CHEMISTRY
PAPER - 2 (THEORY)

(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**.

The intended marks for questions or parts of questions are given in brackets [ ]. Balanced equations must be given wherever possible. When solving numericals 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 x10^{23}.*

SECTION A - 14 MARKS

Question 1

(A) Fill in the blanks by choosing the appropriate word/words from those given in the brackets: **[4]**

[aniline, phenol, benzene, common ion effect, decreased, increased, acetone, acetyl chloride, 3, 2,4, 27S^4, S^2,S^3]

(i) -------- on treatment with Zn-dust followed by treatment with --------- gives acetophenone.

(ii) The oxidation number of Fe in $[Fe(CN)_6]^{3-}$ is ------, but in $[Fe(H_2O)_6]^{2+}$ is ------.

(iii) The dissociation of H_2S is ---------- in the presence of HCl due to ----------.

(iv) Ksp = --------- for $Fe(OH)_3$ and Ksp = ---------- for KNO_3

(B) Complete the following by selecting the correct alternatives from the choices given: **[7]**

(i) An increase in the pressure on $2SO_2 + O_2 \leftrightarrow 2SO_3$ + heat will:

(a) shift the equilibrium forward (b) maintains the equilibrium at constant volume

(c) shift the equilibrium backward (d) maintains the equilibrium at constant pressure

(ii) O_2^+ is paramagnetic because of the presence of unpaired electron in:

(a) π* 2py (b) π* 2pz (c) both π* 2py and π* 2pz (d) π2py

(iii) The correct matched order of the B.O of the below given species is:

Species:	Bond orders:
1. O_2	A- 2
2. N_2	B- 0.5
3. He_2^+	C- 3
4. N_2^+	D- 2.5

(a) 1 - A, 2 - B 3 - C, 4 - D (b) 1- D, 2 - C, 3 - B, 4 - A

(c) 1 - A, 2 - C, 3 - B, 4 - D (d) 1 - B, 2 - A , 3 - C, 4 - D

(iv) Ethyne on treatment with Hg^{2+}/ H_2O in presence of dil.H_2SO_4 gives --------- which upon treatment with HI in presnce of red P at 473 K gives ----------

(a) acetaldehyde, ethanol (b) ethanal, ethane

(c) ethane, acetaldehyde (d) acetone, propane

(v) An aqueous solution of CH_3COONa is basic due to:

(a) Anion hydrolysis (b) Cation hydrolysis

(c) Weak acid formation (d) Option (b) and (c)

(vi) ASSERTION: When HCl gas is passed through a saturated solution of common salt, pure NaCl gets precipitated.

REASON: The ionic product of NaCl gets lowered.

(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 of Assertion.

(c) Assertion is true but Reason is false. (d) Assertion is false but Reason is true.

(vii) ASSERTION: p- nitro benzoic acid is more acidic than p- methyl benzoic acid.

REASON: Electron donating effect of - I effect groups are more pronounced at p- position than at m- position.

(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 of 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: **[3]**

The compounds which have the same molecular formula but differ from each other in physical or chemical properties are called isomers and the phenomenon is called isomerism. When the isomerism is due to difference in the arrangement of atoms within the molecule, without any reference to space, the phenomenon is called structural isomerism. In other words, structural isomers are compounds that have the same molecular formula but different structural formulas. When the isomerism is due to difference in the arrangement of atoms within the molecule, with any reference to space and the effect of rotation of the plane of a plane polarised light, the phenomenon is called stereo isomerism. The isomers of a compound which differ only in the position of the protons and electrons are called tautomers.

(i) Analyse the below given pairs of compounds. If they satisfy the condition to exhibit isomerism, then state the type of isomerism exhibited by the pairs of compounds.

CH_3-CH(CH_3)-CH_2-CH_3 and CH_3-CH_2-CH(CH_3)-CH_3

(ii) Which of the following sets of compounds *do not* have same molecular formula? Also state the type of isomerism exhibited by set (3) compounds.

(1) Butane and iso-butane (2) Cyclohexane and hexane (3) Propanal and propanone

(iii) For the molecule **CHCl=CHBr**, draw the cis and trans isomers and explain why geometrical isomerism is possible in this case?

(iv) Draw the enantiomers of the molecule CH_3-CH(OH)-CH_2-CH_3, and explain why they are mirror images of each other.

