

CHEMISTRY PAPER 2 (PRACTICAL)

Attempt *all* questions

Question 1

[8]

You are provided with two solutions as follows:

- **C-10** is a solution containing 1.60gms of potassium manganate (VII), KMnO_4 per litre.
- **C-11** is a solution prepared by dissolving 20.3gms of hydrated ammonium iron (II) sulphate crystals, $(\text{NH}_4)_2\text{SO}_4 \cdot \text{FeSO}_4 \cdot x\text{H}_2\text{O}$ per litre.

PROCEDURE:

Rinse and fill the burette with the given solution **C-10** (KMnO_4). Pipette out 20 ml or 25ml of **C-11** (hydrated ammonium iron (II) sulphate solution) and transfer into a clean conical flask. To this, add 20 ml of **C-12** (dilute sulphuric acid) specially provided for titration.

Titrate the solution in the conical flask with **C-10** (KMnO_4) slowly till one drop of this gives a light permanent pink colour to the solution **C-11** in the flask. The pink colour should not disappear on shaking the contents in the conical flask.

Repeat the above procedure to get at least **two** concordant readings.

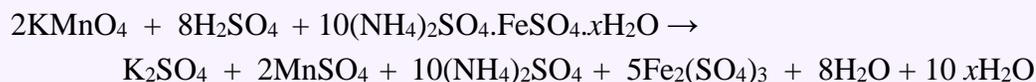
Tabulate your readings.

State:

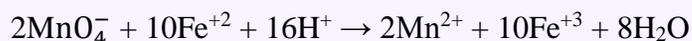
- The capacity of the pipette used.
- The titre value you intend to use in your calculations.

Show the titre value to the Visiting Examiner.

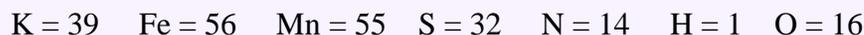
The equations for the above reactions are as follows:



The ionic equation for the reaction is:



Relative atomic masses:



Calculate the following:

- The **molarity** of the solution of potassium manganate(VII) **C-10**.
- The **molarity** of hydrated ammonium iron(II) sulphate solution **C-11**.

- (iii) The **molecular mass** of hydrated ammonium iron(II) sulphate deduced from the experimental data.
- (iv) The numerical value of x , i.e. the number of molecules of water of crystallization in $(\text{NH}_4)_2\text{SO}_4 \cdot \text{FeSO}_4 \cdot x\text{H}_2\text{O}$.

Note: *Molarity must be calculated up to at least 4 decimal places.*

Comments of Examiners

A number of candidates did not seem to be aware of the significance of tabulating the readings.

- They did not write initial and final readings;
 - Many just gave one titre value; they had no concept of concordant readings;
 - Some used average value with a difference between two readings of more than 0.2;
 - Some candidates gave burette readings up to 2 decimal places;
 - Some candidates did not read the question paper carefully and used wrong solutions in the burette and pipette;
 - Overwriting in the titre value continued to appear;
- (i) Several candidates used wrong formula and wrong atomic weights for calculating molecular weight of KMnO_4 .
- (ii) Many candidates used wrong formula to calculate molarity of hydrated ferrous ammonium sulphate i.e. gms per litre/molecular weight instead of $M_1 V_1 / M_2 V_2 = n_1 / n_2 = 1/5$.
- Some candidates rounded off the value of molarity in questions (i) and (ii) and used only two places after the decimal instead of four (all molarity calculations should be up to four decimal places).
- (iii) Some candidates reported molarity of C_{10} and C_{11} correctly upto 4 places of decimal but when they substituted that value for part (iii) calculation, they rounded off the value.
- Molecular weight of hydrated ferrous ammonium sulphate was incorrectly calculated as the question was not read carefully i.e. theoretical value of x was substituted and molecular weight determined.
- (iv) The numerical value of (x) water of crystallization was reported in fraction and it was not rounded off to the closest whole number.

Suggestions for teachers

- Insist that students tabulate the titre value correctly. Teach them the tabular form and explain the significance of each column. Insist on one trial run and two concordant readings. Tell them the average should not be taken and overwriting in the readings should be strictly avoided.
- Give sufficient practice in calculating molarity (not normality), percentage purity, water of crystallization for all oxidation/reduction titration in the syllabus. Students must do the experiments throughout the year under the supervision of the teacher.
- Tell students it is absolutely imperative to write upto at least four decimal places in the calculation of molarities, and at least two decimal places for molecular weight and percentage purity. They must also round off the value of water of crystallization to the nearest whole number.
- Students should be asked to read the question paper carefully, refer to the formula of the substances and atomic weights as given in the question paper. They must follow the chemical equation given in the question paper and apply that for the number of moles.
- Explain that for only pure compounds students can use $\text{molarity} = \frac{\text{weight dissolved}}{\text{molecular weight}} \times \text{volume}$.
- All students at a centre must be given pipettes of the same size.

