(aq)/N(s)}^{\circ}$.

$$L^{2+(aq)/L(s)} = -0.80 \text{ V}$$

E

Out of the two cells one has $E_{cell} = 0.30$ V and the other has $E_{cell} = 1.10$ V

Highest E_{cell} is between L²⁺(aq)/L electrode and M²⁺(aq)/M electrode.

The lowest E_{cell} is between $L^{2+}(aq)/L$ electrode and $N^{2+}(aq)/N$ electrode.

 $E^{0}_{M2+(aq)/M} - E^{0}_{L2+(aq)/L} = 1.10 V$ (05)

 $E^{0}_{M2+(aq)/M} = 1.10 \text{ V} - 0.80 \text{ V} = 0.30 \text{ V}$ (05)

And

 $E^{0}_{N2+(aq)/N} - E^{0}_{L2+(aq)/L} = 0.30 V$ (05)

$$E^{0}_{N2+(aq)/N} = 0.30 V + (-0.80V) = -0.50 V$$
 (05)

Alternate answer	
Based on the order of reducing ability, L^{2+}/L should be the	anode in
both the cells.	
$E^{0}_{cathode} - E^{0}_{L2+/L} = 1.10 V$	
Therefore $E_{cathode}^{0}$ = 1.10 V – 0.80 V = 0.3 V	(05)
$E^0_{cathode} - E^0_{L2+/L} = 0.3 V$	
Therefore $E_{cathode}^{0}$ = 0.3 V – 0.80 V = -0.5 V	(05)
Therefore,	
$E^{0}_{M2+/M} = 0.3 V$	(05)
$E^{0}_{N2^{+}/N} = -0.5 V$	(05)

(iii) You are provided with the following arrangement, where a potentiometer (P) is connected between the metal rods L and N.



- I. Calculate the potentiometer reading.
- II. Write the electrode reactions that occur at each of the electrodes (A), (B), (C) and (D) separately when the potentiometer is removed and L and N are connected by a conductor.

Potentiometer reading (P),

$P = E^{0}_{\operatorname{cell}(1)} + E^{0}_{\operatorname{cell}(2)}$	(05)
$= (E^{0}_{M2^{+}(aq)/M} - E^{0}_{L2^{+}(aq)/L}) + (E^{0}_{N2^{+}(aq)/N} - E^{0}_{M2^{+}(aq)/M})$	(05)
$= E^{0}_{N2+(aq)/N} - E^{0}_{L2+(aq)/L}$	(05)
= -0.50 V – (-0.80 V)	
= 0.30 V	(05)

II. Write the electrode reactions that occur at each of the electrodes (A), (B), (C) and (D) separately when the potentiometer is removed and L and N are connected by a conductor.

Electrode reactions when a current is drawn.

Electrode (A)	$L(s) \rightarrow L^{2+}(aq) + 2e$	(05)
Electrode (B)	$M^{2+}(aq) + 2e \rightarrow M(s)$	(05)
Electrode (C)	$M(s) \rightarrow M^{2+}(aq) + 2e$	(05)
Electrode (D)	$N^{2+}(aq) + 2e \rightarrow N(s)$	(05)

7(a): 75 marks

(b) The following questions are based on the element manganese (Mn).	
(i) Write the complete electronic configuration of Mn.	
$1s^22s^22p^63s^23p^63d^54s^2$	(03)
(ii) Write three common oxidation states of Mn.	
+2, +3, +4, +7 (any three)	(02 x 3)
(iii) When $MnSO_4 \cdot H_2O$ is dissolved in water, solution P is obtained.	al como di bic
I. State the colour of solution P.	
 Give the chemical formula and the IUPAC name of the spe colour. 	ecies responsible for this
I. very pale pink/ pale pink/ colourless	(03)
II. [Mn(H ₂ O) ₆] ²⁺ (aq)	(03)
hexaaquamanganese(II) ion	(03)
(iv) What would you observe when	5
I. dilute NaOH is added to solution P?	
II. the mixture from (iv)(I) above is exposed to air?	
III. conc. HCl is added to the mixture from (iv)(I) above?	
I. white/cream precipitate	(03)
II. brown precipitate or blackish-brown precipitate	(03)
	(03)

(v) Give the chemical formulae of five oxides of Mn, and write the oxidation state of Mn in each. State the nature of each of the oxides as basic, weakly basic, amphoteric, weakly acidic, acidic.

