Classification of Cations

The list of cations comprising the seven groups and the group reagent used for precipitating them out from the solution is tabulated below.

Group		Cations	Group Reagents
Zero		NH_4^+, K^+	Tested using the mixture.
I		Ag^+, Hg_2^{2+}, Pb^{2+}	HCl
II	A	Hg^{2+}, Pb^{2+}, Cu^{2+}, Bi^{3+}, Cd^{2+}	
	B	As^{3+}, Sb^{3+}, Sn^{2+}	H_2S in the presence of HCl
III		Al^{3+}, Cr^{3+}, Fe^{3+}	$NH_4Cl + NH_4OH$
IV		Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}	H_2S in presence of NH_4Cl and NH_4OH
V		Ba^{2+}, Ca^{2+}, Sr^{2+}	$NH_4Cl + NH_4OH + (NH_4)_2CO_3$
VI		Mg^{2+}, K^+	

Materials Required

1. Test tubes
2. Boiling tubes
3. Test tube holder
4. Test tube stand
5. Corks
6. Filter paper
7. Delivery tube
8. Reagents
9. Measuring cylinder

Procedure

(i) Preliminary Test of Cations

Colour	Inference
Blue or bluish green	Copper or Nickel salts
Light green	Ferrous salts
Dark green	Chromium salts
Dark brown	Ferric salts
Light pink or Flesh colour	Manganese salts
White	Absence of Cu, Ni, Fe, Mn and Co salts

(ii) Charcoal Cavity Test

In this test the cations is converted into the metal carbonate in a charcoal cavity which decomposes on heating to metal oxide or even to the metallic state. The cation present can be detected from the colour of the bead or residue left in the cavity or deposit formed outside the cavity called incrustation.

$ZnSO_4 + Na_2CO_3 \rightarrow ZnCO_3 + Na_2SO_4$

$ZnCO_3 \rightarrow ZnO$ (yellow when hot) + CO_2

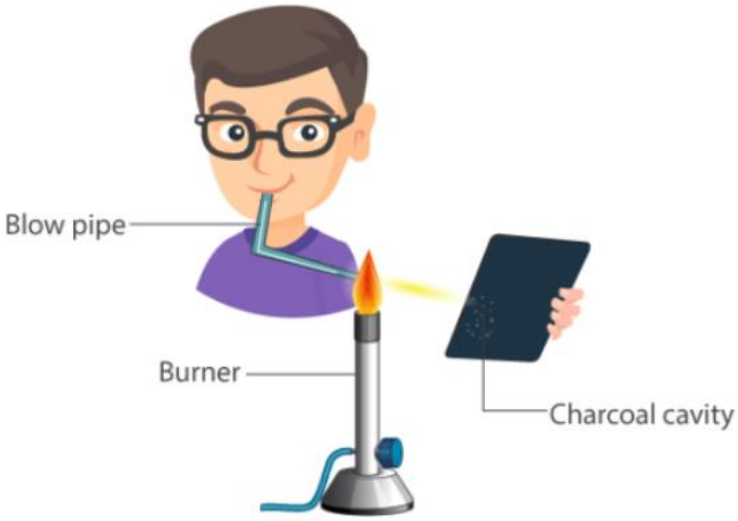
$CuSO_4 + Na_2CO_3 \rightarrow CuCO_3 + Na_2SO_4$

$CuCO_3 \rightarrow CuO + CO_2$

$CuO + C \rightarrow Cu$ (reddish) $+ CO$

$CdCl_2 + Na_2CO_3 \rightarrow CdCO_3 + 2NaCl$

$CdCO_3 \rightarrow CdO$ (reddish brown) $+ CO_2$



Procedure for Charcoal Cavity Test

Make a small cavity in charcoal block with the help of a borer. Mix the given mixture with sodium carbonate or fusion mixture, moisten it with a drop of water, heat it in the charcoal cavity in the reducing flame with the help of a mouth blowpipe and observe the colour of the residue left.

(iii) Borax Bead Test

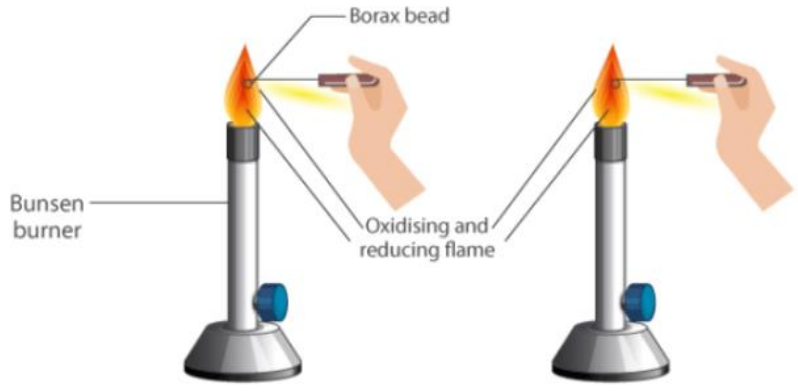
This test is used for the detection of cations in coloured mixtures which may contain copper, nickel, iron or manganese. The borax bead reacts with these metal oxides to form metabolites which have characteristic colour. Some metaborates when heated in reducing flame form lower metaborates or even metals thus causing a change in the colour of bead.

