

ISC - PART II
SCIENCE & MATHEMATICS

ANALYSIS OF PUPIL PERFORMANCE



Council for the Indian School Certificate Examinations

ISC EXAMINATION 2015

FOREWORD

This document of the analysis of pupils' performance at the ISC Year 12 and ICSE Year 10 Examination is one of its kind. It has grown and evolved over the years to provide feedback to schools in terms of the strengths and weaknesses of the candidates in handling the examinations.

We commend the work of Mrs. Poonam Sodhi and the ISC Division of the Council who have painstakingly prepared this analysis. We are grateful to the examiners who have contributed through their comments on the performance of the candidates under examination as well as for their suggestions to teachers and students for the effective transaction of the syllabus.

We hope the schools will find this document useful. We invite comments from schools on its utility and quality.

November 2015

**Gerry Arathoon
Chief Executive & Secretary**

INTRODUCTION

The Council has consistently been bringing out the “Pupil Performance Analysis” document since 1994. This document is reviewed every year and changes incorporated based on suggestions received from various quarters which include experts in the field of education as well as heads of schools and teachers, in order to make the study more useful and meaningful.

This document comprises of qualitative analysis of performance of pupils at the ISC examinations. Performance Analysis has been carried out for the most popular subjects that are largely ascribed to, by the schools. The purpose of this study is to enable teachers to see at a glance, overall performance of all candidates who have taken the examination and examiners comments on each question. This would enable the teachers to understand the assessment of the ISC examinations better and would help them to guide their students more effectively.

The qualitative analysis details the assessment criteria followed for evaluation of answer scripts. Once the process of evaluation of scripts is over, examiners are requested to give detailed comments on the performance of candidates for each question. This includes the examiners’ response on what constitutes a good answer; common errors made by candidates while answering the questions; their popularity with students and overall performance of students.

Mrs. Shilpi Gupta along with Dr. M.K. Gandhi, Mrs. Desiree Tennent and Ms. Mansi Guleria have done commendable work in ensuring that this document is prepared well in time, in order to guide students who will be appearing for the ISC Examination.

November 2015

**Poonam Sodhi
Deputy Secretary**

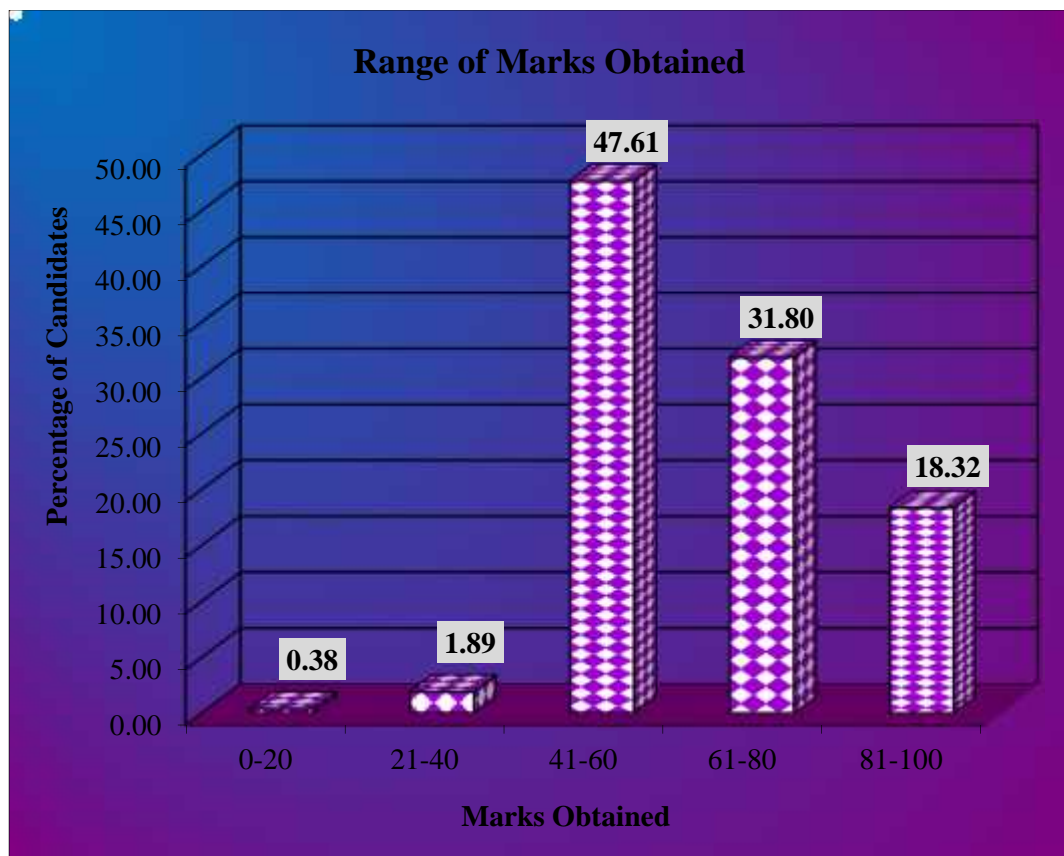
CHEMISTRY

STATISTICS AT A GLANCE

| | |
|---|--------|
| Total Number of students who took the examination | 36,423 |
| Highest Marks Obtained | 100 |
| Lowest Marks Obtained | 4 |
| Mean Marks Obtained | 64.21 |

Percentage of Candidates according to marks obtained

| Details | Mark Range | | | | |
|--------------------------|------------|-------|-------|-------|--------|
| | 0-20 | 21-40 | 41-60 | 61-80 | 81-100 |
| Number of Candidates | 138 | 690 | 17342 | 11582 | 6671 |
| Percentage of Candidates | 0.38 | 1.89 | 47.61 | 31.80 | 18.32 |
| Cumulative Number | 138 | 828 | 18170 | 29752 | 36423 |
| Cumulative Percentage | 0.38 | 2.27 | 49.89 | 81.68 | 100.00 |



B. ANALYSIS OF PERFORMANCE

PART I (20 Marks)

Answer *all* questions.

Question 1

- (a) Fill in the blanks by choosing the appropriate word/words from those given in the brackets: [5]

(increases, decreases, positive, efficient, 68, non-efficient, no -hydrogen, -hydrogen, negative, Rosenmund's, greater, Cannizzaro, 74, common-ion effect, lesser, buffer action, diamagnetic, paramagnetic)

- (i) The more _____ the standard reduction potential of a metal, the _____ is its ability to displace hydrogen from acids.
- (ii) Both ccp and hcp are _____ packings and occupy about _____% of the available space.
- (iii) Solubility of silver chloride _____ in the presence of sodium chloride because of _____.
- (iv) Benzaldehyde undergoes _____ reaction on treatment with concentrated sodium hydroxide because it has _____ atom.
- (v) The transition metals show _____ character because of the presence of unpaired electrons and Cu^+ is _____ because its electronic configuration is $[\text{Ar}]3d^{10}$.
- (b) Complete the following statements by selecting the **correct alternative from the** choices given: [5]

- (i) The molal freezing point constant of water is $1.86 \text{ K kg mol}^{-1}$. Therefore, the freezing point of 0.1 M NaCl solution in water is expected to be:

- (1) -1.86°C
(2) -0.372°C
(3) -0.186°C
(4) $+0.372^\circ\text{C}$

- (ii) For a first order reaction the rate constant for decomposition of N_2O_5 is $6 \times 10^{-4} \text{ sec}^{-1}$. The half-life period for the decomposition in seconds is:

- (1) 11.55
(2) 115.5
(3) 1155
(4) 1.155

- (iii) When acetaldehyde is treated with Grignard reagent, followed by hydrolysis the product formed is:
- (1) Primary alcohol
 - (2) Secondary alcohol
 - (3) Carboxylic acid
 - (4) Tertiary alcohol
- (iv) The geometry of XeF_6 molecule and the hybridization of Xe atom in the molecule is:
- (1) Distorted octahedral and sp^3d^3
 - (2) Square planar and sp^3d^2
 - (3) Pyramidal and sp^3
 - (4) Octahedral and sp^3d^3
- (v) In the complexes $[\text{Fe}(\text{CN})_6]^{3-}$ and $[\text{Pt}(\text{en})(\text{H}_2\text{O})_2(\text{NO}_2)(\text{Cl})]^{2+}$ the respective oxidation numbers of central metal atoms are :
- (1) + 3 and +4
 - (2) +6 and +4
 - (3) +6 and +3
 - (4) +3 and +3

(c) Answer the following questions: [5]

- (i) What is the effect of temperature on the ionic product of water? How will it change the pH value of a neutral solution?
- (ii) How many hours does it take to reduce 3 moles of Fe^{3+} to Fe^{2+} with 2.0 A current intensity?
- (iii) How is urea prepared by Wohler synthesis?
- (iv) Two liquids A and B form type II non ideal solution which shows a minimum in its temperature -mole fraction plot (T- diagram). Can the two liquids be completely separated by fractional distillation?
- (v) The aqueous solution of sodium acetate is basic. Explain.

