Salt Analysis

What is Salt Analysis?

Salt analysis (also known as systematic qualitative analysis or qualitative inorganic analysis) involves the identification of the cation and anion of an inorganic salt. This is done by conducting a series of tests in a systematic manner and using the observations to confirm the absence or presence of specific cations and anions. Salt analysis is an integral part of the CBSE class 12 chemistry practical examinations and is a topic that several students struggle with. Therefore, we at BYJU'S have channelled our efforts into explaining this topic in a manner that is easy to understand and remember. This article also touches on certain tricks and shortcuts that students can employ to quickly analyze their assigned salts in their chemistry practical examinations.

Access in-depth procedures for the tests that must be performed during salt analysis by visiting the links listed below.

- Systematic Analysis of Cations
- Systematic Analysis of Anions

In the examination, students will receive an inorganic salt whose chemical composition they must identify. This can be done by individually identifying the cation and the anion of the salt.

Step-by-Step Process for Salt Analysis

- **Step 1:** Obtain the inorganic salt whose cation and anion you must identify.
- **Step 2:** Conduct preliminary tests for the anion group-wise until you obtain a positive result. Anions and cations are classified into groups that share the same group reagent and therefore, have similar preliminary tests.
- **Step 3:** Once you get a positive result for a preliminary test for an anion, conduct a confirmatory test for that anion. (If you get a positive result, move on to step 4. If you don't, go back to conducting preliminary tests for anions.)
- **Step 4:** Conduct preliminary tests for cations group-wise until you obtain a positive result.
- **Step 5:** Once a positive result is obtained, conduct a confirmatory test for that cation.
- **Step 6:** Now that the cation and the anion are identified, obtain the chemical formula of the salt by balancing the charges of the cation and anion. For example, if your cation is Fe^{3+} and your anion is Cl^-, the chemical formula of the salt will be $FeCl_3$.

Note: You can also identify the cation first and then move on to identifying the anion.

Salt Analysis Answer Format (Sample)

A sample answer format for salt analysis is provided below.

Aim: To identify the acidic radical and the basic radical of the given inorganic salt.

Apparatus Required: Fill as per requirement.
Procedure:
(i) Preliminary Test for Anion:

Experiment	Observation	Inference

(ii) Confirmatory Test for Anion:

Experiment	Observation	Inference

(iii) Preliminary Test for Cation:

Experiment	Observation	Inference

(iv) Confirmatory Test for Cation:

Experiment	Observation	Inference

Result: The acidic radical is (anion), and the basic radical is (cation). Therefore, the given salt is identified to be (salt).

Tricks and Shortcuts for Salt Analysis

Always check the colour of the salt first. Certain cations have coloured salts. If the salt is coloured, you can directly conduct a preliminary test for the cation that forms salts of that colour. The cations that form coloured salts are tabulated below:

Colour of the Inorganic Salt	Cation
Blue	Cu^{2+}
Deep blue	Co^{2+} (anhydrous salt)
Greenish-blue	Cu^{2+} (hydrated salt)
Green	Ni^{2+} (hydrated salt)
Light green	Fe^{2+}
Yellow, brown, or yellowish-brown	Fe^{3+}
Pale pink	Mn^{2+}
Rose-red	Co^{2+} or mercuric iodide (HgI_2)
Purple or dark green	Cr^{3+}

If the salt is colourless, perform a flame test first (since the presence of 3 different cations can be confirmed by it). An easier way to perform the flame test is to pick up a chunk of the salt with test tube holders, pour a few drops of concentrated HCl on it, and expose it to the flame of a Bunsen burner.

If you do not gain any insight into the cation from the flame test (or from visual inspection), proceed with group-wise preliminary tests for cations. Note that some cations do not form salts with certain anions, as listed below.

- Ba^{2+}, Sr^{2+}, Pb^{2+}, and Ca^{2+} do not form salts with the sulphate anion (SO_4^{2-}).
- Only group 0, group 1, and group 2 cations form salts with the phosphate anion (PO_4^{3-}).

If you identify one of these cations in the salt analysis, you need not conduct tests for the corresponding anions.

Finally, certain salts are very common in salt analysis examinations. For example, the most common salt containing the bromide ion (Br^-) is NH_4Br and the most common salt containing the calcium cation (Ca^{2+}) is $CaCl_2$. Also, some salts can be identified by observing their texture and appearance (for example, calcium carbonate has the texture of powdered chalk). Therefore, visiting your chemistry laboratory and physically examining the salts may help you quickly analyze the salt in the practical examination.

