PART A — STRUCTURED ESSAY

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

Do not write in this column.

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

(i) The Lyman series observed in the emission spectrum of atomic hydrogen lies in the ultra-violet region of the electromagnetic spectrum. .....

(ii) There are only 10 electrons in a calcium atom with the azimuthal quantum number $l = 0$. .....

(iii) The number of Lewis dot-dash structures (resonance structures) that can be drawn for the N_2O molecule is 3. .....

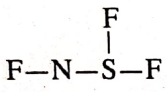
(iv) Among the second row elements of the Periodic Table, fluorine has the largest negative value of electron gain energy. .....

(v) The boiling point of argon (Ar) is higher than that of chlorine (Cl_2). .....

(vi) Ne has the highest first ionization energy, among the noble gases He, Ne and Ar. .....

(24 *marks*)

(*b*) (i) The skeleton of a molecule containing only the elements N, F and S is given below. Draw the **most** acceptable Lewis dot-dash structure for this molecule.

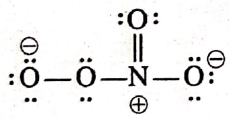


(ii) Give, (I) shapes around the N and S atoms and (II) oxidation numbers of the atoms in the structure drawn in (i) above.

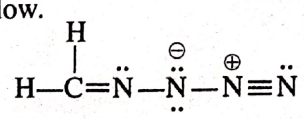
(I) N ..... , S ..... (shape)

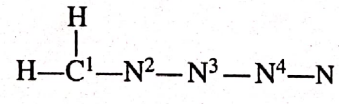
(II) N ..... , S ..... (oxidation number)

(iii) A Lewis dot-dash structure for the NO_4^- ion is given below. Draw **three** more Lewis dot-dash structures (resonance structures) for the NO_4^- ion .



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





		C^1	N^2	N^3	N^4
I.	the number of VSEPR pairs around the atom				
II.	electron pair geometry around the atom				
III.	shape around the atom				
IV.	hybridization of the atom				

[*see page three*

Do not write in this column.

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

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

I.	$H—C^1$	H	C^1 .....
II.	$C^1—N^2$	C^1	N^2 .....
III.	$N^2—N^3$	N^2	N^3 .....
IV.	$N^3—N^4$	N^3	N^4 .....
V.	$N^4—N$	N^4	N .....

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

I.	$C^1—N^2$	C^1	N^2 .....
II.	$N^4—N$	N^4	N .....
		N^4	N .....

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

C^1....., N^2 ....., N^3 ....., N^4.....

(viii) Arrange the atoms N^2, N^3 and N^4 in the **increasing** order of their electronegativity.

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

(56 *marks*)

(*c*) Arrange the following species in the **increasing** order of the property indicated in parentheses. Reasons are **not** required.

(i) CaF_2, $CaCl_2$, $CaBr_2$, CaI_2 (ionic character)

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

(ii) ClF_5, ClF_2^+, ClF_2^- (bond angle)

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

(iii) Na^+, S^{2-}, Cl^-, K^+ (ionic radius)

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

(iv) CO, CO_3^{2-}, HCO_2^-, H_2CO, CH_3OH (C—O bond length)

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

(v) Li, N, F, Mg, P (first ionization energy)

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

(20 *marks*)

100

Do not write in this column.

2. *(a)* The questions (i), (ii) and (iii) are based on the following reactions.

A is an ionic compound composed of three elements in the ratio 1 : 4 : 1 (Not in order of the chemical formula). One of these is a *d*-block element that belongs to the fourth period of the Periodic Table. When **A** is subjected to the flame test, a lilac (purple) flame is observed. On dissolving **A** in water, a purple coloured solution is obtained.

B is also an ionic compound composed of the same three elements as in **A**. **B** dissolves in water to give a green coloured solution.

C is a viscous colourless liquid composed of two elements. It disproportionates to give another colourless liquid **D** as one of the products. **C** can act as an oxidizing agent as well as a reducing agent. When **C** is added to a solution of **B**, the brown precipitate **E** is obtained.

F is a compound composed of three elements. One of these elements is a 3*d* element found in hematite. When $BaCl_2(aq)$ is added to an aqueous solution of **F**, the white precipitate **G** that is insoluble in dil. H_2SO_4 is formed.