(d) Match the following: [5]

- | | |
|--|------------------------------|
| (i) Disaccharide | (a) Lucas reagent |
| (ii) Carbylamine | (b) Condensation polymer |
| (iii) Dacron | (c) Obnoxious smell |
| (iv) Low spin complex, d^2sp^3 | (d) Sucrose |
| (v) Anhydrous ZnCl_2 + conc. HCl | (e) Hexaamminecobalt(III)ion |

Comments of Examiners

- (a) (i) Instead of writing 'negative' and 'greater' many candidates wrote 'positive' and 'lesser'.
- (ii) In place of 'efficient' and '74' which was the correct answer, some candidates wrote 'inefficient' and '68'.
- (iii) The concept of common ion effect was not very clear to the candidates. A few candidates wrote 'increases' in place of 'decreases'. Many candidates wrote 'buffer action' in place of 'common ion effect'.
- (iv) In the first blank, a few candidates wrote 'Rosenmund's' reaction in place of 'Cannizzaro's' reaction. For the second blank, instead of 'no hydrogen' many candidates wrote 'hydrogen' which was not correct.
- (v) Several candidates reversed the order i.e. diamagnetic and paramagnetic instead of paramagnetic and diamagnetic.
- (b) (i) Most of the candidates chose the wrong alternative i.e. -0.186°C instead of -0.372°C which was the correct answer. Vant Hoff factor (i) was ignored by the candidates.
- (ii) Many candidates were unaware of the formula and hence gave wrong answers.
- (iii) A number of candidates were unaware that the reactions between acetaldehyde and Grignard's reagent, followed by hydrolysis, gives secondary alcohol.
- (iv) A number of candidates wrote the geometry and hybridization of XeF_6 molecule as 'octahedral and sp^3d^3 ' instead of 'distorted octahedral and sp^3d^3 '.
- (v) The oxidation numbers of central metal atom were reported correctly by many candidates but some candidates choose option +3 and +3.
- (c) (i) Many candidates wrote incomplete answers. The ionic product of water is directly proportional to temperature. Many candidates were not sure how the pH value of neutral solution changes with increase in temperature.
- (ii) Several candidates were unable to calculate the time period in hours and reported the answer in seconds or minutes. Some candidates did not take into account that 3 moles of Fe^{3+} should be reduced to Fe^{2+} .

Suggestions for teachers

- Electro chemical series should be explained properly with reasons. The selection of cathode and anode on the basis of standard electrode potential must be explained to candidates.
- Packing fraction in cubic solids should be explained clearly.
- Students must be explained how the presence of common ion in a solution decreases the dissociation of weak electrolyte. Suitable examples must be used.
- Emphasis should be laid upon the named organic reactions. The conditions for reaction must be explained clearly.
- Vant Hoff factor must be explained clearly to students.
- The relationship between the rate constant and half-life period must be explained clearly.
- Chemical properties of Grignard's reagent, for the preparation of various organic compounds must be properly explained.
- Geometry and hybridization of compounds of inert gases must be discussed in class. The shape and geometry depends on both the bonding and non-bonding electrons of central atoms.
- The calculation of oxidation state of the central metal atom in coordination compounds should be taught in detail.
- The relationship between the concentration of H^+ and OH^- and pH value should be explained to students. Variation of ionic product of water with temperature must be discussed

(iii) For preparation of urea by Wohler synthesis, many candidates did not mention the proper conditions. Unbalanced equations were given by many candidates.

(iv) Instead of writing that the two liquids cannot be separated completely by fractional distillation, some candidates wrote that they can be separated. In some cases, conditions were not mentioned - that liquid A and B will form a constant boiling azeotropic mixture.

(v) The concept of salt hydrolysis was not clear to some candidates. Anionic hydrolysis was not mentioned by several candidates.

(d) Most of the candidates matched the answers correctly.

- Discuss Faraday's law of electrolysis and explain the following concepts :

$1F = 96,500 \text{ coulomb} = 1 \text{ mole of } e^-$
Students must be told to express the answer in hours if asked in question paper.

- Stress upon writing balanced equations with correct conditions.

- The salt hydrolysis of all the four types of salts must be explained with suitable examples.

MARKING SCHEME

Question 1

(a) (i) negative, greater

(ii) efficient, 74

(iii) decreases, common-ion effect

(iv) Cannizzaro, no - hydrogen

(v) paramagnetic, diamagnetic

(b) (i) (2) -0.372°C

(ii) (3) 1155

(iii) (2) secondary alcohol

(iv) (1) distorted octahedral and sp^3d^3

(v) (1) +3 and +4

(c) (i) Ionic product increases with increase in temperature because the dissociation of water increases with increase of temperature. With increase in concentration of H_3O^+ ions, pH of the neutral solution will decrease.

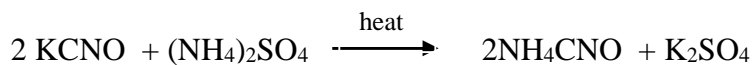
(ii) Reduction of 1 mol of Fe^{3+} requires = 96500 C

Reduction of 3 mol of Fe^{3+} require = $3 \times 96500 \text{ C} = 2.895 \times 10^5 \text{ C}$

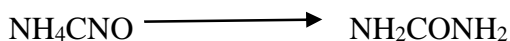
$$Q = I \times t$$

$$\text{Time} = \frac{2.895 \times 10^5}{2} = 1.4475 \times 10^5 \text{ sec.} = \frac{1.4475 \times 10^5}{60 \times 60} = 40.21 \text{ hours}$$

(iii)



Molecular arrangement



- (iv) The two liquids cannot be separated completely by fractional distillation because they form a constant boiling azeotropic mixture, therefore at a definite composition both the liquids will distil over without any change in composition.
- (v) Sodium acetate undergoes anionic hydrolysis and forms weakly dissociated CH_3COOH and highly dissociated NaOH .
- (d) (i) Disaccharide (d) sucrose
(ii) carbylamine (c) obnoxious smell
(iii) Dacron (b) condensation polymer
(iv) Low spin complex, d^2sp^3 (e) hexaamminecobalt(III) ion
(v) anhydrous $\text{ZnCl}_2 + \text{conc. HCl}$ (a) Lucas reagent

PART II (50 Marks)

Answer six questions choosing two from Section A, two from Section B and two from Section C.

SECTION A

Answer any two questions.