$Na_2B_4O_7.10H_2O \rightarrow Na_2B_4O_7$(*White porous mass*) $\rightarrow NaBO_2 + B_2O_3$

$B_2O_3 + CuSO_4 \rightarrow Cu(BO_2)_2$(*blue green cupric metaborate*) $+ SO_3\uparrow$

$2Cu(BO_2)_2 + C \rightarrow 2CuBO_2$(*colourless coprous metaborate*) $+ B_2O_3 + CO\uparrow$

$2CuBO_2 + C \rightarrow 2Cu$ (*red*) $+ B_2O_3 + CO\uparrow$



Procedure for Borax Bead Test

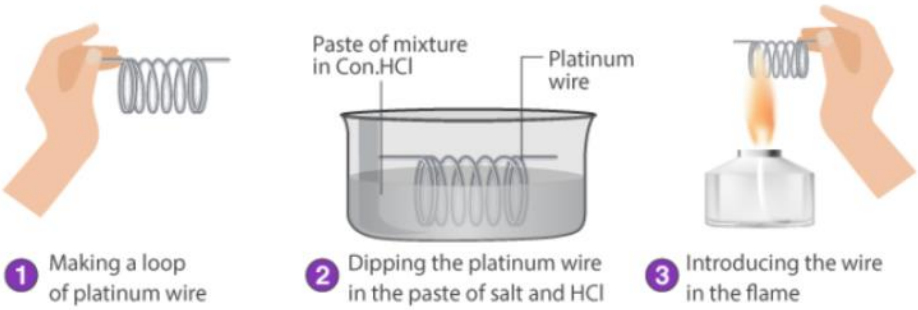
- Make a small loop at the end of the platinum wire.
- Heat the loop in a Bunsen flame until it is red hot.
- Dip it into powdered borax placed on a watch glass and heat again.

The borax will first swell up and will fuse giving a colourless, transparent glass like bead.

- Touch the hot bead with conc.HCl and touch it with the given mixture or salt. Heat it in an oxidising (non-luminous) and reducing (luminous) flame. Observe the colour of the bead and draw inferences.

(iv) Flame Test

Certain cations like fifth group radicals Ba^{2+}, Sr^{2+} and Ca^{2+} in the form of their chlorides impart characteristic colours to the non-luminous flame. The chlorides of these cations are thermally ionised. The ions so formed absorb heat energy and get excited. The extra energy is released in the form of light of the characteristic colour in the visible part of spectrum. Since different metal ions emit light energy of different wavelengths, the colours imparted by the different cations to the flame are also different.



Procedure for Flame Test

- Take a platinum wire and dip it in conc.HCl taken on a watch glass and heat it strongly in the flame. Repeat this process until the wire does not impart any colour to the flame.
- Dip platinum wire in con.HCl and then touch it with a given salt and heat it in the flame of the Bunsen burner. Observe the colour of the flame and draw inferences.

Observation and Inference

(i) Charcoal Cavity Test

S. No	Observation	Inference
1	Shining metallic bead with yellow incrustation soft and mark paper.	Pb^{2+}(Lead)
2	Shining metallic bead does not mark paper.	Ag^{+}(Silver)
3	Brittle bead with yellow or brown incrustation.	Bi^{3+}(Bismuth)
4	White incrustation with white fumes having garlic odour.	As^{3+}(Arsenic)
5	Brown residue and brown incrustation.	Cd^{2+}(Cadmium)
6	Red residue without incrustation.	Cu^{2+}(Copper)
7	Yellow residue and yellow incrustation when hot and white in cold.	Zn^{2+}(Zinc)
8	White residue	May be Al^{3+}, Ca^{2+}, Ba^{2+} or Mg^{2+}

9	Black residue without incrustation.	Fe^{3+}, Ni^{3+}, Mn^{2+}
10	No bead, white liquid globule and smoke.	Hg (Mercury)

(ii) Borax Bead Test

.No	Colour of the Bead in Oxidising Flame		Colour of the Bead in Reducing Flame		Inference
	Hot	***Cold***	***Hot***	***Cold***	
	Green	Blue	Reddish or Colourless	Reddish or Colourless	Copper
	Yellow	Yellow	Green	Green	Iron
	Brown	Brown	Grey or Black	Grey or Black	Nickel
	Pink	Pink	Colourless	Colourless	Manganese

(iii) Flame Test

.No	Colour of the Flame		Inference
	With Naked Eye	Through Blue Glass	
	Golden Yellow	Nil	Sodium (Na^+)
	Violet	Pink	Potassium (K^+)
	Crimson red	Purple or crimson	Strontium (Sr^{2+})
	Brick red	Light yellow	Calcium (Ca^{2+})
	Light green	Bluish green	Barium (Ba^{2+})
	Bluish green or blue	Bluish green or blue	Copper (Cu^{2+})
	Flashes of green	Not characteristic	Zinc (Zn^{2+}) or Manganese (Mn^{2+})

Results

The given salt contains _____ (NH_4^+, K^+, Ag^+, Hg_2^{2+}, Pb^{2+}, Hg^{2+}, Cu^{2+}, Bi^{3+}, Cd^{2+}, As^{3+}, Sb^{3+}, Sn^{4+}, Al^{3+}, Fe^{3+}, Co^{2+}, Ni^{2+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+}, Mg^{2+}, Na^+) cation.

Questions on Systematic Analysis of Cations

Q1 : Name the group 1 cation which forms white precipitate.

Q2 : Name the group 2 cation which forms chocolate brown precipitate.

Q3 :Name the group 3 cation which produces a deep red colour.

Q4 : Name the group 4 cation which obtains a black precipitate.

Q5 : Name the group 4 cation which obtains a white precipitate.