

Practical Chemistry: Comprehensive Viva Voce Guide

Based on Class 12 / JEE / NEET Laboratory Syllabus — 110 Curated Questions & Answers

Scope & Coverage: This question bank spans all key areas of practical chemistry: Qualitative Organic Analysis (Lassaigne's test & functional group tests), Volumetric Analysis / Titrations, Inorganic Salt Analysis (cations & anions), Preparation of Inorganic & Organic Compounds, Physical Chemistry Experiments (thermochemistry, chemical kinetics, surface chemistry/colloids), and Standard Laboratory Techniques & Safety.

Section 1: Qualitative Organic Analysis — Detection of Extra Elements (Lassaigne's Test)

Q1. What is the principle behind Lassaigne's test (sodium fusion test)?

Ans: Organic compounds contain elements (N, S, Halogens) in covalent bonding. By fusing the compound with metallic sodium, these covalent elements are converted into water-soluble ionic sodium salts (NaCN , Na_2S , NaX), which can then be detected using standard ionic inorganic wet tests.

Q2. Why is sodium metal stored under kerosene oil or paraffin?

Ans: Sodium is highly reactive and oxidizes rapidly upon exposure to atmospheric oxygen and moisture, reacting violently to form sodium hydroxide and hydrogen gas. Kerosene shields it from air and water.

Q3. Why is a freshly cut piece of sodium metal dried with filter paper before heating in the ignition tube?

Ans: Kerosene adhering to the sodium surface can vaporize or burn upon heating, leading to spitting, cracking of the fusion tube, or inaccurate results.

Q4. Why is distilled water used to extract the fused mass rather than tap water?

Ans: Tap water contains dissolved ions like chloride (Cl^-), sulfate (SO_4^{2-}), and calcium (Ca^{2+}), which interfere with tests and give false positive results (e.g., precipitation of AgCl).

Q5. Why is the red-hot ignition tube plunged into distilled water in a porcelain dish?

Ans: The sudden thermal shock breaks the thin glass tube instantly, allowing distilled water to rapidly dissolve the water-soluble sodium salts formed during fusion.

Q6. Why is the sodium fusion extract boiled and filtered before testing?

Ans: Boiling ensures complete dissolution of all soluble sodium salts from the crushed glass residue, and filtration removes unreacted carbon particles and glass fragments, yielding a clear filtrate.

Q7. Write the chemical equations for the reaction of sodium with carbon and nitrogen, sulfur, and halogens during fusion.

Ans: $\text{Na} + \text{C} + \text{N} \rightarrow \text{NaCN}$ (Sodium cyanide); $2\text{Na} + \text{S} \rightarrow \text{Na}_2\text{S}$ (Sodium sulfide); $\text{Na} + \text{X} \rightarrow \text{NaX}$ (Sodium halide, where $\text{X} = \text{Cl}, \text{Br}, \text{I}$); $\text{Na} + \text{C} + \text{N} + \text{S} \rightarrow \text{NaSCN}$ (Sodium thiocyanate, if N and S are both present and Na is limited).

Q8. Describe the chemistry and reaction involved in the detection of Nitrogen in Lassaigne's extract.

Ans: The extract is boiled with freshly prepared FeSO_4 solution and acidified with dilute H_2SO_4 , followed by a few drops of FeCl_3 . A Prussian blue precipitate or coloration confirms nitrogen: $\text{Fe}^{2+} + 6\text{CN}^- \rightarrow [\text{Fe}(\text{CN})_6]^{4-}$; $4\text{Fe}^{3+} + 3[\text{Fe}(\text{CN})_6]^{4-} \rightarrow \text{Fe}_4[\text{Fe}(\text{CN})_6]_3$ (Ferri ferrocyanoide / Prussian Blue).

Q9. Why is freshly prepared FeSO₄ solution used in the Prussian blue test?

Ans: On standing, FeSO₄ oxidizes by atmospheric oxygen to basic ferric sulfate, Fe(OH)SO₄, which interferes with the test. Fresh solution ensures a sufficient concentration of pure Fe²⁺ ions.

Q10. Why is dilute H₂SO₄ added during the nitrogen test instead of concentrated H₂SO₄ or HNO₃?

Ans: Dilute H₂SO₄ dissolves the greenish precipitate of Fe(OH)₂ and prevents basic salt precipitation. Concentrated HNO₃ is an oxidizing agent and would oxidize CN⁻ ions or interfere, while HCl may introduce chloride ions.

Q11. Why does an organic compound containing both nitrogen and sulfur sometimes give a blood-red color instead of Prussian blue?

Ans: If sodium metal is used in insufficient amounts, sodium thiocyanate (NaSCN) is formed instead of separate NaCN and Na₂S. Upon reaction with Fe³⁺ ions, it forms the blood-red complex [Fe(SCN)]²⁺ (or [Fe(SCN)₃]).

Q12. How can the formation of NaSCN be prevented if both N and S are present?

Ans: By fusing the organic compound with an excess of sodium metal. Excess sodium decomposes sodium thiocyanate into separate sodium cyanide and sodium sulfide: NaSCN + 2Na → NaCN + Na₂S.

Q13. Describe the sodium nitroprusside test for sulfur detection.

Ans: A few drops of freshly prepared sodium nitroprusside solution, Na₂[Fe(CN)₅NO], are added to Lassaigne's extract. The appearance of a deep violet / purple coloration confirms sulfur: S²⁻ + [Fe(CN)₅NO]²⁻ → [Fe(CN)₅NOS]⁴⁻ (Sodium thionitroprusside complex).

Q14. Describe the lead acetate test for sulfur.

Ans: The Lassaigne's extract is acidified with dilute acetic acid, and lead acetate solution is added. Formation of a black precipitate of lead sulfide (PbS) confirms the presence of sulfur: Na₂S + (CH₃COO)₂Pb → PbS↓ (black) + 2CH₃COONa.