Question 2

- (a) (i) A solution containing 0.5 g of KCl dissolves in 100 g of water and freezes at -0.24°C . Calculate the degree of dissociation of the salt. (K_f for water = 1.86°C) Atomic weights [K = 39, Cl = 35.5] [3]
- (ii) If 1.71 g of sugar (molar mass = 342) are dissolved in 500 ml of an aqueous solution at 300 K, what will be its osmotic pressure? [1]
- (iii) 0.70g of an organic compound when dissolved in 32g of acetone produces an elevation of 0.25°C in the boiling point. Calculate the molecular mass of organic compound (K_b for acetone = $1.72 \text{ K kg mol}^{-1}$). [1]
- (b) (i) What is the difference between order of a reaction and the molecularity of a reaction? [2]
- (ii) A substance decomposes by following first order kinetics. If 50% of the compound is decomposed in 120 minutes, how long will it take for 90% of the compound to decompose? [2]
- (c) Name the crystal structure of the copper metal. [1]

Comments of Examiners

- (a)(i) Some candidates did the calculations upto vant Hoff factor but the degree of dissociation of salt was not calculated. The relationship between degree of dissociation (α) and vant Hoff factor (i) was not clear to a few candidates.
- (ii) Some candidates did not mention the unit i.e. atm along with the answer. Several candidates used the incorrect value of R, instead of $0.0821 \text{ Lit-atm K}^{-1} \text{ mole}^{-1}$ the value used was $R=8.314 \text{ J K}^{-1} \text{ mole}^{-1}$.
- (iii) The molecular weight of organic compound was calculated correctly by most of the candidates. In some cases wrong unit for molecular weight was mentioned.
- (b)(i) Some candidates just defined the terms. In a number of cases, all the differences were not given. The concept of rate law for order of reaction was not clear to many candidates. A few candidates interchanged the differences.
- (ii) Time taken for 90% decay was calculated correctly by many candidates. Some candidates took the value of [A] as 90 instead of [A] = 10, if $[A_0] = 100$ and thus got wrong answer. Some candidates failed to write the correct unit.
- (c) Some candidates wrote 'hexagonal close packing' or 'body centered cubic' instead of 'face centered cubic' or 'cubic closed packing'.

Suggestions for teachers

- Give practice to students in doing numericals. Numerical problems based on abnormal molecular weights, calculation of degree of dissociation and association should be given.
- Students must be told that while solving numerical problems, they must write the formula, substitute correctly and write the answer with the correct unit.
- Order of reaction and molecularity of reaction should be explained with examples.
- More practice must be given in solving problems based on half-life period of radioactive substances. The answer should be given with the same unit as mentioned in the question paper.
- Crystal structure of all types of crystalline solids must be explained to students.

MARKING SCHEME

Question 2

- (a) (i) (i) Observed molecular mass

$$m = \frac{K_f \times w \times 1000}{T_f \times W}$$

$$= \frac{1.86 \times 0.5 \times 1000}{0.24 \times 100} = 38.75$$

Normal molecular mass of KCl = 74.5

$$\begin{aligned} \text{Van't Hoff factor, } i &= \text{normal molar mass} / \text{observed molar mass} \\ &= 74.5 / 38.75 = 1.92 \end{aligned}$$

KCl dissociates as



Moles after dissociation 1 -

Total no. of moles after dissociation = 1 +

$$i = \frac{\text{Observed moles of solute}}{\text{normal moles of solute}} = \frac{1+i}{1}$$

$$\frac{1+i}{1} = 1.92 \quad = 1.92 - 1 = 0.92$$

Degree of dissociation = 92 %

(ii)

$$\pi = CRT$$

$$\pi = n / V RT = w RT / m V$$

$$= 1.71 \times 0.082 \times 300 / 342 \times 500/1000$$

$$= 0.246 \text{ atm}$$

(iii)

$$m = \frac{1000 \times k_b w}{\Delta T_b \times w} \text{ or } \frac{1000 \times 1.72 \times 0.70}{0.25 \times 32}$$

$$= 150.5 \text{ g mol}^{-1}$$

(b)

(i)

Difference between order of reaction and molecularity of a reaction:

| S.NO. | Order of reaction | Molecularity of reaction |
|-------|--|--|
| 1. | It is equal to the sum of the powers of the molar concentrations of the reactants in the rate law. | It is equal to the total number of molecules of the reactants which take part in a single step chemical reaction. |
| 2. | It may be in fractions or may be zero or negative. | It is always a positive whole number value. |
| 3. | It is for the overall reaction and an experimentally determined quantity. | It is theoretical concept and depends on the rate determining step in the reaction mechanism because overall molecularity of a complex reaction has no significance. |

(any two of the above)

(ii)

$$k = 0.6930 / t \frac{1}{2}$$

$$k = 0.6930 / 120 = 5.77 \times 10^{-3} \text{ min}^{-1}$$

Now for the first order reaction,

$$t = 2.303 / k \log [A]_0 / [A]$$

$$= 2.303 / 5.77 \times 10^{-3} \log 10 = 399 \text{ minutes}$$

(c)

Face centered cubic (fcc) or Cubic close packing (ccp)

Question 3

- (a) (i) Chromium metal crystallises with a body centered cubic lattice. The edge length of the unit cell is found to be 287 pm. Calculate the atomic radius. What would be the density of chromium in g / cm³? (atomic mass of Cr = 52.99) [2]
- (ii) Why does sodium chloride on heating with sodium vapours acquire yellow colour? [1]
- (iii) The equilibrium constant for the reaction: [1]
- $$\text{N}_{2(\text{g})} + 3\text{H}_{2(\text{g})} \rightleftharpoons 2\text{NH}_{3(\text{g})} \text{ at } 715 \text{ K, is } 6.0 \times 10^{-2}.$$
- If, in a particular reaction, there are 0.25 mol L⁻¹ of H₂ and 0.06 mol L⁻¹ of NH₃ present, calculate the concentration of N₂ at equilibrium.
- (iv) Calculate the concentration of OH⁻ ions in solution when [H⁺] = 6.2 x 10⁻² molL⁻¹. [1]
- (v) State the Le-Chatelier's principle. [1]
- (b) For a crystal of sodium chloride, state: [2]
- (i) The type of lattice in which it crystallises.
- (ii) The coordination number of each sodium ion and chloride ion in the crystal lattice.
- (iii) The number of sodium ions and chloride ions present in a unit cell of sodium chloride.
- (iv) The structural arrangement of the sodium chloride crystal.
- (c) Consider the following reaction: [2]
- $$\text{N}_2\text{O}_{4(\text{g})} + \text{Heat} \rightleftharpoons 2\text{NO}_{2(\text{g})}$$
- How is the composition of equilibrium mixture affected by:
- (i) a change in temperature
- (ii) a change in pressure
- (iii) a change in concentration of N₂O₄
- (iv) the removal of NO₂ from the reaction mixture

Comments of Examiners

- (a)(i) The value of Z (no. of particles) was not taken correctly by some candidates. Instead of '2' the value taken was '4'. The edge length 'a' was not converted to centimetre in some cases. The density of chromium and atomic radius were not calculated correctly by a few candidates.
- (ii) This part was not answered well by many candidates.
- (iii) The concentration of N_2 (g) at equilibrium was calculated correctly by many candidates but some did not mention the correct unit.
- (iv) In this part, some candidates calculated pOH value instead of OH^- ion concentration. The value of K_w was taken as 10^{14} instead of 10^{-14} .
- (v) In this part, a few candidates failed to write the term 'equilibrium'.
- (b) (i) A few candidates wrote the type of lattice of NaCl as octahedral or hcp instead of fcc or ccp.
- (ii) Most candidates were able to attempt this part correctly.
- (iii) Some candidates reported the wrong value of number of sodium and chloride ions present in a unit cell of sodium chloride.
- (iv) Most of the candidates could not write the structural arrangement correctly. Some wrote fcc instead of octahedral structure.
- (c)(i) Many candidates considered the reaction as exothermic although it was an endothermic reaction. Increase in temperature favours the forward reaction. Many candidates wrote - favours forward reaction with the change in temperature, without mentioning 'increase in temperature'.
- (ii) Increase in pressure favours the backward reaction. Some candidates wrote - equilibrium changes with change in pressure.
- (iii) Increase in concentration of N_2O_4 shifts the equilibrium in forward direction. Some candidates wrote, "with change in concentration of N_2O_4 " without mentioning increase and decrease.
- (iv) The removal of NO_2 favours the forward reaction. Some candidates wrote that rate of backward reaction will increase.

Suggestions for teachers

- The value of Z changes with the type of unit cell. The density must be reported in gm/cm^3 . Students must be told to calculate the radius of atoms of different types of unit cell.
- The imperfections in solids must be clearly explained to students.
- Chemical equilibrium and its characteristics must be explained to the students. More practice must be given in equilibrium constant (K_c) and its calculation.
- More practice must be given in numerical problems based on pH value and ionic products of water.
- Students should be asked to learn definitions with proper key words.
- Explain the crystal lattice of sodium chloride with the help of proper diagram.
- Coordination number of each ion in sodium chloride should be clearly explained.
- Calculation of number of atoms present in a unit cell must be explained clearly. The corner atom contributes (1/8), face centered atom (1/2) body centered (1) and edge center (1/4) to the unit cell.
- While teaching chemical equilibrium, the Le Chatelier's principle should be explained clearly. Practice must be given in shifting of equilibrium under all conditions of temperature, pressure and concentration.