MnO	+2	basic	(02 x 3)
Mn ₂ O ₃	+3 🔪 🚽	weakly basic	(02 x 3)
MnO ₂	+4	amphoteric	(02 x 3)
MnO₃	+6	weakly acidic	(02 x 3)
Mn ₂ O ₇	+7	acidic	(02 x 3)

(vi) Give the chemical formula of the most common oxoanion of Mn.

MnO₄-

(03)

(vii) Give balanced ionic half equations to indicate how the oxoanion given by you in (vi) above behaves as an oxidizing agent in acidic and basic media.

Acidic MnO₄⁻(aq) + 8H⁺(aq) + 5e \longrightarrow Mn²⁺(aq) + 4H₂O(I) (06)

Alkaline MnO₄-(aq) + 2H₂O(I) + 3e \longrightarrow MnO₂(s) + 4OH⁻(aq) (06)

(viii) State one use of MnSO4 in the analysis of water quality parameters.

Determination of dissolved O₂ in water samples

7(b): 75 marks

(03)



(b) (i) Propose a method to prepare a mixture of o-nitrobenzoic acid and p-nitrobenzoic acid from benzene using not more than three (03) steps.



(c) The structure of benzene is represented as the resonance hybrid of the following two hypothetical six membered cyclic structures (cyclohexatriene). Using the standard enthalpy data of hydrogenation given below, show that benzene is more stable than hypothetical 'cyclohexatriene'. $+ H_2 \longrightarrow \bigcirc$ $\Delta H^{\circ} = -120 \text{ kJ mol}^{-1}$ cyclohexene cyclohexane Benzene + $3 H_2$ \longrightarrow cyclohexane $\Delta H^{\circ} = -208 \text{ kJ mol}^{-1}$ (20 marks) = -120 kJ mol⁻¹ (c) Standard enthalpy of hydrogenation of cyclohexene Expected enthalpy of hydrogenation of hypothetical "cyclohexatriene" = -120×3 kJ mol⁻¹ 10 = -360 kJ mol⁻¹ Standard enthalpy of hydrogenation of benzene = -208 kJ mol⁻¹ 10 Stabilization energy of benzene = - 152 kJ <u>mol⁻¹</u> OR Н "cyclohexatriene" 152 kJ 120 kJ x 3 10 =360 kJ benzene stabilization energy of benzene 10 208 kJ cyclohexane NB. 10 marks for calculating the expected enthalpy of hydrogenation of "cyclohexatriene" 10 Marks for stating or indicating the stabilization of benzene. This 10 marks can be awarded even if the stabilization energy is not calculated but indicating by a statement such as following.

Hydrogenation of both benzene and "cyclohexatriene" (with 3H₂) give cyclohexane. However, benzene evolves less energy than "cyclohexatriene" in this process. Therefore, it is more stable.

8(c):20 marks

9. (a) The following question is based on the qualitative analysis of cations.

An aqueous solution **Q** contains **four** cations of metals **A**, **B**, **C** and **D**. **Q** is subjected to the reactions given in the scheme below.

The symbols given in the box are used to represent precipitates with solutions, solids and solutions.





(i) A₁, A₂, A₃, B₁, B₂, C₁, C₂, and D₁ are compounds/species of the four cations A, B, C, and D. Identify A₁, A₂, A₃, B₁, B₂, C₁, C₂, and D₁.
(Note: Write only chemical formulae. Chemical equations and reasons are not required.)

