Quiz (Detecting the Presence of Cations)

1. Some information of three unknown elements *A*, *B* and *C* is given in the table below.

	A	B	C
Appearance	Black powder	Yellow powder	Grey granules
Action of heat	Burns and colourless gas *X* evolves which turns limewater milky	Burns and colourless gas *Y* evolves which gives a choking smell	Burns and a white powder is left behind
pH of aqueous solution of its combustion products	6	2	11

   (a) Classify *A*, *B* and *C* as metals or non-metals based on the pH values of the aqueous solutions of the combustion products. Explain your answer.
   (b) Suggest what *X* and *Y* may be.
   (c) Suggest what *A* and *B* may be.
   (d) The combustion product of *C* reacts with water and a colourless solution is obtained after filtration. This solution turns milky when gas *X* is bubbled through it. Suggest what *C* may be. Explain briefly with the aid of chemical equation(s).

2. Compound *X* is one of the following compounds:
   $CuSO_4$, $BaSO_4$, $Fe(NO_3)_3$, NH_4Cl, KCl, $CaCO_3$

   Tests are performed on *X*, and the results are tabulated below:

	Preliminary test	**Result**
(1)	Solubility	Soluble in water
(2)	Colour of aqueous solution	Colourless
(3)	Action of heat	No observable change

   (a) Deduce from the result of test (1) only, which of the above compounds are NOT likely to be *X*? Explain your answer.
   (b) Deduce from the result of test (2) only, which of the above compounds are NOT likely to be *X*? Explain your answer.
   (c) Deduce from the result of test (3) only, which of the above compounds are NOT likely to be *X*? Explain your answer.
   (d) By considering your answers in (a), (b) and (c), deduce what *X* is.

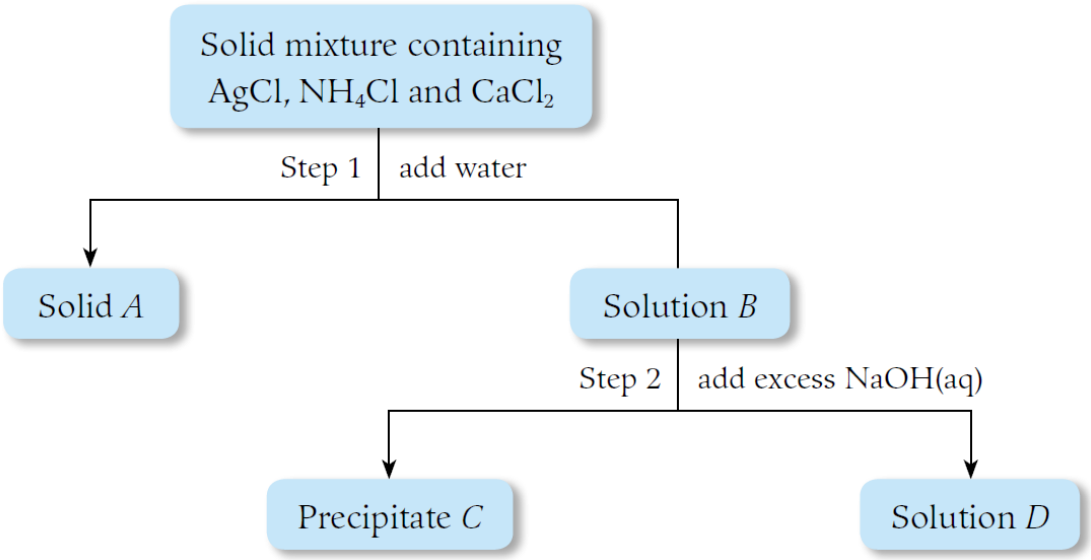
3. Suggest a chemical test to distinguish between each of the following pairs of compounds. For each test, state the expected observations.
   (a) Sodium chloride solid and potassium chloride solid
   (b) Magnesium chloride solution and ammonium chloride solution
   (c) Aluminium sulphate solution and zinc sulphate solution

4. The following tests were carried out to identify the cation present in a chloride salt.

Test	**Result**
Solubility in water	Soluble in water
Colour of aqueous solution	Colourless
Addition of sodium hydroxide solution	White precipitate formed. The white precipitate dissolved in excess sodium hydroxide solution.
Addition of aqueous ammonia	White precipitate formed. The white precipitate dissolved in excess aqueous ammonia.

What cation is present in the chloride salt? Explain your answer.

5. A solid mixture is known to contain AgCl, NH_4Cl and $CaCl_2$. The following flow chart outlines the tests used to detect the presence of those cations in the solid mixture.