MARKING SCHEME

Question 3

(a)(i) For bcc crystal, atomic radius, $r = \frac{\sqrt{3}a}{4}$

a = edge length

$$r = 3/4 \times 287 = 124.27 \text{ pm}$$

density = mass of unit cell / volume of the unit cell

$$= Z \times \text{atomic mass} / N_A \times a^3$$

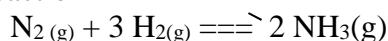
Here $Z = 2$ (for bcc)

$$\text{Volume of the unit cell} = a^3 = (287 \text{ pm})^3 = (287 \times 10^{-10} \text{ cm})^3$$

$$\begin{aligned} \text{Density} &= 2 \times 52.99 / 6.023 \times 10^{23} \times (2.87 \times 10^{-10} \text{ cm})^3 \\ &= 7.44 \text{ g cm}^{-3} \end{aligned}$$

(ii) On heating sodium chloride with sodium vapours, the chloride ions diffuse to the surface of the crystals and combine with Na atoms which get ionized to Na^+ ions by losing electrons. These electrons get trapped in anion vacancies and act as F⁻ centres which impart colour to the crystal.

(iii) For the reaction



$$k = \frac{[\text{NH}_3]^2}{[\text{N}_2] [\text{H}_2]^3} = 6.0 \times 10^{-2}$$

$$k = (0.06)^2 / (0.25)^3 [\text{N}_2] = 6.0 \times 10^{-2}$$

$$[\text{N}_2] = (0.06)^2 / (0.25)^3 (6.0 \times 10^{-2}) = 3.84 (\text{mol L}^{-1})^{-2}$$

(iv) $K_w = [\text{H}^+] [\text{OH}^-]$

$$[\text{OH}^-] = K_w / [\text{H}^+] = 10^{-14} / 6.2 \times 10^{-2} = 1.6 \times 10^{-11} \text{ mol L}^{-1}$$

(v) If an equilibrium is subjected to a stress (change in concentration, pressure or temperature etc.) equilibrium shifts in such a way so as to undo or decrease the effect of stress imposed.

(b)(i) Face-centered cubic lattice (fcc) (or) cubic close-packing(ccp)

(ii) Coordination number of each Na^+ ion as well as Cl^- ion is 6.

(iii) The unit cell of sodium chloride possess 4 sodium ions and 4 chloride ions.

(iv) Octahedral.

- (c)(i) Increase in temperature favors the forward reaction, concentration of NO₂ increases and vice versa.
- (ii) Increase in pressure favors backward reaction and vice versa.
- (iii) Addition of N₂O₄ favors the forward reaction and vice versa.
- (iv) Removal of NO₂ increases the rate of forward reaction or equilibrium will shift to the forward direction.

Question 4

- (a) The specific conductance of a 0.01 M solution of acetic acid at 298 K is $1.65 \times 10^{-4} \text{ ohm}^{-1} \text{ cm}^{-1}$. The molar conductance at infinite dilution for H⁺ ion and CH₃COO⁻ ion are $349.1 \text{ ohm}^{-1} \text{ cm}^2 \text{ mol}^{-1}$ and $40.9 \text{ ohm}^{-1} \text{ cm}^2 \text{ mol}^{-1}$ respectively. Calculate: [3]
- (i) Molar conductance of the solution.
- (ii) Degree of dissociation of CH₃COOH.
- (iii) Dissociation constant for acetic acid.
- (b) (i) Calculate the e.m.f. of the following cell reaction at 298 K: [2]
- $$\text{Mg}_{(s)} + \text{Cu}^{2+}(0.0001 \text{ M}) \rightleftharpoons \text{Mg}^{2+}(0.001 \text{ M}) + \text{Cu}_{(s)}$$
- The standard potential (E^0) of the cell is 2.71 V.
- (ii) The solubility product (K_{sp}) of BaSO₄ is 1.5×10^{-9} . Calculate the solubility of barium sulphate in pure water and in 0.1 M BaCl₂. [2]
- (c) Explain the following :
- (i) When NH₄ Cl and NH₄OH are added to a solution containing both, Fe³⁺ and Ca²⁺ ions, which ion is precipitated first and why? [2]
- (ii) Dissociation of H₂S is suppressed in acidic medium. [1]

Comments of Examiners

- (a)(i) Some candidates were unable to do this part correctly. They used wrong formula to calculate the molar conductance at infinite dilution. A few candidates wrote wrong units or did not write the unit at all.
- (ii) The correct value of degree of dissociation was not calculated by some candidates.
- (iii) Since parts (i) and (ii) were not answered correctly by some candidates, the dissociation constant (K) was also not calculated correctly.
- (b)(i) Most of the candidates answered this part correctly. Some candidates did not give Nernst equation correctly and got wrong e.m.f. value. In some cases the unit was not mentioned.

Suggestions for teachers

- Calculation of molar conductance, specific conductance, degree of dissociation and dissociation constant along with their relationship must be explained clearly to students.
- Give more practice in calculation of E^0_{cell} and E_{cell} for electrochemical cell.

- (ii) Solubility of BaSO_4 in pure water was reported correctly by most of the candidates, but the solubility of BaSO_4 in 0.1 M BaCl_2 solution was not reported correctly by many candidates.
- (c)(i) A number of candidates were able to give the correct answer i.e. Fe^{3+} will be precipitated first. Some wrote that Ca^{2+} will be precipitated first. The explanation given by candidates did not match with the correct answer.
- (ii) The answers given by candidates were correct in most of the cases. A few candidates did not mention that it is due to common ion effect.

Suggestions for teachers

- Numericals based on solubility product, solubility and their relationship for different kinds of sparingly soluble electrolytes should be explained clearly.
- Explain the concept of solubility product (K_{sp}) and ionic concentration product (ICP) in the practical class. Explain that the precipitation occurs when $\text{ICP} > K_{sp}$.
- How common ion affects the dissociation of weak electrolyte must be explained by giving examples.

MARKING SCHEME

Question 4

(a) (i) Molar conductance = $\frac{\Lambda_m \times 1000}{C} = \frac{1.65 \times 10^{-4} \times 1000}{0.01} = 16.5 \text{ ohm}^{-1} \text{cm}^2 \text{mol}^{-1}$

(ii) Degree of dissociation

$$= \frac{\Lambda_m^c}{\Lambda_m}$$

$$\Lambda_m = 16.5 \text{ ohm}^{-1} \text{cm}^2 \text{mol}^{-1}$$

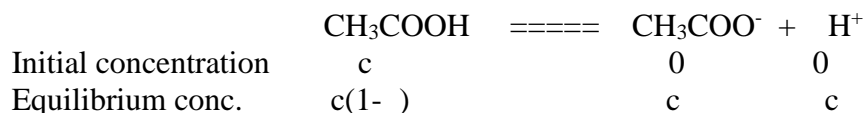
$$\Lambda_m (\text{CH}_3\text{COOH}) = \Lambda_m (\text{H}^+) + \Lambda_m (\text{CH}_3\text{COO}^-)$$

$$= 349.1 + 40.9 = 390 \text{ ohm}^{-1} \text{cm}^2 \text{mol}^{-1}$$

$$= 16.5 / 390 = 0.0423$$

(iii) Dissociation constant (K)

