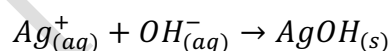


[2021 HSC] A student was trying to identify the ions present in a dilute aqueous solution. The solution contained ions of barium, calcium or magnesium, and ions of hydroxide or acetate. The student performed the following tests and recorded their observations. A fresh sample of the solution was used for each test.

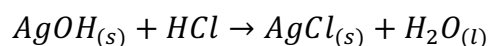
- When aqueous sodium chloride was added, no visible reaction was observed.
- When aqueous silver nitrate was added, brown precipitate was produced. The precipitate dissolved when dilute hydrochloric acid was added.
- When concentrated aqueous sodium sulfate was added, white precipitate was produced.

Evaluate this procedure as a method of identifying the ions. (7 marks)

The addition of  $NaCl$  is not helpful in identifying the ions – chloride does not precipitate with any of the cations that may be present, and sodium does not precipitate with any of the anions that may be present. The addition of  $AgNO_3$  is helpful in identifying the presence of  $OH^-$ .  $Ag^+$  and  $OH^-$  form a brown precipitate:



This brown precipitate is basic and will react with acidic  $HCl$  to form  $AgCl$ , which is white.

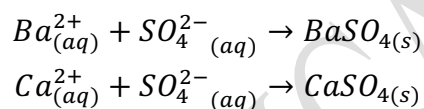


- $NO_3^-$  does not form a precipitate with any of the listed cations.
- $Ag^+$  and  $CH_3COO^-$  form the water-soluble (though slightly)  $AgCH_3COO$ .

This step confirms the presence of  $OH^-$  (by the formation of the brown precipitate that dissolves in  $HCl$ ), but does not help in determining the presence of  $CH_3COO^-$  (if multiple anions are present in the mixture).

The addition of  $Na_2SO_4$  is not helpful at all in determining the cation.

- $Mg^+$  and  $SO_4^{2-}$  form the water-soluble  $MgSO_4$ , which.
- $Ba^{2+}$  and  $Ca^{2+}$  both form white precipitates with  $SO_4^{2-}$ , and they cannot be distinguished:



This step cannot distinguish between the three cases:  $Ba^{2+}$  present,  $Ca^{2+}$  present or both present. In fact, this step cannot distinguish between the cases:  $Mg^{2+}$  present, and  $Mg^{2+}$  not present.

Thus, the student's procedure is ineffective overall. His procedure cannot be used to determine, with certainty, the cations and anions present in the sample (especially in the situation where the mixture contains multiple different ions). His procedure is only useful in determining whether  $OH^-$  ions are present. The student must perform more tests to determine the presence of the other ions.