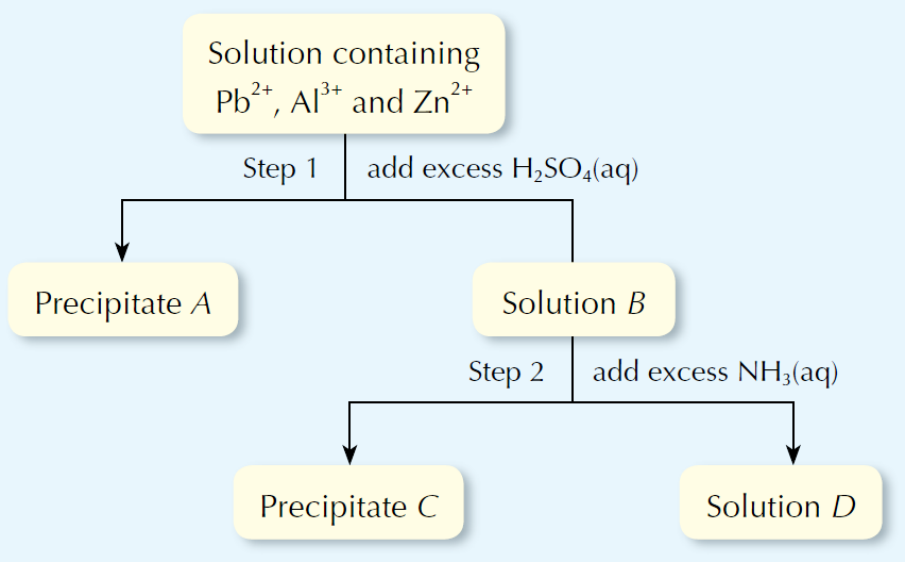


(a) (i) What is solid *A*?
(ii) Name the physical method for the separation of solid *A* in Step 1.
(iii) Explain why solid *A* can be separated from the mixture.

(b) (i) What is precipitate *C*?
(ii) Write an ionic equation for the formation of precipitate *C* in Step 2.
(iii) Suggest how to identify the cation in precipitate *C*.

(c) Which one of the three cations is present in solution *D*? How do you detect the presence of this cation?

6. The flow chart below shows the tests used to detect the presence of cations in a solution containing lead(II) ions, aluminium ions and zinc ions.



(a) (i) What is precipitate *A*?
(ii) Write an ionic equation for the formation of precipitate *A* in Step 1.

(b) (i) What is precipitate *C*?
(ii) Write an ionic equation for the formation of precipitate *C* in Step 2.

(c) Explain why aqueous ammonia used in Step 2 should be in excess.

Suggested Answer

1. (a) *A* and *B* are non-metals while *C* is a metal.
The combustion products are sometimes oxides. When a metal oxide dissolves in water, an alkaline solution (pH > 7) forms. When a non-metal oxide dissolves in water, an acidic solution (pH < 7) forms.

   (b) *X*: carbon dioxide; *Y*: sulphur dioxide

   (c) *A*: carbon; *B*: sulphur

   (d) *C* may be calcium.
The combustion product of *C* is calcium oxide, which reacts with water to form calcium hydroxide.

   The colourless solution obtained after filtration is limewater.
   $CaO(s) + H_2O(l) \longrightarrow Ca(OH)_2(aq)$

   Limewater turns milky when carbon dioxide is bubbled through it. This is because a white insoluble solid of calcium carbonate is produced.
   $CO_2(g) + Ca(OH)_2(aq) \longrightarrow CaCO_3(s) + H_2O(l)$

2. (a) $BaSO_4$ and $CaCO_3$ are not likely to be X because they are insoluble in water.

   (b) $BaSO_4$ and $CaCO_3$ are not likely to be X because they are insoluble in water. $CuSO_4$ and $Fe(NO_3)_3$ are blue and yellow in colour respectively.

   (c) NH_4Cl and $CaCO_3$ are not likely to be X because they decompose on heating.

   (d) X is KCl.

3. (a) Perform flame test. Sodium chloride solid gives a golden yellow flame white potassium chloride solid gives a lilac flame in the test.

   (b) Test with sodium hydroxide solution or aqueous ammonia. Magnesium chloride solution gives a white precipitate while there is no observable change for ammonium chloride solution.

   (c) Add aqueous ammonia dropwise to each of the solution samples until in excess. Both aluminium sulphate solution and zinc sulphate solution give a white precipitate. However, only the precipitate in zinc sulphate solution dissolves in excess aqueous ammonia to give a colourless solution.

4. Zinc ion is present in the chloride salt.

   Zinc ion gives a white precipitate upon addition of sodium hydroxide solution and aqueous ammonia. Only zinc hydroxide dissolves in both excess sodium hydroxide solution and excess aqueous ammonia. Furthermore, zinc chloride is soluble in water and its aqueous solution is colourless.

5. (a) (i) Silver chloride
   (ii) Filtration
   (iii) Silver chloride is insoluble in water while calcium chloride and ammonium chloride are soluble in water.

   (b) (i) Calcium hydroxide
   (ii) $Ca^{2+}(aq) + 2OH^{-}(aq) \longrightarrow Ca(OH)_2(s)$
   (iii) By carrying out flame test, a brick-red flame colour is observed.

   (c) Ammonium ion is present in solution *D*. It can be tested by warming solution *D*. Ammonia is produced, which turns moist red litmus paper blue.

6. (a) (i) Lead(II) sulphate
   (ii) $Pb^{2+}(aq) + SO_4^{2-}(aq) \longrightarrow PbSO_4(s)$

   (b) (i) Aluminium hydroxide
   (ii) $Al^{3+}(aq) + 3OH^{-}(aq) \longrightarrow Al(OH)_3(s)$

   (c) Solution B contains Al^{3+} and Zn^{2+}. Both Al^{3+} and Zn^{2+} give a white precipitate when a small amount of aqueous ammonia is added to them. However, only the white precipitate formed by Zn^{2+} (i.e. $Zn(OH)_2(s)$) can dissolve in excess aqueous ammonia to give a colourless solution.