Acetic acid dissociates as



$$K = \frac{[\text{CH}_3\text{COO}^-][\text{H}^+]}{[\text{CH}_3\text{COOH}]} = \frac{c \times c}{c(1-c)} = \frac{0.01 \times (0.0423)^2}{1 - 0.0423}$$

$$= 1.86 \times 10^{-5}$$

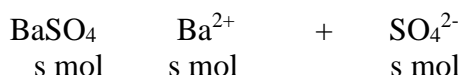
(b) (i) $E_{\text{cell}} = E^{\circ}_{\text{cell}} - \frac{0.0591}{2} \log \frac{[\text{Mg}^{2+}][\text{Cu}]}{[\text{Mg}][\text{Cu}^{2+}]}$

$$= 2.71 - \frac{0.0591}{2} \log \frac{0.001}{0.0001}$$

$$= 2.71 - 0.0295$$

$$= 2.6805 \text{ V}$$

(ii) Solubility of BaSO₄ in water



$$K_{\text{sp}} = [\text{Ba}^{2+}][\text{SO}_4^{2-}]$$

$$K_{\text{sp}} = s \cdot s = s^2$$

$$s = 1.5 \times 10^{-9} = 3.87 \times 10^{-5} \text{ mol L}^{-1}$$

solubility of BaSO₄ in 0.1 M BaCl₂

$$[\text{Ba}^{2+}] = 0.1 + s, \quad [\text{SO}_4^{2-}] = s$$

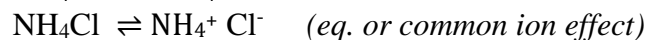
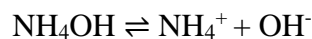
$$K_{\text{sp}} = [\text{Ba}^{2+}][\text{SO}_4^{2-}]$$

$$= [0.1 + s][s] = 0.1s$$

$$0.1s = 1.5 \times 10^{-9}$$

$$s = 1.5 \times 10^{-8} \text{ mol L}^{-1}$$

(c) (i) Fe³⁺ ion will precipitate out first.



Due to common ion effect less OH⁻ ions are produced, which are large enough to cause the precipitation of Fe³⁺ ions. As its solubility product is less (K_{sp} is less for Fe(OH)₃ and K_{sp} is more for Ca(OH)₂).

(ii) This is due to common ion effect. The suppression of degree of dissociation of a weak electrolyte by (H₂S) the addition of a strong electrolyte (HCl) having a common ion with the weak electrolyte (H₂S).

SECTION B

Answer any two questions

Question 5

- (a) Write the IUPAC names of the following coordination compounds: [1]
- (i) $[\text{Cr}(\text{NH}_3)_4(\text{H}_2\text{O})_2]\text{Cl}_3$
- (ii) $[\text{PtCl}_2(\text{NH}_3)_4][\text{PtCl}_4]$
- (b) State the hybridization and magnetic property of $[\text{Fe}(\text{CN})_6]^{3-}$ ion according to the valence bond theory. [1]
- (c) (i) What type of isomers are $[\text{Co}(\text{NH}_3)_5\text{Br}]\text{SO}_4$ and $[\text{Co}(\text{NH}_3)_5\text{SO}_4]\text{Br}$? Give a chemical test to distinguish between them. [2]
- (ii) Write the structures of optical isomers of the complex ion $[\text{Co}(\text{en})_2\text{Cl}_2]^+$ [1]

Comments of Examiners

- (a) (i) Many candidates wrote 'amine' instead of 'ammine' for NH_3 . Oxidation state was reported wrongly in some cases while some others did not give the order of ligands alphabetically.
- (ii) Many candidates wrote wrong oxidation states of central metal atom.
- (b) Many candidates reported sp^3d^2 and diamagnetic whereas the correct answer was d^2sp^3 hybridization and paramagnetic.
- (c) (i) The type of isomerism was reported correctly by most of the candidates. The chemical test to distinguish between the isomers was not given correctly in a few cases.
- (ii) The structure of optical isomers of complex ion $[\text{Co}(\text{en})_2\text{Cl}_2]^+$ was not given correctly.

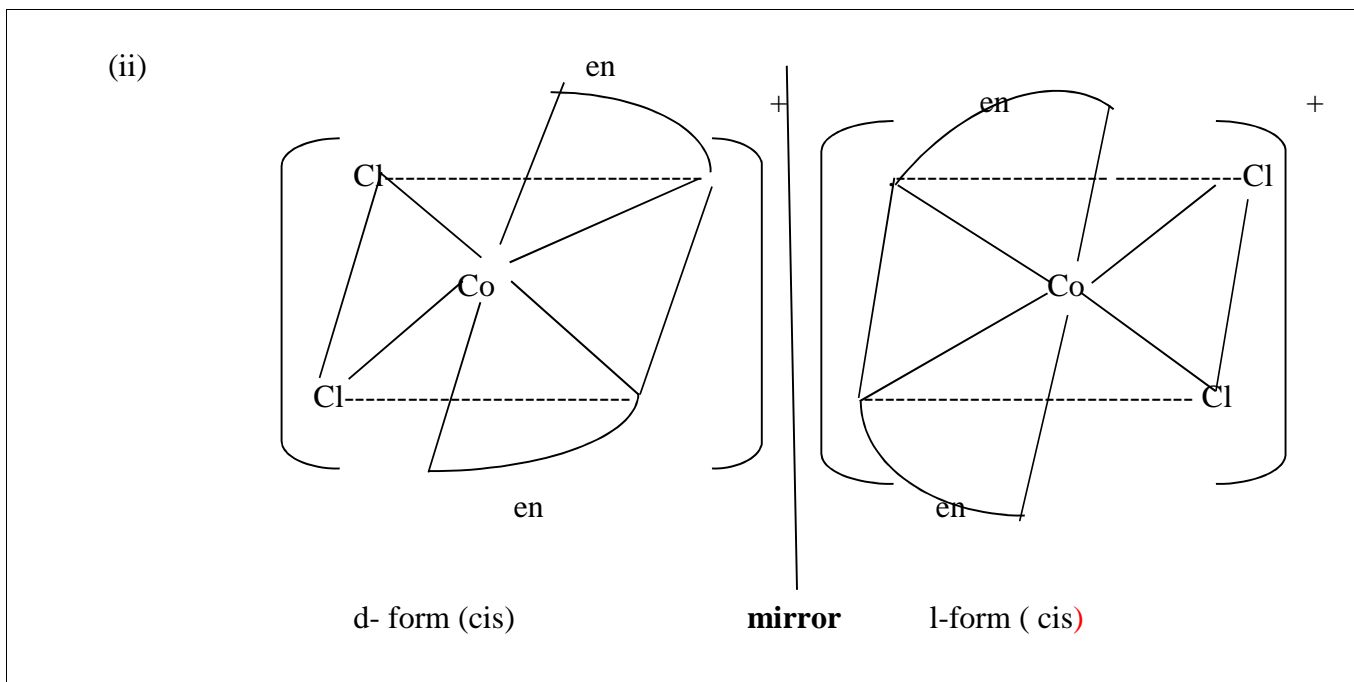
Suggestions for teachers

- More practice should be given in naming coordination compounds. Calculation of oxidation state of the central metal atom/ ion should be explained clearly. While writing names of the ligands, alphabetical order must be followed.
- Explain the valence bond theory in detail and give enough practice using different examples.
- Explain all the types of isomerism shown by coordination compounds.
- More practice should be given in the structure of optical isomers by using mirror image.

MARKING SCHEME

Question 5

- (a) (i) tetraamminediaquachromium(III)chloride
- (ii) tetraamminedichloroplatinum(IV)tetrachloroplatinate(II)
- (b) d^2sp^3 hybridisation and paramagnetic
- (c) (i) Ionisation isomers
One of these is red-violet and forms a precipitate with BaCl_2 indicating that sulphate ion is outside the coordination sphere. The second one is red and does not form ppt. with BaCl_2 but forms a ppt. of AgBr with AgNO_3 indicating that bromide ion is outside the coordination sphere. (or any other correct chemical test)



Question 6

- (a) Give balanced chemical equations for the following reactions: [3]
- (i) Fluorine is passed through cold, dilute NaOH solution.
 - (ii) Hydrogen peroxide is treated with acidified KMnO_4 solution.
 - (iii) Sulphuric acid is treated with hydrogen sulphide.
- (b) Draw the structure of xenon tetrafluoride molecule and state the hybridization of the central atom and the geometry of the molecule. [2]

Comments of Examiners

- (a) A number of candidates gave unbalanced equations. In some cases, all the products were not mentioned. Some candidates wrote wrong products.
- (b) The structure of XeF_4 was drawn correctly but some candidates failed to show the lone pairs of electrons. The hybridization and geometry was given correctly by most of the candidates. A few candidates gave wrong hybridization. Instead of sp^3d^2 they wrote d^2sp^3 .