Ċ

SUKS

A 1	PbCl ₂	
A 2	Pbl ₂	
A 3	PbS	
B ₁	AI(OH) ₃	
B ₂	NaAlO ₂ or AlO ₂ ⁻ or [Al(OH) ₄] ⁻ or Na[Al(OH) ₄]
C ₁	ZnS	
C ₂	Zn(OH) ₂	
D ₁	SrCO ₃	

(08 marks x 8 = 64 marks)

(ii) Give a reason for the use of NH₄OH/NH₄Cl as a reagent when obtaining the white gelatinous precipitate (*). (75 marks)

	9(a): 75 ı	marks
	(11	marks)
$OH_{(aq)} \implies OH_{(aq)} + OH_{(aq)}$ and the concentration OH- is reduced K_{sp} of $Zn(OH)_2 > Al(OH)_3$ Therefore, precipitation of $Zn(OH)_2$ can be prevented by using NH_4Cl / NH_4OH	OT	(02) (03)
or Addition of NH ₄ Cl shifts the equilibrium position of NH ₄ OH	ŕ	
their hydroxides. NH ₄ Cl is added to reduce the concentration of OH ⁻ (common ic	on effect).	(02)
<u>Alternate Answer</u> NH ₄ OH is added to precipitate Al ³⁺ as the hydroxide.		(02)
	(11 ma	rks)
This allows Fe ³⁺ , Al ³⁺ and Cr ³⁺ hydroxides to be precipitated w the hydroxides of Zn ²⁺ , Mn ²⁺ , Co ²⁺ and Ni ²⁺ remain in solution.	nile	(03)
OH- is reduced The K _{sp} of hydroxides of Group IV metal ions is greater than those of the Group III metal ions.		(02)
Addition of NH ₄ Cl shifts the equilibrium position of NH ₄ OH NH ₄ OH(aq) \longrightarrow NH ₄ ⁺ (aq) + OH ⁻ (aq) and the concentration	of	
may also precipitate together with the hydroxides of Group III r NH ₄ Cl is added to reduce the concentration of OH ⁻ (common ic or	netal ions. on effect).	(02)
as hydroxides. Then, the hydroxides of Group IV metal ions (Zn ²⁺ , Mn ²⁺ , Co ²⁺	and Ni ²⁺)	(02)
NH ₄ OH is added to precipitate the Group III ions (Fe ³⁺ , Al ³⁺ an	d Cr³⁺)	(02)

02 - Chemistry (Marking Scheme) | G.C.E. (A/L) Examination 2021 (2022) | Amendments to be included.

(04)

(04)

- (b) A mixture X contains only aluminium sulfide (Al₂S₃) and ferric sulfide (Fe₂S₃). The following procedure was carried out to calculate the mass percentages of Al₂S₃ and Fe₂S₃ in X. When a mass m of mixture X was heated at high temperature under H₂ gas, Al₂S₃ remains unchanged but Fe₂S₃ was converted to iron (Fe) metal. The final mass obtained was 0.824 g. When another mass m of mixture X was heated at high temperature in air, both Al₂S₃ and Fe₂S₃ decomposed, giving SO₂ gas. This SO₂ gas was bubbled through a solution of H₂O₂ and oxidized to H₂SO₄ acid, which is the only product. When this entire solution was titrated with a standard 1.00 mol dm⁻³ NaOH solution in the presence of phenolpthalein indicator, the burette reading was 36.00 cm³.
 - (i) Write the balanced chemical equation for the reaction of Fe₂S₃ with hydrogen gas

$$Fe_2S_3 \ \ \text{+} \ \ 3H_2 \ \rightarrow \ 2Fe \ \ \text{+} \ \ 3H_2S$$

(ii) Write the balanced chemical equation for the reaction of SO₂ with H₂O₃ to give H₂SO₄.

$$SO_2 + H_2O_2 \rightarrow H_2SO_4$$

(iii) Calculate the mass percentages of
$$AI_2S_3$$
 and Fe_2S_3 in mixture X.

