Quiz (Scheme of Separating a Mixture)

1. Devise a scheme to separate the cations from a mixture containing aluminium ions, copper(II) ions and calcium ions.

2. Devise a scheme to separate the anions from a mixture containing nitrate ions, sulphate ions and iodide ions.

3. Describe briefly how you would accomplish the following tasks in the laboratory.
   (a) Obtain calcium carbonate from a solid mixture of calcium carbonate and calcium chloride.
   (b) Obtain butanal (b.p. = 74.8°C) from a mixture of butanal and methanoic acid (b.p. = 101°C).
   (c) Obtain heptane (b.p. = 98.0°C) from a mixture of heptane and methanoic acid (b.p. = 101°C).

4. Explain whether the proposed method in the following cases is suitable for the separation of substances in a mixture. If not, suggest an appropriate method.
   (a) Separate a mixture of ethanol (b.p. = 78.3°C) and pentane (b.p. = 36°C) by separating funnel.
   (b) Separate a mixture of sodium chloride and ammonium chloride by adding water followed by filtration.

5. A mixture of hexanal and acidified potassium dichromate solution is heated under reflux. The following reaction occurs:

   $$CH_3CH_2CH_2CH_2CH_2CHO(l) \xrightarrow{[O]} CH_3CH_2CH_2CH_2CH_2COOH(l)$$

   A student carries out the following steps to obtain hexanoic acid from the reaction mixture.

   Step (1): *Add excess sodium carbonate solution to the reaction mixture.*
   Step (2): *Discard the organic layer.*
   Step (3): *Add a small amount of dilute hydrochloric acid to the aqueous layer.*
   Step (4): *Obtain hexanoic acid from the aqueous layer.*

   (a) What is the purpose of adding excess sodium carbonate solution to the reaction mixture?
   (b) Name the apparatus used in Step (2).
   (c) What is the purpose of adding a small amount of dilute hydrochloric acid in Step (3)?
   (d) Suggest a separation method that can be used to obtain pure hexanoic acid in Step (4).

6. Outline how cyclohexane can be separated from a mixture of hexane, cyclohexane and water by physical methods.
   (Boiling points: hexane = 68.7°C, cyclohexane = 80.7°C, water = 100°C)

Suggested Answer

1. Add excess $Na_2SO_4(aq)$ to the solution. $SO_4^{2-}(aq)$ forms insoluble white precipitate $CaSO_4(s)$ with $Ca^{2+}(aq)$.