MARKING SCHEME	
Question 1.	
Let the titre value be 25.6 ml	
(i)	<p>Molarity of the solution C – 10 (KMnO₄)</p> $\text{Molarity of C-10} = \frac{\text{wt of KMnO}_4 \text{ in g/lit}}{\text{Mol.wt of KMnO}_4}$ $= \frac{1.6}{158} = 0.0101 \text{ M}$
(ii)	<p>Molarity of the solution , C-11 (Hydrated ammonium iron (II) Sulphate)</p> $\frac{M_1 \times V_1}{M_2 \times V_2} = \frac{n_1}{n_2}$ <p> M₁– Molarity of C-10 V₁ – Volume of C-10 n₁ – Number of moles of C-10 M₂ – Molarity of C-11 V₂ – Volume of C-11 n₂ – Number of moles of C-11 </p> $\frac{0.0101 \times 25.6}{M_2 \times 25.0} = \frac{2}{10}$ $M_2 = 0.05178 \text{ M}$
(iii)	<p>Molecular weight of C-11 (hydrated ammonium iron (II) sulphate)</p> $\text{Molecular weight} = \frac{\text{Wt of C-11 in g/lit}}{\text{Molarity (M}_2\text{)}}$ $= \frac{20.3}{0.05178} = 392$
(iv)	<p>Value of x: (NH₄)₂SO₄.FeSO₄.xH₂O = 392.0</p> $392 = 284 + 18x$ $18x = 392 - 284 = 108$ $x = \frac{108}{18} = 6.0$

Question 2

[5]

This experiment is designed to find the effect of concentration of the reactants on the rate of a chemical reaction.

You are provided with two solutions:

- (a) **C-13** is a solution of sodium thiosulphate crystals (Na₂S₂O₃.5H₂O) of strength 0.2 M.
- (b) **C-14** is a solution of HCl of strength 0.1 M.

PROCEDURE:

Take 5 beakers labelled **1** to **5**. With the help of a measuring cylinder, put sodium thiosulphate solution $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$ (**C-13**) and distilled water according to the table given below:

Beaker no.	Volume of the solution C-13	Volume of distilled water	Time in seconds
1	50ml	0ml	
2	40ml	10ml	
3	30ml	20ml	
4	20ml	30ml	
5	10ml	40ml	

Place beaker number **1** over a piece of paper with a cross mark on it.

Now add 10ml of the solution **C-14** (HCl) to this solution and start the stop-watch at the same time. Swirl the contents of the beaker and return it over the cross mark.

Look down vertically on to the cross mark and stop the stop-watch as soon as the cross on the paper becomes invisible. Note the time in the stop-watch.

The disappearance of the cross mark is due to the formation of colloidal sulphur in the reaction. The reaction is given as:



Repeat the experiment by adding 10 ml of **C-14** to the beakers labelled **2**, **3**, **4**, and **5** and note the time taken in each case for the cross mark on the paper to become invisible.

Tabulate the readings. From your results:

- (i) Plot a graph of the concentration of sodium thiosulphate solution (in terms of the volume of the sodium thiosulphate taken) against time taken for the cross mark to become invisible.
- (ii) Predict the effect of change in concentration of sodium thiosulphate on the rate of the above reaction from the nature of your graph.
- (iii) From the graph, find the time taken for the reaction when 25 ml of the solution **C-13** is used.

Comments of Examiners

- (i) A tabular column was provided in the question paper which many candidates did not follow and complete by filling up time in seconds.
- (a) The question required candidates to plot a graph of the concentration of sodium thiosulphate solution (in terms of the volume) against time. Several candidates first calculated the molarity of sodium thiosulphate (concentration) which was not required. Only volume was to be used.
- (b) Some candidates took the wrong axis for volume versus time. Volume should have been y-axis and time x-axis.
- (c) Many candidates did not mention what was taken on which axis and units like ml & sec were also missing.
- (d) In several cases, the scale for the x and y axis was incorrect and haphazard.
- (e) In several cases, the curve was not hyperbolic. It should have been drawn free-hand, instead it was drawn using a ruler by some candidates.
- (f) Some candidates plotted $1/T$ versus volume which was not asked for and got a straight line from the origin instead of a curve.
- (ii) The time for the reaction when 15 ml of C-13 is used was not interpreted correctly from the graph. Instead a vague value was reported by many candidates.
- (iii) Many candidates used vague, incomplete and inappropriate language for prediction of the effect of change in concentration of sodium thiosulphate and rate of reaction.