Q15. Why is acetic acid used to acidify the solution in the lead acetate test instead of dilute H₂SO₄?

Ans: Dilute H₂SO₄ would react with lead acetate to form an insoluble white precipitate of lead sulfate (PbSO₄), which would mask the black PbS precipitate. Acetic acid forms soluble lead salts.

Q16. Why must Lassaigne's extract be boiled with concentrated HNO₃ before testing for halogens?

Ans: If nitrogen and/or sulfur are present, CN⁻ and S²⁻ ions would react with AgNO₃ to give white AgCN or black Ag₂S precipitates, interfering with halogen detection. Boiling with conc. HNO₃ decomposes NaCN into HCN↑ and Na₂S into H₂S↑, expelling them.

Q17. How do you distinguish between AgCl, AgBr, and AgI precipitates obtained with AgNO₃?

Ans: AgCl is white and readily soluble in dilute aqueous ammonia (forming [Ag(NH₃)₂]⁺). AgBr is pale yellow and sparingly soluble in concentrated ammonia. AgI is dark yellow and completely insoluble in aqueous ammonia.

Q18. What is the 'Layer Test' for bromine and iodine?

Ans: Lassaigne's extract is acidified with dilute HNO₃, mixed with an organic solvent like CCl₄ or CHCl₃ or CS₂, and treated with chlorine water. Chlorine oxidizes Br⁻ to Br₂ (giving an orange-brown organic layer) or I⁻ to I₂ (giving a distinct violet organic layer).

Q19. Why is potassium metal generally not used in place of sodium for Lassaigne's fusion?

Ans: Potassium is far more reactive and reacts explosively with organic compounds, making the fusion dangerous and uncontrollable in standard school/college laboratory apparatus.

Q20. Can hydrazine (NH₂-NH₂) or urea give a positive Lassaigne's test for nitrogen on its own?

Ans: Hydrazine contains no carbon, so it cannot form NaCN during fusion and gives a negative test unless carbon (e.g., starch or sugar) is intentionally added. Urea contains carbon and nitrogen, so it forms NaCN and gives a positive Lassaigne's test.

Section 2: Detection of Organic Functional Groups

Q21. What is the Ceric Ammonium Nitrate (CAN) test and which functional group does it detect?

Ans: The CAN test detects alcoholic -OH groups. When ceric ammonium nitrate, (NH₄)₂[Ce(NO₃)₆], is treated with an alcohol, it forms a red-colored alkoxy-cerium complex: (NH₄)₂[Ce(NO₃)₆] + ROH → [(NH₄)₂Ce(OR)(NO₃)₅] (red) + HNO₃.

Q22. What is Lucas reagent, and what is its principle?

Ans: Lucas reagent is an equimolar mixture of anhydrous ZnCl₂ (a Lewis acid catalyst) and concentrated HCl. It converts alcohols into insoluble alkyl chlorides. ZnCl₂ coordinates with the hydroxyl oxygen, facilitating C-O bond cleavage and carbocation formation.

Q23. How does the Lucas test distinguish between primary, secondary, and tertiary alcohols?

Ans: Tertiary alcohols react immediately, producing turbidity instantly (via stable 3° carbocation). Secondary alcohols produce turbidity within 3–5 minutes. Primary alcohols do not produce turbidity at room temperature; turbidity appears only upon heating.

Q24. What is the structural requirement for an organic compound to give a positive Iodoform test?

Ans: The compound must contain either a methyl carbonyl group (CH₃-C=O) or a methyl carbinol group (CH₃-CH(OH)- attached to H or an alkyl/aryl group). Examples include ethanol, acetone, acetaldehyde, and 2-propanol.

Q25. What is the reagent and observation in a positive Iodoform test?

Ans: The compound is warmed with iodine (I₂) in aqueous sodium hydroxide (NaOH) or sodium carbonate. Formation of a canary yellow crystalline precipitate of iodoform (CHI₃) with a characteristic medicinal antiseptic smell confirms the group.

Q26. Why does methanol NOT give the iodoform test, but ethanol does?

Ans: Methanol (CH₃OH) lacks the CH₃-CH(OH)- unit; oxidation yields formaldehyde (HCHO), which has no α-methyl group. Ethanol (CH₃CH₂OH) oxidizes to acetaldehyde (CH₃CHO), which possesses the required CH₃-C=O group.

Q27. What is the Neutral FeCl₃ test for phenols?

Ans: Phenols react with neutral ferric chloride solution to produce intense violet, blue, or green colored soluble coordination complexes: 6ArOH + FeCl₃ → [Fe(OAr)₆]³⁻ (colored complex) + 3H⁺ + 3Cl⁻.

Q28. How is neutral ferric chloride solution prepared?

Ans: Dilute ammonium hydroxide (NH₄OH) is added dropwise to FeCl₃ solution until a faint brown precipitate of Fe(OH)₃ appears. The solution is then filtered or cleared with a minimal trace drop of FeCl₃ to make it strictly neutral.

Q29. Explain the Phthalein Dye test for phenol.

Ans: Phenol is heated with phthalic anhydride in the presence of concentrated H₂SO₄ as a dehydrating agent. The resulting product is phenolphthalein. When poured into dilute NaOH, it yields an intense pink coloration due to the formation of the quinoid disodium salt.

Q30. What reagent is used in the 2,4-DNP (Brady's) test, and what does it detect?

Ans: 2,4-Dinitrophenylhydrazine dissolved in methanol and acid. It reacts with carbonyl groups (aldehydes and ketones) to produce yellow, orange, or red crystalline precipitates of 2,4-dinitrophenylhydrazones.

Q31. What is Tollen's reagent and how is it freshly prepared in the laboratory?