H is composed of three elements. When an aqueous solution of **H** in a test tube is treated with a saturated solution of **F**, followed by addition of a small volume of conc. H_2SO_4 slowly, along the wall of the test tube, a brown colouration is seen on the surface where the liquids meet. The species responsible for the brown colouration is **I**. Brown fumes are not evolved when dil. H_2SO_4 is added to **H**. When **H** is subjected to the flame test, a yellow flame is observed.

J is the sodium salt of a weak dibasic acid. On treatment of a solution of **J** with $CaCl_2(aq)$, the white precipitate **K** is formed. **K** reacts with dil. H_2SO_4 to give the weak dibasic acid **L** as one of the products. A warm solution of **J** acidified with dil. H_2SO_4 decolourizes an aqueous solution of **A**.

(i) Identify **A** to **L**. **Note**: Write the chemical formulae.

A ..... **G** .....

B ..... **H** .....

C ..... **I** .....

D ..... **J** .....

E ..... **K** .....

F ..... **L** .....

(ii) Give balanced chemical equations for the following (physical states not required).

I. Formation of **D** from **C**.

II. Formation of **I**.

III. Formation of **K**.

[*see page five*

Do not write in this column.

(iii) Give balanced ionic equations for the reactions that take place when **A** is added to the following solutions (physical states not required).

I. an acidified solution of **C**

II. an aqueous solution of **F** acidified with dil. H_2SO_4

III. an acidified solution of **J**

(80 *marks*)

(*b*) Give balanced chemical equations for the reactions that take place between the following (physical states not required). State the function (oxidizing agent/reducing agent) of H_2S and SO_2 in reactions (i)–(iii).

(i) Mg(s) and $H_2S(g)$ .....

H_2S: .....

(ii) Mg(s) and $SO_2(g)$ .....

SO_2: .....

(iii) $H_2S(g)$ and $SO_2(g)$ .....

H_2S: ....., SO_2: .....

(iv) S(s) and conc. $HNO_3(aq)$ .....

(20 *marks*)

100

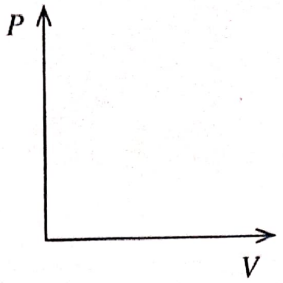
3. (*a*) (i) A closed container equipped with a piston contains a given mass of an ideal gas at a constant temperature T. Give the relationship between pressure P and volume V of the gas using a mathematical expression.

(ii) Show that the density d of the ideal gas in (i) above, at a constant temperature T is directly proportional to the pressure P.

[*see page six*

Do not write in this column.

(iii) Show the variation of P with V of the system in (i) above at the two different temperatures of 300 K and 500 K, by drawing two graphs in the figure given below. Indicate clearly the temperature corresponding to each graph.



(30 *marks*)

(*b*) Depletion of $O_3(g)$ occurs according to the mechanism given below in the presence of Cl(g) and O(g) atoms,

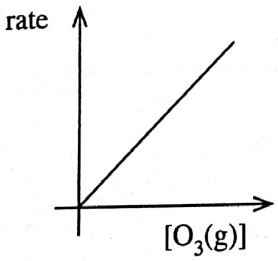
Step 1: $O_3(g) + Cl(g) \rightarrow O_2(g) + ClO(g)$

Step 2: $ClO(g) + O(g) \rightarrow Cl(g) + O_2(g)$

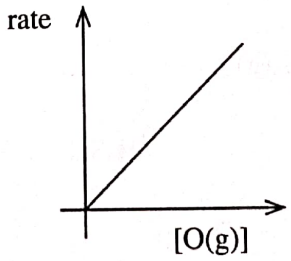
(i) Write the overall reaction for the mechanism given above.

(ii) Giving reasons, identify the **catalyst** and the **intermediate product** of the above mechanism.

(iii) The following graphs were obtained from an experiment carried out in relation to the overall reaction in (i) above at temperature T. Rates and concentrations are measured in units of mol dm^{-3} s^{-1} and mol dm^{-3} respectively.



Graph 1



Graph 2

Graph 1 was obtained by keeping [O(g)] constant.

Graph 2 was obtained by keeping $[O_3(g)]$ constant.

I. With the help of graphs 1 and 2, deduce orders of the reaction with respect to $O_3(g)$ and O(g). What is the overall order of the reaction?