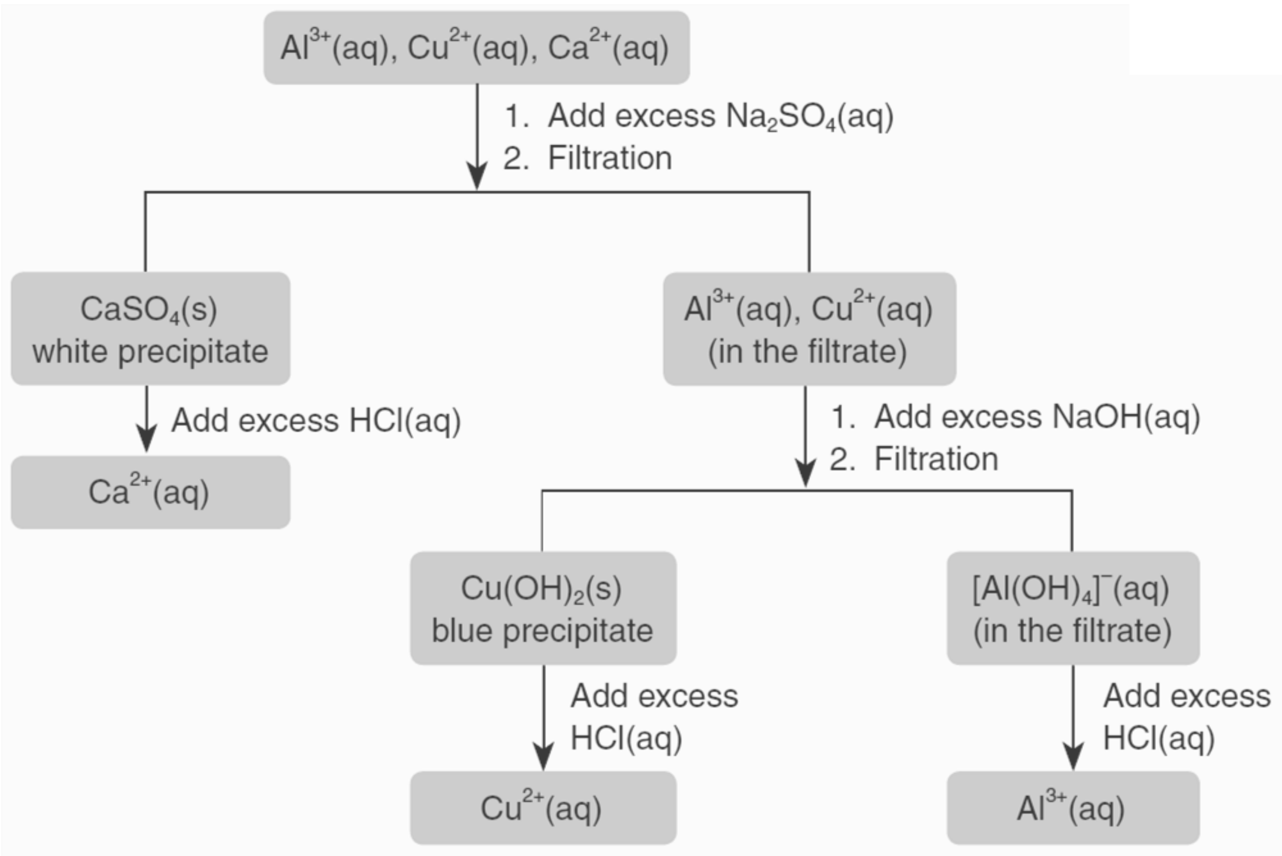
   Filter the mixture. The residue is $CaSO_4(s)$. The filtrate contains $Al^{3+}(aq)$ and $Cu^{2+}(aq)$.

   Add HCl(aq) to dissolve the white precipitate (residue). The solution formed contains $Ca^{2+}(aq)$.

   Add a little and then excess NaOH(aq) to the filtrate. $Cu^{2+}(aq)$ forms an insoluble blue precipitate $Cu(OH)_2$. $Al^{3+}(aq)$ forms an insoluble white precipitate $Al(OH)_3(s)$ first and it dissolves in excess NaOH(aq) to give a colourless solution containing $[Al(OH)_4]^-(aq)$.

   Filter the mixture. Add excess HCl(aq) to the filtrate and the resultant solution contains $Al^{3+}(aq)$.

   Add excess HCl(aq) to dissolve the blue precipitate (residue). The solution formed contains $Cu^{2+}(aq)$.

