SAMPLE PAPER 1

CHEMISTRY PAPER 1
(THEORY)

Maximum Marks: 70

Time Allowed: Three Hours

*(Candidates are allowed **additional 15 minutes** for **only** reading the paper.*

*They must **NOT** start writing during this time.)*

This paper is divided into four sections – A, B, C and D.
*Answer **all** questions.*
***Section – A** consists of **one** question **having sub-parts** of **one** mark each.*
***Section – B** consists of **ten** questions of **two** marks each.*
***Section – C** consists of **seven** questions of **three** marks each, and*
***Section – D** consists of **three** questions of **five** marks each.*
Internal choices have been provided in one question each in Section B,
Section C and Section D.
All working, including rough work, should be done on the same sheet as, and adjacent to the
rest of the answer.
The intended marks for questions or parts of questions are given in brackets [ ].
Balanced equations must be given wherever possible and diagrams where they are helpful.
When solving numerical problems, all essential working must be shown.
In working out problems, use the following data:
Gas constant $R = 1.987$ cal deg^{-1} mol^{-1} = 8.314 JK^{-1} mol^{-1} = 0.0821 dm^3 atm K^{-1}mol^{-1}
1 L atm = 1 dm^3 atm = 101.3 J, 1 Faraday = 96500 coulombs,   Avogadro's number = 6.023 x 10^{23}

SECTION A – 14 MARKS

Question 1

(A) Fill in the blanks by choosing the appropriate word(s) from those given in the brackets:
[increase, decrease, 3, 5, 6, 7, more, less, lowest, highest, half, two, four, eight, ortho-para, ortho-meta, meta-para]

(i) In the reaction $2A + B \rightarrow A_2B$, if the concentration of A is doubled and of B is halved, then the rate of the reaction will _____ by _____ times.

(ii) The coordination number and the oxidation state of the element E in the complex, $[E(en)_2(C_2O_4)]NO_2$, where (*en*) is ethylenediamine are, respectively _____ and _____.

(iii) Chlorobenzene exhibits _____ directing behavior in electrophilic substitution reactions but it is extremely _____ reactive in nucleophilic substitution reactions.

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(iv) Of the three isomeric nitrophenols, the *ortho* isomer exhibits steam volatility, has the _____ boiling point, and shows the _____ solubility in water.

(B) Select and write the correct alternative from the choices given below:

(i) A certain first order reaction has a half-life of 10 minutes. When a catalyst is added, the half-life is reduced to 5 minutes. Which one of the following statements explains this?

  (P) The catalyst increases the activation energy of the reaction.
  (Q) The catalyst provides an alternative pathway with a lower activation energy.
  (R) The catalyst increases the rate of the reaction.
  (S) The concentration of the reactants doubles with the addition of the catalyst.

 (a) Only P and R
 (b) Only Q and R
 (c) Only Q and S
 (d) Only P and S

(ii) For the same metal, the same ligands and metal-ligand distances, the correct relationship between Δ_t and Δ_0 is expressed as
 (a) $\Delta_t = (9/4)\Delta_0$
 (b) $\Delta_t = (5/7)\Delta_0$
 (c) $\Delta_t = (7/5)\Delta_0$
 (d) $\Delta_t = (4/9)\Delta_0$

(iii) What is the observed colour change when hydrogen peroxide (H_2O_2) is added to a potassium permanganate ($KMnO_4$) solution under acidic conditions?
 (a) Purple to red
 (b) Purple to green
 (c) Purple to colourless
 (d) Purple to blue

(iv) $CHCl_3$ and KOH on heating with a compound from a bad smelling product. The bad smelling product is
 (a) C_2H_5CN
 (b C_2H_5NC
 (c) C_2H_5OH
 (d) $C_2H_5NH_2$

(v) Which of the following solutions is expected to have the highest boiling point?
 (a) 0.1 M KCl
 (b) 0.1 M $MgCl_2$
 (c) 0.1 M $NaNO_3$
 (d) 0.1 M $K_4[Fe(CN)_6]$)

(vi) <u>**Assertion**</u>: Molar conductivity of a weak electrolyte at infinite dilution cannot be determined experimentally.

<u>**Reason**</u>: Kohlrausch law helps to find the molar conductivity of a weak electrolyte at infinite dilution.