II. If the rate constant of the reaction is k at temperature T, write the rate law of the reaction.

[*see page seven*

Do not write in this column.

III. Derive the units of k.

IV. In an experiment carried out at temperature T, the concentrations of $O_3(g)$ and $O(g)$ were 1.0×10^{-3} mol dm^{-3} and 1.0×10^{-4} mol dm^{-3} respectively. The rate of the reaction was found to be 1.0×10^{-3} mol dm^{-3} s^{-1}. Calculate the value of k.

100

(70 *marks*)

4. (*a*) **A**, **B** and **C** are hydrocarbons having the molecular formula C_5H_{10}. None of them show geometric isomerism. Both **A** and **B** are chain isomers of **C**. When **A** and **B** are separately treated with cold concentrated H_2SO_4 and the products obtained are diluted with water and heated, **D** and **E** are formed respectively. Of the two compounds **D** and **E**, only **D** shows optical isomerism. On catalytic hydrogenation, both compounds **A** and **B** give the same compound **F**, while compound **C** gives **G**. When **B** reacts with HBr in the presence of peroxide, **H** which is a primary alkyl halide is formed. Compound **H** when treated with aqueous NaOH gives **I**.

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

A

B

C

D

E

F

G

H

I

[*see page eight*

(ii) Describe a chemical test to distinguish **D**, **E** and **I** from one another.

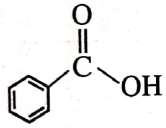
Do not write in this column.

(60 *marks*)

(*b*) (i) Draw the structures of the products **J**, **K**, **L**, **M** and **N** of the following reactions (I – V) in the given boxes.

(I) $CH_3CH(CH_3)CH_2CH_2Br$ —alcoholic KOH→

J

(II)  —conc. HNO_3/conc. H_2SO_4→

K

(III) $CH_3C(CH_3)=CH_2$ —HBr→

L

(IV) $CH_3COCH_2CH_3$ —HCN→

M

(V) $CH_3CH_2CH(CH_3)CH_2Br$ —KCN→

N

(ii) Selecting from the reactions I – V, give **one** example each, for each type of reaction given below.

Nucleophilic addition .....

Electrophilic addition .....

Elimination reaction .....

(40 *marks*)

100

* *

[*see page nine*

සියලු ම හිමිකම් ඇවිරිණි/முழுப் பதிப்புரிமையுடையது/All Rights Reserved]

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Department of Examinations, Sri Lanka Department of Examinations, Sri Lanka Department of Examinations, Sri Lanka Department of Examinations, Sri Lanka
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இலங்கைப் பரீட்சைத் திணைக்களம்
Department of Examinations, Sri Lanka

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2022(2023)
கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2022(2023)
General Certificate of Education (Adv. Level) Examination, 2022(2023)

රසායන විද්‍යාව	II	02 E II
இரசாயனவியல்	II	
Chemistry	II	

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

PART B — ESSAY

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

5. (*a*) Consider the reaction (1) given below at a temperature of 800 °C.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \text{ ---------- (1)}$$

Initially, 0.45 mol of HI(g) was introduced into a 1.0 dm^3 evacuated rigid closed container at 800 °C, and allowed to reach the equilibrium given above. It was found that 0.05 mol of $H_2(g)$ was present at equilibrium.

(i) Calculate the equilibrium constant K_{C_1}, for the above equilibrium at a temperature of 800 °C.

(ii) In a separate similar evacuated container at a temperature of 800 °C, reaction (2) takes place with an equilibrium constant $K_{C_2} = 1.2 \times 10^8\ mol^{-1}\ dm^3$.

$$2H_2(g) + S_2(g) \rightleftharpoons 2H_2S(g) \text{ ---------- (2)}$$

When the two containers are connected together, the following reaction (3) takes place at a temperature of 800 °C.

$$2I_2(g) + 2H_2S(g) \rightleftharpoons S_2(g) + 4HI(g) \text{ ---------- (3)}$$

Calculate the equilibrium constant K_{C_3} for the reaction (3) at a temperature of 800 °C.

(iii) A 1.0 dm^3 rigid closed container at a temperature of 800 °C contains an equilibrium mixture of (3) in (ii) above with 5.00×10^{-5} mol HI(g), 1.25×10^{-6} mol $S_2(g)$ and 2.50×10^{-5} mol $H_2S(g)$. Calculate the number of moles of $I_2(g)$ in the above mixture.