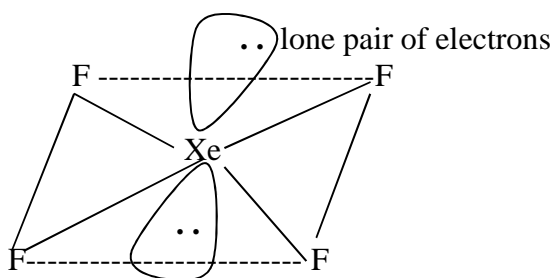
Suggestions for teachers

- Teach the chemical reactions of inorganic chemistry in detail and give practice in balancing equations.
- Explain the shape, hybridization and the structure of compounds of inert gases diagrammatically.

MARKING SCHEME

Question 6

- (a) (i) $2 \text{F}_2 + 2 \text{NaOH} \xrightarrow{\text{(cold \& dilute)}} 2 \text{NaF} + \text{H}_2\text{O} + \text{OF}_2$
(oxygen difluoride)
- (ii) $2 \text{KMnO}_4 + 3 \text{H}_2\text{SO}_4 + 5 \text{H}_2\text{O}_2 \rightarrow \text{K}_2\text{SO}_4 + 2 \text{MnSO}_4 + 8 \text{H}_2\text{O} + 5 \text{O}_2$
- (iii) $\text{H}_2\text{SO}_4 + \text{H}_2\text{S} \rightarrow \text{S} + \text{SO}_2 + 2 \text{H}_2\text{O}$
- (b) XeF_4 molecules a square planar geometry and is formed by the sp^3d^2 hybridisation.



Question 7

- (a) Name the important ore of silver. Write all the steps and reactions involved in the Cyanide process for the extraction of silver from its ore. [3]
- (b) Explain the following: [2]
- (i) Why do transition metal ions possess a great tendency to form complexes?
- (ii) The paramagnetic character in 3d-transition series elements increases up to Mn and then decreases.

Comments of Examiners

- (a) The formula of ore of silver was given instead of name of the ore by many candidates. Proper reactions and steps of metallurgy were not given in many cases. Electrolytic refining of silver was not shown by some candidates.
- (b) (i) Most of the candidates did not write 'presence of vacant 'd' orbital', instead they mentioned (n-1) d orbital, partially filled 'd' orbital, etc. Candidates seemed to be unaware of the significance of vacant 'd' orbital in the formation of complexes.
- (ii) Relationship between unpaired/paired electrons and magnetic behaviour was not understood by many candidates.

Suggestions for teachers

- The extraction of metals must be taught in detail. All the steps must be shown in proper order with balanced chemical equations.
- Explain the role of vacant 'd' orbital in the formation of complexes. Important properties of 'd' block elements must be told to students.
- Reason for paramagnetism, electronic configuration of elements should be explained in detail.

MARKING SCHEME

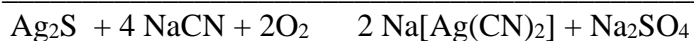
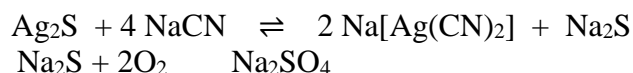
Question 7

(a) Argentite (silver glance), Ag_2S or Horn silver

Concentration – The sulphide ore is crushed, powdered and then concentrated by the Froth flotation process.

Treatment with sodium cyanide

The concentrated ore is agitated with dilute solution of NaCN in the presence of air
When soluble sodium argentocyanide is obtained.



Precipitation of silver



Silver thus obtained is in the form of dark amorphous mass.

Fusion

The precipitated silver is filtered, pressed, dried and fused with borax when a bright Compact mass is obtained.

Electrolytic refining process

Silver thus obtained usually contain impurities of Zn, Cu and gold.

Thin sheet of pure silver – cathode

A block of impure silver – anode

$\text{K}[\text{Ag}(\text{CN})_2]$ or a solution of silver nitrate containing 1% HNO_3 is used as a electrolyte.

On passing electricity pure silver gets deposited on the cathode.

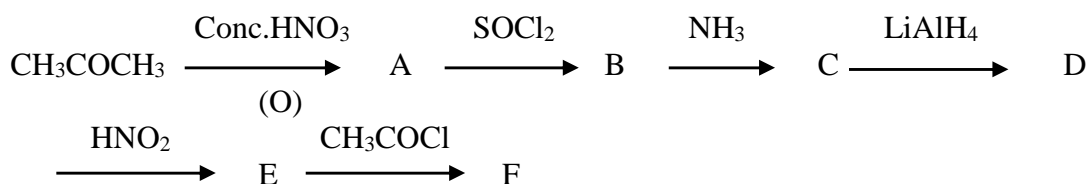
- (b) (i) Due to small size, high nuclear charge, availability of vacant d- orbitals of suitable energy to accommodate lone pairs of electrons donated by the ligands.
- (ii) On moving from Sc to Mn, the number of unpaired electrons increases and hence Paramagnetic character increases. But after Mn, the pairing of electrons in the d-subshell starts and the number of unpaired electrons and hence paramagnetic character decreases.

SECTION C

Answer any **two** questions.

Question 8

- (a) How can the following conversions be brought about:
- (i) Glycerol to formic acid [1]
- (ii) Chlorobenzene to phenol [1]
- (iii) Diethyl ether to ethanol [1]
- (iv) Phenol to aniline. [2]
- (b) (i) How is iodoform prepared from ethanol? Give balanced equation. [1]
- (ii) What will be the product formed when chlorobenzene is heated with sodium metal in the presence of dry ether? [1]
- (c) Identify the compounds **A, B, C, D, E** and **F**: [3]

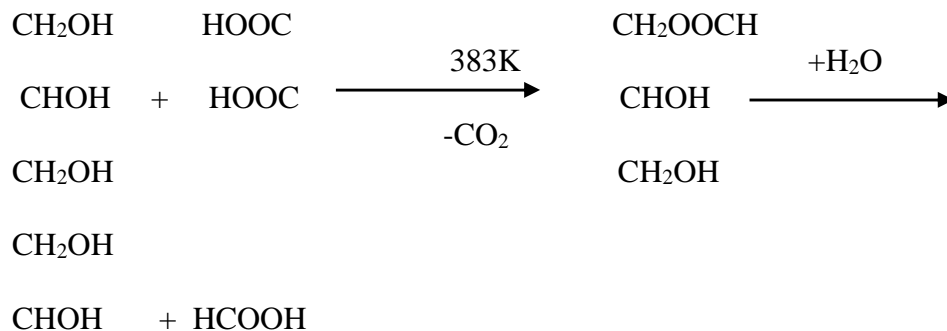
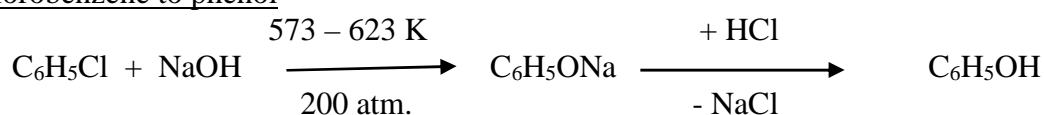
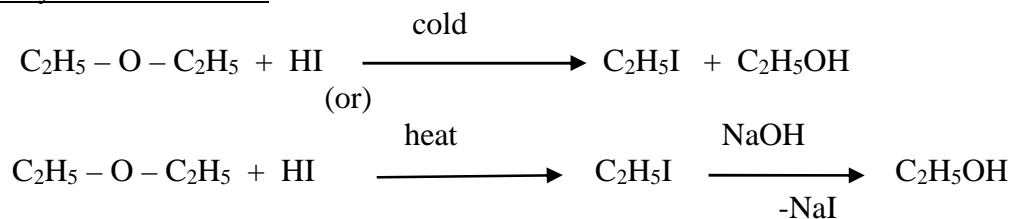