List of Common Cations (Basic Radicals) for Salt Analysis

***Note: Multiple Ions belonging to the same group have the same preliminary test but different confirmatory tests.**

Group	**Cations**
Group 0	NH_4^+
Group 1	Pb^{2+}
Group 2	Cu^{2+}
Group 3	Fe^{3+}, Fe^{2+}, Al^{3+}
Group 4	Co^{2+}, Mn^{2+}, Ni^{2+}, Zn^{2+}
Group 5	Ba^{2+}, Ca^{2+}, Sr^{2+}
Group 6	Mg^{2+}

List of Common Anions (Acidic Radicals) for Salt Analysis

Group	**Anions**
Group 1	CO_3^{2-}, NO_2^-, SO_3^{2-}, S^{2-}
Group 2	Cl^-, Br^-, I^-, CH_3COO^-, NO_3^-, $C_2O_4^{2-}$
Group 3	PO_4^{3-}, SO_4^{2-}

Preliminary Test for Anions

In salt analysis, preliminary tests for anions are conducted group-wise to find the anion of the salt. After getting a positive preliminary test for an anion, a confirmatory test must be conducted to confirm the presence of that anion in the salt.

Preliminary Test for Group 1 Anions

Experiment: Add a few drops of dilute H_2SO_4 (sulfuric acid) to a small quantity of the salt in a test tube (If nothing happens, move on to preliminary test for group 2 anions).

Anion	**Positive Result**
Carbonate (CO_3^{2-})	Colourless and odourless gas that turns limewater milky
Sulphite (SO_3^{2-})	Colourless, pungent-smelling gas
Sulphide (S^{2-})	Colourless gas which smells like rotten eggs
Nitrite (NO_2^-)	Light brown gas having a pungent smell

Preliminary Test for Group 2 Anions

Experiment: Take a small chunk of the salt in a test tube and add a few drops of concentrated H_2SO_4 (sulfuric acid) to it (If nothing happens, move on to preliminary test for group 2 anions).

Anion	**Positive Result**
Chloride (Cl^-)	White, pungent-smelling fumes that intensify when a glass rod dipped in ammonium hydroxide is brought to the mouth of the test tube
Bromide (Br^-)	Reddish-brown fumes
Iodide (I^-)	Violet fumes
Acetate (CH_3COO^-)	Pungent fumes that smell like vinegar
Nitrate (NO_3^-)	Brown fumes with a pungent smell
Oxalate ($C_2O_4^-$)	Bubbly effervescence of a combination of carbon monoxide and carbon dioxide gas

Preliminary Test for Group 3 Anions

The sulphate and phosphate ions (group 3 anions) do not have any preliminary tests. If no positive preliminary tests are obtained for group 1 and group 2 anions, you can directly jump to confirmatory tests for the sulphate and phosphate anions.

Confirmatory Test for Anions

***Note:** Water extract of the salt can be prepared by dissolving a pinch of the inorganic salt in a few drops of water.

Anion	**Confirmatory Test**	**Positive Observation**
Carbonate (CO_3^{2-})	Add magnesium sulphate ($MgSO_4$) to the water extract of the salt	Formation of a white precipitate.
Sulphite (SO_3^{2-})	Add aqueous barium chloride ($BaCl_2$) to the water extract	Formation of a white precipitate which disappears when diluting hydrochloric acid (HCl) is added.
Sulphide (S^{2-})	(i) Add sodium nitroprusside to the water extract (ii) Add aqueous lead acetate to the water extract	(i) The solution turns purple or violet (ii) Formation of a black precipitate
Nitrite (NO_2^-)	Boil a mixture of the water extract and dilute H_2SO_4. Now add solid potassium iodide and starch solution to it	The solution develops a deep blue colour
Chloride (Cl^-)	Add silver nitrate ($AgNO_3$) to the water extract	Formation of a white precipitate which is soluble in ammonium hydroxide (NH_4OH)
Bromide (Br^-)	Add silver nitrate to the water extract	Formation of a yellow precipitate which is partially soluble in ammonium hydroxide
Iodide (I^-)	Add silver nitrate to the water extract	Formation of a yellow precipitate which is insoluble in NH_4OH
Nitrate (NO_3^-)	Mix the water extract with iron (II) sulphate solution ($FeSO_4$) and add one drop of concentrated nitric acid (HNO_3) along the side of the test tube.	Formation of a brown ring at the junction of the acid and the solution.
Acetate (CH_3COO^-)	Add concentrated H_2SO_4 and some ethanol to the salt.	Development of a fruity smell (due to the formation of an ester)
Oxalate ($C_2O_4^-$)	Add acetic acid and calcium chloride to the water extract and boil the solution.	Formation of a white precipitate that dissolves upon the addition of dilute HNO_3

Sulphate (SO_4^{2-})	Add aqueous barium chloride ($BaCl_2$) to the water extract	Formation of a white precipitate which is insoluble in concentrated hydrochloric acid (HCl)
Phosphate (PO_4^{3-})	Add dilute nitric acid (HNO_3) and ammonium molybdate ($(NH_4)_2MoO_4$) to the water extract and boil the resulting solution.	Formation of a yellow, crystalline precipitate

Shortcut: Ammonium bromide (NH_4Br) is the most common salt containing the bromide ion in school laboratories. If you confirm the presence of bromide ions in the salt, you can immediately try a confirmatory test for the ammonium cation (NH_4^+)

Preliminary Test for Cations

In salt analysis. preliminary tests for cations must be conducted in order to check for the presence of different cations in the inorganic salt. This is done in a manner that is similar to the preliminary tests for anions. Note that some cation groups (such as group 0 and group 6 cations) do not have any preliminary tests. For these cations, confirmatory tests may be conducted directly.
Note: The original solution (OS) of the salt can be prepared by mixing a small amount of the inorganic salt with water and acid.