(iv) An extra 2.50×10^{-5} mol $I_2(g)$ was added to the equilibrium mixture in (iii) above at a temperature of 800 °C.

I. Calculate the reaction quotient (Q_C) at the moment the extra $I_2(g)$ is added.

II. Explain the change in the equilibrium that takes place upon the addition of extra $I_2(g)$.

III. Sketch the variation in the concentrations of each constituent in the mixture, with time, upon the addition of extra $I_2(g)$. **(60 *marks*)**

(*b*) (i) Using the data given below, calculate ΔH°, ΔS° and ΔG° for the reaction (4) at 27 °C.

$$H_2(g) + I_2(g) \longrightarrow 2HI(g) \text{ ---------- (4)}$$

At 27 °C : $H_2(g) + I_2(s) \longrightarrow 2HI(g)$; $\Delta H^\circ = 53\ kJ\ mol^{-1}$, $\Delta S^\circ = 410\ J\ K^{-1}\ mol^{-1}$

$I_2(s) \longrightarrow I_2(g)$; $\Delta H^\circ = 63\ kJ\ mol^{-1}$, $\Delta S^\circ = 260\ J\ K^{-1}\ mol^{-1}$

(ii) Using the data given below, calculate ΔH°, ΔS° and ΔG° for the reaction (5) at 27 °C.

$$2H_2S(g) \longrightarrow 2H_2(g) + S_2(g) \text{ ---------- (5)}$$

At 27 °C:

	ΔH_f° / kJ mol^{-1}	ΔS_f° / J K^{-1} mol^{-1}
$H_2(g)$:	0	130
$S_2(g)$:	127	230
$H_2S(g)$:	–20	200

[*see page ten*

(iii) Using the answers obtained in (*b*)(i) and (*b*)(ii) above, predict giving reasons whether the reaction (6) below is spontaneous or not at 27 °C.

$2I_2(g) + 2H_2S(g) \longrightarrow S_2(g) + 4HI(g)$ ---------- (6)

(60 *marks*)

(*c*) An aqueous solution of volume 1.0 dm^3 in a beaker at a temperature of 25 °C contains 2.0×10^{-2} mol of $Cl^-(aq)$ ions and 2.0×10^{-2} mol of $CrO_4^{2-}(aq)$ ions. Small portions of concentrated aqueous $AgNO_3$ solution were added **slowly** to the above solution. At 25 °C, K_{sp} (AgCl(s)) = 1.60×10^{-10} mol^2 dm^{-6} and K_{sp} (Ag_2CrO_4(s)) = 8.0×10^{-12} mol^3 dm^{-9}. Assume that there was no significant change in solution volume upon the addition of $AgNO_3$(aq) solution.

(i) Show that AgCl precipitates first by a suitable calculation.

(ii) Calculate the concentration of $Cl^-(aq)$ ions present in the solution at the time Ag_2CrO_4 starts to precipitate.

(30 *marks*)

6. (*a*) You are provided with an aqueous solution of sodium acetate (CH_3COONa) at 25 °C.

(i) Write the equilibrium reaction for the hydrolysis of sodium acetate in aqueous medium.

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

(iii) If the dissociation constants for CH_3COOH (aq), and H_2O (l) are K_a and K_w respectively at 25 °C, show that $K_h = \frac{K_w}{K_a}$.

(iv) Given that, $K_a = 1.8 \times 10^{-5}$ mol dm^{-3} and $K_w = 1.0 \times 10^{-14}$ mol^2 dm^{-6} at 25 °C, calculate the value of K_h at 25 °C.

(v) A portion of 25.00 cm^3 of 0.10 mol dm^{-3} CH_3COONa solution is titrated with a solution of 0.10 mol dm^{-3} HCl. What is the volume of 0.10 mol dm^{-3} HCl required to reach the equivalence point? Calculate the pH of the solution at the equivalence point.

(vi) Sketch the titration curve (pH *vs.* volume of HCl) for the above titration in (v).

(vii) State an indicator which can be used for the titration in (v) above.

(viii) Explain why it is **not** possible to titrate a 0.10 mol dm^{-3} CH_3COOH solution with a solution of 0.10 mol dm^{-3} aqueous ammonia.