Comments of Examiners

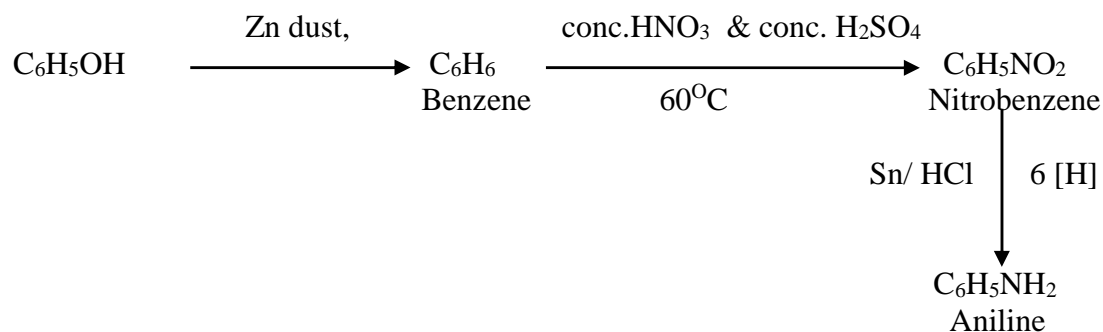
- (a) (i) In the conversion of glycerol to formic acid by using oxalic acid, the temperature was not mentioned by many candidates.
- (ii) The conditions required for the conversion of chlorobenzene to phenol were not given by many candidates.
- (iii) The condition that HI used for the conversion of diethyl ether to ethanol should be cold or hot was not mentioned by many candidates. Acid catalysis was not mentioned by many candidates.
- (iv) The steps shown by candidates for the conversion of phenol to aniline were mostly correct but in a few cases, the conditions were missing.
- (b)(i) The conversion of ethanol to iodoform was done correctly by many candidates but in some cases, instead of iodoform reaction, candidates first converted $\text{C}_2\text{H}_5\text{OH}$ to CH_3CHO then formed iodoform.
- (ii) Chlorobenzene when heated with sodium metal in presence of dry ether gives diphenyl but some candidates gave incorrect answers.
- (c) Most of the candidates identified the compounds A, B, C, D and E correctly. Some were not able to identify compound F. Instead of $\text{CH}_3\text{COOC}_2\text{H}_5$ they identified compound F as $\text{C}_2\text{H}_5\text{-COOCH}_3$.

Suggestions for teachers

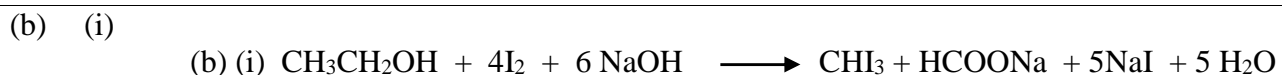
- Stress should be laid upon giving the correct conditions and catalysts.
- Insist that candidates learn all important name reactions. Stress upon writing complete balanced equations. Explain iodoform reaction in one step with I_2 and NaOH .
- Explain Wurtz- Fittig reaction in detail with proper conditions.

MARKING SCHEME**Question 8**(a) (i) Glycerol to formic acid(ii) Chlorobenzene to phenol(iii) Diethyl ether to ethanol

(or any other correct method)

(iv) Phenol to aniline

(any other correct method)



(OR)



- (c) A – CH_3COOH (Acetic acid)
B – CH_3COCl (Acetyl chloride)
C - CH_3CONH_2 (Acetamide)
D – $\text{CH}_3\text{CH}_2\text{NH}_2$ (Ethylamine)
E – $\text{CH}_3\text{CH}_2\text{OH}$ (Ethyl alcohol)
F – $\text{CH}_3\text{COOC}_2\text{H}_5$ (Ethyl acetate)

Question 9

- (a) Give balanced equations for the following name reactions: [3]
(i) Reimer-Tiemann reaction.
(ii) Rosenmund reaction
(iii) Hoffmann's degradation reaction
- (b) Give one chemical test to distinguish between the following pairs of compounds: [3]
(i) Ethylamine and diethylamine.
(ii) Acetaldehyde and benzaldehyde
- (c) (i) Arrange the following compounds in the ascending order of their basic strength and give reasons for your answer: [2]
Methylamine, Aniline, Ethylamine, Diethyl ether
(ii) Name the monomers and the type of polymerization in each of the following [2]
polymers:
(a) Polyester
(b) Bakelite

Comments of Examiners

- (a)(i) Reimer-Tiemann reaction: the reactants and the products given in the chemical equation were correct in most cases but equation was not balanced in many cases.
- (ii) Rosenmund reaction: correct equations were given by most candidates. Some candidates failed to mention the catalyst i.e. Pd and BaSO₄ while a few used 2[H] for reduction instead of H₂.
- (iii) Hoffmann's degradation reaction: some candidates were not able to write this equation correctly. On the product side, only methyl amine was written in several cases; all the products formed were not mentioned by candidates.
- (b)(i) To distinguish between ethyl amine and diethyl amine, some candidates only mentioned the name of the test but the observations were not given.
- (ii) To distinguish between acetaldehyde and benzaldehyde, candidates used Tollen's reagent which is given by both the compounds.
- (c)(i) The order was given incorrectly in most cases. Aniline was shown as the most basic compound. Many candidates were unable to explain the correct reasons for basicity, i.e. +I effect, steric effect.
- (ii)(a) The monomers given were wrong in several cases. The type of polymerization given by some candidates was 'addition' polymerization instead of 'condensation' polymerization.
- (b) Most candidates wrote cross linked polymerization instead of condensation polymerization.

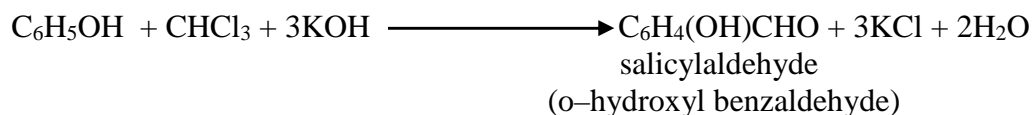
Suggestions for teachers

- The named organic reactions must be taught in detail. The following points must be stressed upon:
 - Reactants and conditions of named reactions;
 - Balancing of equations.
- Students must be told to give the reagent used, observations made and one positive test for each compound.
- Reaction mechanism must be taught properly with suitable examples.
- Polymerisation should be taught in detail and the monomers for different polymers explained to students.
- Teach monomers, polymers, type of polymerisation and uses in a tabular form.

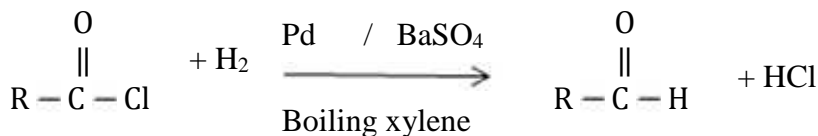
MARKING SCHEME

Question 9

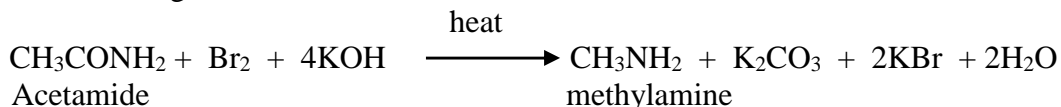
- (a) (i) Reimer-Tiemann reaction



- (ii) Rosenmund reaction



- (iii) Hoffmann's degradation reaction

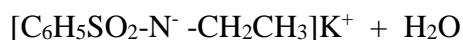
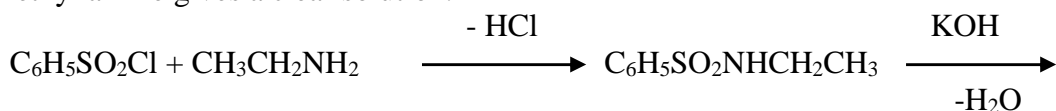


(b) Chemical test to distinguish between the following pairs:

(i) Ethyl amine and diethylamine

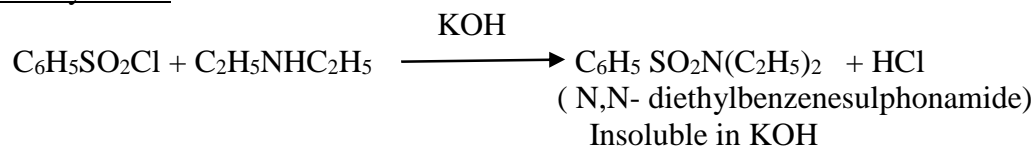
Hinsberg's test

Ethylamine – when shaken with benzene sulphonyl chloride and aqueous KOH solution, ethyl amine gives a clear solution.