Preliminary Test for Group 1 Cations

Experiment: Add a few drops of dilute hydrochloric acid (HCl) to the original solution.

Cation	**Positive Result**
Lead (Pb^{2+})	Formation of a white precipitate

Preliminary Test for Group 2 Cations

Experiment: Add a few drops of dilute HCl and hydrogen sulphide (H_2S) to the original solution.

Cation	**Positive Result**
Copper (Cu^{2+})	A black precipitate is formed

Preliminary Test for Group 3 Cations

- Ferrous salts (featuring Fe^{2+} ions) are green in colour and ferric salts (featuring Fe^{3+} ions) are brown in colour.
- For aluminium (Al^{3+} ion), a gelatinous white precipitate is obtained when the solid ammonium chloride (NH_4Cl) and excess ammonium hydroxide are added to the original solution.

Preliminary Test for Group 4 Cations

Experiment: Add solid NH_4Cl and excess NH_4OH to the original solution. Now pass H_2S gas through it.

Cation	**Positive Result**
Cobalt (Co^{2+}) and Nickel (Ni^{2+}), conduct both confirmatory tests	Formation of a black precipitate
Manganese (Mn^{2+})	A skin-coloured precipitate is formed
Zinc (Zn^{2+})	A greyish-white precipitate is formed

Preliminary Test for Group 5 Cations

Experiment: Add ammonium carbonate ($(NH_4)_2CO_3$), ammonium chloride (NH_4Cl), and ammonium hydroxide to the original solution. If you obtain a white precipitate, the cation might be a group 5 cation. Add dilute acetic acid (CH_3COOH) to dissolve the white precipitate. Now do the following tests in the same order followed in the tabular column provided below.

Cation	**Positive Result**
Barium (Ba^{2+})	A yellow precipitate is formed when K_2CrO_4 is added to the solution.
Strontium (Sr^{2+})	A white precipitate is formed when aqueous $(NH_4)_2SO_4$ is added to the solution.
Calcium (Ca^{2+})	A white precipitate is formed when aqueous $(NH_4)_2C_2O_4$ (ammonium oxalate) and NH_4OH are added to the solution.

Confirmatory Tests for Cations

Cation	**Confirmatory Test**	**Positive Observation**
Ammonium (NH_4^+)	Add sodium hydroxide to the original solution and treat it with Nessler's reagent (K_2HgI_4)	Formation of a yellow or brown precipitate
Lead (Pb^{2+})	(i) Add potassium iodide (KI) to the original solution (ii) Add potassium chromate (K_2CrO_4) to the original solution	Formation of a yellow precipitate (for both the tests)
Copper (Cu^{2+})	In the preliminary test, a black precipitate is obtained from the addition of dilute HCl and H_2S to the original solution. Isolate the black precipitate	A blue coloured solution is formed

	and add excess ammonium hydroxide to it	
Iron (Fe^{3+})	Add concentrated nitric acid to the original solution and heat it. A brown precipitate will form. Add HCl and potassium ferrocyanide ($K_4[Fe(CN)_6]$) to it	A blue precipitate is formed
Aluminium (Al^{3+})	A gelatinous white precipitate is obtained when NH_4Cl and excess NH_4OH are added to the original solution. Isolate the precipitate and dissolve it in HCl. now add blue litmus and NH_4OH to it drop-by-drop	A floating, blue layer is formed on the surface of the clear solution
Cobalt (Co^{2+})	Add solid NH_4Cl and excess NH_4OH to the original solution and pass H_2S gas through it. Dissolve the resulting blue residue in water and add dilute CH_3COOH and KNO_2 to it. Now warm the mixture.	A yellow precipitate is obtained.
Nickel (Ni^{2+})	Add solid NH_4Cl and excess NH_4OH to the original solution and pass H_2S gas through it. Dissolve the resulting yellow residue in water (you will now obtain a green-coloured solution). Add NaOH and bromine water to this mixture and boil it.	A black precipitate is formed
Manganese (Mn^{2+})	To the skin-coloured precipitate obtained in the preliminary test, add dilute HCl and boil off the H_2S. Now add NaOH.	Formation of a white precipitate that turns brown or black when bromine water is added
Zinc (Zn^{2+})	Add NaOH (in excess) to the greyish-white precipitate obtained in the preliminary test.	The white precipitate is dissolved
Barium (Ba^{2+}), Strontium (Sr^{2+}), and Calcium (Ca^{2+})	**Flame test:** Make a paste of the salt by mixing it with a few drops of concentrated hydrochloric acid. Now skim off some of the paste with a glass rod and expose it to a Bunsen Burner's flame.	**Ba^{2+}:** Green-coloured flame **Sr^{2+}:** Crimson red flame **Ca^{2+}:** Brick red flame
Magnesium (Mg^{2+})	Add NH_4Cl, $(NH_4)_3PO_4$ (ammonium phosphate) and excess NH_4OH to the original solution.	A white precipitate is obtained.

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