(90 *marks*)

(*b*) An ideal binary liquid mixture was prepared by mixing two volatile liquids **A** and **B** at a given temperature. When the composition of the liquid phase was $X_A = 0.2$ and $X_B = 0.8$, the pressure of the vapour phase was P (X_A and X_B are mole fractions of **A** and **B** respectively in the liquid phase). When the composition of the liquid phase was changed to $X_A = 0.5$ and $X_B = 0.5$, the pressure of the vapour phase becomes $\frac{5}{3}P$. At this temperature, saturated vapour pressures of **A** and **B** are P_A° and P_B° respectively.

(i) Show that $P_A^\circ = 5P_B^\circ$.

(ii) Draw the corresponding composition - vapour pressure diagram for the mixture of **A** and **B** by showing the variations in P_A, P_B and P_{total} and label the diagram.

(iii) Calculate the composition of the liquid phase at the point where $P_A = P_B$.

(60 *marks*)

[*see page eleven*

7. (*a*) A galvanic electrochemical cell was constructed at 25 °C based on the following half - reactions (1) and (2).

$2H_2O(l) + O_2(g) + 4e \longrightarrow 4OH^-(aq)$ ---------- (1); $E° = 0.40$ V

$2H_2O(l) + 2e \longrightarrow H_2(g) + 2OH^-(aq)$ ---------- (2); $E° = -0.83$ V

(i) Identify the anodic and cathodic half reactions of the cell.

(ii) Write the overall balanced cell reaction of the cell.

(iii) Calculate E°_{cell} of the cell at 25 °C.

(iv) The cell was operated for a duration of 600 s. During this period, 1.0 mol $H_2(g)$ was consumed.

I. Calculate the number of moles of electrons which passed through the cell.

II. Calculate the amount of electricity (in coulombs) generated in the cell during its operation (1 F = 96500 C mol^{-1}).

III. Assuming that the current drawn from the cell is constant during the operation, calculate its value.

(v) In the above galvanic electrochemical cell propane ($C_3H_8(g)$) is used instead of $H_2(g)$.

I. Write the half-cell reaction for the propane electrode assuming propane is converted to $CO_2(g)$ and $H_2O(l)$.

II. Derive the balanced equation for the overall cell reaction by using propane instead of $H_2(g)$ in the answer given in (ii) above.

III. Giving reasons, state one environmental advantage of the cell which uses $H_2(g)$ over the cell that uses propane.

(75 *marks*)

(*b*) (i) **X** is a *d*-block element that belongs to the fourth period of the Periodic Table. On reacting **X** with dil. HCl, the colourless solution $\mathbf{X_1}$ and the gas $\mathbf{X_2}$ are obtained. When $\mathbf{X_1}$ is treated with dil. NH_4OH/NH_4Cl and H_2S is bubbled through the solution thereafter, the white precipitate $\mathbf{X_3}$ is obtained. $\mathbf{X_3}$ is soluble in dil. HCl. On addition of dil. NaOH to $\mathbf{X_1}$, the gelatinous white precipitate $\mathbf{X_4}$ is formed. $\mathbf{X_4}$ dissolves in excess dil. NaOH and in excess dil. NH_4OH to give $\mathbf{X_5}$ and $\mathbf{X_6}$ respectively. Both $\mathbf{X_5}$ and $\mathbf{X_6}$ are colourless.

I. Identify the species **X** and $\mathbf{X_1}$ to $\mathbf{X_6}$. (Give chemical formulae) **Note**: Reasons are not required.

II. Write the electronic configuration of **X**.

III. Explain why $\mathbf{X_1}$ is colourless.

IV. Write the IUPAC name of $\mathbf{X_6}$.

(ii) **Y** is also a *d*-block element that belongs to the same row as **X** in the Periodic Table. **Y** has two common oxidation numbers **n** and **m**. **m** is greater than **n**. $\mathbf{Y^{n+}}$ forms the pink coloured species $\mathbf{Y_1}$ in aqueous solution. On treatment of the solution containing $\mathbf{Y_1}$ with dil. NaOH the pink precipitate $\mathbf{Y_2}$ is formed. When H_2S is bubbled through a slightly basic solution containing $\mathbf{Y_1}$, the black precipitate $\mathbf{Y_3}$ is obtained. The yellowish-brown species $\mathbf{Y_4}$ is formed on addition of excess conc. ammonia to a solution containing $\mathbf{Y_1}$. On treatment of a solution containing $\mathbf{Y_1}$ with conc. HCl, the blue coloured species $\mathbf{Y_5}$ is obtained. On exposure of $\mathbf{Y_4}$ to air, the brownish-red species $\mathbf{Y_6}$ is formed.