(v) Write two isomers with the formula C4H8.

SECTION B - 20 MARKS

Question 2

(i) What is the value of ΔG at 298 K for the reaction A→B when ΔS = ˉ175.6 J /K /mol and ΔH = ˉ57.2 kJ/ mol ? **[2]**

(ii) Predict whether at 27°C the following reaction is spontaneous or not.

$4NH_3$ (g) + $5O_2$ (g) → 4NO(g) + $6H_2O$(l) (ΔH = 9.08 kJ/mol ΔS = 0.0357 kJ $K^{-1}mol^{-1}$)

(iii) Using MOT concepts, answer the following for N_2^{2+} and N_2^{+}.

(a) Write the molecular orbital configuration.

(b) Which of these does show highest paramagnetism?

Question 3

(i) The enthalpy change (Δ*H*$_{vap}$) for the transition of liquid water to steam is 40.8 KJ/ mol at 100°C. Calculate the following: **[2]**

(a) entropy change (Δ*S*$_{vap}$) for the process. (b) free energy change for this vapourisation process.

(ii) State the following :

(a) First law of thermodynamics (b) Hess's law

Question 4

A compound known by the name gammaxane (BHC) is widely used in agricultural fields. It's prepared from the parent aromatic hydrocarbon benzene. **[2]**

(a) Give a balanced equation for the preparation of gammaxane from benzene.

(b) What will be the product formed when benzene is subjected to electrophilic substitution with Cl_2 in presence of $FeCl_3$?

(c) How will you convert benzene to nitrobenzene? Give the equations.

(d) How can benzene be converted to ethyl benzene via Friedel crafts alkylation? Give the equations.

Question 5

(i) In which direction will the following equilibria shift with a decrease in temperature? **[2]**

(a) $2\,H_2\,(g) + O_2\,(g) \rightleftarrows 2\,H_2O\,(l) + Q_1$

(b) $2\,NH_3\,(g) \rightleftarrows N_2\,(g) + 3\,H_2\,(g) - Q_2$

(c) $CaCO_3\,(s) + Q_3\,(g) \rightleftarrows CaO\,(s) + CO_2\,(g)$

(ii) Rehan was asked to analyse the below given processes and find out the one which is accompanied by an increase of entropy. Help him identify the correct option by supporting with a suitable reason, keeping in mind; entropy is measure of disorder.

(a) Dissolution of iodine in a solvent.

(b) Addition of HCl to $AgNO_3$ solution causing the precipitation of AgCl.

(c) A partition is removed to allow two gases to mix.

Question 6

(i) If 0.561 gram of KOH is dissolved in water to give 200 ml of solution at 298 K. Calculate the concentrations of potassium, hydrogen and hydroxyl ions. what is the pH of this solution? **[2]**

(ii) The concentration of Hydronium ion in a sample of soft drink is 3.8×10^{-3}M. What is the pH?

Question 7

Write the structures of the following and classify them as 1^o, 2^o and 3^o alcohols: **[2]**

(i) isobutyl alcohol

(ii) neo- pentyl alcohol

(iii) 3 - methyl 3 - hydroxy hexane

(iv) 3- hexen 1- ol

Question 8

(i) What is the molarity of a solution prepared when 20 gram of solute (molar mass 342 g/ mol) are dissolved in enough water to make a final volume up to 2 litres. **[2]**

(ii) Calculate the molarity and normality of an aqueous solution which contains 19.6 g of sulphuric acid in two litre (molar mass of H_2SO_4 = 98 g/mol).

(iii) A sample of $NaNO_3$ weighing 0.38 g is placed in a 50 mL capacity volumetric flask and the flask is filled fully with water. What is the molarity of the solution?

Question 9

(i) Give reasons for the following: **[2]**

Kiran was analysing the influence of H- bonding on the physical properties viz: boiling point, melting point, viscosity, etc of compounds. He studied the two types of H-bondings existing in molecules. Now he has to find scientific reasons for the following observations made. Help him to frame out correct reasons based on the extent and types of H- bonding:

(a) Acetic acid exists as a dimer. (b) Alcohols are miscible with water.

(ii) Below given is a box containing few properties.Classify them as intensive or extensive properties.

pressure, volume, temperature, concentration, entropy, enthalpy, mass

OR

(iii) State which of the following are spontaneous and nonspontaneous processes? Give reason for your inference.