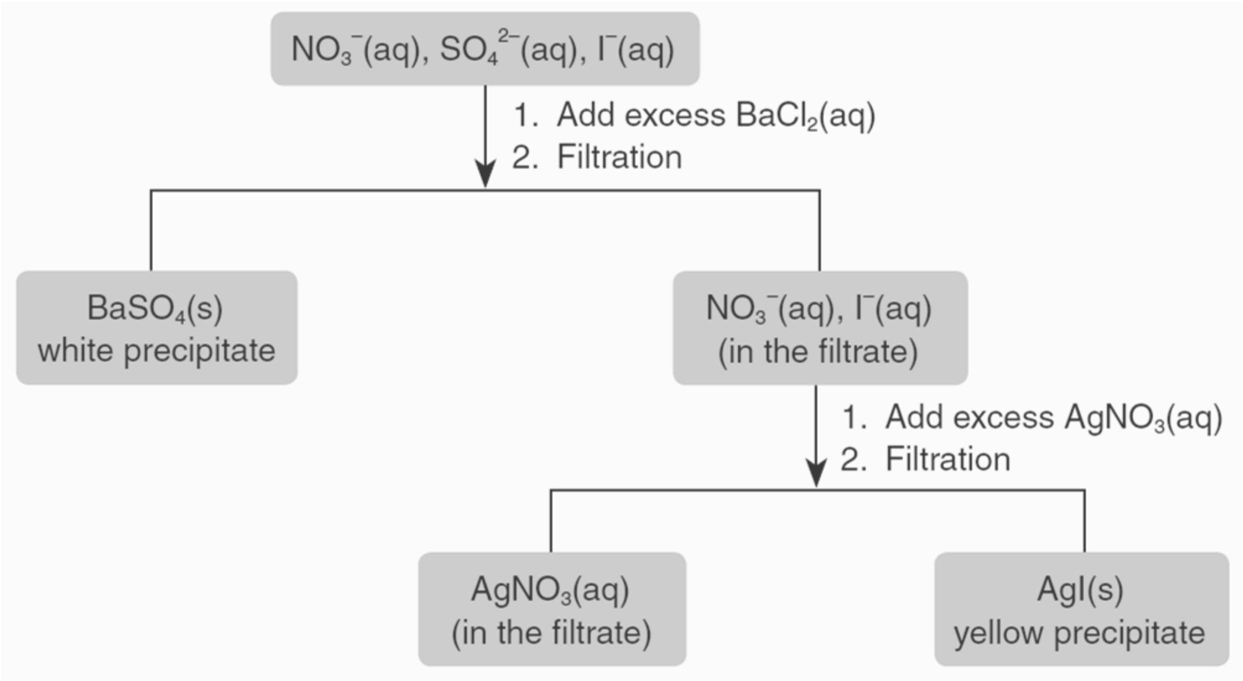


2. Add excess $BaCl_2(aq)$ to the solution. $SO_4^{2-}(aq)$ forms insoluble white precipitate $BaSO_4(s)$ with $Ba^{2+}(aq)$.

   Filter the mixture. The residue is $BaSO_4(s)$. The filtrate contains $NO_3^-(aq)$ and $I^-(aq)$.

   Add excess $AgNO_3(aq)$ to the filtrate. $I^-(aq)$ forms insoluble yellow precipitate $AgI(s)$ with $Ag^+(aq)$.

   Filter the mixture. The residue is $AgI(s)$. The filtrate contains $NO_3^-(aq)$ as the only anion.



3. (a) Add water to the solid mixture with stirring until no more solids can dissolve. Filter the mixture and the residue is calcium carbonate.

   (b) Distill the liquid mixture. Collect the distillate (butanal) with a boiling point range from 72.8 °C to 76.8 °C.

   (c) Add excess sodium hydrogencarbonate solution to the mixture in a separating funnel and shake the mixture, until no more colourless gas evolves. Methanoic acid reacts with sodium hydrogencarbonate solution and dissolves in the solution (aqueous layer). Heptane has no reaction and forms the organic layer.

   Allow the aqueous layer and organic layer to separate. Discard the aqueous layer.

   Add anhydrous calcium chloride to the organic layer. Filter the organic layer and carry out distillation of the filtrate.

   Collect the distillate (heptane) with a boiling point range from 96 °C to 100 °C.

4. (a) As ethanol and pentane are miscible, the mixture cannot be separated by using a separating funnel. The mixture can be separated by simple distillation.

   (b) As both sodium chloride and ammonium chloride are soluble in water, the mixture cannot be separated by dissolution and filtration. The mixture can be separated by heating as only ammonium chloride sublimes on heating.

5. (a) This is to extract all hexanoic acid from hexanal (hexanoic acid is converted into sodium hexanoate).

   (b) Separating funnel

   (c) To regenerate the hexanoic acid from the aqueous layer.

   (d) By carrying out distillation / fractional distillation.

6. Use a separating funnel to remove water (the lower layer) from the mixture. The upper layer remaining in the funnel is a mixture of hexane and cyclohexane. Carry out simple distillation on the upper layer. Hexane and cyclohexane can then be separated.