I. Give the values of **n** and **m**.

II. Identify the species **Y** and $\mathbf{Y_1}$ to $\mathbf{Y_6}$. (Give chemical formulae) **Note**: Reasons are not required.

III. Write the electronic configurations of $\mathbf{Y^{n+}}$ and $\mathbf{Y^{m+}}$.

IV. Write the IUPAC name of $\mathbf{Y_5}$.

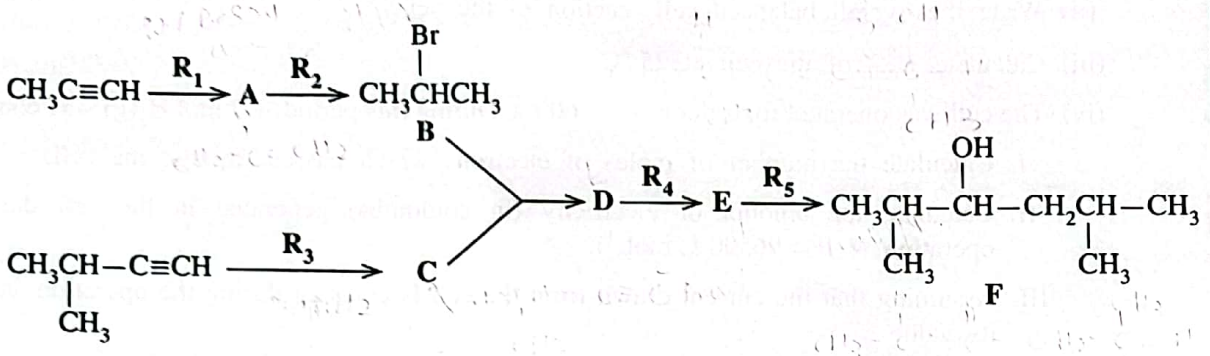
(75 *marks*)

[*see page twelve*

PART C — ESSAY

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

8. (*a*) Preparation of the compound **F** has been carried out using $CH_3C{\equiv}CH$ and $(CH_3)_2CHC{\equiv}CH$ according to the reaction scheme given below.



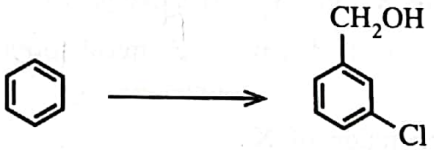
(i) Give the structures of the compounds **A**, **C**, **D** and **E** and the reagents $\mathbf{R_1}$, $\mathbf{R_2}$, $\mathbf{R_3}$, $\mathbf{R_4}$, and $\mathbf{R_5}$.
Only the chemical substances given below should be used either **singly or as combinations** as reagents.

Chemical substances:
H_2, $NaNH_2$, $NaBH_4$, $HgSO_4$, HBr, dil. H_2SO_4, Pd-$BaSO_4$/Quinoline catalyst, CH_3OH

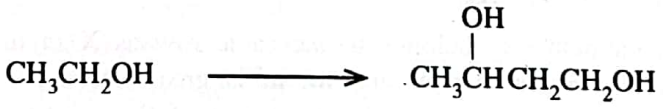
(ii) Compound **F** was reacted with $H^+/K_2Cr_2O_7$. When the product obtained from this reaction is reacted with 2, 4-dinitrophenylhydrazine (2, 4-DNP), compound **G** is formed. Give the structure of **G**.

(60 ***marks*****)**

(*b*) (i) Show how the transformation given below can be carried out using not more than **four (04)** steps.

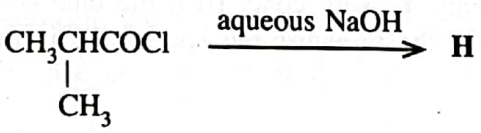


(ii) Show how the transformation given below can be carried out using not more than **three (03)** steps.



(60 ***marks*****)**

(*c*) Give the structure of the product **H** of the following reaction. Write the mechanism of this reaction.