(a) Diffusion of a gas from higher pressure to lower pressure.

(b) Flow of heat from lower to higher temperature.

(c) Precipitation of AgCl in the reaction when solutions of silver nitrate and sodium nitrate are mixed.

(iv) "Entropy of the universe is not constant." Comment on this statement from the background of ' thermal death' which is likely to be witnessed in the coming years.

(v) Write the electronic configurations of the below given atoms. Indicate the number of unpaired electrons and the orbital in which those unpaired electrons are present in the following atoms: (a) P (Z = 15) (b) Ni (Z = 28)

Question 10

(i) Find the pH of a solution containing 0.098 g of H_2SO_4 per litre of the solution. **[2]**

(ii) Norah has to compute the pH of the following two solutions. The only information given regarding the solutions were about the RMM of the solutes present in the solutions. Help her to calculate the pH of these two solutions. (Hint: one solution is acidic and the other one is basic)

(a) 10^{-8} M solution (M' = 36.5) (b) 10^{-8} M solution (M' = 40)

Question 11

The concepts of VBT, MOT and hybridization plays a remarkable phase in the history of chemical bonding. Keeping the principles of hybridisation, refer to ethyne (C_2H_2) molecule and state the following: **[2]**

(i) Type of hybridization (ii) Bond angle (iii) Structure/shape

(iv) Total number of sigma and pi bonds (v) No. of C - C sigma and C -C pi bonds

(vi) No. of C - H sigma bonds (vii) Percentage of s and p characters

SECTION C - 21 MARKS

Question 12

(i) A solution contains 25% water, 25% ethanol (C_2H_5OH) and 50% acetic acid (CH_3COOH). Find the mole fraction of each component. **[3]**

(ii) Calculate the equivalent weights of the following: (Given: R.A.M of O = 16, Al = 27, Cl = 35.5)

(a) $AlCl_3$ (b) Oxygen

(iii) What is the molality of a semimolar NaCl solution if the density of the solution is $1.16 g/cm^3$

Question 13

(i) It is highly interesting to know about the better yield concept as per the le- chatellier's principle in the reversible chemical equilibria. Study the following equilibrium and state the following: $X_2 + 4Y_2 \Leftrightarrow 2XY_4$ H = +ve **[3]**

Where would the equilibrium shift towards if:

(a) pressure is increased (b) temperature is decreased

(c) Ne added at constant volume (d) few moles of X_2 is removed

(ii) Give reasons for the following:

(a) A white ppt is formed when dilute H_2SO_4 is added to $BaCl_2$.

(b) Cu^{2+}(Group II) is precipitated as CuS in acid medium while Ni^{2+}(Group IV) is precipitated as NiS in basic medium. Why?

Question 14

(i) Copy down the below given reactions and complete them. **[3]**

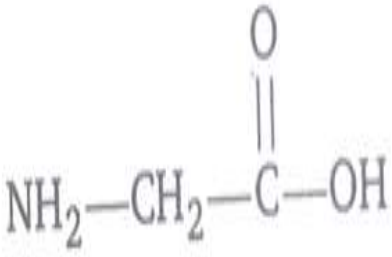
(a) $CH_3\text{-}CH_2\text{-}CO\text{-}CH_3$ + red P $_{(523K)} \rightarrow$

(b) $CH_3\text{-}CH_2\text{-}CH_2\text{-}OH$ + conc.H_2SO_4 $_{(443K)} \rightarrow$

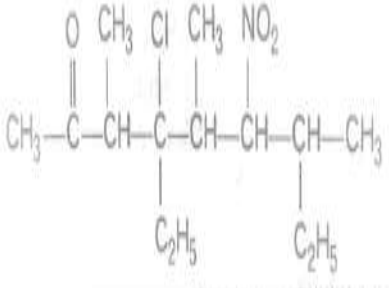
(c) C_6H_{14} + Cr_2O_3, Al_2O_3 $_{(770K)} \rightarrow$

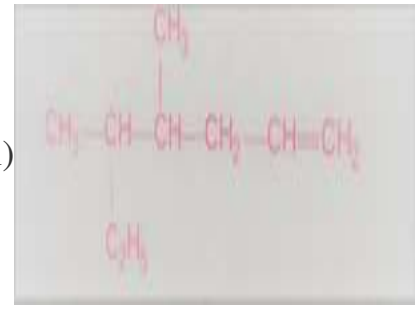
(ii) Write the IUPAC names of the following organic compounds:

(i)



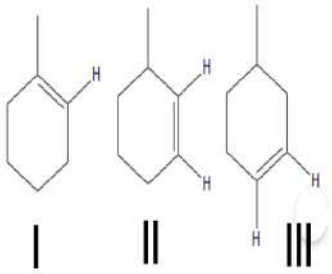
(ii)



(iii) 

Question 15

(i) **[3]**



compound I	1-methyl cyclohexene
compound II	3-methyl cyclohexene
compound III	4-methyl cyclohexene

Analyse the above given aromatic alkenes and identify the major stable product formed according to Saytzeff's rule among them. (Hint : Check the substitution across the double bond)

(ii) Calculate ($\Delta S°$) for the given reaction at 25°C. $SO_2(g) + {}^1/_2\, O_2\,(g) \rightarrow SO_3\,(g)$

The absolute entropies at 25°C and 1 atm pressure for $SO_2(g)$, $O_2(g)$ and $SO_3(g)$ are 248.5, 205.0 and 256.2 J /K / mol respectively.

Question 16

(i) Lactic acid (2- hydroxy propanoic acid) and tartaric acid are optically active. They exists in different isomeric forms. **[3]**

(a) Draw the isomers of lactic acid.

(b) Which are the optical isomers of lactic acid?

(c) Is the racemic mixture of lactic acid optically active? Why?

(d) Does mesotartaric acid exhibit optical activity? Why?

(ii) Write the structure of 2- chloro 2- methyl propan 1- al. Is this compound optically active / inactive ? Give reason also.

(iii) Complete the given reaction by identifying the unknown compounds in the reaction sequence:

$A + \text{alc.KOH} \rightarrow B + CH_3\text{-}CH{=}CH_2 + KCl$

OR

(iv) Predict the hybridizations of the central atom in the following:

(a) IF_5 (b) XeO_3

(v) Arrange 2- nitro butanoic acid, 3- nitro butanoic acid, butanoic acid and 4-nitrobutanoic acid in the increasing order of acidic strength.

(vi) It is observed that when an unsymmetrical alkene is subjected to addition of a hydrogen halide, say HBr two different products are formed as major and minor ones based on certain rules.

(a) Which are the major and minor products when 1- propene is subjected to addition of HBr?

(b) Name the rule that governs the above addition reaction in (a).

(c) Write chemical equations showing this addition reaction.

(d) Which are the major and minor products when 1- pentene is subjected to addition of HBr in the presence of an organic peroxide?

(e) Name the rule that governs the above addition reaction in (d).

Question 17

(i) During a process, a system absorbs 710 KJ of heat and does 250 J of work. Calculate the change in the internal energy of the system. **[3]**

(ii) A gas expands against a constant pressure of 1 atm from a volume of 5L to 10L. During the process, system absorbs 400 J of heat from the surroundings. Calculate the change in the internal energy of the system. (1L atm = 101.3 J)

(iii) Calculate the mass of the solute in the following solutions: (given R. A. M of K = 39, O= 16, Cl= 35.5, H =1)

(a) 150 cm^3 of M/2 HCl (b) 100 cm^3 of N/10 KOH

(iv) In the qualitative Inter-group separation of cations, the group reagents pertaining to each group are added from minimum amount onwards so as to ensure the relative increase of Ksp from group -1 to group - 6. A student was asked to perform the qualitative analysis of the cations. A set of three salts were given. He was asked to determine the following three cations. (A) Al^{3+} (B) Cu^{2+} (C) Mg^{2+}

(a) Which among the following needs maximum amount of HCl for the precipitation as the respective chloride? Why?

(b) What is Cu^{2+} precipitated as in group -II. Specify the reagents.

(c) What is the reagent for the precipitation of Al^{3+}?