Suggestions for teachers

- Instruct students to read the experiment carefully and then carry it out. Tabulation must be done correctly in the given format with correct units.
- Plan out more experiments based on the rate of reaction and practice with students.
- Provide digital stop-watches for students to record time accurately.
- Plotting of graph must be done properly - explain selection of axis, appropriate scale, how and when to join points on a graph free-hand /use a ruler, depending on the shape of the curve.
- Interpretation from the graph must be shown on the graph paper, and reported on the answer script as well.
- Emphasise the importance of correct language /expression while answering conceptual question or stating laws or principles.
- Please relate the practical experiments done with the theoretical concepts of Chemical Kinetics - then and only then will the students have a clear understanding.

MARKING SCHEME	
Question 2.	
Tabulation of time in ascending order (<i>any value – minimum three</i>)	
(i)	Time in seconds along x – axis. Volume of $\text{Na}_2\text{S}_2\text{O}_3$ undiluted along y – axis.
Correct shape of the curve (rectangular hyperbole)	
(ii)	The rate of reaction increases with increase in concentration of $\text{Na}_2\text{S}_2\text{O}_3$ /

	rate of reaction \propto to concentration of $\text{Na}_2\text{S}_2\text{O}_3$ / time of reaction $\frac{1}{\propto}$ to concentration of $\text{Na}_2\text{S}_2\text{O}_3$ / time of reaction $\frac{t}{\propto}$ to rate
(iii)	Time required when 25 ml of $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$ solution was taken (exact position for 25ml from the graph.)

Question 3

[7]

Analyse qualitatively the substance **C-15** which contains *two* anions and *two* cations. Identify these ions.

(a) While testing for **anions** you must mention:

- (i) How the solution/soda extract was prepared.
- (ii) How the gases were identified.
- (iii) The confirmatory test for each anion.

Show the results as required to the Visiting Examiner.

(b) While testing for **cations** you must mention:

- (i) How the original solution for group analysis was prepared.
- (ii) The formal group analysis with pertinent group reagents.
- (iii) The confirmatory test for each cation.

Show the results as required to the Visiting Examiner.

Note: Use of qualitative analysis booklet/table is not allowed.

Comments of Examiners

(a) Wet tests for anions were performed by many candidates using either the aqueous solution or soda extract, instead of neutralized soda extract.

Common errors made by candidates are as follows:

- The confirmatory test for sulphate was performed with lead acetate instead of barium chloride which was not acceptable.
- The confirmatory test of sulphate was left incomplete since the solubility of the precipitate in all mineral acids was not done.
- Test for carbonate ion was done with original solution instead of salt mixture.
- Several candidates reported heat for carbonate ion which is not acceptable.
- Candidates added lime water to the test solution instead of passing the evolving gas through lime water.

(b) Preparation for original solution for cation detection was not done correctly by many candidates. Salt mixture or if residue of sodium carbonate extract was used, should have been dissolved in hot dilute HCl/ dilute HNO₃.

Common errors made by candidates are as follows:

- Absence of group I & II was not reported.
- H₂S was not boiled of before group III reagents were added.
- Most of the candidates did not add concentrated nitric acid in group III, boil and cool before adding group reagents.
- The order of preparing the buffer medium in group III was incorrect.
- The white precipitate obtained in group III was supposed to be used for confirmatory test of aluminum by dissolving in minimum quantity of dilute HCl, instead candidates used original solution.

- In group zero, candidates used original solution instead of salt mixture and omitted heat in the test.
- Candidates performed the confirmatory test for ammonium ion incorrectly by adding Nessler's reagent to the test solution instead of passing the gas evolved into Nessler's reagent.

Suggestions for teachers

- Teach students the steps for preparing the original solution.
- Insist that the wet tests for the anion should be performed with neutralized sodium carbonate extract, even if the salt mixture is more or less soluble in water.
- Correct reagents must be used for test for anions and the test must be completed.
- Concepts of formal group analysis like common ion, buffer and solubility product must be taught thoroughly before doing salt analysis.
- Practice mixture analysis and guide student on how to record formal group analysis correctly and meaningfully with pertinent group reagents.
- Ask students to use reagents and tests that are acceptable.
- Explain to students the importance of adding concentrated nitric acid and boiling to convert ferrous to ferric.
- Removal of H₂S before group III and V must be taught clearly.
- Tell students that while reporting the groups which are present, it is equally important to mention groups which are absent so that the analysis is systematic.