Ans: Tollen's reagent is ammoniacal silver nitrate, $[\text{Ag}(\text{NH}_3)_2]\text{OH}$. It is prepared by adding dilute NaOH to AgNO_3 solution to form a grey-brown precipitate of Ag_2O , which is then dissolved by dropwise addition of dilute aqueous ammonia.

Q32. What is the observation and reaction in Tollen's test?

Ans: Aldehydes reduce Ag^+ to metallic silver, forming a shining silver mirror on the clean inner glass wall: $\text{R-CHO} + 2[\text{Ag}(\text{NH}_3)_2]^+ + 3\text{OH}^- \rightarrow \text{R-COO}^- + 2\text{Ag}\downarrow (\text{silver mirror}) + 4\text{NH}_3 + 2\text{H}_2\text{O}$. Ketones do not reduce Tollen's reagent.

Q33. What is Fehling's reagent, and why are solutions A and B stored separately?

Ans: Fehling A is aqueous copper(II) sulfate ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$). Fehling B is an alkaline solution of Rochelle's salt (sodium potassium tartrate + NaOH). If stored premixed, Cu^{2+} would slowly precipitate or reduce over time; mixing them just prior to testing keeps the Cu^{2+} stabilized as a soluble tartrate complex.

Q34. What is the positive observation for Fehling's test, and which aldehydes fail it?

Ans: Aliphatic aldehydes reduce Cu^{2+} to cuprous oxide, producing a characteristic brick-red precipitate of Cu_2O : $\text{R-CHO} + 2\text{Cu}^{2+} + 5\text{OH}^- \rightarrow \text{R-COO}^- + \text{Cu}_2\text{O}\downarrow (\text{brick-red}) + 3\text{H}_2\text{O}$. Aromatic aldehydes (e.g., benzaldehyde) do not reduce Fehling's solution.

Q35. What is Schiff's reagent and how does it react with aldehydes?

Ans: Schiff's reagent is p-rosaniline hydrochloride (magenta dye) decolorized by sulfur dioxide (SO_2). Aldehydes restore the magenta/pink color without heating. Ketones generally do not respond.

Q36. What is Benedict's solution and how does it compare with Fehling's solution?

Ans: Benedict's solution contains CuSO_4 , sodium citrate, and sodium carbonate. It is an all-in-one single, stable reagent that can be stored indefinitely, unlike Fehling's reagent which requires separate A and B stock solutions.

Q37. How does the Sodium Bicarbonate (NaHCO_3) test detect carboxylic acids?

Ans: Carboxylic acids are stronger acids than carbonic acid; they displace CO_2 from NaHCO_3 , producing vigorous brisk effervescence: $\text{R-COOH} + \text{NaHCO}_3 \rightarrow \text{R-COONa} + \text{H}_2\text{O} + \text{CO}_2\uparrow$. Phenols (except picric acid) do not give this test.

Q38. Describe the Esterification test for carboxylic acids.

Ans: The carboxylic acid is warmed with an alcohol (e.g., ethanol) and a few drops of concentrated H_2SO_4 . The mixture is poured into dilute Na_2CO_3 solution; evolution of a fruity, sweet aroma indicates ester formation: $\text{R-COOH} + \text{R}'\text{OH} \rightleftharpoons \text{R-COOR}' + \text{H}_2\text{O}$.

Q39. What is the Carbylamine (Isocyanide) test?

Ans: Primary amines (aliphatic or aromatic) when heated with chloroform (CHCl_3) and ethanolic KOH produce extremely offensive, foul-smelling isocyanides (carbylamines): $\text{R-NH}_2 + \text{CHCl}_3 + 3\text{KOH} \rightarrow \text{R-NC} + 3\text{KCl} + 3\text{H}_2\text{O}$. Secondary and tertiary amines do not react.

Q40. Describe the Azo Dye test for primary aromatic amines.

Ans: Aniline (or 1° aromatic amine) is dissolved in dilute HCl and cooled to 0–5 °C. Cold NaNO₂ solution is added to form benzene diazonium chloride (diazotization). When this mixture is coupled with an alkaline solution of β-naphthol, a brilliant scarlet-red azo dye precipitates.

Q41. Why must the temperature be strictly kept below 5 °C during diazotization?

Ans: Benzene diazonium salts are thermally unstable at higher temperatures; above 5 °C, they hydrolyze rapidly with water to yield phenol and nitrogen gas: $\text{C}_6\text{H}_5\text{N}_2^+\text{Cl}^- + \text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_5\text{OH} + \text{N}_2\uparrow + \text{HCl}$.

Q42. What is Hinsberg's reagent and how does it distinguish 1°, 2°, and 3° amines?

Ans: Hinsberg reagent is benzenesulfonyl chloride (C₆H₅SO₂Cl). Primary amines form an N-alkylbenzenesulfonamide that is soluble in NaOH (due to acidic N-H). Secondary amines form an N,N-dialkyl derivative insoluble in NaOH. Tertiary amines do not react.

Section 3: Titrimetric Analysis (Volumetric Estimations)

Q43. What is a primary standard substance, and what are its key criteria?

Ans: A primary standard is a substance of high purity, high stability, definite known chemical composition, high equivalent mass, and non-hygroscopic nature, allowing standard solutions to be prepared directly by exact weighing (e.g., oxalic acid, Mohr's salt, Na₂CO₃).

Q44. Why is sodium hydroxide (NaOH) or KMnO₄ NOT a primary standard?

Ans: NaOH is deliquescent and absorbs atmospheric CO₂ and moisture. KMnO₄ is difficult to obtain in 100% pure form, contains traces of MnO₂ impurities, and is slowly reduced by atmospheric dust and light. Both must be standardized against primary standards.

Q45. What is the chemical formula and molar mass of Mohr's salt?

Ans: FeSO₄·(NH₄)₂SO₄·6H₂O (Ferrous Ammonium Sulfate). Its molar mass is 392.14 g/mol, and its equivalent weight in redox titration is 392.14 (n-factor = 1).