Potassium salt
(soluble in KOH)
Clear solution

Diethylamine – on similar treatment forms an insoluble substance.



(or any other correct test)

(ii) Acetaldehyde to Benzaldehyde

Acetaldehyde gives iodoform test with Iodine and alkali, benzaldehyde does not give iodoform test.
(or any other correct test)

(c) Increasing order of basic strength

(i) Diethyl ether < Aniline < methylamine < ethylamine

Reason- + I effect of the alkyl groups
Steric effects of alkyl groups
Aromatic amines are weaker bases than aliphatic amines.

(ii)(a) Polyester

Monomer – ethylene glycol + terephthalic acid (or formulae of monomers)

Condensation polymer/ polymerisation

(b) Bakelite

Monomer – Phenol + Formaldehyde

Condensation polymer / polymerisation

Question 10

- (a) An organic compound A with molecular formula C_2H_7N on reaction with nitrous acid gives a compound B. B on controlled oxidation gives compound C. C reduces Tollen's reagent to give silver mirror and D. B reacts with D in the presence of concentrated sulphuric acid to give sweet smelling compound E. Identify A, B, C, D and E. Give the reaction of C with ammonia. [3]
- (b) Give balanced equations for the following reactions: [4]
- How will you convert ethyl amine to methyl amine?
 - What is the effect of denaturation on the structure of proteins?
 - Name the nitrogen base residues present in DNA.
- (c) Give balanced equations for the following reactions: [3]
- Aniline is treated with nitrous acid and HCl at low temperature.
 - Acetyl chloride is treated with ethyl alcohol.
 - Formaldehyde is treated with ammonia

Comments of Examiners

- (a) The identification of compounds A, B, C, D and E was done correctly by most of the candidates. Many candidates were not able to write the reaction between compound C and ammonia. In some cases, D was identified as HCOOH instead of CH_3COOH .
- (b) (i) Conversion of ethylamine to methylamine was done correctly by a number of candidates. In some cases, correct conditions were not shown.
- (ii) During denaturation of protein, secondary and tertiary structures are destroyed but primary structures remains unchanged. Some candidates wrote primary structure changes. The point that globular proteins are converted into fibrous protein was not reported by many candidates.
- (iii) The nitrogenous base residues adenine, guanine, cytosine and thymine present in DNA were named correctly by many candidates. Some candidates reported 'uracil' which was not correct.
- (c) (i) In a number of cases, the equation was not balanced and by product i.e. H_2O was not given.
- (ii) This part was answered correctly by most of the candidates. Some candidates forgot to write HCl.
- (iii) Many candidates were not able to write this reaction correctly. The main product given by some of the candidates was wrong. The equation given was unbalanced in some cases.

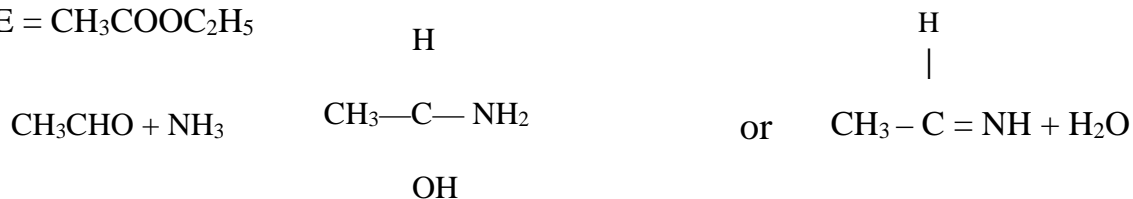
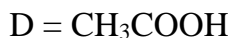
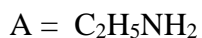
Suggestions for teachers

- Give practice to students in solving such type of problems in which the identification of compounds is based on different chemical reactions.
- Explain denaturation of proteins by explaining the changes in structure of proteins.
- Structure of DNA and RNA must be explained with the help of diagrams.
- Give sufficient practice in writing organic reactions with correct names.
- Formula and structure of urotropine should be explained.

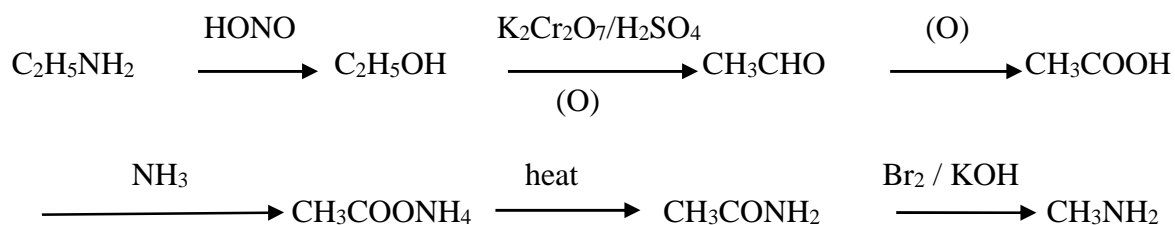
MARKING SCHEME

Question 10

(a) Identify A, B, C, D and E



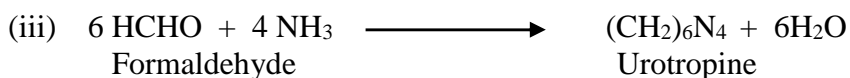
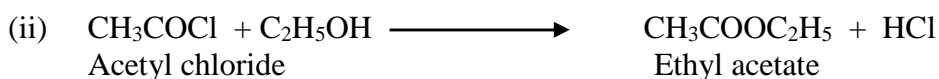
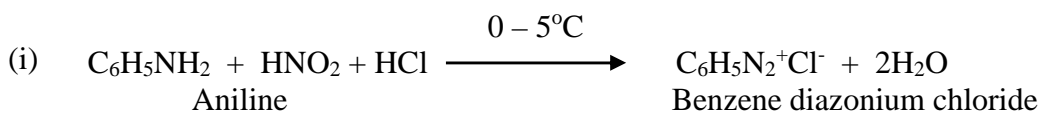
(b) (i) Ethylamine to methylamine



(ii) During denaturation, secondary and tertiary structures of proteins are destroyed but primary structures remain as such. Again, the globular proteins are converted into fibrous proteins and their biological activity is lost.

(iii) Adenine, guanine, cytosine and thymine

(c) Balanced equations for the following:



GENERAL COMMENTS:

(a) Topics found difficult by candidates in the Question paper:

- Relative molecular mass and mole (numerical problems), abnormal molecular weights.
- Solid state, voids and defects in solid state.
- Ionic equilibria (numerical problems) concept of solubility product, ionic product and common ion effect.
- Electrolytic conductance, electrode potential and Nernst equation.
- Nomenclature, isomerism, hybridization and geometry of coordination compounds.
- Balancing of equations for inorganic compounds.
- Organic conversions, named reactions and balancing of equations.
- Bio molecules.
- Polymers.

(b) Concepts between which candidates got confused:

- Vant Hoff factor, calculation of degree of dissociation.
- Azeotropic mixtures, ideal and non-ideal solutions.
- Order and molecularity of reaction, calculation of time period for the decomposition of radioactive elements by 1st order kinetics.
- Le Chatelier's principle, change in equilibrium with change in pressure and temperature.
- Electrolytic conductance, numerical problems, calculation of E°_{cell} and E_{cell} by using Nernst equation.
- Calculation of solubility from solubility product, common ion effect and buffer solution.
- Nomenclature, isomerism, hybridization and geometry of coordination compounds.
- Conversion of organic compounds, conditions and catalyst, named organic reactions.
- Polymerisation, biomolecules.

(c) Suggestions for candidates:

- Avoid selective study, give equal importance to all the topics.
- Practice writing the IUPAC names for coordination compounds as well as organic compounds.
- Practice more numerical problems. Solve the problems step-wise with correct formula and units.
- Learn both positive and negative chemical tests in organic reactions as it will help in distinguishing between organic compounds.
- Learn the reactions both organic and inorganic with proper conditions. Always write the correct balanced equations.
- Learn the shapes and hybridization of molecules with diagram.
- Read questions carefully and understand what is required before attempting the question.
- While solving numerical problems, proper steps should be followed, i.e. formula, substitution and correct answer with units.
- Do not give dual statements for any answer.
- Learn to write the key words in the answer.