    (a) Both Assertion and Reason are true and Reason is the correct explanation of Assertion.

    (b) Both Assertion and Reason are true but Reason is not the correct explanation for Assertion.

    (c) Assertion is true but Reason is false.

    (d) Assertion is false but Reason is true.

(vii) <u>**Assertion**</u>: Gabriel-phthalimide reaction cannot be used to prepare aromatic primary amines.

<u>**Reason**</u>: Aryl halides are more reactive than alkyl halides towards nucleophilic substitution reactions.

    (a) Both Assertion and Reason are true and Reason is the correct explanation of Assertion.

    (b) Both Assertion and Reason are true but Reason is not the correct explanation for Assertion.

    (c) Assertion is true but Reason is false.

    (d) Assertion is false but Reason is true.

(C) Read the passage given below carefully and answer the questions that follow.

The solubility of gases increases with increase of pressure. William Henry made a systematic investigation of the solubility of a gas in a liquid. According to Henry's law "the mass of a gas dissolved per unit volume of the solvent at constant temperature is directly proportional to the pressure of the gas in equilibrium with the solution". Dalton during the same period also concluded independently that the solubility of a gas in a liquid solution depends upon the partial pressure of the gas. If we use the mole fraction of gas in the solution as a measure of its solubility, then Henry's law can be modified as "the partial pressure of the gas in the vapour phase is directly proportional to the mole fraction of the gas in the solution".

    (i)   When a can of soda is opened, why do bubbles form and carbon dioxide (CO_2) is released into the air? Explain using Henry's law.

    (ii)   How does the Henry's law constant change with temperature, and what implications does this have for the solubility of gases in liquids?

    (iii)   Henry's law constant for the solubility of methane in benzene at 298 K is 4.27×10^5 mmHg. What is the solubility of methane in benzene at 298 K under 760 mmHg ?

SECTION B – 20 MARKS

Question 2

(i) Arrange the following compounds in the increasing order of their acidic character.
   p-nitrophenol, ethanol, phenol
(ii) Ethers are insoluble in water. Justify the statement.

Question 3

Give a reason for each of the following:

(i) Scandium (Z=21) is a transition element but zinc (Z=30) is not.

(ii) Ionisation enthalpies of Ce, Pr and Nd are higher than Th, Pa and U.

Question 4

Give balanced chemical equations to convert the following:

(i) Ethyl benzene to 2-phenylpropanoic acid
(ii) Benzene to m-nitro benzoic acid

Question 5

Answer for the following:

(i) Among Cu_2Cl_2 and $CuCl_2$, which is more stable and why?
(ii) Transition elements show variable oxidation states. Why?

Question 6

Two compounds, [Co(NH₃)₅Cl]Cl₂ and its mirror image, are enantiomers of each other.
Name one physical property that is:

(i) same for [Co(NH₃)₅Cl]Cl₂ and its enantiomer.
(ii) different for [Co(NH₃)₅Cl]Cl₂ and its enantiomer.

Question 7

(i) Can Fe^{3+} oxidise Br^- to Br_2 under standard conditions? Justify your answer.
$$E^{\ominus}_{Fe^{3+}/Fe^{2+}} = 0.77 \text{ W}, E^{\ominus}_{Br_2/Br^-} = 1.09 \text{ W}$$
(ii) If cell ' A ' has $E_{Cell} = 0.5$ V and cell ' B ' has $E_{Cell} = 1.1$ V then what will be the reaction at cathode and anode.

Question 8

(i) What happens when

(a) Anisole is treated with CH₃Cl/ anhydrous AlCl₃?
(b) Phenol is treated with Zn dust?
(Write chemical reactions only)

<div align="center">**OR**</div>

(ii) An organic compound (A) having molecular formula C_2H_6O on oxidation with $Na_2Cr_2O_7$ / H_2SO_4 produces a compound (B) which reduces Tollen's reagent. Both (A) and (B) produce a yellow solid on treatment with I_2 /OH⁻.

(a) Identify A and B.

(b) Write the reaction for the formation of B from A.

Question 9

When 1.5 g of a non-volatile solute was dissolved in 90 g of benzene, the boiling point of benzene raised from 353.23 K to 353.93 K. Calculate the molar mass of the solute. (K_b for benzene = 2.52 kg mol⁻¹)

Question 10

(i) Although phenoxide ion has more number of resonating structures than carboxylate ion, carboxylic acid is a stronger acid than phenol. Why?