Q46. Why is dilute H₂SO₄ added during the preparation of a standard Mohr's salt solution?

Ans: Dilute H₂SO₄ suppresses the hydrolysis of ferrous ions (Fe²⁺) into brown ferrous hydroxide and ferric oxide by providing H⁺ ions (Le Chatelier's principle), keeping the solution clear.

Q47. Why is hydrochloric acid (HCl) or nitric acid (HNO₃) NEVER used to acidify KMnO₄ titrations?

Ans: HCl is oxidized by KMnO₄ into toxic chlorine gas ($2\text{KMnO}_4 + 16\text{HCl} \rightarrow 2\text{KCl} + 2\text{MnCl}_2 + 5\text{Cl}_2\uparrow + 8\text{H}_2\text{O}$), causing excess KMnO₄ consumption. HNO₃ is a strong oxidizing agent itself, which would oxidize the titrand and cause serious errors.

Q48. What is meant by the term 'Self-Indicator'?

Ans: A titrant that undergoes a sharp and distinct color change at its own equivalence point without requiring any external indicator. KMnO₄ is a self-indicator: pink in oxidized form (MnO₄⁻) and colorless in reduced form (Mn²⁺).

Q49. What is the equivalent weight of KMnO₄ in acidic, neutral, and alkaline media?

Ans: In acidic medium: Eq wt = M / 5 (Mn⁷⁺ → Mn²⁺, change of 5e⁻). In neutral/faintly alkaline medium: Eq wt = M / 3 (Mn⁷⁺ → Mn⁴⁺ in MnO₂, change of 3e⁻). In strongly alkaline medium: Eq wt = M / 1 (Mn⁷⁺ → Mn⁶⁺ in MnO₄²⁻, change of 1e⁻).

Q50. Why is the oxalic acid solution heated to 60–70 °C before titrating against KMnO_4 ?

Ans: The reaction between oxalic acid and KMnO_4 has a high activation energy and is extremely slow at room temperature. Heating to 60–70 °C accelerates the reaction rate significantly.

Q51. Why does the first drop of KMnO_4 take several seconds to decolorize in oxalic acid titration, while subsequent drops decolorize instantly?

Ans: This is an autocatalytic reaction. The Mn^{2+} ions formed during the reduction of the first few drops act as a catalyst for the subsequent reaction steps: $2\text{MnO}_4^- + 5\text{C}_2\text{O}_4^{2-} + 16\text{H}^+ \rightarrow 2\text{Mn}^{2+} + 10\text{CO}_2 + 8\text{H}_2\text{O}$.

Q52. Why should oxalic acid NOT be heated above 70 °C or boiled prior to titration?

Ans: Oxalic acid decomposes at higher temperatures into carbon dioxide and formic acid (or water and carbon monoxide): $\text{H}_2\text{C}_2\text{O}_4 \rightarrow \text{CO}_2 + \text{HCOOH}$, leading to significant volumetric errors.

Q53. How do you read the meniscus in a burette for colorless vs dark-colored solutions?

Ans: For clear, colorless, or lightly colored solutions, the bottom (lower) meniscus is read. For intensely colored or opaque solutions like KMnO_4 , the upper meniscus is read because the lower boundary cannot be seen clearly.

Q54. What is the role of Rochelle's salt in Fehling's solution or tartaric acid in complexometric titrations?

Ans: It acts as a chelating agent to keep metal cations (like Cu^{2+}) soluble in strongly alkaline media by preventing their precipitation as insoluble hydroxides.

Q55. Why is an air bubble trapped in the burette nozzle a source of error, and how is it removed?

Ans: The air bubble occupies volume credited to liquid delivery. When displaced during titration, it causes an overestimation of the titrant consumed. It is removed by rapidly turning the stopcock to flush liquid through the tip.

Q56. What is the end point in the titration of Mohr's salt versus KMnO_4 ?

Ans: Appearance of a permanent faint pink coloration that persists for at least 30 seconds, indicating a slight excess of unreduced MnO_4^- ions.

Q57. State the ionic half-reactions for Mohr's salt titration with KMnO_4 in acidic medium.

Ans: Reduction: $\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^- \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O}$. Oxidation: $5\text{Fe}^{2+} \rightarrow 5\text{Fe}^{3+} + 5\text{e}^-$. Overall: $\text{MnO}_4^- + 5\text{Fe}^{2+} + 8\text{H}^+ \rightarrow \text{Mn}^{2+} + 5\text{Fe}^{3+} + 4\text{H}_2\text{O}$.

Q58. What is the difference between an end point and an equivalence point?

Ans: The equivalence point is the theoretical stoichiometric point at which chemically equivalent quantities of reactants have reacted. The end point is the experimental observation (color change, precipitate) that signals the titration is complete.

Q59. Why must volumetric flasks and pipettes never be dried with a hot flame or in an oven?

Ans: Thermal expansion changes the internal calibrated volume of volumetric glassware permanently, leading to inaccurate volume measurements.

Q60. What is the correct way to blow out the last drop from a transfer pipette?

Ans: You should NOT blow out the last drop. Standard transfer pipettes are calibrated 'to deliver' (TD); the small amount retained in the tip due to surface tension is already accounted for in the calibration.

Section 4: Qualitative Inorganic Salt Analysis (Cations & Anions)

Q61. What is the classification basis of cations into analytical groups?

Ans: Cations are classified into analytical groups (0 to VI) based on the solubility product (K_{sp}) of their insoluble salts (chlorides, sulfides, hydroxides, carbonates) formed with specific group reagents.

Q62. List the analytical groups, their group reagents, and the precipitating forms of the cations.