$2\text{Al}_2\text{S}_3 \ \textbf{+90}_2 \ \rightarrow \ 2\text{Al}_2\text{O}_3 \ \textbf{+} \ 6\text{SO}_2$	or $Al_2S_3 : SO_2 = 1 : 3$	(03)
$2Fe_2S_3 \ \texttt{+}9O_2 \ \rightarrow \ 2Fe_2O_3 \ \texttt{+} \ 6SO_2$	or $Fe_2S_3:SO_2 = 1:3$	(03)
$H_2SO_4 \ \textbf{+}\ \textbf{2NaOH} \ \rightarrow \ \textbf{Na}_2SO_4 \ \textbf{+} \ \textbf{2H}_2O$	or H ₂ SO ₄ : NaOH = 1 : 2	(03)
Molar mass of $Al_2S_3 = (27x2)+(32x3)$	= 150	(02)

Molar mass of
$$Fe_2S_3 = (56x2) + (32x3) = 218$$
 (02)

Assume mass of Al_2S_3 to be m_1 and Fe_2S_3 to be m_2

Mass of Fe from Fe₂S₃ after heating under H₂

$$\frac{m_2}{208} \times 56 \times 2 \tag{04}$$

Total mass after heating under H₂

$$m_1 + \frac{m_2}{208} \times 56 \times 2 = 0.824g$$
 [1] (08]

From heating under air

Mols of H₂SO₄ from Al₂S₃ =
$$\frac{m_1}{150} \times 3$$
 (04)

Mols of H₂SO₄ from Fe₂S₃ =
$$\frac{m_2}{208} \times 3$$
 (04)

Total mols from both Fe₂S₃ and Al₂S₃ =
$$\frac{m_1}{150} \times 3 + \frac{m_2}{208} \times 3$$
 (04)

Mols of NaOH for titration
$$=\frac{1}{1000} \times 36$$
 (02)

Mols of H₂SO₄ from titration
$$=\frac{1}{1000} \times \frac{36}{2} = 18 \times 10^{-3}$$
 (02)

$$\frac{3m_1}{150} + \frac{3m_2}{208} = 18 \times 10^{-3} g \rightarrow [2]$$
(08)

$$m_1 + \frac{m_2}{208} \times 112 = 0.824 g \rightarrow [1]$$
(3)

$$\frac{3m_1}{150} + \frac{3m_2}{208} = 18 \times 10^{-3} g \rightarrow [2]$$
Solving equations [1] and [2] for m_1 and m_2

$$\frac{m_1}{50} + \frac{3m_2}{208} = 0.018 \rightarrow [3]$$
(3) $\times 50$

$$m_1 + \frac{150m_2}{208} = 50 \times 0.018 \rightarrow [4]$$
(4) $-[1]$

$$\frac{150m_2}{208} - \frac{112m_2}{208} = 0.900 \times 0.824$$

$$m_2 = 0.416 g \text{ in eq [1]}$$

$$m_1 + \frac{0.416 \times 112}{208} = 0.824$$

$$m_1 = 0.600 g$$
(02)

$$\%m_1 = \frac{0.600 g}{0.416 + 0.600} \times 100\% = 59.06\% \text{ or } 59\%$$
(04)

$$\%m_2 = 100 - 59.06 = 40.94\% \text{ or } 41\%$$
(04)