(30 ***marks*****)**

[*see page thirteen*

9. (*a*) **A** and **B** are water soluble inorganic compounds. **A** is coloured while **B** is colourless. When aqueous solutions of **A** and **B** are mixed together, the white precipitate **C** and the water soluble compound **D** are formed. **C** dissolves in dil. HCl to give the gas **E** with a pungent smell as one of the products. When **E** is passed through a solution of acidified $K_2Cr_2O_7$, the solution turns green. Addition of dil. NH_4OH to an aqueous solution of **A** gives a green precipitate **F**. **F** dissolves in excess dil. NH_4OH to give a dark blue solution **G**. A black precipitate is formed when H_2S is bubbled through an aqueous solution of **A** to which NH_4OH/NH_4Cl has been added. On addition of $AgNO_3(aq)$ to an aqueous solution of **B**, a white precipitate **H** that is soluble in dil. NH_4OH is formed. Addition of $Pb(NO_3)_2(aq)$ to an aqueous solution of **B** gives a white precipitate **I** that is soluble in hot water. When dil. H_2SO_4 is added to an aqueous solution of **B**, a white precipitate **J** that is insoluble in dil. HCl is formed. **B** gives a green coloured flame in the flame test.

(i) Identify the species **A** to **J**. (Give chemical formulae) **Note**: Reasons are not required.

(ii) Write balanced chemical equations for the following.

I. Formation of **C** and **D**

II. Dissolution of **C** in dil. HCl

(75 *marks*)

(*b*) An iron ore, **X**, contains FeO, Fe_2O_3 and inert substances. The following experimental procedure was used to determine the mass percentages of FeO and Fe_2O_3 in **X**.

A mass of 0.4800 g of **X** was dissolved in 10 cm^3 of concentrated acid. This solution was filtered to remove insoluble matter, and thereafter diluted to 50.00 cm^3 using distilled water. This entire diluted solution was titrated with 0.020 mol dm^{-3} $KMnO_4$ solution. The titration reading at the end point was 20.00 cm^3. The pH of the entire solution, obtained after the titration, was raised to 12. At this stage, the metal ions in solution were precipitated as their hydroxides. The precipitate was filtered and dried until a constant mass was obtained. The mass of the precipitate obtained was 0.5706 g.

(i) Write balanced chemical equations for titration and precipitation reactions.

(ii) Calculate the mass percentages of FeO and Fe_2O_3 in **X**.
Note: Assume that the composition does not change during drying of metal hydroxides and there is no effect from dissolved oxygen in solution.
(H = 1, O = 16, Mn = 55, Fe = 56)

(75 *marks*)

[*see page fourteen*

10.(*a*) The following questions [(i) – (v)] are based on the manufacture of sulphuric acid by the Contact Process.

(i) State the **three** raw materials used.

(ii) Write balanced chemical equations for the reactions taking place. State proper conditions where necessary.

(iii) State **two** strategies used to increase the efficiency of the Contact Process.

(iv) State **two** principles used in the determination of the optimum conditions for the Contact Process and briefly explain each principle using a reaction you specified in part (ii) above.

(v) Name **two** industries which utilize sulphuric acid as a raw material.

(50 *marks*)

(*b*) Gaseous compounds of carbon, nitrogen and sulphur with various oxidation numbers directly contribute to global environment issues.

(i) Name **two** non-halogenated carbon compounds and **one** nitrogen compound that directly contribute to global warming and state the oxidation numbers of C and N in these compounds.

(ii) State how the three compounds you named in (i) above are released to the atmosphere due to human activities.

(iii) Explain how the compounds you mentioned in (i) above contribute to global warming.

(iv) Name **two** nitrogen compounds with the oxidation numbers of N that directly contribute to photochemical smog.

(v) Write balanced chemical equations for the formation of tropospheric ozone by a nitrogen compound you stated in (iv) above.

(vi) Explain why the tropospheric ozone level reaches its maximum level in the afternoon.

(vii) State **three** water quality parameters that are affected as a result of the dissolution of oxides of nitrogen and sulphur in water bodies.

(50 *marks*)

(*c*) The following questions are based on chemical products related to plant sources.

(i) Give relevant balanced equations to indicate the chemical changes that take place when ethanol in coconut toddy is produced by fermentation of sweet toddy.

(ii) Explain why it is necessary to remove free fatty acids from plant oils taken as raw materials in the production of bio-diesel.

(iii) Explain briefly why essential oils can be extracted from plant materials by steam distillation, at a temperature which is below the boiling points of both pure water and essential oil.

(50 *marks*)

* * *

[*see page fifteen*