Ans: Group 0: None (NH_4^+ detected by NaOH); Group I: Dilute HCl (insoluble chlorides: Pb^{2+}); Group II: H_2S gas in dilute HCl (insoluble sulfides: Cu^{2+} , Pb^{2+}); Group III: NH_4OH in presence of NH_4Cl (insoluble hydroxides: Fe^{3+} , Al^{3+}); Group IV: H_2S gas in presence of NH_4OH (insoluble sulfides: Zn^{2+} , Ni^{2+}); Group V: $(\text{NH}_4)_2\text{CO}_3$ in presence of NH_4OH and NH_4Cl (insoluble carbonates: Ba^{2+} , Sr^{2+} , Ca^{2+}); Group VI: Na_2HPO_4 (Mg^{2+}).

Q63. Why is dilute HCl added before passing H_2S in Group II cation precipitation?

Ans: HCl is a strong electrolyte that provides H^+ ions. Due to the common ion effect, it suppresses the ionization of the weak diprotic acid H_2S , keeping $[\text{S}^{2-}]$ very low—just sufficient to exceed the K_{sp} of Group II sulfides, but below the higher K_{sp} of Group IV sulfides.

Q64. Why is solid NH_4Cl added before NH_4OH in Group III precipitation?

Ans: NH_4Cl dissociates completely, providing excess NH_4^+ ions. By the common ion effect, this suppresses the ionization of weak NH_4OH , lowering $[\text{OH}^-]$ so that only Group III hydroxides ($\text{Al}(\text{OH})_3$, $\text{Fe}(\text{OH})_3$) precipitate, while more soluble Group IV and V hydroxides remain in solution.

Q65. Why must Group II filtrate be boiled with concentrated HNO_3 before proceeding to Group III?

Ans: 1) Boiling expels dissolved H_2S gas, which would otherwise precipitate Group IV cations in the alkaline Group III stage. 2) HNO_3 oxidizes any Fe^{2+} ions to Fe^{3+} , because $\text{Fe}(\text{OH})_2$ has a higher K_{sp} and would not precipitate completely in Group III.

Q66. Why is NH_4Cl added before $(\text{NH}_4)_2\text{CO}_3$ in Group V cation separation?

Ans: To suppress the ionization of $(\text{NH}_4)_2\text{CO}_3$ so that the carbonate ion concentration $[\text{CO}_3^{2-}]$ is sufficient to precipitate BaCO_3 , SrCO_3 , and CaCO_3 , but not MgCO_3 (which has a higher K_{sp} and is retained in Group VI).

Q67. What is the confirmatory test for Ammonium (NH_4^+ , Group 0)?

Ans: When treated with Nessler's reagent (alkaline $\text{K}_2[\text{HgI}_4]$), ammonium ions yield a brown precipitate or coloration of iodide of Millon's base: $2\text{K}_2[\text{HgI}_4] + \text{NH}_3 + 3\text{KOH} \rightarrow \text{H}_2\text{N-Hg-O-Hg-I} \downarrow (\text{brown}) + 7\text{KI} + 2\text{H}_2\text{O}$.

Q68. How is Lead (Pb^{2+}) confirmed in Group I?

Ans: PbCl_2 dissolves in hot water and precipitates upon cooling as shining white needles. With potassium chromate (K_2CrO_4), it gives a bright yellow precipitate of PbCrO_4 . With KI , it gives golden-yellow spangles of PbI_2 .

Q69. How is Copper (Cu^{2+}) confirmed in Group II?

Ans: CuS precipitate is dissolved in 50% HNO_3 . Addition of excess NH_4OH gives an intense deep Prussian-blue solution of tetraamminecopper(II) ion, $[\text{Cu}(\text{NH}_3)_4]^{2+}$. Addition of potassium ferrocyanide gives a chocolate-brown precipitate of $\text{Cu}_2[\text{Fe}(\text{CN})_6]$.

Q70. How is Aluminum (Al^{3+}) confirmed in Group III (Lake Test)?

Ans: The $\text{Al}(\text{OH})_3$ precipitate is dissolved in dilute HCl , a few drops of blue litmus solution are added, followed by NH_4OH dropwise. A floating blue gelatinous lake appears due to adsorption of litmus dye on $\text{Al}(\text{OH})_3$ precipitate.

Q71. How is Ferric ion (Fe^{3+}) confirmed in Group III?

Ans: $\text{Fe}(\text{OH})_3$ is dissolved in dilute HCl . Addition of potassium ferrocyanide, $\text{K}_4[\text{Fe}(\text{CN})_6]$, gives an intense Prussian blue precipitate of $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$. Addition of potassium thiocyanate (KCNS) gives a blood-red coloration of $[\text{Fe}(\text{SCN})]^{2+}$.

Q72. How is Nickel (Ni^{2+}) confirmed in Group IV?

Ans: The solution is made alkaline with NH_4OH , and dimethylglyoxime (DMG) is added. A bright cherry-red coordination precipitate of nickel dimethylglyoximate, $[\text{Ni}(\text{DMG})_2]$, is formed.

Q73. How is Zinc (Zn^{2+}) confirmed in Group IV?

Ans: ZnS is dissolved in dilute HCl and boiled. With NaOH added dropwise, a white gelatinous precipitate of $\text{Zn}(\text{OH})_2$ forms, which dissolves in excess NaOH to give sodium zincate, Na_2ZnO_2 . Addition of H_2S reprecipitates white ZnS .

Q74. How do you distinguish between Barium (Ba^{2+}), Strontium (Sr^{2+}), and Calcium (Ca^{2+}) in Group V?

Ans: The carbonates are dissolved in hot dilute acetic acid. 1) Ba^{2+} gives a yellow precipitate of BaCrO_4 with K_2CrO_4 . 2) In the filtrate, Sr^{2+} gives a white precipitate of SrSO_4 with saturated $(\text{NH}_4)_2\text{SO}_4$. 3) In the final filtrate, Ca^{2+} gives a white precipitate of CaC_2O_4 with ammonium oxalate.