Alternate answer 01 for (iii)			
$2AI_2S_3 \texttt{+9O}_2 \ \rightarrow \ 2AI_2O_3 \ \texttt{+} \ 6SO_2 \qquad \qquad \text{or} AI_2S_3 : SO_2 \ \texttt{=} \ 1:3$	(03)		
$2Fe_2S_3 \ \ \text{+}9O_2 \ \rightarrow \ 2Fe_2O_3 \ \ \text{+} \ \ 6SO_2 \qquad \text{or} \ \ Fe_2S_3 \ : \ SO_2 \ \ \text{=} \ \ 1 \ : \ 3$	(03)		
H_2SO_4 + 2NaOH \rightarrow Na ₂ SO ₄ + 2H ₂ O or H_2SO_4 : NaOH = 1 : 2	(03)		
	2		
Molar mass of Al ₂ S ₃ = (27x2)+(32x3) = 150	(02)		
Molar mass of $Fe_2S_3 = (56x2)+(32x3) = 218$	(02)		
Assuming mols of Al ₂ S ₃ is n_1 and mols of Fe ₂ S ₃ as n_2			
Mols of Fe from Fe ₂ S ₃			
$n_2 \times 56 \times 2$	(04)		
Total mass after heating under H ₂			
$150n_1 + 112n_2 = 0.824 \rightarrow \underline{[1]}$	(08)		
Mols of NaOH for titration $=\frac{1}{1000} \times 36$	(02)		
Mols of H ₂ SO ₄ from titration $=\frac{1}{1000} \times \frac{36}{2} = 18 \times 10^{-3}$	(02)		
Mols of H_2SO_4 from $Al_2S_3 = 3n_1$	(04)		
Mols of H ₂ SO ₄ from Fe ₂ S ₃ = $3n_2$	(04)		
Total mols of $H_2SO_4 = 3n_1 + 3n_2$	(04)		
Therefore,			
$3n_1 + 3n_2 = 0.018 \qquad \rightarrow [2]$	(08)		
Solving equation [1]and [2] for n_1 and n_2			
$[2] \times 50 \qquad 150n_1 + 150n_2 = 0.9 \qquad \rightarrow [3]$			
$[3] - [1] \qquad 38n_2 = 0.076$			
$n_2 = 2 \times 10^{-3} \text{ mol}$	(02)		
Substituting n_2 in [2]			
$3n_1 + 3 \times 0.002 = 0.018$			
$n_1 = 0.004 \text{ mol}$	(02)		

Mass of $Al_2S_3 = 0.004 \text{ mols x } 150 \text{ gmol}^{-1} = 0.600 \text{ g}$ Mass of $Fe_2S_3 = 0.002 \text{ mols x } 208 \text{ gmol}^{-1} = 0.416 \text{ g}$ % mass of $Al_2S_3 = \frac{0.600}{0.600 + 0.416} \times 100\% = 59.06$ or 59 % (04) % mass of $Fe_2S_3 = 100 - 59.06 = 40.94$ or 41 % (04)

Alternate answer 02 for (iii)

$2AI_2S_3 \textbf{+9O}_2 \rightarrow 2AI_2O_3 \ \textbf{+} \ 6SO_2$	or Al_2S_3 : $SO_2 = 1:3$	(03)
$2Fe_2S_3 \ \textbf{+}9O_2 \rightarrow 2Fe_2O_3 \ \textbf{+} \ 6SO_2$	or $Fe_2S_3:SO_2 = 1:3$	(03)
$H_2SO_4 \ \textbf{+}\ \textbf{2NaOH} \ \rightarrow \ \textbf{Na}_2SO_4 \ \textbf{+} \ \textbf{2H}_2O$	or H ₂ SO ₄ : NaOH = 1 : 2	(03)
Molar mass of $Al_2S_3 = (27x2)+(32x3) = 1$	50 g mol ⁻¹	(02)
Molar mass of $Fe_2S_3 = (56x2)+(32x3) =$	218 g mol ⁻¹	(02)
Assume mass of AI_2S_3 in the mass of 0.8	324 g is as m	

$$n_{Fe} = \frac{(0.824 - m)}{56} mol$$
(06)

$$n_{Fe_2S_3} = \frac{1}{2} \frac{(0.824 - m)}{56} mol$$
 [1] (06)

$$n_{SO_2} = 3 \times \frac{m}{150} + 3 \times \frac{1}{2} \frac{(0.824 - m)}{56} mol$$
(10)

Mols of NaOH for titration
$$=\frac{1}{1000} \times 36 \, mol$$
 (02)

Mols of H₂SO₄ from titration
$$=\frac{1}{1000} \times \frac{36}{2} = 18 \times 10^{-3} mol$$
 (02)

Therefore,

 $n_{SO_2} = 0.018 \, mol$

$$n_{SO_2} = 3 \times \frac{m}{150} + 3 \times \frac{1}{2} \frac{(0.824 - m)}{56} = 0.018$$
 [2] (10)

Solving equation [2] for m

$$\frac{m}{150} + \frac{(0.824 - m)}{112} = 0.006$$
$$112m + 150(0.824 - m) = 0.006 \times 150 \times 112$$

0epartment of tr.