Question 18

(i) Below given is a table of a few polymers, their uses and the monomer units. Match the polymers with their respective monomers and uses correctly. **[3]**

Polymers	Uses	Monomers
1. Teflon	Pipes / taps, toys	Vinyl chloride

2. PVC	Non - stick cookwares	Styrene
3. Styron	Refrigerator liners, insulation materials	Tetrafluoroethylene

(ii) Write the mathematical expression for the equilibrium constant (Kc) for the following reversible reactions:

(a) $^1/_2\ N_2O_{4\,(g)} \Leftrightarrow NO_{2\,(g)}$

(b) $CH_3COOC_2H_{5\,(aq)} + H_2O_{\,(l)} \Leftrightarrow CH_3COOH_{\,(aq)} + C_2H_5OH_{\,(aq)}$

(iii) Write the Ksp - S relation for the below given sparingly soluble salts:

(a) $Ca_3(PO_4)_2$ (b) $MgCl_2$

(iv) Upon passing H_2S in presence of dil.HCl which among Cu^{2+} and Zn^{2+} gets precipitated. Why?

SECTION D - 15 MARKS

Question 19

(i) How will you bring about the following conversions: **[5]**

(a) ethene to formaldehyde (b) propanoic acid to ethene

(c) ethane to methane (d) propanone to 2- bromopropane

(e) ethanol to ethoxyethane (f) methane to ethane

(g) 2- propanol to ethene (h) ethyne to ethyl magnesium bromide

(ii) How will you convert the following aromatic compounds?

(a) sodium benzoate to chlorobenzene (b) Phenol to toluene

Question 20

(i) Balance the following equations by oxidation – number method: **[5]**

(a) $KMnO_4 + H_2C_2O_4 + H_2SO_4 \rightarrow K_2SO_4 + MnSO_4 + CO_2 + H_2O$

(b) $HNO_3 + H_2S \rightarrow NO + S + H_2O$

(ii) Identify the substance undergoing oxidation and reduction, the oxidising agent and reducing agent in the given reaction:

$3MnO_2 + 4Al \rightarrow 3Mn + 2Al_2O_3$

(iii) Calculate the oxidation number of the underlined element in the following species:

(a) $K_3[\underline{Co}(CN)_6]$ (b) $[\underline{Cr}(Cl)_4(NH_3)_2]^{2+}$ (c) $\underline{Cr}_2O_7^{2-}$ (d) $\underline{Br}O^-$

(iv) What are the hydronium and hydroxyl ion concentrations in 0.04M HCl.

(v) Calculate the pH of the solution containing 0.28 g of KOH in 1 litre of water.

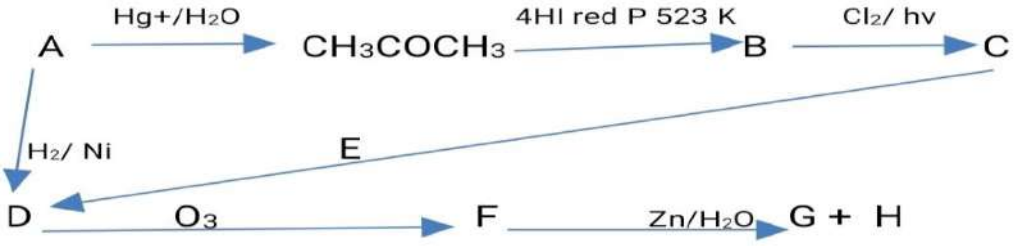
(M' of KOH = 56)

Question 21

(i) Identify the unknown compounds from A to H in the below given reaction sequence. **[5]**

Write the chemical equations involved while identifying the compounds. After identifying the unknown compounds, carry out the following conversions:

(a) compound C to hexane by using Wurtz reaction (b) compound B to isobutane



OR

(ii) For a reaction M→N, calculate equilibrium constant at 400 K given that $\Delta H^\circ = 77.2$ kJmol and $\Delta S^\circ = 0.122$ kJ K^{-1} mol^{-1} at 400 K.

(iii) What is the molality of ammonia in a solution containing 0.85 g of NH_3 in 100 cm^3 of a liquid of density 0.85 g/cm^3?

(R.A.M of N = 14, H =1)

(iv) Identify the element with the given electronic configuration - [Ne] $3s^2$ $3p^6$ $4s^2$

(v) An organic compound A on reaction with 4HI and Red P at 423 K gave another compound B. B is chlorinated in presence of hv to get C. C on reaction with Mg in presence of dry ether gave D. D when treated with water gave E. E on chlorination can give C. C when treated with alc.KOH followed by ozonolysis and Zn/H_2O treatment gives formaldehyde. Identify the unknown compounds from A to E. Write the reactions involved during the identification.

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