Q75. What flame colors are imparted by Ba^{2+} , Sr^{2+} , and Ca^{2+} ?

Ans: Ba^{2+} gives an apple-green flame; Sr^{2+} gives a crimson-red flame; Ca^{2+} gives a brick-red flame.

Q76. Why is concentrated HCl used to prepare the salt paste for flame tests?

Ans: Metal chlorides are much more volatile than sulfates, nitrates, or oxides, allowing them to vaporize easily in the non-luminous Bunsen burner flame and impart their characteristic spectral colors.

Q77. Why is platinum wire used in flame tests?

Ans: Platinum has a very high melting point, is chemically inert, and imparts no color of its own to the flame.

Q78. How is Magnesium (Mg^{2+}) confirmed in Group VI?

Ans: The filtrate from Group V is treated with disodium hydrogen phosphate, Na_2HPO_4 , in the presence of NH_4OH and NH_4Cl . A white crystalline precipitate of magnesium ammonium phosphate, $\text{Mg}(\text{NH}_4)\text{PO}_4$, confirms Mg^{2+} .

Q79. How are anions classified in systematic qualitative analysis?

Ans: Anions are divided into three groups: 1) Dilute H_2SO_4 group (CO_3^{2-} , S^{2-} , SO_3^{2-} , NO_2^-) — evolve gases with dilute acid; 2) Concentrated H_2SO_4 group (Cl^- , Br^- , I^- , NO_3^- , $\text{C}_2\text{O}_4^{2-}$) — evolve gases with concentrated acid; 3) Independent group (SO_4^{2-} , PO_4^{3-}) — detected by individual precipitation reactions.

Q80. Describe the confirmatory test for Carbonate (CO_3^{2-}).

Ans: Treating the salt with dilute $\text{H}_2\text{SO}_4/\text{HCl}$ produces brisk effervescence of colorless, odorless CO_2 gas, which turns clear lime water milky due to CaCO_3 formation. Continued bubbling clears the milkiness due to soluble $\text{Ca}(\text{HCO}_3)_2$.

Q81. Describe the Brown Ring test for Nitrate (NO_3^-).

Ans: A freshly prepared saturated solution of FeSO_4 is added to the aqueous salt extract. Concentrated H_2SO_4 is slowly poured down the side of the tilted test tube without disturbing. A dark brown ring of nitrosyl ferrous sulfate, $[\text{Fe}(\text{H}_2\text{O})_5(\text{NO})]\text{SO}_4$, forms at the liquid-liquid junction.

Q82. Why does the brown ring disappear upon shaking or heating?

Ans: The nitrosyl complex is thermally unstable. Shaking generates heat from mixing acid and water, dissociating $[\text{Fe}(\text{H}_2\text{O})_5(\text{NO})]^{2+}$ into Fe^{3+} , NO gas, and water.

Q83. Describe the Chromyl Chloride test for Chloride (Cl^-).

Ans: The dry chloride salt is heated with solid $\text{K}_2\text{Cr}_2\text{O}_7$ and concentrated H_2SO_4 . Red-orange vapors of chromyl chloride (CrO_2Cl_2) evolve. When passed into NaOH, a yellow sodium chromate (Na_2CrO_4) solution forms, which yields a yellow PbCrO_4 precipitate upon adding acetic acid and lead acetate.

Q84. Why do salts of mercury, tin, silver, and lead (e.g., Hg_2Cl_2 , AgCl) fail the chromyl chloride test?

Ans: These chlorides are largely covalent or insoluble, and do not readily yield free chloride ions to form volatile chromyl chloride.

Q85. How is Sulfate (SO_4^{2-}) confirmed?

Ans: Barium chloride (BaCl_2) solution is added to the acidified salt solution (with dilute HCl). A thick white precipitate of barium sulfate (BaSO_4) forms, which is completely insoluble in concentrated HCl and concentrated HNO_3 .

Section 5: Preparation of Inorganic & Organic Compounds

Q86. What is a double salt? Give two examples.

Ans: A double salt is a molecular addition compound that exists only in solid crystalline state and dissociates completely into its individual constituent simple ions when dissolved in water (e.g., Mohr's salt: $\text{FeSO}_4 \cdot (\text{NH}_4)_2\text{SO}_4 \cdot 6\text{H}_2\text{O}$; Potash alum: $\text{K}_2\text{SO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$).

Q87. How does a double salt differ from a complex salt?

Ans: A double salt dissociates into simple ions in water and retains no identity in aqueous solution. A complex salt contains coordinate bonds and retains the complex ion identity in aqueous solution without complete dissociation into constituent simple ions (e.g., $\text{K}_4[\text{Fe}(\text{CN})_6]$ gives K^+ and $[\text{Fe}(\text{CN})_6]^{4-}$).

Q88. What is the chemical formula of Potash Alum?

Ans: $\text{K}_2\text{SO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$ (Potassium aluminum sulfate 24-hydrate).

Q89. Why is dilute H_2SO_4 added during the preparation of potash alum?

Ans: To prevent the hydrolysis of aluminum sulfate, $\text{Al}_2(\text{SO}_4)_3$, into insoluble gelatinous aluminum hydroxide, $\text{Al}(\text{OH})_3$, thereby ensuring a clear solution for crystallization.

Q90. What is meant by 'crystallization point'?

Ans: The point during the concentration of a solution at which it becomes saturated at that temperature, verified when a drop taken on a glass rod and cooled by blowing air produces solid crust/crystals.

Q91. Why should the saturated solution of alum or Mohr's salt be cooled slowly without disturbance?

Ans: Slow, undisturbed cooling allows uniform nucleation and crystal growth, producing large, pure, well-defined crystals. Rapid cooling or agitation leads to tiny, imperfect crystals that trap mother liquor impurities.

Q92. What is mother liquor?

Ans: The residual liquid remaining after the separation of crystals by filtration or decantation.