Su

$$38m = 22.8$$

$$m = m_{Al_2S_3} = 0.60 g$$
(02)
Substituting m= 0.60 g in equation [1]
$$n_{Fe_2S_3} = \frac{1}{2} \frac{(0.824 - 0.60)}{56} mol = 0.002 mol$$

$$m_{Fe_2S_3} = 0.002 \times 208 gmol^{-1} = 0.416 g$$
(02)
Therefore
% mass of Al₂S₃ = $\frac{0.600}{0.600 + 0.416} \times 100\% = 59.06\%$ or 59 %
(04)
% mass of Fe₂S₃ = 100% - 59.06\% = 40.94\% or 41%
(04)
(iv) If the above titration is carried out using methyl orange as the indicator instead of phenolphtalein, would there be a change in the bureter reading? Explain your answer. (Relative atomic mass: Al=27, S=32, Fe=56) (75 marks)
No
(02)
Because this is a strong acid- strong base titration
(02)
So the color change pH interval of methyl orange and phenolphthalein both falls into vertical region of the titration curve.
(02)

9(b): 75 marks

10.(a) The following flow chart shows the industrial extraction/production of three important elements/ compounds P_1 , P_2 and P_3 .

There is evidence to show that our ancestors produced P_1 thousands of years ago. P_1 is used as a catalyst in M_2 . P_3 is used in the manufacture of explosives.



- (vi) Give balanced chemical equations for reactions taking place in the processes M₁, M₂ and M₃. Appropriate conditions (temperature, pressure, catalysts, etc.) must be stated as required.
 (Note: For the M₁ process, give only the reactions showing the conversion of R₂ to P₁.)
 - M1: $3Fe_2O_3 + CO \rightarrow Fe_3O_4 + CO_2$ (02) $Fe_3O_4(s) + CO \rightarrow 3FeO(s) + CO_2(g)$ (02)

$$FeO(s) + CO(s) \rightarrow Fe(l) + CO_2(g) \quad ----(A)$$

2FeO(s) + C(s) \rightarrow 2Fe(l) + CO_2(g) $\quad ----(B)$

Either (A) or (B)

(02)

(02)

M2:

$$N_{2}(s) + 3H_{2}(g) \xrightarrow{200 - 300 \text{ atm (01)}} 2NH_{3}(s)$$

Fe catalyst (01)
K₂O and Al₂O₃ promoters (01)

101

200 200

(Any pressure between 200 – 300 atm and any temperature between 400 – 500 °C accepted)

M3:

$$4NH_3(g) + 5O_2 \xrightarrow{800 - 900 \circ C (01)} 4NO + 6H_2O(g)$$
(02)
$$2NO(g) + O_2 \rightarrow 2NO_2$$
(02)

$$4NO_2(g) + 2H_2O(I) + O_2(g) \rightarrow 4HNO_3$$
 (02)

(vii) Give two uses each of P_1 , P_2 and P_3 (other than what is indicated in the flow chart or given in the question).