(ii) Oxidation of propanal is easier than propanone. Why?
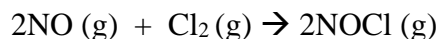
Question 11

(i) Give a reason to explain why transition metals can form coloured compounds.
(ii) Explain why Zn, Cd and Hg are generally not considered as transition metals.

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SECTION C – 21 MARKS

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Question 12

For the reaction:
2NO (g) + Cl_2 (g) → 2NOCl (g)

The following data were collected. All the measurements were taken at 263 K.

| Experiment	Initial [NO] (M)	Initial [Cl₂] (M)	Initial rate of disappearance of Cl₂ (M) min.
1	0.15	0.15	0.60
2	0.15	0.30	1.20
3	0.30	0.15	2.40
4	0.25	0.25	?

(a) Write the expression for rate law.

(b) Calculate the value of rate constant and specify its units.

(c) What is the initial rate of displacement of Cl_2 in experiments?

Question 13

(i) Arrange the following in increasing order of solubility in water:

$$C_6H_5NH_2, (C_2H_5)_2NH, C_2H_5NH_2$$
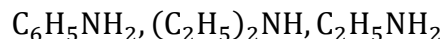
(ii) Arrange the following in decreasing order of the pK_b values:

$$C_2H_5NH_2, C_6H_5NHCH_3, C_6H_5NH_2$$

Question 14

(i) Which one of the following is a polysaccharide: Starch, Maltose, Fructose, Glucose?

(ii) What one difference between α-helix and β pleated sheet structure of protein.

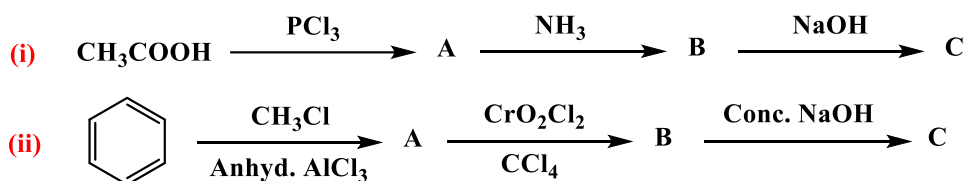**(iii)** Write the name of the disease caused by the deficiency of Vitamin B_{12}.

Question 15

Vapour pressure of water at 20°C is 17.5 mm of Hg and lowering of vapour pressure of a sugar solution is 0.061 mm of Hg. Calculate

(a) relative lowering of vapour pressure

(b) vapour pressure of the solution.

(c) mole fraction of sugar and water.

Question 16

Identify the compounds [A], [B] and [C].

(i) $CH_3COOH \xrightarrow{PCl_3} A \xrightarrow{NH_3} B \xrightarrow{NaOH} C$

(ii) (benzene ring) $\xrightarrow[\text{Anhyd. AlCl}_3]{CH_3Cl} A \xrightarrow[\text{CCl}_4]{CrO_2Cl_2} B \xrightarrow{\text{Conc. NaOH}} C$
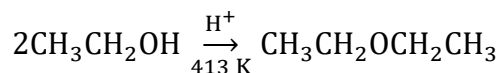
Question 17

(i) How will the following be obtained? (Give chemical equations only)

(a) Benzyl chloride to Benzyl alcohol

(b) Anisole to *p*-Bromoanisole
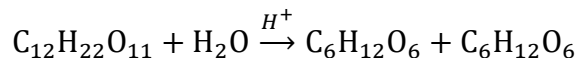
(c) Nitrobenzene to Acetanilide

OR

(ii) Write the mechanism of acid dehydration of ethanol to yield ether:

$$2CH_3CH_2OH \xrightarrow[413\ K]{H^+} CH_3CH_2OCH_2CH_3$$

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Question 18

(i) The decomposition of A into products has a value of k as 4.5×10^3 s^{-1} at 10°C and energy of activation 60 kJ mol^{-1}. At what temperature would k be 1.5×10^4 s^{-1} ?