Q93. Why are Mohr's salt and alum crystals washed with an alcohol-water mixture rather than pure water?

Ans: They are moderately soluble in pure water and would dissolve during washing. Alcohol reduces their solubility, washing away mother liquor without dissolving the crystals.

Q94. What reaction is involved in the preparation of Acetanilide from aniline?

Ans: Acetylation of aniline: Aniline reacts with acetic anhydride (or acetyl chloride) in the presence of glacial acetic acid and zinc dust to form acetanilide: $\text{C}_6\text{H}_5\text{NH}_2 + (\text{CH}_3\text{CO})_2\text{O} \rightarrow \text{C}_6\text{H}_5\text{NHCOCH}_3 + \text{CH}_3\text{COOH}$.

Q95. What is the role of zinc dust in the preparation of acetanilide?

Ans: Zinc dust acts as a reducing agent to prevent atmospheric oxidation of aniline to dark colored impurities, and decolourizes any pre-existing oxidized products, ensuring pure white crystals.

Q96. What is the reaction for preparing p-nitroacetanilide from acetanilide?

Ans: Electrophilic aromatic nitration: Acetanilide is dissolved in glacial acetic acid and treated with a nitrating mixture (concentrated HNO_3 + concentrated H_2SO_4) below 10°C . The bulky $-\text{NHCOCH}_3$ group directs the $-\text{NO}_2$ group almost exclusively to the para position, yielding p-nitroacetanilide.

Q97. Why is the amino group in aniline protected by acetylation before nitration?

Ans: Direct nitration of aniline with $\text{HNO}_3/\text{H}_2\text{SO}_4$ oxidizes the strongly activated, sensitive $-\text{NH}_2$ group to black tarry oxidation products. Acetylation reduces electron density on the nitrogen by resonance with the carbonyl, protecting the ring and moderating reactivity.

Q98. What is Aniline Yellow, and how is it synthesized?

Ans: Aniline Yellow is p-aminoazobenzene, a monoazo dye. It is synthesized by diazotizing aniline at $0-5^\circ\text{C}$ to form benzene diazonium chloride, followed by coupling with excess aniline in mild acidic conditions to form diazoaminobenzene, which rearranges into p-aminoazobenzene.

Q99. What is the chemical reaction for the preparation of Iodoform from acetone?

Ans: $\text{CH}_3\text{COCH}_3 + 3\text{I}_2 + 4\text{NaOH} \rightarrow \text{CHI}_3 \downarrow$ (yellow precipitate) + $\text{CH}_3\text{COONa} + 3\text{NaI} + 3\text{H}_2\text{O}$. The methyl ketone undergoes α -iodination followed by base-catalyzed nucleophilic acyl cleavage.

Section 6: Physical Chemistry Practical Experiments

Q100. Define enthalpy of solution (heat of solution).

Ans: The enthalpy change (ΔH_{sol}) when one mole of a solute is completely dissolved in a specified large excess of solvent such that further dilution produces no additional heat effect.

Q101. Is the dissolution of anhydrous CuSO_4 exothermic or endothermic, and why?

Ans: It is highly exothermic (ΔH is negative). The hydration enthalpy of Cu^{2+} and SO_4^{2-} ions exceeds the lattice energy of anhydrous CuSO_4 .

Q102. Is the dissolution of hydrated $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ exothermic or endothermic?

Ans: It is endothermic (ΔH is positive). The lattice energy required to break down the pre-hydrated crystal lattice exceeds the small enthalpy change of further hydration.

Q103. Define enthalpy of neutralization.

Ans: The enthalpy change when one gram-equivalent of an acid is completely neutralized by one gram-equivalent of a base in dilute aqueous solution.

Q104. Why is the enthalpy of neutralization of any strong acid with any strong base always constant at approximately -57.1 kJ/mol (-13.7 kcal/mol)?

Ans: Because both strong acids and strong bases are completely ionized in dilute aqueous solution. The net chemical reaction in all such neutralizations is identically: $\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l})$; $\Delta H = -57.1 \text{ kJ/mol}$.

Q105. Why is the enthalpy of neutralization of a weak acid (e.g., CH_3COOH) with a strong base less than -57.1 kJ/mol?

Ans: Weak acids are incompletely ionized. A portion of the heat evolved during neutralization is consumed as dissociation enthalpy to completely ionize the weak acid molecules into H^+ and acid anions.

Q106. What is the water equivalent (W) of a calorimeter?

Ans: The mass of water that would absorb or release the same quantity of heat as the calorimeter apparatus (vessel, thermometer, stirrer) for an identical temperature change: $W = m_{\text{cal}} \cdot s_{\text{cal}}$.

Q107. What is a lyophilic sol? Give two examples.

Ans: A liquid-loving colloidal sol in which there is strong affinity and interaction between the dispersed phase and the dispersion medium (e.g., starch sol, gelatin sol, egg albumin).

Q108. What is a lyophobic sol? Give two examples.

Ans: A liquid-hating colloidal sol in which there is little or no interaction between the dispersed phase and the dispersion medium. They are thermodynamically unstable and easily coagulated (e.g., ferric hydroxide sol, arsenious sulfide sol, gold sol).

Q109. Why are lyophilic sols reversible, while lyophobic sols are irreversible?

Ans: If the dispersion medium is evaporated from a lyophilic sol, it can be easily reconstituted simply by adding the solvent back. In lyophobic sols, once the particles coagulate, adding solvent does not restore the colloidal state.

Q110. How is a Ferric Hydroxide [$\text{Fe}(\text{OH})_3$] sol prepared in the laboratory?

Ans: By hydrolysis: A 2% solution of FeCl_3 is added dropwise to boiling distilled water with continuous stirring: $\text{FeCl}_3 + 3\text{H}_2\text{O} \rightarrow \text{Fe}(\text{OH})_3(\text{sol}) + 3\text{HCl}$. The $\text{Fe}(\text{OH})_3$ particles preferentially adsorb Fe^{3+} ions, acquiring a positive charge.