P1 – to make alloy steel / construction industry to provide strength	
to structures / in machinery and tool manufacture	(01 x 2)

P2 – production of fertilizers / production of nylon / in petroleum industry to neurtralize acide in crude oil constituents / water and waste water treatment / as refrigerant / to prevent coagulation of rubber (01 x 2)

P3 – manufacture of fertilizer / in industries which require nitrates such as KNO₃ in explosive manufacture and AgNO₃ in photography / to clean surfaces when welding metals / aqua regia (01 x 2)

(viii) State whether the M2 process would be favoured at very high temperatures. Explain your
answer using ΔH , ΔS and ΔG .(50 marks)Reaction is exothermic. ΔH is (-ve)(50 marks)No of gaseous moles decrease. ΔS decreases (-ve)(01)According to $\Delta G = \Delta H - T\Delta S$ (01)When ΔS is negative, $-T\Delta S$ term is +ve.(01)As temperature increases, +ve term overrides -ve term, making ΔG +ve.(01)

Therefore not favoured at high temperature. (01)

10(a): 50 marks

- (b) The following questions are based on photochemical smog and water pollution.
 - State the major types of gaseous chemical pollutants and conditions that are required for the formation of photochemical smog.

 NO_x (NO or NO_2), Volatile hydrocarbon (VOC), sunlight/solar radiation, temperature above 15 °C (02 x 4)

(ii) State why the strength of photochemical smog is low in the morning and evening.

(03)

Therefore photochemical smog is weak in the morning and evening.

The intensity of solar radiation is low during morning and evening.

(iii) Using balanced chemical equations, explain how ozone is formed in the lower atmosphere due to photochemical smog.

 $\begin{array}{rcl} 2NO(g) + O_2(g) & \rightarrow & 2NO2(g) \\ NO_2(g) & \rightarrow & NO(g) + & O(g) \\ O(g) + & O_2(g) & \rightarrow & O_3(g) \end{array}$

(03 x 3)

(iv) State four major products (excluding ozone) of photochemical smog.

PAN (peroxy acetyl nitrate) PBN (peroxy benzoyl nitrate) Short chain(volatile) aldehydes Particles (particulate matter)

(02 x 4)

(v) State three free radicals produced during the formation of photochemical smog.

OH' (hydroxyl radical), ROO'(peroxy radical), R' (alkyl radical), RO' (Alkoxy radical), O' (oxygen radical), NO

(02 x 3)

(vi) Many countries now promote the use of electric vehicles. State how the use of electric vehicles affect the formation of photochemical smog.

Electric vehicles do not release ingredients for photochemical smog. (02)

Therefore, electric vehicles contribute for the reduction of photochemical smog/ no contribution for photochemical smog. (02)

(vii) State an environmental problem, other than photochemical smog, that could ease due to the use of electric vehicles.

Global warming/acid rain

(03)

(viii) A ship carrying the following chemicals sank in the sea. Na₂HPO₄, HNO₃, Pb(CH₃COO)₂ State an effect from each chemical on the water quality parameters of the water surrounding the ship, by the release of the above chemicals. (50 marks) PO₄³⁻, NO₃⁻, Reduction of dissolved oxygen level. HNO₃ Increases the acidity/decreases pH Pb²⁺ -Increases the heavy metal level of sea water /Increases the lead level of water (03 x 3) 10(b): 50 marks (c) The following questions are based on natural rubber and additives used for polymer related products. (i) Sketch the repeating unit of natural rubber. (10) (ii) Give a compound that can be used to prevent coagulation of natural rubber latex. NH₃ solution (04) (iii) State a compound that can be used to coagulate natural rubber latex and explain how it acts. Acids such as acetic/formic acid. (04)H+ can neutralize the COO- groups, making the surface of rubber particles neutral. Particles can then combine together and become as a mass. $(02 \times 4 = 08)$ (iv) Briefly state how the 'vulcanization' of natural rubber is carried out. rubber is heated with 1-3% sulfur $(03 \times 3 = 09)$ (v) State two types of substances used to increase the efficiency of vulcanization. Organic catalysts Catalyst promoters or ZnO $(03 \times 2 = 06)$ (vi) Give three properties, which can be enhanced by adding additives to polymer products. Increase flexibility Decrease flammability Prevent damage by UV rays Increase mechanical and/or physical strength (Any three) $(03 \times 3 = 09)$ 10(c): 50 marks