(ii) For the reaction

$$C_{12}H_{22}O_{11} + H_2O \xrightarrow{H^+} C_6H_{12}O_6 + C_6H_{12}O_6$$

Write:

(a) Rate of reaction expression

(b) Rate law equation,

(c) Molecularity,

(d) Order of reaction

SECTION D – 15 MARKS

Question 19

(i) Give a reason for each of the following:
   (a) HCOOH does not give HVZ reaction while CH$_3$COOH does.
   (b) Oxidation of alcohols to get aldehyde is carried out under controlled conditions.
   (c) Ethanal is soluble in water.

(ii) An unknown aldehyde ' A ' on reacting with alkali gives a β-hydroxy aldehyde, which loses water to form an unsaturated aldehyde, But-2-enal. Another aldehyde ' B ' undergoes disproportionation reaction in the presence of conc. alkali to form products C and D. C is aryl alcohol with the formula, C_7H_8O. Identify A and B.

Question 20

**(i)** If one mole of a different isomer of [Cr(H$_2$O)$_6$]Cl$_3$ complex reacts with AgNO$_3$, resulting in the formation of 1 mole of AgCl precipitate, provide the formula for this isomer and explain the variations in metal-ligand bonding among the isomers.

(ii) In a coordination compound demonstrating d^2sp^3 hybridization, categorize the ligand as either weak or strong. Determine the compound's geometry based on this hybridization.
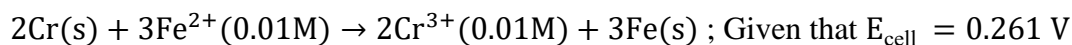
Question 21

(i) (a) For the cell:

$$Zn|Zn^{2+}(a = 1) \parallel Cu^{2+}(a = 1)|Cu$$
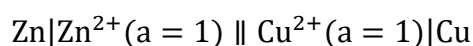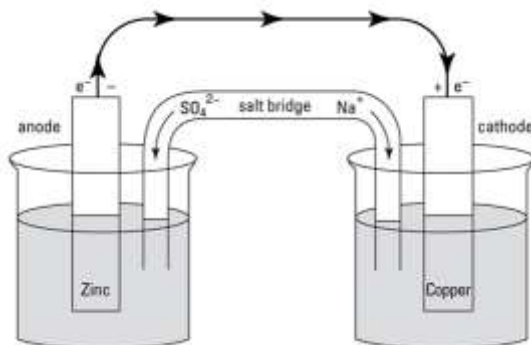
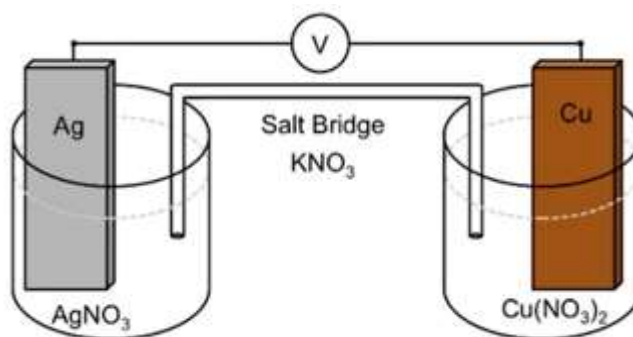Given that $E^o_{Zn^{2+}/Zn} = -0.761$ V; $E^o_{Cu^{2+}/Cu} = 0.339$ V

(a) Write the cell reaction and calculate the emf and free energy change at 298 K involved in the cell.

(b) Calculate E^0_{cell} for the following at 298 K :

$$2Cr(s) + 3Fe^{2+}(0.01M) \rightarrow 2Cr^{3+}(0.01M) + 3Fe(s) \text{ ; Given that } E_{cell} = 0.261 \text{ V}$$

OR

(ii) (a) A copper-silver cell is set up

The copper ion concentration is 0.01 M. The concentration of silver ion is not known. The cell potential was found to be 0.422 V. Determine the concentration of silver ions in the cell. (Given: $E^o_{Ag^+/Ag} = +0.80$ V; $E^o_{Cu^{2+}/Cu} = 0.34$ V)

(b) Silver is uniformly electro-deposited on a metallic vessel of total surface area 500 cm² by passing a current of 0.5 ampere for 2 hours. Calculate the thickness of silver deposited.

(Given density of silver = 10.5 g cm⁻³. Atomic mass of silver = 108 amu, F = 96500 C mol⁻¹)

*************************** The End ***************************