Q111. Why is boiling water used in the preparation of $\text{Fe}(\text{OH})_3$ sol?

Ans: Boiling drives the endothermic hydrolysis of ferric chloride rapidly toward completion, producing colloidal aggregates of $\text{Fe}(\text{OH})_3$.

Q112. How is Arsenious Sulfide [As_2S_3] sol prepared, and what is its charge?

Ans: By passing H_2S gas through a cold saturated aqueous solution of arsenious oxide (As_2O_3): $\text{As}_2\text{O}_3 + 3\text{H}_2\text{S} \rightarrow \text{As}_2\text{S}_3(\text{sol}) + 3\text{H}_2\text{O}$. The colloidal particles preferentially adsorb S^{2-} ions, making it a negatively charged sol.

Q113. What is dialysis in colloidal chemistry?

Ans: The process of purifying colloidal solutions from dissolved crystalloid impurities (electrolytes) by allowing the small ions to diffuse out through a semipermeable membrane (parchment/cellophane) into flowing distilled water.

Q114. What is peptization?

Ans: The process of converting a freshly precipitated substance into a colloidal sol by shaking it with the dispersion medium in the presence of a small amount of an electrolyte (peptizing agent).

Q115. What is the Hardy-Schulze rule?

Ans: The coagulating or flocculating power of an electrolyte is directly proportional to the fourth to sixth power of the valency of the active coagulating ion (counter-ion): $\text{Al}^{3+} > \text{Ba}^{2+} > \text{Na}^{+}$ for negatively charged sols.

Q116. Describe the chemical reaction studied in the kinetics experiment of iodide ions with hydrogen peroxide.

Ans: $\text{H}_2\text{O}_2 + 2\text{I}^{-} + 2\text{H}^{+} \rightarrow \text{I}_2 + 2\text{H}_2\text{O}$. In the presence of a known fixed amount of sodium thiosulfate ($\text{Na}_2\text{S}_2\text{O}_3$) and starch indicator, the liberated iodine is instantaneously consumed: $\text{I}_2 + 2\text{S}_2\text{O}_3^{2-} \rightarrow 2\text{I}^{-} + \text{S}_4\text{O}_6^{2-}$. Once all thiosulfate is consumed, free I_2 reacts with starch to produce an abrupt blue color (Clock Reaction).

Q117. Why is starch indicator added in the $\text{H}_2\text{O}_2 - \text{I}^{-}$ kinetic study?

Ans: Starch forms an intense blue-colored inclusion complex with free molecular iodine (triiodide), signaling the exact moment all thiosulfate has been consumed, giving an accurate measure of reaction time.

Q118. How does temperature affect the rate of the reaction between H_2O_2 and iodide ions?

Ans: The reaction rate increases exponentially with temperature (roughly doubling for every 10°C rise, per the Arrhenius relationship) due to a greater fraction of molecules having kinetic energy equal to or exceeding the activation energy.

Q119. What is the order of the reaction between H_2O_2 and KI with respect to each reactant?

Ans: First order with respect to H_2O_2 and first order with respect to I^{-} , making it an overall second-order reaction.

Section 7: Laboratory Apparatus, Safety & General Techniques

Q120. Why are boiling chips (porcelain pieces) added to liquids before distillation or boiling?

Ans: Boiling chips provide microscopic nucleation sites for vapor bubble formation, promoting smooth, steady boiling and preventing violent superheating and dangerous bumping.

Q121. Why should you never add boiling chips to a liquid that is already near its boiling point?

Ans: Introducing nucleation sites into a superheated liquid can cause instantaneous violent flashing of vapor, erupting boiling liquid out of the flask neck.

Q122. What is the difference between a volumetric pipette and a graduated Mohr pipette?

Ans: A volumetric (transfer) pipette is calibrated to deliver a single, highly precise fixed volume (e.g., exactly 10.0 mL or 25.0 mL). A graduated pipette has marked graduations along its barrel to dispense variable volumes.

Q123. Why is water entered from the lower inlet of a Liebig condenser and exited from the upper outlet?

Ans: Counter-current flow against gravity ensures that the condenser jacket remains completely filled with cold water with no air pockets, maximizing thermal cooling efficiency.

Q124. What first aid should be administered immediately if concentrated acid splashes on the skin?

Ans: Flush the affected area immediately with large volumes of running cold water for at least 15 minutes, then bathe gently with saturated sodium bicarbonate (NaHCO_3) solution, and seek medical attention.

Q125. What first aid should be administered if concentrated alkali (NaOH) splashes on the skin?

Ans: Rinse immediately with continuous cold water for at least 15 minutes, wash with dilute (1%) acetic acid or boric acid solution, and seek medical attention.

Q126. Why must a test tube never be pointed toward yourself or another student during heating?

Ans: Liquids in narrow test tubes can suddenly boil over (bump), spraying hot, corrosive, or toxic chemicals out of the mouth.

Q127. What is a desiccator, and what desiccant is typically placed in its lower base?

Ans: A sealed glass vessel containing a drying agent used to preserve moisture-sensitive samples or cool heated crucibles in a dry atmosphere. Common desiccants include anhydrous calcium chloride (CaCl_2) or silica gel.

Q128. What is the principle of paper chromatography?

Ans: Partition chromatography: Components of a mixture distribute themselves between a stationary phase (water bound to cellulose fibers of filter paper) and a mobile phase (developing solvent) based on differential partition coefficients.

Q129. Define the R_f value in chromatography.

Ans: R_f (Retardation / Retention Factor) = (Distance traveled by the solute center from the baseline) / (Distance traveled by the solvent front from the baseline). It is dimensionless and always ≤ 1.0 .