MARKING SCHEME
Question 3.
Substance C-15
Mixture C-15 contains aluminium sulphate and ammonium carbonate in the ratio (1:1) by mass.
Preparation of original solution
Carbonate ion
Sulphate ion
Identification of Group III
Confirmatory test of aluminium ion
Identification of Group Zero
Confirmatory test of ammonium ion
Test for carbonate (CO_3^{2-}): Salt + dil H_2SO_4 or dil HCl – Brisk effervescence. The gas evolved when passed in lime water turns lime water milky. Carbonate confirmed/present.
Test for sulphate (SO_4^{2-}): To the neutral Na_2CO_3 extract (acidified with dil HCl / acetic acid / nitric acid). BaCl_2 solution is added. A white precipitate insoluble in any mineral acids - SO_4^{2-} ion confirmed.
Preparation of the original (O.S.). The original solution is prepared in dil HCl .
After reporting the Group I and II absent with proper group reagents. Test for Group III. Boil off the H_2S gas from the solution after group II, cool and then add few drops of concentrated nitric acid, heat the content then cool and add ammonium chloride(s) followed by excess of ammonium hydroxide solution. Gelatinous white precipitate is obtained. Group III is present (Al^{3+} ion may be present).
Test for Al^{3+} ion. Dissolve the precipitate in dil HCl and divide it into two parts. To the first part, add NaOH solution. White precipitate is formed which dissolved in excess of NaOH - Al^{3+} confirmed. OR To the second part, add blue litmus solution, then add NH_4OH solution drop by drop, blue floating precipitate/lake is formed. Al^{3+} confirmed.
To the salt (C-15) 2 ml of NaOH solution and heat gently – a colourless, characteristic pungent odour gas is evolved (smell of ammonia) – Zero group is present (ammonium ion may be present)
Pass the gas evolved in Nessler's reagent. The Nessler's reagent turns brown. Ammonium ion (NH_4^+) confirmed.

Solution is prepared in HCl	No precipitate	O.S
Salt/Original solution +dil. HCl	No precipitate	Group I absent
Above Solution\filtrate\O.S (provided group I is absent) after Group I / filtrate Pass H ₂ S gas	No precipitate	Group II absent
Above Solution\filtrate\O.S can be accepted if Group I, II is absent after Group II / filtrate Boil off H ₂ S gas - (add conc. HNO ₃ and boil) cool - add NH ₄ Cl solid and NH ₄ OH solution	gelatinous white precipitate	Group III present
Salt + NaOH solution and heat.	Smell of ammonia pungent gas evolved	Group zero present

GENERAL COMMENTS

(a) Topics found difficult by candidates:

- Concepts of molarity based on (grams/liter)/ molecular weight for pure substances and molarity based on titer value.
- Plotting of graphs in chemical kinetics.
- Principles of formal group analysis.

(b) Concepts between which candidates got confused:

- Confusion in reporting whole number for water of crystallization of Mohr's salt.
- Choice of axis, correct scale, joining of points, shape of curve etc. in the graph of chemical kinetic.
- Solubility of mixture or preparation of original solution for group separation.
- Use of neutralized sodium carbonate extract for confirmatory test of anion.
- Identification of gases correctly.
- Systematic analysis from zero to III and reporting absence and presence of groups.

(c) Suggestions for candidates:

- Practice makes perfect, hence practice as many salt mixtures as possible.
- Perform experiments on chemical kinetics carefully after understanding the theoretical concepts. Also practice plotting graphs for these experiments.
- Plan before writing formal group analysis.
- Do not forget the use of concentrated nitric acid in group III. Also understand why it is being used.
- Learn formal group separation thoroughly with principles like buffer, common ion and solubility products.
- Titre value must be concordant and not average.

- Listen to the teacher's instructions carefully, read the experiment thoroughly and then perform them.
- Develop a habit of observation and note them down correctly and to the point.
- Remember to tabulate your readings neatly, keeping in mind concordant readings not average and avoid overwriting in the tabular column.
- Do not round off molarity values, report to minimum four decimal places.
- Do follow the molecular formula given in the question paper, whether it is hydrated or anhydrous
- Round off water of crystallization to a whole number.
- Remember to pass gas through a reagent and never add reagent to gas.